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HYDROGEOLOGY, GEOCHEMISTRY, AND WELL CONSTRUCTION OF THE TREASURE VALLEY HYDROLOGIC PROJECT MONITORING WELL #1, ADA COUNTY, IDAHO

Oct. 22, 1999 Final Report to the TVHP Technical Advisory Committee

by

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Treasure Valley
Hydrologic Project

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INTRODUCTION

In December 1996, United Water Idaho, Inc. (UWID) completed a 1,005-foot deep exploratory test-well in west Boise, Ada County, Idaho (legal location T4N, R1E, NW$^1/_4$, SW$^1/_4$, SW $^1/_4$, Sec. 14). The location of this well, now named the Treasure Valley Hydrologic Project #1 Monitoring Well (TVHP #1), is shown on Figure 1. The well was originally drilled to evaluate for potential aquifer units that might be developed for municipal water supply for the City of Boise. Although an accumulated thickness of 100 feet of potentially productive aquifer sands were located, a series of water sampling piezometers completed to four depths showed some of the water quality to be less than desirable. Owing to elevated concentrations of dissolved iron, UWID decided against developing a municipal supply well at this site. Instead, UWID worked with the land owner, Mr. Bill Pierce, and with Mr. Hal Anderson of the Idaho Department of Water Resources (IDWR) who negotiated and secured a 50-year access agreement to the well in order to preserve it as a long-term observation well. The well is completed as a piezometer nest (Figure 2.), and is currently monitored by IDWR to document the annual water-level fluctuations in four sub-aquifer zones.

The well has been donated to the State of Idaho for continuing water chemistry and water-level monitoring. This report presents details of well construction, lithology, water chemistry, and water-level data obtained as a result of the drilling, completion, and monitoring of this well. UWID recognizes the need for a network of designated (long-term) observation wells in the Boise River Valley and has put special effort into preparing this report for the Treasure Valley Hydrologic Project.

WELL CONSTRUCTION

Drilling

The drilling of the exploratory test-well commenced in late October 1996 by Ron Stevens of Stevens & Sons Drilling, Inc. An 8-inch (.0250-inch wall) steel casing with drive shoe was drilled-and-driven through the unconsolidated sands and gravels of the present day Boise River floodplain using a Bucyrus Erie 22-L cable-tool drill. The oversized drive-shoe was stopped in a clay layer at 76 feet as a surface seal. A "Portadrill" direct mud-rotary rig was used to advance an 8-inch diameter bore from 76 to 1,005 feet below ground level (total drilled depth reached on 11/22/96). Drill cuttings, collected by the driller at 5-foot intervals during drilling, were examined in the Boise State University Department of Geoscience's soils lab.

Monitoring Well Design

UWID Geosciences ran natural gamma-ray, single point resistance, and normal resistivity geophysical logs (Figure 3) in the mud-filled borehole on 11/22/96. Several sand units between 15 and 25 feet in thickness, and separated by clay units of variable thicknesses, were delineated below the bottom of the steel casing (76 feet) and above 362 feet. Below 362 feet, mudstone accounts for 90 percent of the drilled section with the remaining 10 percent consisting of thin (2-to-10-foot thick) fine sand lenses of low water production potential.

Based upon a comparison of the borehole geophysical logs with drill-cuttings from the bore, and taking into account distinct color differences within the drilled section, a "nest" of piezometers was constructed as follows.

Completion

The well was completed with 2-inch diameter schedule-80 flush-joint PVC pipe and factory-slotted PVC screens. Fresh drilling mud was circulated throughout the borehole prior to installation of flush-joint steel grout pipe (2-inch diameter) and four piezometer tubes. The viscosity of the drilling mud was lowered to facilitate pouring of the filter sand through the mud, from land surface (a Marsh Funnel viscosity of about 35 seconds was achieved). Caving sediments filled or bridged the borehole up to 410 feet sometime after geophysical logs were run and prior to well construction. A 53-foot thick cement pressure grout seal was placed on top of this bridged zone. This cement seal serves as a base for the piezometer nest.

Four, 2-inch diameter piezometers with slotted intervals were placed in the well as shown in Figure 2. Filter-pack was poured from the surface through the annular space between the drilled hole and the plastic casings. A weighted tag-line, inside the grout-pipe, was used to verify placement. Calculated volumes of cement grout were pumped through the grout pipe, at the top of each filter packed zone so that the grout was forced upwards. Between each grouting episode, the grout pipe was flushed with just enough water to displace the grout remaining in the pipe and to clear the pipe so a tag-line could be dropped through it. The process was repeated as alternating seals and filter envelopes were installed. Well construction is diagrammed in Figure 2. The uppermost seal is a high-solids (>21% bentonite by weight) bentonite grout. Powdered bentonite ("Industrial 200") from Teague Mineral Products pits in Adrian Oregon was used in this grout.

LITHOLOGY

Beneath the TVHP #1 site, the 30 foot thickness of river gravels (present day Boise River floodplain) are underlain by alternating sand and silty clay layers of variable thickness to 370 feet below ground level (bgl) (Figure 2). Three distinctly different color intervals, above 360 ft., were evident in the drill cuttings. Color changes occur at 167 ft. and 260 ft (Figure 3).Between about 370 feet and 500 feet, the silty clay steadily grades into a thick section of mudstone. A color change within the mudstone, from gray above to dark gray below occurs at about 700 feet. Sand lenses are present within the mudstone section between 780 feet and 900 feet.

The thick mudstone section encountered in the TVHP #1 well is probably correlative to the mudstone facies of the Terteling Springs Formation as mapped by Dr. Spencer Wood on the Boise North quadrangle (Spencer H. Wood, personal communication, 1999). The geologic section from 515-to-365 feet bgl is interpreted as continuous deposition in an overall coarsening upwards sequence. This gradual change is best shown on the open hole electrical logs of Figure 3 and to a lesser extent (because of sampling inconsistencies) on the grain size percentage log (Figure 4). This 150-foot thick section may represent a regressive pro-delta gradation to delta sands of the Glenn's Ferry or Pierce Gulch sands as they are currently being differentiated by Dr. Wood. His evolving conceptual model , envisions the upper 360 feet of sand dominated section as meandering braided stream deposits overlaying a pro-delta sequence. The thin, discontinuous, fine-grained sand lenses within the thick mudstone section may be shoal deposits or fining upwards turbidite deposits from shoreline sands avalanching off of the delta front.

Grain-size percentage log

A grain-size percentage log of the TVHP #1 drill cuttings is shown on Figure 4. Boise State University graduate students Brian Cavanaugh and Mike Guilbert, of the Department of Geosciences, analyzed the drill cuttings mineralogy and grain-size distribution. In an attempt to be objective with respect to sample description, each five foot sample interval was wet-washed through a stack of U.S. Standard sieves and the percentage retained, by volume was measured. The silt and clay fractions were estimated by settling the wash-through water, and delineated from one another by setting time in a graduated cylinder.

The grain-size log cannot be directly correlated, by depth, with geophysical logs (or lithologic logs based on geophysics) owing to the "lag time" between when the cuttings were first drilled and when they arrived at the surface and also because of mixing within the drill stream. In addition, cavings from the borehole wall, and fine sand entrained within the drilling fluid affected the cuttings. The effects of the downhole mixing of drill cuttings within the mud stream increase with depth. For example, the thin sand layers, obvious on the geophysical logs between 770 feet and 900 feet, were not differentiable in the cuttings.

The grain-size percentage log covers the interval from 60-to-600 feet, and omits the lower 400 feet of the drilled section, which is dominantly olive gray, silty clay-to-mudstone with a few interbedded sand lenses, two-to-10 feet thick. The total cumulative thickness of the sand section within the mudstone totals about 40-feet. These beds stand out clearly on the geophysical logs, but are not well represented in the drill samples because of mixing within the mud-stream as cuttings are pumped to the surface. within the drill stream combine to effectively mask the identity of these sediments.

The complete lithologic log, inferred from cuttings analysis and geophysical logs, is shown on Figure 3. Four distinguishable color intervals are noted. The grain-size log shows the major color changes to be shifted downward due to cuttings return lag-time. In the lithologic log of Figures 2 and 3, adjustments have been made using the geophysical logs to show the color changes at the interpreted actual depth.

The sediments are predominantly arkosic sands derived from the granitic rocks of the Idaho Batholith, with medium-to-coarse-grained sand dominating above 362 feet. Sixty percent of the grains pass through a #18 US Standard sieve and are retained on a #30 sieve. The sands are poorly sorted (well graded), and grains range from angular to sub-angular. The ratio of quartz to feldspar, which comprise essentially 100% of the sand grains, varies from 80/20-to-40/60. Comprising less than 5 percent of the samples are muscovite, biotite, and lithic fragments of igneous intrusive rocks, usually in trace amounts.

Sand-sized pieces of wood are present in the cuttings below 175 feet. Wood comprises up to 5 percent of most samples between 175 feet and 362 feet. The wood is typically black in color and first appears in the sticky clay at 175 feet with the transition from oxidized to reduced sediments. Trace amounts of wood are present throughout the lower drill cuttings, but some or all of these may be re-circulated cuttings from the overlying section.

Iron oxide cementation, and staining of sand grains, occurs down to a depth of 365 feet (the top of the silty clay/ mudstone transition). In the upper oxidized zone (above 175 feet) up to 30% of the sand grains are coated with a red, rusty colored crust which acts as a cement. The mineral pyrite is also present as a cementing agent and grain coating below the oxidized/ reduced boundary at 175 feet bgl.

Calcite cementation, identified by reaction with dilute hydrochloric acid, was found on the very fine sand grains within the mudstone between about 450 feet and 650 feet. The major mineralogic variations with depth are diagrammed on Figure 5.

Geophysical logs

Natural gamma-ray, single-point resistance, and 16-inch and 64-inch normal resistivity logs were run in the open, mud-filled borehole to 1005-feet on 11/22/96. Logs were run immediately after the drill column was removed from the hole. A temperature log was not run because the borehole fluid had been circulated just prior to logging thus negating the potential to obtain meaningful information from this log. Geophysical logs to 450 feet below ground are shown in Figure 3.

The grain-size percentage log would suggest that less than one quarter of the section above 362 feet is comprised of silt sized or finer particles. However, the geophysical logs indicate that the actual percentage of sands is approximately equal to the silts and clays (above 362 ft.). This discrepancy points out the influence, on samples, of re-circulating sands within the drilling mud and the loss of silt-to-clay sized grains during sample collection.

Single point resistance log

The single point resistance log most clearly shows the lithologic contacts between the sand and silty clay beds. Sand units show measured resistance between about 110 and

150 ohms. Above 400 feet, silt and clay units measure about 100 ohms or less. The log below 500 ft. has generally lower resistance values than that measured above 400 ft. An interval of decreasing resistance, showing the transition from silty clay to a fissile mudstone, is apparent between 365 ft. and 515 ft. The steady decrease in measured resistance with depth, over this interval is interpreted to indicate increasing clay content, and diminishing coarse silt-to-sands. The higher-resistance excursions on the log between 760 feet and 900 feet are interpreted as thin sand units within the massive mudstone. Electrical logs were necessary to delineate these lower sands, as these beds were not readily apparent in the drill cuttings, and only weakly expressed on the natural gamma-ray log.

Natural gamma-ray log

The formation above 400 feet has more definition than the underlying mudstone. Natural gamma counts peak at 140 counts per second for the silts and clays above 400 feet. The mudstone section, between 400 and 770 feet is generally less radioactive than the overlying clay beds, averaging about 100 counts per second. The lower, 2-to-10-foot thick sand units have gamma counts similar to sands above 400 feet.

Normal resistivity logs

The slight separation between the 16-inch (short) normal and 64-inch (long) normal resistivity logs indicate that there was invasion of borehole fluids into most sandy units above 400 feet.

