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memorandum

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FROM: Charlie Nylander, ESH-18

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DATE: February 7, 2001

MAIL STOP/TELEPHONE: K497/5-4681

SUBJECT: **QUARTERLY MEETING NOTES – JANUARY 30, 2001**

Attached are the minutes from the January 30, 2001 Hydrogeologic Characterization Program Quarterly Meeting held in Los Alamos, New Mexico. A number of major issues were discussed. These minutes are being sent to you because you have received a copy of the Laboratory's Hydrogeologic Workplan and a binder for the Annual Reports and Meeting Minutes or you have requested to be on the distribution list. If you are not interested in continuing to receive meeting minutes, please contact me at the address or telephone number listed below.

The action items resulting from the meeting follow. The organization responsible for completion of each action item is given in parentheses.

- New URL for Information Management database access will be e-mailed to distribution pending finalization of upgrade to new interface (LANL).
- The sampling approach for the R-wells, once drafted, will be discussed with the NMED, DOE, and stakeholders (LANL).
- The draft *Groundwater Annual Status Report for Fiscal Year 2000* will be distributed by February 9, 2001 for review and comment (LANL).

Please review these 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, or by telephone at 665-4681. Additionally, I would appreciate a reply from the New Mexico Environment Departments' Hazardous and Radioactive Materials Bureau indicating their concurrence with the meeting minutes and action items.

CN/rm

13476

Enclosures: 'a/s

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J. Young, NMED/HRMB, Santa Fe, NM, w/enc.
M. Leavitt, NMED/GWQB, Santa Fe, NM, w/enc.
P. Bustamante, NMED/GWQB, Santa Fe, NM, w/enc.
J. Davis, NMED/SWQB, Santa Fe NM, w/enc.
J. Parker, NMED/DOE/OB, Santa Fe, NM, w/enc.
P. Maggiore, NMED Secretary, Santa Fe, NM, w/enc.
J. Mullany, NMED/GWQB, Santa Fe, NM w/enc.
G. Lewis, NMED/HRMB, Santa Fe, NM w/enc.
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D. Duffy, Jemez Pueblo, Jemez, NM, w/enc.
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Los Alamos National Laboratory
Hydrogeologic Characterization Program
Quarterly Meeting
January 30, 2001

INTRODUCTION

Charlie Nylander (LANL) welcomed everyone. This is the third year of conducting quarterly meetings. The Hydrogeologic Workplan was approved in May 1998. The quarterly meetings are held to informally get together with regulators and stakeholders and to bring them up to speed on the progress.

In 1995, the NMED sent several letters requesting a Hydrogeologic Workplan for the site-wide Hydrogeologic setting under RCRA/HSWA. When approved, it included three major activities: 1) drilling wells, 2) modeling activities as tool for visualizing data and hypothesizing transport, and 3) information management.

The Hydrogeologic Workplan is a regulatory document, includes NMED's HMB, DOE-OB, and GWB at meetings. Schedule over 7 years, 32 regional wells, 51 alluvial wells. Implementation is an integrated effort and cooperative work from groups within the Laboratory. Integration is accomplished through the GIT. The GIT brings together professionals who look at the data and information and make recommendations to project managers.

Mechanisms of communications include the quarterly meetings, annual report that has activities from previous year and well completion reports that contain data and interpretations from a particular well.

WELL CONSTRUCTION SUBCOMMITTEE

Ted Ball (LANL) presented well construction status. (see attached viewgraphs)
R-7 is being backfilled. Should be done this week. TD 1097 ft. Geophysics run on Jan 13. Has 3 screens, 2 in the perched zone, 1 at top of regional aquifer.

Have conducted quarterly sampling for R-9, R-9i, R-12, R-15, and R-19. Backlog of analyses due to the Cerro Grande Fire but analytical results are starting to come in.

R-22 finished drilling Oct 11 and Westbay installed Dec 18. Hydrologic testing during development. First quarterly sample to be taken in June.

Quarterly sampling conducted on R-25 and R-31.

CDV 15-3 drilling completed April 26, Westbay installed Sept 20, first quarterly sample taken in Jan 2001.

Negotiations on R-5 drilling, finalizing FIP, location picked, expect to start in about 10 days.

GEOLOGY

Dave Vaniman (LANL)presented geology encountered during drilling of R-7 and R-22 (see attached viewgraphs).
R-7 is in NW part of Lab and R-22 in east. Didnt have previous info to constrain geology.

For R-7, predicted vs actual stratigraphy:

- Cerros del Rio lava not present. Does not extend this far to the west.
- Perched water was in top of Puye, not in Guaje pumice.

- Puye subdivided into upper and lower
  coarse detritus
  vitric pumice rich

also seen in CDV 15-3

- minor river gravel (Totavi)
- possibly some Santa Fe

R-22 predicted vs actual:

- Cerros del Rio much thicker than predicted and thicker than anywhere else. May be near a paleocanyon.
- More complex stratigraphy, below basalts in sequence of intermixed fanglomerates, river gravels, volcanic sandstone and sandstones from plutonic sources. Appears to be a mixture of what would have been called Totavi, Puye, and Santa Fe,. Probably zone of interfingering of sediments from north, west, and east
- no Cerro Toledo, but Bandelier is thicker than predicted.

HYDROLOGY

David Rogers (LANL) presented water supply monitoring conducted in 2000 (see attached viewgraphs). In 1999, data problems identified with Sr-90 data analyzed by internal lab. Found out that manufacturer had changed resins in the extraction process. Samples are being sent to outside labs for analyses.

- NMED found 1.1 pCi/L Sr-90 in supply well PM-1 in March 99. LANL samples collected at same time were non-detect. 16 analyses since that show no detections.
- No Sr-90 or HE in water supply wells. 11 wells sampled, 58 samples collected. MCL is 8pCi/L. Method detection limit is 0.2 pCi/L. Initial detections in O-1 and G-3A have not been repeated. Rad results near the detection limit are a problem to resolve. Better to look at a body of data.
- O-1 is downstream from County wastewater treatment plant and past LANL discharges. Samples have perchlorate, nitrate, and tritium. Sr-90 also detected, but not replicated so probably not there. Nitrate below water standards. Discharge from plant into infiltration area creates mound. County actions to improve infiltration may have increased infiltration of contaminants from sewage and ones that were already there.
- No current standard for perchlorate in groundwater. Used in Laboratory processes. 4-18 ppb is range for various agencies as action levels. Values measured in O-1 are >1 to 5 ppb although most are near 1 ppb. Likely source is cold-war era effluents.
- Tritium standard for drinking water is about 20000 pCi/L. NMED and Lab have verified about 40 pCi/L in O-1. TW-1 has 360 pCi/L at the top of the regional aquifer. Lab discharges are likely source.
- Summary: No Sr or HE believed to be present. Only O-1 has tritium and perchlorate. Lab will continue monitoring.

Don Diego Gonzales (Pueblo de Cochiti) asked how could Lab say nothing was found in the water when some of the samples were above detection. David Rogers (LANL) discussed the noise levels associated with trying to measure radionuclides near the detection limit because of the changing background of the instrument.

There are definitely places where there is Sr-90 in the water like Mortandad and LA canyons. It shows up in every sample, not always at the same level, but detected in every sample.

HYDROLOGIC TESTING IN R-WELLS

Bill Stone (LANL) presented tables showing hydrologic observations and testing that have been performed on the R-wells (see attached viewgraphs).

It is perceived that a lot of chemical data is being collected but not much hydrologic data. Don't see the hydrologic data because it gets put into the well completion reports. Well completion reports have summary tables in them. Separate reports will give the meta data on the tests on an annual basis.

R-25 (in table) shows no data because while the zones produce water, they will not take water for doing an injection test. Quarterly samples were able to be collected from the screens.

MODELING

Bruce Robinson (LANL) discussed the canyon modeling (see attached viewgraphs)

Los Alamos Canyon model. Modeling tritium concentrations. Conceptual model downcanyon where basalts are. Get rapid transport by fracture flow. Upper canyon where tuff is transport is much slower by matrix flow. Predicted arrival of tritium at water table. Mass rate of tritium arrived since 1967. Travel time 5-10 years in releases in lower canyon. Longer time for releases further up canyon. Looking at alternate conceptual models of shallow alluvial water flow.

MDA-G model and R-22 data. Model used for Performance Assessment for MDA-G. Looked at R-22 data and it agrees with model. Model outputs:

- Travel times >1000 years
- Area L no significant downward migration of vapor

R-22 data

- No VOCs or leached rads at depth, consistent with model results
- Mesa setting, very low infiltration
- small amounts of tritium in R-22. Pursue vapor phase transport.
- Hydrostratigraphy is different than the geologic model at the time. Different depth to water and thicker basalts. Travel time controlled by low infiltration on mesa top, so conclusions unlikely to change, even though there is thicker section of basalt.

Regional Model

Elizabeth Keating (LANL) presented the status of the regional aquifer model. (see attached viewgraphs).

- Transport simulations for tracers compared to observed values.
- Formal incorporation of transient water level data for model calibration. Bulk permeability of Santa Fe Group well known.
- Uncertainty analysis for groundwater flow. Critical need for multi-level water level data in western part of Lab.
- Geostatistical representation of heterogeneity of Puye using outcrop data. Predict travel times trom TA-16 with a range of answers. Distribution of plausible travel times and directions.

Tracer transport simulation. C-14 ages.

Complexity of geology in Pajarito Plateau is reflected in structure of C-14 ages. In western part of Lab, 5000-50000 year range in groundwater age older from top to bottom. Measured ages fall within range of predicted ages. Mostly sampling younger water from shallower units.

Near the Rio Grande, model predicts young water, but measuring old water. Red flag that something is amiss in that area.

FY-01 Integrated Modeling Task
Diana Hollis (LANL) presented planned modeling activities (see attached viewgraphs)

- First order groundwater pathway assessment. Map contaminants ER Project identified and results of R-wells and models to predict transport times to receptor wells.
- Plateau-wide infiltration mapping. Compile existing data. Identify inconsistency and uncertainty.
- 3-D geologic model uncertainty assessment
- Geophysical surveys to supplement wells. Hope to be able to map basalts and other hydrologically important zones.
- Statistical analysis of spatial placement of R-wells.

GEOCHEMISTRY
Brent Newman (LANL) presented geochemistry data. (see attached viewgraphs).
Quarterly sampling. Collected filtered and unfiltered samples. Collected rad, metals, cations, anions, HE, volatiles and semivolatiles, TOC, DOC, stable isotopes. Table summarizes field parameters. High pH in R-25 at 1055-1065 feet depth possibly result of cement. Analytical results are being validated.

TA-16

- Potential barium colloids in springs investigated. Filtered and unfiltered samples consistently showed higher values in unfiltered for all three springs.
- Geochemical model indicates supersaturation in the springs suggesting it may be barite.
- Fe and Al have same filtered vs unfiltered bias so barium nay be sorbing on Fe or Al rather than barite. Two possible phases: barite and iron and aluminosilicate. PHREQE model confirms both possibilities. Estimate that 10% of Barium is in colloids.

