2004 Annual Report on Corrective Action Keypoints and Rationale for Changes to Standards

United Nuclear Corporation Church Rock Site

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Meeting at Church Rock, May 5, 2005

Docket: 40-8907

Presentation objectives

- 2004 report keypoints and groundwater quality trends in all three hydrostratigraphic units.
- Discussion of NA, especially in the Southwest Alluvium (SWA)
  - Indicator parameters, especially bicarbonate.
  - COC focus – combined Ra, U, Mn, CHCl3.
- Data and rationale for changes to standards
  - Revise site-wide ROD background concentrations for Mn, combined Ra, Ni.
  - For chloroform set the site-wide GWPS (currently 1 ug/L) to current MCL (80 ug/L).

SWA groundwater quality performance monitoring program

- POC wells
  - 509 D EPA 23 632
  - GW 1 GW 2 GW 3 EPA 28
- Important long-term conclusion – no seepage-derived COCs cross the property boundary at levels exceeding background or site standards
  - Conclusion stands regardless of extraction well pumping

Bicarbonate isoconcentration & sulfate October 2004

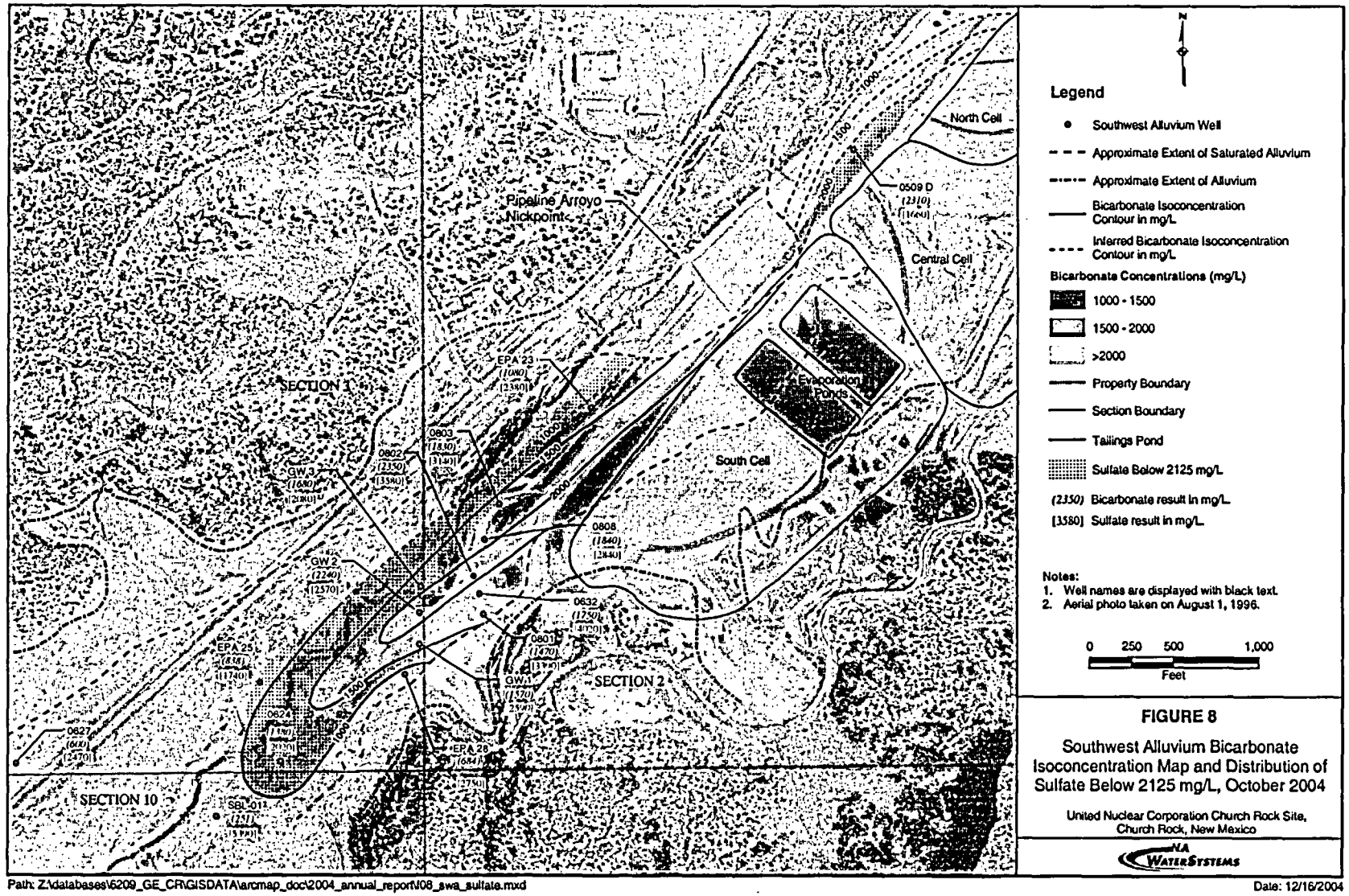

FIGURE 8

Southwest Alluvium Bicarbonate Isoconcentration Map and Distribution of Sulfate Below 2125 mg/L, October 2004

United Nuclear Corporation Church Rock Site, Church Rock, New Mexico

NA WaterSystems

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Date: 12/16/2004

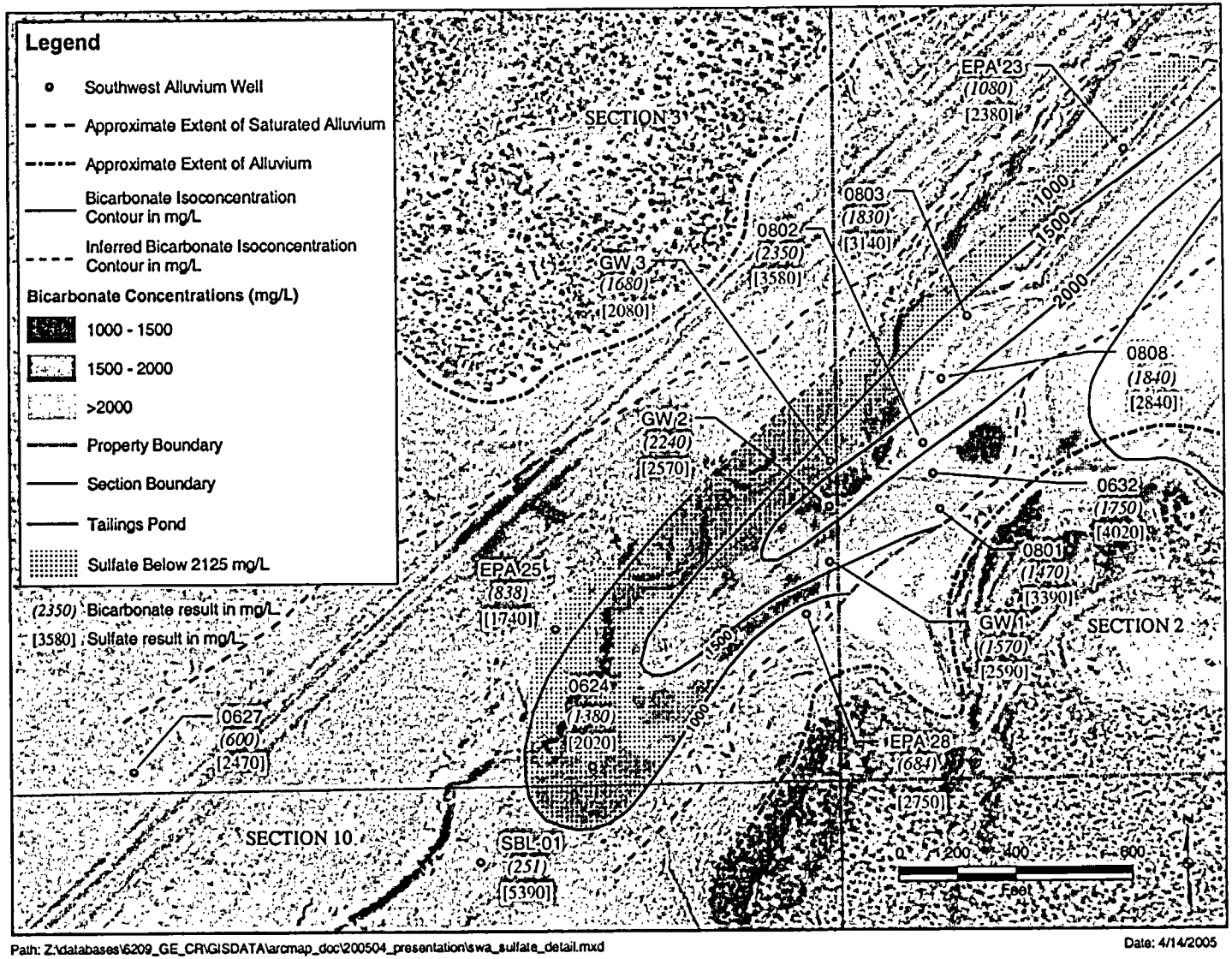
Key governing reaction

? $CaCO_3 + H^- + SO_4^{-2} + 2H_2O$

<< >>

$CaSO_4 \bullet 2H_2O + HCO_3^-$

Bicarbonate isoconcentration & sulfate October 2004



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Date: 4/14/2005

Comparing SBL 1 water with seepage-impacted water

- Both waters are alike in that
  - In ~ equilibrium with assemblage of Ca-SO4 (anhydrite or gypsum), Mg-carbonate (magnesite or dolomite), and CaCO3 (calcite).
- MINTEQ simulations show that
  - When acidic water contacts these mineral phases, geochemical shift toward higher bicarb & lower sulfate (e.g. 624) vs. case where acid absent (e.g. SBL 1).
- Ratio of sulfate/bicarb should be at minimum where tailings seepage front meets and reacts with non-impacted areas in alluvium
  - Figure 8 confirms sulfate concentrations lowest along margin of seepage front.

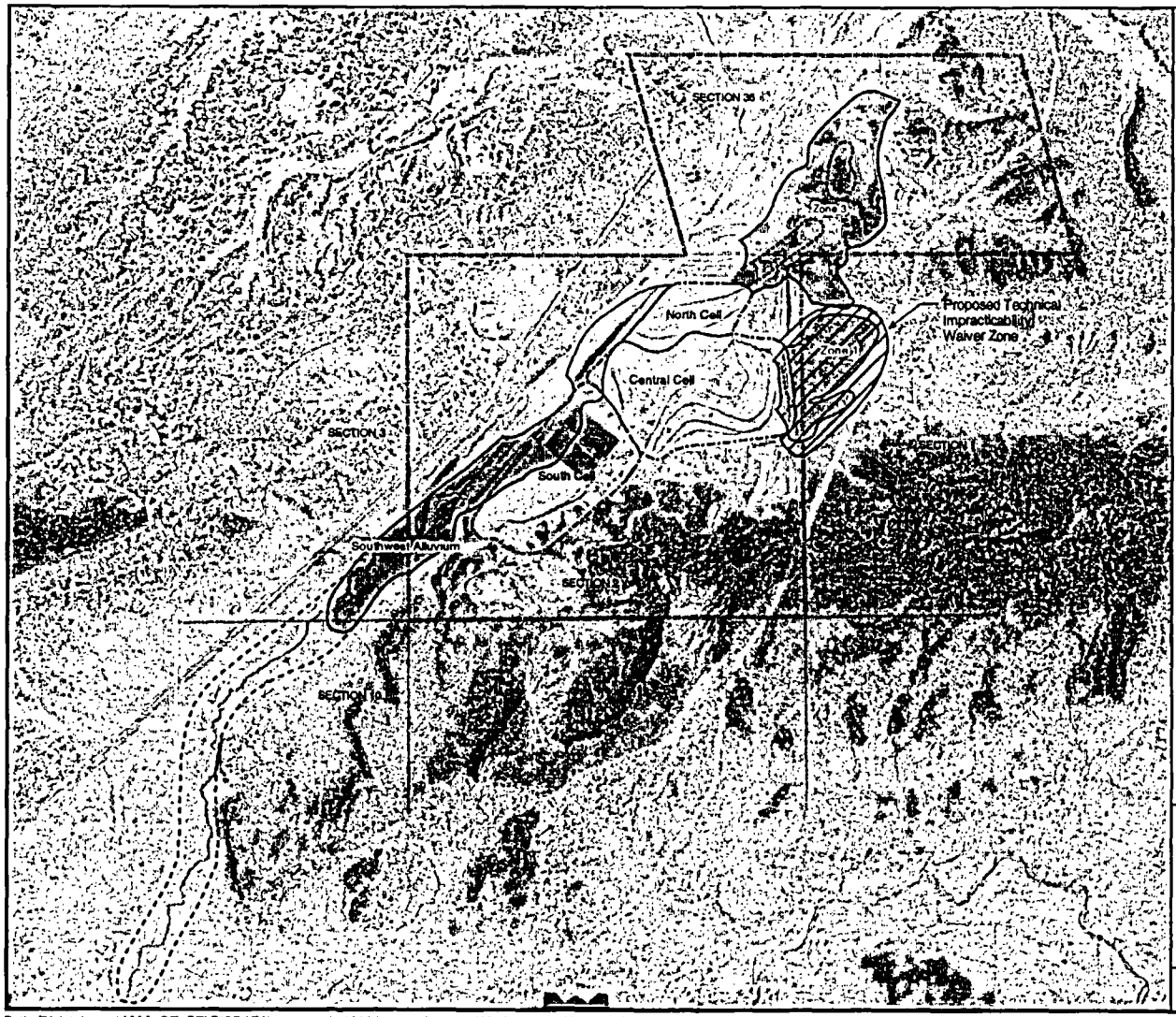
Sulfate is everywhere and in equilibrium with gypsum

- Except along the migrating reaction zone along the seepage-impact front.
- Nonimpacted SBL 1 has the highest sulfate and TDS concentrations of all wells.

Conclusions

- No situation can be envisioned in which the natural quality of alluvium groundwater offsite can be degraded by the migration of seepage-impacted water
  - For sulfate, the seepage-impacted water may be viewed as an improvement.
- Dewatering SWA?
  - Only way to achieve sulfate/TDS standards.

Extrapolated SWA seepage impact year 2204



Legend

- Section Boundary
- Property Boundary
- Tailings Pond
- Groundwater with pH <= 4
- Seepage-Impacted Groundwater
- Propsoed Technical Impracticability Waiver Zone
- Seepage Impact in 2204
- Extrapolated Extent of Seepage Impact in Southwest Alluvium in 2204

Notes:
1. Extrapolated Extent of Southwest Alluvium Seepage Impact in 2204 based upon an average annual seepage impact advance of 30 feet per year.
2. Aerial photo taken on August 1, 1996.

0 650 1,300 2,600
Feet

FIGURE 58

Proposed TI Waiver for Zone 1 and Extrapolated Extent of Southwest Alluvium Seepage Impact in 2204

United Nuclear Corporation Church Rock Site
Church Rock, New Mexico

N.A. WaterSystems

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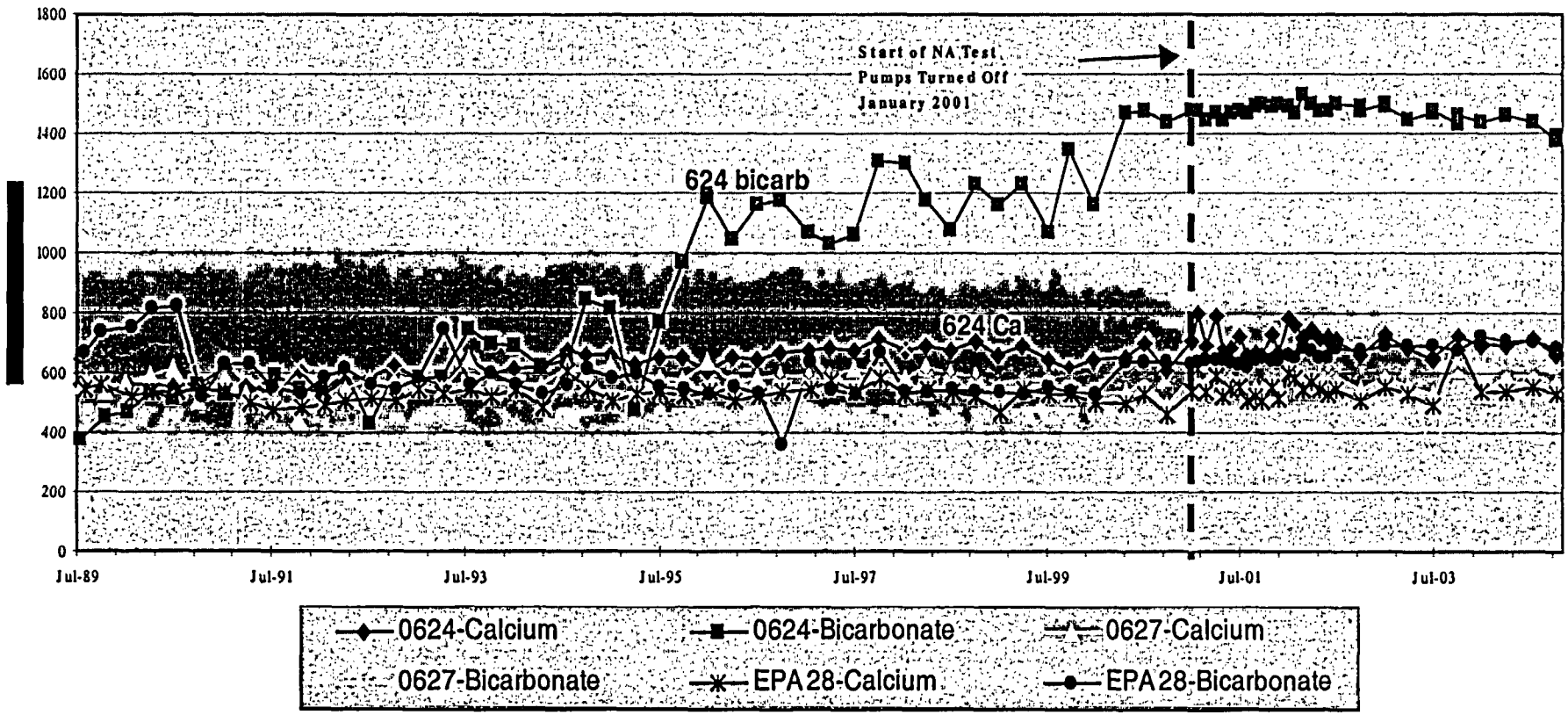
Date: 12/23/2004

SWA calcium & bicarbonate in select wells 1989 October 2004

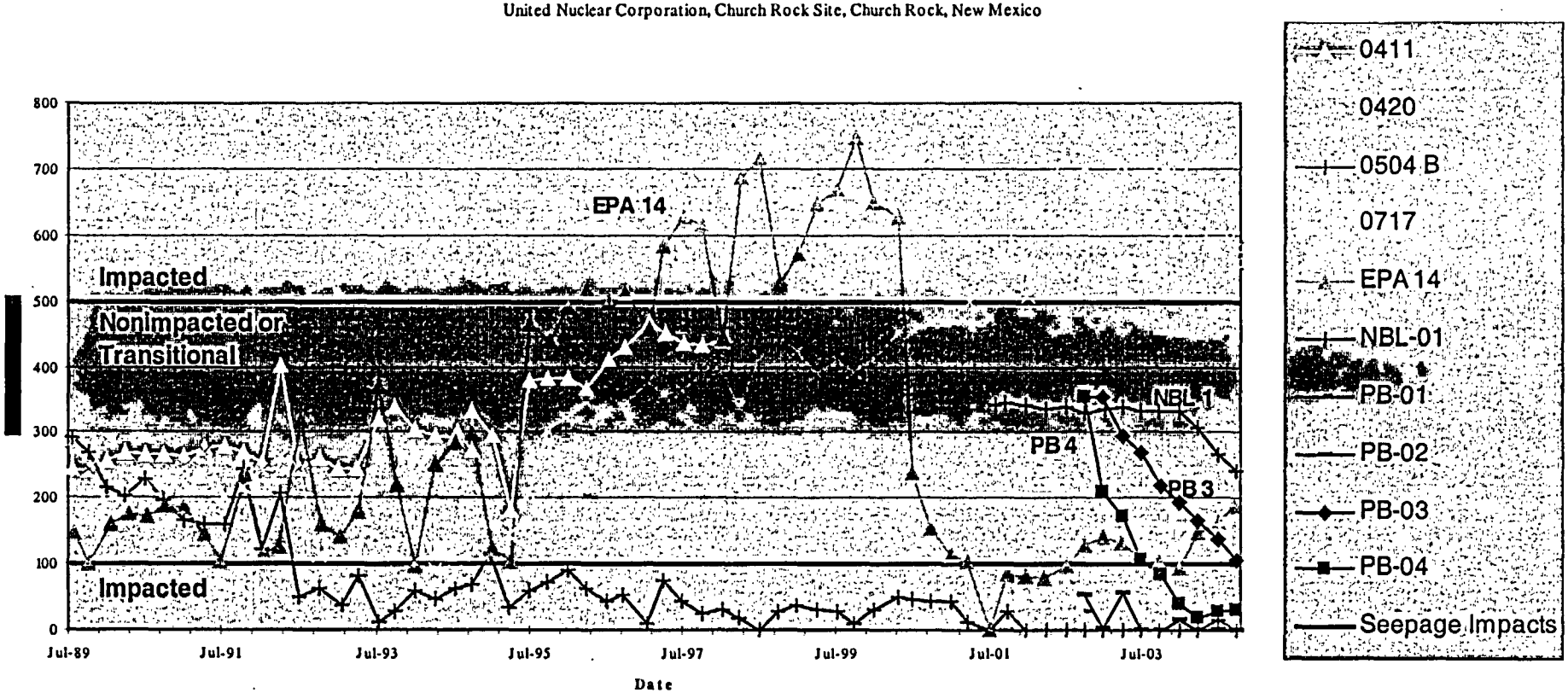
FIGURE 11

Calcium and Bicarbonate Concentrations in Selected Backgound and Seepage-Impacted Wells
United Nuclear Corporation, Church Rock site, Church Rock, New Mexico



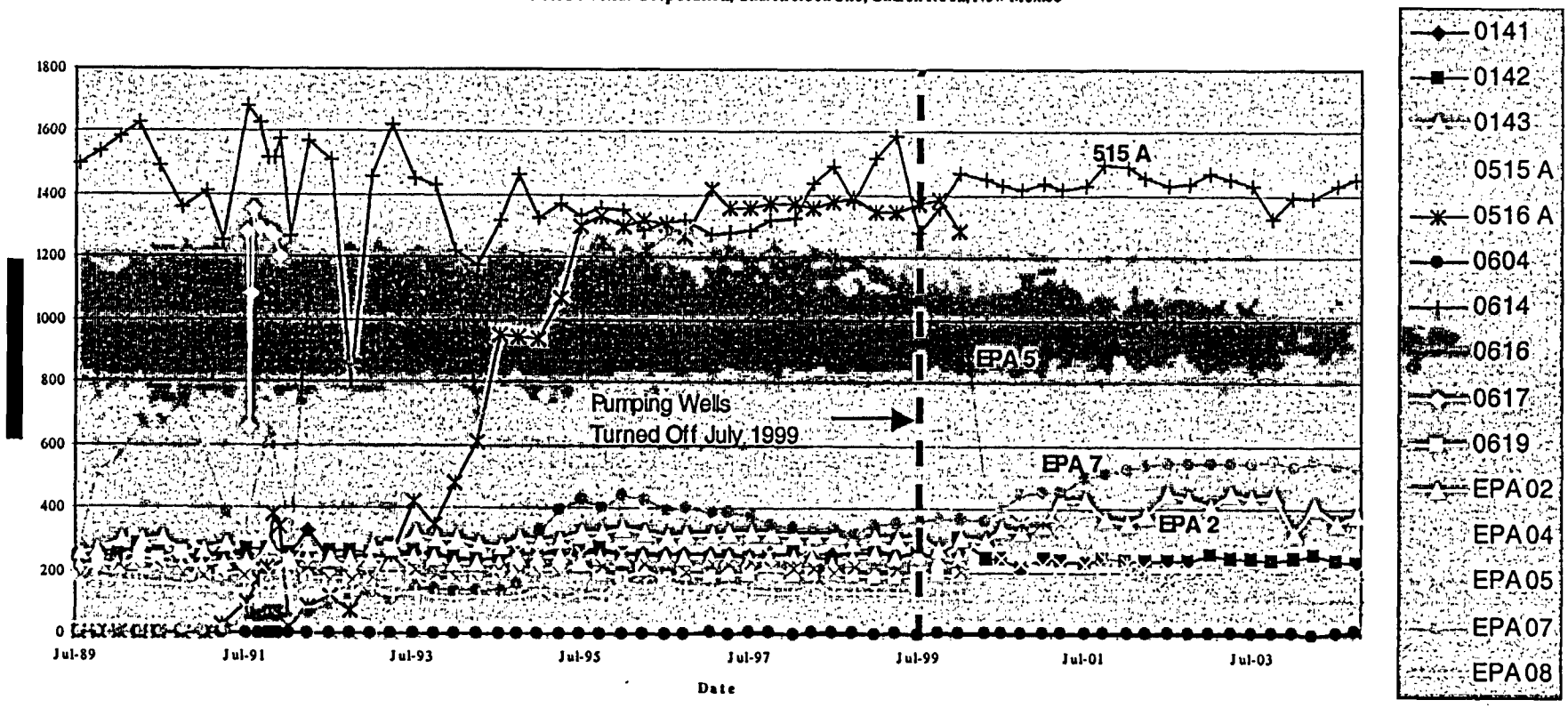
Zone 3 impact-perimeter bicarbonate 1989 to October 2004

FIGURE 41
Zone 3 Impact Perimeter Bicarbonate Concentrations Over Time
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico

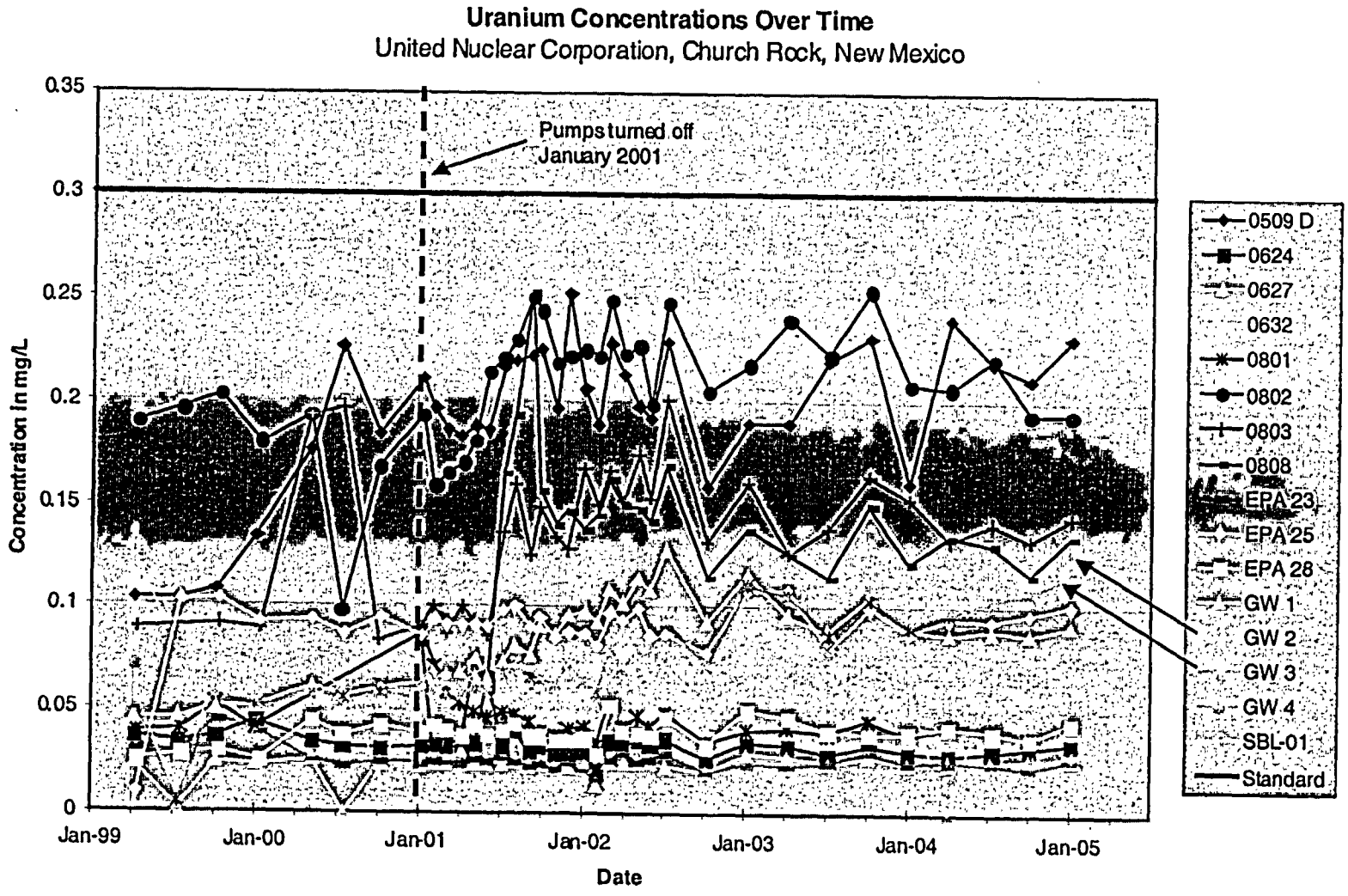


Zone1 bicarbonate 1989 to October 2004

FIGURE 54
Zone 1 Bicarbonate Concentrations Over Time
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico



SWA uranium 1999 to January 2005



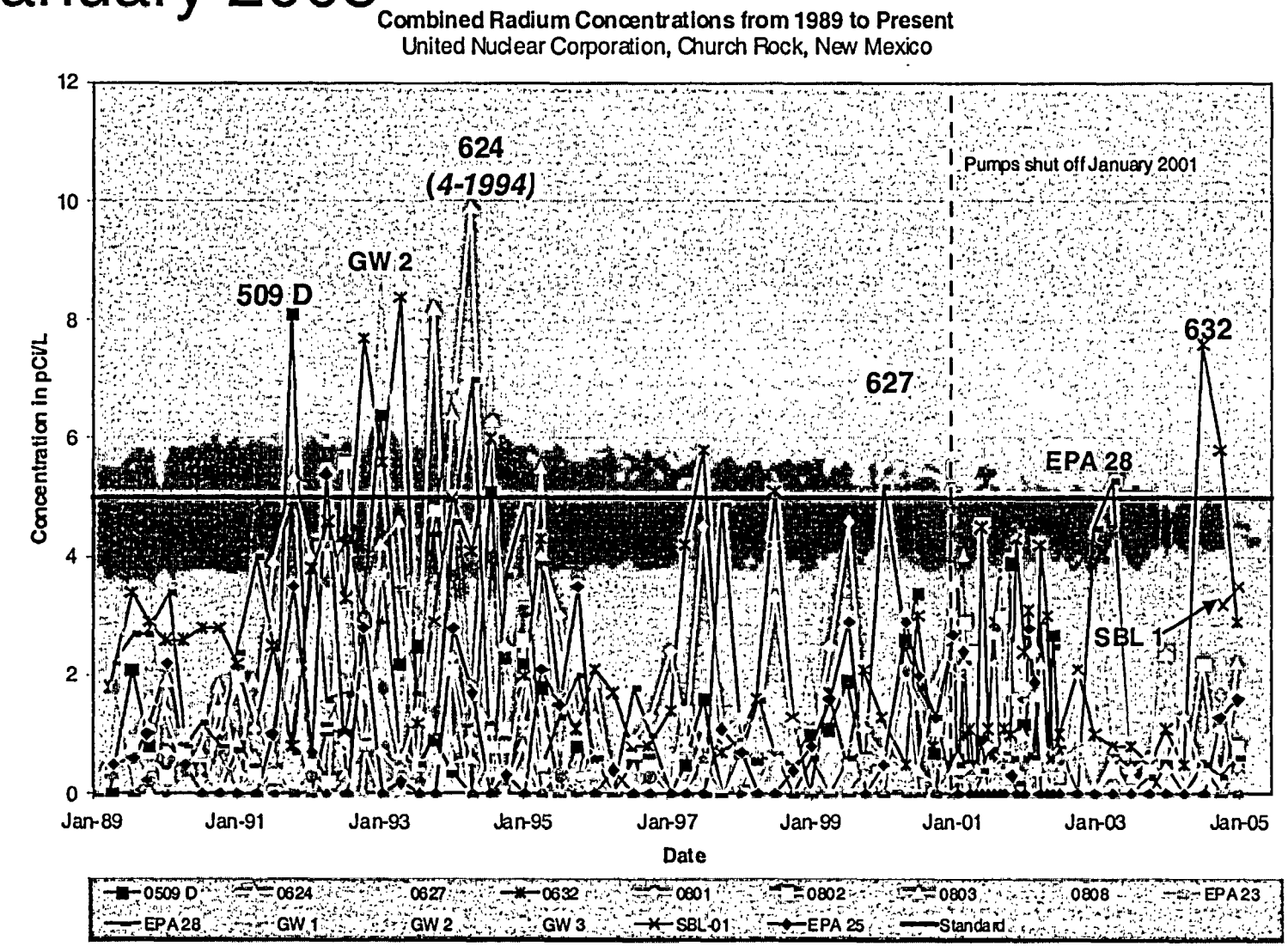
SWA seepage-impacted area has attained ALARA goals

- In future, should be managed by ACLs established by NRC and/or TI Waiver.
- TI Waiver would be non-traditional
  - Background water quality likely to exceed site standards for sulfate and TDS downgradient for miles – but this water quality is unrelated to seepage impact.
- Instead, UNC proposes that the 200-year projected seepage front be used.

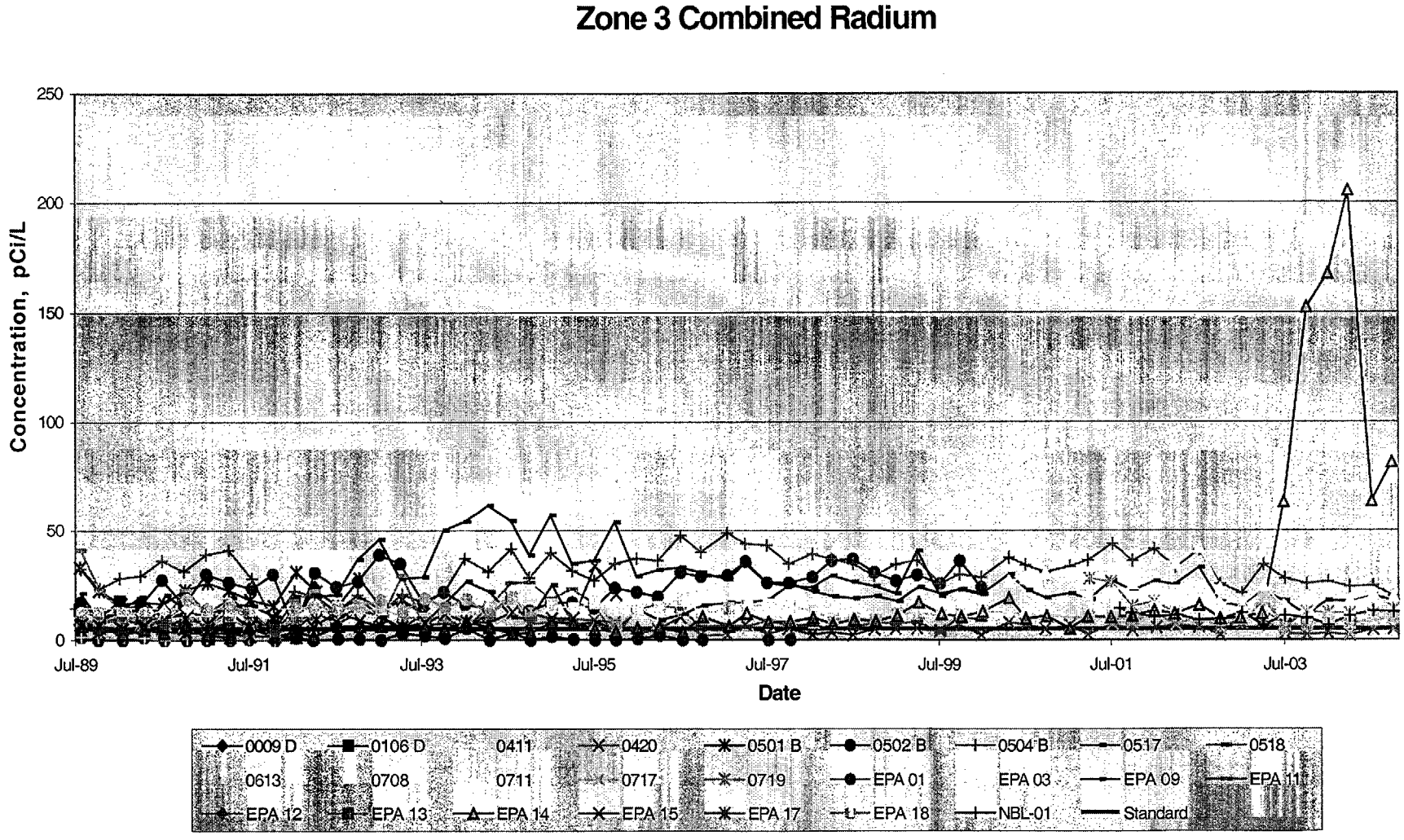
SWA combined radium summary statistics 1989 to January 2005

Background water quality								n >=5		n >=2		# NDs
	Well Type	Data Years	n	Mean	Median	max	n >=5	as %	n >=2	as %	# NDs	as %
644	dry, far upgrad bkgnd	1989-1992	14	1.9	1.1	6.6	1	7	6	43	1	7
639	dry, far upgrad bkgnd	1989-1994	21	2.6	1.8	12	2	10	9	43	3	14
642	dry, far upgrad bkgnd	1989-1995	25	1.5	0.7	6.3	3	12	6	24	5	20
GW 4	dry, upgrad bkgnd	1989-1999	25	2.1	1.1	15.3	3	12	8	32	7	28
0029 A	dry, sidegrad bkgnd	1989-1994	23	1.7	0.4	10.9	2	9	7	30	8	35
627	down&sidegrad bkgnd	1989-2005	75	1.2	0.7	6.7	3	4	18	24	16	21
EPA 28	POC & down&sidegrad bkgnd	1989-2005	76	1.5	0.8	7	3	4	23	30	14	18
SBL 1	new downgrad bkgnd	2004-2005	2	NA	NA	3.5	0	NA	2	NA	NA	NA
EPA 25	down&sidegrad interpreted	1989-2005	76	0.8	0.0	5.4	1	1	12	16	41	54
	borderline early impact vs bkgnd											
Impacted water quality								n >=5		n >=2		# NDs
	Well Type	Data Years	n	Mean	Median	max	n >=5	as %	n >=2	as %	# NDs	as %
624	downgrad early impact	1989-2005	76	0.9	0.3	9.9	3	4	11	14	35	46
	starting 1995 (bicarb)											
0509 D	POC & upgrad impacted	1989-2005	76	1.0	0.5	8.1	3	4	14	18	20	26
EPA 23	POC & sidegrad impacted	1989-2005	76	0.7	0.0	4.4	0	0	12	16	41	54
803	downgrad impacted	1989-2005	73	0.7	0.0	8.2	2	3	9	12	37	51
802	impacted core zone bicarb	1989-2005	74	0.7	0.3	5.6	1	1	12	16	34	46
632	POC & downgrad impacted	1989-2005	76	2.5	2.1	8.4	9	12	35	46	2	3
801	downgrad impacted	1989-2005	71	1.3	0.9	6.3	2	3	15	21	11	15
GW 3	POC & downgrad impacted	1989-2005	77	0.7	0.3	4.6	0	0	8	10	33	43
GW 2	POC & downgrad impacted	1989-2005	76	1.0	0.1	8.7	3	4	15	20	38	50
GW 1	POC & downgrad impacted	1989-2005	76	0.8	0.0	6.8	2	3	11	14	39	51

SWA combined radium 1989 to January 2005

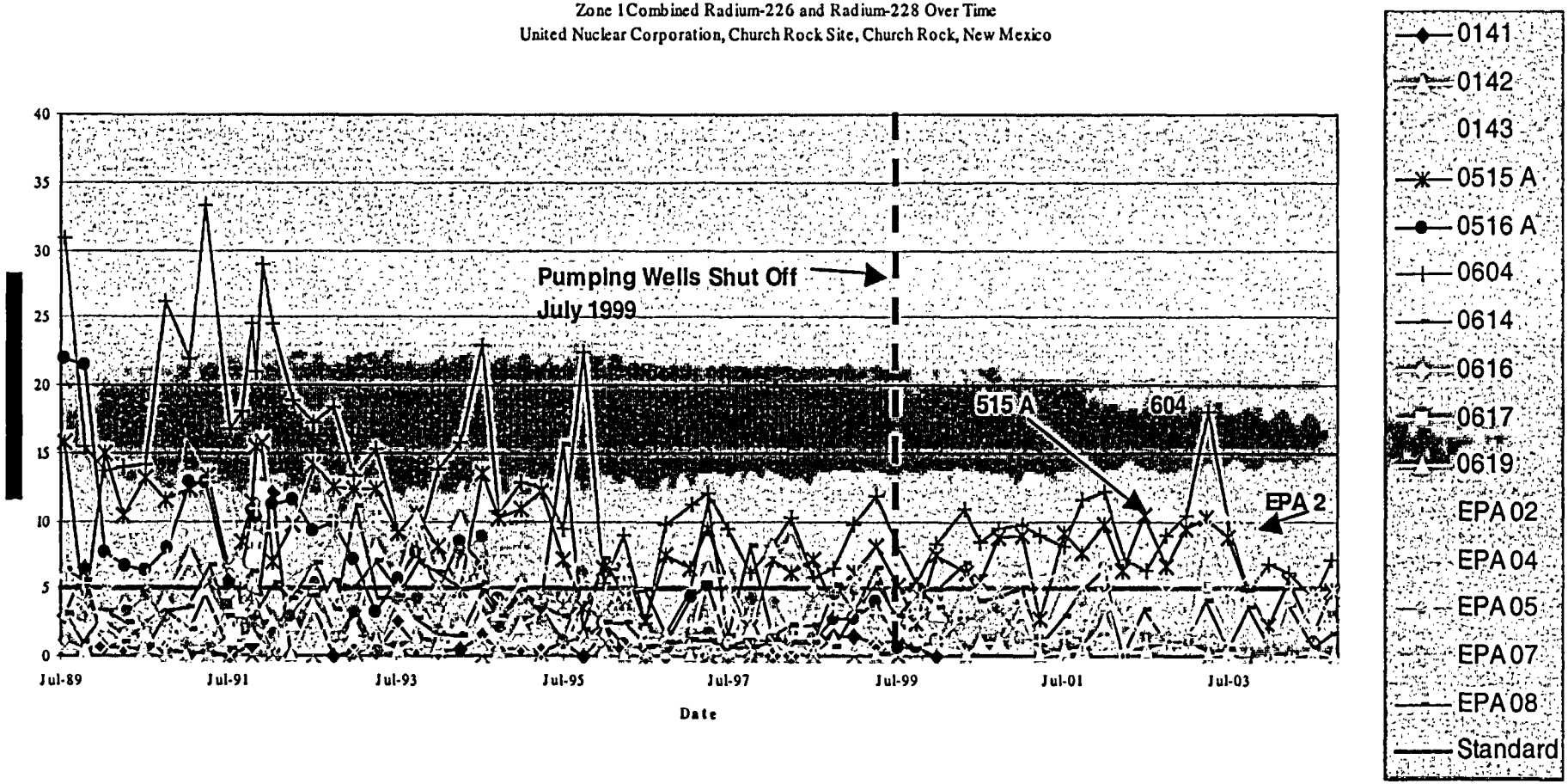


Zone 3 combined radium 1989 to October 2004

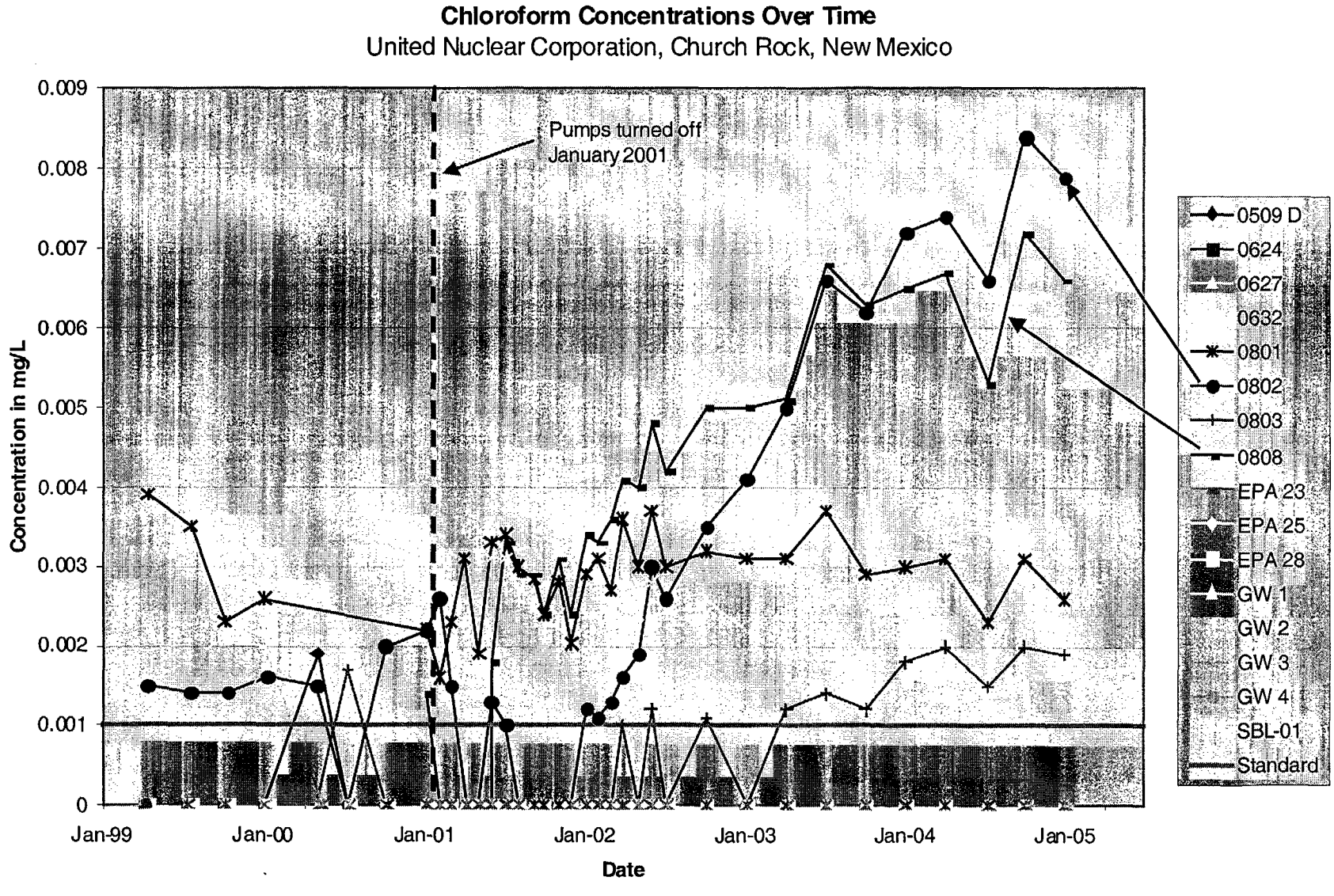


Zone 1 combined radium 1989 to October 2004

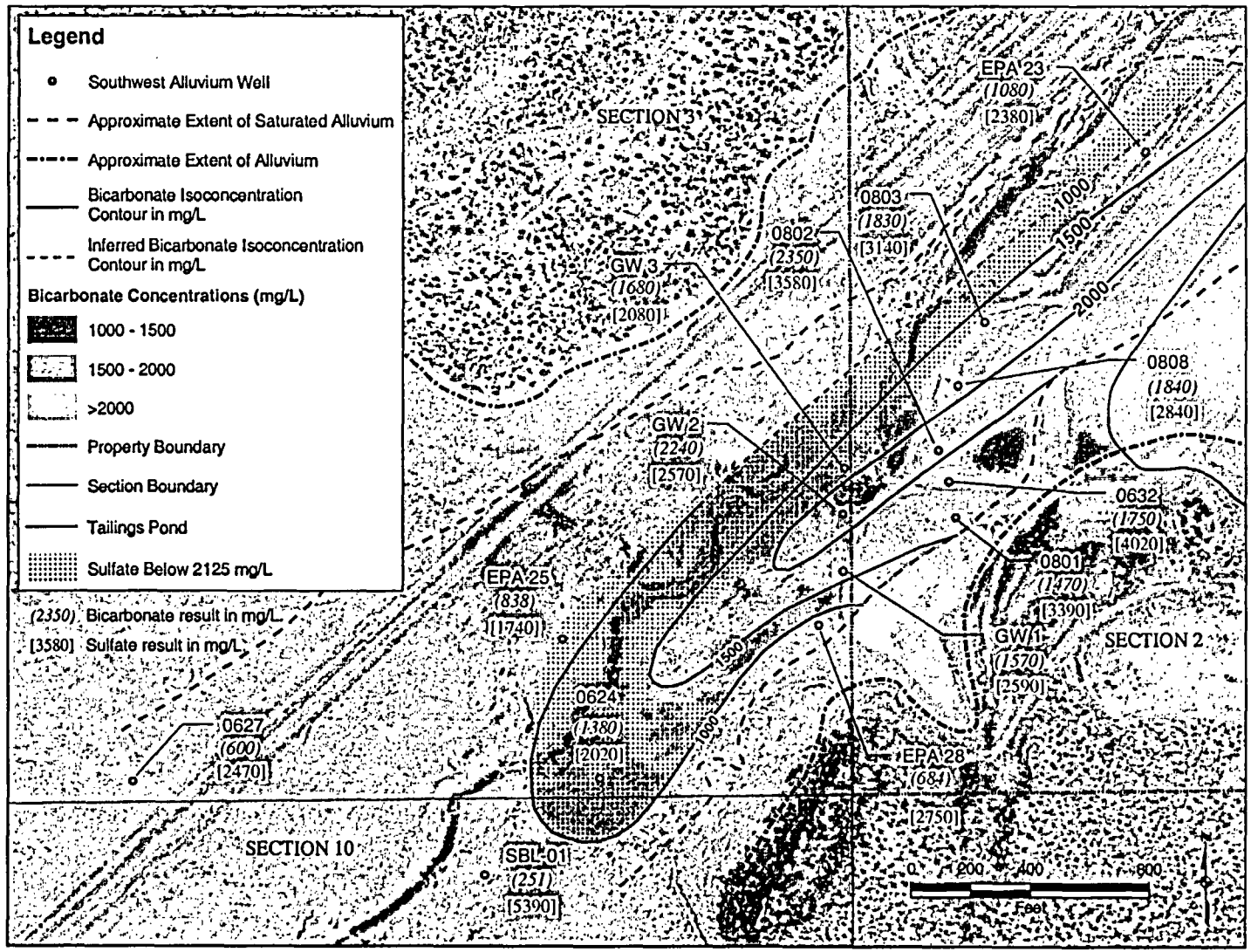
FIGURE 57
Zone 1 Combined Radium-226 and Radium-228 Over Time
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico



SWA chloroform 1999 to January 2005



SWA bicarbonate isoconcentration & sulfate October 2004



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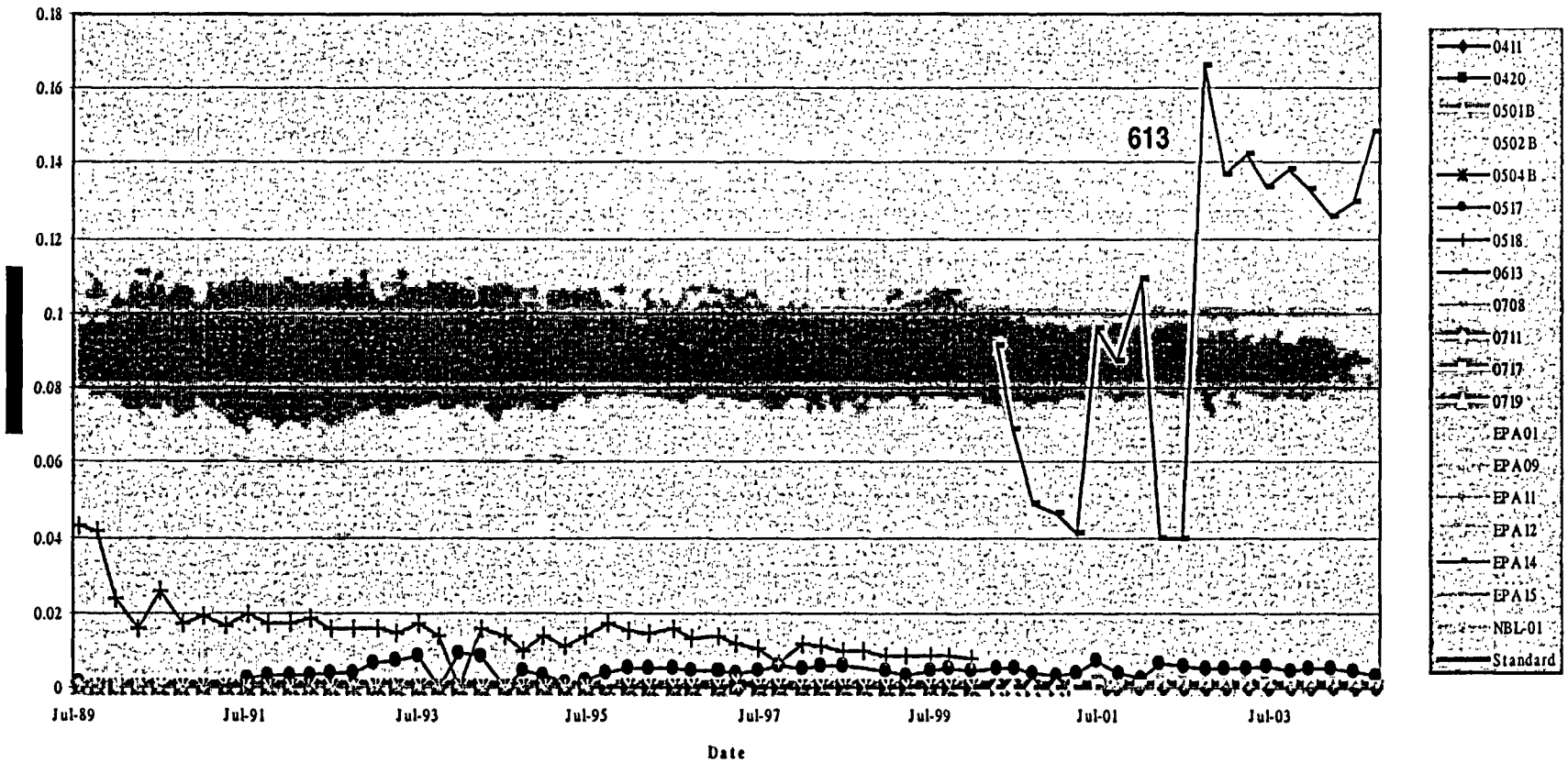
Date: 4/14/2005

Zone 3 chloroform 1989 to October 2004

FIGURE 45
Zone 3 Chloroform Concentrations Over Time
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico



Zone 3 approximate extent seepage impacts October 2004

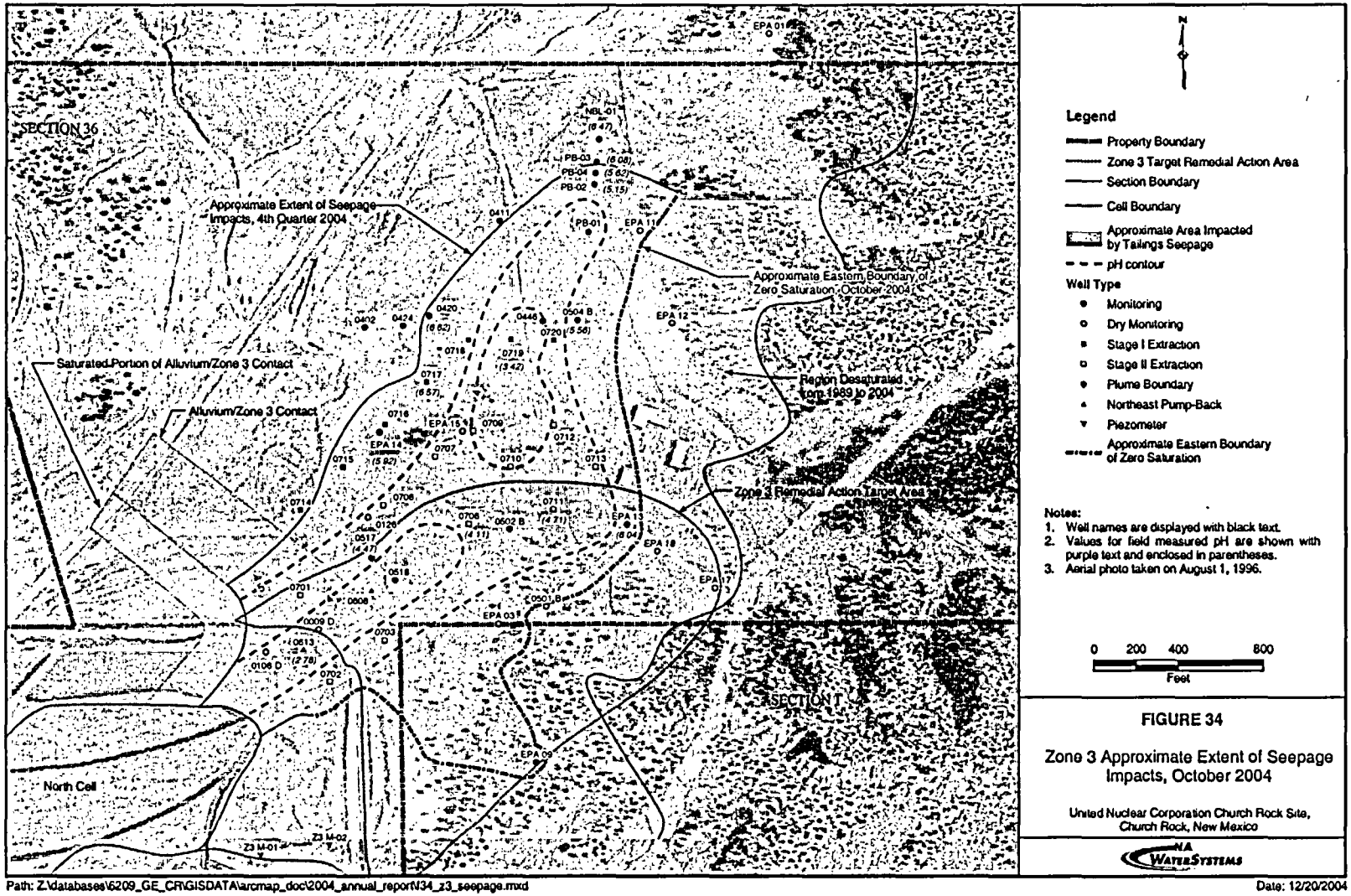


FIGURE 34

Zone 3 Approximate Extent of Seepage Impacts, October 2004

United Nuclear Corporation Church Rock Site, Church Rock, New Mexico

NA WaterSystems

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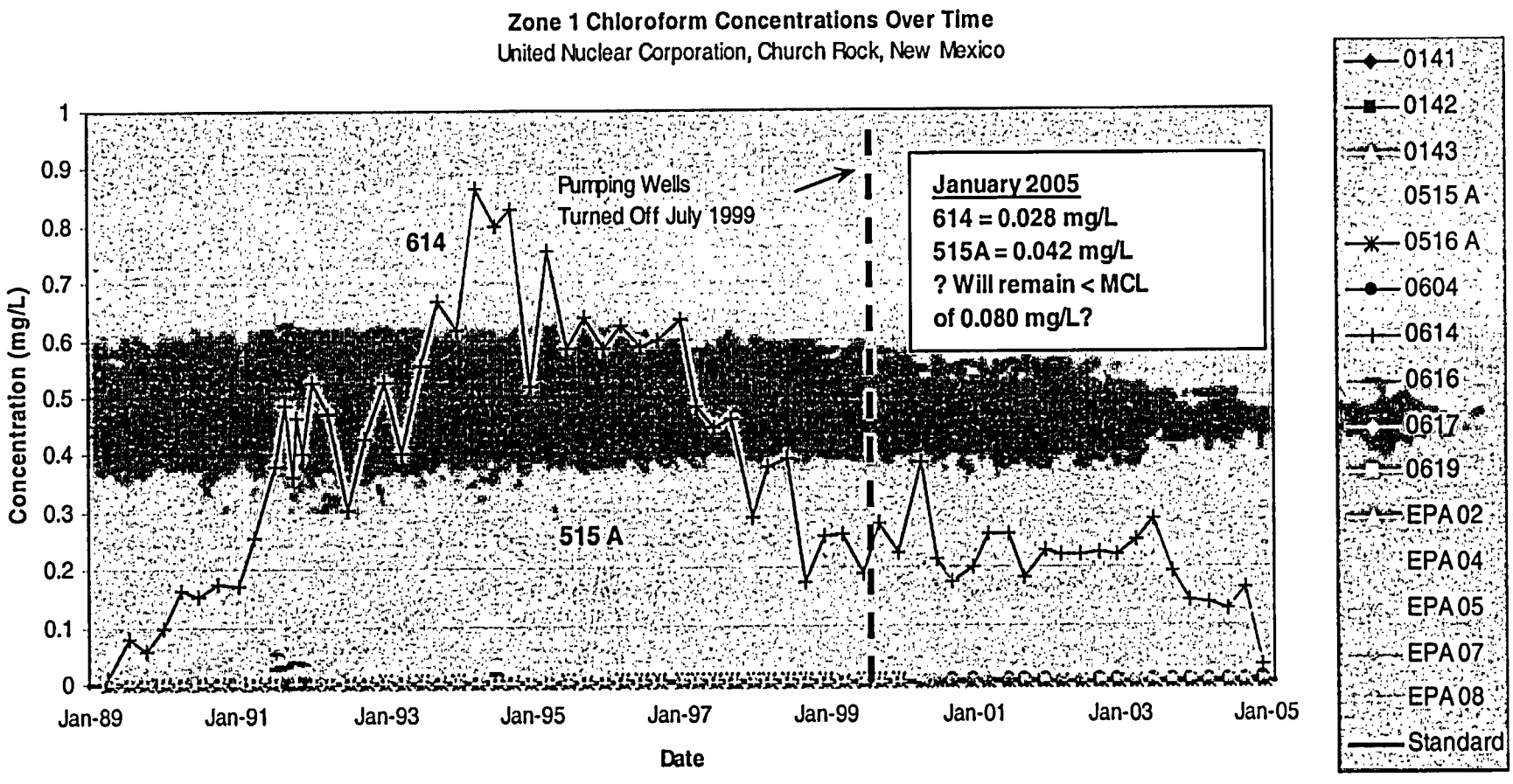
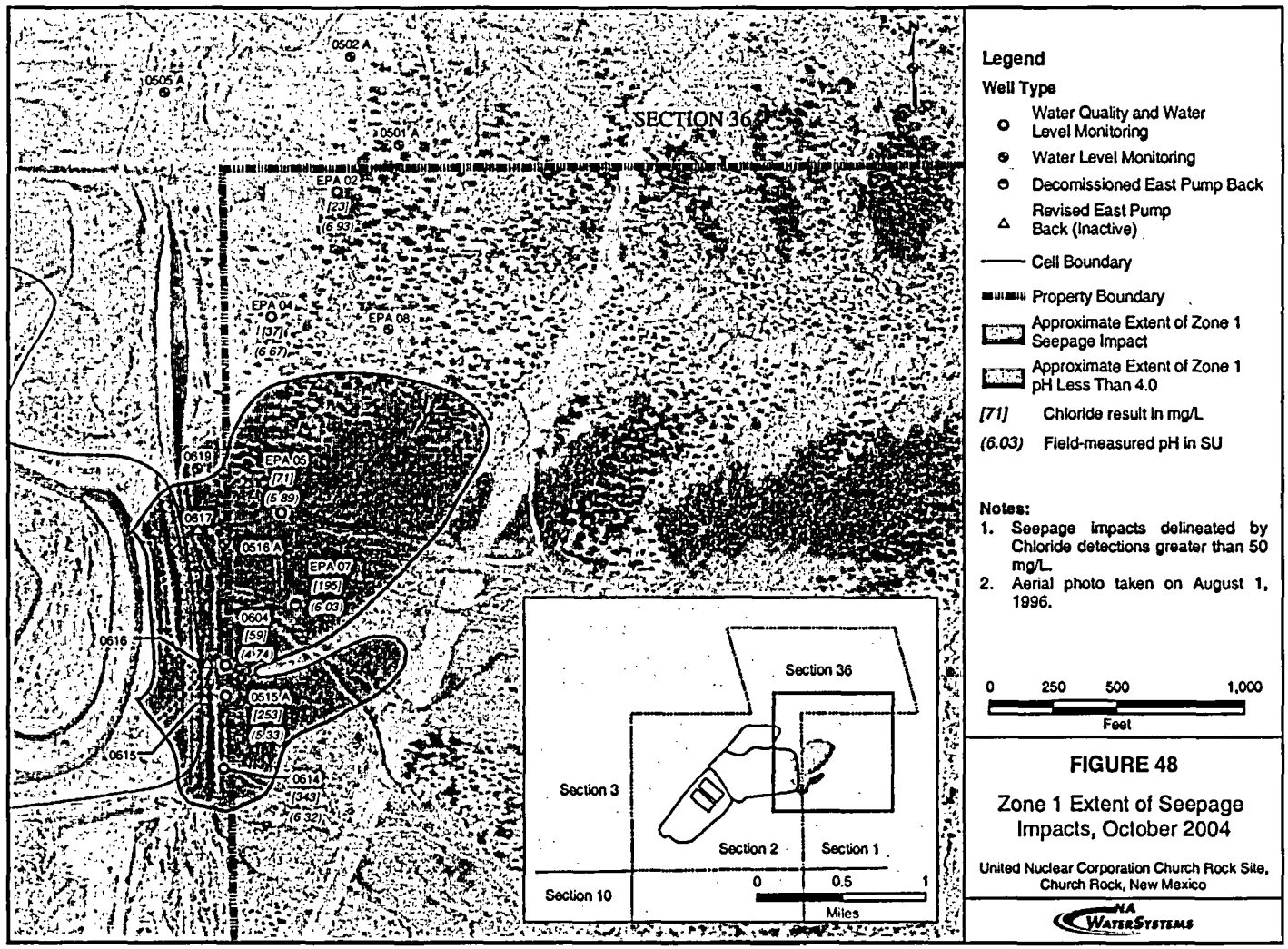
Date: 12/20/2004

Zone 1 chloroform 1989 to January 2005



Zone 1 extent seepage impacts October 2004



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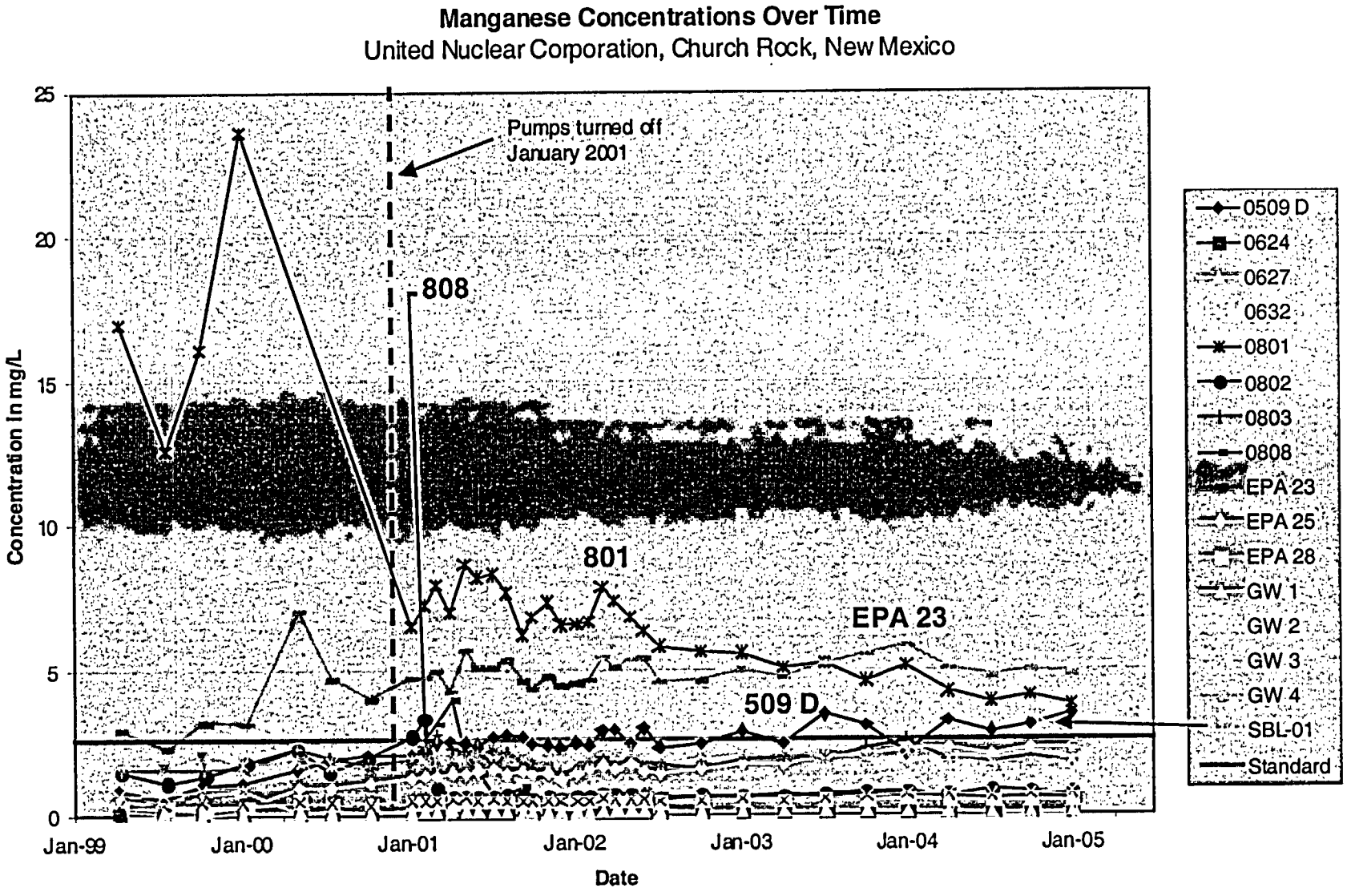
Date: 12/21/2004

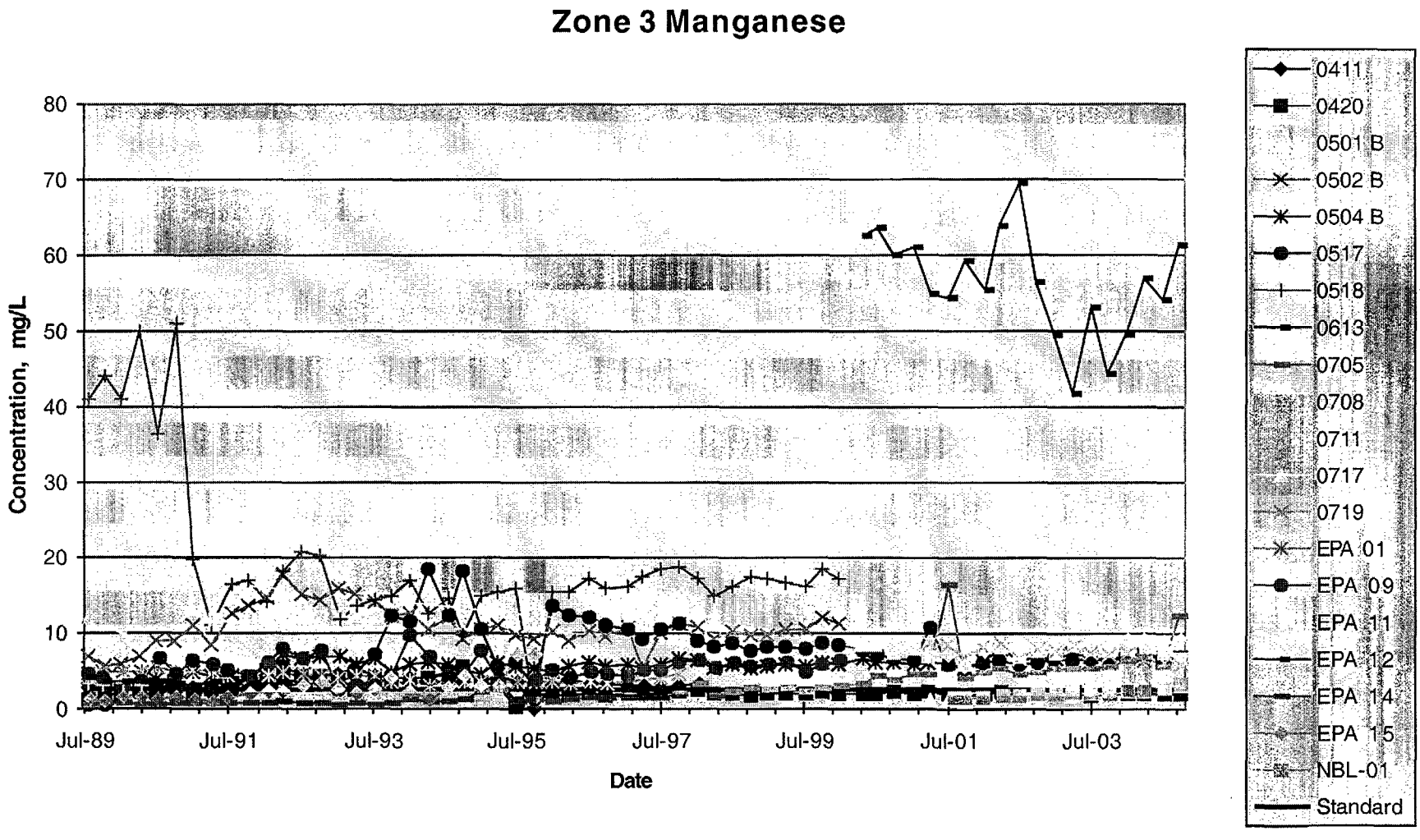
SWA -- SBL 1 metals exceedances October 2004

- Seepage-impacted groundwater has not yet reached this location.
- Background water exceedances:
  - Mn 3.35 mg/L (EPA site standard = 2.6).
  - Ni 0.17 mg/L (NRC site standard = 0.05).
  - Co 0.06 mg/L (EPA site standard = 0.05).
- UNC recommends revising ROD background standards to recognize these metals' background levels.

SWA manganese 1999 to January 2005

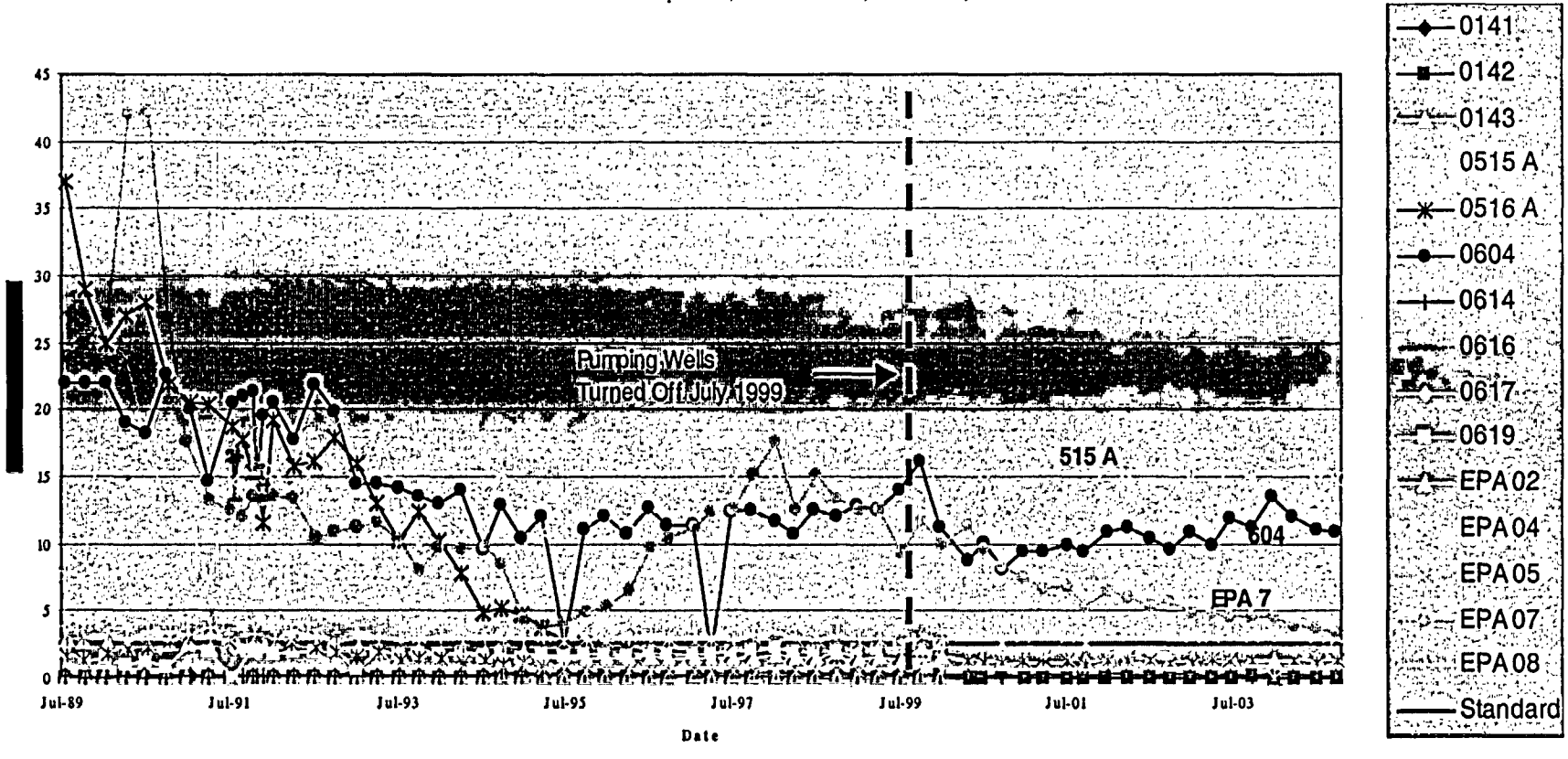


Zone 3 manganese 1989 to October 2004



Zone 1 manganese 1989 to October 2004

FIGURE 52
Zone 1 Manganese Concentrations Over Time
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico



Summary of Keypoints

Well SBL 1 is key for closing several open issues

- Mn background.
- Sulfate and TDS TI.

- "Sulfate, TDS and Mn should not be used as a basis for Corrective Action"
  - *NRC August 1996*

POC wells in SWA meet standards

- Exceptions only at 632 and only for chloroform, combined Ra.
- 632 is surrounded by other POC wells.
- Equivalent performance whether or not wells are pumped.

Chloroform

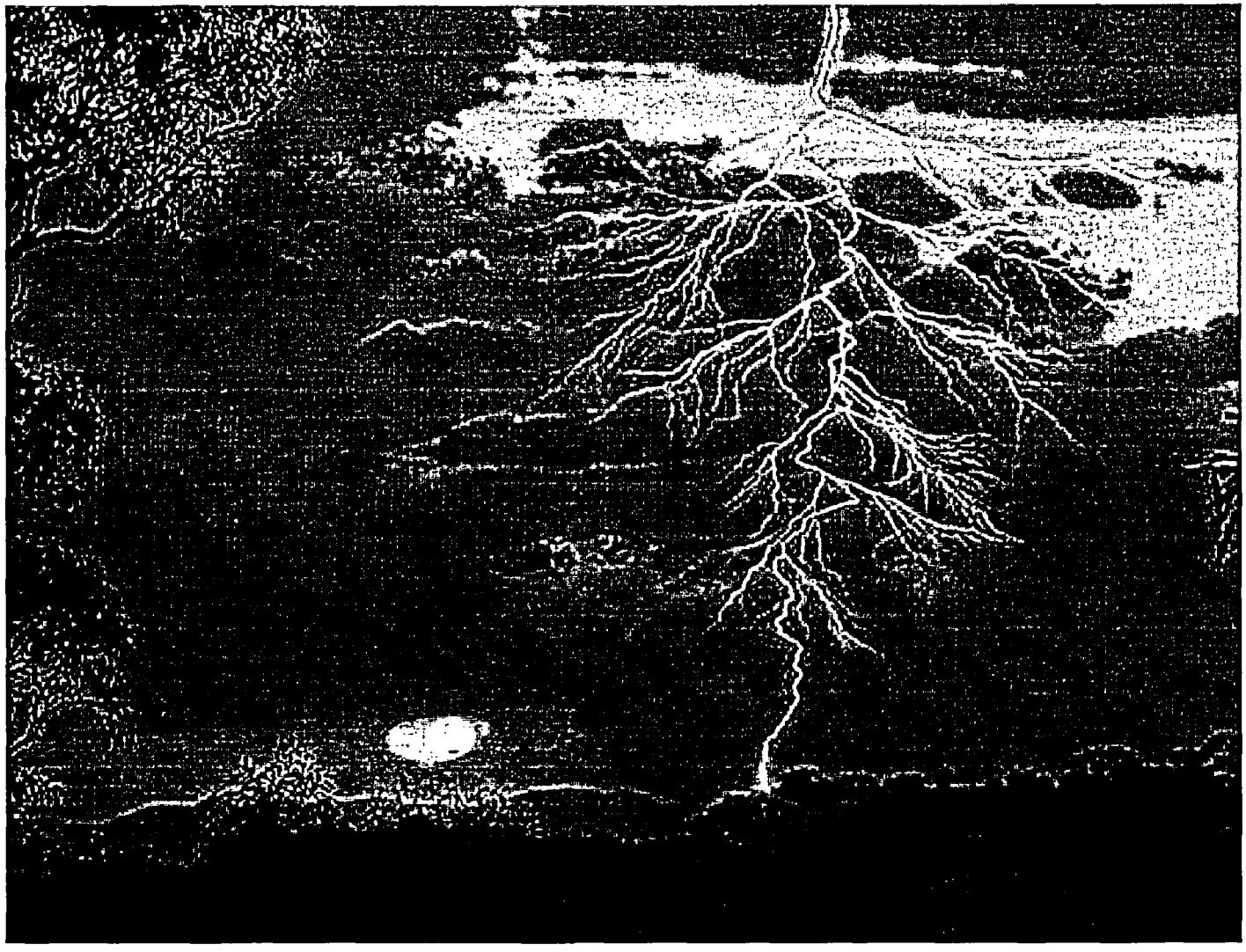
- ? Rapidly attenuates in all zones
  - ? Downgrad decreases with distance from cells well established by data, even in absence of pumping.
  - ? No potential for exposure – has been, is, and extremely likely to continue to be confined to area titled over to DOE for LT surveillance monitoring.
- ? Meets Federal MCL everywhere.
- ? Declining in Zone 1.
- ? Stable in SWA
  - ? 808 and 802 increases likely reflect absence of former pumping well dilution from radial inflow.