Both normal resistivities, below 400 feet and within the mudstone, are very closely spaced indicating that very little invasion of drilling fluids has occurred in the mudstone. The long-normal resistivity is quite low in the sands between 770 ft. and 900 ft. whereas the short-normal and single point resistances are fairly high. This contrast is probably due to the larger radius of investigation of the 64-inch normal reading which incorporates a percentage of the clayey sediments enveloping the very thin sand units. Groundwater chemistry may be a contributing factor as well. Higher salinity is expected on the deeper reading 64-inch normal log because of the stagnant or relatively slow moving groundwater within this low permeability section. The specific conductivity of the borehole fluid at the time of logging was measured at 509 uS. Later, after the well was air-lift developed, the conductivity of water pumped from the aquifer zones was found to be in the 200-275 uS range. The calibration of the electric logs was checked prior to logging.

WATER CHEMISTRY

The piezometer tubes were developed by bailing and air-lifting on 12/12/96. Each piezometer tube was air-lift developed for 1½ to 2 hours at a flow rate of about 10 gallons per minute until clear and sand-free. On 12/13/96 water quality samples were collected from each tube. A submersible sampling pump was used to purge 5 to 10 well-bore volumes prior to sampling. A 0.45-micron filter was used to filter water analyzed for dissolved metals. Inorganic analyses for each zone are tabulated in Figure 2. Duplicate samples were submitted to separate commercial labs (Alchem Laboratories, Inc., and

Analytical Laboratories, Inc.) for analysis. Laboratory results for individual constituents generally agree within 10%. The variation in the sulfide results between the two laboratories suggests that the sample submitted to Alchem may have oxidized some sulfide to sulfate.

Groundwater from all four zones is quite similar. All are a calcium-bicarbonate water chemistry type with a very dilute total dissolved solids (TDS) ranging from 164-to-200 milligrams per liter (mg/L) and a near-to-moderately alkaline field pH ranging from 7.03-to-7.42. With the exception of groundwater from zone-3, TDS ranges only from 164-to-188 mg/L. Groundwater from zone-3 has a slightly higher concentrations of iron, manganese, calcium, magnesium, potassium, and sulfated than the other three zones. Dissolved silica generally increases with depth and temperature. Other parameters are similar between zones.

A dissolved iron concentration of 0.5 mg/L was measured in zone-3 water, while the other zones have iron concentrations less than 0.05 mg/L. Fine crystalline iron sulfide (pyrite) was found on between 10-and-40 percent of the sand grains, both, on and as part of the cement between the sand grains. Finer-grained sands have a higher percentage of iron sulfide than the coarser-grained sands. Iron sulfide was absent or present only in trace amounts throughout the shallower and deeper parts of the boring but yellow-brown-to-brown iron oxyhydroxide occurs as both a stain and as a cementing agent throughout most of the boring.

The presence of dissolved iron in the groundwater of zone-3 was observed during the purging of the piezometer. The groundwater turned from clear to a yellow color when left standing, exposed to atmosphere, in a bucket for 15 minutes. The 210-to-250-foot depth interval is apparently somewhat isolated from both the upper and lower sub-aquifer units at this location. Also, the amount of iron sulfide undergoing oxidation only slightly increases the concentrations of other constituents. The dissolution of the minerals contributing these constituents serves to neutralize the acidity created by the oxidation of iron sulfide to a pH of 7.18, which is higher than the deepest zone-1 groundwater (7.03). The groundwater must be only slightly oxidizing in zone-3 compared to moderately-to-highly oxidizing in the other three zones to have a dissolved iron concentration of0.5 mg/L.

The color variations of freshly drilled sediments between the zones also serve as indicators of the oxidation-reduction potential of the groundwater. Drill-cuttings from zone–3 sub-aquifer unit are dark olive gray in color while the other zones are lighter hues of yellow-brown-to-pale gray. The light yellow-brown coloration in the shallowest depth interval (zone-4) is probably the most highly oxidized, zone-3 the most reduced, and the deeper sediments intermediate between these two shallow zones. The deeper zones are probably less oxidized because they of several interbedded thin clay zones that contain traces-to-abundant wood fragments. The organic wood materials, buried within the aquifer sediments, consume dissolved oxygen and thereby decrease the oxidation-reduction potential even in these moderately oxidized sediments.

WATER-LEVEL MONITORING

A hydrograph, from April 1997 to December 1998, of monthly water-level measurements taken near the beginning of each month, is shown on Figure 6. The missing data points occurred during access negotiations with the owners of the property on which the test well is located. The graph clearly shows that pressure increases with depth, and that fluctuations in the individual aquifer zones mirror one another. The head in the shallowest completion (zone 4) is approximately three feet below that of the other zones. The heads in the three lower zones are typically within ½ foot of one another and show increasing potential with depth.

A seasonal water-level fluctuation of approximately 3 ½-feet is apparent within all 4 zones. The water-level low occurs in December, and the water-level high occurs in the spring or early summer. The seasonal high and low water-levels coincide with increased flow in the Boise River, which begins in January or February (Figure 7.

It is unlikely that the aquifer zones tapped by the piezometers are directly hydraulically connected to nearby surface water sources because of artesian pressures which occur at relatively shallow depths (below 200 feet). Confining conditions are suggested in even the shallowest (zone-4) aquifer completion intervals (130 ft. to 140 ft. and 150 ft. to 170 ft.). Also, the hydrograph does not indicate recharge from nearby laterals because recovery begins before March when canals begin to fill.

A record of the daily water-level fluctuation is shown on Figure 8. These data are from a Stevens F-type water-level recorder and show the continuous day-to-day water-level fluctuation. Zone-1 (the deepest zone) was measured from 4/17/97 through 7/1/97. From 7/1/97 to 10/8/97 the recorder was measuring the water-level in zone-4 (the shallowest zone). The hydrograph for zone-1 begins when the head is at its highest. Ignoring smaller-scale fluctuations, both hydrographs in Figure 8 show an average decline of about 0.007 feet per day. The smaller-scale peaks and valleys, which range up to about 0.5 ft. from trough-to-crest, have not yet been evaluated for barometric effects.

SUMMARY AND CONCLUSIONS

The hydrogeologic conditions and geologic section beneath the TVHP #1 test well site have been investigated to a depth of 1005 feet bgl. Geophysical logs, grain-size distribution, lithologic log, and sub-aquifer water chemistry data are presented in this report. The following is a brief summary.

Underlying a 30-foot thickness of coarse, sandy river gravels, are alternating sand, silt and clay beds, about 2-to-40 feet in thickness, to a depth of 370 feet bgl. The sand layers comprise sub-aquifer units which are somewhat confined by lower permeability silts and clays. Sand and/ or predominantly sandy beds comprise about half of the section below the surficial river gravel to a depth of about 370 feet. Four piezometer tubes were completed into the thickest of the sand beds between 130 and 340 feet (Figure 2). Below a depth of 370 feet the geologic section is comprised of silty clay which grades into a thick mudstone. Between 770 feet and 900 feet, the mudstone is punctuated by several fine to medium grained sand beds up to 10 feet in thickness (Figure 3).

Water-level measurements of the four piezometer tubes show that aquifer pressures increase with depth beneath this area of west Boise, To date, a 21-month water-level record has been collected for each piezometer. The water-level measurement in the deepest piezometer, open to aquifer zones between 300 feet and 340 feet, reaches a maximum of about two feet above ground level in late Spring. There is a seasonal water-level fluctuation of about four feet in each of the piezometers (Figure 6). The lowest pressure-level in each aquifer zone occurs in January and the highest-pressure levels occur in June, mirroring stream flow rate changes in the Boise River (Figure 7). Further monitoring would suggest the variability of seasonal changes, and whether or not the mean water/pressure-levels are declining, rising, or maintaining. While no piezometer tubes tap the sand beds between 770 feet and 900 feet, these likely have artesian pressures greater than those of the monitoring well piezometers.

Overall, water chemistry is similar within the interbedded section between 130 feet and 340 feet. Distinct color changes are present. The most significant water-quality difference occurs in the aquifer zone between 210 feet and 250 feet (zone-3) where dissolved iron is present at a concentration of 0.5 mg/l, compared to less than 0.05 mg/l in the other zones.

The cooperative work of United Water Idaho with IDWR through the Treasure Valley Hydrologic Project to obtain a long-term lease agreement to this well establishes the first designated long-term monitoring well for the Treasure Valley. It is our hope that this well is the first of many wells in a network of lasting water-level and water quality monitoring points for the Treasure Valley. United Water Idaho is pleased to contribute to the growing body of knowledge being synthesized for Treasure Valley Hydrologic Project.

The authors would like to recognize the contributions of the following people: Spencer Wood (BSU) for review and for pointing out the Boise River's effects on aquifer pressures, Brian Cavenaugh and Mike Guilbert (BSU) for laboratory analysis of drill cuttings, Dick Glanzman (CH2M Hill) for geochemistry review, and Hal Anderson (IDWR) for consistent support and for his persistence in securing the long-term site easements.

FIGURES

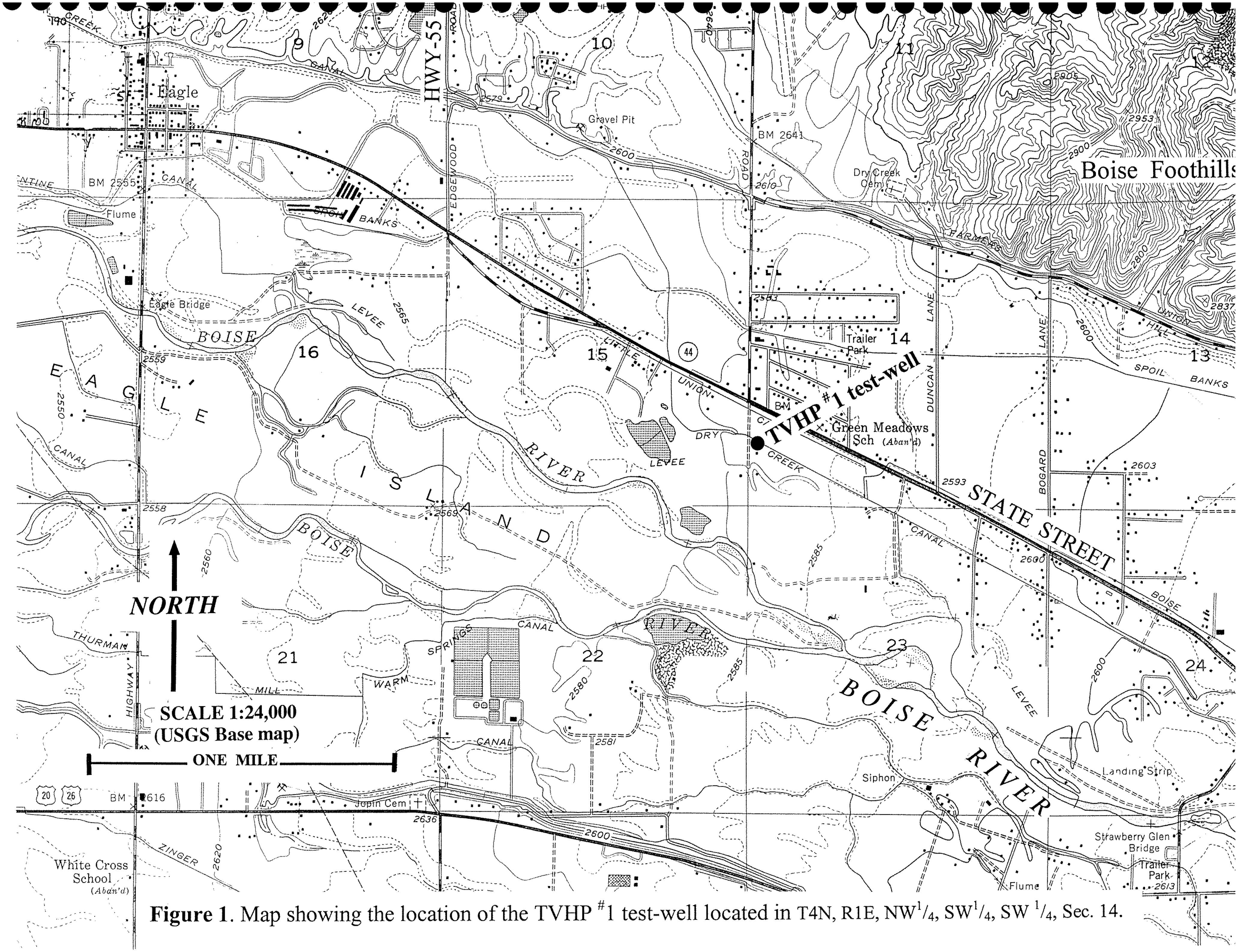


Figure 1. Map showing the location of the TVHP #1 test-well located in T4N, R1E, NW$^{1}/_{4}$, SW$^{1}/_{4}$, SW $^{1}/_{4}$, Sec. 14.