R-22 borehole sampling

- Sr-90, Pu, Am-241, and perchlorate less than detection.
- Tritium 109 pCi/l
- Acetone in 833 ft sample at 820 ug/L probably from quickfoam. Acetone and isopropyl alcohol elute from gas chromatograph at same time so cant distinguish between the two compounds. Acetone (or alcohol) found in frac tanks also. Short residence time in aqueous system. Isopropyl alcohol oxidizes to acetone . Acetone also showed up in R-19 where quickfoam was used.

INFORMATION MANAGEMENT
Kendra Henning (LANL) presented the status of information management (see attached viewgraphs).

- Primary efforts focused on software development, report development, data migration of legacy data, and performance enhancements
- Software development. Data steward tools for review, validator data in electronic format, Discharge Monitoring Reporting system report format for stormwater.
- Report development. Chemistry, gage and flow data.
- Data Migration. 2000 chemistry data almost all in from ESR. Legacy chemistry from 1994 to 1999 ESR and some from prior to 1994. Sample tracking (chain-of-custody). Daily flow data, 5-minute flow, 5-minute gage height, 25 stations for 1994-1999.

- Performance. Poor performance for accessing data from outside Lab. Technology was web-based but requires one time installation of J initiator. Will upgrade to different interface that is purely HTML and does not require J initiator, is platform independent (ibm vs mac) and is faster. Will e-mail new URL.

Next Quarter.
- Continued software development
- Data migration focus on water level and hydrologic properties
- Continued report development and fix performance. Hope to have input on report formats.

MANAGEMENT OVERVIEW ON STATUS OF HYDROGEOLOGIC MODELING
Charlie Nylander (LANL) presented information covering four points (see attached viewgraphs).
- Computer programs selected for modeling
- Status of model development
- Programmatic decisions supported by models
- Desired input from NMED.

Model Uses
Assimilate and interpret data, prioritize and site subsequent wells, design monitoring network
2-D/3-D process, models vadose zone, saturated flow and transport
Identified system models to integrate
quantitative 3-D representation of flow and transport in regional aquifer and estimates of uncertainty.

Computer programs
FEHM.
- Used in many projects at LANL and other places.
- Code selection based on capabilities and intended use, pedigree, acceptance, ease of use.
- Complexity is attribute of modeling situation, not the code.
- Validity based on conceptual model and data, not on code (as long as used within range of validity of code)
- Simpler is better, but conditions require more complex code. FEHM chosen because complex hydrostratigraphy, scale of problem requires large and complex model
- Use process model and pathway model. FEHM used for process model. GOLDSIM used for pathway model.

(See table for comparison of FEHM to MODFLOW)

Results of models used to
- guide data collection of HWP (siting wells, data collection required)
- support interim measures in ER (MDA AB, MDA L)

Decisions requiring modeling
- Additional monitoring required
- Maximum of contamination-time and space
- Natural attenuation

Users manuals and other documentation available. NMED managers had no problem with selection of code. Did express concern about how complex model needs to be. Concerned that data from R-wells is not being used in model. Assured data is being used.

GROUNDWATER INVESTIGATIONS FOCUS AREA

Julie Canepa (LANL) presented the organization of the Groundwater Investigations Focus Area. (see attached viewgraphs).

The ER Project is the constuction manager for the wells. Added focus area for groundwater. Deba Daymon was the focus area leader but left. Teams that Deba had set up remain in place. R-7 started under new drilling contract. Ted Ball is acting as Focus area leader with John McCann as UTR for the drilling contract until the leader position is filled. Needs more project management control and more stringent evaluation of data requirements. Developing more formal system of recommendations from GIT.

SAMPLING AND ANALYTICAL APPROACH

Charlie Nylander (LANL) presented work-in-progress on developing a sampling approach (see attached viewgraphs).

Technical Approach

- Initial approach was to drill and sample water encountered in borehole. If contaminated, then install an intermediate well. If not, then no further monitoring.
- NMED letter said borehole samples not adequate for regulatory decisions
- Revised approach was to screen all saturated zones.

Hydro Workplan commitments and concerns. Based on 3 years of experience.
Areas of future analytical proposal

- Determining when samples are representative
- Frequency of analytical suites on subsequent samples
- Analysis for dissolved and total constituents
- Analytical Methods

ANNUAL REPORT

Committed to distribute Feb 9. Draft for comment, finalize before annual meeting. Incorporation of information by reference. Intended to be a summay report.

Annual meeting will be week of March 19.

- Monday for Senior Management Steering Committee
- Tuesday and Wednesday at Ghost Ranch for subcommittee reports, technical presentations, Stakeholder meeting
- Thursday for EAG to meet with GIT
- Friday for EAG close-out

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Quarterly Meeting
January 30, 2001

NAME	AFFILIATION	E-MAIL
Bob Beers	ESH-18	
Pat Ortiz	ESH-14	plortiz@lanl.gov
Deborah Woitte	LC	dwoitte@lanl.gov
Brent Newman	EES-15	bnewman@lanl.gov
William Stone	EES-A	wstone@lanl.gov
Elizabeth Keating	EES-A	ekeating@lanl.gov
Mike Klahn	Schlumberger	mklahn@bryan.ipm.slb.com
Bruce Johnson	Westbay/Schlumberger	bjohnson@slb.com
Naomi Archuleta	Pueblo of San Ildefonso	
Ryan Gonzales	Pueblo of San Ildefonso	
Mark Everett	Washington Group International	meverett@lanl.gov
John Young	NMED-HWB	
Michael Dale	NMED-DOE-OB	mdale@lanl.gov
Diana Hollis	E-ER	dhollis@lanl.gov
Michael Taylor	Pueblo of San Ildefonso	mataylor@trail.com
Sue Johnson	LATA/ESH-18	sjohnson@lata.com
Karen Agogino	DOE	kagogino@doeal.gov
Ted Taylor	DOE-LAAO	
Kelly Bitner	Neptune & Co	bitner@neptuneandco.com
Rich Daily	DOE-HQ	
Kendra Henning	ESH-IM	khenning@lanl.gov
Sue Kinkead	ESH-IM	suek@lanl.gov
Don Diego Gonzales	Pueblo de Cochiti	dondiego@pecos-nm.com
Lindsey Lovejoy	NM Attorney General	llovejoy@ago.state.nm.us
Gary Valdo	Pueblo de Cochiti	gvaldo@ix.netcom.com
Lee Suina	Pueblo de Cochiti	lsuina@ix.netcom.com
John McCann	E-ER	
Charlie Nylander	ESH-18	nylander@lanl.gov
Greg Cole	EES-1	gcole@lanl.gov
Dave Broxton	EES-1	broxton@lanl.gov
Dave McInroy	ER	mcinroy@lanl.gov
Bob Charles	EAG	conehead@fiberpipe.net
Robert Powell	EAG	rpowell@powellassociates.com
Kay Birdsell	EES-A	khb@lanl.gov
Carol LaDelfe	EES-B	cladelfe@lanl.gov
Steve Bolivar	EES-13	bolivar@lanl.gov
Paul Aamodt	EES	paamodt@lanl.gov
Dave Vaniman	EES	vaniman@lanl.gov
David Rogers	ESH-18	slug@lanl.gov
Ted Ball	ER	tedball@lanl.gov
Bruce Gallaher	ESH-18	gallaher@lanl.gov
Suzanne Maez	LATA	s_maez@lanl.gov

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Quarterly Meeting Agenda
January 30, 2001
LATA 4th Floor Conference Room

9:00 Welcome and Introductions (Charlie Nylander)
9:15 Subcommittee Status Reports
- Well Construction (Ted Ball)
- Hydrology (David Rogers)
- Modeling (Bruce Robinson and Diana Hollis)
- Geochemistry (Brent Newman)
- Information Management (Kendra Henning)

10:30 Break
10:45 Management overview on status of hydrogeologic modeling (Charlie Nylander/Julie Canepa)
11:15 Groundwater Investigations Focus Area Organization (Julie Canepa)
11:30 Sampling and analytical approaches (Charlie Nylander)
11:45 Annual Report and Proposed Annual Meeting Agenda (Charlie Nylander)
12:00 Adjourn

Groundwater Investigation Team
Regional Well Status Table
January 30 2001

Well	Watershed	Depth (ft)/Screens	Current Status	Ongoing Activities
R-7	LA/Pueblo	1097/3	Well drilled to TD of 1097 on 1/12/01. Geophysics run on 1/13-14/01. Construction started 1/16/01	Complete construction, development, testing and Westbay installation before T&E shutdown on 3/1/01
R-9	LA/Pueblo	771/1	Second quarter of sampling conducted in September 00	Third quarter sampling planned for January & February 01
R-9i	LA/Pueblo	323/2	First quarter of sampling conducted in September 00	Second quarter sampling planned for January and February 01
R-12	Sandia	886/3	First quarter of sampling conducted in September 00	Second quarter sampling planned for March 01
R-15	Mortandad	1107/1	Second quarter of sampling conducted in September 00	Third quarter sampling planned for February 01
R-19	Pajarito	1902/7	First quarter of sampling conducted in September 00	Second quarter sampling planned for February 01
R-22	Pajarito	1489/5	Drilling completed 10/11/00; geophysical logs performed by Schlumberger on 10/13/00; well construction completed 11/3/00; well development completed 11/19/00; Westbay installed 12/18/00	First quarter sampling planned for June 01
R-25	Water/Valle	1942/9	First quarter sampling conducted in November 00	Second quarter sampling planned for March 01
R-31	Ancho	1103/5	First quarter sampling conducted in December 00	Second quarter sampling planned for March 01
CdV-15-3	Water/Valle	1680/7	Drilling completed 4/26/00; geophysical logs performed by Schlumberger on 4/27-28/00; well construction completed 6/9/00; well development completed 8/4/00; Westbay installed 9/20/00; first quarter sampling conducted in January 01	Second quarter sampling planned for April 01

New Stratigraphic Information from Drill Holes R-7 and R-22

•At R-7, perched water was encountered below rather than within the Guaje pumice. The Cerros del Rio lavas, which host perched water farther to the east in Los Alamos Canyon, were not present in R-7. A two-part subdivision of Puye sediments into upper non-pumiceous and lower pumice-rich deposits is consistent with data from R-9, R-12, R-15, R-19 and CdV-R-15-3, indicating a widespread sedimentary transition.

•At R-22, the Cerrros del Rio lavas were considerably thicker than anticipated, suggesting accumulation within a paleochannel to the west of the present Rio Grande. The top of the zone of regional saturation at R-22 is within lava flows rather than within Puye sediments. Sediments beneath the Cerros del Rio lavas include a complex interlayering of volcanic detritus derived from the west and north, riverine gravels from the north, and plutonic detritus from the north and east.

