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Los Alamos National Laboratory

GROUNDWATER INTEGRATION TEAM ANNUAL MEETING

March 20-23, 2001

VIEWGRAPH PRESENTATIONS

13493

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Annual Meeting
March 20-23, 2001

Tuesday, March 20
Annual Meeting

New Arts Building, Ghost Ranch

8:30	Welcome, introductions, agenda review (Charlie Nylander)
8:45	Groundwater Integration Team (GIT) Subcommittee Status Reports ▪ Information Management (Kendra Henning) ▪ Well Construction (Steve Pearson) ▪ Geochemistry (Pat Longmire) ▪ Hydrology (David Rogers) ▪ Modeling and Risk (Bruce Robinson)
10:30	Break
10:45	Management Report (Charlie Nylander) ▪ FY00 Accomplishments and FY01activities ▪ FY02 Planned Activities ▪ Quality Improvements (Larry Maassen)
11:30	Lunch
1:00	External Advisory Group session with stakeholders
3:00	Response to stakeholder concerns (Charlie Nylander)
4:30	Geology Hike
7:00	Campfire session

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Annual Meeting
March 20-23, 2001

Wednesday, March 21
Annual Meeting

New Arts Building, Ghost Ranch

8:30	Evolution of Well Drilling, Construction, Development (Ted Ball and Steve Pearson)
8:45	Observations on Geology from Regional Wells (David Vaniman and Greg Cole)
9:00	Well Logs, Geology, and Hydrology (David Broxton, Rick Lewis)
9:15	Hydraulic Conductivity and Geology (Bill Stone, S. McLin, D. Vaniman)
9:30	Quantifying Heterogeneity within the Puye Formation (Elizabeth Keating)
9:45	Poster Viewing
10:45	Databases - Water Quality and Environmental Restoration (Kendra Henning, Cathy Smith, and Ann Lee)
11:00	DOE role in Oversight (Karen Agogino, Russel Edge)
11:15	Water Supply Well Sampling (David Rogers)
11:30	Results of Quarterly Sampling (Pat Longmire)
11:45	Lunch
1:00	Poster viewing
2:00	Overview of Modeling Activities and Deliverables (Diana Hollis)
2:15	Los Alamos Canyon Flow and Transport Model (Bruce Robinson)
2:30	NMED/DOE-OB Conceptual Model for Los Alamos Canyon (Michael Dale)
2:45	Validation of Conceptual Models for Vadose Zone Flow and Transport Beneath the Pajarito Plateau (Kay Birdsell)
3:00	Model Uncertainty, Sensitivity Analysis, and Data Needs (Elizabeth Keating)
3:15	Poster Viewing
4:15	Adjourn

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Annual Meeting
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Thursday, March 22
EAG Meetings with GIT Subcommittees

LANL, various rooms

9:00	EAG representatives meet with NW IF&C
10:00	EAG meets with Hydrology and Modeling subcommittees
12:00	Lunch
1:00	EAG meets with Geochemistry and Well Construction subcommittees
3:00	EAG meets with GIT members involved in risk assessment

Friday, March 23
Close-out Meetings

LANL study center, San Ildefonso Room

9:00	EAG close-out meeting with Managers
10:00	Break
10:30	EAG close-out meeting with GIT
11:30	Lunch
1:00	EAG working session

Information Management Subcommittee Status Report

Hydrogeologic Characterization Program Annual Meeting
March 19-23, 2001

Year in Review

- Software Development
- Data Import/Migration
- Report Development
- Website Development

Software Development

- Sampling/Chain of Custody
- Data Validation
- Data Import Routines
- Data Steward QA/QC Tools
- Discharge Monitoring Report

FY 2000 Data Import/Migration

Data Set Description	# of Records
Year 2000 Analytical Chemistry Results	40,000+
Year 2000 Sample Tracking/Chain of Custody	12,000+
1994 – 1999 Daily Flow Data	35,000+
1994 – 1999 Five Minute Flow & Gage Height Data	8,000,000+

Report Development

- Stations *
- Chemistry *
- Gage/Flow Data *
- Sample Tracking
- Discharge Monitoring Report

* = available on WQDB website

Website Development

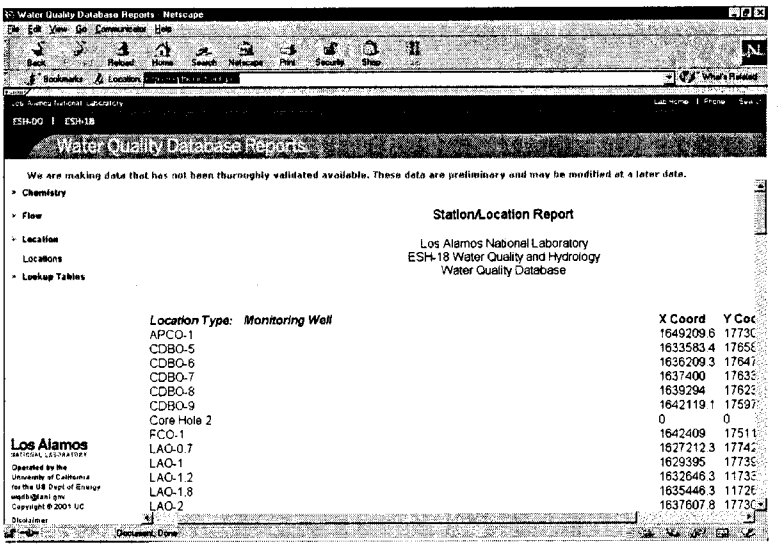
- JInitiator (Java) Interface
- HTML Interface & Improved Query Performance (Netscape Only)
- Improved HTML Interface (Netscape & IE)

Accessing the WQDB Website

http://wqdb.lanl.gov
(LANL internal)

http://wqdbworld.lanl.gov
(public)

WQDB Website – Screen Shot



Goals for FY 20001

Activity	Details	Status
Software Development	Sample Planning/Tracking	In Progress
Data Migration	Legacy Chemistry (300,000+ records) Water Levels Hydrologic Properties	In Progress Pending Pending
Report/Website Development	All WQDB Data	In Progress
ERDB/WQDB Data Exchange	R-well data and related lookup table data exchange	Pending

Question & Answer

2000 Monitoring Well Installation Activities

GW Investigation Focus Area

Well R-7

- Drilled to TD of 1097 feet on 1/12/01
- Construction completed 1/30/01
- Westbay installed 2/26/01
- Surface completion in progress
- First sampling planned for Summer 01

Well R-9

- Second sampling event conducted 9/29/00
- Third sampling event conducted 2/13/01
- Fourth sampling event scheduled June 01
- Geochemistry Report scheduled for Oct 01

Well R-9i

- First sampling event conducted 9/15/00
- Second sampling event conducted 2/21/01
- Third sampling event scheduled June 01
- Fourth sampling event scheduled Sept 01
- Geochemistry Report scheduled for Jan 02

Well R-12

- First sampling event conducted 9/20/00
- Second sampling event conducted 3/12/01
- Third sampling event scheduled June 01
- Fourth sampling event scheduled Sept 01
- Geochemistry Report scheduled for Jan 02

Well R-15

- First sampling event conducted 2/24/00
- Second sampling event conducted 9/12/00
- Third sampling event conducted 2/15/01
- Fourth sampling event scheduled July 01
- Geochemistry Report scheduled for Oct 01

Well R-19

- First sampling event conducted 9/30/00
- Second sampling event conducted 3/19/00
- Third sampling event conducted June 01
- Fourth sampling event scheduled Sept 01
- Geochemistry Report scheduled for Jan 02

Well R-22

- Drilled to TD of 1489 feet on 10/11/00
- Construction completed 11/3/00
- Westbay installed 12/18/00
- Surface completion in progress
- First sampling event conducted 3/6/01
- Second sampling event planned Summer 01

Well R-25

- First sampling event conducted 12/12/00
- Second sampling event scheduled for April 01

Well R-31

- First sampling event conducted 12/19/00
- Second sampling event planned for Fall 01

Los Alamos National Laboratory

Environmental Restoration
Groundwater Investigation Focus Area

Drilling "Time Out"

Drilling "Time Out"

- Rational
- Objectives
- Accomplishments
- Planned "Restart"

Rational for "Time Out"

- Budget Constraints
  - Time for R-5, MCOBT-4.4, MCOBT-8.5, R-13, start CdV-37-2
  - Dollars for R-5, MCOBT-4.4, MCOBT-8.5, start R-13
- Contracting
  - Cost proposal not yet approved
- Anticipated Rig Standby Costs
  - Rig finished at R-22 before pad at R-5 ready

Objectives of "Time Out"

- Revise project management approach with Subcontractor
- Transfer quality assurance activities to Subcontractor
- Get planning and contracting in place for future wells

Accomplishments during "Time Out"

- Subcontractor to take responsibility for project management
- Contract for Task Order 18 modified to transfer QA to Subcontractor
- Contracts in place for R-5, MCOBT-4.4 and 8.5, SOW for R-13 at Subcontractor
- NMED and LANL prioritized next six wells

Planned "Restart"

- Readiness review preparations for R-5 proposed to start March 26
- Drill R-5 mid May to mid June
- Drill MCOBT-8.5 mid June to early July
- Drill MCOBT-4.4 early July to late July
- Drill R-13 or R-18 late July to late Sept

Priorities for Future Wells

- Propose a 2 to 3 well list for DP and ER
- As a well is completed, stakeholders meet and add another well to the list
- Wells already in the list can't be changed
- Current proposed list is
  - ER R-13, R-18, R-21
  - DP R-8, R-14, R-20

Priorities for Future Wells

- Must keep contracting and preparation out ahead of drilling

ANNUAL STATUS REPORT FOR THE GEOCHEMISTRY SUBCOMMITTEE, GROUNDWATER INTEGRATION TEAM

BY

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

MARCH 20, 2001

1. EES-6, 2. AURORA TECHNICAL SERVICES, AND 3. EES-16

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, 1999 through September 30, 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 and CDV-15
- Collection of water quality samples from test wells and supply wells
- Performance of geochemical modeling using MINTEQA2 and PHREEQC to quantify aqueous speciation, mineral equilibrium, and adsorption reactions

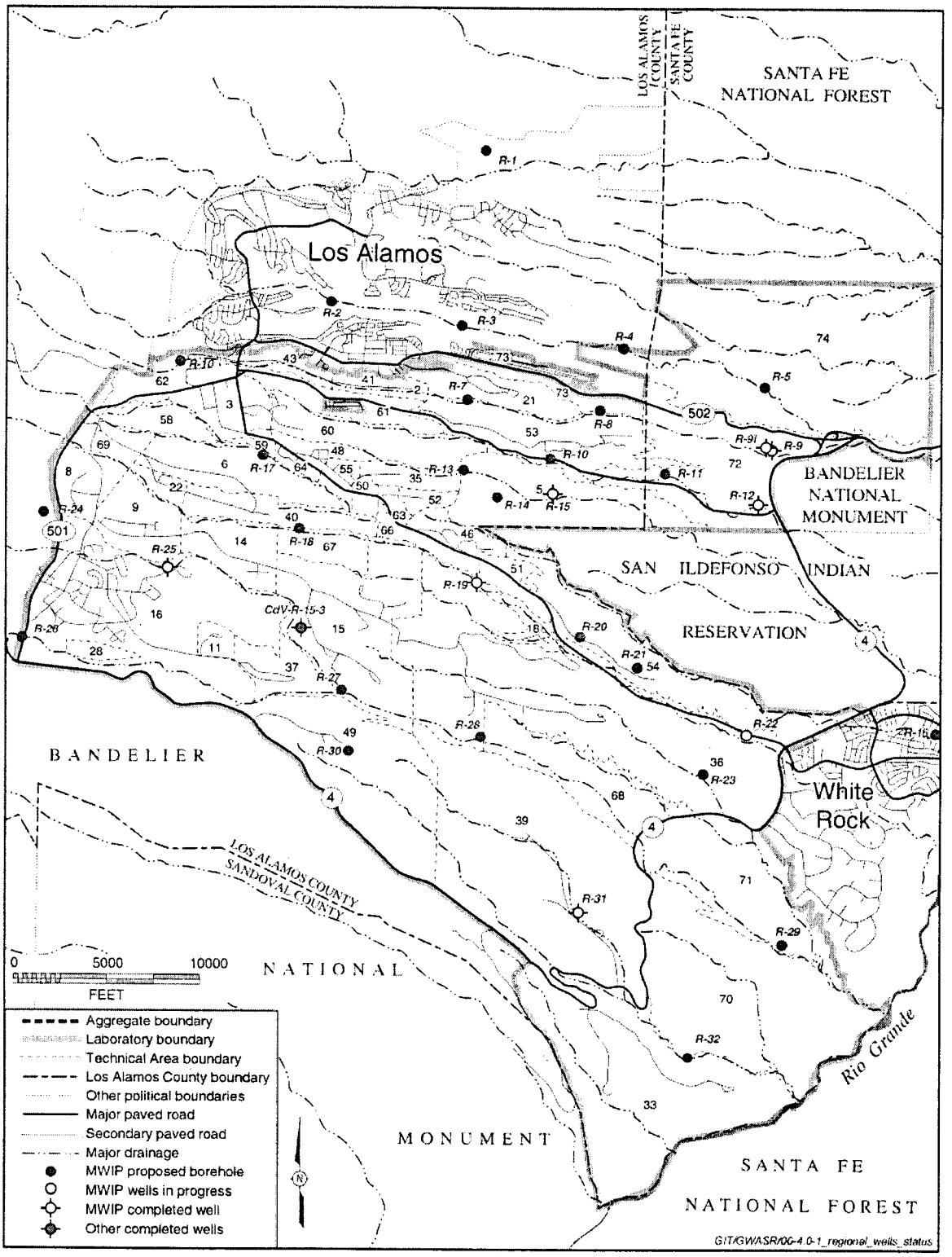


Figure 4.0-1. Completed, in progress, and proposed MWIP regional aquifer wells as of the end of FY00.

INITIAL ANALYTES FOR SAMPLING OF R WELLS

Field Parameters

Temperature, pH, specific conductance, and turbidity

Radionuclides (Filtered and Non Filtered Samples)

Tritium (non filtered only), 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

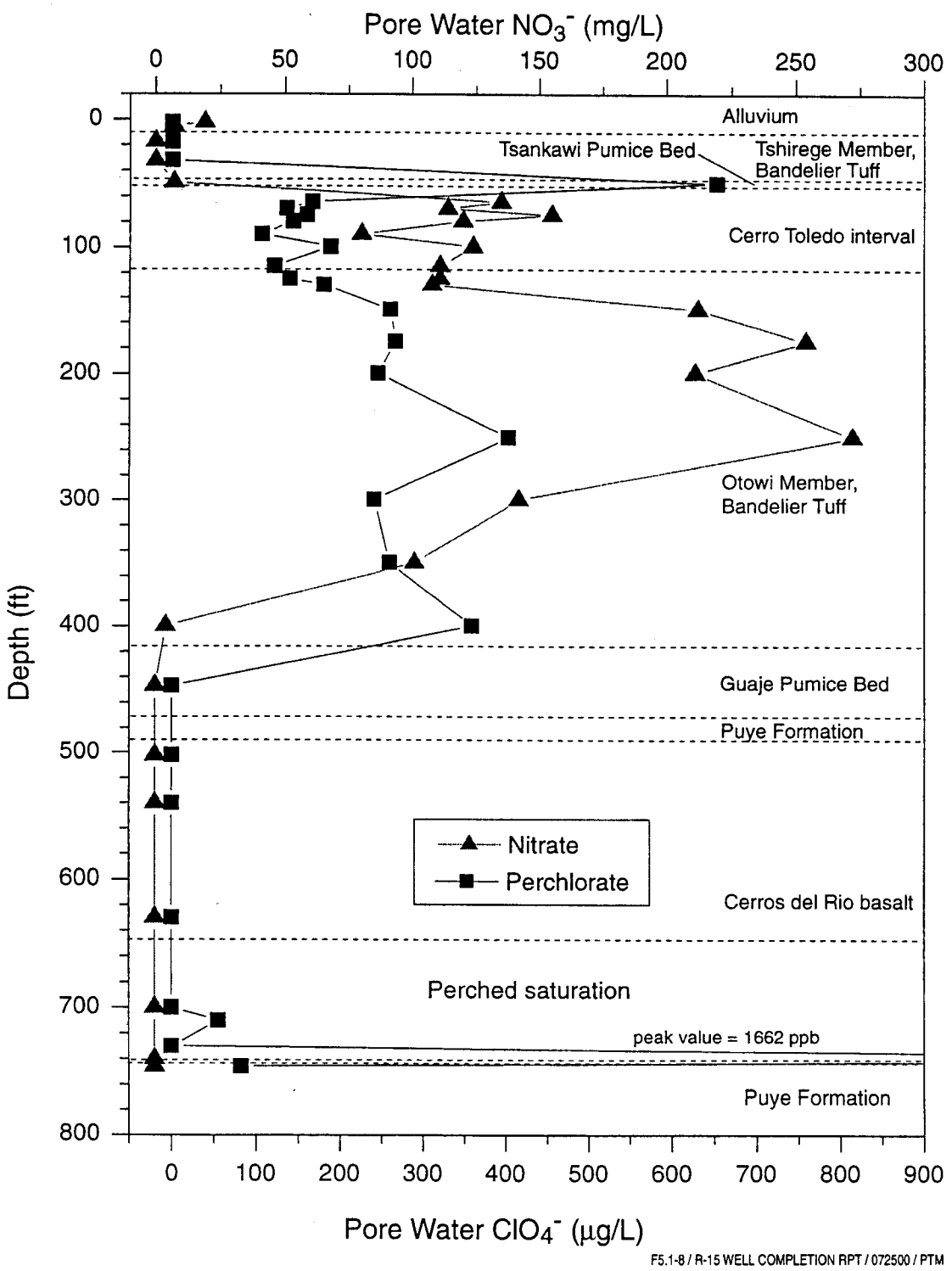
Alkalinity, HCO_3^-, PO_4^{3-}, HN_4^+, TKN, Cl^-, F^-, Br^-, NO_3^-, NO_2^-, $C_2O_4^{2-}$, ClO_4^-, and SO_4^{2-}

Organic Compounds (Non Filtered Samples)

Volatile, Semivolatile (e.g. PCBs, PAHs, Pesticides), High Explosive Compounds and Degradation Products, TOC, and DOC fractionation

Stable Isotopes (Non Filtered Samples)

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



Nitrate-perchlorate in R-15

QUARTERLY SAMPLING OF R-WELLS AND FIELD-MEASURED PARAMETERS

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-9	00/09/29	689 - 704 (SFG basalt) Reg. Aq.	8.03	200	23.4	4.2
R-9I	00/09/14	189 - 199 (CDR basalt) Perched	8.04	160	19.64	3
R-9I	00/09/15	270 - 280 (CDR basalt) Perched	7.5	140	13.5	1.9
R-12	00/09/18	459 - 467 (CDR basalt) Perched	8.01	280	21.8	3.3
R-12	00/09/19	504 - 508 (CDR basalt) Perched	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) Perched	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

QUARTERLY SAMPLING OF R-WELLS AND FIELD-MEASURED PARAMETERS

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-25	00/11/14	738 - 759 (BT) Perched	7.65	225	9.0	1.6
R-25	00/11/15	883 - 894 (PF) Perched	8.83	322	9.0	41.7
R-25	00/12/01	1055 - 1065 (PF) Perched	11.63	490	9.9	1.9
R-25	00/12/04	1185 - 1195 (PF) Perched	7.64	716	8.8	5.3
R-25	00/12/07	1296 - 1306 (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
R-31	00/12/14	827 - 837 (PF) Perched	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) Perched	6.8	790	15.5	46.7
R-31	00/12/16	515 - 546 (PF) Perched	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; and Reg. Aq. means regional aquifer. An upper saturated zone is present at R-25. Jennifer Fofoed supervised quarterly sampling at R-9, R-9i, R-12, and R-25. Jon Marin supervised quarterly sampling at R-15, R-19, and R-31.

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, 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 ± 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 ± 4.5 (1σ) pCi/L at 883 ft.

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

FY-2001 GEOCHEMISTRY DATA COLLECTION ACTIVITIES

- Collection of core and cuttings for geochemical-contaminant analyses during drilling of boreholes R-5, R-7, and R-22 and potential intermediate borehole(s) in Mortandad Canyon.

- Collection of groundwater samples both during drilling and from newly completed wells to evaluate natural solute(inorganic-radionuclide) and contaminant distributions in perched zones and the regional aquifer.

- Collection of groundwater samples from alluvial wells in Pueblo Canyon, Los Alamos Canyon, Mortandad Canyon, and Cañon de Valle to evaluate water and contaminant balance, and estimate residence times and mixing of groundwater and surface water.

- Collection of water quality samples from test wells and supply wells on and adjacent to the Pajarito Plateau as part of the annual environmental surveillance and compliance monitoring activities.

FY-2001 GEOCHEMISTRY DATA INTERPRETATION ACTIVITIES

- Complete the LANL natural solute (background) investigation for the ER project and finalizing the report.
- Continue to incorporate the effects of monitored natural attenuation into the decision-making process within the GIT and ER Project.
- Evaluate distribution of solutes measured at different characterization wells using statistical analyses, and geochemical modeling. Validated analytical results will be included as part of the data analysis and assessment.
- The Geochemical Conceptual Model will be refined based on knowledge gained in FY2001 data collection and analytical results.
- Available data shall be compiled and interpreted on major ions chemistry and stable isotopes throughout the Española Basin to evaluate and quantify recharge and groundwater chemistry along flow paths.

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 that most of the Ba is dissolved and estimated colloidal percentages are usually less than 10%.