Treasure Valley Hydrologic Project Monitoring Well #1

Comparison of Water Chemistry in Piezometer Completion Zones

(Analyses in mg/l unless note otherwise.)

Constituent screen setting (ft below ground)	Zone 4 130-140 ft. 150-170 ft.		Zone 3 210-220 ft. 240-250 ft.		Zone 2 270-290 ft.		Zone 1 300-310 ft. 330-340 ft.	
Laboratory X: Alchem Y: Analytical	X	Y	X	Y	X	Y	X	Y
Date sampled	12/13/98		12/13/98		12/13/98		12/13/96	
Chloride	3.20	3	2.63	3	1.73	2	2.05	2
Fluoride (direct)	0.33	0.75	0.37	0.05	0.36	0.66	0.34	0.57
Nitrate (N)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	0.16
Sodium	24.9	24.2	20.3	19.4	15.2	14.2	17.3	15.8
Sulfate	10.2	11	22.5	22	11.4	12	14.4	14
Sulfide	<0.05	0.19	<0.05	0.16	<0.05	0.23	<0.05	0.07
Calcium	37.5	33.3	39.0	35.1	28.1	25.8	28.9	29.2
Potassium	2.17	1.64	2.55	2.06	2.07	1.63	2.00	1.58
Magnesium	4.16	3.62	7.22	6.55	3.94	3.70	4.54	4.58
Iron-total	0.03	<0.05	0.63	0.50	0.05	<0.05	0.06	<0.05
Iron-dissolved *	0.01	<0.05	0.57	0.45	0.01	<0.05	0.02	<0.05
Manganese-total	0.01	<0.05	0.06	0.05	0.04	<0.05	0.03	<0.05
Manganese -dissolved *	0.01	<0.05	0.05	0.05	0.04	<0.05	0.03	<0.05
Silica	28.7	30.6	31.5	32.9	33.6	33.6	32.5	29.9
Alkalinity	139.0	143	132.0	138	101.0	103	112.0	114
Conductivity - lab (uS)	299	294	313	305	224	237	260	255
Conductivity - field (uS)	262		273		213		247	
Corrosivity (Langlier)	-0.33	-0.7	-0.35	-0.8	-0.54	-0.8	-0.87	-1.1
Hardness	111.0	108	129.0	125	86.4	93.7	90.9	99.9
Phosphorus (total)	0.05	0.08	0.04	0.06	0.03	0.07	0.04	0.07
Total dissolved solids	248.0	188	173.0	200	188.0	164	218.0	182
pH –lab (standard units)	7.70	8.0	7.65	7.9	7.70	8.1	7.30	7.6
pH – field (standard units)	7.36		7.18		7.42		7.03	
Temperature	54.8 °F		56.6 °F		58.0 °F		58.4 °F	

* Samples for dissolved Iron and Manganese were filtered in the field

Location: NW ¼, SW ¼, SW ¼, Section 14, T4N, R1E, B.M., Ada County, Idaho
Well design by United Water Idaho Geosciences
Well completed 12/5/96 by Stevens & Sons Well Drilling, Boise, ID.

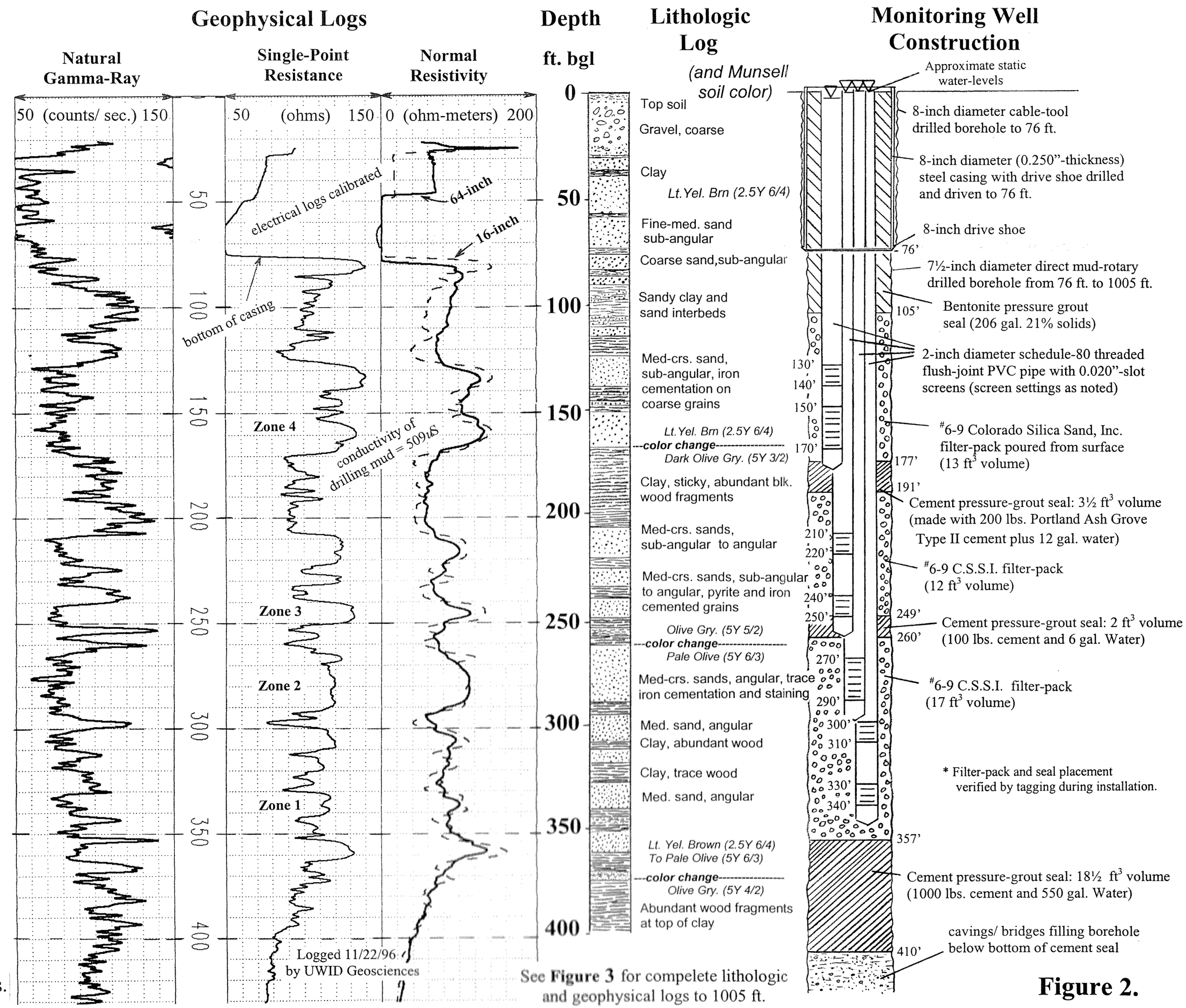


Figure 2. Composite diagram showing well construction, lithologic log, geophysics and water chemistry at various depths.

Figure 2.

Geophysical Logs and Lithologic Log

of the

Treasure Valley Hydrologic Project #1 test-well

T4N, R1E, NW$^1/_4$, SW$^1/_4$, SW $^1/_4$, Sec. 14

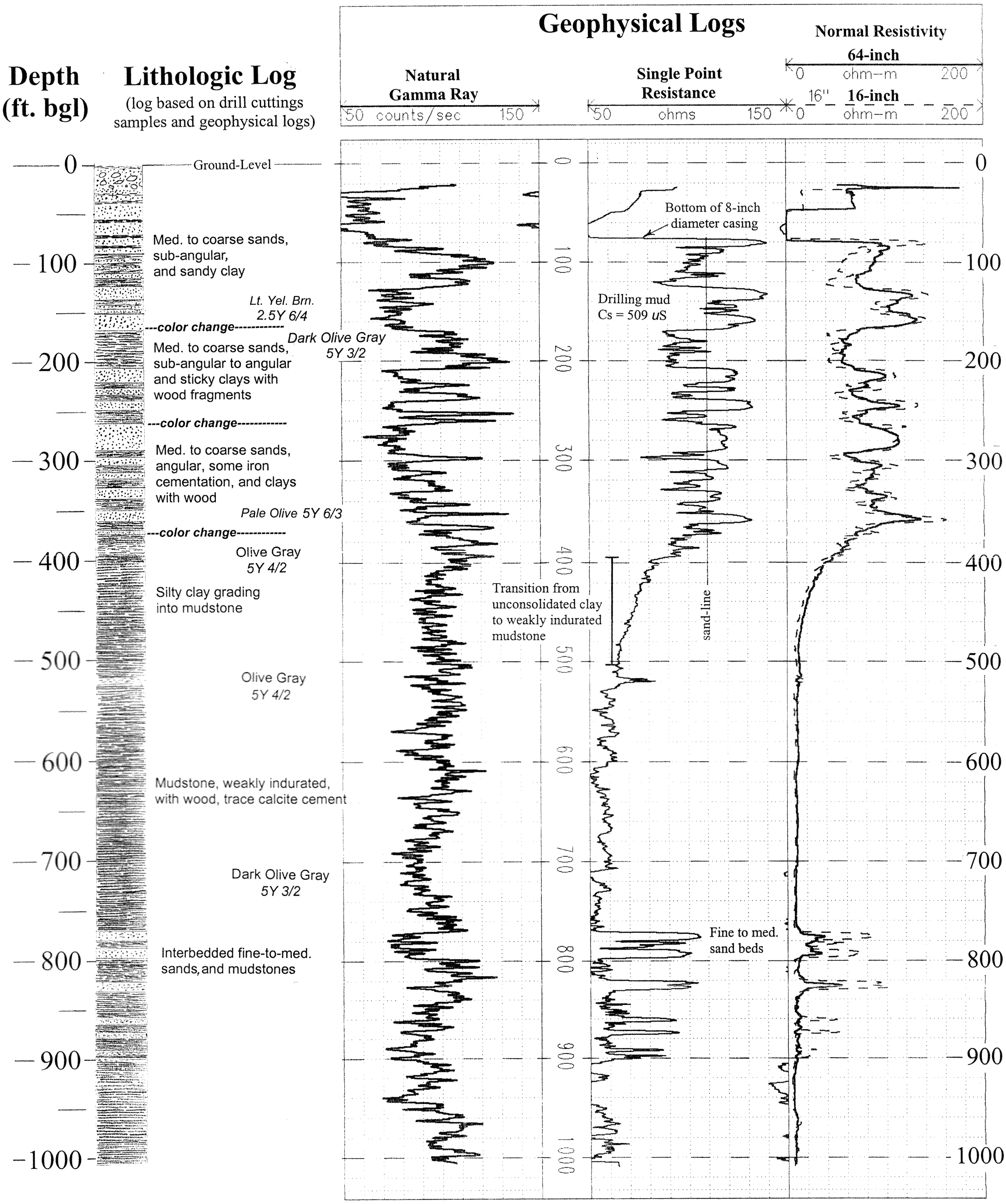
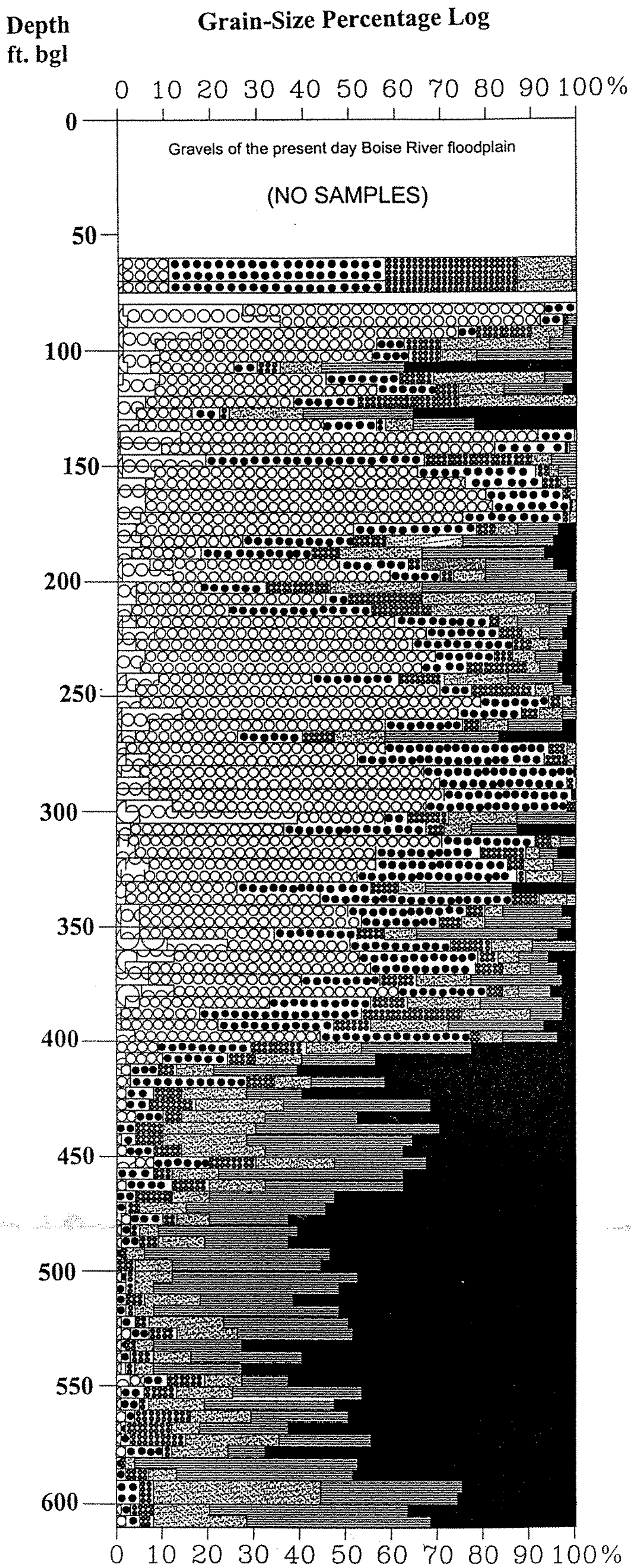
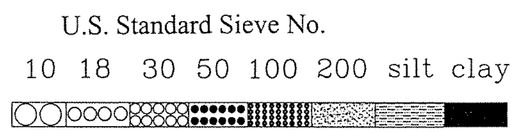