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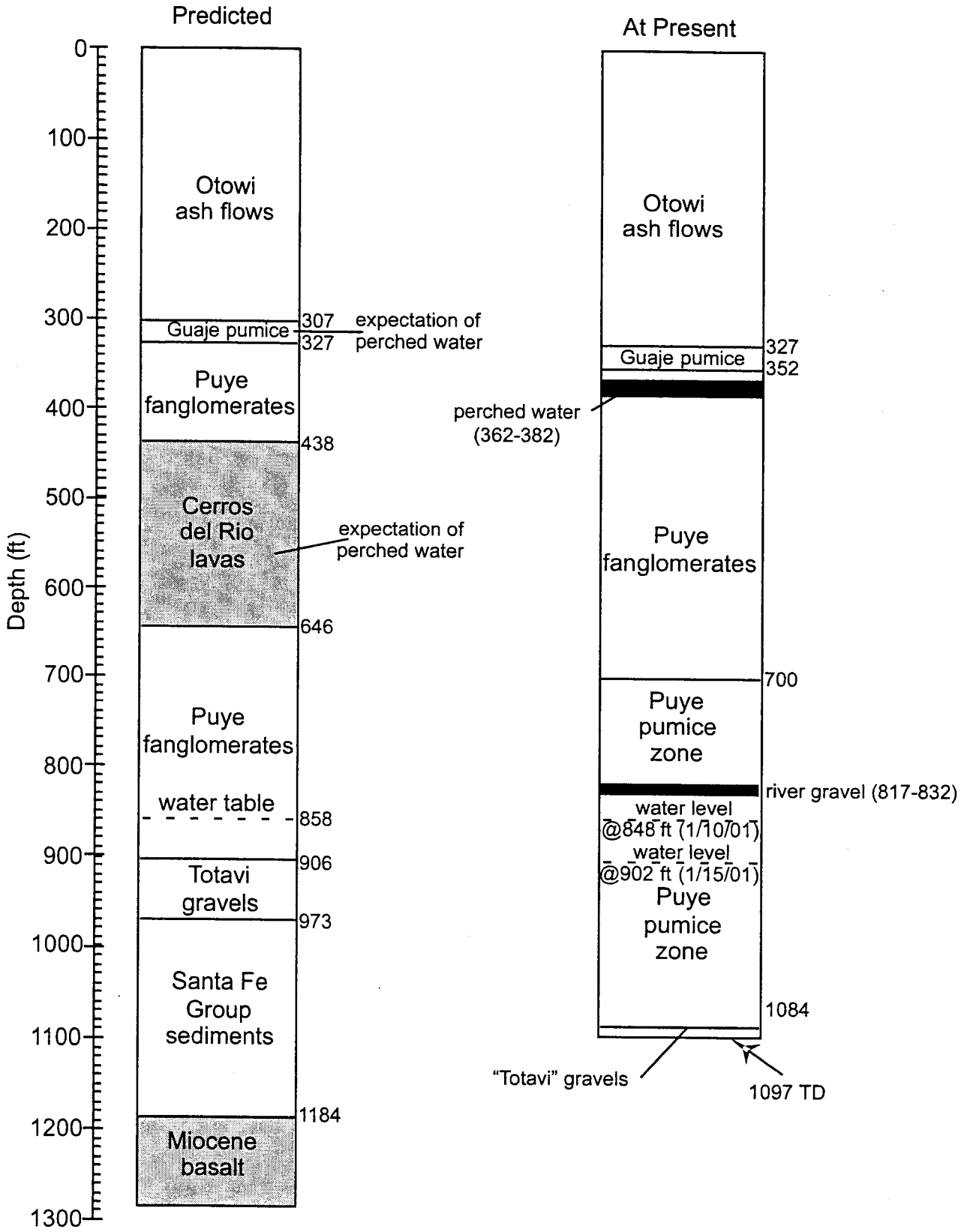
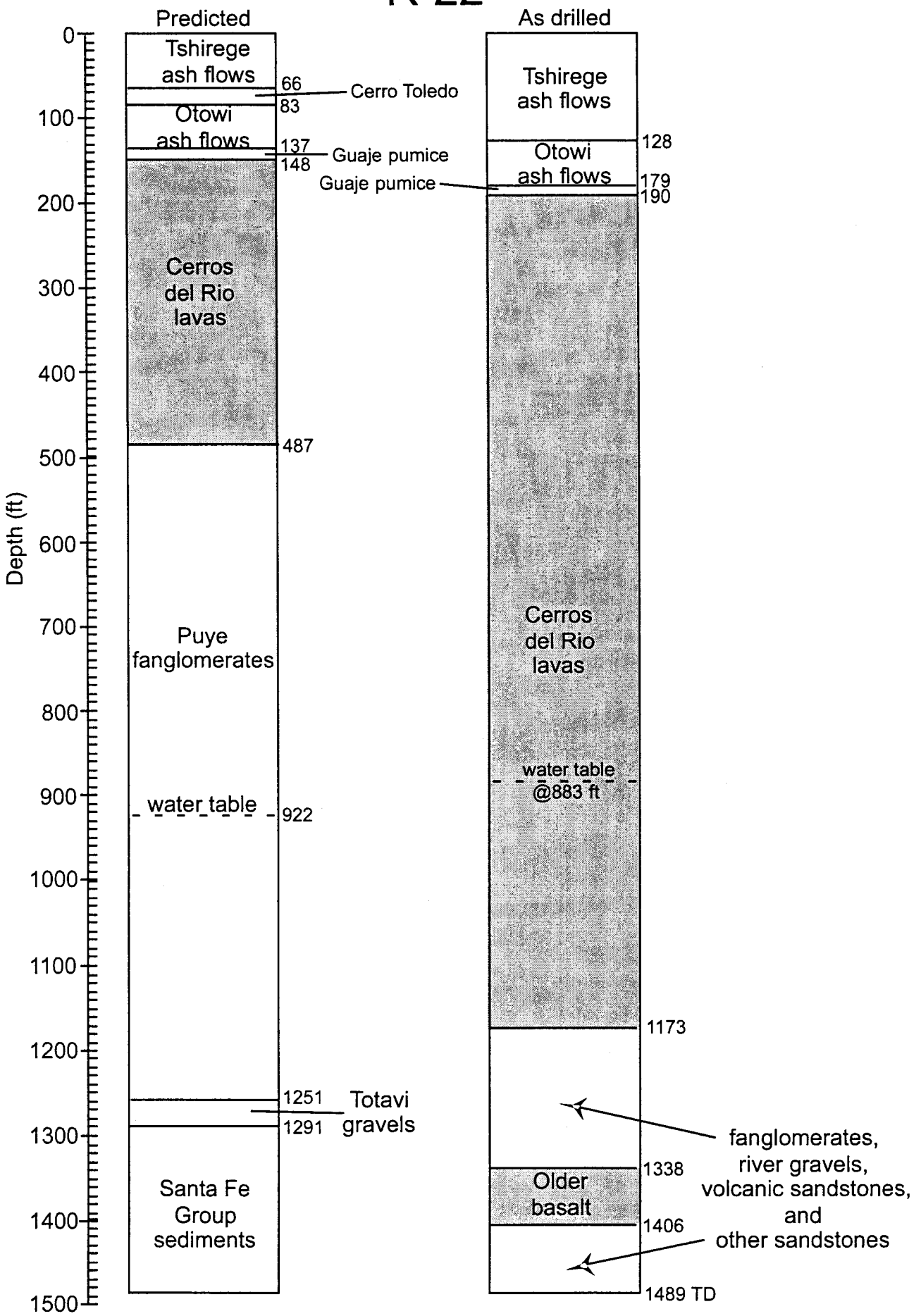
R-7


Predicted
At Present
Depth (ft)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Otowi ash flows
Guaje pumice
307
327
expectation of perched water
Puye fanglomerates
438
Cerros del Rio lavas
expectation of perched water
646
Puye fanglomerates
water table
858
906
Totavi gravels
973
Santa Fe Group sediments
1184
Miocene basalt
Otowi ash flows
327
Guaje pumice
352
perched water (362-382)
Puye fanglomerates
700
Puye pumice zone
river gravel (817-832)
water level @848 ft (1/10/01)
water level @902 ft (1/15/01)
Puye pumice zone
1084
"Totavi" gravels
1097 TD

R-22


Predicted
As drilled
Depth (ft)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Tshirege ash flows
66
Cerro Toledo
83
Otowi ash flows
137
Guaje pumice
148
Cerros del Rio lavas
487
Puye fanglomerates
water table
922
1251
Totavi gravels
1291
Santa Fe Group sediments
Tshirege ash flows
128
Otowi ash flows
179
Guaje pumice
190
Cerros del Rio lavas
water table @883 ft
1173
fanglomerates, river gravels, volcanic sandstones, and other sandstones
1338
Older basalt
1406
1489 TD

Los Alamos Water Supply Well Monitoring during 2000

LANL Hydrogeologic Characterization

Program Quarterly Meeting

January 30, 2001

David B. Rogers and Robert S. Beers

Water Quality & Hydrology Group, ESH-18

1999 Strontium-90 Data Issues

- 1999 Environmental Surveillance strontium-90 were not usable due to analytical laboratory problems
- This conclusion was based on comparison to previous data, to NMED split samples, and reanalysis of samples
- Inconsistent analyses resulted from manufacturer's change in extraction resins
- All stations continue to be monitored for strontium-90
- Samples are now sent to an outside laboratory for analysis

NMED Strontium-90 Detection at PM-1

- PM-1 is in Sandia Canyon and is not near any strontium-90 sources
- NMED found strontium-90 at 1.1 pCi/L in a March 1999 PM-1 sample
- A LANL split sample found no strontium-90
- Strontium-90 is persistent and would appear in many samples if present in the aquifer
- Of 16 analyses (4 in 2000) for strontium-90 from PM-1 the NMED March 1999 sample is the only detection

Special Water Supply Sampling in 2000

- Los Alamos water supply wells sampled for strontium-90, tritium, high explosives, and perchlorate
- Frequency and choice of analytes vary with location
- No strontium-90 found in wells
- No high explosives found in wells
- Only Otowi 1 has perchlorate
- Only Otowi 1 has tritium above background

Strontium-90 Water Supply Sampling in 2000

- LANL analyzed 58 total samples from 11 wells for strontium-90 in 2000
- EPA MCL for strontium-90 is 8 pCi/L
- Average detection limit was 0.2 pCi/L (0.1 to 0.74 pCi/L)
- Samples from Otowi 1 and Guaje 3A initially showed detections
- Reanalysis and subsequent sampling did not confirm detections
- These two "hits" are analytical outliers

Otowi 1 Contamination

- Otowi 1 is in Pueblo Canyon
- The well is downstream from Los Alamos County sanitary treatment effluent and past LANL discharges
- Perchlorate, nitrate, and tritium have been detected in Otowi 1 at levels below drinking water standards but above background
- One sample in 2000 apparently showed strontium-90 but is not confirmed by 10 other analyses in 2000

Perchlorate in Drinking Water

- No current drinking water standard for perchlorate
- EPA added perchlorate to its Safe Drinking Water Act Contaminant Candidate List in 1998
- EPA is reviewing perchlorate toxicology
- California has a water supply action level of 18 ppb and EPA indicates a provisional cleanup level of 4-18 ppb

Otowi 1 Perchlorate

- Otowi 1 samples analyzed 16 times for perchlorate in 2000
- Results are near detection limit and range from <1 to 5 ppb
- Source may be LANL cold war era effluents: 1943-1964