SUPPLEMENTAL MATERIAL FOR GEOCHEMISTRY SUBCOMMITTEE ANNUAL REPORT (FY2000)

ENVIRONMENTAL RESTORATION PROJECT

R-WELL COMPLETION (SCREENS)

- R-9, Single Screen (689 - 704 ft)
- R-9I, Double Screens (189 - 199 ft and 270 - 280 ft)
- R-12, Triple Screens (459 - 468 ft, 505 - 508 ft, and (801 -884 ft)
- R-15, Single Screen (959 - 1020 ft)
- R-19, Multiscreens (893 - 910 ft, 1171 - 1215 ft, 1583 - 1590 ft, 1727 - 1734 ft, 1832 - 1839 ft)

ANALYTICAL METHODS EPA SW846

- Metals- Inductively Coupled Plasma Optical Emission Spectroscopy and Inductively Coupled Plasma Mass Spectrometry
- Anions- Ion Chromatography

Organic Compounds- Gas Chromatography and Gas Chromatography-Mass Spectrometry

- High Explosive Compounds- High Pressure Liquid Chromatography
- Radionuclides- Alpha Spectrometry, Gas Proportional Counting, Gamma Spectroscopy, Direct Counting, Electrolytic Enrichment
- Stable Isotopes- Isotope Ratio Mass Spectrometry

SAMPLING PROTOCALS AT R-WELLS

- Purge single completed wells, removing at least 3 well bore volumes; measure field parameters; collect; filter; and preserve (if required).

- Collect groundwater samples at multicompleted wells; measure field parameters; filter; and preserve (if required). Groundwater samples are collected using Westbay Instruments at a rate of four liters per hour (one hour per trip).

FIELD-MEASURED PARAMETERS AT R-9

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-9	00/02/28	689 - 704 (SFG basalt) Reg. Aq.	7.45	239	22.7	2.02
R-9	00/09/29	689 - 704 (SFG basalt) Reg. Aq.	8.03	200	23.4	4.2
R-9	01/02/16	689 - 704 (SFG basalt) Reg. Aq.	8.13	259	23.0	2.4

Note: SFG means Santa Fe Group and Reg. Aq. means regional aquifer. Jennifer Kofoed supervised quarterly sampling at R-9.

FIELD-MEASURED PARAMETERS AT R-9I

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-9i	00/09/14	189 - 199 (CDR basalt) Perched	8.04	160	19.6	3.0
R-9i	01/02/20	189 - 199 (CDR basalt) Perched	7.35	272	12.8	1.2
R-9i	00/09/15	270 - 280 (CDR basalt) Perched	7.5	140	13.5	1.9
R-9i	01/02/21	270 - 280 (CDR basalt) Perched	7.25	215	12.3	1.4

Note: CDR basalt means Cerros del Rio basalt. Jennifer Kofoed supervised quarterly sampling at R-9i.

FIELD-MEASURED PARAMETERS AT R-15

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-15	00/02/24	960 - 1020 (SFG basalt)Reg. Aq	8.0	126	20.6	4.8
R-15	00/10/10	960 - 1020 (SFG basalt)Reg. Aq	7.9	130	16.9	3.0
R-15	01/02/15	960 - 1020 (SFG basalt)Reg. Aq	8.15	146	19.0	2.6

Note: SFG means Santa Fe Group and Reg. Aq. means regional aquifer. Jon Marin and Jennifer Kofoed supervised quarterly sampling at R-15.

FIELD-MEASURED PARAMETERS AT R-22

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (µSi/cm)	Temp. (C)	Turbidity (NTU)
R-22	01/03/13	872 - 914 (CDR basalt)Reg. Aq.	7.21	458	19.6	9.3
R-22	01/03/12	947 - 989 (CDR basalt)Reg. Aq.	8.35	153	17.0	0
R-22	01/03/09	1272 - 1279 (Totavi) Reg. Aq.	8.21	487	19.5	3.8
R-22	01/03/08	1378 - 1384 (SG bslt) Reg. Aq.	7.21	533	16.7	12.8
R-22	01/03/06	1447 - 1452 (older volcanic gravels) Reg. Aq.	7.01	290	19.0	3.1

Note: CDR basalt means Cerros del Rio basalt; SFG means Santa Fe Group; PF means Puye Formation; and Reg. Aq. means regional aquifer. Jennifer Kofoed supervised quarterly sampling at R-22.

SELECTED VALIDATED ANALYTICAL RESULTS OF QUARTERLY SAMPLING OF R-WELLS (FILTERED)

Well	Date received by analytical lab. (y/m/d)	$NO_3^- + NO_2^-$ (mg/L)	TKN (mg/L)	Tritium (CPI/L)	ClO_4^- (μg/L)	2-A-DNT (μg/L)	4-A-DNT (μg/L)	TOC (mg/L)	Other (μg/L or ‰)
R-9	00/10/02	0.650	0.350	4.84	NA	ND	ND	2.70	toluene,12
R-9I screen 1	00/09/18	0.100 U	0.400	81.4	1.04 U	ND	ND	3.00	U*, 0.641; 3-NT, 0.15; δ18O, -10.9 ‰
R-9I screen 2	00/09/18	0.100 U	0.10 U	69.4	1.04 U	0.15	ND	4.20	2,4-DNT, 0.5; RDX, 0.49; U*, 0.068; δ18O, -10.9 ‰
R-12 scrn 1	00/09/20	0.100 U	0.910	60.3	1.04 U	ND	ND	7.70	NH_4^+, 1,100; U*, 0.927; δ18O, -11.4 ‰; Bisphthalate, 3.2
R-12 scrn 2	00/09/21	0.100 U	0.570	30.1	1.04 U	ND	ND	16.00	δ18O, -11.5 ‰; δ15N, -3.7 ‰; CS_2, 1.7
R-12 scrn 3	00/09/25	0.100 U	0.250	25.9	1.04 U	ND	ND	45.00	U*, 0.896; δ18O, -11.3 ‰

Scrn means screen; 3-NT means 3-nitrotoluene; U means not present; ND means not detected; U* in other chemicals means uranium; Sb means antimony; NB means nitrobenzene; 2,4-DNT means 2,4-dinitrotoluene; 1,3DNB means 1,3-dinitrobenzene; TKN means total Kjeldahl nitrogen (organic nitrogen).

SELECTED VALIDATED ANALYTICAL RESULTS OF QUARTERLY SAMPLING OF R-WELLS (FILTERED)

Well	Date received by analytical lab. (y/m/d)	$NO_3^- + NO_2^-$ (mg/L)	TKN (mg/L)	Tritium (pCi/L)	ClO_4^- (µg/L)	2-A-DNT (µg/L)	4-A-DNT (µg/L)	DOC (mg/L)	Other (µg/L or ‰)
R-15	00/10/11	2.30	0.550	0.77	2.8 U	ND	ND	6.10	NH_4^+, 160; U*, 0.33; δ18O, -10.9 ‰; δ15N, +0.9 ‰; Bisphthalate, 5.9; toluene, 0.69
R-19 scrn 2	00/09/25	0.690	0.280	-0.04 U	1.04 U	ND	ND	3.30	RDX, 0.098; δ18O, -10.5 ‰; δ15N, +6.6 ‰
R-19 scrn 3	00/09/18	0.340	0.650	-0.1 U	1.68	ND	ND	4.20	Sb, 5.67; 2,4-DNT, 0.5; RDX, 0.49; U*, 0.068; δ18O, -10.7 ‰; δ15N, +1.9 ‰
R-19 scrn 5	01/10/1	0.100 U	0.910	0.1 U	1.04 U	ND	ND	7.70	δ18O, -10.9 ‰; 1,3-DNB, 0.22; 2,4-DNT, 0.3
R-19 scrn 6	00/10/05	0.50 U	6.30	0.08 U	1.04	ND	ND	6.80	NH_4^+, 500; 2-Butanone, 1.6; δ18O, -11.0 ‰; NB, 0.41
R-19 scrn 7	00/10/05	0.50 U	4.60	0.21 U	1.04 U	ND	0.22	3.30	NH_4^+, 210; As, 3.5; 1,3-DNB, 0.24; δ18O, -11.0 ‰

Scrn means screen; 3-NT means 3-nitrotoluene; U means not present; ND means not detected; U* in other chemicals means uranium; Sb means antimony; NB means nitrobenzene; 2,4-DNT means 2,4-dinitrotoluene; 1,3-DNB means 1,3-dinitrobenzene; TKN means total Kjeldahl nitrogen (organic nitrogen).

TA-16 INVESTIGATIONS, BARIUM COLLOIDS

Filtered and nonfiltered Ba data indicate a systematic bias where nonfiltered Ba concentrations are usually higher than filtered.

PHREEQC results suggest barite oversaturation in the springs.

- SI for barite in Burning Ground Spring is about 0.3

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

- Suggests Ba may also be adsorbed

PHREEQC results suggest various iron and aluminosilicate minerals are oversaturated 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.

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:
$CH_3CCHOHCH_3 + 0.5O_2 + \text{microbe} \rightarrow CH_3COCH_3 + H_2O$.

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

GIT Hydrology Subcommittee Report for FY 00

LANL Hydrogeologic Characterization

Program Annual Meeting

March 20, 2001

David B. Rogers

Water Quality & Hydrology Group, ESH-18

Hydrogeologic Atlas

- Bill Stone has completed the FY 00 LANL Hydrogeologic Atlas
- A copy is available for examination
- The Atlas incorporates the FY 99 geologic model

Hydrologic Testing

- Hydraulic properties were determined by straddle packer/ injection testing
- Wells R-9i, 19, 22, 31, and CdV-R-15-3
- Pump test in R-15
- Results will be summarized in a poster

Water Level Data

Water levels are collected with transducers at 3 hr intervals:

- 8 Regional aquifer test wells and 1 former supply well
- 6 intermediate perched zone wells
- 6 alluvial groundwater wells in Los Alamos Canyon
- 14 alluvial groundwater wells in Mortandad Canyon
- R wells are being added to water level program

Water level data are on the web at:

http://www.esh.lanl.gov/~esh18/teams/hydrology/Welldata.htm

Low-Head Weir Investigation

- Three boreholes will investigate infiltration beneath the low-head weir in Los Alamos Canyon
- The holes will be drilled in late March 2001
- Hydrologic properties of basalt underlying the weir will be evaluated

EAG Recommendations

p. 11 If data quality problems are occurring with americium analyses as they did for ^{90}Sr analyses, these should either be quickly addressed or turned over to an external laboratory.

- This comment refers to analyses done for the Environmental Surveillance Program rather than for the ER Project.
- The Environmental Surveillance Program moved its analyses to outside analytical laboratories during calendar year 2000.

EAG Recommendations

p. 14 The hydraulic testing approach and expectations for O-1/R-5 need to be articulated and reviewed by the EAG to verify that this significant expenditure of funds will yield valuable information.

- R-5 is no longer being drilled near enough to O-1 to be used as a hydrologic testing well.

EAG Recommendations

p. 14 Spinner tests should be conducted on as many municipal wells as possible.

p. 14 The use of properly designed recovery tests, as opposed to constant rate pumping tests, should be explored as a more pragmatic way of obtaining municipal well hydraulic data.

p. 14 Limiting factors should be reviewed to see if actions can be taken to obtain hydraulic data from municipal wells sooner, rather than later, to support model development.

EAG Recommendations

p. 24 Develop (or articulate) criteria for selecting screen zones in R wells.

p. 26 A logical and consistent approach is needed for determining where to screen the wells and the methods for calculating the depths of the screens, seals, and sand packs. The EAG recommends that the GIT develop this approach and have a single individual, highly trained in geology and/or hydrology, make these onsite decisions for all the remaining R wells.

EAG Recommendations

A committee (including experts in geology, hydrology, and geochemistry) decides the location of screen zones in R wells. The criteria can be generalized as follows-

- Larger perched zones are screened.
- The top of the regional aquifer is screened.
- Deeper portions of the regional aquifer are screened.
- Depths for screening are based on geologic strata encountered, presence of water during drilling, and logs.

EAG Recommendations

p. 26 The EAG recommends that the GIT follow ASTM guidelines for well development, and encourages the last step of the process to be pumping of each of the screened intervals with a pump using packers to isolate the individual intervals.

- We are familiar with ASTM development guidelines and what we do conforms to them.
- A dual packer development system is being developed.

Modeling Subcommittee Report

2001 Annual Meeting

March 20, 2001

Bruce Robinson

Outline

- Modeling Accomplishments
  - Regional Aquifer
  - MDAs and Canyons
- Other Subcommittee Activities
  - Rewriting of modeling plan
  - Establishing priorities for hydrogeologic data collection
- Current Work

Modeling Accomplishments - Regional Aquifer

- Transport simulations for groundwater tracers (^{3}H, ^{14}C, ^{18}O, Cl), and comparison to measured values
- Formal incorporation of transient water level data into model calibration process, reducing parameter uncertainty
- Uncertainty analysis for groundwater flow directions
- Further development of geostatistical representation of heterogeneity within the Puye Formation, using R-well and outcrop data to derive statistical parameters.

Modeling Accomplishments - MDAs and Canyons

- Updated LA Canyon 3D model of flow and tritium transport
- Preliminary TA-16 vadose zone flow and transport model
- Examination and synthesis of vadose zone conceptual model validation
  - TA-50 water injection test
  - TA-49 moisture studies
  - TA-21 flow and transport model
  - Simulation of LA Weir site flow and transport
- Fire-related issues
  - Modeling of ponded conditions in the canyon bottom
  - Influence of temporary high infiltration events due to flooding

Update of Modeling Plan

- This writeup replaces the original chapter describing the modeling in the Workplan
- The new plan is more detailed and comprehensive
- Approximate schedules are provided for most tasks

Modeling Plan - Generic Plan for Process Model Development

If a numerical model is necessary:

- Develop conceptual model
- Compile data, identify gaps
- Construct numerical model (grid, parameter distributions, boundary conditions, etc.)
- Calibrate model to existing data
- Incorporate new data, iterate by revisiting any or all of the previous steps, as necessary

Models may be used to perform predictions during this process, but results may change as the model improves

Prioritization of Hydrogeologic Data Collection

- **Prioritization criteria**
  - **Focus on "least-well-characterized" hydrogeologic units**
  - **Ensure data collection covers regions of highest fluxes and/or transport velocities**
  - **Fill in gaps where spatial coverage is insufficient**
- **Parameters of Greatest Importance**
  - **Head**
  - **Permeability**
  - **Storativity**
  - **Porosity**

Prioritization of Hydrogeologic Data Collection Example: Permeability Data

Method: Examination of model sensitivity to permeability using the calibrated regional aquifer establishes whether additional data are required to reduce uncertainty

Results: Prioritization of further characterization of permeability of different units is in the following order (most to least important):

- Puye Formation and Cerros del Rio Basalts
- Tschicoma Formation
- Santa Fe Group

Current Work: FY01 Integrated Modeling Tasks

- First-order groundwater pathway assessment
- Regional aquifer model development - ongoing
- Plateau-wide infiltration mapping
- 3D geologic model uncertainty assessment
- Geophysical surveys to supplement spatial hydrogeologic data
- Interpretation of R-well hydrologic and contaminant 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

Hydrogeologic Characterization: FY00 Accomplishments and FY01 Activities

Charles Nylander
nylander@lanl.gov
LANL Water Quality and Hydrology
(ESH-18)

FY00 Accomplishments: Field Activities

- Drilled and constructed four wells (R-19, R-9i, CDV-15, and R-31); completed four wells (R-15, R-25, R-9, R-12); started drilling R-22
- Conducted two rounds of quarterly sampling (R-9, R-9i, R-12, R-15)
- Well Completion Reports for R-9, -9i, -12, -15, -19
- Awarded a task order for ER Project Groundwater Investigation Focus Area field support and drilling
- Implemented well head protection after Cerro Grande fire

FY00 Accomplishments: Documents and Assessments

- Data reports on the mechanical testing of hydrologic properties on samples from R-9, -12, -25
- Expanded Hydrogeologic Atlas
- Database runoff flow and chemistry modules available to public at http://wqdbworld.lanl.gov
- Management Assessment for compliance with ER Project QA Plan
- Audit for compliance with LIRs by the Project Management Division

FY00 Accomplishments: Regional Aquifer Modeling Activities

- Developed a stochastic approach to modeling variations in hydraulic conductivity within the Puye Formation
- Evaluated pump test simulations for possible O-1/R-5 cross-hole testing in support of R-5 siting decision
- Analyzed site-wide hydraulic conductivity trends using hydraulic conductivity data, water levels and inverse modeling

FY00 Accomplishments: Vadose Zone Modeling Activities

- Updated Los Alamos Canyon model, including predicting potential impacts of the Cerro Grande fire
- Completed Area L organic vapor plume study, documented in a written report and web-based presentation

FY00 Accomplishments: GIT Activities

- Held GIT bi-weekly meetings, 3 quarterly meetings and the Annual Meeting
- EAG conducted 2 reviews, resulting in two reports and two corresponding action plans
- Produced the FY99 Status Report, published as a LANL Status Report (LA-13710-SR)
- Participated in ESH Division Review and the presentation was rated as "outstanding" and received Los Alamos Achievement Award

FY00 Accomplishments: Project Management Activities

- Incorporated DP Monitoring Well Project into ER Project "Project Planning and Control System" (PP&CS)
- Produced monthly joint DP/ER status reports

FY01 Activities: Field Work

- Drilled and completed R-22, R-7, and R-5, and 2 intermediate wells in Mortandad Canyon
- Quarterly sampling of R-5, R-9, R-9i, R-12, R-15, R-19, R-22, R-25, R-31
- Well completion reports for R-25 and R-31
- Airborne electromagnetic and magnet survey

FY01 Activities: Information Management

- Software Development
- Migration of data: Legacy Chemistry, Water Levels, Hydrologic Properties
- Report/Website Development
- ERDB/WQDB Data Exchange

FY01 Activities: Modeling

- Model parameters: facies model and permeability of Puye and Santa Fe; general probability distribution of key model inputs; recharge across plateau; update geologic model
- Uncertainty Analysis: data collection to reduce model uncertainty, uncertainty analysis of geologic model, stochastic analysis of regional aquifer flow
- Pathway Analysis: first-order pathway assessment

FY01 Activities: GIT

- Develop Annual Report, support interpretative tasks
- Three quarterly meetings, one Annual Meeting, and bi-weekly meetings
- External Advisory Group reviews, reports, and corresponding action plans.

FY02 Planned Hydrogeologic Characterization Activities

Charlie Nylander
nylander@lanl.gov
LANL Water Quality and
Hydrology Group (ESH-18)

FY02 Planned Field Activities

- Wells to be drilled and completed: R-8, R-14, R-20 (DP); R-13, R-18, R-21 (ER)
- Quarterly sampling in R-5, R-8, R-13, R-18, R-14, R-25, R-31

FY02 Planned Information Management Activities

- System maintenance and administration
- Data Import
- Legacy data migration
- Report development

FY02 Planned Modeling Activities

- Link Los Alamos and Mortandad canyon models to regional model
- Examine effect of local recharge on aquifer
- Update geologic model
- Effects of Pajarito Plateau faults on hydrogeologic system
- Tracer test experiment

FY02 Planned GIT Activities

- Develop Annual Report, support interpretative tasks
- Three quarterly meetings, one Annual Meeting, and bi-weekly meetings
- External Advisory Group reviews, reports, and corresponding action plans.