Figure 3.

Figure 3. Geophysical logs and lithologic log of the TVHP #1 test-well. Geophysical logs were run in open mud-filled hole by UWID Geosciences on 11/22/96.





CUTTINGS RETAINED ON SIEVE NO.	GEOLOGIC MATERIAL SIZE RANGE	GRAIN-SIZE RANGE (inches)
#10	> Very Fine Gravel	> 0.079 in.
#18	Very Coarse Sand	0.079 - 0.039
#30	Coarse Sand	0.039 - 0.023
#50	Medium Sand	0.023 – 0.012
#100	Fine Sand	0.012 – 0.006
#200	Fine Sand to Silt	0.006 – 0.003
< #200	Silt/ Clay	< 0.003

Figure 4.

Figure 4. Grain-size percentage log of drill-cuttings from the TVHP #1 test-well. Each five-foot sample interval was wet-washed through a stack of U.S. Standard sieves and the relative percentages retained, by volume,were measured. The silt and clay fractions were estimated by settling the wash-through water, and delineated from one another by setting time in a graduated cylinder. Sieve analysis by Boise State University graduate students Brian Cavanagh and Mike Guilbert of the Department of Geosciences. The log is meant to be an objective representation of grain size distribution with depth, however, recirculated sand, cavings, and the loss of clay and silt particles in the drill-cuttings can affect the log. The log cannot be directly correlated with geophysical logs owing to the cuttings return "lag time".

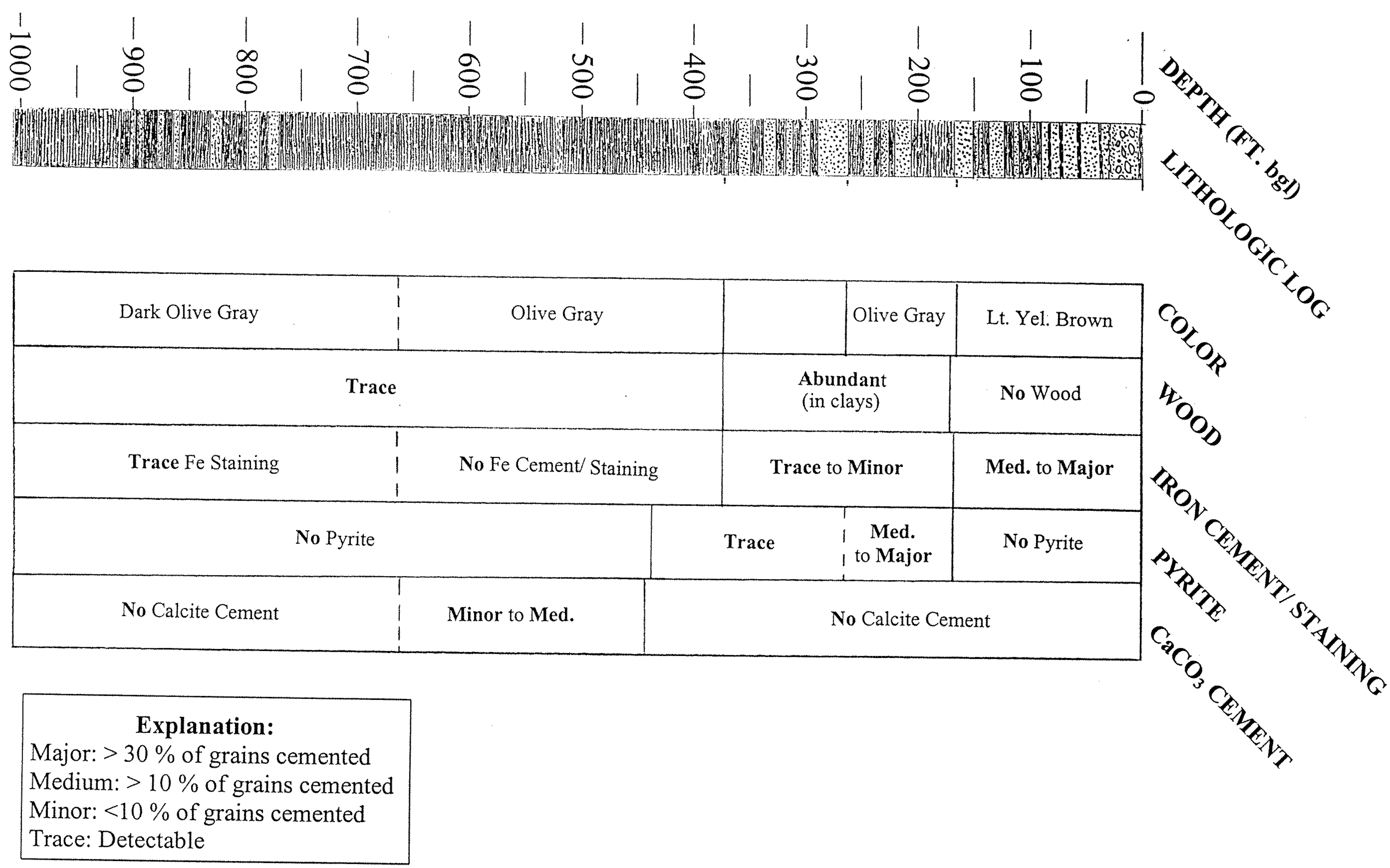


Figure 5. Occurrence of reduced wood chips, iron cemented or staining, fine pyrite crystals as cement, and calcite cement on sand grains in the TVHP #1 test well samples.

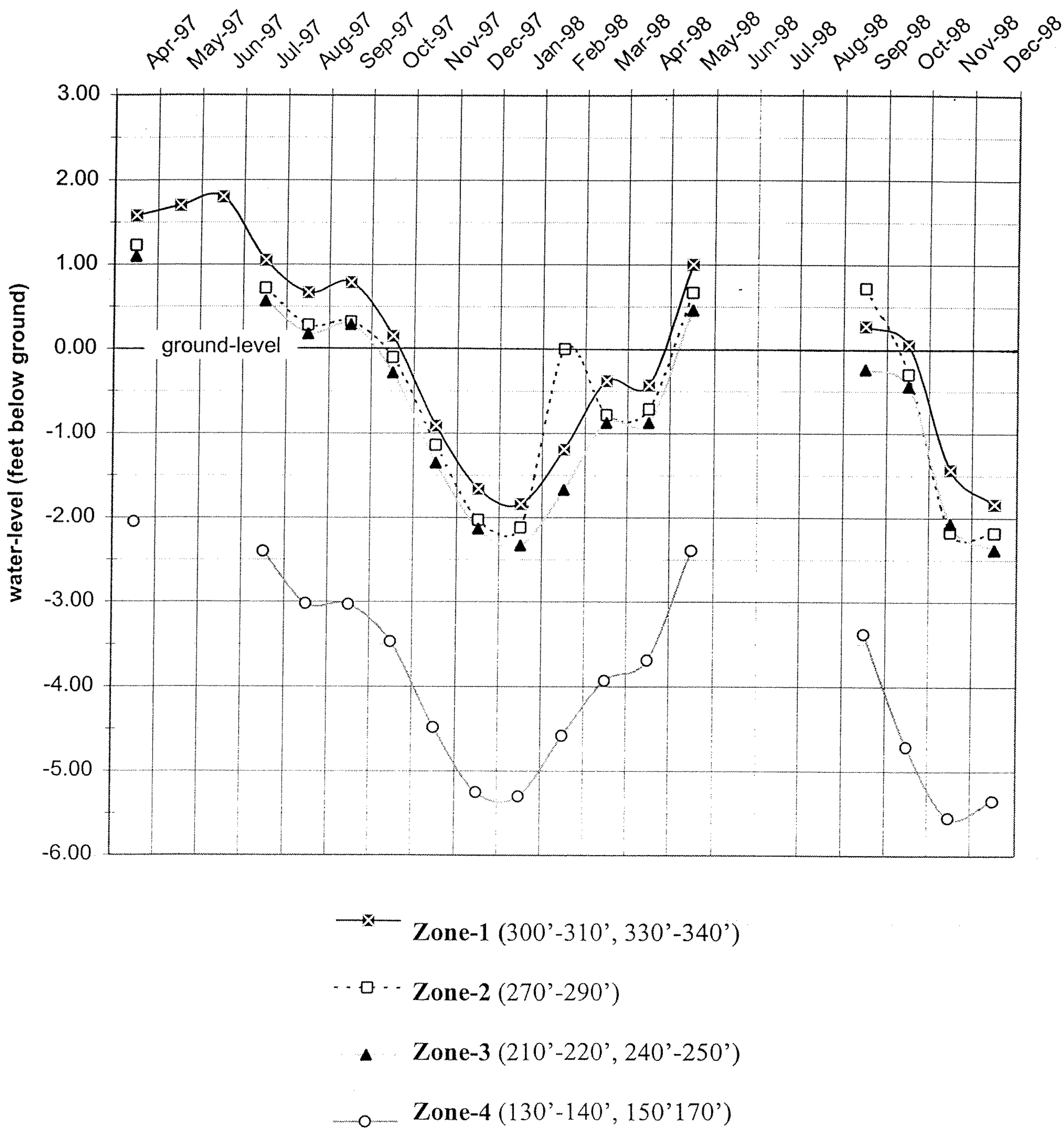


Figure 6. Hydrograph of monthly water-level measurements of the TVHP #1 test-well piezometers. Measurements were taking near the beginning of each month, except June through August 1998, when land owners prevented access.