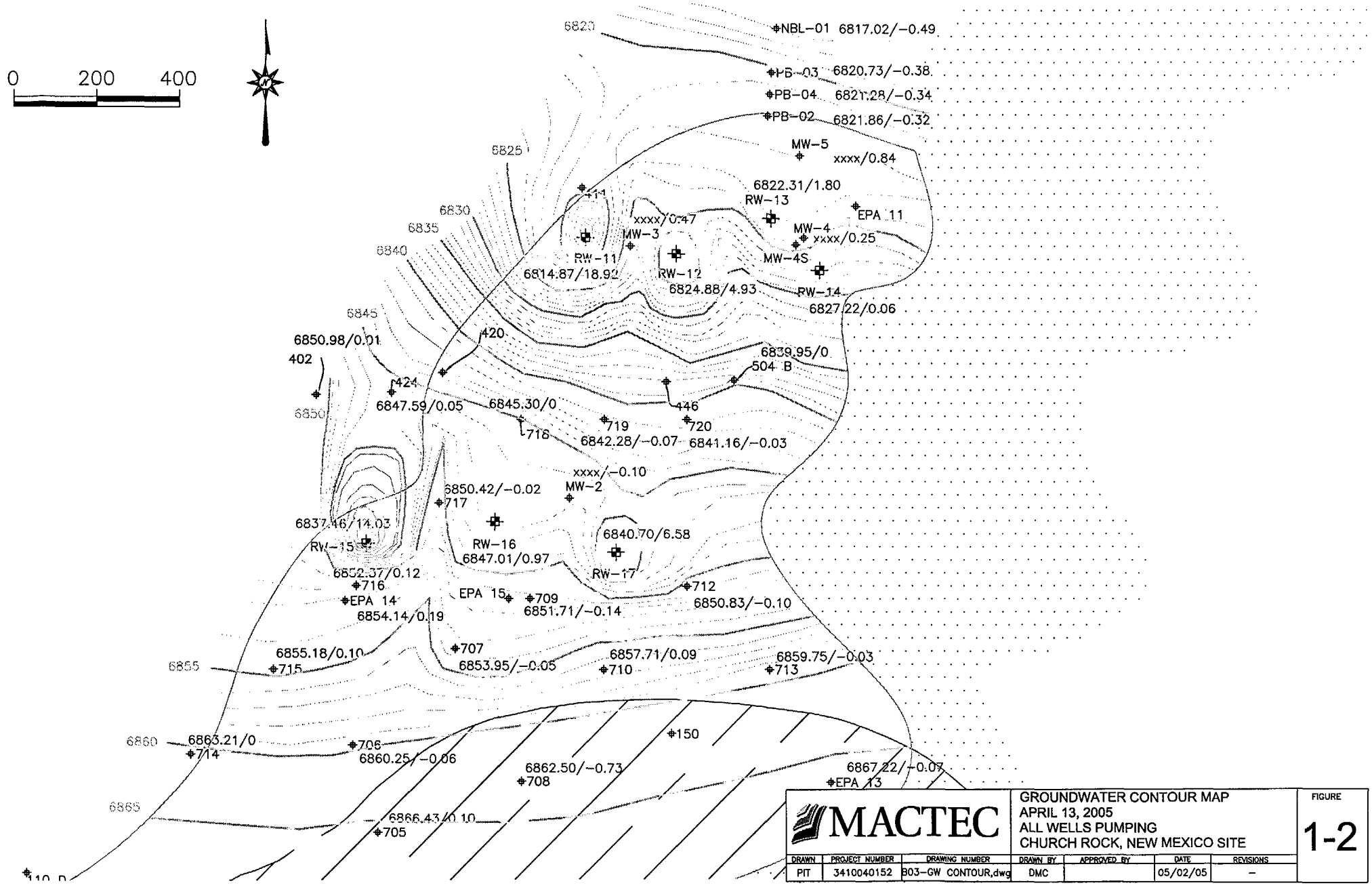
Revise combined Ra standard based on realistic background

- ? New wells and careful review of historic data make this possible and necessary.

Zone 1 POC wells meet site standards with few exceptions

- Combined Ra and chloroform as discussed earlier.
- The exceptions are improving under non-pumping conditions.



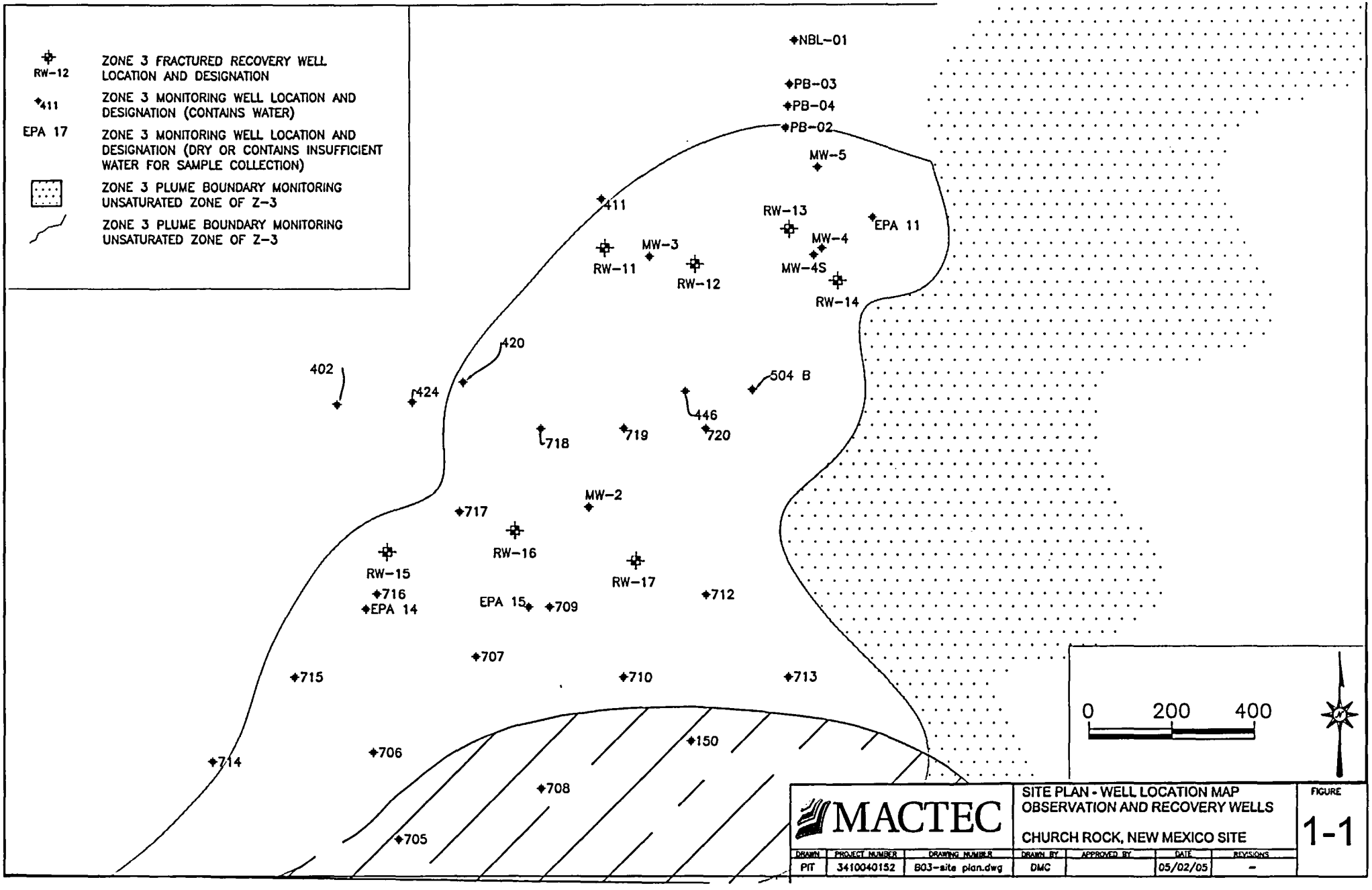


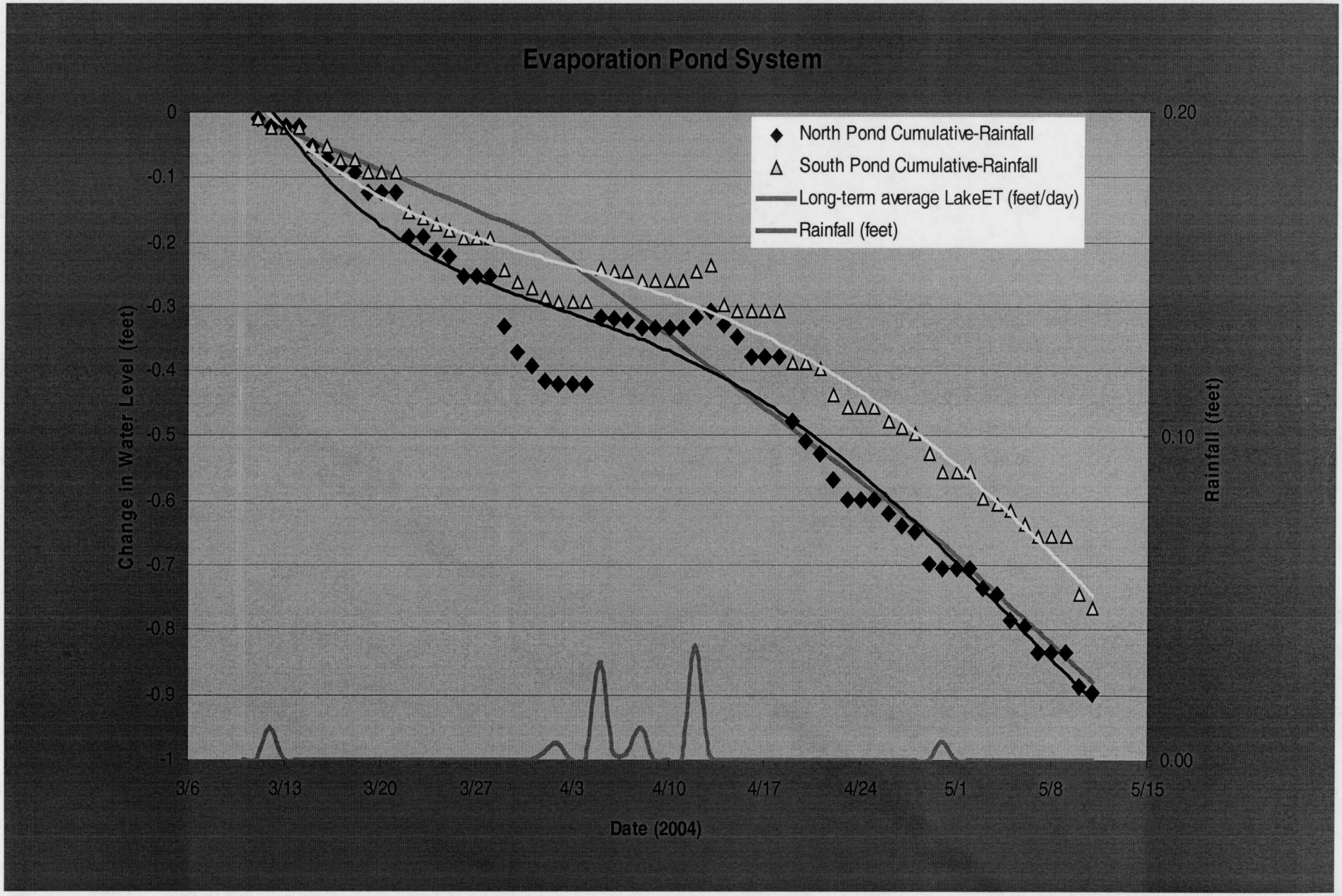
MACTEC

GROUNDWATER CONTOUR MAP
APRIL 13, 2005
ALL WELLS PUMPING
CHURCH ROCK, NEW MEXICO SITE

FIGURE 1-2

DRAWN	PROJECT NUMBER	DRAWING NUMBER	DRAWN BY	APPROVED BY	DATE	REVISIONS
PIT	3410040152	803-GW CONTOUR.dwg	DMC		05/02/05	–


RW-12
ZONE 3 FRACTURED RECOVERY WELL LOCATION AND DESIGNATION
411
ZONE 3 MONITORING WELL LOCATION AND DESIGNATION (CONTAINS WATER)
EPA 17
ZONE 3 MONITORING WELL LOCATION AND DESIGNATION (DRY OR CONTAINS INSUFFICIENT WATER FOR SAMPLE COLLECTION)
ZONE 3 PLUME BOUNDARY MONITORING UNSATURATED ZONE OF Z-3
ZONE 3 PLUME BOUNDARY MONITORING UNSATURATED ZONE OF Z-3
NBL-01
PB-03
PB-04
PB-02
MW-5
411
RW-13
EPA 11
MW-3
MW-4
RW-11
RW-12
MW-4S
RW-14
420
402
504 B
424
446
718
719
720
MW-2
717
RW-16
RW-15
RW-17
716
712
EPA 14
EPA 15
709
707
715
710
713
0
200
400
150
714
706
708
705
MACTEC
SITE PLAN - WELL LOCATION MAP
OBSERVATION AND RECOVERY WELLS
CHURCH ROCK, NEW MEXICO SITE
FIGURE
1-1
DRAWN
PIT
PROJECT NUMBER
3410040152
DRAWING NUMBER
B03-site plan.dwg
DRAWN BY
DMC
APPROVED BY
DATE
05/02/05
REVISIONS
-



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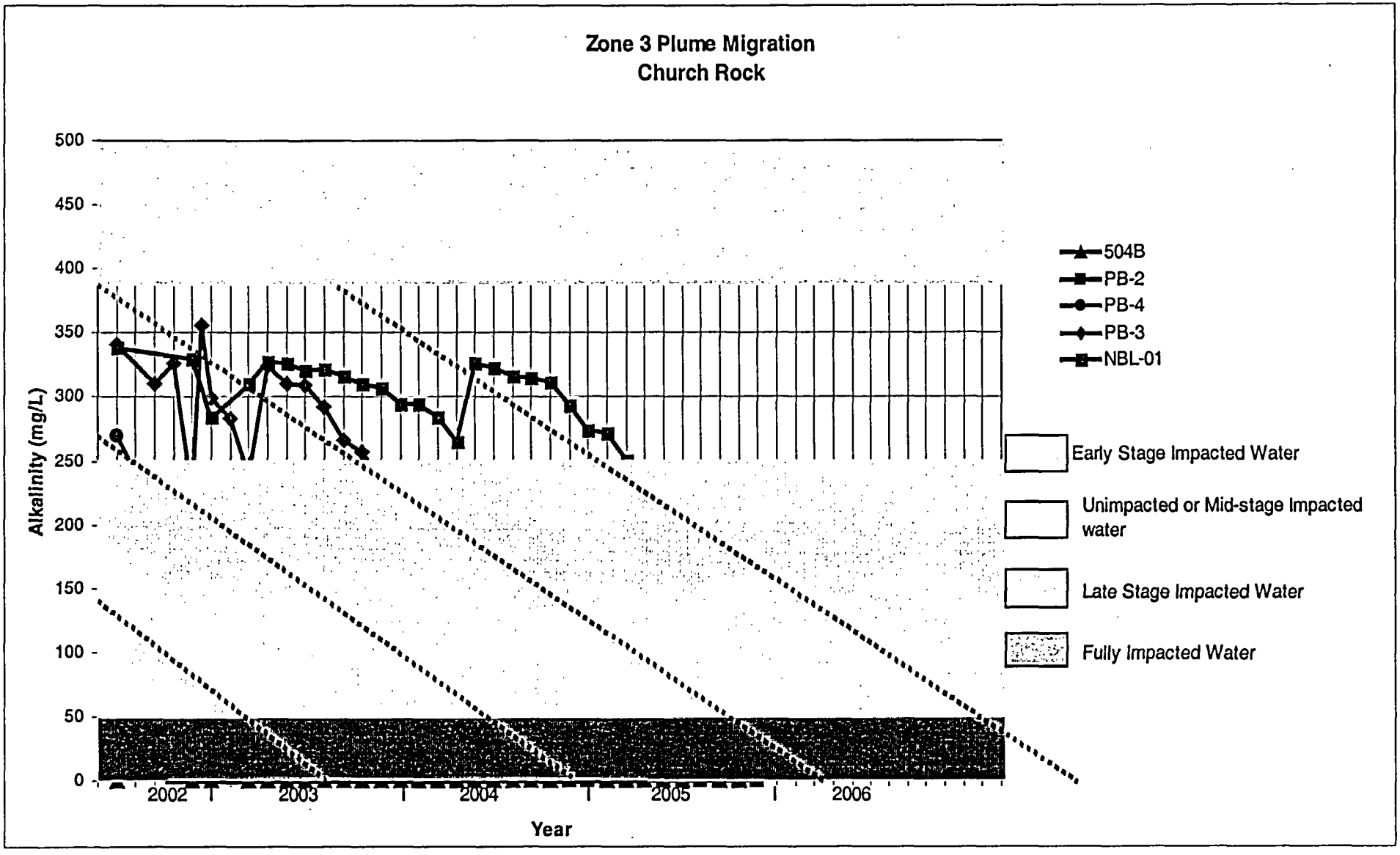


UNC Church Rock
06/17/2005

Uranium species stability

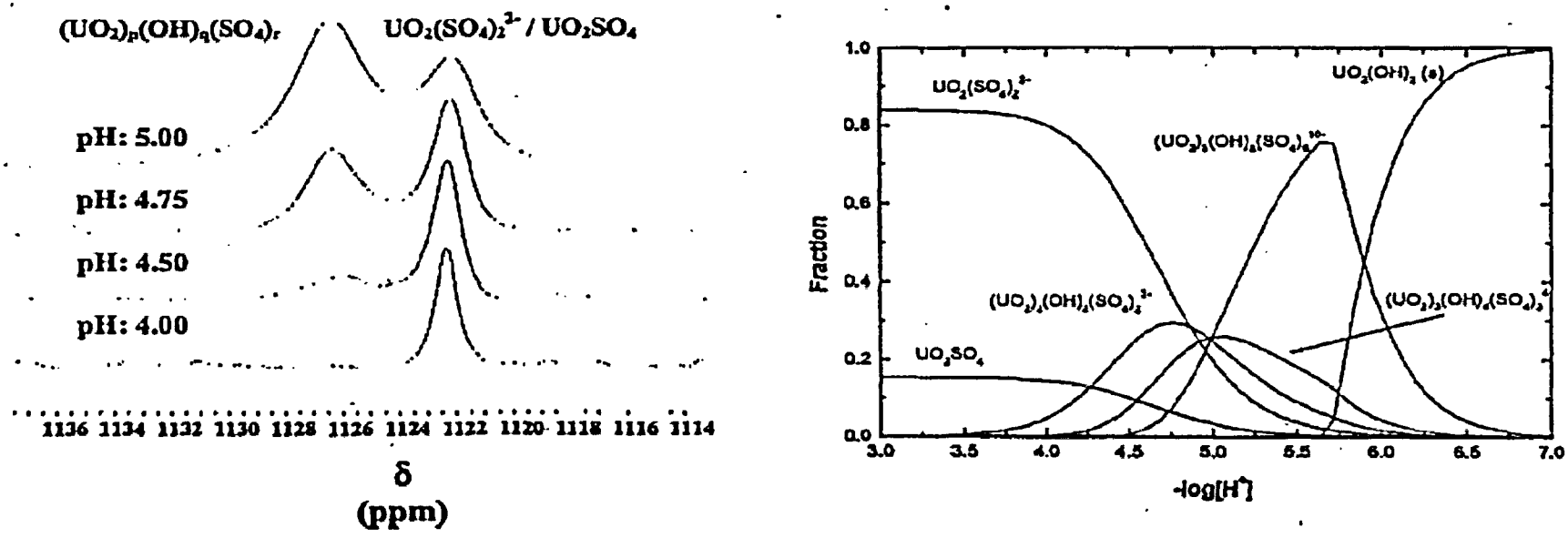


Figure 2: ^{17}O-NMR spectra and the distribution diagram for solutions of $[UO_2^{2+}]_{total}$: 0.05 M, $[SO_4^{2-}]$: 0.5 M at 25 °C and varying -log[H^+] from 4.0 to 5.0.

Moll, H., et. Al. (September 1999) Project Group ESRF-Beamline (ROBL-CRG), FZR-275. Solution Coordination Chemistry of Uranium in the Binary UO_2^+ - $SO_4^=$ and the ternary UO_2^+ - $SO_4^=$ - OH^- System

Principal governing reaction:

$$\underset{\text{(Calcite)}}{CaCO_3} + \underset{\text{(Acid)}}{H^+} + \underset{\text{(Sulfate)}}{SO_4^{2-}} + \underset{\text{(Water)}}{2H_2O} \;? \quad \underset{\text{(Gypsum)}}{CaSO_4 \bullet 2H_2O} + \underset{\text{(Alkalinity)}}{HCO_3^-}$$

Reaction 1:

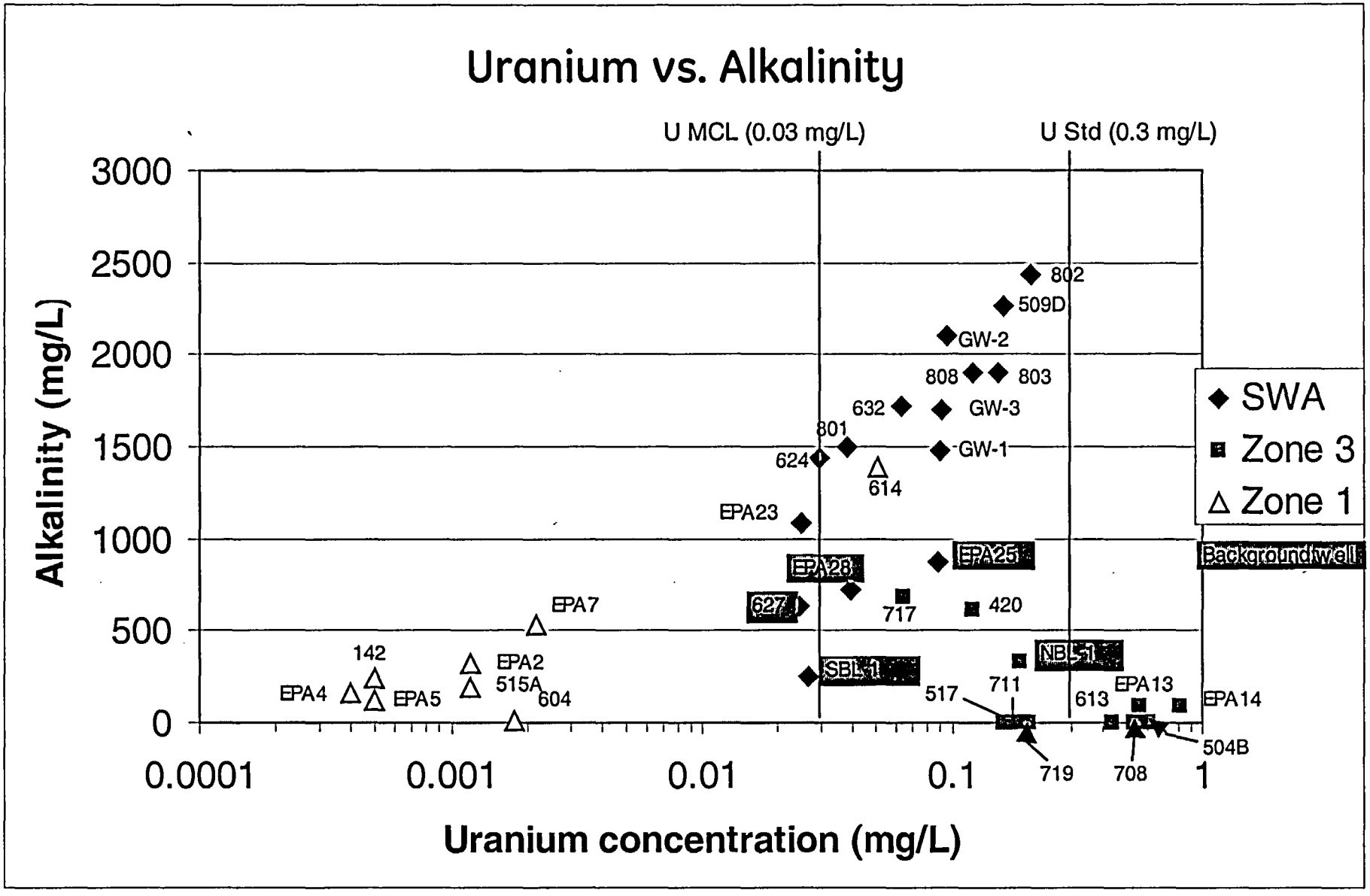
$$UO_2(SO4)_3^{4-}\ (aq) \quad ? \quad UO_2^{2+}(aq) + 3SO_4^{2-}\ (aq)$$

Reaction 2:

$$UO_2^{2+}(aq) + H_2O \quad ? \quad UO_3(s) + 2H^+$$

or

$$UO_2^{2+}(aq) + 2H_2O \quad ? \quad UO_2(OH)2(s) + 2H^+$$



UNC Church Rock
06/17/2005

Would revising the cleanup goals for Uranium matter at Church Rock?

- Zone 1 essentially meets Federal MCL and NM MCL
  - Only "new" exceedance would be at well 614 where concentrations have remained stable over long-term and attenuation prevents migration
- Remedial activity in Zone 3 will not be affected
  - Zone 3 does not meet current ROD Standard, Fed MCL or NM MCL throughout region of plume
  - Other regulated constituents do not meet standards either
  - Therefore, plume size and management not affected by differing uranium cleanup criteria
  - Background uranium concentrations are greater than the Fed and State MCLs and would have to be factored into a revised site standard
- Uranium concentrations stable in SWA
  - For almost 20 years
  - With or without pumping
  - Background uranium concentrations are greater than the Fed and State MCLs and would have to be factored into a revised site standard
    - minewater discharges permitted up to 2 ppm of uranium
    - Abundant analyses of uranium concentrations in minewater
-

Only if the goal is to completely desaturate the SWA

- There is no other technology that would result in the attainment of revised cleanup goals
  - recognized in the 1989 ROD
- It is uncertain if natural attenuation will ultimately hold the line at more stringent cleanup levels
  - Natural attenuation works under the current cleanup goals
  - Cleanup goals would currently be exceeded at the property boundary using the new MCL, but for how far away from site and how long into the future?
- At virtually any location and at any time there is a likelihood of exceeding the Fed MCL

The NCP . . .

- There would have to be a formal revision to the ROD that would
  - Justify the adoption of stricter cleanup goals to be protective of human health and the environment
  - Carefully prepare a statistical representation of background

Uranium species stability

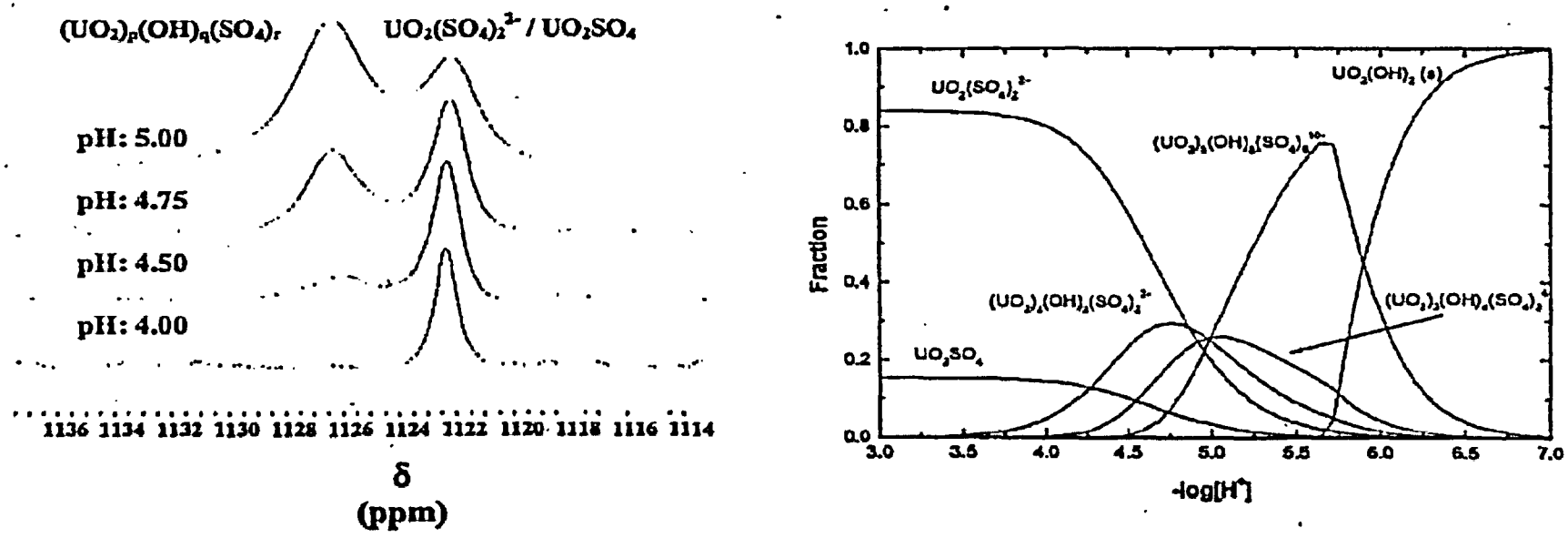


Figure 2: ^{17}O-NMR spectra and the distribution diagram for solutions of $[UO_2^{2+}]_{total}$: 0.05 M, $[SO_4^{2-}]$: 0.5 M at 25 °C and varying -log[H^+] from 4.0 to 5.0.