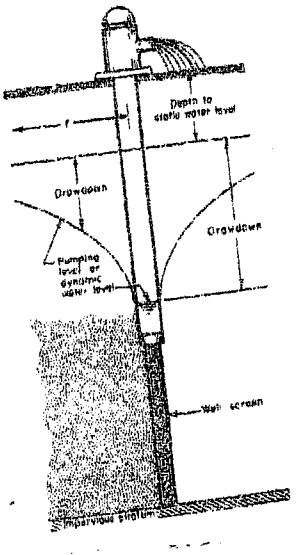
Otowi 1 Tritium

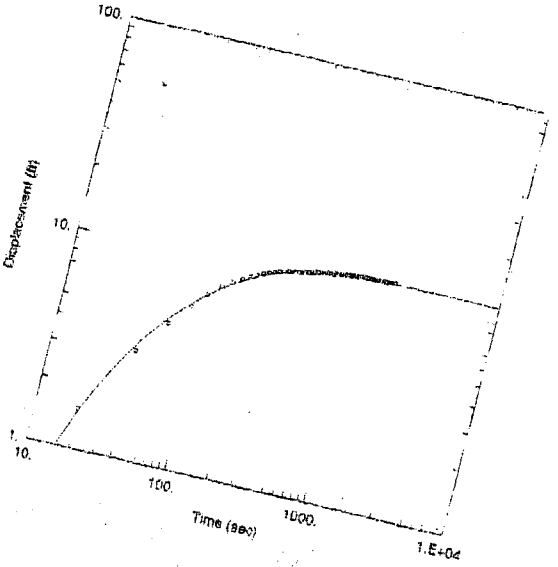
- Drinking water MCL is 20,000 pCi/L
- Levels in other water supply wells generally 1 pCi/L
- NMED reported 40 pCi/L in Otowi 1- or 1/500 of MCL
- Nearby test well has 360 pCi/L tritium
- Subsequent sampling confirms 40 pCi/L in Otowi 1
- Source may be LANL cold war era effluents: 1943-1964

Conclusion

- No strontium-90 found in water supply wells
- No high explosives found in water supply wells
- Only Otowi 1 has perchlorate
- Only Otowi 1 has tritium above background, 1/500 of MCL
- Monitoring will continue
- Hydrogeologic Workplan characterization will evaluate contaminant sources and pathways near wells

WHERE ARE THE HYDROLOGIC DATA?





William Stone
Hydrology Task Leader, Regional Well Program

Quarterly GIT Meeting
30 January 2001

Problem

- "R wells yielding chemical data; what about hydro data?"
- Hydrologic data *are* routinely collected also.
- Well completion reports always include results of testing.
- Those not out yet, so effort/results are not widely known.

Table 4.2-1
Summary of Data for Straddle-Packer/Injection Testing of Pre-Puye Deposits at R-19

Screen #	Static Water-Level Elevations (ft)	Average Injection Rate (gpm)	Injection Rate Variation (gpm)	Test Duration (min)	Hydraulic Conductivity (ft/d)	Analytical Method
6	5932.2	11.8	0.2 (1.4%)	94	17.5	Cooper & Jacob (1946, 66645)
7	5903.5	14.6	0.2 (1.7%)	86	19.6	Cooper & Jacob (1946, 66645)

Solution

- A summary table of work to date.
- It's what you would get if combined info in all well reports.
- Purpose today is a status report on R-well hydro data.

Work Continues

- Further analyzing hydrologic-test results
- Writing up details of tests in a separate report
- Evaluating hydraulic properties vs geologic units
- Defining further data needs (parameter, unit, place)

SUMMARY OF HYDROLOGIC OBSERVATIONS, REGIONAL WELLS

W. Stone, December 2000

Well	TD (ft)	Ground Elevation (ft) [1]	Saturated Zone/Unit [2]	Saturated Interval (ft)[3]	Screened Interval (ft)[4]	Head (ft)[5]	K(ft/d)[6]
R-9	771	6383r	R/Tsfb	688-TD	683-748	5695	--
R-9i	322	6383r	UP/Tb	142-236	189-199	6241	37.07
			LP/Tb	264-282	270-280	6119	0.78
R-12	886	6504r	P/Tb	424-520	459-467	6080	--
					504-508	NA	NT
			R/Tsfb	805-TD	801-839	5699	--
R-15	1107	6818r	P/Tb	646-740	None	NA	NT
			R/Tpf	964-TD	960-1020	5854	**3.31[7]**
							T= 198.3[7]
							S = 0.0204[7]
R-19	1885	7075f	UP/Qbof	738-?	827-844	6337	NT
	Sloughed		LP/Tpf	837-950	893-910	6238	NT
	From 1902		R/Tpf	1187-TD	1171-1215	5888	NT
					1410-1417	NA	NT
					1583-1590	NA	NT
					1727-1734	5932t	17.5
					1832-1839	5903t	19.6
R-22	1489	6625f	R/Tb	895-TD	*872-914*	5730 t	NT
					947-989	5725 t	NT
					1272-1279	5682 t	Being
					1389-1385	5670 t	Analyzed
					1447-1452	<5670 t	"
R-25	1942	7512ir	P/Qbof, Tpf	711-	738-759	>6787w	--
					883-894	6749w	--
					1055-1065	6454w	--
					1185-1195	6342w	--
			R/Tpf	1286-TD	1296-1306	6220w	--
					1406-1416	6203w	--
					1606-1616	6177w	--
					1796-1806	6153w	--
					1896-1906	>6088w	--
R-31	1103	6375f	P/Tb	439-455	439-455	Dry	1.07
			R/Tb	522-TD	515-546	5853w	0.42
					666-676	5852w	3.62
					827-837	5854w	0.009
					1007-1017	5851w	0.007
CdV-R-15-3	1720	7257ir	UP/Qbof	Dry	618-624	NA	NT
			MP/Tpf	Dry	801-808	NA	NT
			LP/Tb	nearly dry	965-981	NA	NT
			R/Tpf	1245-TD	1235-1279	NA	NT
					1348-1355	6018t	0.25
					1638-1645	6024t	0.10

[1] **r** = final from well completion report, **ir** = approximate from interim well completion report, **f** = approximate from FIP

[2] U = upper, M = middle, L = lower, P = perched, R = regional; Qbof = Otowi Member, Bandelier Tuff, Tb = Cerros del Rio basalt, Tpf = Puye Formation, Tsfb = Santa Fe Group basalt

[3] based on observations during drilling or geophysical logs

[4] italics indicate interval is that of just the screen openings; otherwise, interval is that of entire screen joint

[5] composite for screened interval; **t** indicates value based on static water level for packed-off interval at time of testing, **w** indicates value from Westbay transducer; otherwise, value is based on water level determined during drilling; NA = not available

[6] based on straddle-packer/injection tests; -- indicates test inconclusive or invalid/property unavailable, NT = not tested; values are preliminary unless in bold

[7] based on pumping test; T = transmissivity (ft^2/d), S = storativity

HYDROLOGIC TESTING AT REGIONAL WELLS

Well	*Saturated Zone*[1]	*Slug Test*[2]	*Pumping Test*
R-9i	U. Perched/Tb	X	X[3]
	L. Perched/Tb	--	
R-15	Perching Horizon/Tb	X	
	Regional/Tp		X
R-19	Regional/Tp (*2*)[4]	X	
R-22	Regional/Tb (*3*)	X	
R-31	Perched/Tb	X	
	Regional/Tp (*4*)	X	
CdV-R-15-3	Regional/Tp (*2*)	X	

[1] Tb = Cerros del Rio or Santa Fe Group basalt, Tp = Puye Formation (fanglomerate or Totavi lentil))

[2] Straddle-packer/injection test; -- = inconclusive (tight)