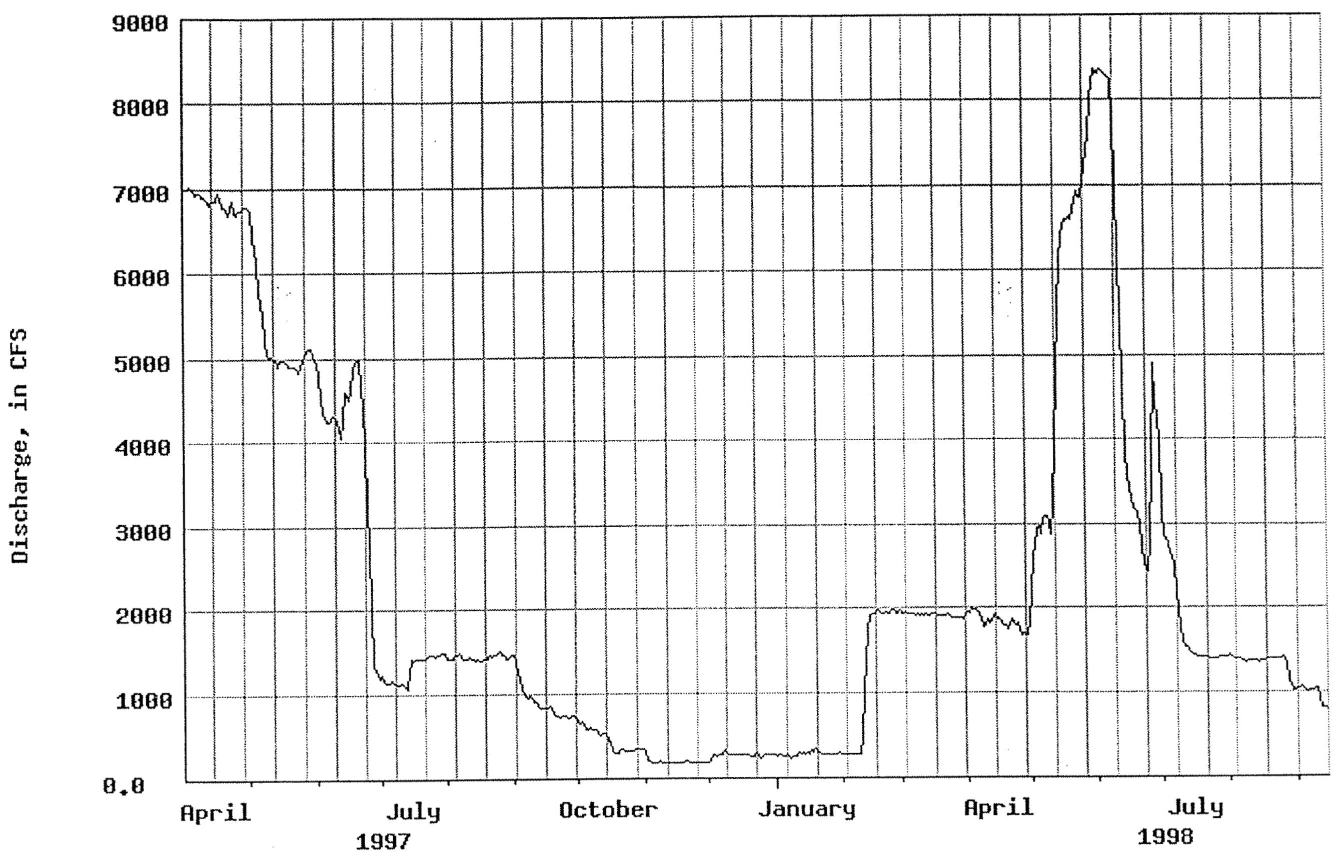
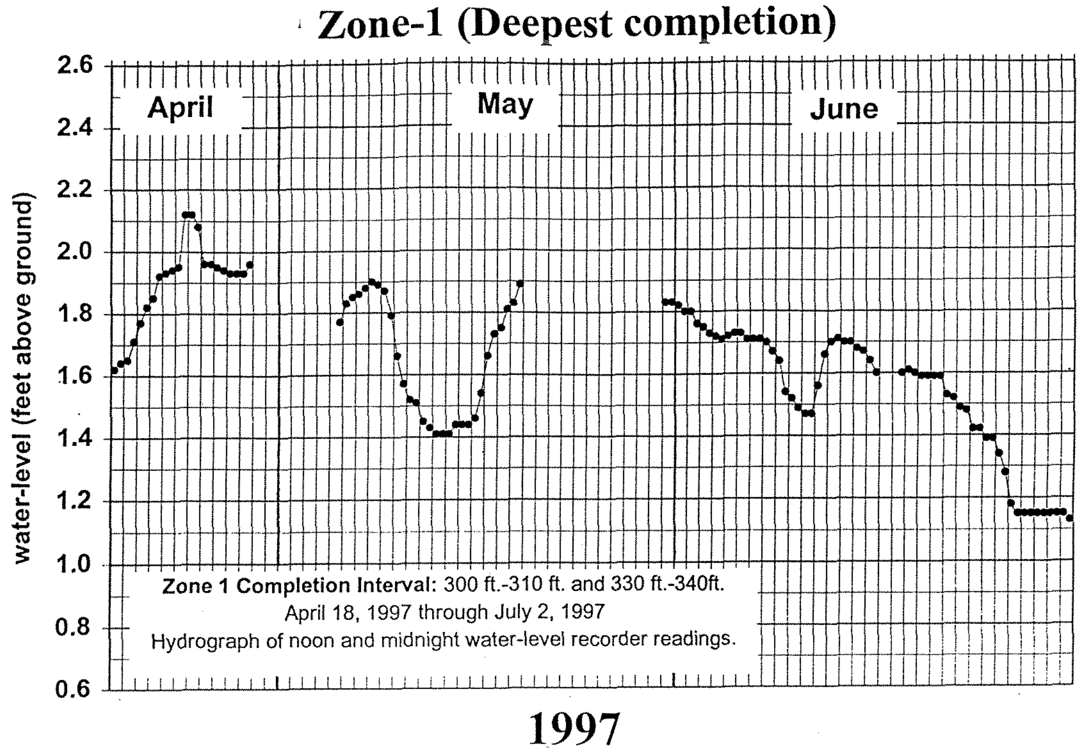


Figure 7. Flow rate of the Boise River at USGS streamflow gauging station number 13206000, located at the Glenwood Bridge, 2.2 miles southeast of the Treasure Valley Hydrologic Project #1 test-well (USGS data). Flow rate in the Boise River corresponds to hydrograph based on monthly water-levels measured in the TVHP #1 test-well over the same time period (see Figure 8).



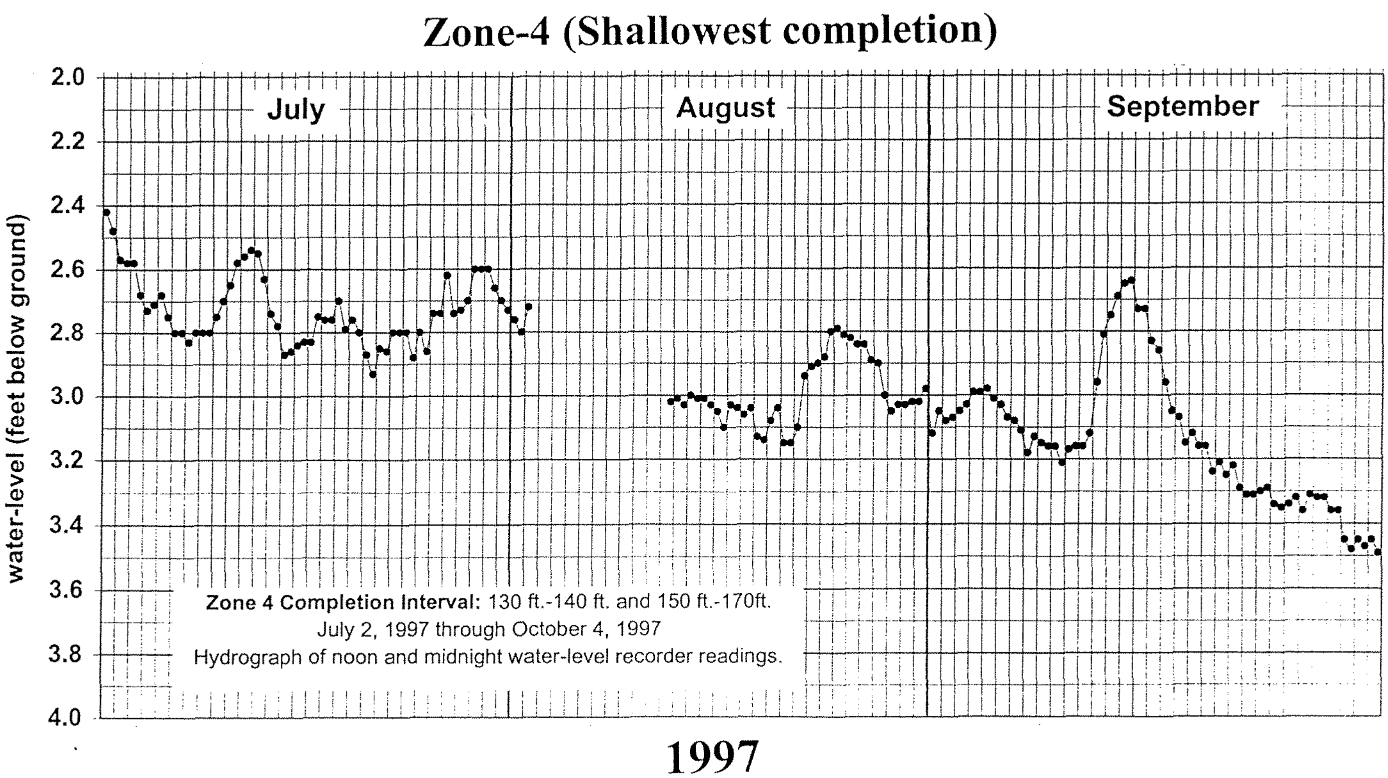


Figure 8. Hydrograph of water-levels for the deepest and shallowest of the four piezometer completion zones in the TVHP #1 test-well , showing the relatively small-scale fluctuations which are probably responses to changes in barometric pressure.

APPENDIX A

WELL DRILLER'S REPORT
to the
Idaho Department of Water Resources

(note: sketch turned in with driller's report is UWID's proposed construction plan which is different from UWID's as-built diagram of this report.)