Moll, H., et. Al. (September 1999) Project Group ESRF-Beamline (ROBL-CRG), FZR-275. Solution Coordination Chemistry of Uranium in the Binary UO_2^+ - $SO_4^=$ and the ternary UO_2^+ - $SO_4^=$ - OH^- System

Principal governing reaction:

$$\underset{\text{(Calcite)}}{CaCO_3} + \underset{\text{(Acid)}}{H^+} + \underset{\text{(Sulfate)}}{SO_4^{2-}} + \underset{\text{(Water)}}{2H_2O} \;? \quad \underset{\text{(Gypsum)}}{CaSO_4 \bullet 2H_2O} + \underset{\text{(Alkalinity)}}{HCO_3^-}$$

Reaction 1:

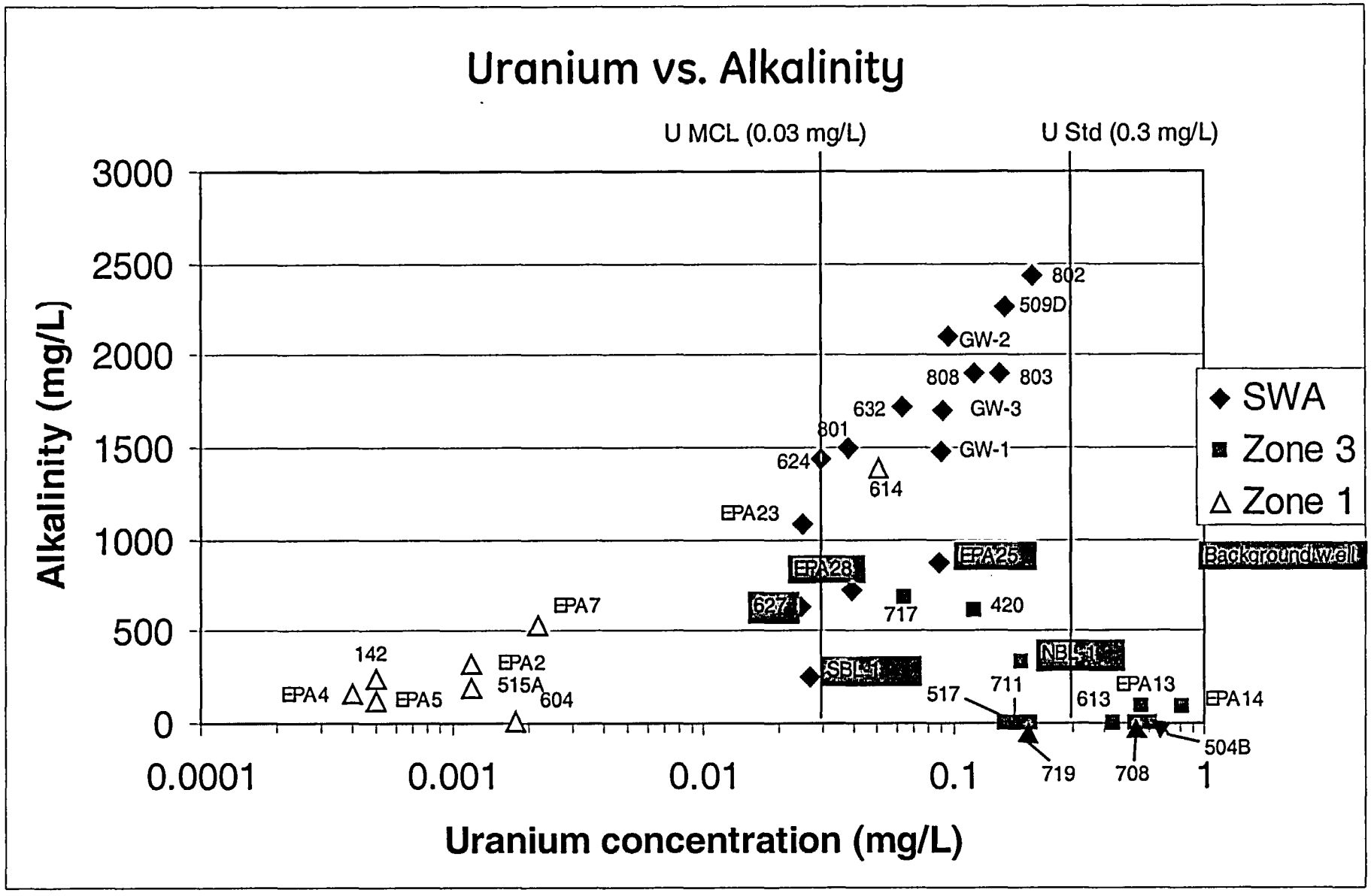
$$UO_2(SO4)_3^{4-}\ (aq) \quad ? \quad UO_2^{2+}(aq) + 3SO_4^{2-}\ (aq)$$

Reaction 2:

$$UO_2^{2+}(aq) + H_2O \quad ? \quad UO_3(s) + 2H^+$$

or

$$UO_2^{2+}(aq) + 2H_2O \quad ? \quad UO_2(OH)2(s) + 2H^+$$



UNC Church Rock
06/17/2005

Would revising the cleanup goals for Uranium matter at Church Rock?

- Zone 1 essentially meets Federal MCL and NM MCL
  - Only "new" exceedance would be at well 614 where concentrations have remained stable over long-term and attenuation prevents migration
- Remedial activity in Zone 3 will not be affected
  - Zone 3 does not meet current ROD Standard, Fed MCL or NM MCL throughout region of plume
  - Other regulated constituents do not meet standards either
  - Therefore, plume size and management not affected by differing uranium cleanup criteria
  - Background uranium concentrations are greater than the Fed and State MCLs and would have to be factored into a revised site standard
- Uranium concentrations stable in SWA
  - For almost 20 years
  - With or without pumping
  - Background uranium concentrations are greater than the Fed and State MCLs and would have to be factored into a revised site standard
    - minewater discharges permitted up to 2 ppm of uranium
    - Abundant analyses of uranium concentrations in minewater
-

Only if the goal is to completely desaturate the SWA

- There is no other technology that would result in the attainment of revised cleanup goals
  - recognized in the 1989 ROD
- It is uncertain if natural attenuation will ultimately hold the line at more stringent cleanup levels
  - Natural attenuation works under the current cleanup goals
  - Cleanup goals would currently be exceeded at the property boundary using the new MCL, but for how far away from site and how long into the future?
- At virtually any location and at any time there is a likelihood of exceeding the Fed MCL

The NCP . . .

- There would have to be a formal revision to the ROD that would
  - Justify the adoption of stricter cleanup goals to be protective of human health and the environment
  - Carefully prepare a statistical representation of background

Agenda

- Summarize initial pilot test
- Review pilot test scale-up program
- Discuss results
  - Frac/Pinnacle
  - Hydrogeological
- Effectiveness monitoring
- Questions

Remedial Objectives

- Primary objective: to prevent migration of impacted groundwater past the UNC property boundary.
- Secondary objective: to dewater the impacted portion of the Z-3, to the extent possible, realizing that it is unlikely all impacted groundwater can be removed by any technology.
- Project will be phased.

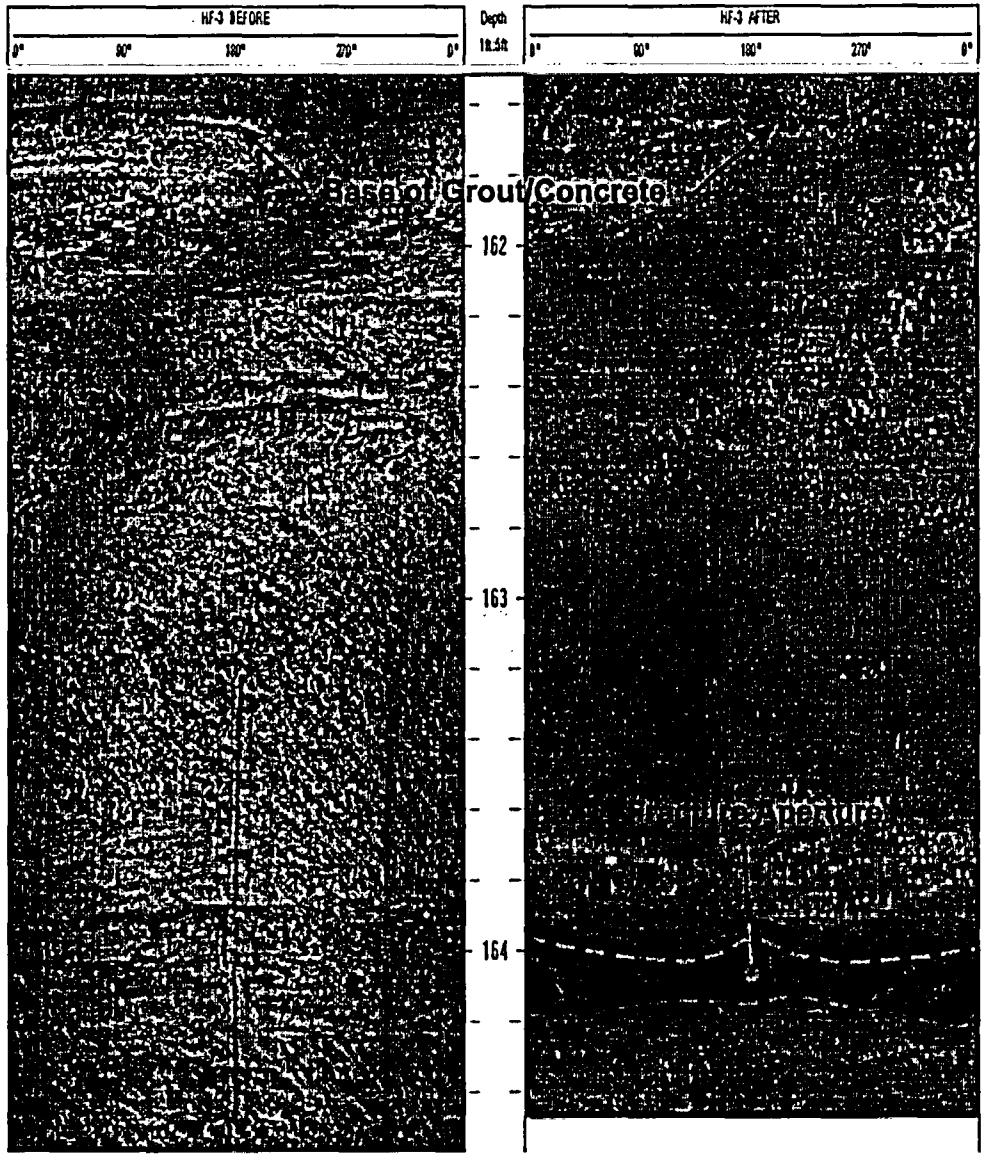
INITIAL PILOT TEST

Summary

- Induced fracture was successfully propagated; mostly horizontal; 35-45 feet radius from wellbore.
- Results indicated that open hole frac was more successful.

Summary (cont.)

- Hydrogeologic results indicated:
  - Significant increase in well efficiency.
  - K increased by a factor of 2 at frac well.
  - Significant increase in safe yield in frac well.
  - Distance drawdown evaluation indicates almost an order of magnitude increase in cone of depression after hydraulic fracturing.
- Initial pilot test appeared to be a success


HF-3 BEFORE
0°
90°
180°
270°
0°
Depth
HF-3 AFTER
0°
90°
180°
270°
0°
Base of Grout/Concrete
162
163
164

PILOT TEST SCALE-UP

Scale-Up Objectives

- Provide hydrodynamic control to retard/halt advancement of the main body of the plume to the north through installation of extraction wells near the leading edge of the plume.
- Allow the formation's remaining buffering capacity to naturally attenuate impacted groundwater that is not captured by the extraction wells.
- Initiate dewatering in the main body of the plume in an area of good saturated thickness though installation of additional extraction wells.

General Approach

- Four recovery were installed near the northern limits of the plume. Three additional recovery wells were installed south of an area within the plume where a significant number of existing monitoring wells are present. All 7 recovery wells were hydraulically fractured.

Methods

- Prior to the completion of hydraulic fracturing of recovery wells, existing monitoring wells located within 100 feet of a recovery well were sealed with a high quality cement job.
- Open-hole hydraulic fracturing was completed at each well in a similar fashion to the Stage 1 treatment conducted during the pilot test.

Methods (continued)

- To monitor the growth and coverage of the induced hydraulic fractures, Pinnacle Technologies was contracted to set up an array of surface tilt meters, similar to the pilot test.

System Operation

- Following completion of the hydraulic fracturing, four monitoring wells were installed to assess the performance of the pumping system. The monitoring wells are open only to the Z-3 aquifer to monitor drawdown created by the recovery wells.
- Existing Z-3 wells were also monitored.

REVIEW RESULTS

- Frac data/Pinnacle data
- Hydrogeological data

Fracture Program Results

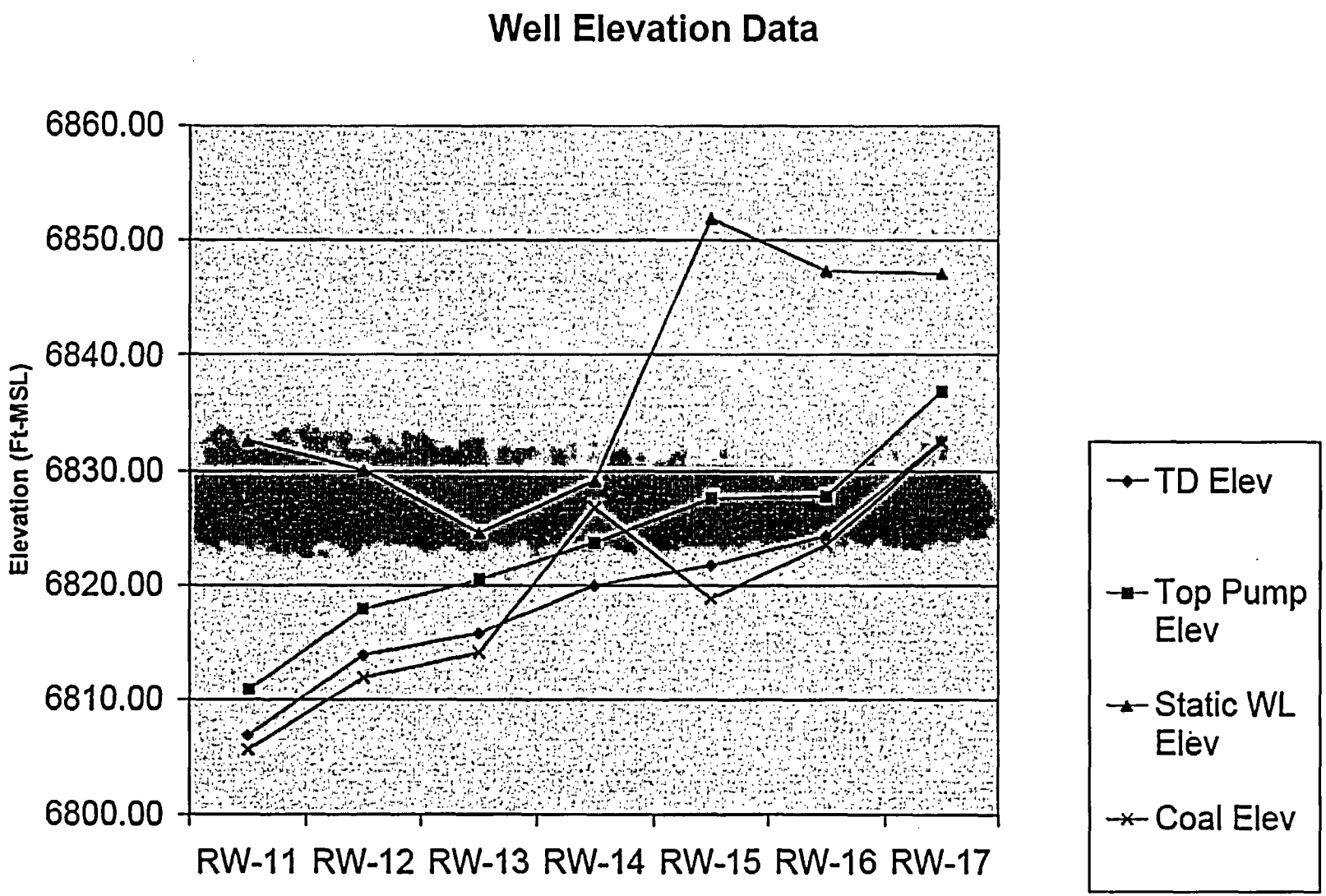
Well	Open Interval (ft. bgs)	Sand (lbs.)	Fracture Depth (+- 20 ft.)	Ave. Pumping Rate (gpm)
RW-11	171-175	9,540	H 150 ft. H 95 ft.	1.3
RW-12	169-173	7,500	H 100 ft.	1.05
RW-13	169-173	31,540	H 160 ft.	2.03
RW-14	164-168	21,000	H 145 ft.	N/A

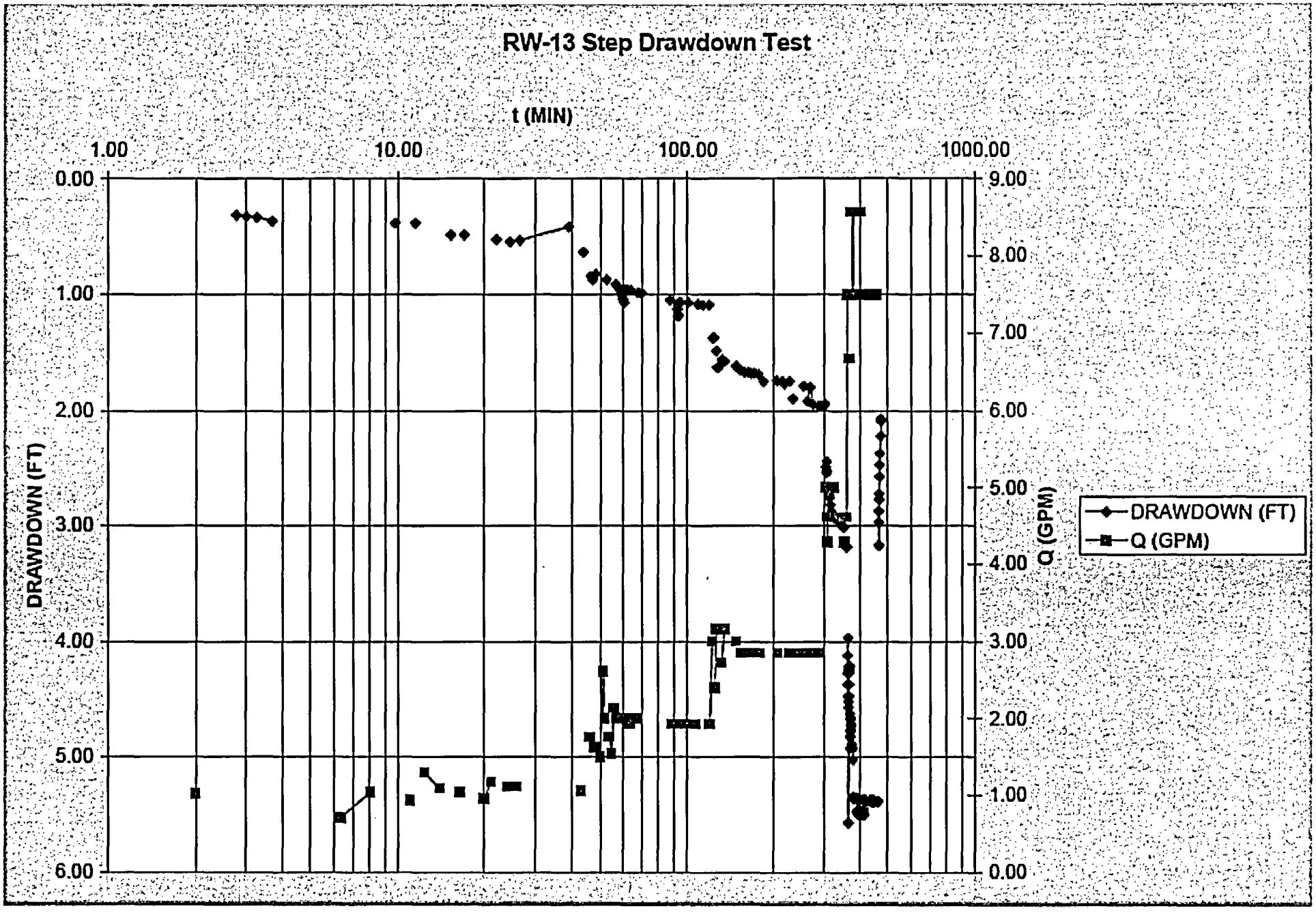
Fracture Program Results (cont.)

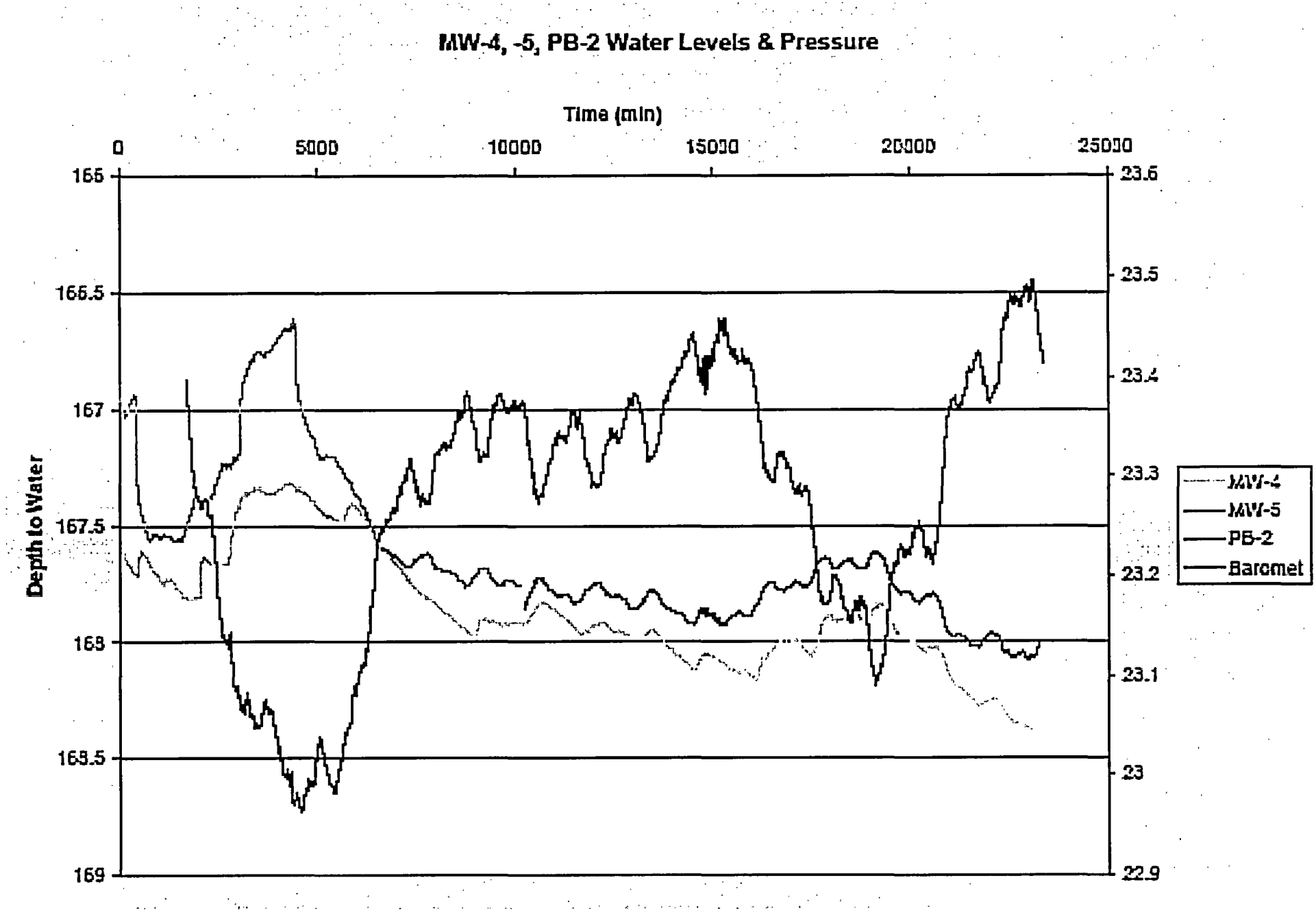
Well	Open Interval (ft. bgs)	Sand (lbs.)	Fracture Depth (+- 20 ft.)	Ave. Pumping Rate (gpm)
RW-15	140-144	10,570 (2 stages)	V 130 ft. H 50 ft.	2.58
RW-16	149-152	27,667	H 130 ft.	2.57
RW-17	174-180	11,554 (2 stages)	H 130 ft. V 60 ft.	1.3