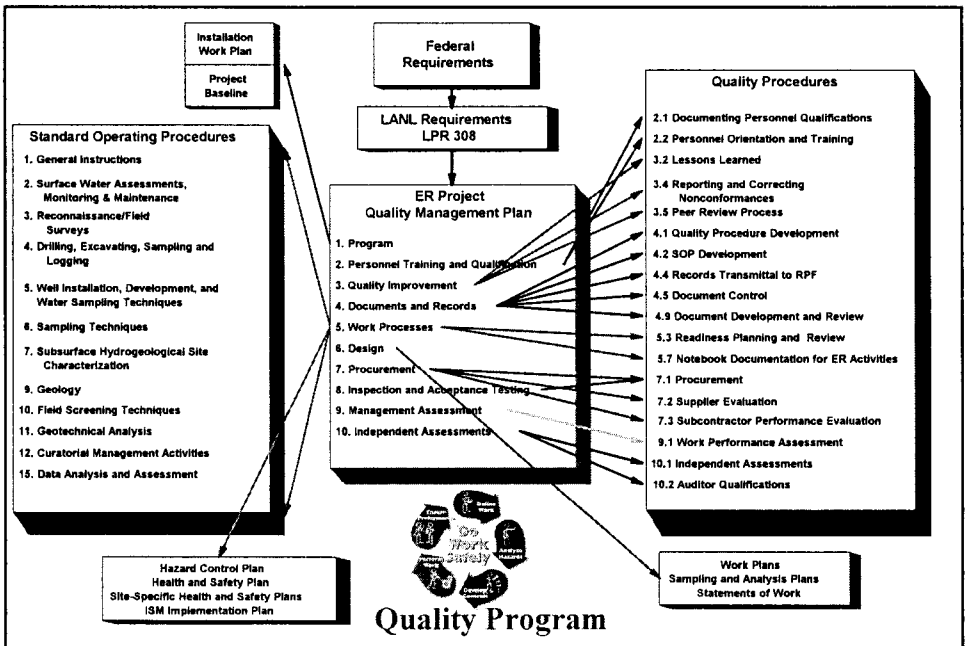
Quality Program Report

Presentation for Annual GIT Meeting

Larry Maassen
Quality Program Project Leader
March 20, 2001

environmental restoration project

Los Alamos
NATIONAL LABORATORY



Quality Program
Implementation Matrix

environmental restoration project

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GWIFA Assessment Follow-Up

Number of Commitments	Category	Status
2	Training	Complete
1	QAPP Prep	OBE
1	Hire QA Assistance	Complete
1	Lessons Learned	In process
8	Procedure Review or Preparation	In process
2	Qualifications of Personnel	Complete
4	Design Control	In process
2	Document Control/Records	Complete
1	Organizational Roles/Responsibilities	Complete
1	Procurement	Complete

environmental restoration project

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Process Improvements

- GWIFA has hired full-time QA specialist
  - In addition to QA expertise, Pat Ortiz has drilling experience
- All Quality Program training has been completed
- Hold and witness points have been added throughout the construction and development of future wells

environmental restoration project

Los Alamos
NATIONAL LABORATORY

Process Improvements

- New Contracting Initiative with WGII
- ER Project QPPL has been given go/no go authority for drilling restart
- Current Focus Area Leadership has an appreciation of the importance QA

New Contracting Initiative

- Current Drilling Contract Has LANL/ER Responsible for Maintaining Quality Program
- Modified Contract Specifies WGII as Totally Responsible for All Aspects of Quality Program
  - Sub will develop own admin procedures, but adopt ER SOPs
  - QII Staff Will Monitor WGII's Implementation Through Audit and Assessment Process

Evolution of Well Drilling, Construction, & Development

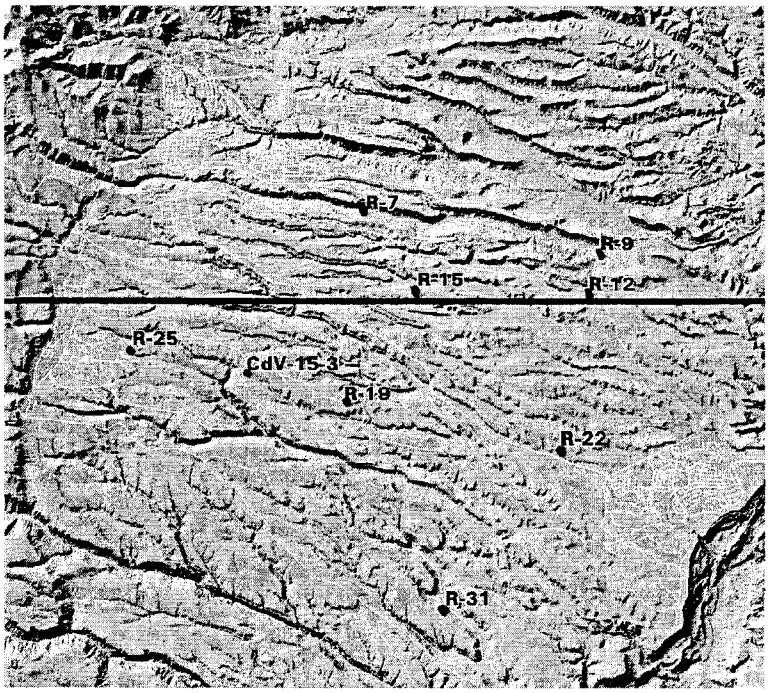
Ted Ball
Steve Pearson

Observations on Geology from Regional Wells: New Data and Inclusion of Mineralogic Analyses

D. Vaniman, J. W. Carey, and G. Cole

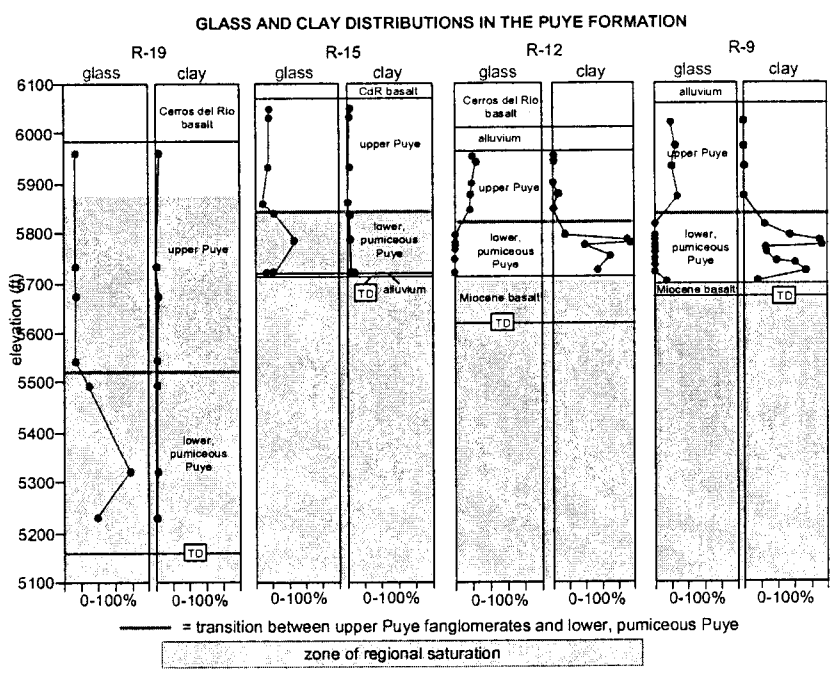
Geologic information from the new ER drill holes R-19, CdV-R-15-3, R-22, and R-7 will require modifications to the site 3D Geologic Model. These modifications include thickening of the Cerros del Rio lavas in paleochannels west of the present Rio Grande and recognition of a pumiceous volcaniclastic unit beneath the Puye fanglomerates. This early pumiceous unit is tentatively assigned to the Puye Formation. Mineralogic information from the pumiceous volcaniclastic unit provides evidence of complete alteration to clay in the east, between the LANL technical areas and the present Rio Grande, but not beneath the central LANL area. This clay barrier may extend to considerable depth, if data from drill hole O-1 are factored into the interpretation. Future work on the 3D Geologic Model will include the clay barrier.

The following figure shows the locations of drill holes cited and a line of cross-section that is used in following figures for comparing new concepts with the existing 3D Geologic Model.



Mineralogic data define the distribution of clay alteration zones within the Puye Formation (data from quantitative X-ray diffraction analysis of core and cuttings).

Volcanic glass is the precursor for clay formation; in the following figure, note that the abundant volcanic glass of the lower, pumiceous Puye is unaltered in R-19 and R-15, but is completely altered to clay in R-12 and R-9. The clay alteration has no apparent relation to the position of the water table. Note also that the stratigraphic contact between the upper Puye and the lower, pumiceous Puye is ~350 ft lower in R-19 than in the other drill holes, suggesting either displacement along a buried fault or extensive erosion to the west before deposition of the upper Puye began.



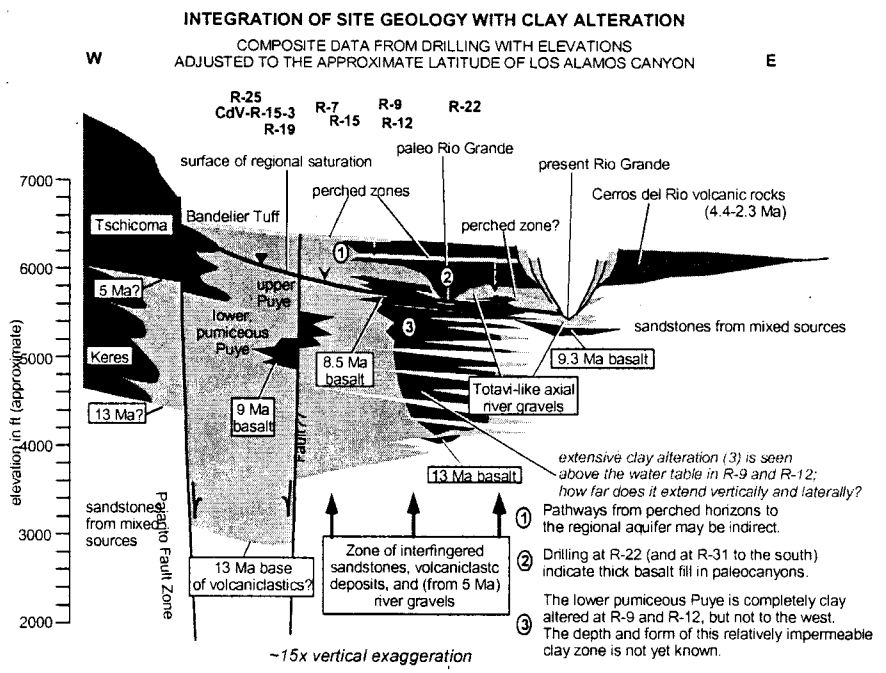
Stratigraphic and mineralogic information from the drill holes: An interpretive cross-section

Three specific features of hydrogeologic significance are numbered on the following figure

(1) From west to east, perched zones beneath canyon bottoms occur at horizons near the Bandelier/Puye contact and then within the Cerros del Rio lavas. The perched horizons generally occur above relatively impermeable clay zones.

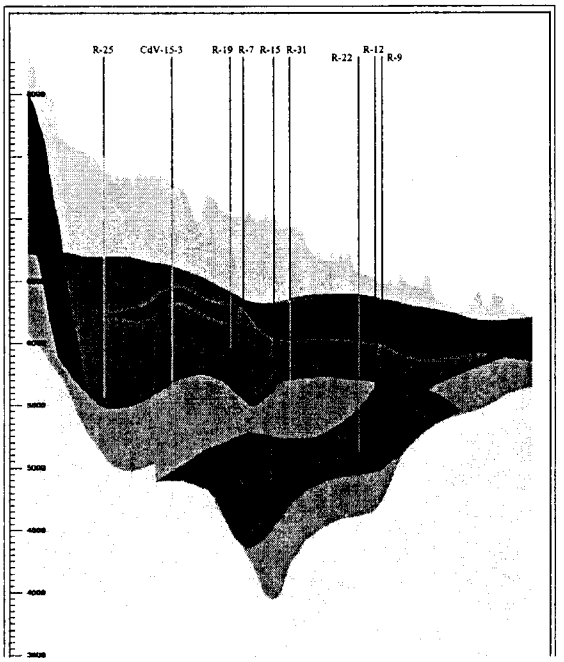
(2) Thick fill of Cerros del Rio lavas in paleocanyons may affect flow paths both in perched horizons within the lavas and in the upper part of the regional aquifer.

(3) From the data in the previous figure, it is known that the lower, pumiceous Puye is thoroughly clay altered near the mouths of Los Alamos and Sandia canyons; a reinvestigation of samples from drill hole O-1 indicates that the same degree of alteration may occur at a comparable location in Pueblo Canyon and that the alteration extends to considerable depth. The "sawtooth" patttern of clay alteration at depth reflects the more ready clay formation expected in the pumiceous Puye but not in glass-free sandstones derived from plutonic rocks. The origin and extent of the clay barrier is under study for incorporation into the 3D Geologic Model.



A west-to-east cross section from the current 3D Geologic Model (following page) at a latitude comparable to the previous interpretive cross-section

The cross-section on the following page is generated from the existing 3D Geologic Model. It shows Bandelier Tuff in yellow, Cerros del Rio lavas in maroon, other lavas in blue, upper Puye in red, the LANL aquifer (lower Puye?) in orange, and Miocene basalts in purple. Differences between the the previous cross-section and the one on the next page reflect impacts of new borehole data that are not yet incorporated in the 3D Geologic Model, as well as the fact that projections of drill hole features onto a single plane include differences in interpretations of available geologic data. These differences, evaluated against the objectives of the Hydrogeologic Workplan and an assessment through modeling of which differences are important, will help in guiding future work



Future directions

Geologic and mineralogic analyses from R-22, R-31, and R-7 are yet to be completed. These new data will help to map the Puye stratigraphy, the paleocanyon lava fills, and the extent of clay alteration above and beneath the regional water table. Drilling yet to be done at R-5 will help considerably in mapping the limits of the Puye clay barrier, and intermediate wells in Mortandad Canyon will add constraints on stratigraphy and mineralogy of perched horizons. The collection of field geophysical data (electrical and gravity data) is planned in order to gain the most from borehole "truth" by allowing extrapolation across the LANL site.

Well Logs, Geology, and Hydrology

David Broxton (LANL)
Rick Lewis (Schlumberger)

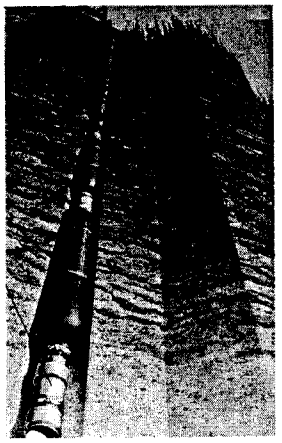
Borehole Geophysics

Use of geophysical logs has steadily increased as drilling methods and requirements for site characterization have evolved during the implementation of the Hydrogeologic Workplan

Why Borehole Geophysics?

- More access to long stretches of open borehole
- Fluid-assisted drilling limits direct identification of perched zones and collection moisture sensitive samples
- Needed to identify of perched groundwater zones, moisture distribution, porosity distribution, and lithology

Borehole Geophysics



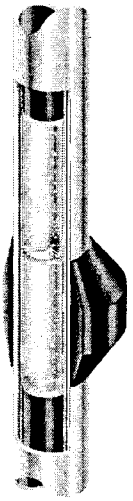
Screen placements for wells rely of integration of :

- geophysical logs
- video logs
- driller's observations
- lithologic information from drill cuttings

Borehole Logging Workshop

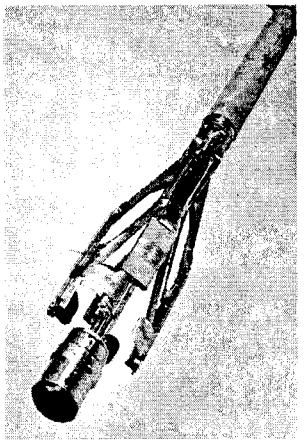
- Held at the LANL Study Center on December 7 and 8, 2000
- The workshop focused on the applicability of geophysical techniques to the Hydrogeologic Workplan and addressed Data Quality Objectives (DQOs) outlined in the workplan.
- Approximately 30 people participated from LANL, AIP, and NMED.

Spectral Gamma Ray



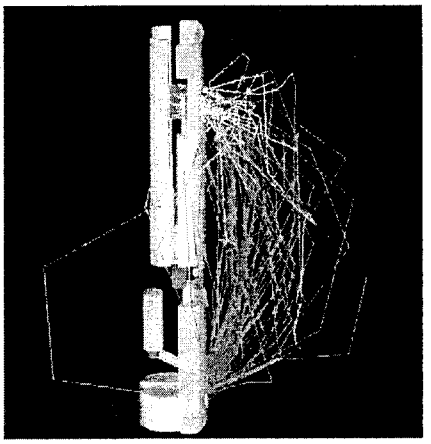
- Deconvolves gamma-ray spectrum into three naturally occurring members – K, U, Th
- K is common in crust
  - K-feldspar, mica, illite
- Th is rare
  - Relatively insoluble
  - Concentrated in clays with high CEC
  - Retained from decomposition of igneous rocks
- U is rare
  - Soluble and mobile in oxidized state
  - Precipitates in reduced zones
- Assumes secular equilibrium for U and Th

Fullbore Formation MicroImager



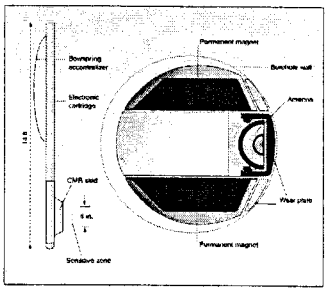
- Oriented electrical image of borehole wall
- Map sedimentary and structural features
- Measure borehole deviation
- Excellent vertical and horizontal resolution (0.2")

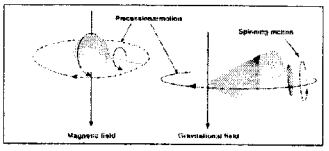
Density Logging Tool



- Measure formation electron density and Pe
- Electron density converted to bulk density and porosity
  - Requires estimate of matrix density
- Pe is measure of formation atomic number
- High vertical resolution, limited depth of resolution

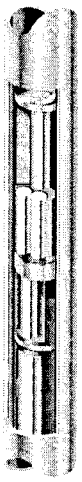
Combinable Magnetic Resonance





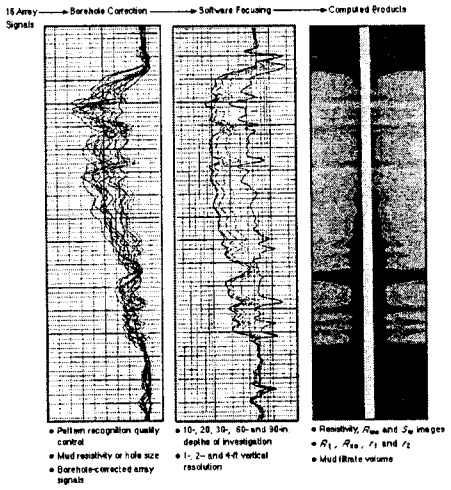
- Nuclear magnetic resonance
- Measures pore size distribution
  - Total and effective porosity
  - Estimate hydraulic conductivity
  - Moisture content in vadose zone
- Accuracy enhances require core

Accelerator Porosity Tool



- Neutron-neutron measurement
  - Sensitive to formation hydrogen content
- Porosity in saturated zone
- Moisture content in unsaturated zone
- Can not distinguish between water and hydroxl

Electrical Induction Tool



- Formation electrical resistivity
  - Five depths of investigation
  - Three vertical resolutions
- Uses
  - Correlation
  - Lithology

HYDRAULIC CONDUCTIVITY VS GEOLOGY

IN NEW LOS ALAMOS WELLS

William Stone, Stephen McLin and David Vaniman

Earth and Environmental Sciences Division
&
Environmental Restoration Project

Los Alamos National Laboratory

HYDRAULIC CONDUCTIVITY VS GEOLOGY IN NEW LOS ALAMOS WELLS

STONE, William, MCLIN, Stephen, and VANIMAN, David
Los Alamos National Laboratory, Los Alamos, NM
wstone@lanl.gov

Eleven screened intervals representing two geologic units have been tested in four new wells at Los Alamos National Laboratory. All of the wells are completed with multiple screens. This paper addresses preliminary results of slug-testing these wells by a straddle-packer/injection method.

Resulting hydraulic-conductivity (K) data range from <1 ft/d to 10's of ft/d. Results vary not only between but also within each of the two major geologic units covered by testing: Cerros del Rio lavas and Puye Formation sediments. In order to better explain the variation in K, data were divided into classes (<1, 1-10, 10-20 and >20 ft/d) and the lithologic character of material behind the screen tested, based on geologic and geophysical logging, was tabulated. Two of the six materials yielding K values in the 0-1 ft/d class are associated with clay-rich basalt flow bases or interflows. Curiously, the remaining four low K values are associated with gravel intervals, all of which made water during drilling. Both values in the 1-10 ft/d class are associated with fractured basalt. Both values in the 10-20 ft/d class are associated with unaltered pumiceous gravel. The single value in the >20 ft/d class was obtained from fractured basalt.

These observations fall within published ranges of K for such materials with one notable exception: values obtained for some of the Puye Formation sediments are much lower than expected. Why would gravels that produced much water during drilling yield the lowest K values when tested? Two possible explanations are that the screen is plugged or head was insufficient to permit injection of water into these materials. The first can be ruled out, as all screened intervals seem to have been adequately developed prior to testing. The second explanation is tempting, as the screened intervals involved are the deepest in their respective wells, lying at depths of 827-1645 ft. Although limited head data suggest vertical gradient is upward in one of the wells, it is not clearly up or down in the other. A third possibility is suggested by neutron logging data that show extensive vertical continuity of free pore water in higher-K sediments, but a lack of such continuity in low-K sediments. This difference may indicate that both vertical and lateral continuity are required for a higher-K response to testing in the Puye Formation, even if the borehole penetrated multiple isolated higher-K zones that produced significant water when connected during drilling. Analysis of the controls of hydraulic conductivity in these materials, as determined by testing, continues.