[3] with well open to both screened intervals

[4] numbers in parens = numbers of intervals tested

GIT Modeling Subcommittee Report

Bruce Robinson

Elizabeth Keating

Diana Hollis

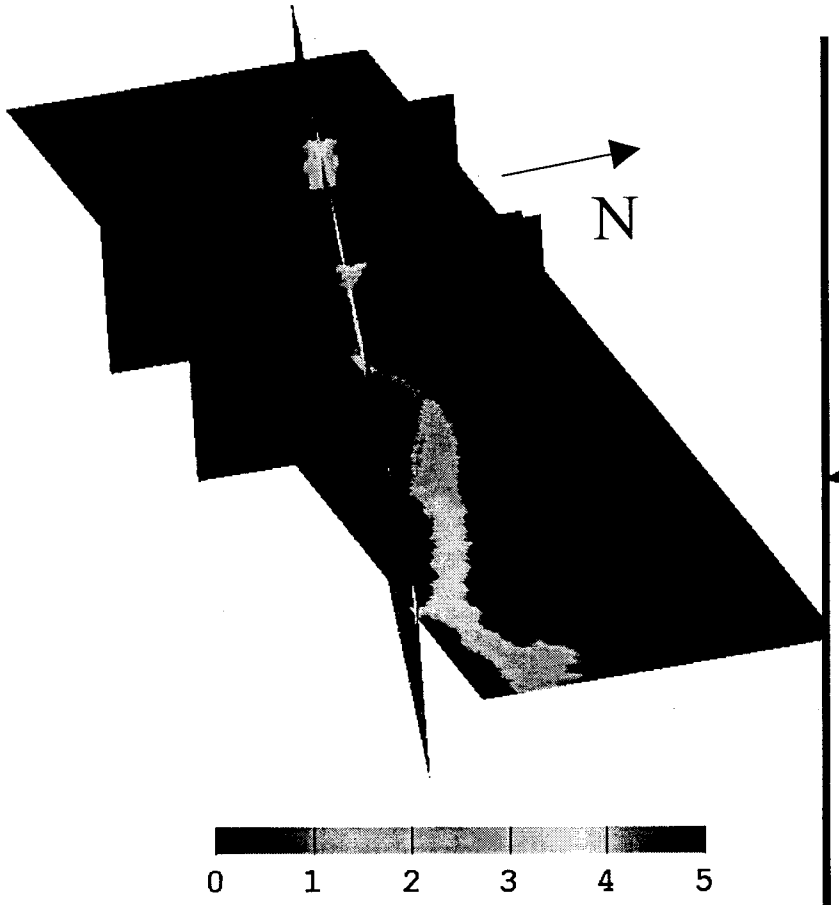
January 30, 2001

Current Modeling Activities

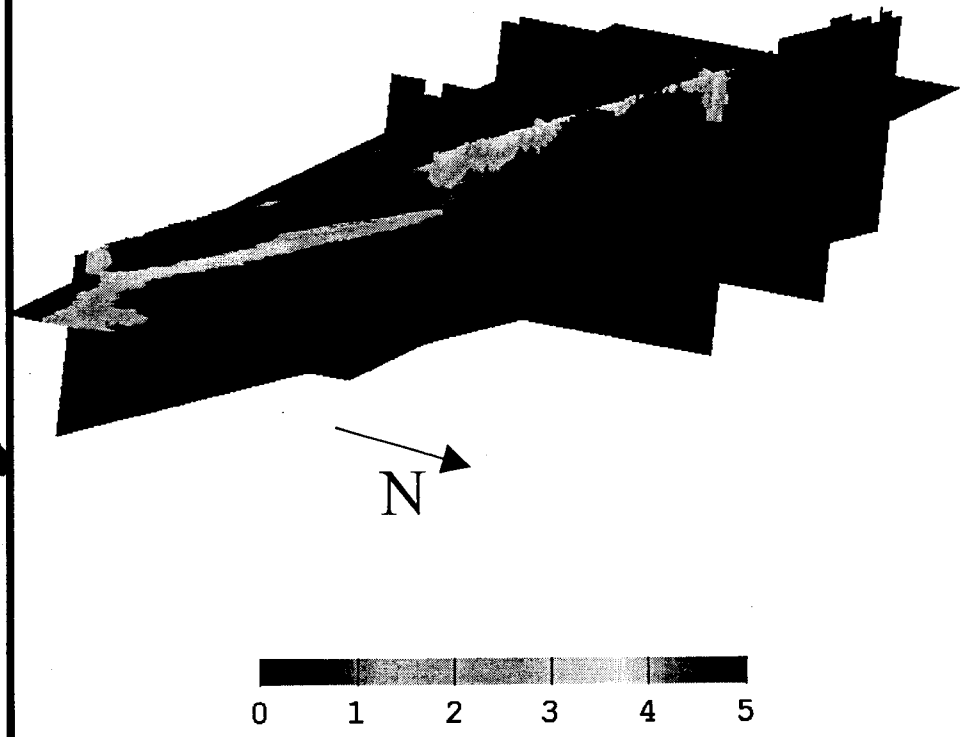
- Los Alamos Canyon Model
- MDA-G Model - comparison to results at R-22
- Regional Aquifer Model

Los Alamos Canyon

Tritium Concentration - Model Prediction



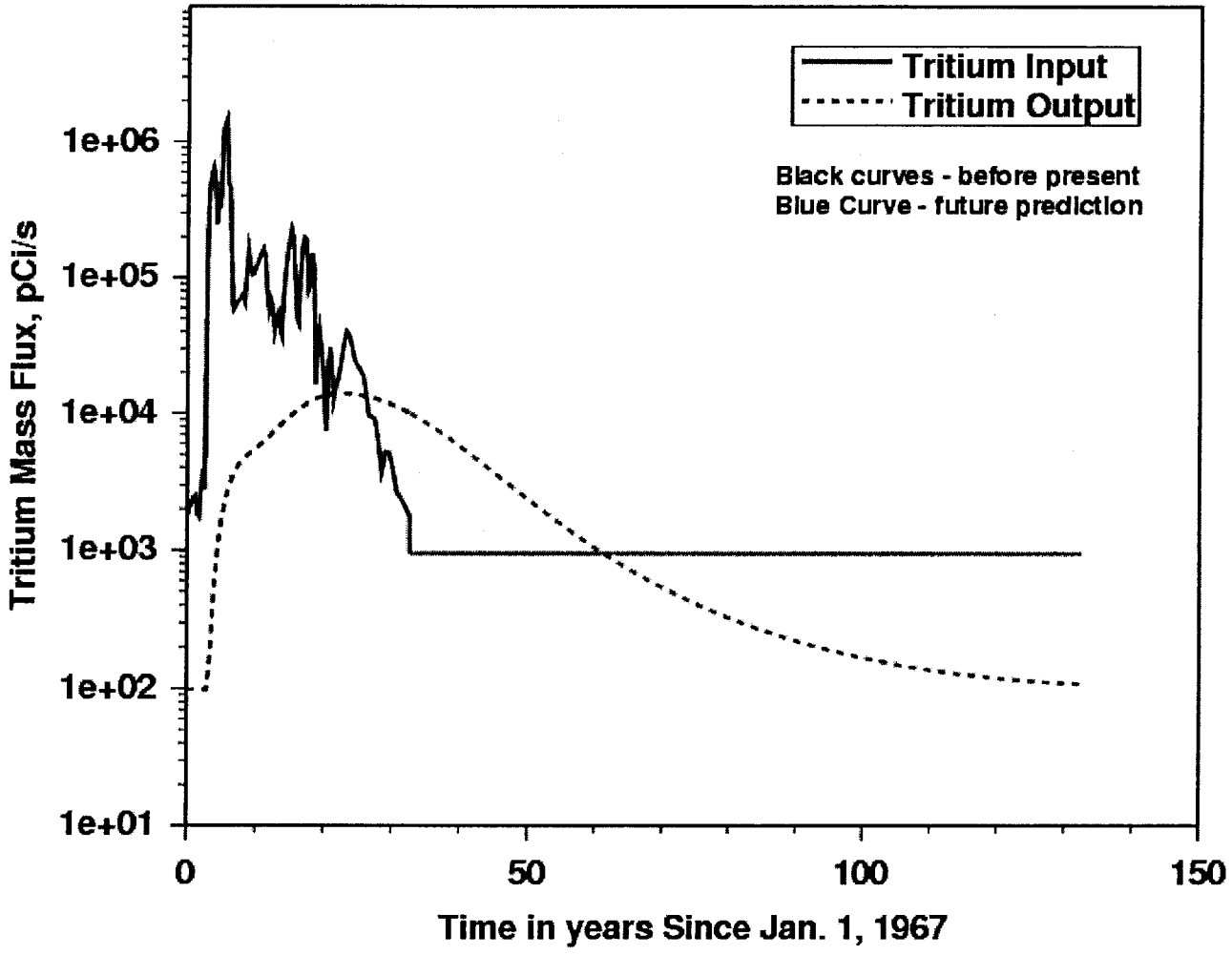
Log Tritium concentration, pCi/L



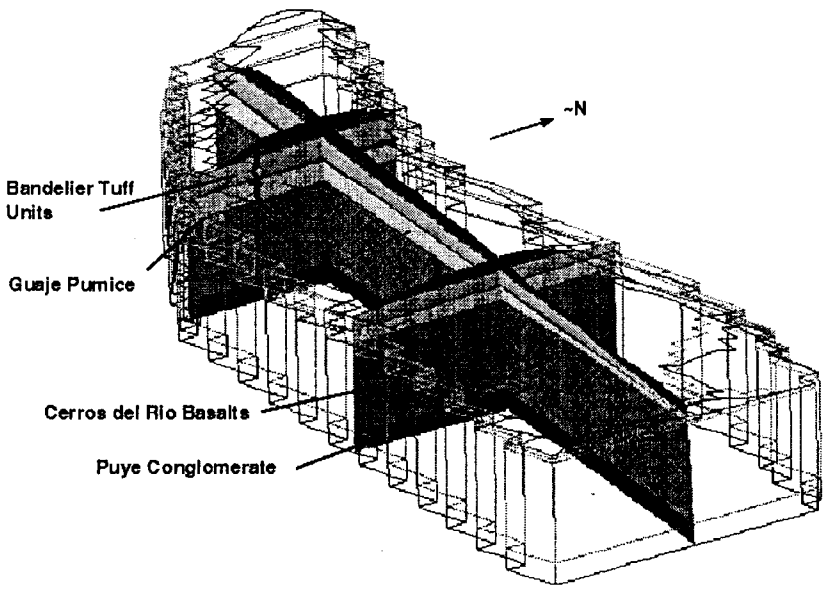
Log Tritium concentration, pCi/L

Los Alamos Canyon

Tritium Arrival at the Water Table - Model Prediction



MDA G Model and R-22 Data

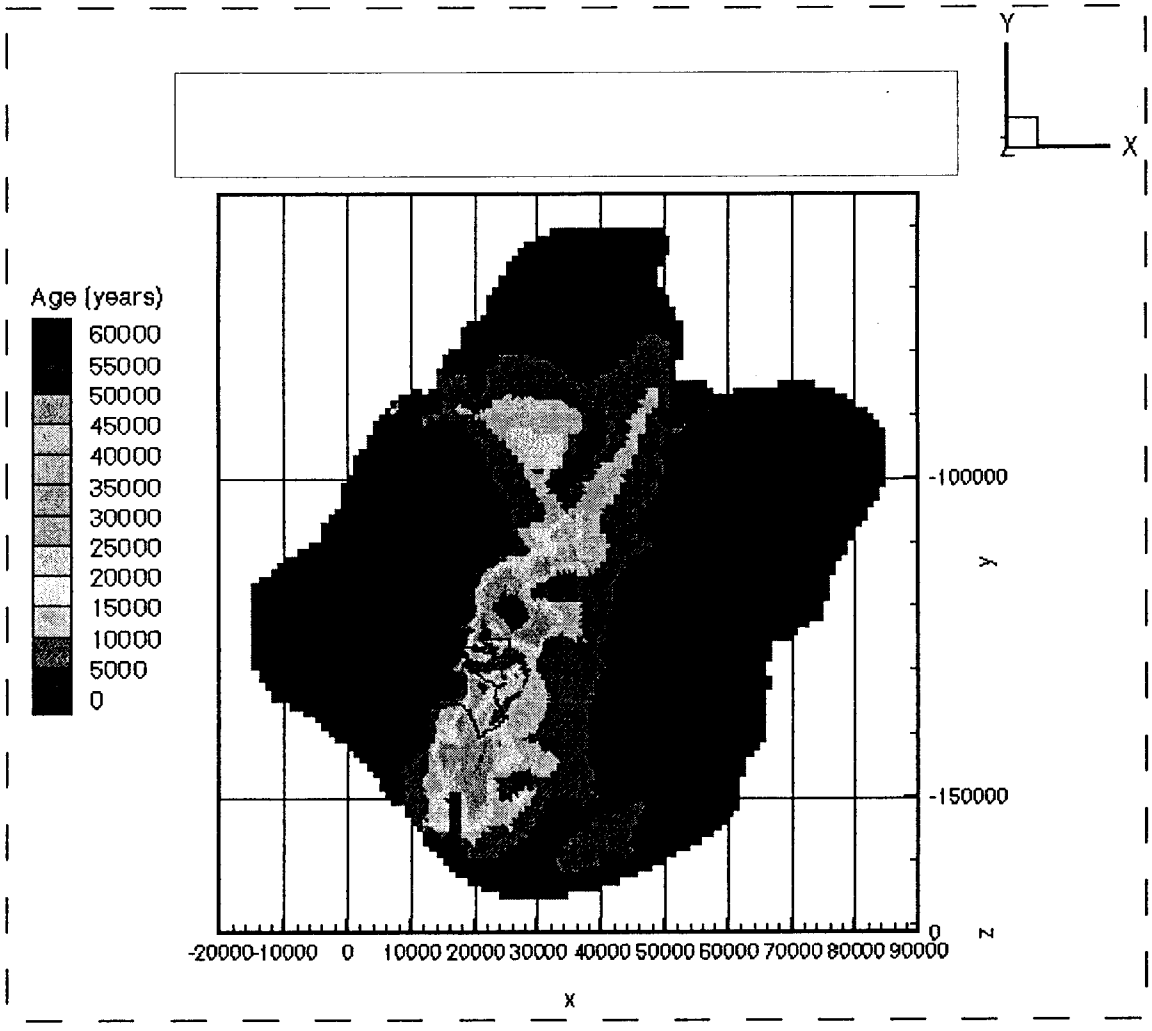


- MDA G model predicted *liquid and solute* travel times to regional aquifer on the order of 1000 yr
- MDA L model predicted no downward migration of VOCs
- R-22 chemistry results: no VOCs or leached radionuclides observed in fluids at depth, tritium perhaps vapor-phase from MDA G
- R-22 goeohydrology results: regional aquifer at about 850 ft, compared with modeled depth of about 900'; regional aquifer in basalt, compared with model of in Puye Fm; may have small effect on dilution, but no change in decisions based on model