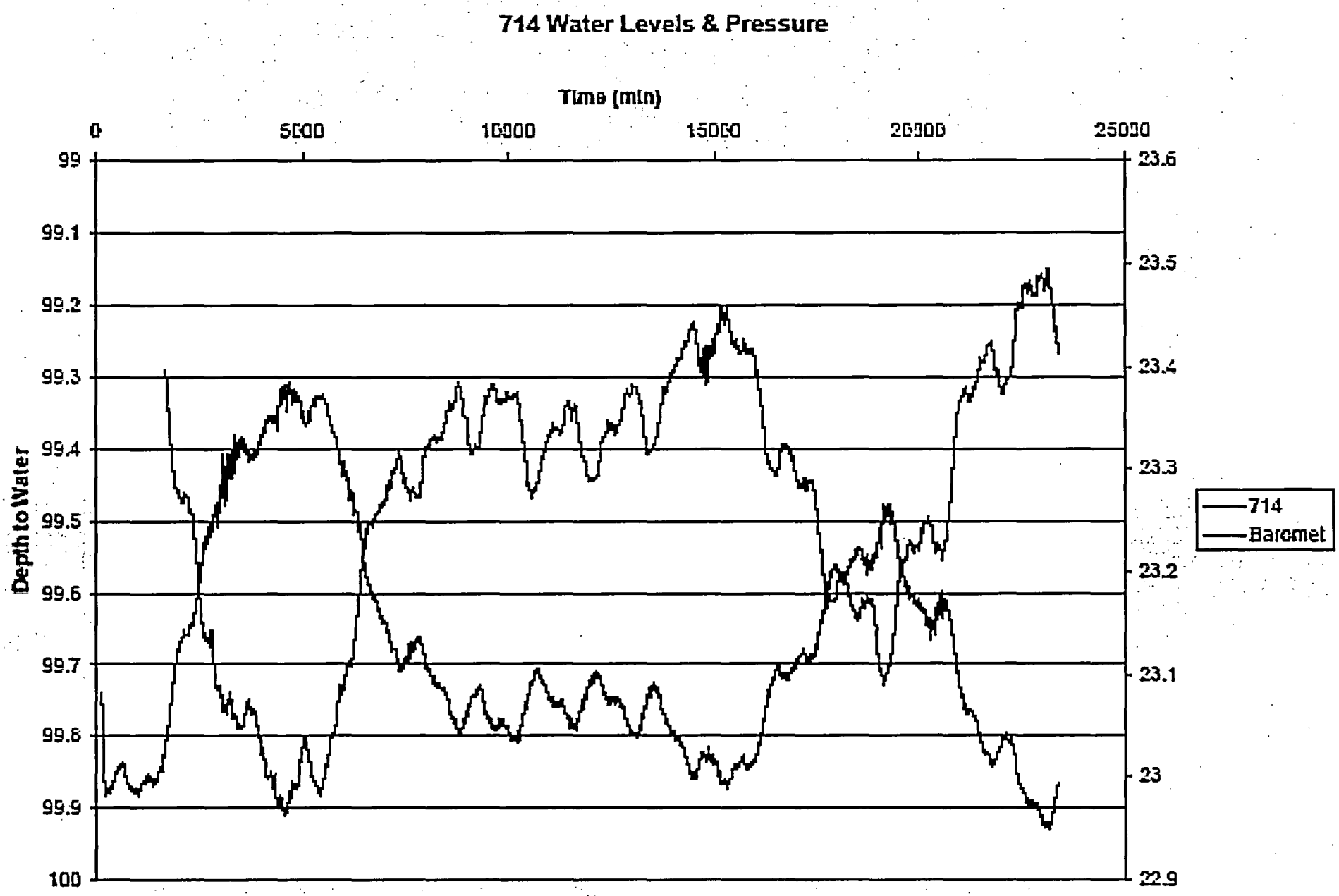
Hydrogeologic Evaluation

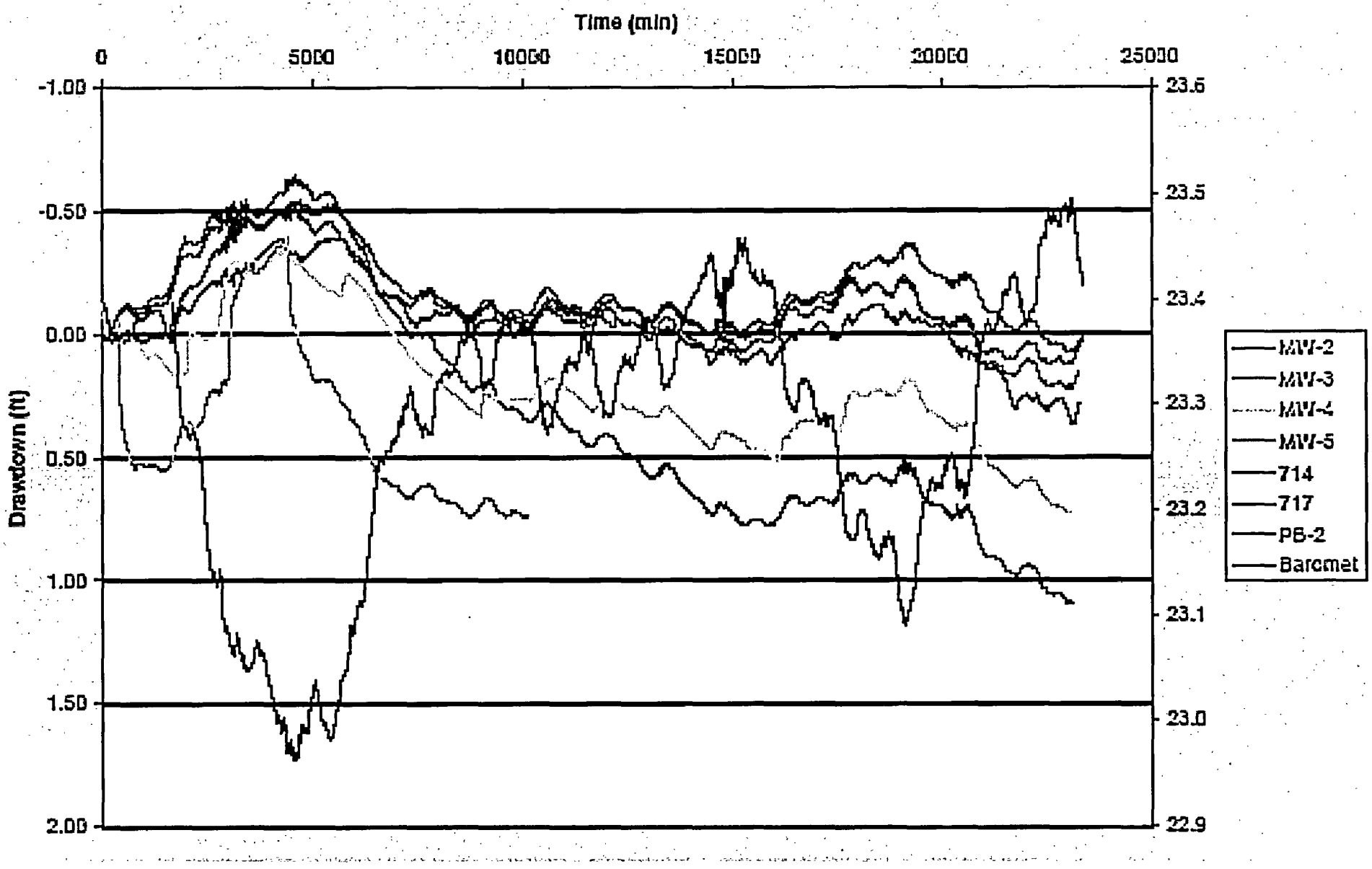
- Completed step drawdown tests to establish target pumping rates.
- Complete round of pre-pumping water levels.
- Transducers installed in MWs.
- Barometric pressure data logging.
- Started pumping systematically (RW-13 started first).
- Conducted test for one week.

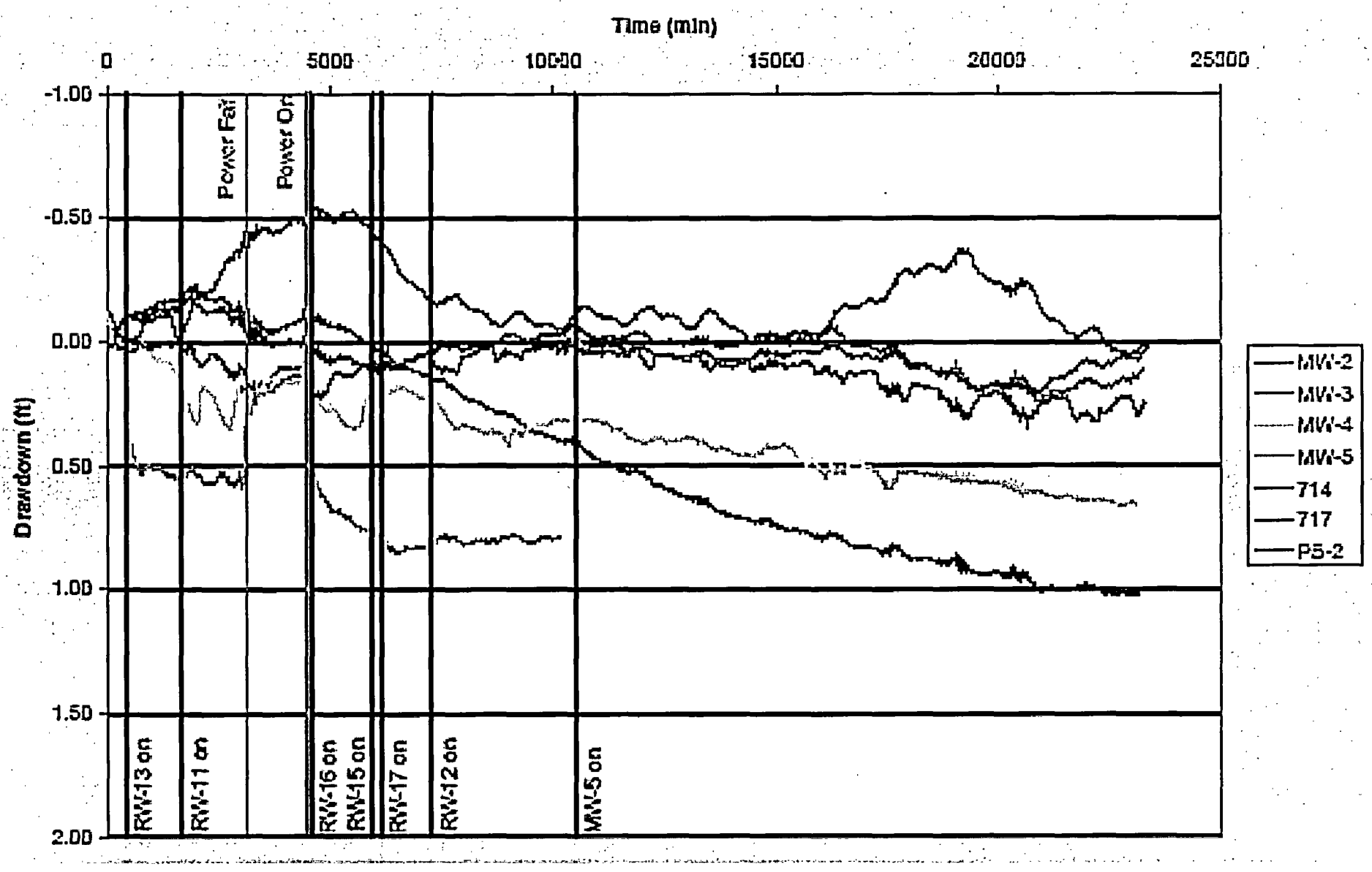

Well Elevation Data
Elevation (Ft-MSL)
6860.00
6850.00
6840.00
6830.00
6820.00
6810.00
6800.00
RW-11
RW-12
RW-13
RW-14
RW-15
RW-16
RW-17
TD Elev
Top Pump Elev
Static WL Elev
Coal Elev


RW-13 Step Drawdown Test
t (MIN)
1.00
10.00
100.00
1000.00
DRAWDOWN (FT)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Q (GPM)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
DRAWDOWN (FT)
Q (GPM)

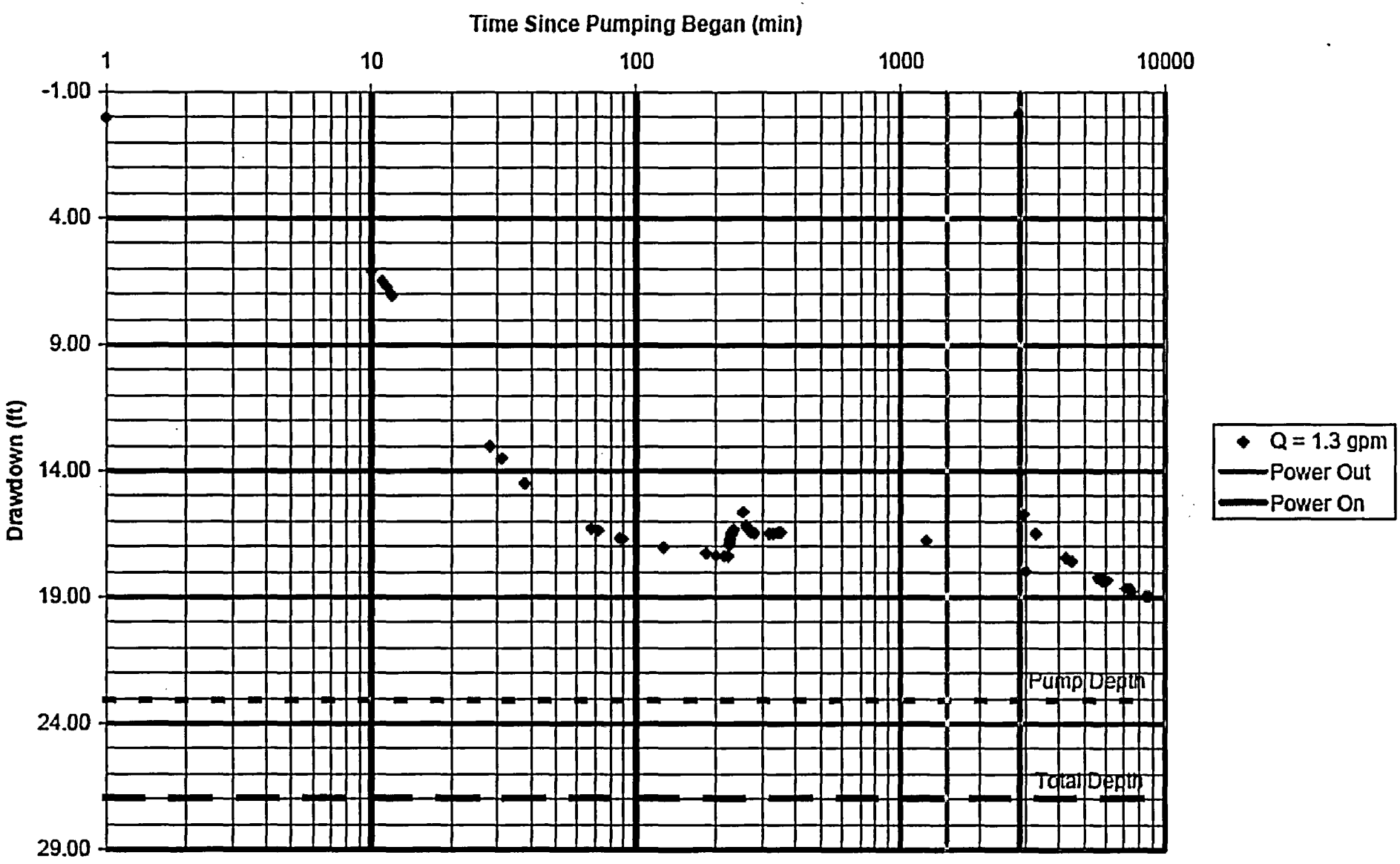

MW-4, -5, PB-2 Water Levels & Pressure
Time (min)
0
5000
10000
15000
20000
25000
Depth to Water
165
165.5
167
167.5
168
168.5
169
23.6
23.5
23.4
23.3
23.2
23.1
23
22.9
MW-4
MW-5
PB-2
Baromet


714 Water Levels & Pressure
Time (min)
0
5000
10000
15000
20000
25000
Depth to Water
99
99.1
99.2
99.3
99.4
99.5
99.6
99.7
99.8
99.9
100
23.6
23.5
23.4
23.3
23.2
23.1
23
22.9
714
Baromet

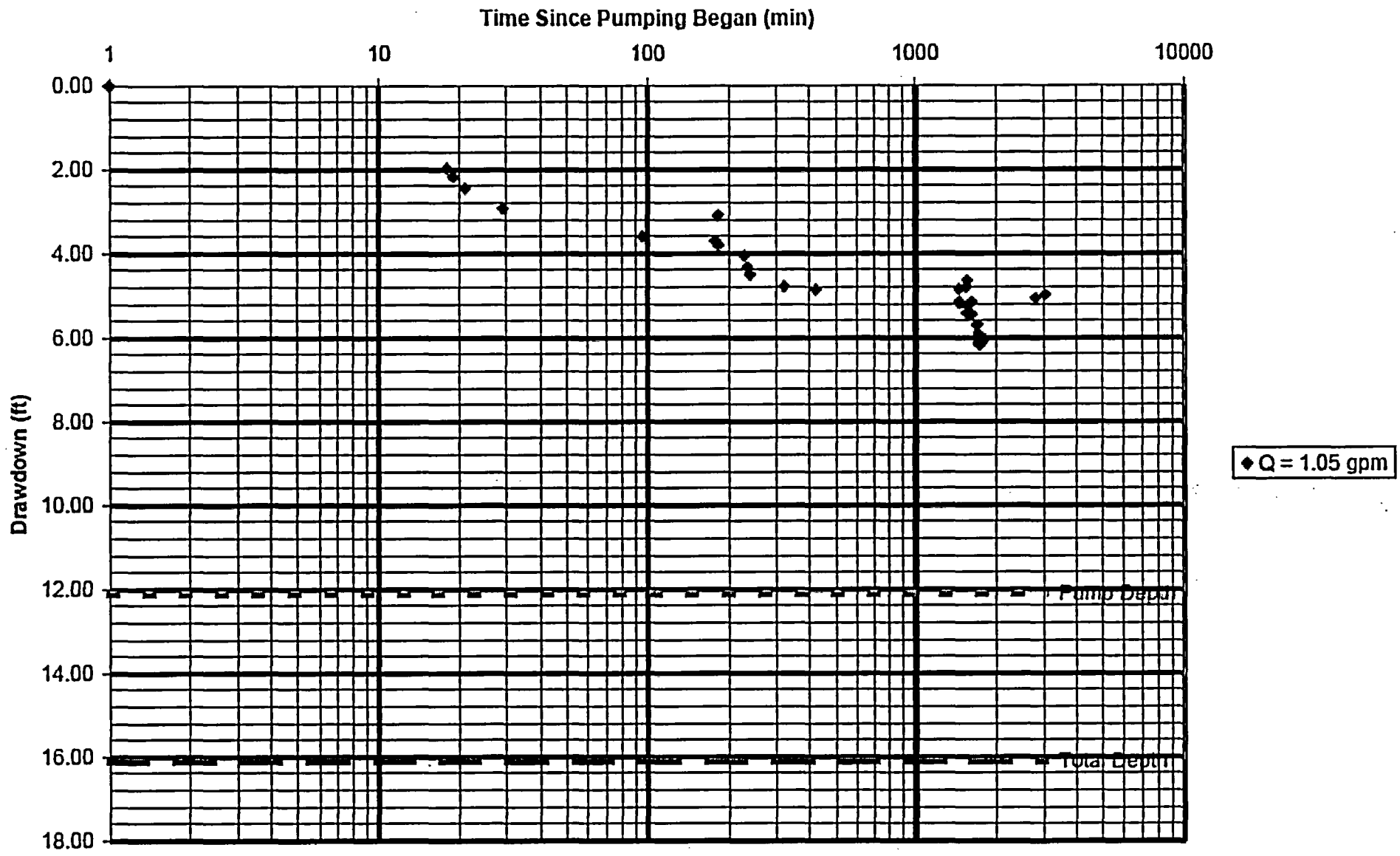

Uncorrected Drawdown & Pressure
Time (min)
0
5000
10000
15000
20000
25000
-1.00
-0.50
0.00
0.50
1.00
1.50
2.00
Drawdown (ft)
23.6
23.5
23.4
23.3
23.2
23.1
23.0
22.9
MW-2
MW-3
MW-4
MW-5
714
717
PB-2
Baromet


Corrected Drawdown
Time (min)
0
5000
10000
15000
20000
25000
Drawdown (ft)
-1.00
-0.50
0.00
0.50
1.00
1.50
2.00
Power Fail
Power On
RW-13 on
RW-11 on
RW-16 on
RW-15 on
RW-17 on
RW-12 on
MW-5 on
MW-2
MW-3
MW-4
MW-5
714
717
P5-2