Form 238-7
3/95

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT
Use Typewriter or Ballpoint Pen

Office Use Only
Inspected by ______
Twp ____ Rge ____ Sec ____
____1/4 ____1/4 ____1/4
Lat: : : Long: : :

1. DRILLING PERMIT NO. 63-96-W-0709 001
Other IDWR No. ______

2. OWNER:
Name United Water Corp
Address Box 7488
City Boise State ID Zip 83707

3. LOCATION OF WELL by legal description:
Sketch map location must agree with written location.

Twp. 4 North XX or South ☐
Rge. 1 East XX or West ☐
Sec. 14, S/W 1/4 (10 acres) S/W 1/4 (40 acres) ____ 1/4 (160 acres)
Gov't Lot ____ County Ada
Lat: : : Long: : :
Address of Well Site State St at Hwy 55
(Pierce Well) City Eagle
(Give at least name of road + Distance to Road or Landmark)
Lt. ____ Blk. ____ Sub. Name ______

4. USE:
☐ Domestic ☐ Municipal XX Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ______

5. TYPE OF WORK check all that apply (Replacement etc.)
XX New Well ☐ Modify ☐ Abandonment ☐ Other ______

6. DRILL METHOD
☐ Air Rotary ☐ Cable XX Mud Rotary ☐ Other ______

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
~~cement~~				
~~grout~~				

Was drive shoe used? XX Y ☐ N Shoe Depth(s) ______
Was drive shoe seal tested? ☐ Y XX N How? ______

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
~~2"~~		~~sch~~	~~80~~	~~PVC~~	☐	☐	☐	☐
~~2"~~		~~sch~~	~~80~~	~~PVC slotted~~	☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe ______ Length of Tailpipe ______

9. PERFORATIONS/SCREENS
☐ Perforations Method ______
☐ Screens Screen Type ______

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
						☐	☐
						☐	☐
						☐	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
____ ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ______

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
8" ~~10"~~			casing to 76 ft set w/ ~~cable~~-tool rig		
	75	78	clay		
8"	78	85	sand		
	85	86	clay		
	86	92	sand		
	92	112	sand & clay streaks, brn		
	112	116	sand, light olive brn.		
	116	125	clay, yel. brn.		
	125	140	sand, medium, brn		
	140	147	clay, light yel. brn		
	147	168	sand, med. pale yellow		
	168	207	clay, olive brn		
	207	222	sand, med., gry-brn.		
	222	226	sandy clay, olive brn		
	226	235	sand, med. brn.		
	235	241	sandy clay, olive brn.		
	241	250	sand, med. gry-brn.		
	250	264	clay w/ sandy silt incenter olive brn		
	264	291	sand, med. light olive brn		
	291	297	clay, yellow brn.		
	297	307	sand, med. light olive brn		
	307	313	clay, yel. brn.		
	313	319	sand, med. light olive brn		
	319	330	clay, yel. brn.		
	330	342	sand, light olive brn.		
	342	345	clay yel. brn		
	345	351	sand silt yel. brn		
	351	354	clay yel. brn		
	354	363	sand med. dark gray brn		
	363	368	clay, dark gray		
	368	374	sand, fine-med dark gry		
	374	771	clay, dark gray		
	771	797	sand, med w/ clay beds @ 780 and 787'		
	797	820	clay, dark gray		

Completed Depth 1000' (Measurable)
Date: Started 10/96 Completed 12/96

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Stevens & Sons Firm No. 153
Firm Official Ron Stevens Date 12/10/96
and
Supervisor or Operator [signature] Date ______
(Sign once if Firm Official & Operator)

FORWARD WHITE COPY TO WATER RESOURCES

Form 238-7
3/95

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT
Use Typewriter or Ballpoint Pen

Office Use Only
Inspected by ______
Twp ____ Rge ____ Sec ____
____1/4 ____1/4 ____1/4
Lat: : : Long: : :

1. DRILLING PERMIT NO. 63 - 96 - W - 0709 001
Other IDWR No. ______

2. OWNER:
Name United Water Corp
Address Box 7488
City Boise State ID Zip 83707

3. LOCATION OF WELL by legal description:
Sketch map location must agree with written location.

Twp. 4 North XX or South ☐
Rge. 1 East XX or West ☐
Sec. 14, S/W 1/4 S/W 1/4 ____ 1/4 (10 acres / 40 acres / 160 acres)
Gov't Lot ____ County Ada
Lat: : : Long: : :
Address of Well Site State St at Hwy 55 (Pierce Well) City Eagle
(Give at least name of road + Distance to Road or Landmark)
Lt. ____ Blk. ____ Sub. Name ____

4. USE:
☐ Domestic ☐ Municipal XX Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK check all that apply (Replacement etc.)
XX New Well ☐ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD
☐ Air Rotary ☐ Cable XX Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
cement				
grout				

Was drive shoe used? XX Y ☐ N Shoe Depth(s) ____
Was drive shoe seal tested? ☐ Y XX N How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
2"		sch	80	PVC	☐	☐	☐	☐
2"		sch	80	PVC slotted	☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
☐ Perforations Method ____
☐ Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
						☐	☐
						☐	☐
						☐	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
____ ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time

Water Temp. ____ Bottom hole temp. ____
Water Quality test or comments: ____
____ Depth first Water Encountered ____

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes
	820	830	Sand, med, gray	
	830	858	Clay, dk. gray	
	858	863	Sand, fine-med, gray	
	863	871	Clay, dark gray	
	871	876	Sand, fine-med gray	
	876	891	clay, dark gray	
	891	893	Sand, fine-med, gray	
	893	897	Clay, gray	
	897	901	Sand, Fine, gray	
	901	1005	Clay, dark gray	

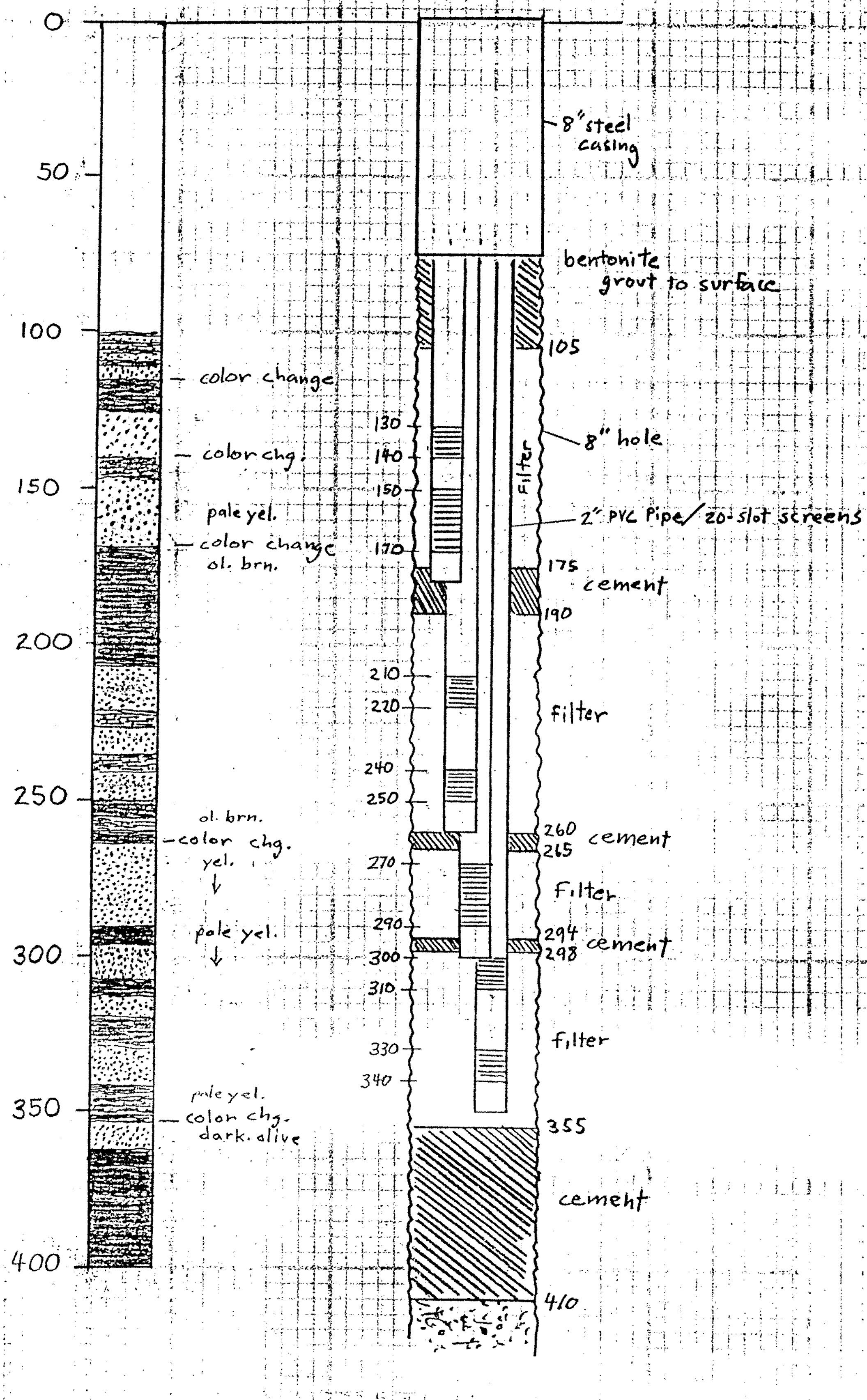
RECEIVED
MAR 13 1997
WATER RESOURCES
WESTERN REGION

Completed Depth 1000' (Measurable)
Date: Started 10/96 Completed 12/96

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Stevens & Sons Firm No. 153
Firm Official Ron Stevens Date 12/10/96
and
Supervisor or Operator [signature] Date ____
(Sign once if Firm Official & Operator)

FORWARD WHITE COPY TO WATER RESOURCES



0
50
100
150
200
250
300
350
400
color change
color chg.
pale yel.
color change
ol. brn.
ol. brn.
color chg.
yel.
pale yel.
pale yel.
color chg.
dark olive
8" steel casing
bentonite grout to surface
105
130
140
150
170
8" hole
Filter
2" PVC Pipe/ 20-slot screens
175
cement
190
210
220
filter
240
250
260
cement
265
270
Filter
290
294
cement
298
300
310
330
340
filter
355
cement
410

APPENDIX B

LABORATORY REPORTS OF WATER QUALITY

Alchem Laboratories, Inc.
104 West 31st Street
Boise, Idaho 83714
Phone (208) 336-1172
FAX (208) 336-7124
Water, Waste Water and Soil Analysis

LABORATORY REPORT

UNITED WATER
P.O. BOX 7488
BOISE, IDAHO 83707-1488

DATE COLLECTED - - -12/13/96
TIME COLLECTED - - -14:00
DATE RECEIVED - - - 12/13/96
DATE REPORTED - - - 12/23/96

ATTENTION: ED SQUIRES
SUBMITTED : ALLRED
SOURCE -: ZONE #4 / STATE ST. TEST WELL shallow: 130-140', 150'-170'

LAB SAMPLE NUMBER - 18075

Results reported unless noted: (Chemistry Analysis as mg/l) (Bacteria as organisms/100 ml)

ANALYSIS	RESULTS	DATE ANALYZED	ANALYST
ALKALINITY	139.0	12/19/96	JD
CALCIUM	37.5	12/17/96	PM
CHLORIDE	3.20	12/13/96	CB
CONDUCTIVITY (umhos/cm)	299.0	12/13/96	GC
CORROSIVITY	-0.33*	12/23/96	CB
FLUORIDE	0.33	12/18/96	JD
HARDNESS	111.0	12/17/96	PM
IRON	0.03	12/17/96	PM
IRON (DISS.)	0.01	12/17/96	PM
MAGNESIUM	4.16	12/17/96	PM
MANGANESE	0.01	12/17/96	PM
MANGANESE (DISS.)	0.01	12/17/96	PM
NITRATE as N	<0.10	12/13/96	CB
POTASSIUM	2.17	12/20/96	SQ
SILICA	28.7	12/16/96	SQ
SODIUM	24.9	12/16/96	SQ
SULFATE	10.2	12/13/96	CB
SULFIDE	<0.05	12/13/96	JD
TEMPERATURE	12.8o C	12/13/96	JA
TOTAL DISS. SOLIDS	248.0	12/17/96	NH
TOTAL PHOSPHORUS as P	0.05	12/17/96	JD
pH (SU)	7.70	12/13/96	GC

COMMENTS: FIELD pH = 7.36 @ 12.8o C
CORROSIVITY: THE WATER IS MODERATELY AGGRESSIVE.