HYDROLOGIC TESTING AT REGIONAL WELLS

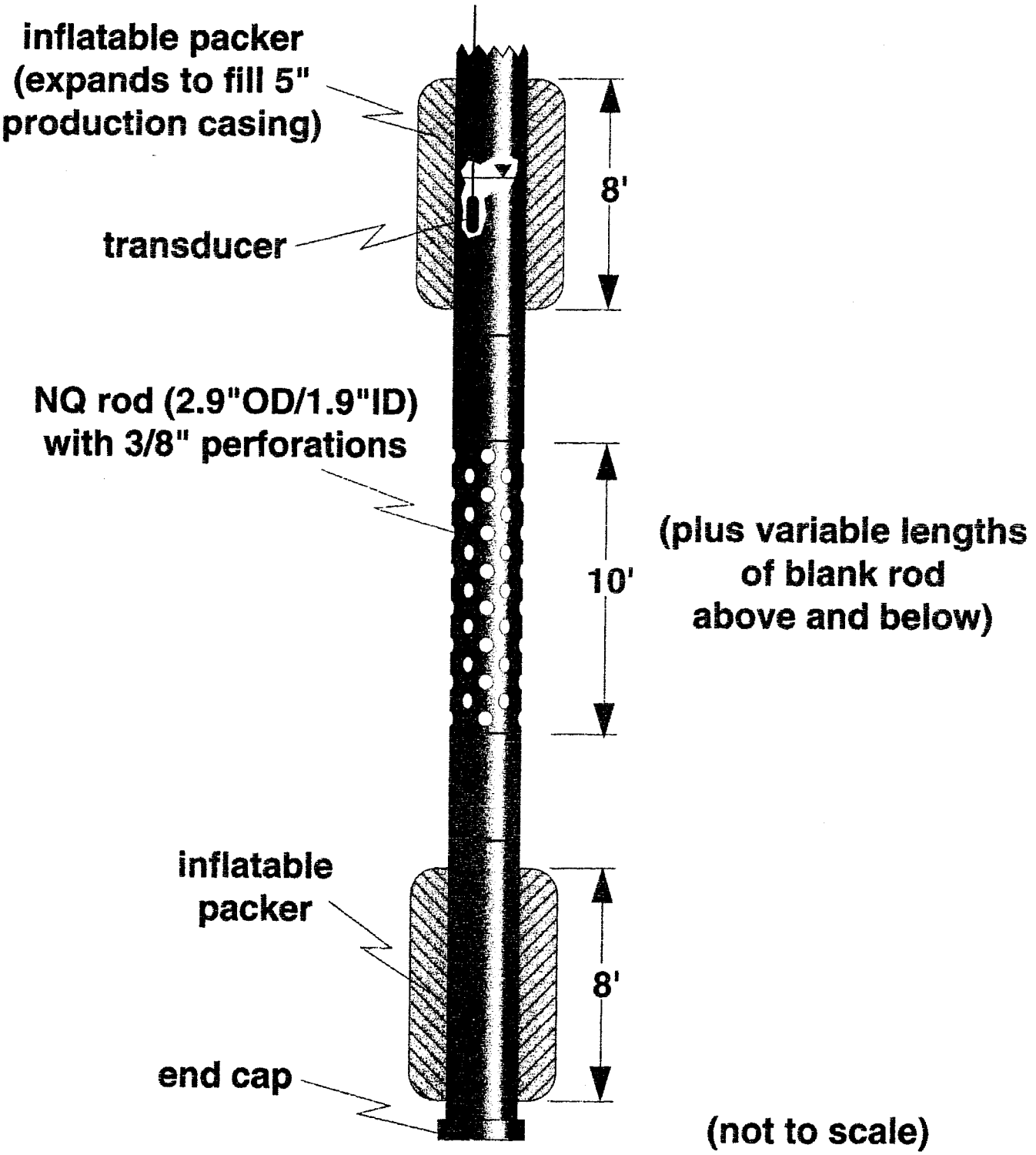
Well	*Saturated Zone*[1]	*Slug Test*[2]	*Pumping Test*
R-9i	U. Perched/Tb	X	X[3]
	L. Perched/Tb	--	
R-15	Perching Horizon/Tb	X	
	Regional/Tp		X
R-19	Regional/Tp (*2*)[4]	X	
R-22	Regional/Tb (*3*)	X	
R-31	Perched/Tb	X	
	Regional/Tp (*4*)	X	
CdV-R-15-3	Regional/Tp (*2*)	X	

[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



Straddle-packer/injection-test assembly

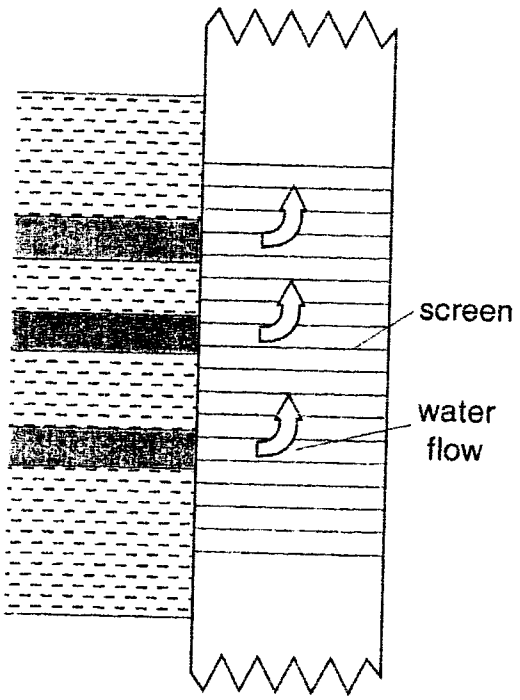
HYDRAULIC CONDUCTIVITY (K) VS GEOLOGIC UNIT

Geologic Unit	*K (ft/d)*	*Well*	*Screen*
Cerros del Rio lavas	37.07	R-9 i	1
	0.78		2
	1.07	R-31	1
	0.42		2
	3.62		3
Puye Formation	17.50	R-19	6
	19.60		7
	0.009	R-31	4
	0.007		5
	0.25	CdV-R-15-3	4
	0.10		5

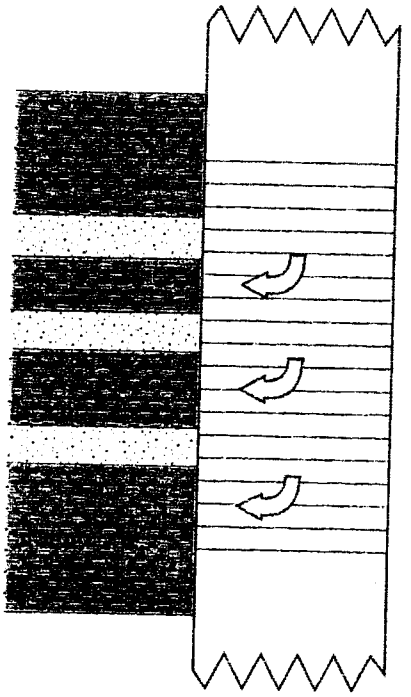
HYDRAULIC CONDUCTIVITY (K) VS LITHOLOGY

K (ft/d)	*Lithology*	*Well*	*Screen*
0-1	clayey flow base	R-9 i	2
	clayey interflow	R-31	2
	axial river gravel	R-31	4, 5
	gravel	CdV-R-15-3	4,5
1-10	fractured flow base	R-31	1
	highly fractured thick flow	R-31	3
10-20	unaltered pumiceous gravel	R-19	6,7
>20	fractured basalt (clay-coated but open)	R-9 i	1

Higher-K zones dominate when pumping



Lower-K zones dominate when injecting



CONCLUSIONS

1. K values obtained by slug testing new wells at LANL vary over several orders of magnitude.

2. This variation occurs not only between but also within major geologic units.

3. Geologic unit, despite major rock- and permeability-type differences (basalt vs fanglomerate) provides no obvious control of K value.

4. K is more dependent on the specific lithology of material behind the screen tested.

5. Both vertical and horizontal continuity of free pore water are necessary for higher-K test results.

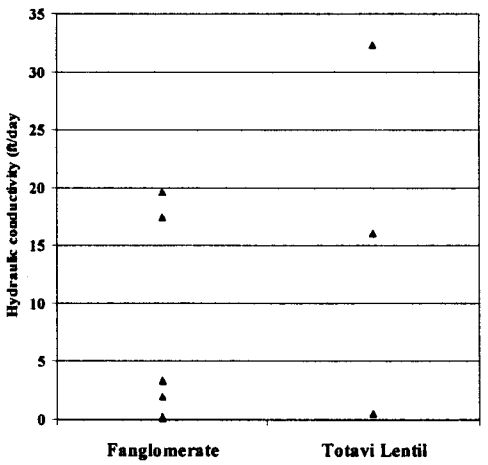
6. Further analysis of the preliminary testing data will no doubt prove beneficial.

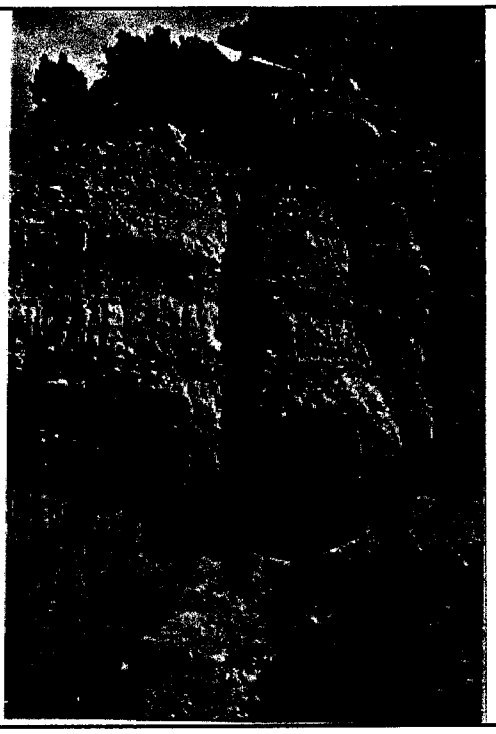
Quantifying heterogeneity within the Puye Formation

Elizabeth Keating
Zhiming Lu
Hydrology, Geochemistry, and Geology Group
Earth and Environmental Sciences Division

Los Alamos National Laboratory

Conductivity of the Puye Formation





Depositional facies within the Puye Formation

	Deposit type	Permeability
Fanglomerate	Channel deposits	high to medium
	Sheet deposits	high to medium
	Clast-rich debris flow	medium to low
	Clast-poor debris flow	low
	Block-and-ash flow	medium to low
	Tephra	medium
	Basalts	high (if fractured)
	Lacustrine	medium to low
Totavi Lentil	Axial stream deposits	high

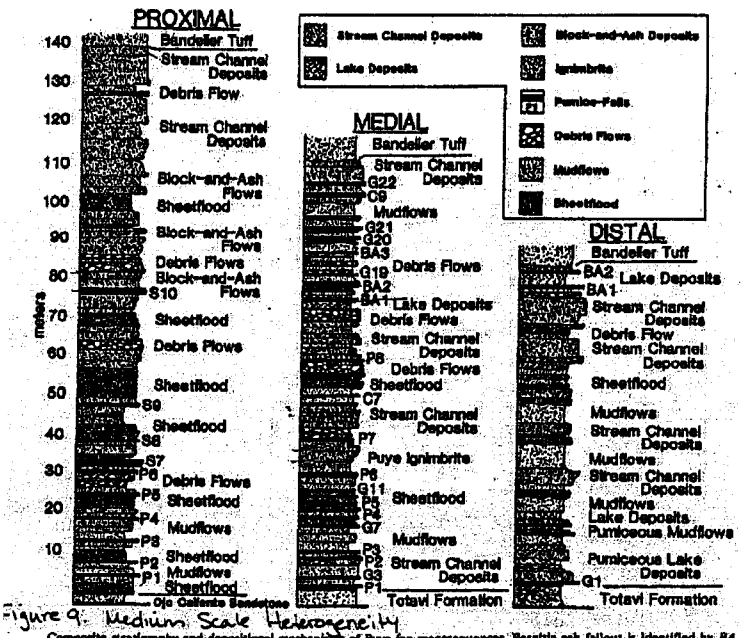
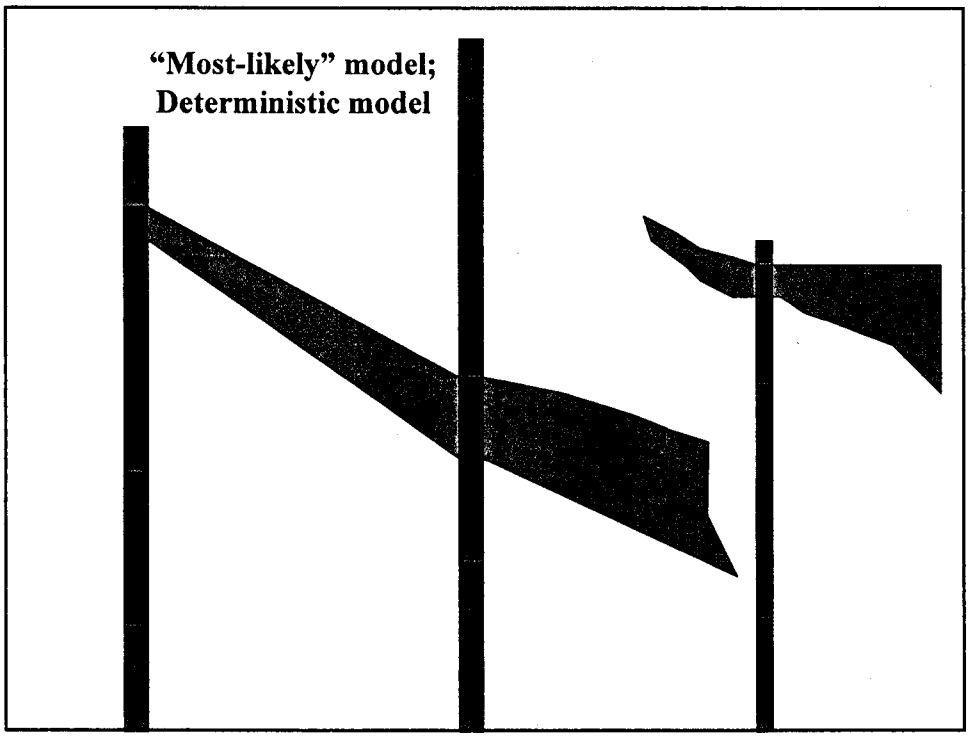
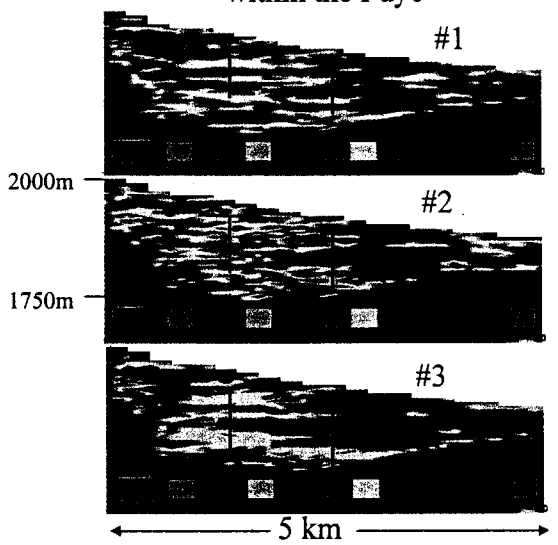


Figure 9. Medium Scale Heterogeneity

Composite stratigraphy and depositional mechanisms of Puye fan megasequences. Basaltic ash fallout is identified by *BA*, whereas other unit designations are felsic pumice fallout beds or ignimbrites. The Puye ignimbrite at approximately 35 m of the medial section was dated as 2.53 ± 0.1 Ma (Turbeville, 1991)



Stochastic model
Three equally-likely representations of heterogeneity within the Puye



Type of representation	Advantages	Disadvantages
Deterministic model	**1. Strictly honors all geologic data** **2. Provides "unique", reliable picture of sub-surface**	**- Difficult to evaluate uncertainty & its effects on groundwater flow and transport**
Geostatistical model	**1. Strictly honors all geologic data** **2. Explicitly acknowledges uncertainty**	**- Can only provide "range" of equally-likely models of flow & transport** **- Computationally intensive**

Requirements for a geostatistical model

Exactly reproduce observed data at boreholes and measured sections

Statistical parameters can be easily derived from data collected in R-wells

Incorporate geologic knowledge about general characteristics of this type of sedimentary deposit

Types of data available:

- Measured sections in outcrop
- Lithologic logs from boreholes
  - water supply wells and older test wells
  - R-wells
- Borehole geophysics
- Hydraulic tests

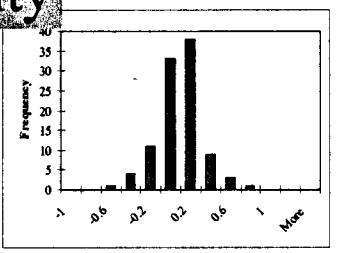
Requirements for a geostatistical model

Exactly reproduce observed data at boreholes and measured sections

Statistical parameters can be easily derived from data collected in R-wells

Incorporate geologic knowledge about general characteristics of this type of sedimentary deposit

Gaussian heterogeneity



Gaussian geostatistical model

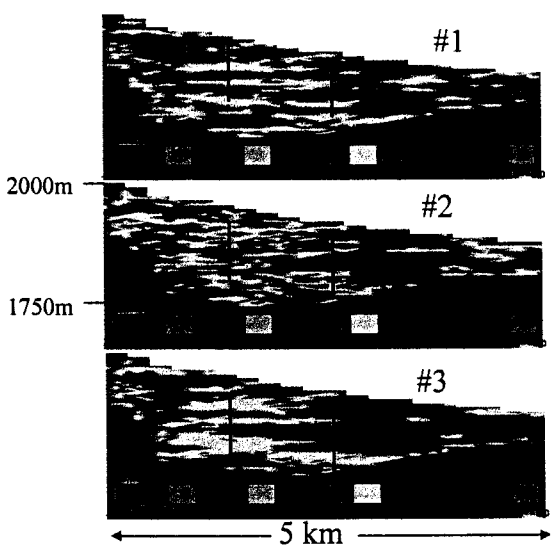
Hydraulic conductivity

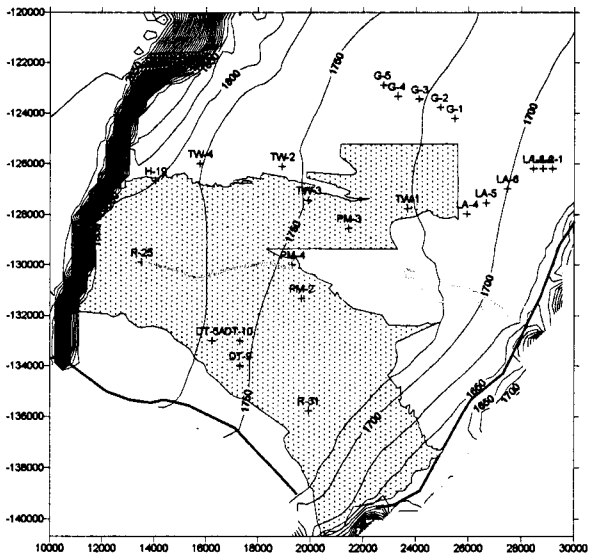
- Varies continuously in space
- Mean, standard deviation specified according to hydraulic test results
- Minimal geologic information content

Geometric characteristics of the Totavi Lentil

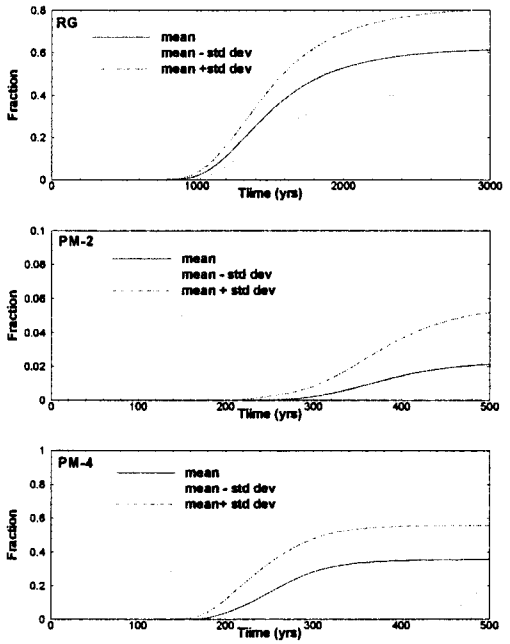
Outcrop	North-South Dimensions		East-West Dimensions		Thickness		Top Elevation
	Min	Max	Min	Max	Min	Max	
Ancho Canyon	20.1	244	80.7	264	18.3	30.5	1755.6
Water Canyon	20.4	223	61	122	12.2	18.3	1524
Mortandad Canyon	61	223	41	548.6	18.3	24.4	1774
Sandia Canyon	41	142	41	771.8	6.1	18.3	1792
Los Alamos Canyon	41	893.7	41	1097.3	6.1	30.5	1823

Three equally-likely representations of heterogeneity within the Puye





Estimated travel times for particles entering water table near R-25



Requirements for a geostatistical model

Exactly reproduce observed data at boreholes and measured sections

Statistical parameters can be easily derived from data collected in R-wells

Incorporate geologic knowledge about general characteristics of this type of sedimentary deposit

Facies-based geostatistical model

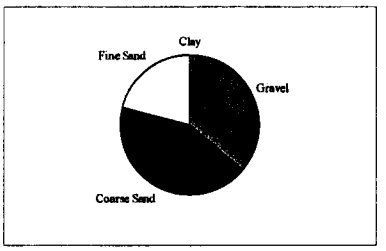
Facies-based geostatistical model

Hydraulic conductivity

- Varies discontinously in space, according to geometric relationships between facies
- Geometric relationships between facies (juxtaposition tendencies, length scales) derived from borehole and outcrop data
- Hydraulic conductivity assigned to each facies according to pump test results

Textural facies in R-wells

Well	Total Thickness	Gravel %	Gravel Thickness	Coarse Sand %	Coarse Sand Thickness	Fine Sand %	Fine Sand Thickness	Clay %	Clay Thickness
R-9	357	30	15	29	12	40	18	1	1
R-12	239	40	24	30	35	24	29	0	0
R-15	380	61	117	8	32	25	95	0	0
CdV-R-15-3	895	10	43	68	47	19	19	0	0
R-19	524	25	13	49	14	3	9	0	0
R-25	1090	15	160	47	86	2	7	0	2
R-31	393	14	55	0	0	0	0	0	0
Average	554	28	61	33	32	16	25	0	0



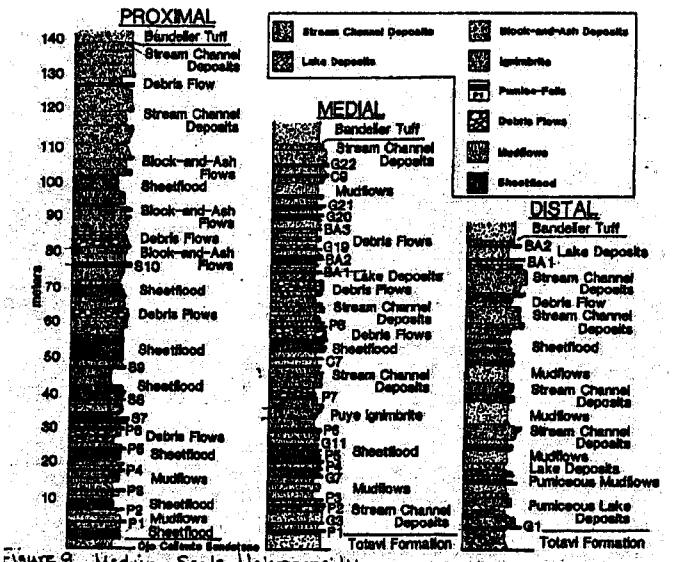


Figure 9. Medium Scale Heterogeneity

Composite stratigraphy and depositional mechanisms of Puye fan megasequences. Bandelier ash fallout is identified by BA, whereas other unit designations are felsic pumice fallout beds or ignimbrites. The Puye ignimbrite at approximately 35 m of the medial section was dated at 2.53 ± 0.1 Ma (Turbeville, 1991)

Current work

Developing a bi-model, facies-based hydraulic conductivity distribution

- Fanglomerate (moderately conductive)
- axial Rio Grande gravel deposits (highly conductive)