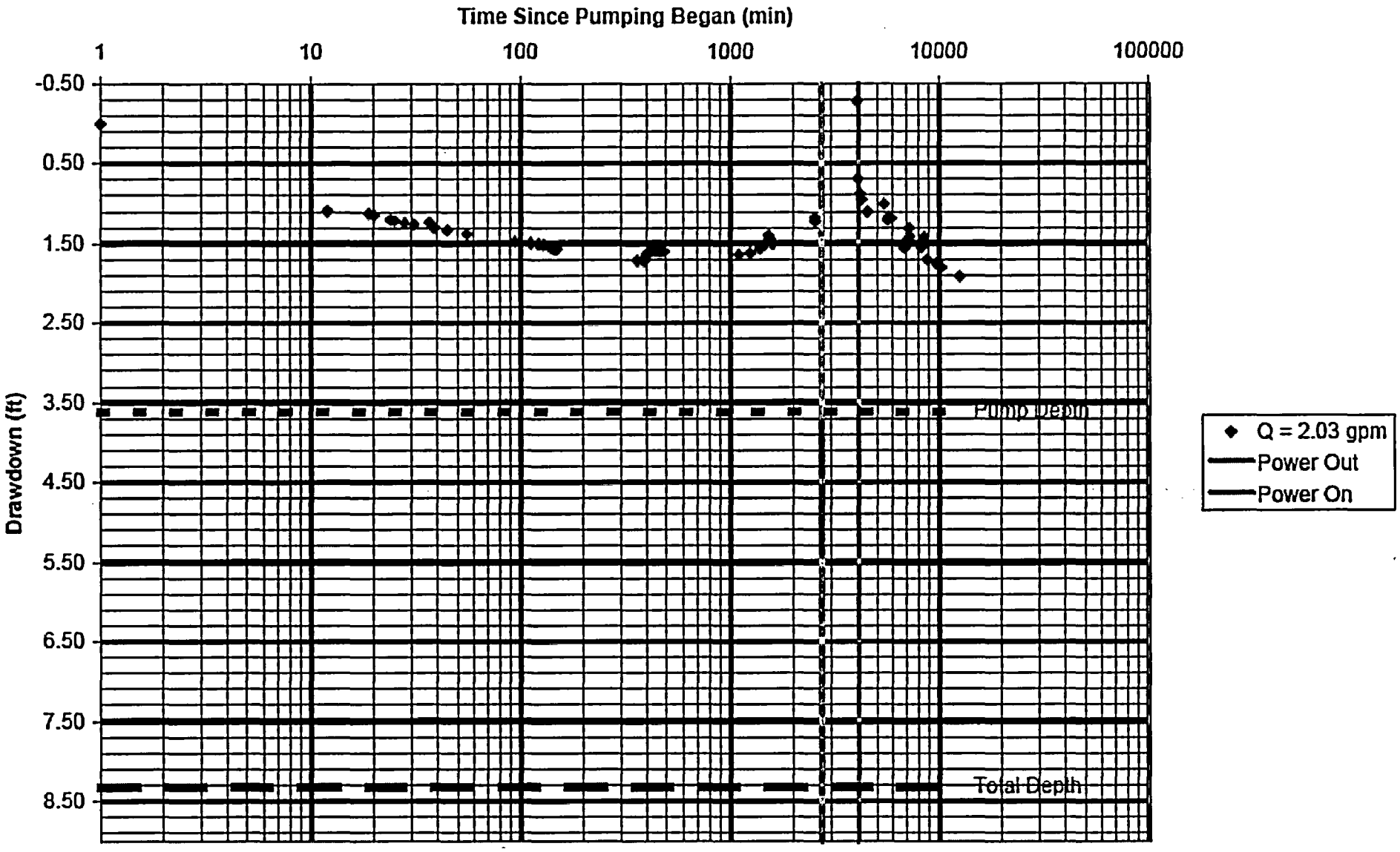
RW-11 Time_Drawdown



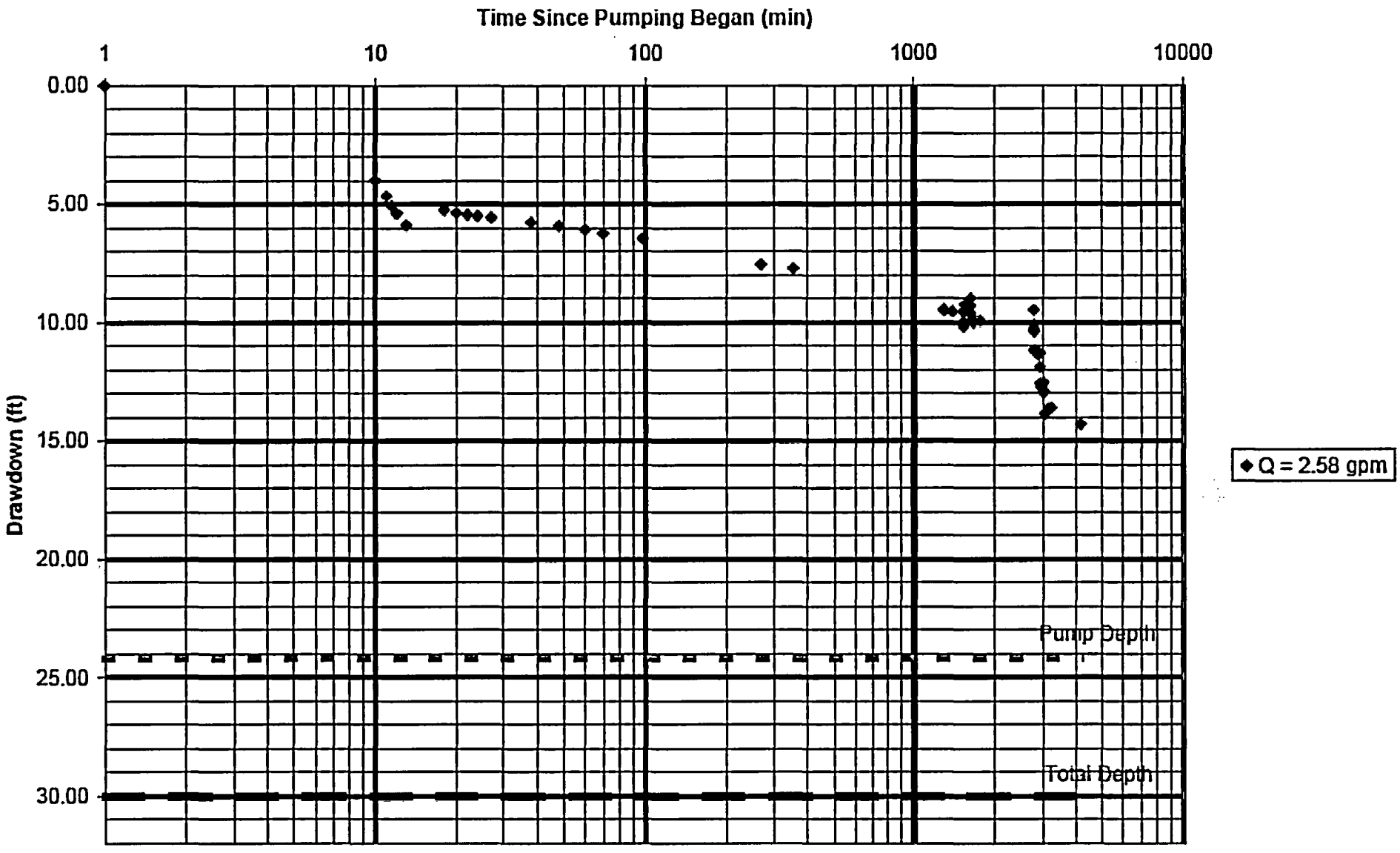
RW-12 Time_Drawdown



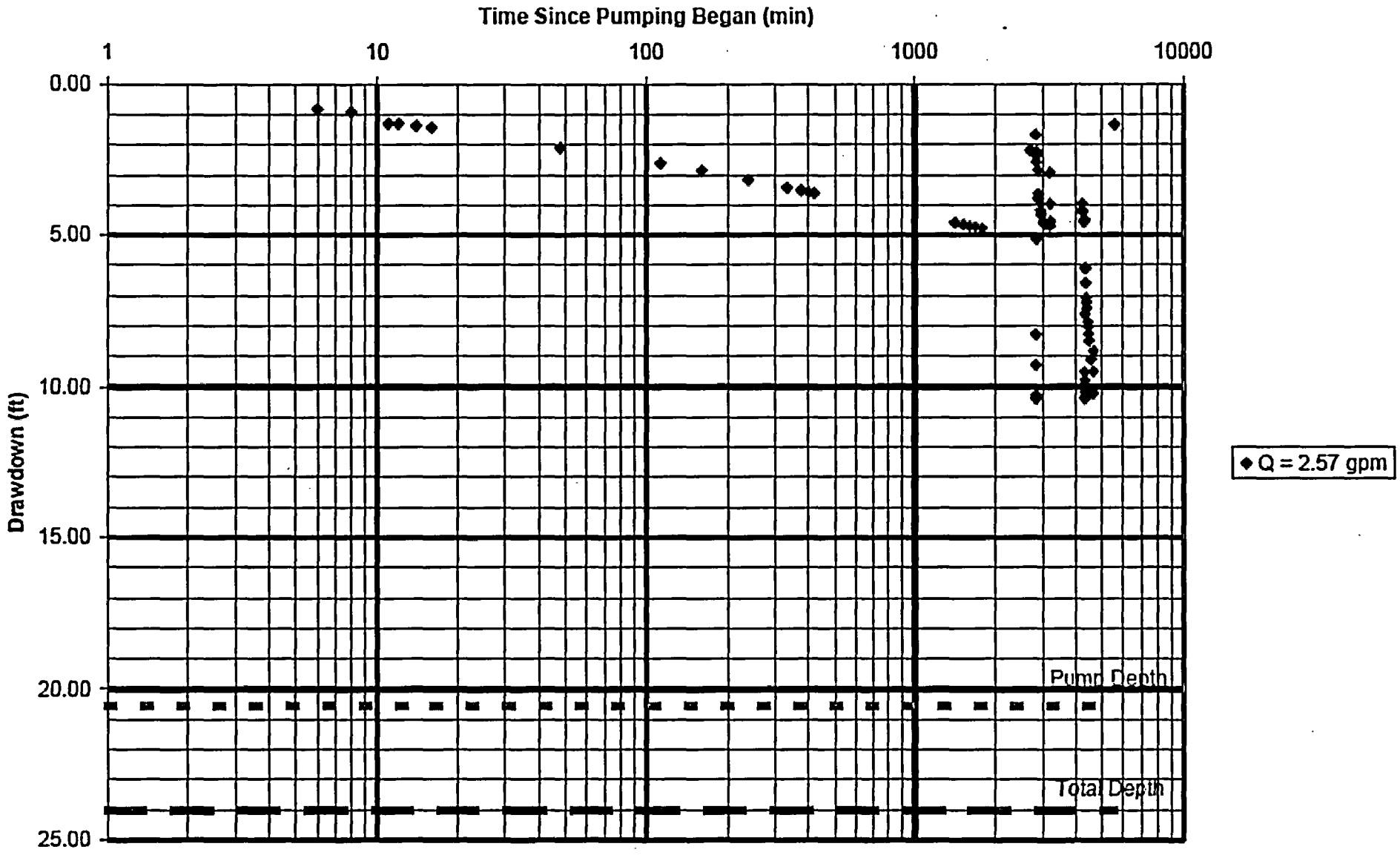
RW-13 Time_Drawdown



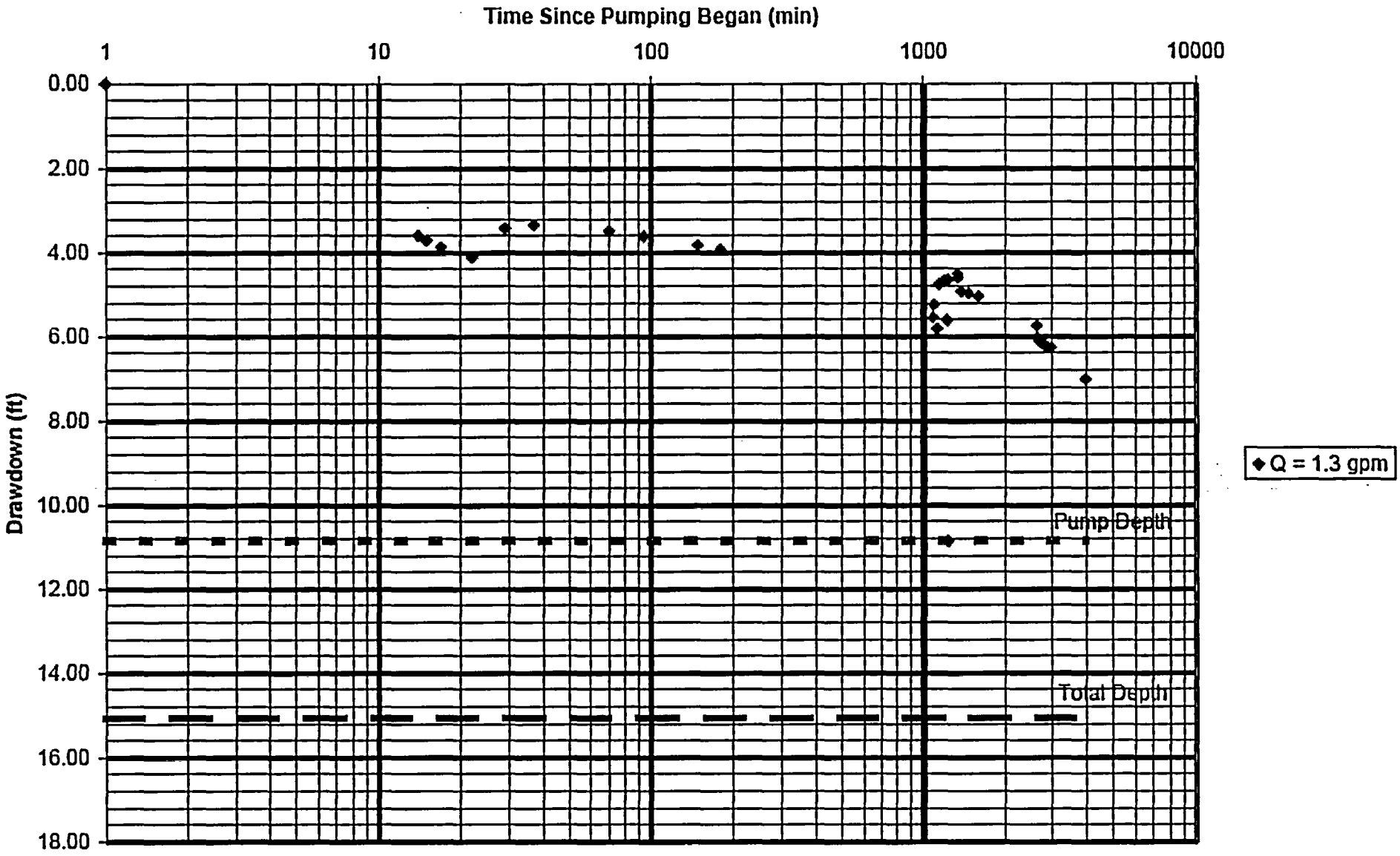
RW-15 Time_Drawdown



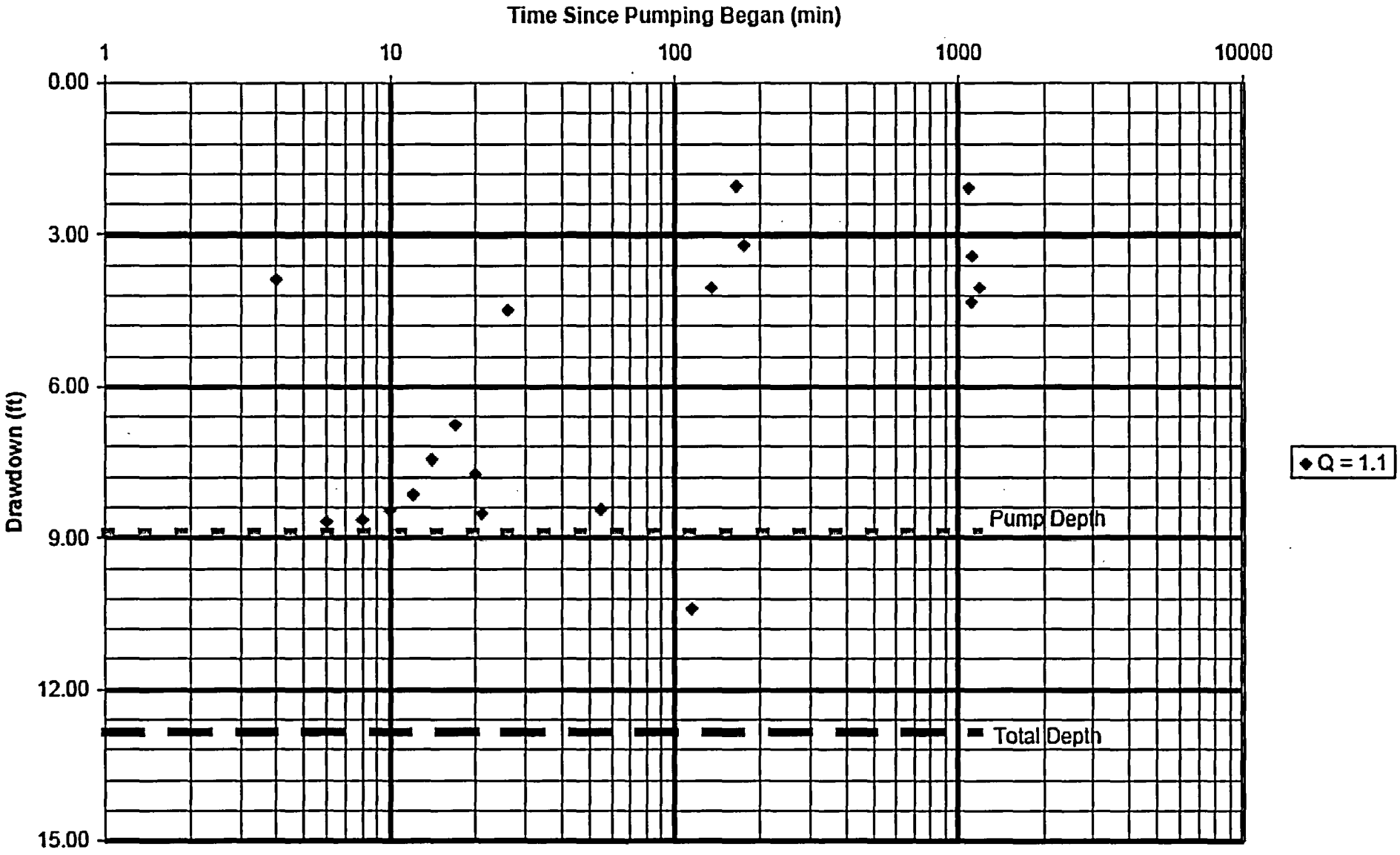
RW-16 Time_Drawdown



RW-17 Time_Drawdown



MW-5 Time_Drawdown



Summary of Preliminary Results

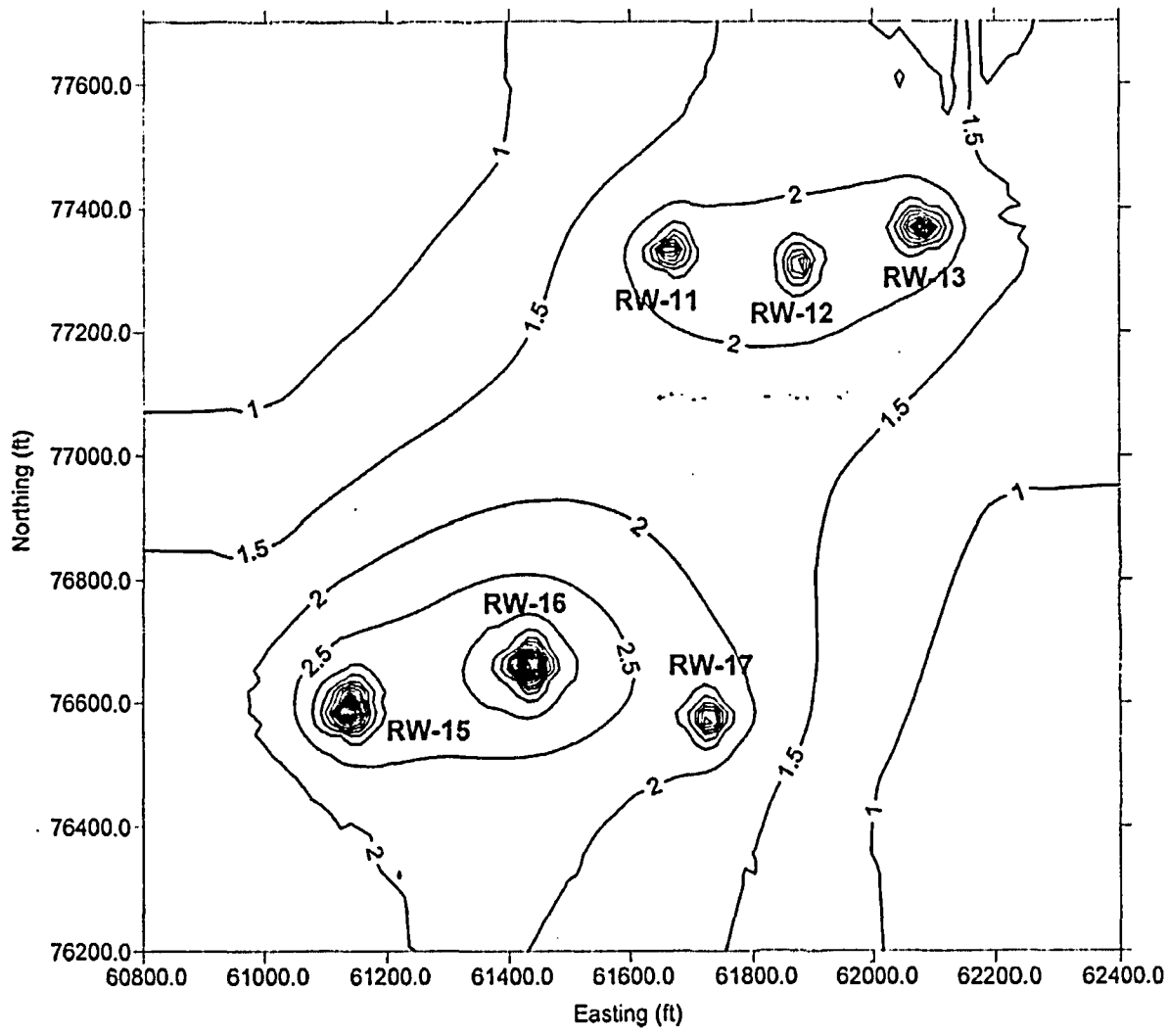
- In the process of preliminary groundwater modeling.
- In order to calibrate the model to the results of the pumping test, we had to increase T approximately 3x above Ts reported in previous studies.
- Preliminary model results were used to predict drawdown at 90 and 180 days.

Summary of Preliminary Results (cont.)

- While hydraulic fracturing appears to have improved recovery in certain areas (i.e., RW-13) its too early to tell the magnitude.
- Fracture control is not as predictable as indicated by the initial pilot test, and upward vertical fracturing sometimes occurs.
- Analysis of current drawdown data indicates that capture zones are developing, particularly at the northern boundary.

FIGURE 2

PREDICTED DRAWDOWN (FT) AFTER 90 DAYS AT UNC CHURCH ROCK, NM FACILITY
RESULTS OF SIMULATION WITH PROGRAM RELIEF6



EFFECTIVENESS MONITORING

Effectiveness Monitoring

- Water levels will be periodically measured in the recovery wells and compared to the anticipated drawdown values. Water levels will also be evaluated in new and existing monitoring wells to evaluate the zone of hydrologic effects. The pumping rates may be adjusted to provide drawdown as required to provide adequate hydrodynamic control and ensure that wells are not over pumped.

Effectiveness Monitoring (cont.)

- As data are received, an evaluation of the effectiveness of capture will continuously be made.
- Based on results, additional extraction wells may be installed to improve or accelerate capture.

QUESTIONS????

Rationale and Field Investigation Work Plan to Evaluate Recharge and Potential Cell Sourcing to the Zone 3 Plume Church Rock Site, Gallup, New Mexico

James Ewart

NA Water Systems

May 2005

Objectives

- ? Assess whether there may be ongoing sources of tailings fluids, particularly to Zone 3
- ? Determine where tailings fluid sources would be more likely, if groundwater were present and capable of migration
  - ? types of groundwater considered include residual pore water and groundwater potentially recharged from surface water
- ? Develop a plan of field work to test for evidence of tailings fluids sourced from the more likely locations

Methods

- Analyze existing information about the geometry and hydraulic properties of the Church Rock tailings cells and substrate materials
- Develop a conceptual model of the tailings cells and surrounding materials
  - Reconstruct the geometry in three dimensions
  - Qualitatively evaluate their potential to generate leachate capable of entering surrounding geologic materials
- Identify the more likely sources and design field tests of those locations

Criteria for Identifying Potential Ongoing Sources

- ? Zone 3 beneath or adjacent to tailings
- ? Thickness of alluvium between tailings and Zone 3
- ? Thickness and permeability of tailings
- ? Potential source of surface water infiltration into tailings

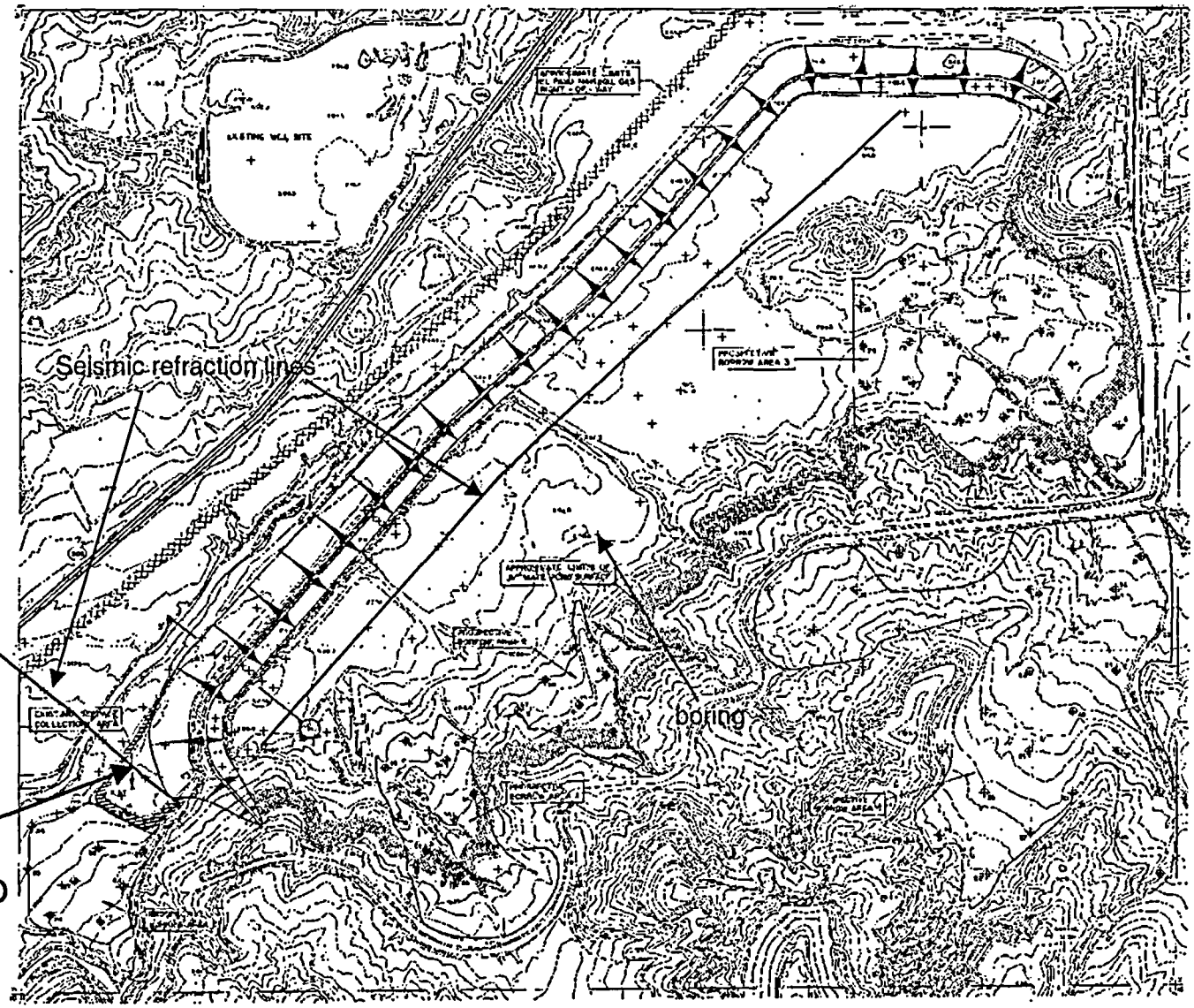
Analyzed Historic Data

- Borings and wells drilled in the area of the tailings cells
  - geologic logs for 215 borings and wells made between 1974 and 1979 throughout the area of the cells
  - geologic logs of 332 additional wells made in areas surrounding and between the cells during and after construction
  - 15 borings that penetrated the tailings
- 1976 seismic refraction survey that transected the length of the tailings deposit area
- Topographic maps made prior to and during construction of the tailings ponds and post-1987 cell reclamation

Analyzed Historic Data

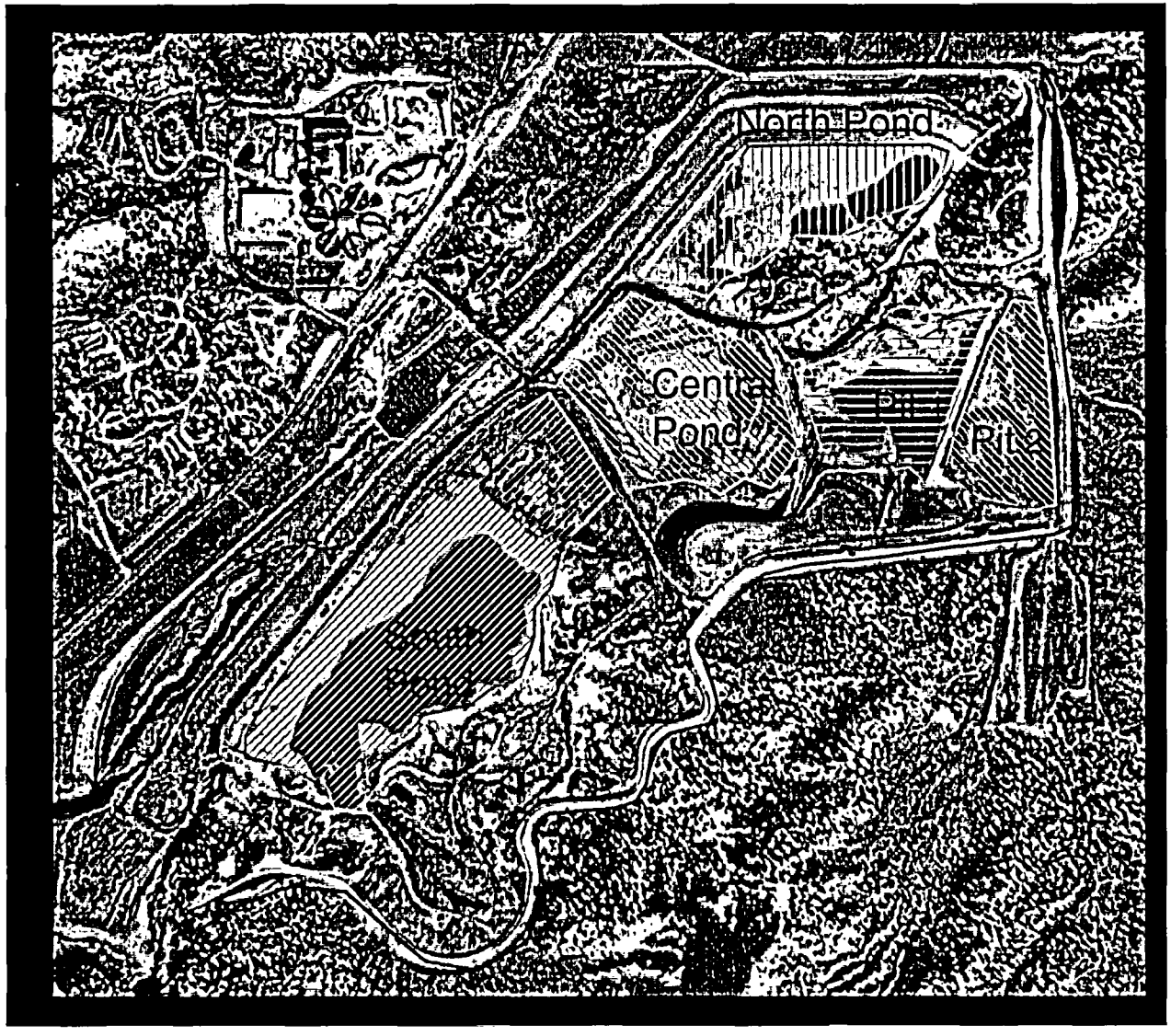
- Geologic map and cross sections by Canonie (1987)
- Aerial photos during tailings deposition and following final reclamation
- Estimates of hydraulic conductivity of geologic media and of the tailings
  - 27 borehole tests made by Sergent, Hauskins & Beckwith (1976)
  - six to eight well tests in each hydrostratigraphic unit made by Billings & Associates, Inc. (1982; 1983; 1985)
  - Tests of tailings and information about tailings deposits

May 1978 Topographic map showing 1974-1979 borings, and 1976 seismic refraction survey used to estimate top-of-rock and base-of-tailings elevations



east arroyo buried

1983 aerial photograph showing tailings ponds and surface water channels and detention basins



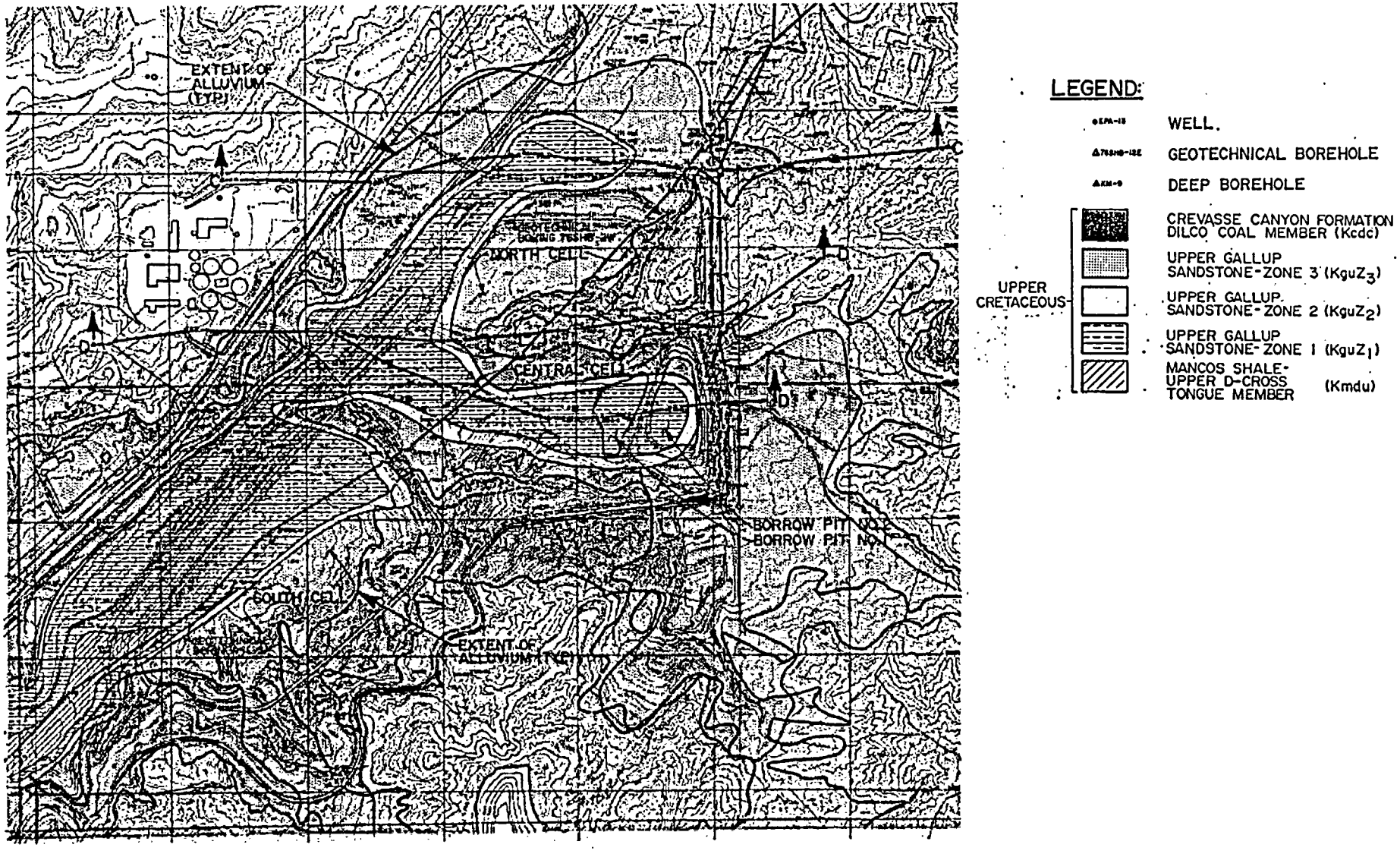
Estimates of the Distribution of Tailings and Underlying Geologic Materials