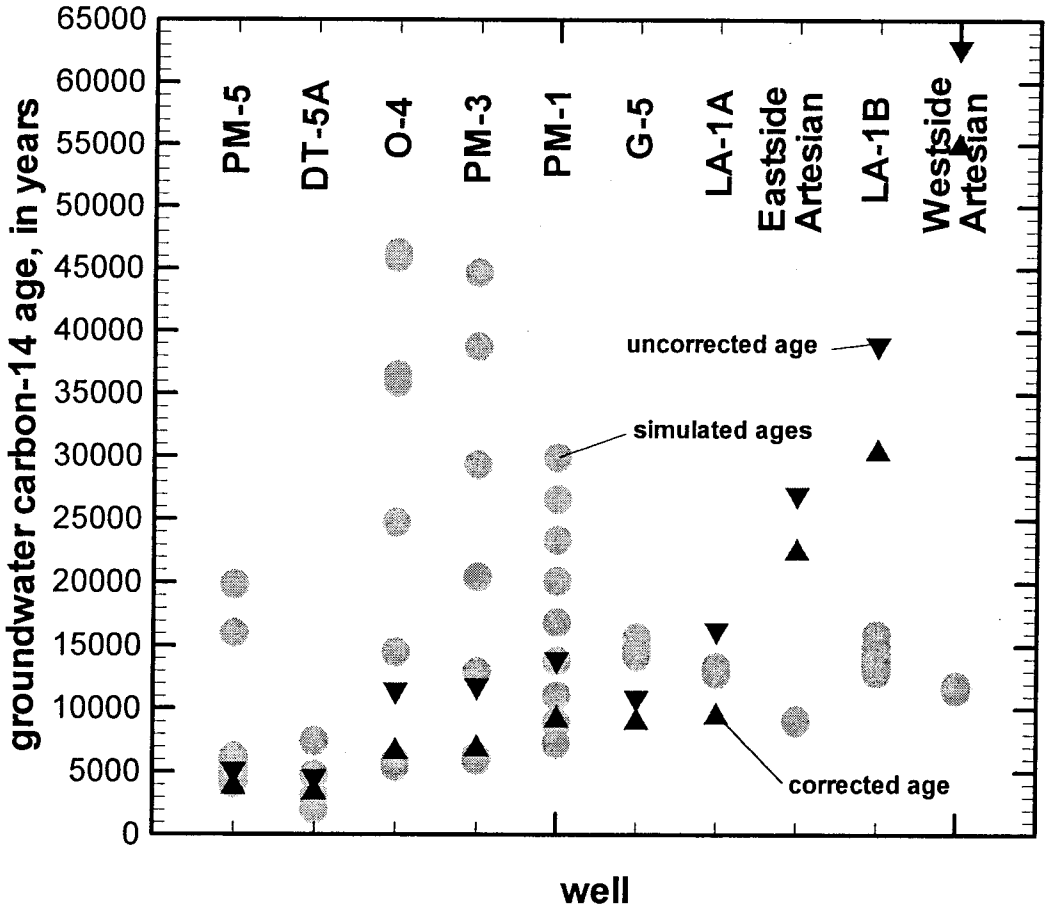
Regional Aquifer Model Activities

- Transport simulations for groundwater tracers (^{3}H, ^{14}C, ^{18}O, Cl), and comparison to measured values
  - provided independent validation of our estimated aquifer recharge rates
  - highlighted inaccuracies in simulated flow field near the Rio Grande
- Formal incorporation of transient water level data into model calibration process
  - provided dramatic improvement in our ability to accurately estimate effective large-scale permeabilities for aquifer
- Uncertainty analysis for groundwater flow directions
  - demonstrated a critical need for multi-level head measurements in the western portion of the plateau.
- Initial development of geostatistical representation of heterogeneity within the Puye Formation, using outcrop data to derive statistical parameters.
  - provided resulting *distribution* of plausible travel times for contaminants originating at TA16 to be transported to water supply wells and/or the Rio Grande

Simulated steady-state distribution C-14 ages



Comparison of Simulated and Measured C-14 Ages



FY01 Integrated Modeling Tasks

Diana Hollis
E-ER

FY01 Integrated Modeling Tasks

- First-order groundwater pathway assessment
- Plateau-wide infiltration mapping
- 3D geologic model uncertainty assessment
- Geophysical surveys to supplement spatial hydrogeologic data
- Statistical analysis of spatial placement of R-wells

All tasks in scope of ER Integrated Modeling Task, which ensures that mathematical models used by the ER Project are documented, transparent, site-specific, technically defensible, and applicable to and necessary for risk-based decisions

QUARTERLY STATUS REPORT FOR THE GEOCHEMISTRY SUBCOMMITTEE, GROUNDWATER INTEGRATION TEAM

BY

PATRICK LONGMIRE[1], BRENT NEWMAN[2], DALE COUNCE[1], JENNIFER KOFOED[3], AND JON MARIN[4]

JANUARY 30, 2001

1. EES-A; 2. EES-F; 3. AURORA TECHNICAL SERVICES; and 4. SAIC

ENVIRONMENTAL RESTORATION PROJECT

OBJECTIVE OF PRESENTATION

Present a status report for the geochemistry subcommittee and geochemical investigations conducted at the Laboratory and surrounding areas from October 1 through December 31, 2000.

Topics of interest include:

- **Quarterly sampling at R-9, R-9I, R-12, R-15, R-19, R-25, and R-31**
- **TA-16**
- **Borehole water sampling at R-22**

ENVIRONMENTAL RESTORATION PROJECT

PRELIMINARY ANALYTES FOR QUARTERLY SAMPLING

Radionuclides (Filtered and Non Filtered Samples)

Tritium, strontium-90, uranium and plutonium isotopes, americium-241, and gamma spectroscopy

Inorganic Constituents (Filtered and Non Filtered Samples)

Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Sr, Na, Tl, U, V, and Zn

HN_4^+, Cl^-, F^-, NO_3^-, NO_2^-, $C_2O_4^{2-}$, ClO_4^-, and SO_4^{2-}

Organic Compounds (Non Filtered Samples)

Volatile, semivolatile (PCBs, PAHs, Pesticides), high explosive compounds and degradation products, TOC, DOC fractionation

Stable Isotopes (Non Filtered Samples)

δDeuterium, δ^{15}Nitrogen, and δ^{18}Oxygen

Analyte list is subject to change in the future depending on site-specific contaminants and data quality objectives for each well.

QUARTERLY SAMPLING OF R-WELLS AND FIELD-MEASURED PARAMETERS

Well	Date (yr/mo/dy)	Sampling Zone, Screen (ft) (hydrogeology) (notes)	pH	Specific Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-9	00/09/29	683 - 748 (SFG basalt) Reg .Aq.	8.03	200	23.4	4.2
R-9I	00/09/14	189 - 199 (CDR basalt) Prch.	8.04	160	19.64	3
R-9I	00/09/15	270 - 280 (CDR basalt) Prch.	7.5	140	13.5	1.9
R-12	00/09/18	459 - 467 (CDR basalt) Prch.	8.01	280	21.8	3.3
R-12	00/09/19	504 - 508 (CDR basalt) Prch.	8.62	200	23.6	2.8
R-12	00/09/20	801 - 839 (SFG basalt) Reg. Aq.	7.24	300	22.5	6.8
R-15	00/10/10	960 - 1020 (SFG basalt) Reg. Aq.	7.9	130	16.9	3
R-19	00/09/22	893 - 910 (PF) Prch.	7.75	120	18.45	1.7
R-19	00/09/27	1171 - 1215 (PF) Reg. Aq.	7.65	100	20.14	1.8
R-19	00/09/27	1583 - 1590 (PF) Reg. Aq.	7.37	130	20.20	19.3
R-19	00/10/03	1832 - 1839 (PF) Reg. Aq.	7.44	230	26.49	35.9
R-19	00/10/05	1727 - 1734 (PF) Reg. Aq.	7.32	170	24.68	1.7
R-25	00/11/14	738 - 759 (BT) Prch.	7.65	225	9.0	1.6
R-25	00/11/15	883 - 894 (PF) Prch.	8.83	322	9.0	41.7
R-25	00/12/01	1055 - 1065 (PF) Prch.	11.63	490	9.9	1.9
R-25	00/12/04	1185 - 1195 (PF) Prch.	7.64	716	8.8	5.3
R-25	00/12/07	1296 - 1096 (PF) Reg. Aq.	7.73	210	10.8	6.2
R-25	00/12/08	1406 - 1416 (PF) Reg. Aq.	7.91	232	10.9	1.8
R-25	00/12/11	1606 - 1616 (PF) Reg. Aq	7.9	186	11.2	3.5
R-25	00/12/12	1796 -1806 (PF) Reg. Aq.	8.07	204	10.9	14.3

Note: CDR basalt means Cerros del Rio basalt; SFG means Santa Fe Group; PF means Puye Formation; BT means Bandelier Tuff; Reg. Aq. means regional aquifer; and Prch. means perched or upper saturated zone (R-25)

QUARTERLY SAMPLING OF R-WELLS AND FIELD-MEASURED PARAMETERS

Well	Date (yr/mo/dy)	Sampling Zone, Screen (ft) (hydrogeology) (notes)	pH	Specific Cond. (μSi/cm)	Temp. (C)	Turbidity (NTU)
R-31	00/12/14	827 - 837 (PF) Prch.	7	195	21.35	1.6
R-31	00/12/15	1007 - 1017 (PF) Reg. Aq.	7	151	22.6	60
R-31	00/12/16	666 - 676 (PF) Prch.	6.8	790	15.5	46.7
R-31	00/12/16	515 - 546 (PF) Prch.	7	395	18.8	23.5

Note: CDR basalt means Cerros del Rio basalt; SFG means Santa Fe Group; PF means Puye Formation; BT means Bandelier Tuff; Reg. Aq. means regional aquifer; and Prch. means perched or upper saturated zone (R-25). J. Harris supervised quarterly sampling at R-9. R-9I, R-12, and R-25. J. Marin supervised quarterly sampling at R-15, R-19, and R-31.

Groundwater samples collected from these wells are being validated by the ER Project and be released following electronic validation.