That is consistent with

- geologic data
- pump test data
- water level data

ER Information Management Databases

LOS ALAMOS NATIONAL LABORATORY
HYDROGEOLOGIC CHARACTERIZATION PROGRAM
ANNUAL MEETING

Steve Bolivar
Alison Dorries
Cathy Smith
Ann Lee

environmental restoration project

Los Alamos
NATIONAL LABORATORY

VG-00-000(1)

ER Information Management Databases: Agenda

- Introduction
- Background
- Accomplishments
- Where we are headed

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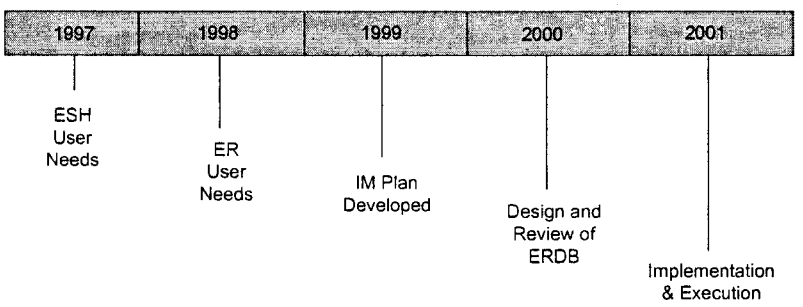
VG-00-000(2)

Mapping & Reporting Tool

ER Information Management Databases: History



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VG-00-000(3)

ER Project IM Needs

- Formal PROCESSES to track information flow
- Effective INFRASTRUCTURE for information storage and retrieval
- Robust information AUDIT TRAIL processes
- Qualified TEAM for information management
- Effective DATA SHARING with Stakeholders
- Defined STRATEGY to implement an information management system

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VG-00-000(4)

Critical Success Factors

- Robust data repository
- Timely & complete data entry
- Documented data integrity
- Controlled data reporting
- Tracked regulatory reporting
- Complete document control

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Accomplishments

- Reengineer business processes
- Implement hardware/software infrastructure
- Design and build database
- Clean up and migrate legacy data
- Design and build software applications

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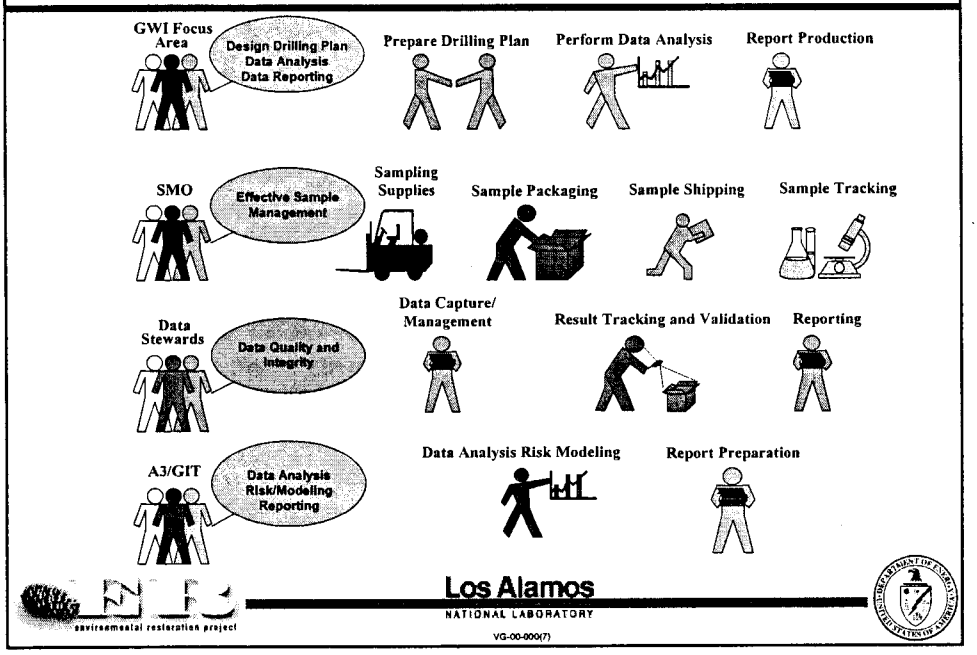
VG-00-000(6)

Process Reengineering



Accomplishments

- Reengineer business processes
- Implement hardware/software infrastructure
- Design and build database
- Clean up and migrate legacy data
- Design and build software applications

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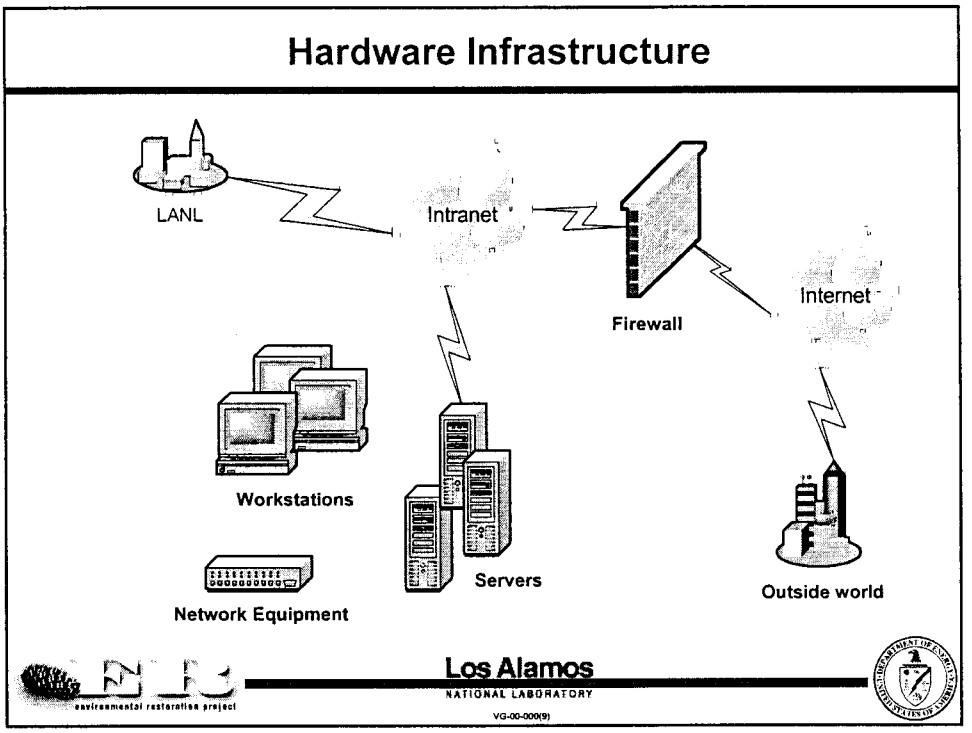

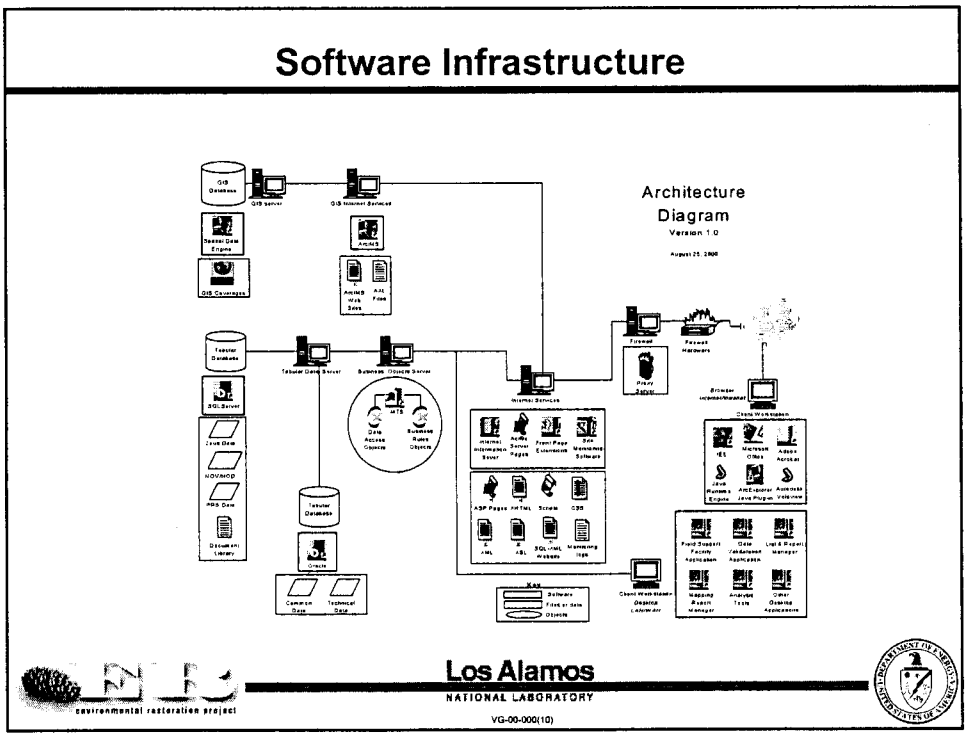

Mapping & Reporting Tool

Accomplishments

- Reengineer business processes
- Implement hardware/software infrastructure
- Design and build database
- Clean up and migrate legacy data
- Design and build software applications

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VG-00-000(11)

Design and Build Database

- ER Project Database Design
  - Supports ER process from cradle to grave
  - Integrates ER technical and management data
  - Triggers and constraints to preserve data integrity
  - Supports data exchange between ER and ESH
  - Complex relationships between 253 tables and over 3 million records
  - Potential for DOE environmental data management standard

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VG-00-000(12)

Design and Build Database

- ER Database Implementation
  - Built in SQL Server
  - Implemented on NT server at Pueblo
  - Assigned a DBA
  - Currently supporting:
    - Data Cleanup and Migration
    - Applications Development
    - V2.1

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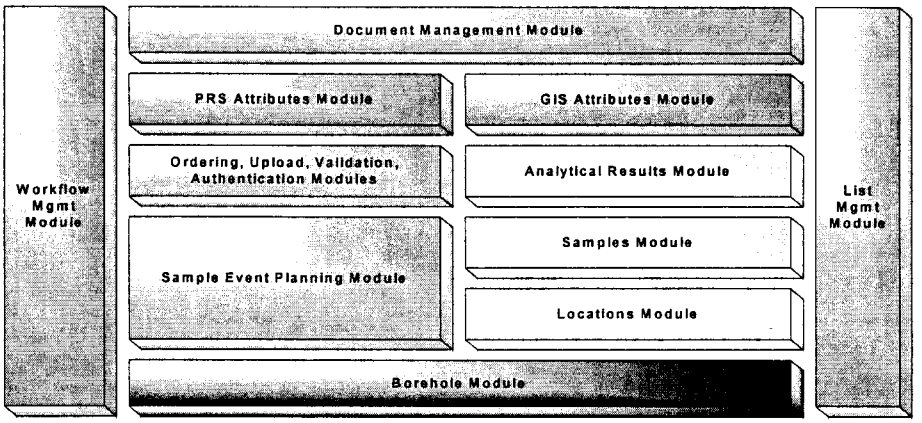
VG-00-000(13)

Database Modules



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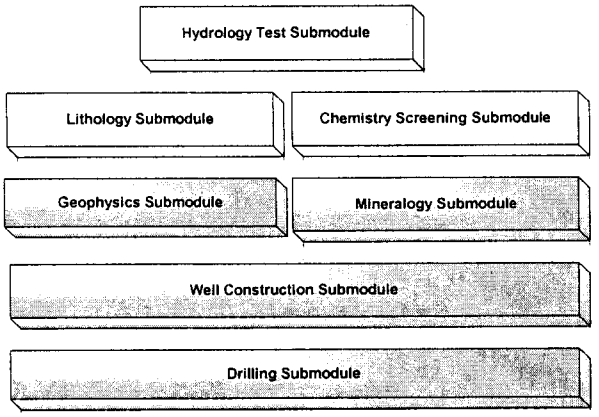
VG-00-000(14)

Borehole Submodules



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VG-00-000(15)

Accomplishments

- Reengineer business processes
- Implement hardware/software infrastructure
- Design and build database
- Cleanup and migrate legacy data
- Design and build software applications

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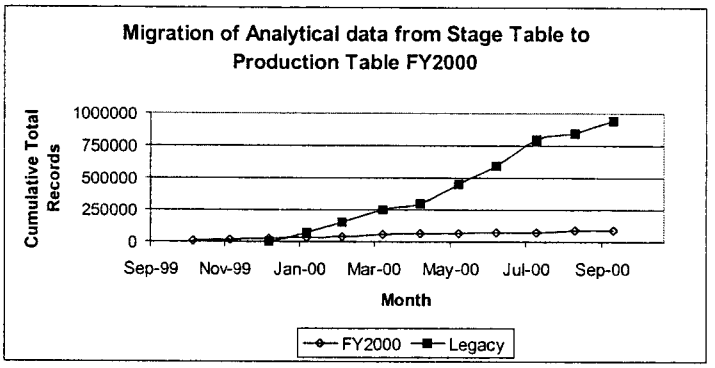
VG-00-000(18)

Data Cleanup and Migration

Move analytical data from Stage table to Production table



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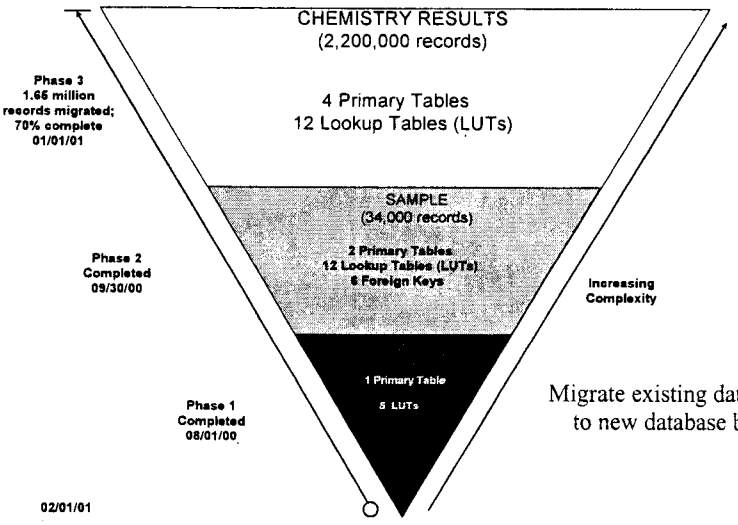
VG-00-000(17)

Data Cleanup and Migration



Migrate existing data from old to new database by "modules"

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VG-00-000(16)

Mapping & Reporting Tool

Accomplishments

- Reengineer business processes
- Implement hardware/software infrastructure
- Design and build database
- Clean up and migrate legacy data
- Design and build software applications

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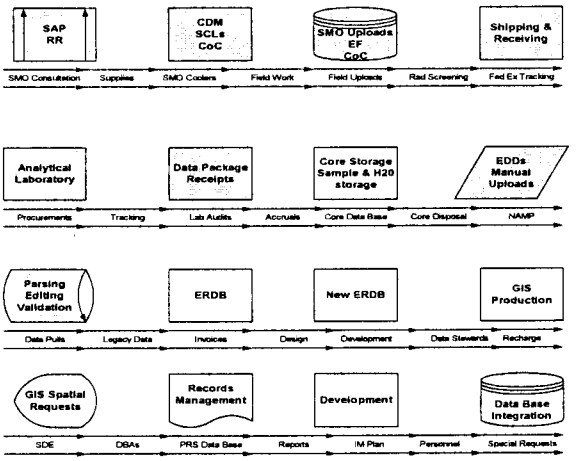
VG-00-000(19)

The Data Process



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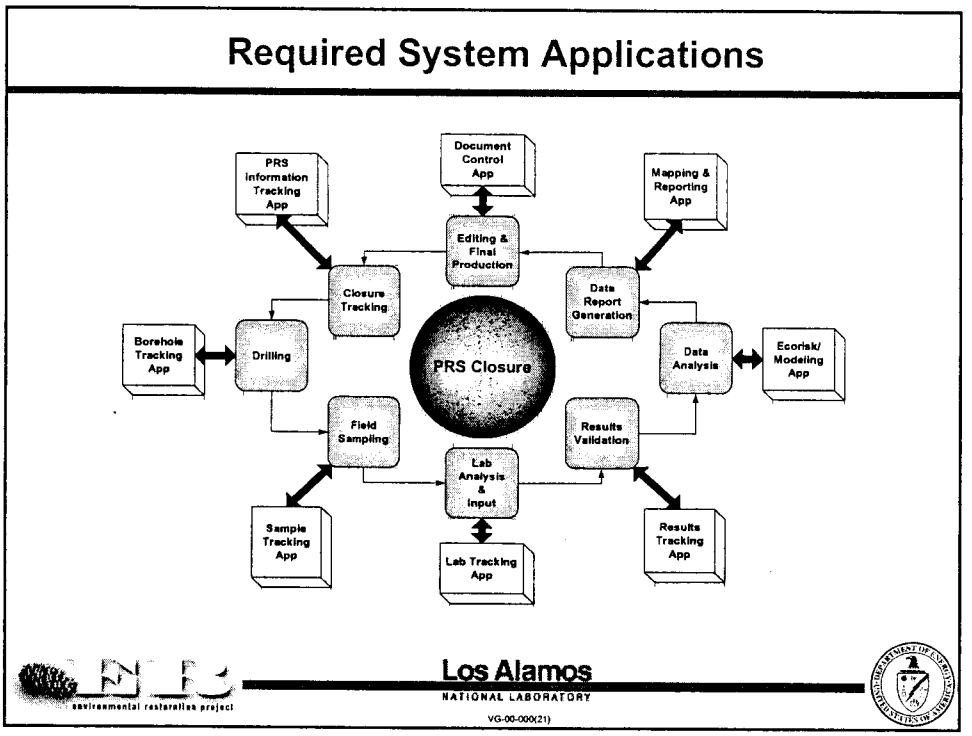
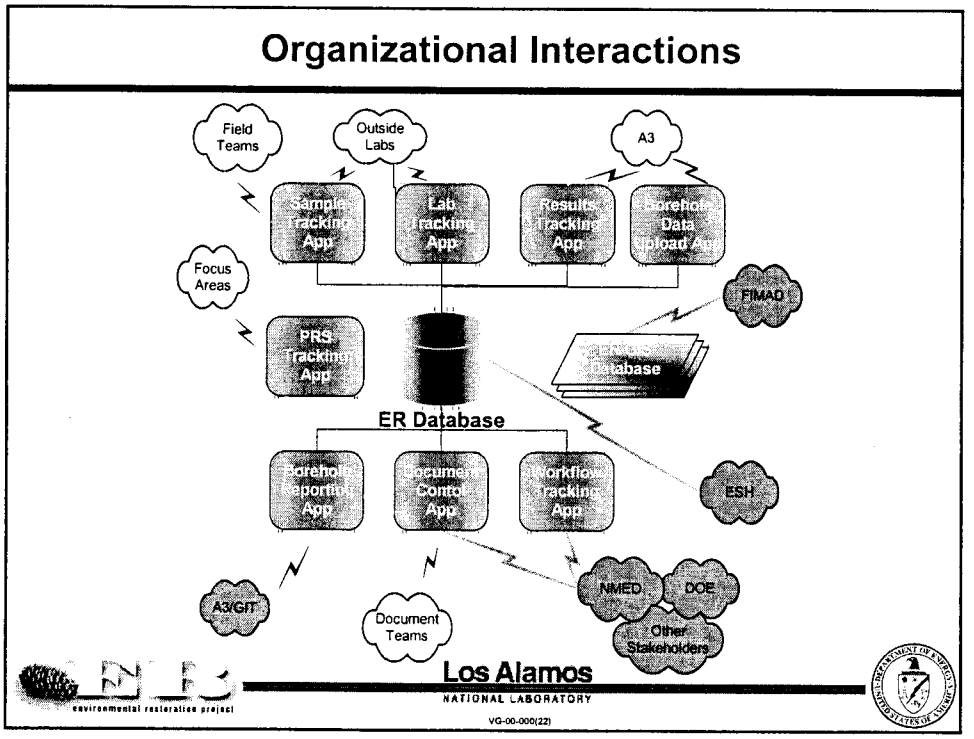
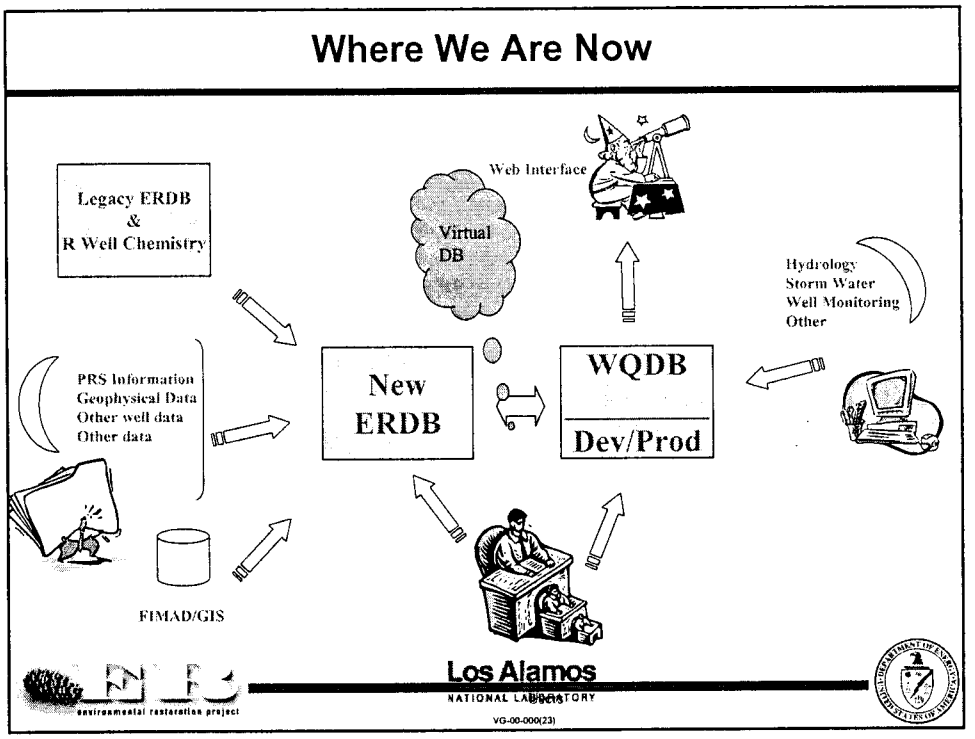
VG-00-000(20)