- The reconstructions divide the materials in and beneath the tailings cells into three categories:
  - capping materials and tailings
  - alluvium
  - rock formations

How the Distribution of Tailings and Underlying Geologic Materials were Reconstructed

- The thickness of alluvium is the calculated difference of the estimated top-of-rock and the base-of-tailings surfaces
  - Alluvial thicknesses are maximum estimates
- The top-of-rock surface was estimated from boring logs and a seismic refraction survey
- The base-of-tailings surface was based primarily on topographic maps from several stages in the development of the tailings deposits
  - Tailings thicknesses are minimum estimates – particularly beneath former Borrow Pit 1

Geologic map on May 1985 topographic base (Canonie, 1987)

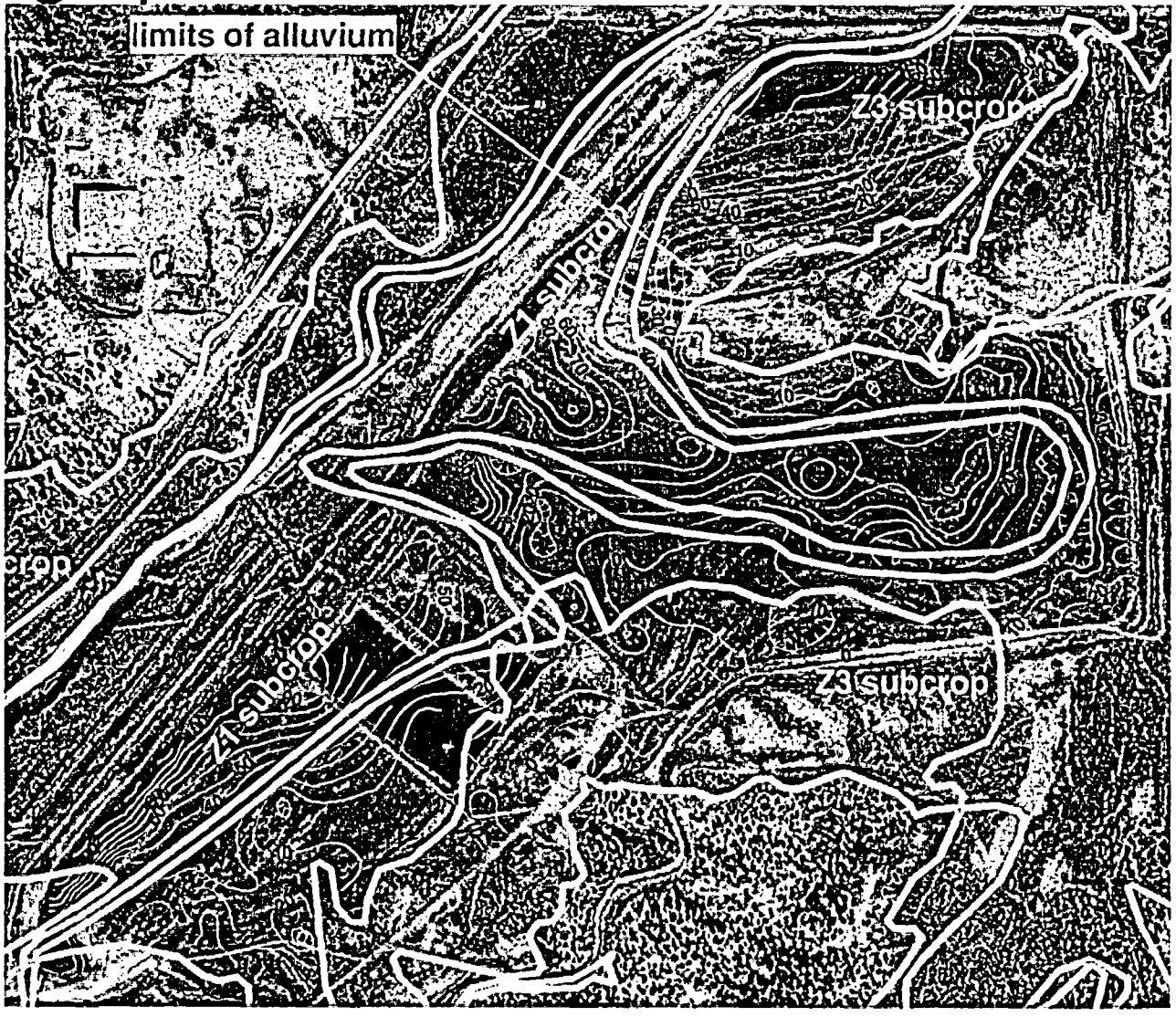


Topography and geology (after Canonie, May 1987) on circa 1983 aerial photograph of tailings ponds

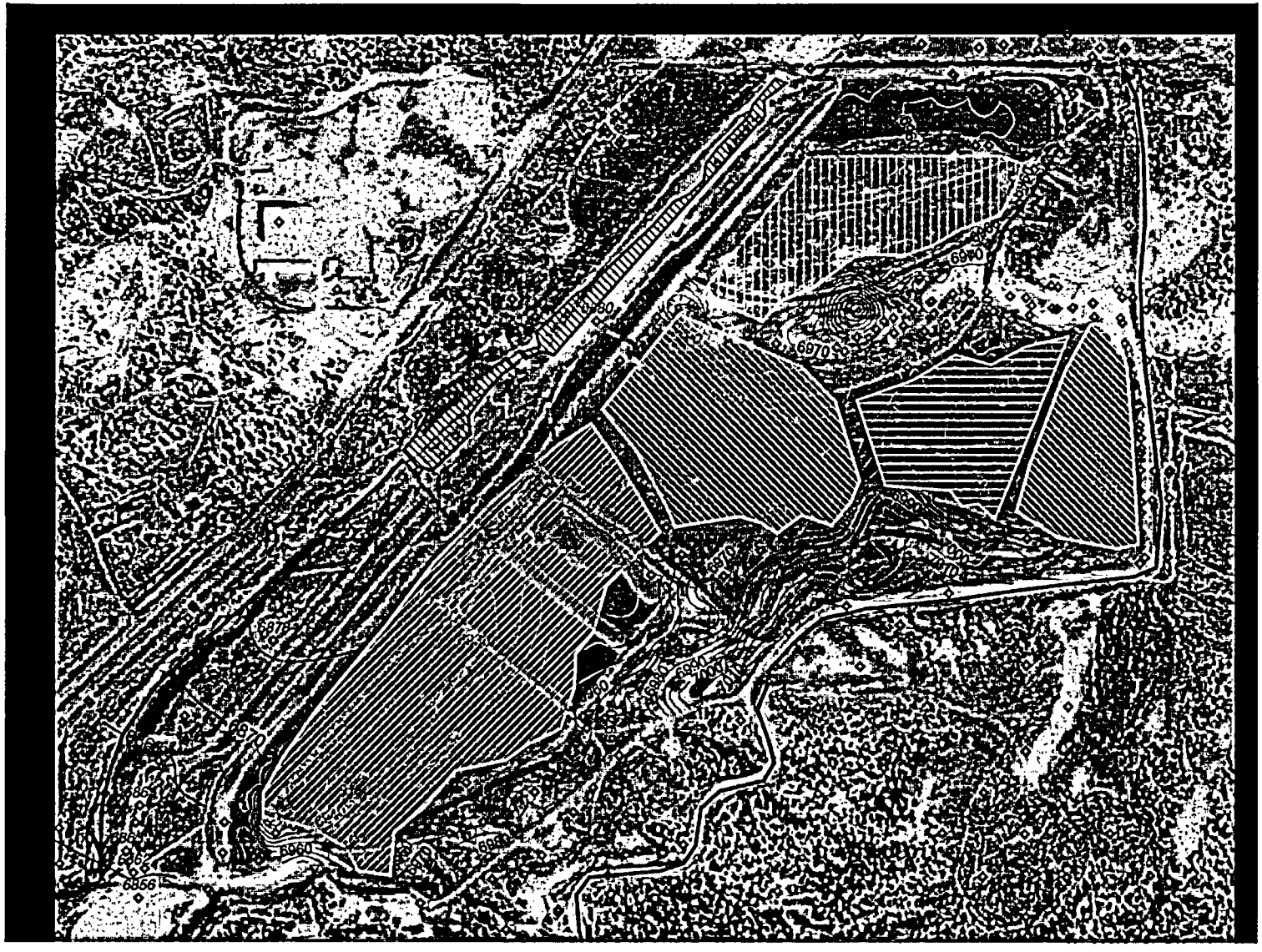
Hydraulic Properties of the Alluvium

- ? Average hydraulic conductivity of the alluvium of 2.7×10^{-5} cm/sec, based on 27 borehole tests
- ? Hydraulic conductivity estimate of 2.3×10^{-3} cm/sec for a representative tailings sediment sample.
- ? Alluvium in most locations is significantly more resistant to vertical as opposed to horizontal flow of groundwater, because of ubiquitous clay layers
- ? Conclusion 1: most tailings are probably more permeable to vertical seepage than the alluvium
- ? Conclusion 2: ongoing tailing fluid sourcing is more likely where tailings are thick and less readily drained than average and where alluvium is thin or absent (if residual or infiltrated fluids are capable of flowing to those locations)

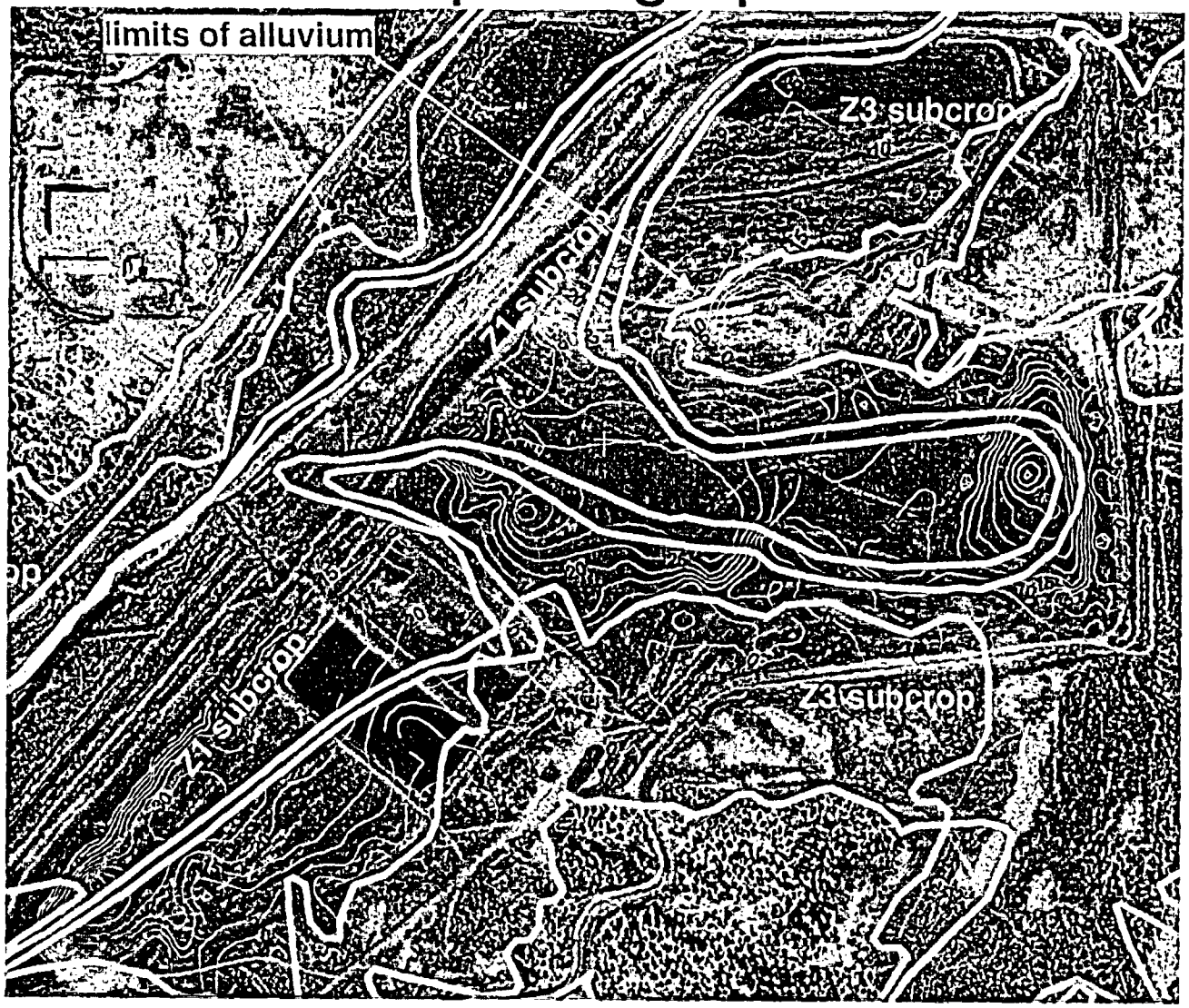
Estimated thickness of alluvium between tailings and rock on circa 1997 aerial photographic base



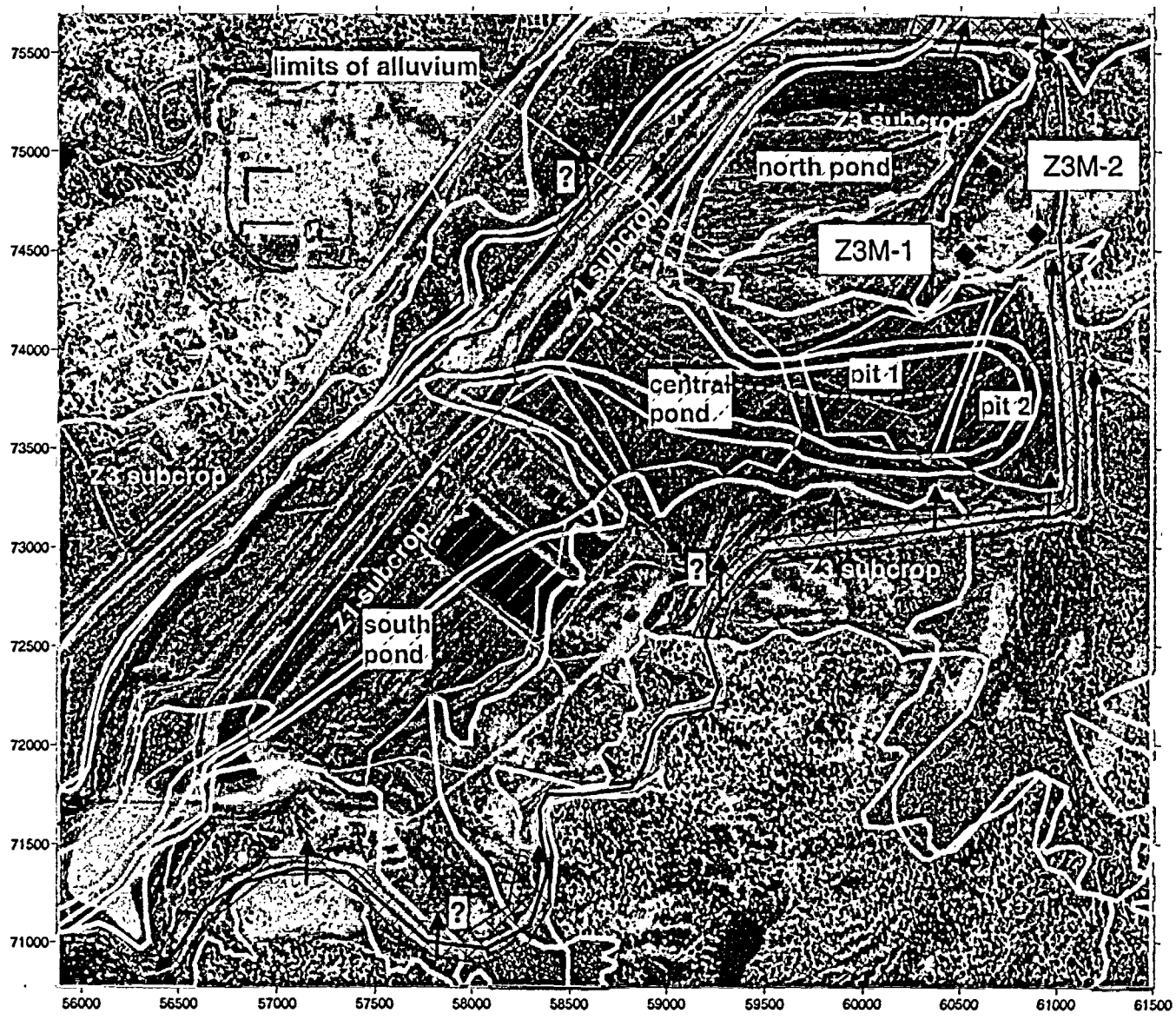
Estimated elevation contours at the base of the tailings

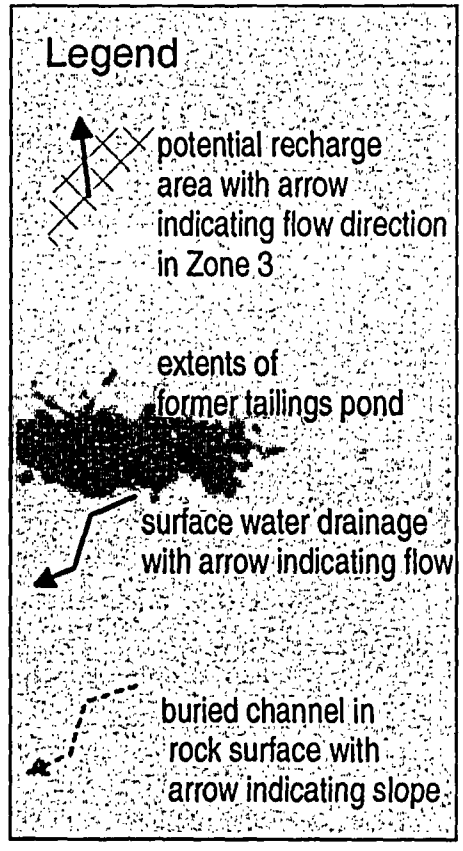


Estimated thickness of tailings and cover in 1997, following final reclamation, on circa 1997 aerial photographic base



Summary of tailings cell features, surface water channels and potential areas of recharge to zone 3



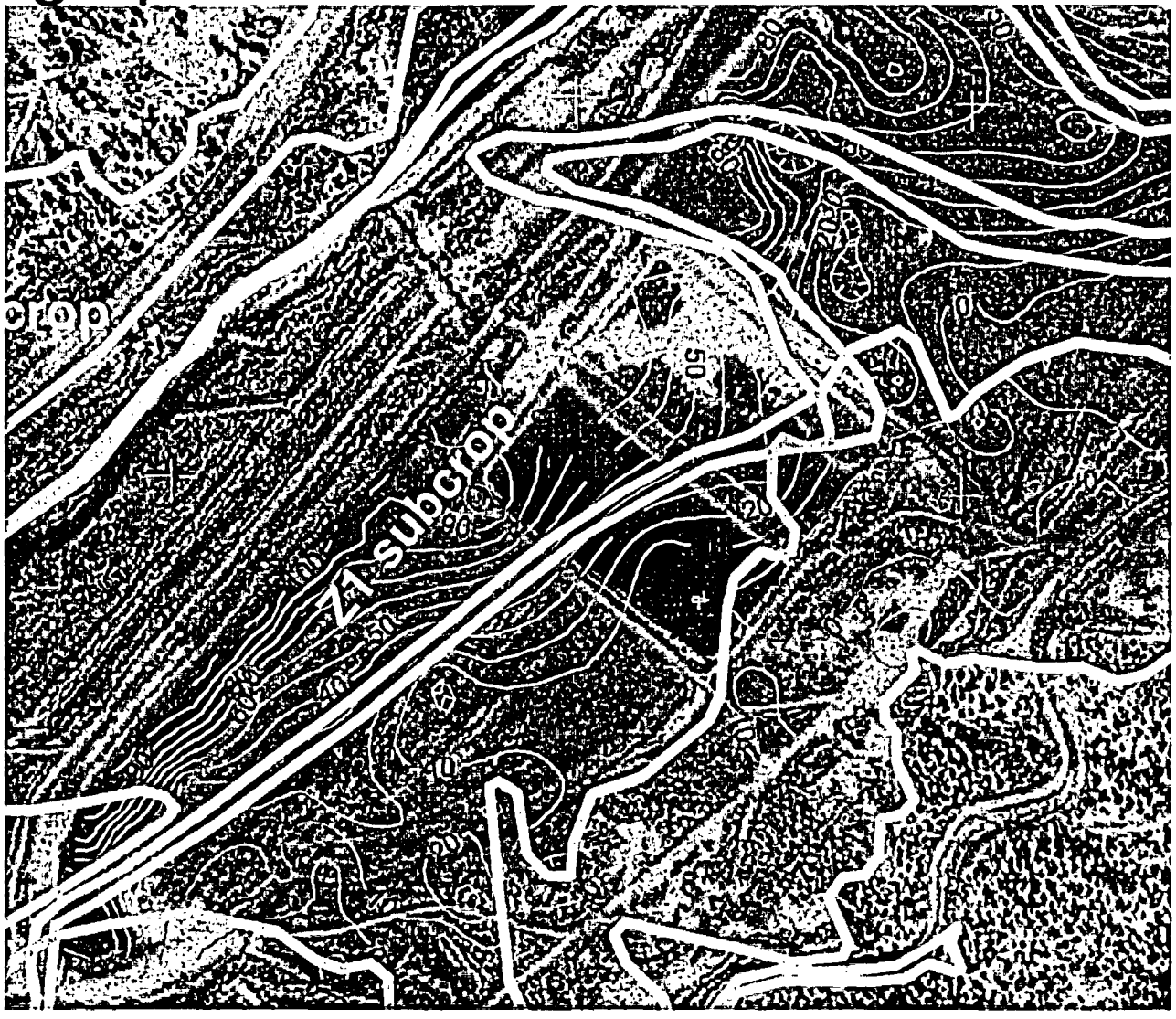


Results of Investigation of Potential Sourcing to Zone 3

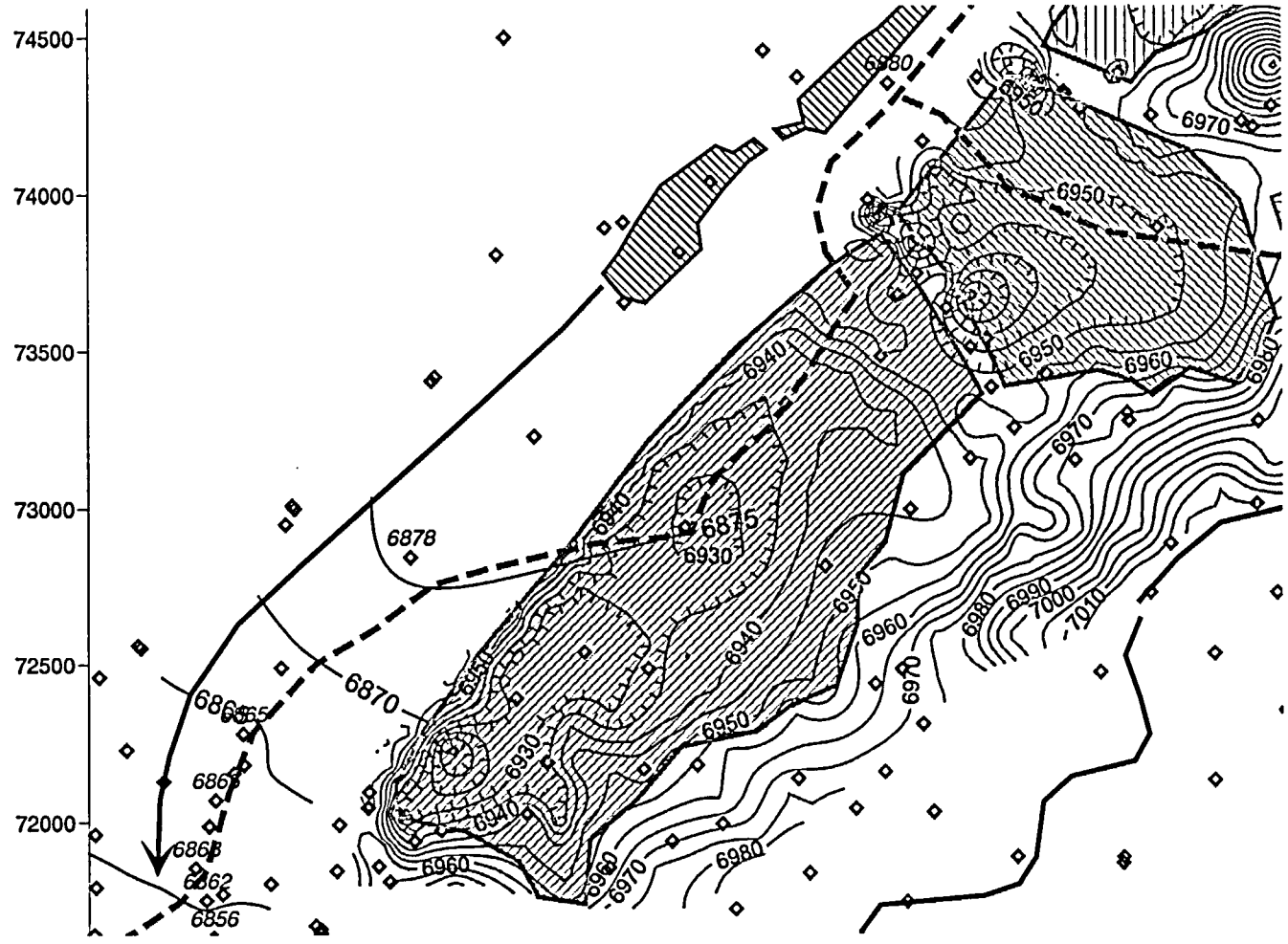
- Piezometers Z3M-1 and Z3M-2 screened into the base of Zone 3 in the area north of the former Borrow Pits 1 and 2.
- Standing water columns of 0.1 feet and 0.3 feet were found in the tail pipes below the screens of Z3M-1 and Z3M-2 when measured in October 2004
- The pH (7) and alkalinity (283 mg/L) of water sampled from the wells is consistent with drilling fluid
- Conclusion – Borrow Pits 1 and 2 are not ongoing sources of tailings fluid
- Ongoing sourcing of tailings fluids from other portions of the tailings cells is unlikely

Implications for Potential Sourcing to Southwest Alluvium

Estimated thickness of alluvium between tailings and rock on circa 1997 aerial photographic base


Z1 subcrop
90
50
40
50
40
50
20
20
20

October 2004 water table in the SW Alluvium was more than 50 feet below the base of tailings



Implications for Potential Sourcing to SW Alluvium

- ? Conclusion 1 – SW Alluvium groundwater and infiltrating surface water do not contact the tailings
- ? Conclusion 2 – These data do not eliminate the possibility of residual tailings fluid sourcing to the SW Alluvium.
- ? However, if such sourcing occurs, it is likely to be negligible, because of the thick layer of low conductivity alluvium separating the tailings from the saturated zone. (i.e. if fluids remain they are essentially trapped as evidenced by the cessation of consolidation)