TA-16 INVESTIGATIONS, Barium Colloids

Filtered and Unfiltered Ba data indicate a systematic bias where unfiltered Ba concentrations are usually higher than filtered

PHREEQC results suggest barite supersaturation in the springs

- SI for barite in Burning Ground Spring is about 0.3

Aluminum and iron concentrations also have a bias where unfiltered concentrations are greater than filtered

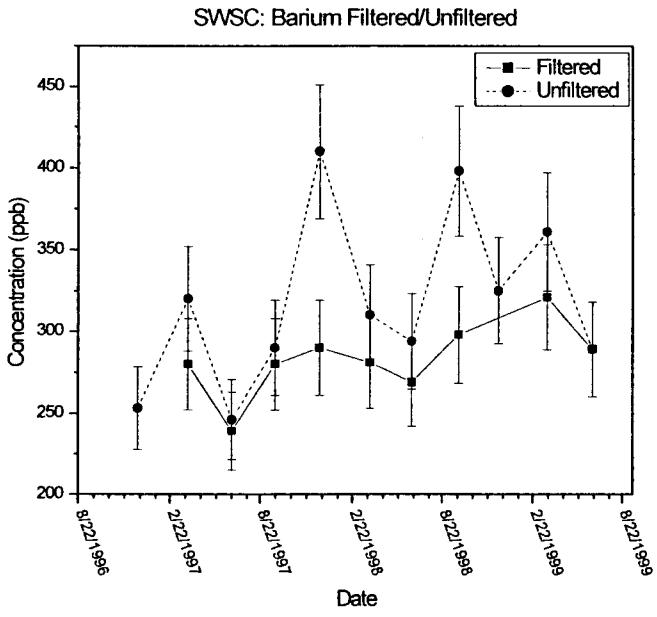
- Suggests Ba may also be adsorbed

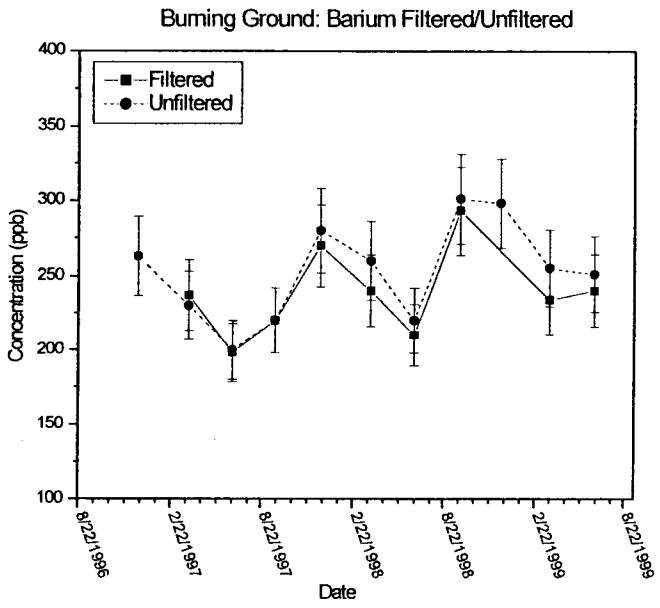
PHREEQC results suggest various iron and aluminosilicate minerals are supersaturated in the springs

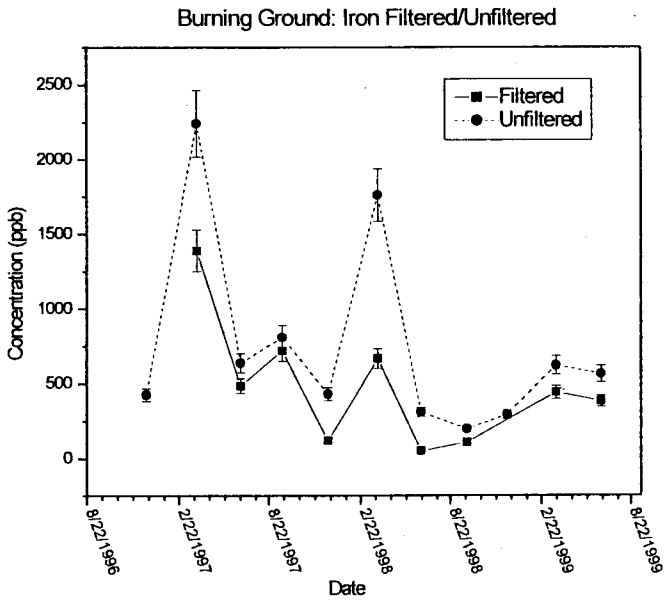
- e.g., Fe-oxyhydroxides, feldspars, and some clays have positive SI values

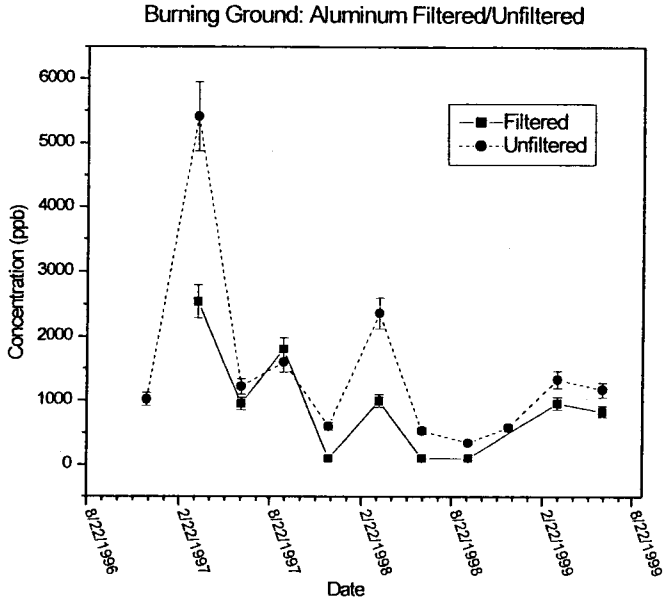
Estimates of Ba colloid percentages are typically <10%, although a few analyses are higher

ENVIRONMENTAL RESTORATION PROJECT




Burning Ground: Barium Filtered/Unfiltered
Filtered
Unfiltered
Concentration (ppb)
400
350
300
250
200
150
100
8/22/1996
2/22/1997
8/22/1997
2/22/1998
8/22/1998
2/22/1999
8/22/1999
Date


Burning Ground: Iron Filtered/Unfiltered
Filtered
Unfiltered
Concentration (ppb)
2500
2000
1500
1000
500
0
8/22/1996
2/22/1997
8/22/1997
2/22/1998
8/22/1998
2/22/1999
8/22/1999
Date


Burning Ground: Aluminum Filtered/Unfiltered
Filtered
Unfiltered
Concentration (ppb)
6000
5000
4000
3000
2000
1000
0
8/22/1996
2/22/1997
8/22/1997
2/22/1998
8/22/1998
2/22/1999
8/22/1999
Date

RESULTS OF BOREHOLE R-22 SAMPLING

The regional aquifer was encountered at 883 ft on September 30, 2000. Borehole groundwater samples were collected and analyzed for americium-241, gamma spectroscopy, strontium-90, tritium, uranium isotopes, screening metals, volatile organic compounds, semivolatile organic compounds, and stable isotopes of hydrogen, nitrogen, and oxygen.

Activities of Sr-90 were less than detection (0.3 $\pm$ 2.4 pCi/L) (MDA = 4 pCi/L).

Activities of Pu-238, Pu-239,240, and Am-241 were less than detection.

Activity of tritium is 109.2 $\pm$ 4.5 (1σ) pCi/L at 883 ft.

Concentration of perchlorate was less than detection (1 μg/L).

RESULTS OF BOREHOLE R-22 SAMPLING

Acetone was apparently detected in groundwater (883 ft) at 820 μg/L.

Acetone and isopropyl alcohol have similar molecular weights and both elute close to the same retention time on a typical GC/MS system.

The most likely source of acetone is from the oxidation of isopropyl alcohol initially present in the Quik Foam.

The oxidation of isopropyl alcohol to acetone is:
$CH_3CHOHCH_3 + 0.5O_2 + \text{microbe} \rightarrow CH_3COCH_3 + H_2O$.

Acetone and isopropyl alcohol have short residence times in aqueous solution due to volatilization and microbial degradation.

Acetone was identified in frac-tanks 370 (610 μg/L) and 371 (24 μg/L). Acetone is analyzed during well development and quarterly sampling.

Keith Greene and Roy Bohn lead the sampling effort to determine the source of acetone observed at R-22.

SUMMARY

Geochemistry subcommittee members have started to collect quarterly groundwater samples from R-9, R-9I, R-12, R-15, R-19, and R-25.

Borehole water samples have been collected from R-22 within the regional aquifer (basalt).

Quik foam contains isopropyl alcohol, which oxidizes to acetone. Acetone is volatile and has a short residence time in aqueous solution.

Evidence for barium colloids in the TA-16 springs

- either as barite or adsorbed on other mineral phases
- analyses suggest most of the Ba is dissolved and estimated colloidal percentages are usually than 10%

GIT
Information Management Subcommittee
Status Report

Water Quality Database

January 30, 2000

Primary Efforts in Past Quarter

- Software Development
- Report Development
- Data Migration
- Improvements to Performance

New Software Development

- Data Import/Entry Software
  - Data Steward QA/QC Tools
  - Validation Data
  - DMR Report System (storm water)