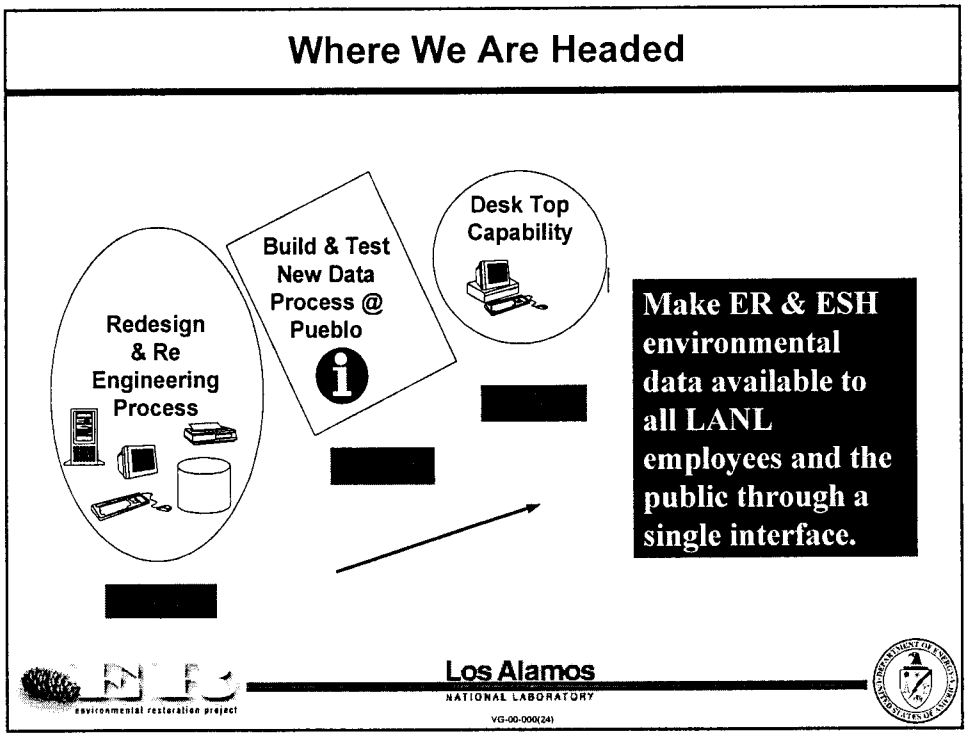
Mapping & Reporting Tool





Mapping & Reporting Tool





Mapping & Reporting Tool

DOE Role in Oversight

Karen Agogino
Russel Edge

FY 2000 Hydrogeologic Characterization Program Annual Meeting

Abstract- 2000 Special Sampling of Los Alamos Water Supply Wells

David B. Rogers and Robert S. Beers **March 21, 2001**

During 2000, the Los Alamos Water Supply Wells were sampled regularly for high explosives, perchlorate, strontium-90, and tritium. The analytes and sampling frequency for each well depend on possible sources of contamination. No high explosives or strontium-90 were found in any of the wells. Only Otowi 1 in Pueblo Canyon had tritium above background levels (at about 1/500 of the drinking water standard). Otowi 1 was also the only well to show perchlorate, at a maximum value of 5 ppb. This compares to a provisional EPA cleanup level of 4 to 18 ppb for perchlorate. The special water supply monitoring will continue in 2001.

R-WELL COMPLETION (SCREENS)

R-9: Single Screen
689 - 704 ft

R-9I: Double Screens
189 - 199 ft
270 - 280 ft

R-12: Triple Screens
459 - 468 ft, 505 - 508 ft, and
801 -884 ft

R-15: Single Screen
959 - 1020 ft

R-19: Multiple Screens
893 - 910 ft, 1171 - 1215 ft,
1583 - 1590 ft, 1727 - 1734 ft, 1832 - 1839 ft

ANALYTICAL METHODS -- EPA SW846

Metals- *Inductively Coupled Plasma Optical Emission Spectroscopy and Inductively Coupled Plasma Mass Spectrometry*

Anions- *Ion Chromatography*

Organic Compounds- *Gas Chromatography and Gas Chromatography-Mass Spectrometry*

High Explosive Compounds- *High Pressure Liquid Chromatography*

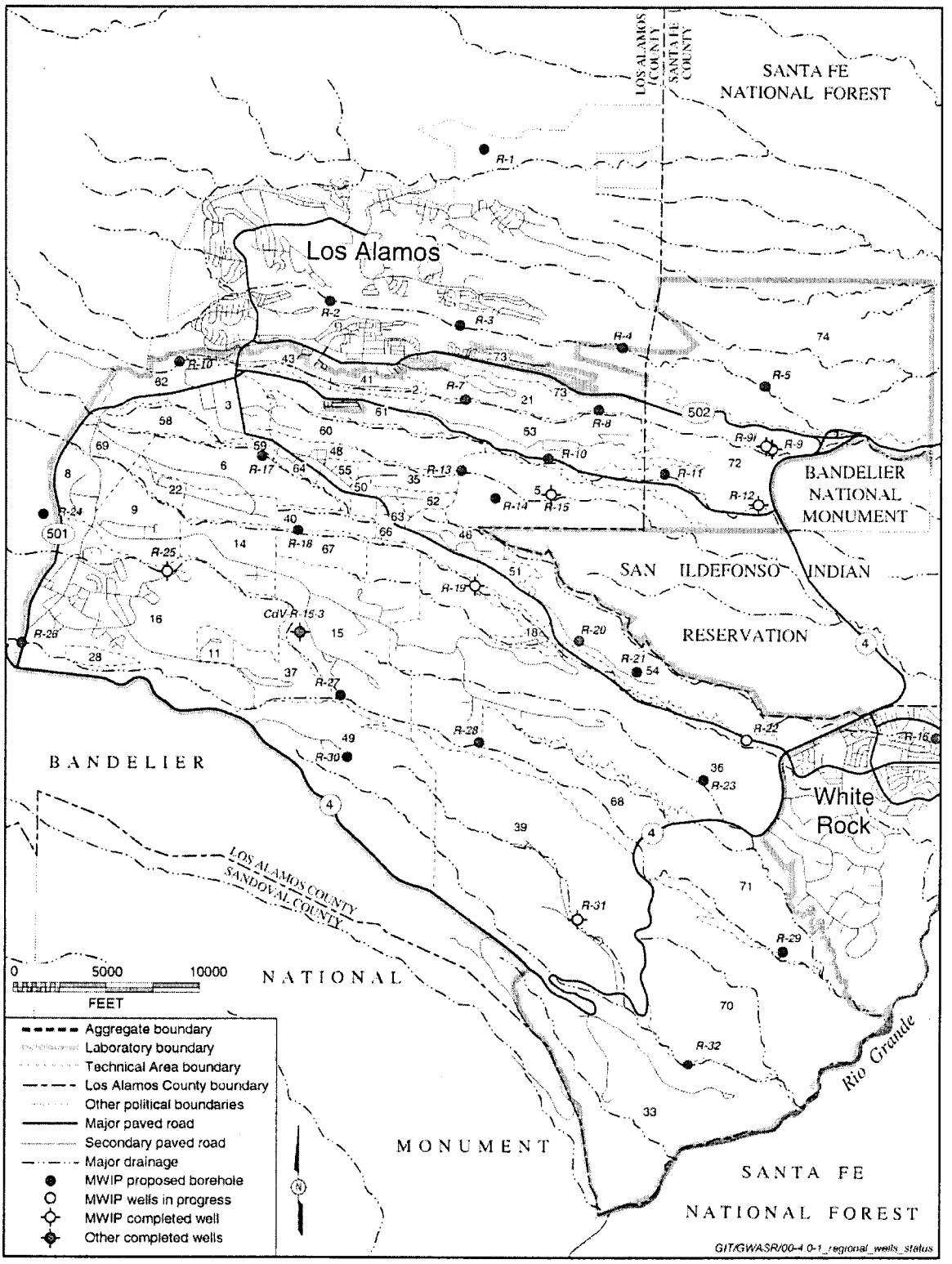
Radionuclides- *Alpha Spectrometry, Gas Proportional Counting, Gamma Spectroscopy, Direct Counting, Electrolytic Enrichment*

Stable Isotopes- *Isotope Ratio Mass Spectrometry*

SAMPLING PROTOCOLS AT R-WELLS

Single Completion Wells: *Purge wells, removing at least 3 well bore volumes; measure field parameters; collect; filter; and preserve (if required).*

Multiple Completion Wells: *Collect groundwater samples; measure field parameters; filter; and preserve (if required). Groundwater samples are collected using the Westbay Instruments at a rate of four liters per hour (one hour per trip).*


SANTA FE NATIONAL FOREST
LOS ALAMOS COUNTY
SANTA FE COUNTY
Los Alamos
BANDELIER NATIONAL MONUMENT
SAN ILDEFONSO INDIAN RESERVATION
White Rock
BANDELIER
NATIONAL
MONUMENT
SANTA FE NATIONAL FOREST
LOS ALAMOS COUNTY
SANDOVAL COUNTY
Rio Grande
CdV-R-15-3
0 5000 10000
FEET
Aggregate boundary
Laboratory boundary
Technical Area boundary
Los Alamos County boundary
Other political boundaries
Major paved road
Secondary paved road
Major drainage
MWIP proposed borehole
MWIP wells in progress
MWIP completed well
Other completed wells
GIT/GWASR/00-4.0-1_regional_wells_status

INITIAL ANALYTES FOR SAMPLING OF R-WELLS

Field Parameters: *Temperature, pH, specific conductance, and turbidity*

Radionuclides (Filtered and Non Filtered Samples): *Tritium (non filtered only), 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*

Organic Compounds (Non Filtered Samples): *Volatile, Semivolatile (e.g. PCBs, PAHs, Pesticides), High Explosive Compounds and Degradation Products, TOC, and DOC fractionation*

Stable Isotopes (Non Filtered Samples): δ *Deuterium,* δ^{15} *Nitrogen, and* δ^{18} *Oxygen*

Other Water Quality Parameters: *Alkalinity,* HCO_3^-, PO_4^{3-}, HN_4^+, *TKN,* Cl^-, F^-, Br^-, NO_3^-, NO_2^-, $C_2O_4^{2-}$, ClO_4^-, *and* SO_4^{2-}

QUARTERLY SAMPLING OF R-WELLS AND FIELD-MEASURED PARAMETERS

Well	*Date (y/m/d)*	*Sampling Zone (ft), Screen (ft) (hydrogeology)*	*pH*	*Sp. Cond. (µSi/cm)*	*Temp. (C)*	*Turbidity (NTU)*
R-9	00/09/29	689 - 704 (SFG basalt) Reg. Aq.	8.03	200	23.4	4.2
R-9I	00/09/14	189 - 199 (CDR basalt) Perched	8.04	160	19.64	3
R-9I	00/09/15	270 - 280 (CDR basalt) Perched	7.5	140	13.5	1.9
R-12	00/09/18	459 - 467 (CDR basalt) Perched	8.01	280	21.8	3.3
R-12	00/09/19	504 - 508 (CDR basalt) Perched	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) Perched	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) Perched	7.65	225	9.0	1.6
R-25	00/11/15	883 - 894 (PF) Perched	8.83	322	9.0	41.7
R-25	00/12/01	1055 - 1065 (PF) Perched	11.63	490	9.9	1.9
R-25	00/12/04	1185 - 1195 (PF) Perched	7.64	716	8.8	5.3
R-25	00/12/07	1296 - 1306 (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
R-31	00/12/14	827 - 837 (PF) Perched	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) Perched	6.8	790	15.5	46.7
R-31	00/12/16	515 - 546 (PF) Perched	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; and Reg. Aq. means regional aquifer. An upper saturated zone is present at R-25. Jennifer Fofoed supervised quarterly sampling at R-9, R-9i, R-12, and R-25. Jon Marin supervised quarterly sampling at R-15, R-19, and R-31.

FIELD-MEASURED PARAMETERS AT R-9

Well	*Date (y/m/d)*	*Sampling Zone (ft), Screen (ft) (hydrogeology)*	*pH*	*Sp. Cond. (μSi/cm)*	*Temp (C)*	*Turbidity (NTU)*
R-9	00/02/28	689 - 704 (SFG basalt) Reg. Aq.	7.45	239	22.7	2.02
R-9	00/09/29	689 - 704 (SFG basalt) Reg. Aq.	8.03	200	23.4	4.2
R-9	01/02/16	689 - 704 (SFG basalt) Reg. Aq.	8.13	259	23.0	2.4

Note: SFG means Santa Fe Group and Reg. Aq. means regional aquifer. Jennifer Kofoed supervised quarterly sampling at R-9.

FIELD-MEASURED PARAMETERS AT R-9I

Well	*Date (y/m/d)*	*Sampling Zone (ft), Screen (ft) (hydrogeology)*	*pH*	*Sp. Cond. (μSi/cm)*	*Temp (C)*	*Turbidity (NTU)*
R-9i	00/09/14	189 - 199 (CDR basalt) Perched	8.04	160	19.6	3.0
R-9i	01/02/20	189 - 199 (CDR basalt) Perched	7.35	272	12.8	1.2
R-9i	00/09/15	270 - 280 (CDR basalt) Perched	7.5	140	13.5	1.9
R-9i	01/02/21	270 - 280 (CDR basalt) Perched	7.25	215	12.3	1.4

Note: CDR basalt means Cerros del Rio basalt. Jennifer Kofoed supervised quarterly sampling at R-9i.

FIELD-MEASURED PARAMETERS AT R-15

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (μSi/cm)	Temp (C)	Turbidity (NTU)
R-15	00/02/24	960 - 1020 (SFG basalt)Reg. Aq	8.0	126	20.6	4.8
R-15	00/10/10	960 - 1020 (SFG basalt)Reg. Aq	7.9	130	16.9	3.0
R-15	01/02/15	960 - 1020 (SFG basalt)Reg. Aq	8.15	146	19.0	2.6

Note: SFG means Santa Fe Group and Reg. Aq. means regional aquifer. Jon Marin and Jennifer Kofoed supervised quarterly sampling at R-15.

FIELD-MEASURED PARAMETERS AT R-22

Well	Date (y/m/d)	Sampling Zone (ft), Screen (ft) (hydrogeology)	pH	Sp. Cond. (μSi/cm)	Temp (C)	Turbidity (NTU)
R-22	01/03/13	872 - 914 (CDR basalt)Reg. Aq.	7.21	458	19.6	9.3
R-22	01/03/12	947 - 989 (CDR basalt)Reg. Aq.	8.35	153	17.0	0
R-22	01/03/09	1272 - 1279 (Totavi) Reg. Aq.	8.21	487	19.5	3.8
R-22	01/03/08	1378 - 1384 (SG bslt) Reg. Aq.	7.21	533	16.7	12.8
R-22	01/03/06	1447 - 1452 (older volcanic gravels) Reg. Aq.	7.01	290	19.0	3.1

Note: CDR basalt means Cerros del Rio basalt; SFG means Santa Fe Group; PF means Puye Formation; and Reg. Aq. means regional aquifer. Jennifer Kofoed supervised quarterly sampling at R-22.

SELECTED VALIDATED ANALYTICAL RESULTS OF QUARTERLY SAMPLING OF R-WELLS (FILTERED)

Well	*Date received by analytical lab. (y/m/d)*	*$NO_3^- + NO_2^-$ (mg/L)*	*TKN (mg/L)*	*Tritium (CPI/L)*	*ClO_4^- (µg/L)*	*2-A-DNT (µg/L)*	*4-A-DNT (µg/L)*	*TOC (mg/L)*	*Other (µg/L or ‰)*
R-9	00/10/02	0.650	0.350	4.84	NA	ND	ND	2.70	toluene, 12
R-9I Screen 1	00/09/18	0.100 U	0.400	81.4	1.04 U	ND	ND	3.00	U*, 0.641; 3-NT, 0.15; δ18O, -10.9 ‰
R-9I Screen 2	00/09/18	0.100 U	0.10 U	69.4	1.04 U	0.15	ND	4.20	2,4-DNT, 0.5; RDX, 0.49; U*, 0.068; δ18O, -10.9 ‰
R-12 Screen 1	00/09/20	0.100 U	0.910	60.3	1.04 U	ND	ND	7.70	NH_4^+, 1,100; U*, 0.927; δ18O, -11.4 ‰; Bisphthalate, 3.2
R-12 Screen 2	00/09/21	0.100 U	0.570	30.1	1.04 U	ND	ND	16.00	δ18O, -11.5 ‰; δ15N, -3.7 ‰; CS_2, 1.7
R-12 Screen 3	00/09/25	0.100 U	0.250	25.9	1.04 U	ND	ND	45.00	U*, 0.896; δ18O, -11.3 ‰
R-15	00/10/11	2.30	0.550	0.77	2.8 U	ND	ND	6.10	NH_4^+, 160; U*, 0.33;

									δ18O, -10.9 ‰; δ15N, +0.9 ‰; Bisphthalate, 5.9; toluene, 0.69
R-19 Screen 2	00/09/25	0.690	0.280	-0.04 U	1.04 U	ND	ND	3.30	RDX, 0.098; δ18O, -10.5 ‰; δ15N, +6.6 ‰
R-19 Screen 3	00/09/18	0.340	0.650	-0.1 U	1.68	ND	ND	4.20	Sb, 5.67; 2,4-DNT, 0.5; RDX, 0.49; U*, 0.068; δ18O, -10.7 ‰; δ15N, +1.9 ‰
R-19 Screen 5	01/10/1	0.100 U	0.910	0.1 U	1.04 U	ND	ND	7.70	δ18O, -10.9 ‰; 1,3-DNB, 0.22; 2,4-DNT, 0.3
R-19 Screen 6	00/10/05	0.50 U	6.30	0.08 U	1.04	ND	ND	6.80	NH_4^+, 500; 2-Butanone, 1.6; δ18O, -11.0 ‰; NB, 0.41
R-19 Screen 7	00/10/05	0.50 U	4.60	0.21 U	1.04 U	ND	0.22	3.30	NH_4^+, 210; As, 3.5; 1,3-DNB, 0.24; δ18O, -11.0 ‰

Scrn means screen; 3-NT means 3-nitrotoluene; U means not present; ND means not detected; U* in other chemicals means uranium; Sb means antimony; NB means nitrobenzene; 2,4-DNT means 2,4-dinitrotoluene; 1,3-DNB means 1,3-dinitrobenzene; TKN means total Kjeldahl nitrogen (organic nitrogen).

SUMMARY

- **QUARTERLY SAMPLES** *have been collected by Geochemistry Subcommittee members from R-9, R-9I, R-12, R-15, and R-19.*
- **CONSTITUENTS OF CONCERN** *in R wells include nitrate (R-15), perchlorate (R-9 and R-15), and HE compounds (R-25) (to be reported).*
- **MEASURABLE TRITIUM** *occurs at R-9. R-9I, and R-12. These wells contain groundwater less than 60 years of age.*
- **RESIDUAL DRILLING FLUIDS** ***MUST*** *be removed from R wells prior to sampling.*
  - *EZ Mud has resulted in false positives for HE compounds and degradation products (contains nitro and amino functional groups).*
  - *TKN and TOC are indicators of residual EZ Mud.*
- **GROUNDWATER MIXING** *information is provided by tritium, anions, and stable isotopes within multicompleted wells.*

HIGHLIGHTS OF QUARTERLY SAMPLING AT R-9, R-9I, R-12, R-15, AND R-19: GEOCHEMISTRY SUBCOMMITTEE, GROUNDWATER INTEGRATION TEAM

BY

PATRICK LONGMIRE[1] AND JENNIFER KOFOED[2]

MARCH 21, 2001

1. EES-6, AND 2. AURORA TECHNICAL SERVICES

OBJECTIVE OF PRESENTATION

Present a summary of groundwater sampling conducted at R-9, R-9I, R-12, R-15, and R-19.

Analytes of Interest Include:

Tritium

Nitrogen Species

Perchlorate

High Explosive Compounds and Degradation Products

Residual Drilling Fluids

Integrated ER/ESH Hydrology Modeling Tasks

Diana Hollis
E-ER

Introductory Comments

- EAG requested additional information in semi-annual report
  - Intended use of models
  - Discussion of regulatory factors
  - DQOs to be met by modeling
  - Descriptions of modeling tasks/analyses
  - Schedule and integration plan
  - Stakeholder communication plan
  - Plans for uncertainty characterization

Introductory Comments

- Intended use of models
  - Assimilate and interpret data from groundwater wells
  - Identify the most significant (sensitive) uncertainties (data gaps)
  - Site and prioritize subsequent wells to fill significant data gaps
  - Support decisions about site-wide and facility-specific actions to ensure protection of groundwater as resource
    - > When/Where/How/What should we monitor?
    - > What/When/Where might maximum groundwater concentration be?
    - > Will natural attenuation be protective?
    - > Is pump-and-treat practicable?