Suzanne Howell, Laboratory Manager

ALCHEM LABORATORIES

Alchem Laboratories, Inc.
104 West 31st Street
Boise, Idaho 83714
Phone (208) 336-1172
FAX (208) 336-7124
Water, Waste Water and Soil Analysis

LABORATORY REPORT

UNITED WATER
P.O. BOX 7488
BOISE, IDAHO 83707-1488

ATTENTION: ED SQUIRES
SOURCE -: ZONE #3 / STATE ST. TEST WELL
(210'-220' 240'-250')

DATE COLLECTED - - -12/13/96
TIME COLLECTED - - -13:00
DATE RECEIVED - - - 12/13/96
DATE REPORTED - - - 12/23/96
SUBMITTED : ALLRED

LAB SAMPLE NUMBER - 18074

Results reported unless noted: (Chemistry Analysis as mg/l) (Bacteria as organisms/100 ml)

ANALYSIS	RESULTS	DATE ANALYZED	ANALYST
ALKALINITY	132.0	12/19/96	JD
CALCIUM	39.6	12/17/96	PM
CHLORIDE	2.63	12/13/96	CB
CONDUCTIVITY (umhos/cm)	313.0	12/13/96	GC
CORROSIVITY	-0.35*	12/23/96	CB
FLUORIDE	0.37	12/18/96	JD
HARDNESS	129.0	12/17/96	PM
IRON	0.63	12/17/96	PM
IRON (DISS.)	0.57	12/17/96	PM
MAGNESIUM	7.22	12/17/96	PM
MANGANESE	0.06	12/17/96	PM
MANGANESE (DISS.)	0.05	12/17/96	PM
NITRATE as N	(0.10	12/13/96	CB
POTASSIUM	2.55	12/20/96	SQ
SILICA	31.5	12/16/96	SQ
SODIUM	20.3	12/16/96	SQ
SULFATE	22.5	12/13/96	CB
SULFIDE	(0.05	12/13/96	JD
TEMPERATURE	13.1o C	12/13/96	JA
TOTAL DISS. SOLIDS	173.0	12/17/96	NH
TOTAL PHOSPHORUS as P	0.04	12/17/96	JD
pH (SU)	7.65	12/13/96	GC

COMMENTS: FIELD pH = 7.18 @ 13.1o C
CORROSIVITY: THE WATER IS MODERATELY AGGRESSIVE.

Suzanne Howell, Laboratory Manager

ALCHEM LABORATORIES

Alchem Laboratories, Inc.
104 West 31st Street
Boise, Idaho 83714
Phone (208) 336-1172
FAX (208) 336-7124
Water, Waste Water and Soil Analysis

LABORATORY REPORT

UNITED WATER
P.O. BOX 7488
BOISE, IDAHO 83707-1488

ATTENTION: ED SQUIRES
SOURCE -: ZONE #2 / STATE ST. TEST WELL
(270'-290')

DATE COLLECTED - - -12/13/96
TIME COLLECTED - - -12:00
DATE RECEIVED - - - 12/13/96
DATE REPORTED - - - 12/23/96
SUBMITTED : ALLRED

LAB SAMPLE NUMBER - 18073

Results reported unless noted: (Chemistry Analysis as mg/l) (Bacteria as organisms/100 ml)

ANALYSIS	RESULTS	DATE ANALYZED	ANALYST
ALKALINITY	101.0	12/19/96	JD
CALCIUM	28.1	12/17/96	PM
CHLORIDE	1.73	12/13/96	CB
CONDUCTIVITY (umhos/cm)	224.0	12/13/96	GC
CORROSIVITY	-0.54*	12/23/96	CB
FLUORIDE	0.36	12/18/96	JD
HARDNESS	86.4	12/17/96	PM
IRON	0.05	12/17/96	PM
IRON (DISS.)	0.01	12/17/96	PM
MAGNESIUM	3.94	12/17/96	PM
MANGANESE	0.04	12/17/96	PM
MANGANESE (DISS.)	0.04	12/17/96	PM
NITRATE as N	<0.10	12/13/96	CB
POTASSIUM	2.07	12/20/96	SQ
SILICA	33.6	12/16/96	SQ
SODIUM	15.2	12/16/96	SQ
SULFATE	11.4	12/13/96	CB
SULFIDE	<0.05	12/13/96	JD
TEMPERATURE	14.1o C	12/13/96	JA
TOTAL DISS. SOLIDS	188.0	12/17/96	NH
TOTAL PHOSPHORUS as P	0.03	12/17/96	JD
pH (SU)	7.70	12/13/96	GC

COMMENTS: FIELD pH = 7.42 @ 14.1o C
CORROSIVITY: THE WATER IS MODERATELY AGGRESSIVE.

Suzanne Howell, Laboratory Manager

RECEIVED

DEC 2 6 1996

UNITED WATER

ALCHEM LABORATORIES

Alchem Laboratories, Inc.
104 West 31st Street
Boise, Idaho 83714
Phone (208) 336-1172
FAX (208) 336-7124
Water, Waste Water and Soil Analysis

LABORATORY REPORT

UNITED WATER
P.O. BOX 7488
BOISE, IDAHO 83707-1488

ATTENTION: ED SQUIRES
SOURCE -: ZONE #1 / STATE ST. TEST WELL
(300-310', 330-340')

DATE COLLECTED - - -12/13/96
TIME COLLECTED - - -11:00
DATE RECEIVED - - - 12/13/96
DATE REPORTED - - - 12/23/96
SUBMITTED : ALLRED

LAB SAMPLE NUMBER - 18072

Results reported unless noted: (Chemistry Analysis as mg/l) (Bacteria as organisms/100 ml)

ANALYSIS	RESULTS	DATE ANALYZED	ANALYST
ALKALINITY	112.0	12/19/96	JD
CALCIUM	28.9	12/17/96	PM
CHLORIDE	2.05	12/13/96	CB
CONDUCTIVITY (umhos/cm)	260.0	12/13/96	GC
CORROSIVITY	-0.87*	12/23/96	CB
FLUORIDE	0.34	12/18/96	JD
HARDNESS	90.9	12/17/96	PM
IRON	0.06	12/17/96	PM
IRON (DISS.)	0.02	12/17/96	PM
MAGNESIUM	4.54	12/17/96	PM
MANGANESE	0.03	12/17/96	PM
MANGANESE (DISS.)	0.03	12/17/96	PM
NITRATE as N	0.13	12/13/96	CB
POTASSIUM	2.00	12/20/96	SQ
SILICA	32.5	12/16/96	SQ
SODIUM	17.3	12/16/96	SQ
SULFATE	14.4	12/13/96	CB
SULFIDE	(0.05	12/13/96	JD
TEMPERATURE	15.0o C	12/13/96	JA
TOTAL DISS. SOLIDS	218.0	12/17/96	NH
TOTAL PHOSPHORUS as P	0.04	12/17/96	JD
pH (SU)	7.30	12/13/96	GC

COMMENTS: FIELD pH = 7.03 @ 15.0o C
CORROSIVITY: THE WATER IS MODERATELY AGGRESSIVE.

Suzanne Howell, Laboratory Manager

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628561

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# **4034**

Time of Collection: **14:00**
Date of Collection: **12/13/96**

Date Received: **12/13/96**
Date Reported: **12/19/96**

Submitted by:

Source of Sample: **ZONE 4**

Test Requested	FRDS #	MCL	Analysis Result Unit	MDL	Method	Date Completed	Analyst Initials
IRON, DISSOLVED			<0.05 mg/L		EPA 200.7	12/18/96	DDB
MANGANESE DISSOLVED			<0.05 mg/L		EPA 200.7	12/18/96	DDB

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628560

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# **4034**

Time of Collection: **13:00**
Date of Collection: **12/13/96**

Date Received: **12/13/96**
Date Reported: **12/19/96**

Submitted by:

Source of Sample: **ZONE 3**

Test Requested	FRDS #	MCL	Analysis Result	Unit	MDL	Method	Date Completed	Analyst Initials
IRON, DISSOLVED			0.45	mg/L		EPA 200.7	12/18/96	DDB
MANGANESE DISSOLVED			0.05	mg/L		EPA 200.7	12/18/96	DDB

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628559

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# **4034**

Time of Collection: **12:00**
Date of Collection: **12/13/96**

Date Received: **12/13/96**
Date Reported: **12/19/96**

Submitted by:

Source of Sample: ZONE 2

Test Requested	FRDS #	MCL	Analysis Result	Unit	MDL	Method	Date Completed	Analyst Initials
IRON, DISSOLVED			<0.05	mg/L		EPA 200.7	12/18/96	DDB
MANGANESE DISSOLVED			<0.05	mg/L		EPA 200.7	12/18/96	DDB

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628558

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# **4034**

Time of Collection: **11:00**
Date of Collection: **12/13/96**

Date Received: **12/13/96**
Date Reported: **12/19/96**

Submitted by:

Source of Sample: ZONE 1

Test Requested	FRDS #	MCL	Analysis Result Unit	MDL	Method	Date Completed	Analyst Initials
IRON, DISSOLVED			<0.05 mg/L		EPA 200.7	12/18/96	DDB
MANGANESE DISSOLVED			<0.05 mg/L		EPA 200.7	12/18/96	DDB

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628557

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# **4034**

Time of Collection: **14:00**
Date of Collection: **12/13/96**

Date Received: **12/13/96**
Date Reported: **12/30/96**

Submitted by:

Source of Sample: **STATE ST TEST WELL ZONE #4** 130'-140'
Shalowest 150-170'

Lab Comment: FIELD PH 7.36 TEMP 12.8c

*VOC SCAN:

BENZENE	<0.5	ug/L
VINYL CHLORIDE	<0.5	ug/L
CARBON TETRACHLORIDE	<0.5	ug/L
1,2-DICHLOROETHANE	<0.5	ug/L
TRICHLOROETHENE	<0.5	ug/L
1,4-DICHLOROBENZENE	<0.5	ug/L
1,1-DICHLOROETHENE	<0.5	ug/L
1,1,1-TRICHLOROETHANE	<0.5	ug/L
CHLOROFORM	<0.5	ug/L
BROMODICHLOROMETHANE	<0.5	ug/L
DIBROMOCHLOROMETHANE	<0.5	ug/L
BROMOFORM	<0.5	ug/L
trans-1,2-DICHLOROETHENE	<0.5	ug/L
CHLOROBENZENE	<0.5	ug/L
1,3-DICHLOROBENZENE	<0.5	ug/L
DICHLOROMETHANE	<0.5	ug/L
cis-1,2-DICHLOROETHENE	<0.5	ug/L
1,2-DICHLOROBENZENE	<0.5	ug/L
DIBROMOMETHANE	<0.5	ug/L
1,1-DICHLOROPROPENE	<0.5	ug/L
TETRACHLOROETHENE	<0.5	ug/L
TOLUENE	<0.5	ug/L
p-XYLENE	<0.5	ug/L
o-XYLENE	<0.5	ug/L
m-XYLENE	<0.5	ug/L
1,1-DICHLOROETHANE	<0.5	ug/L
1,2-DICHLOROPROPANE	<0.5	ug/L
1,1,2,2-TETRACHLOROETHANE	<0.5	ug/L
ETHYLBENZENE	<0.5	ug/L
1,3-DICHLOROPROPANE	<0.5	ug/L
STYRENE	<0.5	ug/L
CHLOROMETHANE	<0.5	ug/L
BROMOMETHANE	<0.5	ug/L
1,2,3-TRICHLOROPROPANE	<0.5	ug/L
1,1,1,2-TETRACHLOROETHANE	<0.5	ug/L
CHLOROETHANE	<0.5	ug/L
1,1,2-TRICHLOROETHANE	<0.5	ug/L
2,2-DICHLOROPROPANE	<0.5	ug/L
2-CHLOROTOLUENE	<0.5	ug/L
4-CHLOROTOLUENE	<0.5	ug/L

(continued)