New Report Development

- Chemistry
- Gage/Flow Data

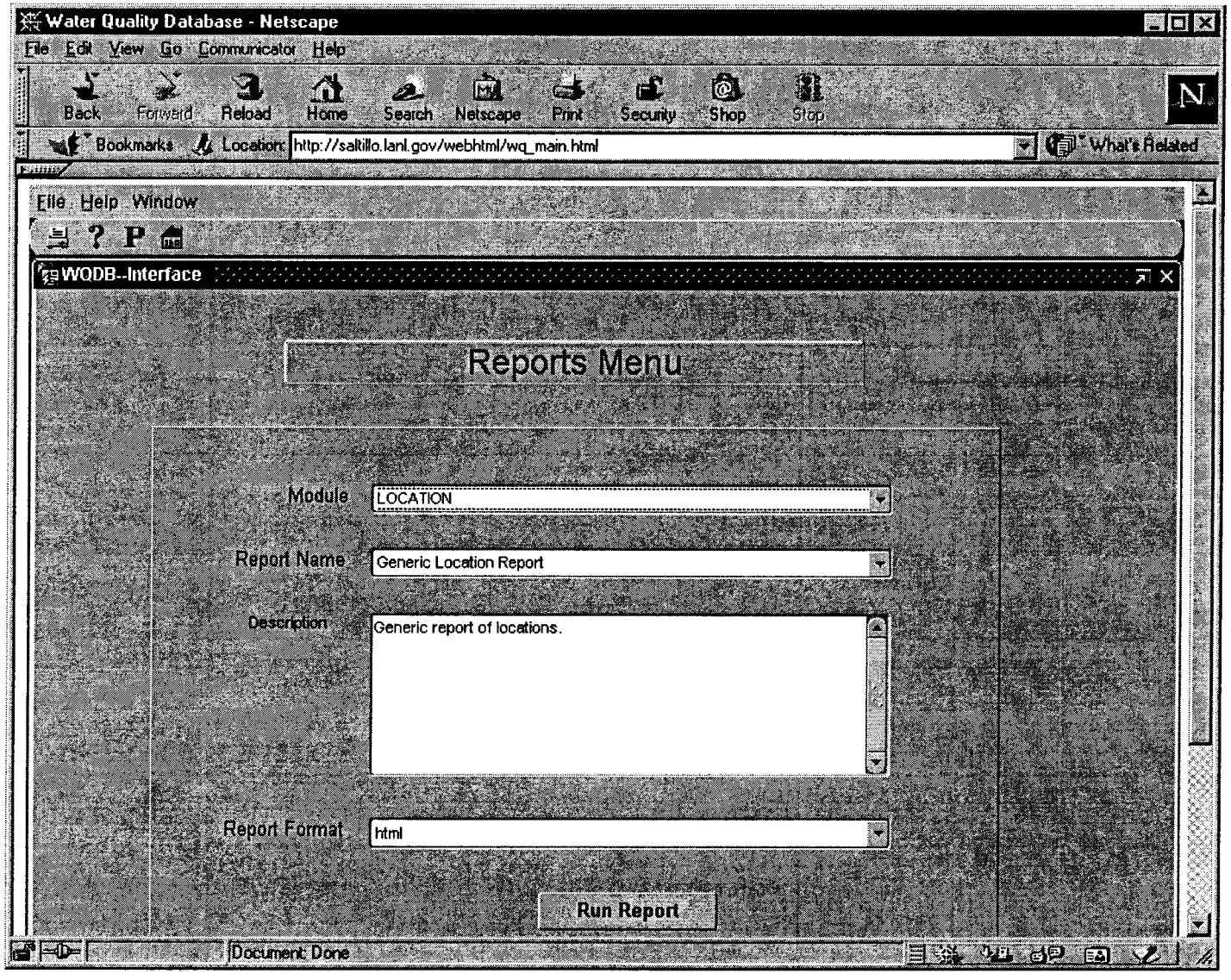
Data Migration

- 2000 Chemistry
- Legacy Chemistry
- Sample Tracking/Chain of Custody
- Daily flow data
- 5-minute flow data
- 5-minute gage heights

Improvements to Performance

Old Interface	New Interface
• Java Applet	• HTML
• Required Jinitiator	• No Jinitiator

"Old" Reports Interface



"New" Reports Interface

Los Alamos National Laboratory

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Water Quality Database Reports

We are making data that has not been thoroughly validated available.
These data are preliminary. The data may be modified at a later date.

- **Chemistry**
- **Location**
- **Lookup Tables**

Analytes
Analytes by Method
Analytical Laboratories
Analytical Methods
Analytical Types
Analytical Suites
Chemistry Units of Measu
Composite Sample Types
Field Matrix
Field Preparation Methods
Laboratory Matrix
Laboratory Qualifiers

Analytes

Los Alamos National Laboratory
ESH-18 Water Quality and Hydrology
Water Quality Database

Analyte Code	Description	Symbol	CAS #	GEDD Analyte Code
35822-46-9	1,2,3,4,6,7,8-HpCDD			
67562-39-4	1,2,3,4,6,7,8-HpCDF			
39227-28-6	1,2,3,4,7,8-HxCDD			
70648-26-9	1,2,3,4,7,8-HxCDF			
40321-76-4	1,2,3,7,8-PCDD			
57117-41-6	1,2,3,7,8-PCDF			
120-82-1	1,2,4-Trichlorobenzene		120-82-1	120-82-1
95-50-1	1,2-Dichlorobenzene		95-50-1	95-50-1
99-35-4	1,3,5-trinitrobenzene		99-35-4	99-35-4
99-65-0	1,3-Dinitrobenzene		99-65-0	99-65-0
541-73-1	1,3-dichlorobenzene		541-73-1	541-73-1

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Last Modified: <January 29, 2001>

Goals for Next Quarter

- Continued Software Development
  - Sample Planning/Tracking
- Continued Data Migration
  - Water Levels
  - Hydrologic Properties
- Continued Report Development
  - All WQDB Data

Question & Answer

Model Uses

- Groundwater models are used to assimilate and interpret data collected through installation of wells to refine the conceptual model.

- Once calibrated, the models will be used to site and prioritize subsequent wells to aid site-wide characterization

- Ultimately, models will be used to make decisions related to design of a monitoring well network

Model Uses

- 2/3D process level groundwater models are being developed simultaneously for unsaturated (vadose zone) and saturated (regional aquifer) flow and transport

- 1D system models may be used to couple pathways and/or sources

- Site-wide characterization of the hydrogeologic system will be judged sufficient, in part, with the provision of a quantitative three-dimensional representation of the groundwater flow (and contaminant transport) in the regional aquifer; and technically defensible estimates of the bounds of uncertainties

Computer Programs Selected

- Groundwater computer code: a general software package that handles the general problem of groundwater flow contaminant transport without reference to a particular site. Examples:
  - FEHM
  - MODFLOW

Computer Programs Selected

- Groundwater model: a synthesis of data and conceptual models in which a computer code is used to quantitatively simulate flow and transport behavior of a particular site, including uncertainty. Examples:
  - Los Alamos Canyon Vadose Zone model
  - MDA G (PA) Vadose Zone Model
  - Espanola Basin Regional Aquifer model
  - Yucca Mountain Project Saturated Zone Process model
  - Nevada Test Site Saturated Zone model

Computer Programs Selected

- Computer code selection should be based on code capabilities with respect to the intended use of the model being developed, code pedigree, acceptance in the scientific community, and ease of use.
- The complexity of a model is an attribute of the model itself, not the computer code chosen to carry out the simulations.
- The validity of a model depends primarily on the conceptual model and availability of data, not on the computer code (as long as the code is used within the range that it has been shown to be valid).

Computer Programs Selected

- We agree that the best model is the *simplest* model that is consistent with available data.
- We make concerted, conscious efforts to build models with the *mimimum* complexity required to reproduce the measured head gradients.
- The very complex hydrostratigraphy at this site argues against the "very simple" approach.
- The combination of 1) complex hydrostratigraphy and 2) the scale of the problem (regional) requires a "large" model (in terms of spatial extent and total number of nodes) and a "complex" model (hydrostratigraphy on the plateau) which in turn makes FEHM the appropriate tool.

Computer Programs Selected

- Two types of models are needed.
  - > Process models that can best represent the complicated 3-D system at LANL (both unsaturated and saturate zones),and
  - > pathway models that provide ways of supporting long-term decisions when uncertainty is present.

Computer Programs Selected

- FEHM for "modular" process-level modeling
  - Wet/Dry Mesa (TA-16/TA-54), unsaturated-zone flow and transport (aqueous- and vapor-phase)
  - Wet/Dry Canyon (Los Alamos and Canon de Valle/Mortandad), unsaturated-zone flow and transport
  - Regional Aquifer, saturated flow and transport
- GoldSim for coupled pathway-level (systems) modeling
  - Surface water → alluvium → vadose zone → regional aquifer

Comparison of FEHM and ModFlow

- **FEHM**
  - *Structured or unstructured grids (able to handle complex 3D geometry)*
  - 1, 2 or 3 dimensional
  - Unsaturated or saturated non-isothermal flow
  - Continuum (matrix) and dual permeability (matrix and fractures) flow
  - Multiple phase (aqueous and vapor) flow and transport
  - Rigorous QA developed through YMP (top down)
- **ModFlow**
  - Structured grids (not able to hand complex 3D geometry)
  - 1 or 2 dimensional
  - Saturated isothermal flow
  - Continuum flow
  - Single phase (aqueous) flow and transport
  - QA accomplished through large user base (bottom up)

Comparison of FEHM and ModFlow

- Structured or unstructured grids (able to handle complex 3D geometry) is especially important in saturated-zone modeling because this feature
  - > Allows variable grid resolution, high resolution in areas with significant geologic heterogeneity, vertical gradients, etc. and lower resolution in "low" priority areas (*Especially* important for the SZ model because you have to consider a much larger area than you do with UZ models, since lateral flow is more significant.)

Comparison of FEHM and ModFlow

- Structured or unstructured grids (able to handle complex 3D geometry) is especially important in saturated-zone modeling because this feature:
  - Provides computational efficiency which allows us to do a 300,000 + node problem (not possible with MODFLOW), which is especially important for uncertainty/sensitivity analyses where we need to make thousands of model runs

Comparison of FEHM and ModFlow

- Structured or unstructured grids (able to handle complex 3D geometry) is especially important in saturated-zone modeling because this feature:
  - > Allows accurate definition of vertical flow, whereas MODFLOW uses a "layer" approach which emphasizes accurate horizontal flow calculations at the expense of vertical flow accuracy (the sensitivity analyses we did for HE transport showed how sensitive transport results are to subtle variations in lateral flow

Computer Programs Selected

- FEHM "approved" by NRC and EPA for YMP application
- FEHM "approved" by DOE Federal Review Panel for Area G Performance Assessment/Disposal Authorization Statement
- EES Division Review Committee peer-reviews broad spectrum of FEHM applications and results
- GIT External Advisory Committee peer-reviews site-specific applications and results

Computer Programs Selected

- FEHM is free and readily available (Web download)

- FEHM's use at Los Alamos is very cost-effective because proximity to the code developers (including some who work on the ER Project) provides instant user support.

- FEHM has wide acceptance and is widely used:
  - National Laboratories (SNL, LANL)
  - Industry (Duke Engineering, IT Geotrans, SAIC, Bechtel)
  - Universities (U of A, U of Illinois, NM Tech, U of Col)
  - International community (Japan, Germany, Romania)

Computer Programs Selected

- Many presentations conducted on general modeling approach and specific results
  - ER monthly colloquia
  - GIT biweekly, quarterly and annual meetings

- Several NMED-specific workshops conducted by LANL on FEHM

- Dedicated 2-day GoldSim workshop for NMED sponsored by ER Project

Status of Model Development

- Results of models have been used to
  - > constrain DQOs for regional wells
    - ♦ prioritize regional wells
    - ♦ site regional wells
  - > support Interim Measure decisions
    - ♦ VZ moisture monitoring at MDA AB
    - ♦ VOC plume monitoring at MDA L

Decisions that Require Modeling

- Is additional groundwater monitoring required?
- When/Where/How/What should we monitor?
- What might maximum groundwater "plume" concentration be from residual contamination?
- Where/When will maximum concentration occur?
- Will natural attenuation be protective?

Intermediate Zones: Technical Approach

- Initial Approach: drill and sample water in the borehole. If contaminated, install intermediate wells at later time. If not contaminated, no further monitoring (Section 1.8).
- NMED letter: borehole samples not adequate for regulatory decisions
- Revised Approach: screen all saturated zones

Analytical Commitments and Concerns

HWP Commitment	Concern
Sample water when encountered during drilling	Interrupting drilling causes problems
Groundwater samples collected from each screen	Greater number of screens than planned
Filtered and unfiltered samples analyzed	Drilling additives confound analysis
Initial sampling full suite	Initial sample may not be representative
Subsequent samples, selected suites	Based on initial sample results

Areas of Future Analytical Proposal

- Determining when samples are representative for initial analysis
- Frequency of analytical suites in subsequent samples
- Analysis for dissolved and total
- Changing analytical methods