Introductory Comments

- Discussion of regulatory factors
  - Models accepted by EPA as effective decision-support tools
  - Groundwater models cannot replace groundwater data
  - The best model is the *simplest* model *that is consistent with available data*
    - Calibration
    - Validation
  - Models must incorporate site-specific data (not default parameters) to the extent available
    - Initial and boundary conditions
    - Material properties (physical and hydrologic)
    - Processes (fracture flow)

Introductory Comments

- DQOs to be met by modeling
  - Bounding values or stochastic distribution of parameters (variables) based on field data
  - Approved confidence intervals for *decision-supporting model results*
  - "Good enough" is good enough
  - May transition to "top-down" approach if decision rules can be agreed upon

Introductory Comments

- Descriptions of modeling tasks/analyses
  - Modular process-level models of different hydrologic regimes
    - > 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), unsaturated-zone flow and transport
    - > Regional Aquifer, saturated flow and transport
  - Coupled pathway-level (systems) modeling
    - > Surface water → vadose zone → regional aquifer → receptor
    - > MDA G, TA-16

Introductory Comments

- Schedule and integration plan
  - General approach
    - Deterministic process-level model for each hydrologic setting to understand dominant processes and significant uncertainties and variability
    - Stochastic system-level model with coupled processes to identify and represent significant system-level uncertainties and variability
  - Planned schedule
    - Dry mesa model completed FY01
    - Wet canyon model completed FY01 or FY02
    - Regional aquifer model completed FY02
  - Integration plan based ER Integrated Modeling Tasks

Introductory Comments

- Stakeholder communication plan
  - To date
    - > Several NMED workshops conducted by LANL on FEHM
    - > Dedicated 2-day GoldSim workshop for NMED sponsored by ER Project
    - > CAB briefing on Los Alamos Canyon tritium model results
  - Planned
    - > CAB briefings on models used to support MDA H corrective measures study
    - > Modeling focus group?

Introductory Comments

- Plans for uncertainty characterization
  - Complete FY01 *integrated modeling tasks*
  - Use either bounding (conservative) estimates or stochastic distributions in models to represent uncertainty, variability and heterogeneity
  - Use models to evaluate alternate conceptual models
  - Incorporate uncertainty management into risk-management decisions where needed

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
- Probabilistic Assessment of Sentry Well Placement

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

First-order Groundwater Pathway Assessment

- Purpose is to rank contaminants of potential risk-significance to groundwater receptors
- Use GIS tools
- Approach is to
  - Map contaminant inventories and/or concentrations
  - Calculate transport times into regional aquifer
  - Calculate lateral transport in regional aquifer
  - Compare estimated cumulative and individual concentrations in supply-well capture zone
  - Normalize estimates to MCLs or ACLs (sum of fractions)
  - *Rank contaminants and sources*

Plateau-wide Infiltration Mapping

- Purpose is to define uncertainties and variabilities in infiltration
- Proposed as HWP "interpretive task"
- Approach is to
  - Compile existing recharge estimates from various methods (water budget, chloride mass-balance, Darcy's Law)
  - Document limitations and uncertainties for each method
  - Identify data gaps
  - *Develop quantitative map of recharge*

Plateau-wide Geologic Model Uncertainty Assessment

- Purpose is to document basis of (hydro)geologic conceptual model and uncertainties
- Proposed by "virtual" GIT geology subcommittee
- Approach is to
  - Review basis of current conceptual model of vadose zone and water-table geology
  - Attempt to quantify uncertainties and variability
  - Establish significance of uncertainties for F & T modeling
  - Evaluate planned R-well placement in context of uncertainty reduction
  - *Identify cost-effective approaches for filling data gaps*

Probabilistic Assessment of Sentry Well Placement

- Purpose is to determine how many surveillance wells are sufficient (and where) to achieve acceptable probability of contaminant detection in advance of arrival at a production well
- Proposed by Kathy Campbell and Elizabeth Keating
- Approach is to
  - Extract simplified probabilistic model for mean flow paths based on FY00 work (Keating et al.)
  - Examine sensitivity of sources of uncertainty not previously considered
  - Calculate dominant flow paths in regional aquifer between known source locations to known production wells
  - *Determine how many wells, sited where, would be required to ensure detection of contamination approaching a given well field with a high degree of confidence and minimum lead time*

Geophysical Surveys

- Purpose is to evaluate geophysical methods to supplement borehole geology and hydrology data
- Approach is to conduct
  - Ground-based electrical and electromagnetic surveys to characterize significant hydrologic features
    - > Pajarito Fault zone
    - > Canon de Valle
    - > Los Alamos/Pueblo Canyon
  - Airborne electromagnetic survey along canyons and over mesas to identify hydrologically significant subsurface features such as clay beds, perched water, paleochannels and basalt

Los Alamos Canyon Flow and Transport Model

Bruce Robinson

Phillip Stauffer

The current conceptual model for groundwater flow and contaminant transport in the vadose zone beneath Los Alamos National Laboratory recognizes two main hydrogeologic settings: mesas and canyons. Flow and transport from mesa tops to the regional aquifer is thought to be slow, while canyons are characterized by focused, high infiltration rates and potentially rapid transport through the vadose zone. Three-dimensional models of the Los Alamos Canyon flow system have been developed based on the hydrogeologic model of the canyon, and flow and transport simulations have been made using the FEHM computer code. Measured hydrologic property values for the geologic units are included in the model, along with model results from a previous water balance study for Los Alamos Canyon. Comparisons of the model with measured moisture content data are being used to constrain model parameters such as infiltration rate. Sensitivity analysis simulations have been performed for variables such as the infiltration rate and uncertainty in the unsaturated hydrologic properties. Taking into account uncertainties in the water budget and the hydrologic properties, the available data are consistent with infiltration scenarios ranging of a factor of 3 above and below the base case estimate. We anticipate that new information from characterization well R-7 and chemical analyses of pore fluids from core samples in LADP-3 and LAOI(A)-1.1 will be useful in further improving the model and constraining transport velocities.

Tritium source term information has also been compiled and simulations have been performed using the calibrated model. The model suggests that transport of tritium and other contaminants is most rapid in the eastern portion of the model, where the uppermost rock units below the alluvium are Basalts or a thin layer of the Puye Formation overlaying the Basalts. In this portion of the domain, fracture flow is likely to occur, resulting in more rapid travel times than in middle Los Alamos canyon, which has a significant thickness of Bandelier tuff. Travel times through the Bandelier tuff and Puye Formation (to the regional aquifer) are predicted to be on the order 50 years or so, versus the likelihood of transport to the water table in 10 years or less through the Basalt units and the Puye Formation. As a result, the total mass flux of tritium reaching the water table is predicted to be dominated by transport from middle to lower Los Alamos canyon through the Basalts and Puye Formation. Wells such as Otowi-1 are susceptible to contamination in this portion of the Laboratory because of the hydrogeology and the lack of sorption of tritium. Although with present data the models cannot be calibrated to predict precise future concentrations of tritium in the aquifer or in a water supply well, the model results suggest that the rate of tritium arrival at the water table (where it may then be brought to the surface in a water supply well) may be at or near its peak. Continued monitoring is required to establish a trend in tritium concentration, but in the absence of a continued high-concentration source at the surface, it is very unlikely that concentrations will climb to values even approaching regulatory limits. This is because of the lack of additional releases, dilution in groundwater and at the pumping wells, and radioactive decay. Long-term monitoring is needed to confirm this conclusion and to establish the time frame over which these concentration changes will occur. Current modeling suggests that several decades of regular monitoring will be necessary to definitively establish long-term trends.

Finally, the Los Alamos Canyon 3D model is also being used to explore hypothetical situations which may arise as a result Cerro Grande fire. Simulations of increased infiltration and associated contaminant transport, caused by high run-off from burned areas ponding in Los Alamos Canyon, are presented as an example of the predictive capabilities of the 3D model. Results indicate that if persistent ponds of water form, there could be a significant enhancement in the rate of migration of conservative contaminants to depth. The duration of the ponded condition is the controlling factor for the depth of penetration of the water and contaminant plume.

Los Alamos Canyon Flow and Transport Model

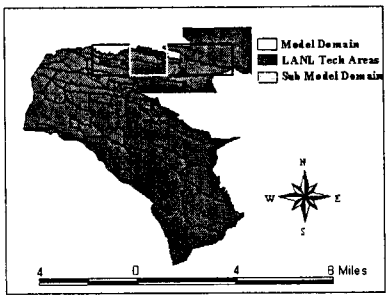
2001 Annual Meeting

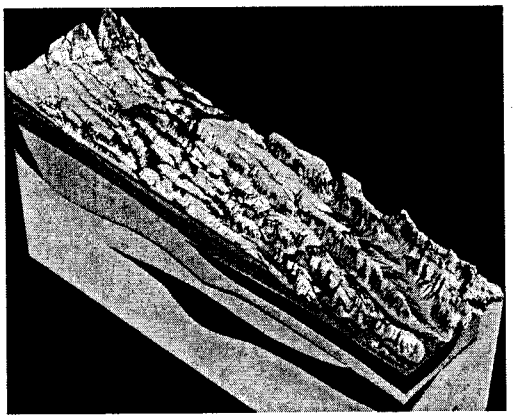
March 20, 2001

Bruce Robinson

Phillip Stauffer

Tritium Modeling - Los Alamos Canyon





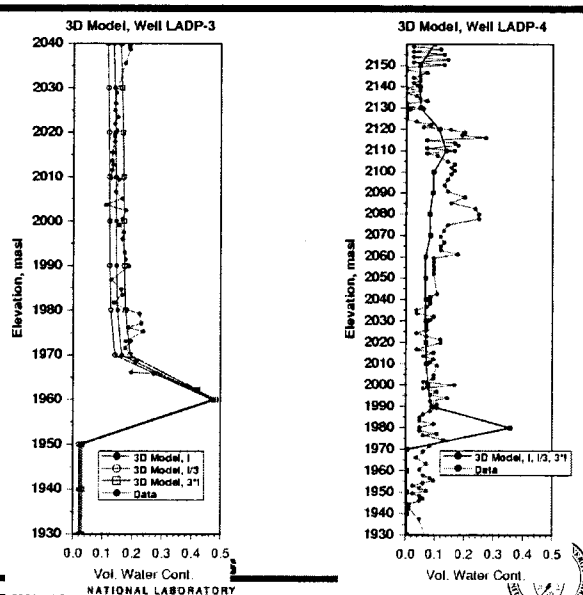
The calibrated flow model for Los Alamos canyon is being used to investigate the potential migration of contaminants from the alluvial groundwater to the regional aquifer under a range of future scenarios

Outline

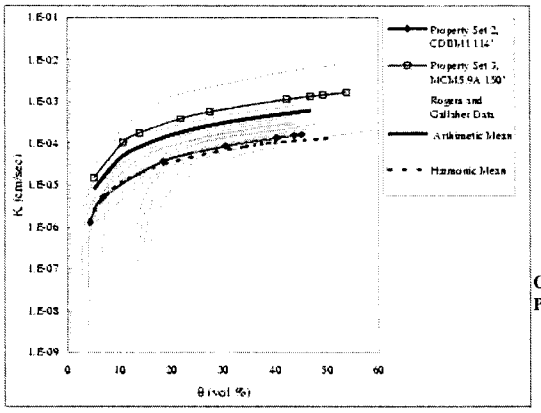
- Calibration of flow model
- Uncertainties and sensitivities
- Tritium transport results
- Potential impact of Cerro Grande fire

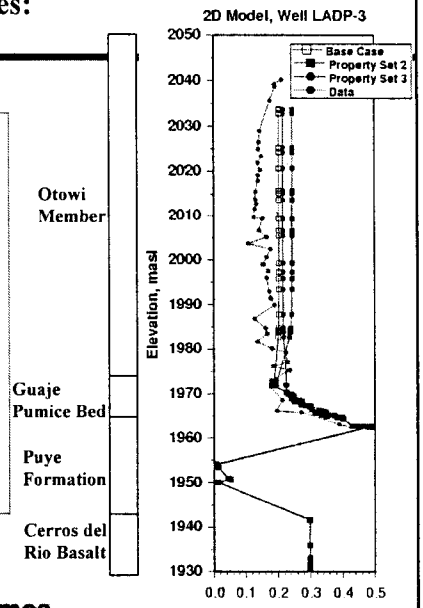
Flow Model Calibration - Canyon Versus Mesa Well

The model captures the wetter conditions in Los Alamos canyon through a spatially varying recharge rate. This approach yields a good fit to the water content data in both the canyons and mesas.



Sensitivity to Hydrologic properties: Otowi Member

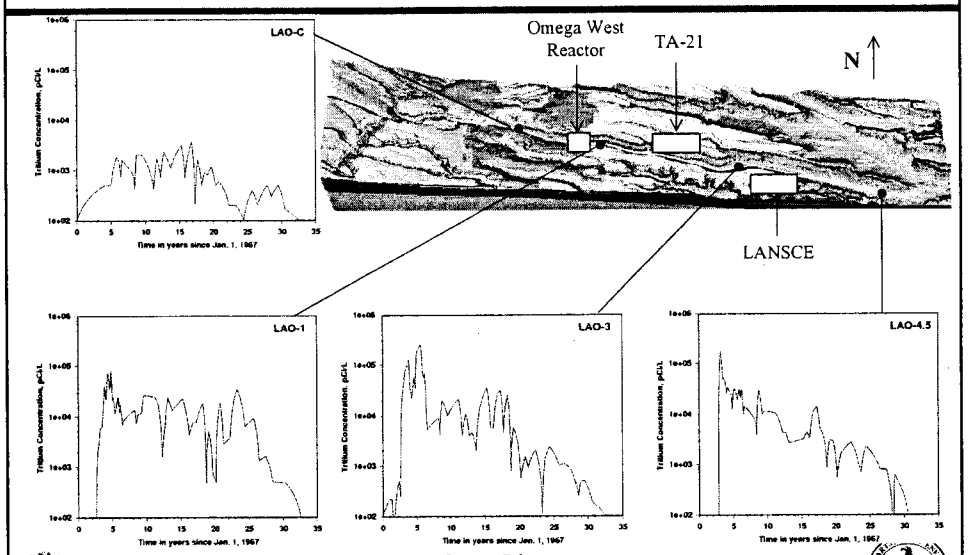




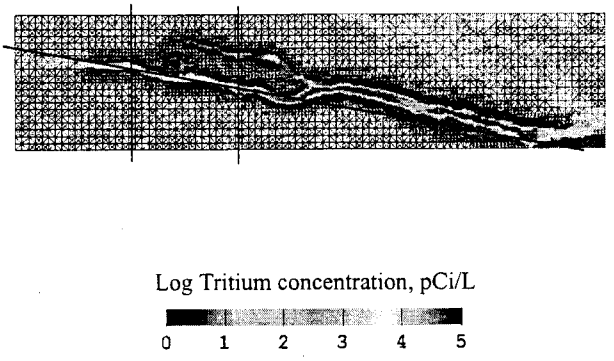
Result of Sensitivity Runs

Taking into account uncertainties in the water budget and the hydrologic properties, the available data are consistent with infiltration scenarios ranging of a factor of 3 above and below the base case estimate.

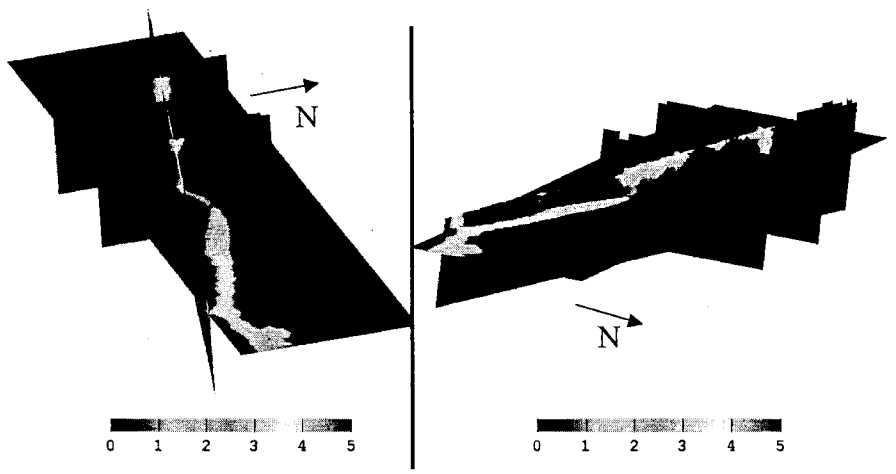
Tritium Concentrations in Alluvial Groundwater



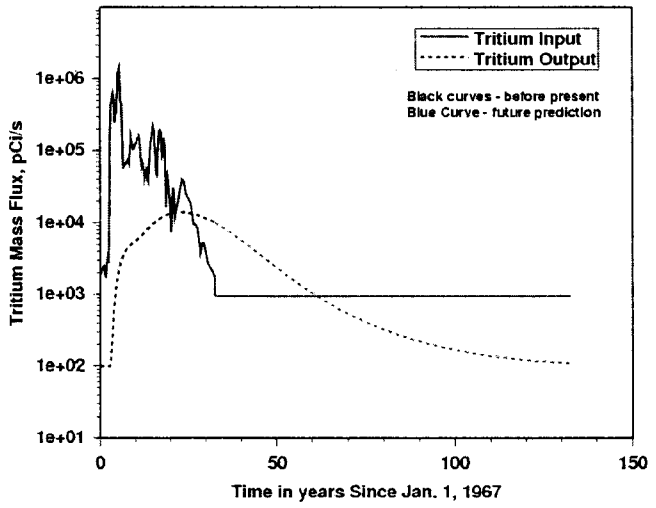
Simulated Tritium Concentrations: Maximum Surface Concentration



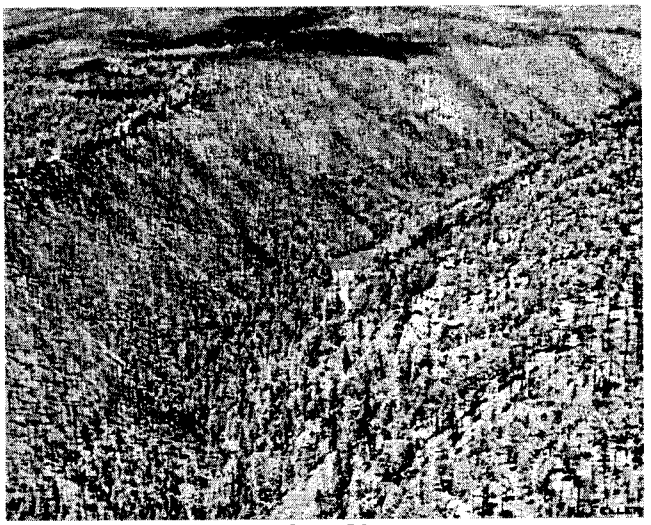
Simulated Tritium Concentration Distributions: Present Day



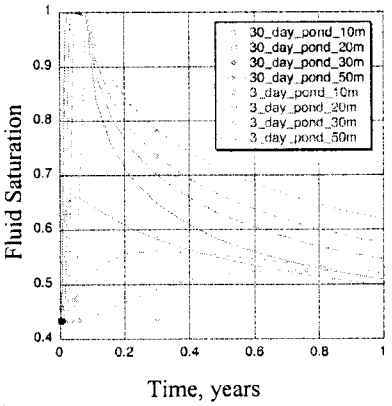
Simulated Tritium Vadose Zone Input and Output Mass Flux

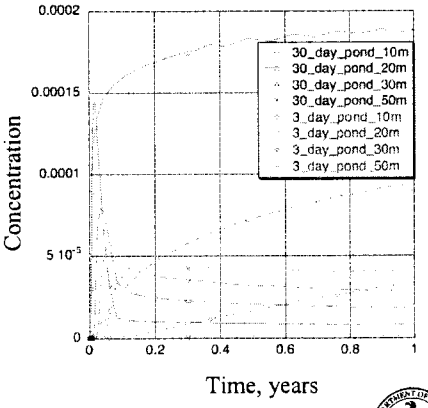


Impact of the Cerro Grande Fire



Near-Surface Saturation and Tracer Profiles Under Ponded Conditions





Ongoing Validation Efforts

- Comparison of model results to R-7 data
- Pre-test predictions of flow and transport response at the LA Weir site
- Measurements of chemical profiles in pore water of samples from LADP-3 and LAOI(A)-1.1
- Consideration of alternate conceptual model for shallow infiltration

NMED/DOE-OB Conceptual Model for Los Alamos Canyon

Michael Dale

Validation of Conceptual Models for Vadose Zone Flow and Transport Beneath the Pajarito Plateau

Kay Birdsell, Bruce Robinson and Diana Hollis

The conceptual model for vadose zone flow and transport beneath the Pajarito Plateau discriminates the rate of these processes by their location. For example, the conceptual model calls out wet canyons, dry canyons and dry mesas. Infiltration beneath wet canyons is the highest with rates on the order of meters per year (100 - 1000 mm/yr). Transport to the regional aquifer beneath wet canyons may be on the order of decades to hundreds of years. Fracture flow, often through basalt units, may play a key role in transporting contaminants beneath wet canyons. In contrast, infiltration beneath dry canyons and dry mesas is much slower with infiltration rates generally believed to be less than tens of millimeters per year. Transport times to the aquifer are expected to be hundreds to several thousands of years. Slow matrix flow through the Bandelier tuff is generally believed to be the dominant transport mechanism. However, in some cases liquid disposals at mesa-top locations may have driven short-term fracture flow and transport.

Such conceptual models of vadose zone processes can be validated through the interpretation of field data with numerical models. This presentation gives examples of the model validation process at five laboratory locations. Three mesa top locations are presented: MDA AB at TA-49, MDA T at TA-21, and an infiltration experiment at TA-50. All three of these sites experienced periods of enhanced water application. The transient responses at the sites are used for model validation. Calculations for one canyon location, the LA-Weir site, are presented to demonstrate how pre-experimental modeling can assist in the design of a field validation exercise, which in turn will be used for model validation. Finally, an example from TA-16 represents a site where infiltration from both mesa and canyon locations is required to fully understand contaminant transport at the site.

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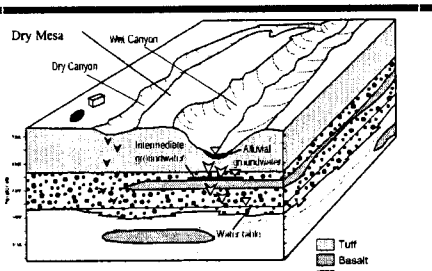
HYDROLOGIC CONCEPTUAL MODEL



- Dry canyons:
  Little recharge under natural conditions
  Significant under disturbed conditions
- Wet canyons:
  Source of recharge to intermediate groundwater and main aquifer
- Intermediate groundwater:
  Significant contaminant transport path
  Source of recharge to main aquifer
  Occurs in larger canyon systems
  Exists beneath canyons, not mesas?
  Laterally extensive near Jemez Mountains?
  Controlled by subsurface lithology

Figure 2-10. Hydrogeologic conceptual model for canyons.

Conceptual Model Validation

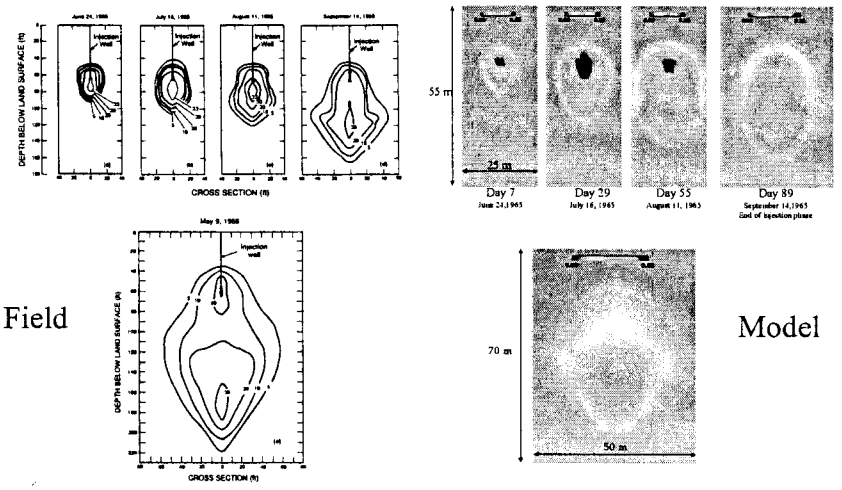
- Interpret or Predict Field Conditions with Numerical Modeling for 5 LANL Sites
  - Enhanced Infiltration at 3 Mesa Top Sites (TA-50, MDA AB at TA-49, MDA T at TA-21)
  - Mesa/Canyon coupled system (TA-16)
  - Canyon Site (LA-Weir)

Validation Process

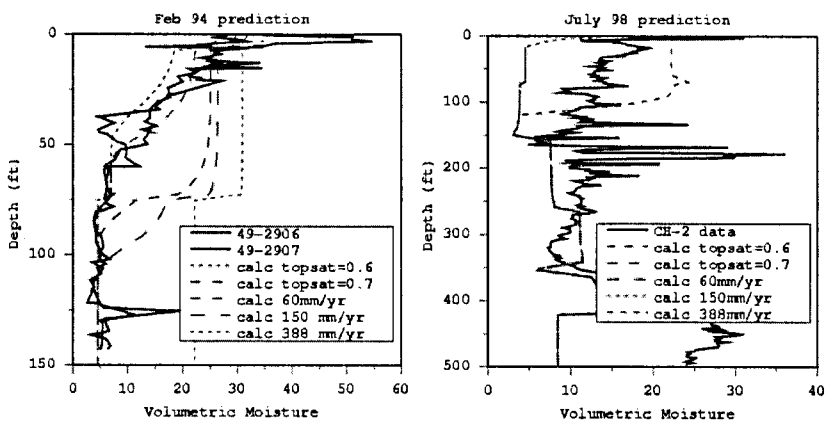
- Input data
  - Stratigraphy, hydrologic properties, expected upper boundary conditions, source concentrations, steady flow conditions
- Compare predicted data to field data
  - subsurface moisture content, contaminant concentrations, in-situ chloride data
- Follow up
  - further comparisons to additional field data

TA-50 Injection Test

Moisture Content

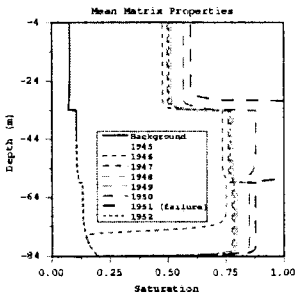


MDA AB at TA-49

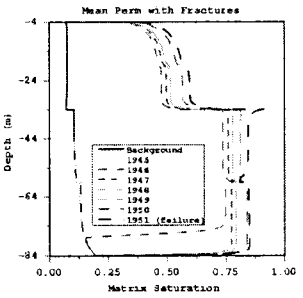


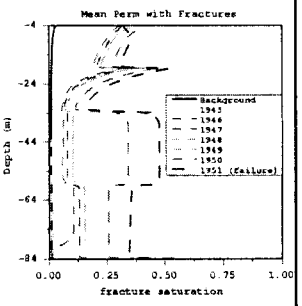
MDA T at TA-21

Matrix Only



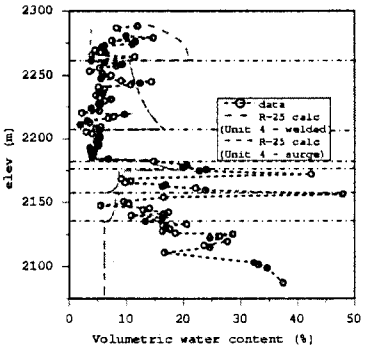
Dual Permeability/Dual Porosity



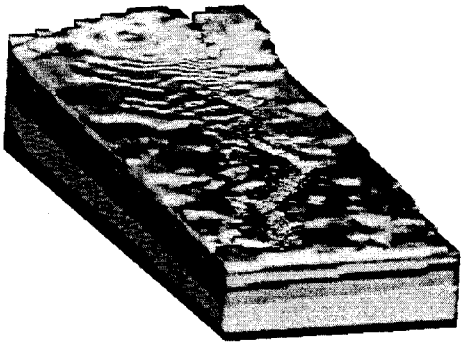


TA-16

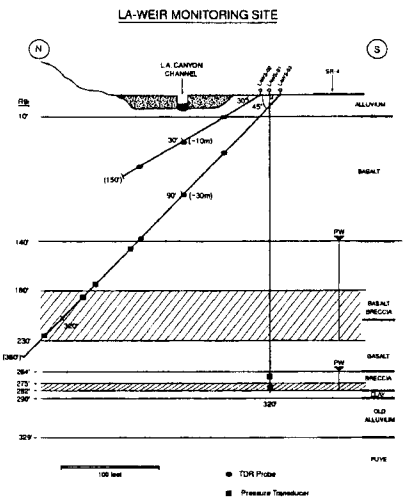
R-25 moisture data compared to 1-D simulations at 1 mm/yr

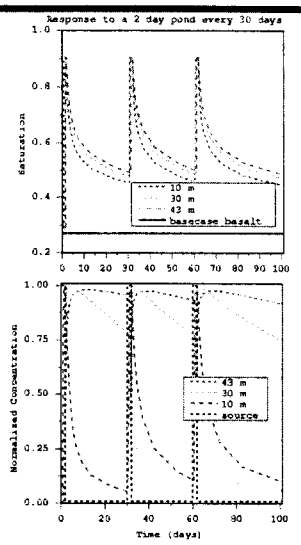


3D Grid



LA-WEIR SITE





RESULTS

- Mesa Top Sites
  - Large volume of water can still result in matrix dominated flow, near full saturation required to cause fracture flow
- TA-16
  - 3-D geometry needed to model this complex site
- LA-Weir
  - Fracture flow in the basalt is expected
  - Field data will be used to determine fracture properties

Implications for Transport Rate

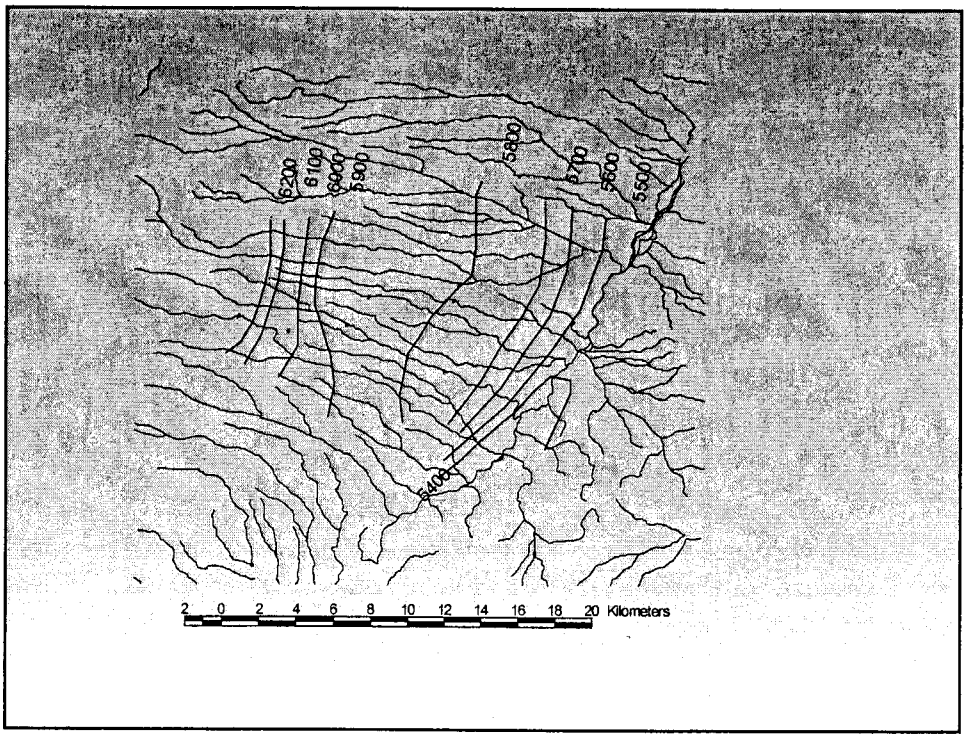
- beneath wet canyons with focused flow
- through fractured basalts
- sometimes laterally in perched zones
- beneath disturbed mesa top sites
- beneath drier canyons
- beneath canyons with a significant thickness of Bandelier tuff
- from undisturbed mesa top sites

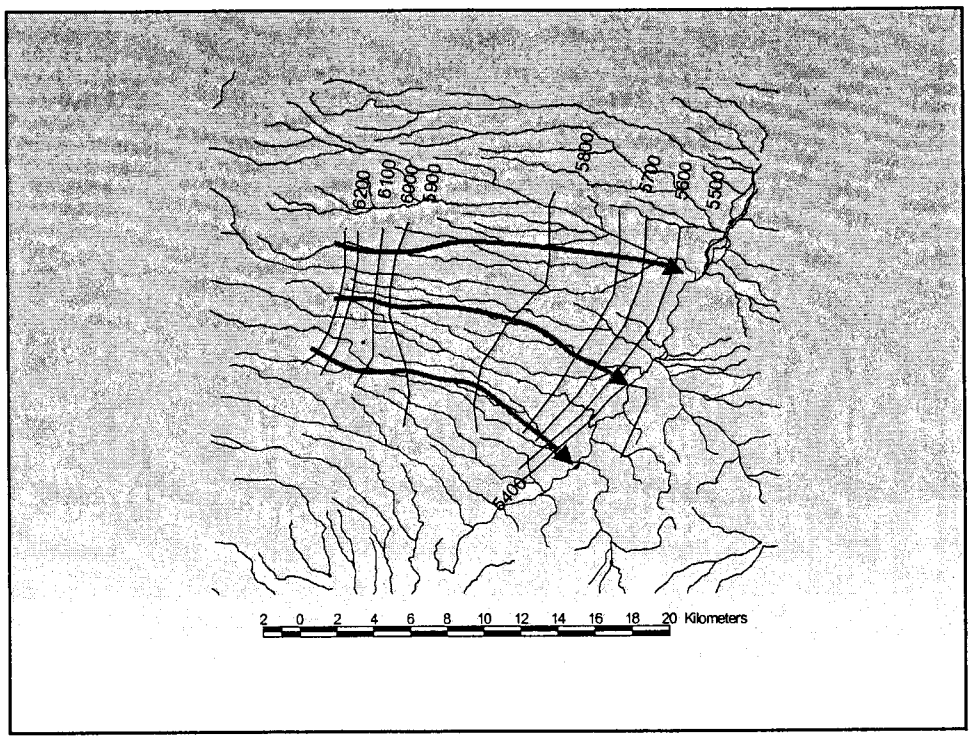
Model uncertainty
Sensitivity analysis
Data needs

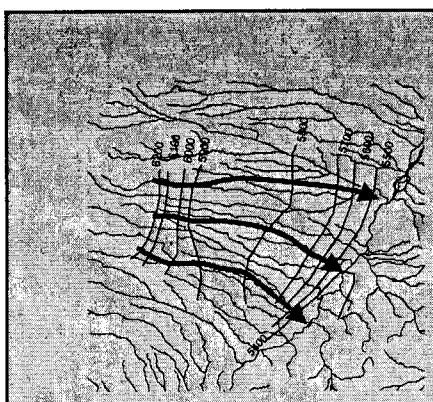
Elizabeth Keating
Velimir Vesselinov

Hydrology, Geochemistry, and Geology Group
Earth and Environmental Sciences Division

Los Alamos National Laboratory



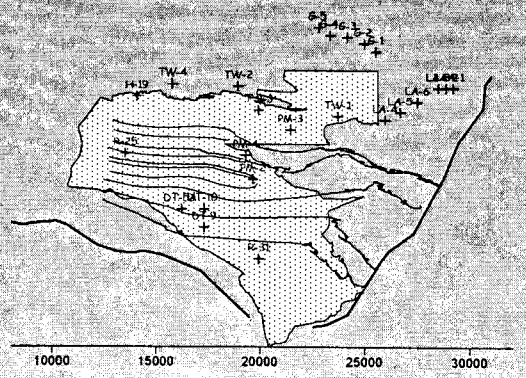




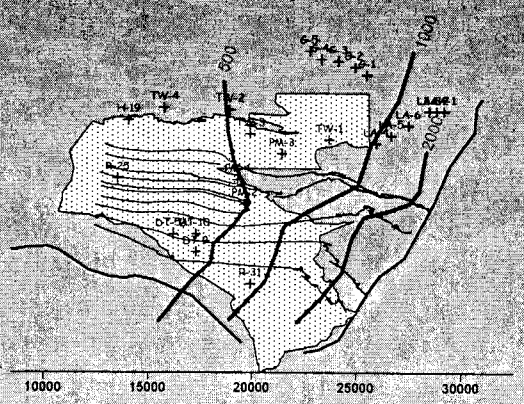
Time to travel 10 km
porosity = 0.2
assume horizontal flow, uniform rock properties
hydraulic gradient = 0.01

K = 4.6 m/day	120 years
K = 0.3 m/day	1,800 years

How certain are these predictions?



Simulated particle tracks



Travel times vary spatially, both horizontally and vertically

Some particles are captured by water supply wells

How certain are these predictions?

Types of data used in groundwater flow modeling:

- Water-level data
- Pumping rates from municipal water supply wells
- Geometry of rock layers
- Estimate of total amount of water moving through the aquifer (recharge/discharge)

Types of data used in groundwater flow modeling:

- Water-level data

Water-levels in ~100 wells "pre-development"

Annual water levels in ~30 wells over 50-yr period

Total: 1500 data points

Uncertainties:

Limited spatial coverage on Pajarito Plateau, especially in vertical dimension

Types of data used in groundwater flow modeling:

➢Pumping rates from municipal water supply wells

Annual withdrawals from all wells in Los Alamos County and City of Santa Fe, including Buckman well field

Uncertainties:

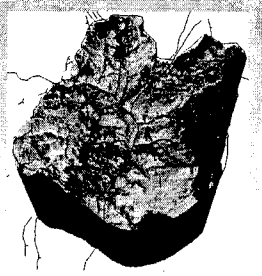
- future pumping rates
- possible new water supply wells
- Withdrawals in other wellfields

other

Types of data used in groundwater flow modeling:

➢Geometry of rock layers

Large-scale hydrostratigraphic zones:
3-D geologic model



Within-hydrostratigraphic unit heterogeneity:
Geostatistical model

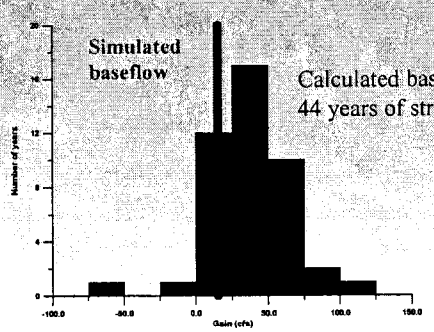
Uncertainties:

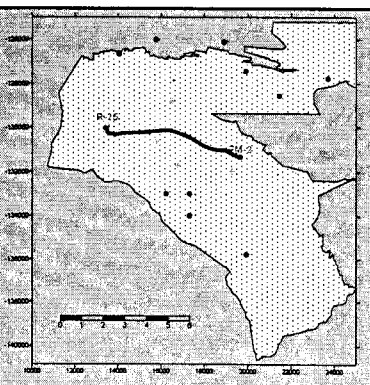
- large-scale, effective permeability and porosity values for hydrostratigraphic zones
- location of hydrologically relevant stratigraphic boundaries

Types of data used in groundwater flow modeling:

➢Estimate of total amount of water moving through the aquifer (recharge/discharge)

Historical streamflow records along Rio Grande (44 years) and Jemez River (27 years)





Ensure the prediction is consistent with observed water levels, available geochemical data, geologic understanding

Sensitivity analysis

How important are various types of uncertainty to our ability to make good predictions? → Prioritize data collection

Sensitivity analysis

Given the available information on water levels, pumping rates, and discharge to neighboring rivers

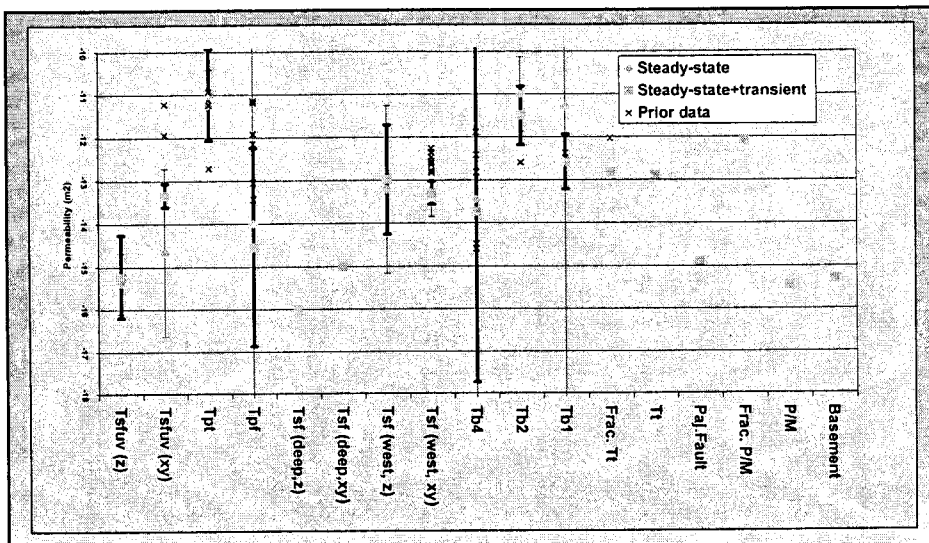
What is the most likely large-scale effective permeabilities of the rock units?

How uncertain are these estimates?

Uncertainty

Low ⟷ High

Sensitivity

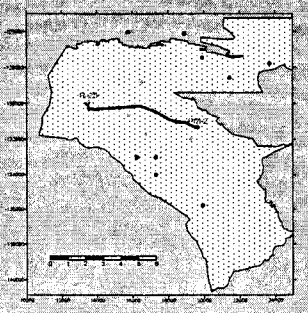


Range of effective permeabilities that are consistent with water level data

Conclusion from sensitivity analysis

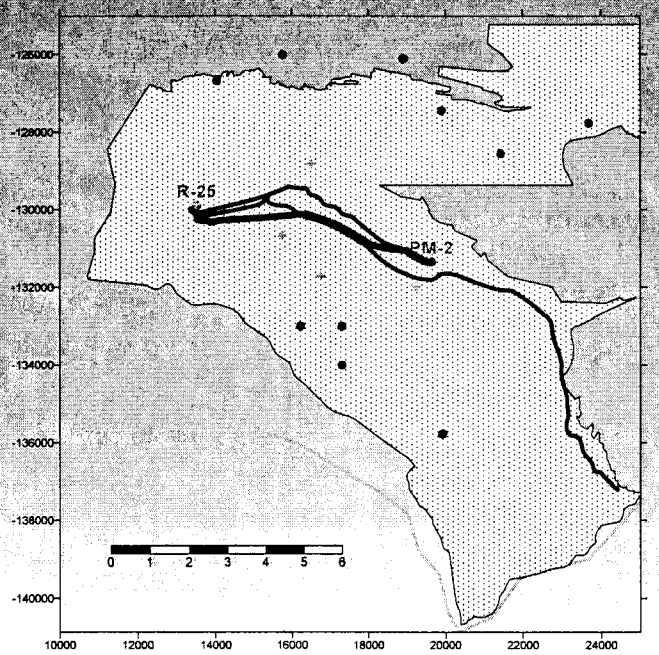
- Santa Fe Group permeability is fairly well constrained; Puye Formation and Basalts are not
- Need multi-level head data within Puye and basalts.
- Pump-test data will help our characterization of heterogeneity within these units

Does the uncertainty matter to a particular prediction??



Predictive analysis

Vary all uncertain parameters as much a possible, *within calibration criteria*, to determine range of possible predictions



Conclusions from predictive analysis

- Despite parameter uncertainty, flow directions away from TA-16 (easterly) are fairly well-constrained
- Travel times are less well constrained

Multi-level head data in the vicinity of TA-16 will reduce the uncertainty in flow direction

Estimates of large-scale "effective" porosity are required to reduce uncertainty in travel time estimations