BROMOBENZENE	<0.5	ug/L
1,3-DICHLOROPROPENE	<0.5	ug/L
1,2,4-TRICHLOROBENZENE	<0.5	ug/L

** WATER WAS MODERATELY AGGRESSIVE.

Test Requested	FRDS #	MCL	Analysis Result	Unit	MDL	Method	Date Completed	Analyst Initials
CHLORIDE	1017		3	mg/L	1.0	EPA 300.0	12/23/96	JAL
FLUORIDE DIRECT	1025	4.0	0.75	mg/L	0.05	SM 4500F-C	12/22/96	KAI
NITRATE N	1040	10.0	<0.10	mg/L	0.10	EPA 300.0	12/23/96	JAL
SODIUM	1052		24.2	mg/L	0.10	EPA 200.7	12/19/96	DDB
SULFATE	1055		11	mg/L	1.0	EPA 300.0	12/23/96	JAL
CALCIUM	1016		33.3	mg/L	0.10	EPA 200.7	12/19/96	DDB
IRON	1028		<0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
POTASSIUM	1042		1.64	mg/L	0.10	EPA 200.7	12/19/96	DDB
MAGNESIUM	1031		3.62	mg/L	0.10	EPA 200.7	12/19/96	DDB
MANGANESE	1032		<0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
SILICON			14.3	mg/L		EPA 200.7	12/19/96	DDB
ALKALINITY	1927		143	mg/L		EPA 310.1	12/19/96	JH
CONDUCTIVITY	1926		294	umhos	2.0	EPA 120.1	12/13/96	MBM
CORROSIVITY	1997		-0.7 **			LANGELIER	12/27/96	DMB
SULFIDE	1027		0.19	mg/L		EPA 376.1	12/30/96	MDM
HARDNESS	1915		108	mg/L	2.0	SM 2340	12/19/96	JH
PHOSPHATE P, TOTAL			0.08	mg/L	0.05	EPA 365.4	12/19/96	JAL
TOTAL DISSOLVED SOLIDS	1930		188	mg/L	1.0	EPA 160.1	12/18/96	MS
pH	1925		8.0	S.U.		EPA 150.1	12/13/96	MBM
VOC			* SCAN	ug/L		EPA 502.2	12/14/96	DMB

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628556

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# 4034

Time of Collection: 13:00
Date of Collection: 12/13/96

Date Received: 12/13/96
Date Reported: 12/30/96

Submitted by:

Source of Sample: STATE ST TEST WELL ZONE #3 210-220'
240-250'

Lab Comment: FIELD PH 7.18 TEMP 13.1c

*VOC SCAN:

BENZENE	<0.5	ug/L
VINYL CHLORIDE	<0.5	ug/L
CARBON TETRACHLORIDE	<0.5	ug/L
1,2-DICHLOROETHANE	<0.5	ug/L
TRICHLOROETHENE	<0.5	ug/L
1,4-DICHLOROBENZENE	<0.5	ug/L
1,1-DICHLOROETHENE	<0.5	ug/L
1,1,1-TRICHLOROETHANE	<0.5	ug/L
CHLOROFORM	<0.5	ug/L
BROMODICHLOROMETHANE	<0.5	ug/L
DIBROMOCHLOROMETHANE	<0.5	ug/L
BROMOFORM	<0.5	ug/L
trans-1,2-DICHLOROETHENE	<0.5	ug/L
CHLOROBENZENE	<0.5	ug/L
1,3-DICHLOROBENZENE	<0.5	ug/L
DICHLOROMETHANE	<0.5	ug/L
cis-1,2-DICHLOROETHENE	<0.5	ug/L
1,2-DICHLOROBENZENE	<0.5	ug/L
DIBROMOMETHANE	<0.5	ug/L
1,1-DICHLOROPROPENE	<0.5	ug/L
TETRACHLOROETHENE	<0.5	ug/L
TOLUENE	<0.5	ug/L
p-XYLENE	<0.5	ug/L
o-XYLENE	<0.5	ug/L
m-XYLENE	<0.5	ug/L
1,1-DICHLOROETHANE	<0.5	ug/L
1,2-DICHLOROPROPANE	<0.5	ug/L
1,1,2,2-TETRACHLOROETHANE	<0.5	ug/L
ETHYLBENZENE	<0.5	ug/L
1,3-DICHLOROPROPANE	<0.5	ug/L
STYRENE	<0.5	ug/L
CHLOROMETHANE	<0.5	ug/L
BROMOMETHANE	<0.5	ug/L
1,2,3-TRICHLOROPROPANE	<0.5	ug/L
1,1,1,2-TETRACHLOROETHANE	<0.5	ug/L
CHLOROETHANE	<0.5	ug/L
1,1,2-TRICHLOROETHANE	<0.5	ug/L
2,2-DICHLOROPROPANE	<0.5	ug/L
2-CHLOROTOLUENE	<0.5	ug/L
4-CHLOROTOLUENE	<0.5	ug/L

(continued)

BROMOBENZENE	<0.5	ug/L
1,3-DICHLOROPROPENE	<0.5	ug/L
1,2,4-TRICHLOROBENZENE	<0.5	ug/L

** WATER WAS MODERATELY AGGRESSIVE.

Test Requested	FRDS #	MCL	Analysis Result	Unit	MDL	Method	Date Completed	Analyst Initials
CHLORIDE	1017		3	mg/L	1.0	EPA 300.0	12/23/96	JAL
FLUORIDE DIRECT	1025	4.0	0.78	mg/L	0.05	SM 4500F-C	12/22/96	KAI
NITRATE N	1040	10.0	<0.10	mg/L	0.10	EPA 300.0	12/23/96	JAL
SODIUM	1052		19.4	mg/L	0.10	EPA 200.7	12/19/96	DDB
SULFATE	1055		22	mg/L	1.0	EPA 300.0	12/23/96	JAL
CALCIUM	1016		35.1	mg/L	0.10	EPA 200.7	12/19/96	DDB
IRON	1028		0.50	mg/L	0.05	EPA 200.7	12/18/96	DDB
POTASSIUM	1042		2.06	mg/L	0.10	EPA 200.7	12/19/96	DDB
MAGNESIUM	1031		6.55	mg/L	0.10	EPA 200.7	12/19/96	DDB
MANGANESE	1032		0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
SILICON			15.4	mg/L	× 2.139 = 32.9 silica	EPA 200.7	12/19/96	DDB
ALKALINITY	1927		138	mg/L		EPA 310.1	12/19/96	JH
CONDUCTIVITY	1926		305	umhos	2.0	EPA 120.1	12/13/96	MBM
CORROSIVITY	1997		-0.8 **			LANGELIER	12/27/96	DMB
SULFIDE	1027		0.16	mg/L		EPA 376.1	12/30/96	MDM
HARDNESS	1915		125	mg/L	2.0	SM 2340	12/19/96	JH
PHOSPHATE P, TOTAL			0.06	mg/L	0.05	EPA 365.4	12/19/96	JAL
TOTAL DISSOLVED SOLIDS	1930		200	mg/L	1.0	EPA 160.1	12/18/96	MS
pH	1925		7.9	S.U.		EPA 150.1	12/13/96	MBM
VOC			* SCAN	ug/L		EPA 502.2	12/14/96	DMB

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628555

Attn. ED SQUIRES — P.O.# **4034**

UNITED WATER
8248 W VICTORY RD
BOISE ID,

Time of Collection: **12:00**
Date of Collection: **12/13/96**

Date Received: **12/13/96**
Date Reported: **12/30/96**

Submitted by:

Source of Sample: **STATE ST TEST WELL ZONE #2** Middle zone 270'-290'

Lab Comment: FIELD PH 7.42 TEMP 14.1c

*VOC SCAN:

BENZENE	<0.5	ug/L
VINYL CHLORIDE	<0.5	ug/L
CARBON TETRACHLORIDE	<0.5	ug/L
1,2-DICHLOROETHANE	<0.5	ug/L
TRICHLOROETHENE	<0.5	ug/L
1,4-DICHLOROBENZENE	<0.5	ug/L
1,1-DICHLOROETHENE	<0.5	ug/L
1,1,1-TRICHLOROETHANE	<0.5	ug/L
CHLOROFORM	<0.5	ug/L
BROMODICHLOROMETHANE	<0.5	ug/L
DIBROMOCHLOROMETHANE	<0.5	ug/L
BROMOFORM	<0.5	ug/L
trans-1,2-DICHLOROETHENE	<0.5	ug/L
CHLOROBENZENE	<0.5	ug/L
1,3-DICHLOROBENZENE	<0.5	ug/L
DICHLOROMETHANE	<0.5	ug/L
cis-1,2-DICHLOROETHENE	<0.5	ug/L
1,2-DICHLOROBENZENE	<0.5	ug/L
DIBROMOMETHANE	<0.5	ug/L
1,1-DICHLOROPROPENE	<0.5	ug/L
TETRACHLOROETHENE	<0.5	ug/L
TOLUENE	<0.5	ug/L
p-XYLENE	<0.5	ug/L
o-XYLENE	<0.5	ug/L
m-XYLENE	<0.5	ug/L
1,1-DICHLOROETHANE	<0.5	ug/L
1,2-DICHLOROPROPANE	<0.5	ug/L
1,1,2,2-TETRACHLOROETHANE	<0.5	ug/L
ETHYLBENZENE	<0.5	ug/L
1,3-DICHLOROPROPANE	<0.5	ug/L
STYRENE	<0.5	ug/L
CHLOROMETHANE	<0.5	ug/L
BROMOMETHANE	<0.5	ug/L
1,2,3-TRICHLOROPROPANE	<0.5	ug/L
1,1,1,2-TETRACHLOROETHANE	<0.5	ug/L
CHLOROETHANE	<0.5	ug/L
1,1,2-TRICHLOROETHANE	<0.5	ug/L
2,2-DICHLOROPROPANE	<0.5	ug/L
2-CHLOROTOLUENE	<0.5	ug/L
4-CHLOROTOLUENE	<0.5	ug/L

(continued)

zone 2
compl. 270-290'

SAMPLE NUMBER - 9628555 page 2

BROMOBENZENE	<0.5	ug/L
1,3-DICHLOROPROPENE	<0.5	ug/L
1,2,4-TRICHLOROBENZENE	<0.5	ug/L

** WATER WAS MODERATELY AGGRESSIVE.

Test Requested	FRDS #	MCL	Analysis Result	Unit	MDL	Method	Date Completed	Analyst Initials
CHLORIDE	1017		2	mg/L	1.0	EPA 300.0	12/23/96	JAL
FLUORIDE DIRECT	1025	4.0	0.66	mg/L	0.05	SM 4500F-C	12/22/96	KAI
NITRATE N	1040	10.0	<0.10	mg/L	0.10	EPA 300.0	12/23/96	JAL
SODIUM	1052		14.2	mg/L	0.10	EPA 200.7	12/19/96	DDB
SULFATE	1055		12	mg/L	1.0	EPA 300.0	12/23/96	JAL
CALCIUM	1016		25.8	mg/L	0.10	EPA 200.7	12/19/96	DDB
IRON	1028		<0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
POTASSIUM	1042		1.63	mg/L	0.10	EPA 200.7	12/19/96	DDB
MAGNESIUM	1031		3.70	mg/L	0.10	EPA 200.7	12/19/96	DDB
MANGANESE	1032		<0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
SILICON			15.7	mg/L (Silica 33.58 (SiO_2))		EPA 200.7	12/19/96	DDB
ALKALINITY	1927		103	mg/L		EPA 310.1	12/19/96	JH
CONDUCTIVITY	1926		237	umhos	2.0	EPA 120.1	12/13/96	MBM
CORROSIVITY	1997		-0.8 **			LANGELIER	12/27/96	DMB
SULFIDE	1027		0.23	mg/L		EPA 376.1	12/30/96	MDM
HARDNESS	1915		93.7	mg/L	2.0	SM 2340	12/19/96	JH
PHOSPHATE P, TOTAL			0.07	mg/L	0.05	EPA 365.4	12/19/96	JAL
TOTAL DISSOLVED SOLIDS	1930		164	mg/L	1.0	EPA 160.1	12/18/96	MS
pH	1925		8.1	S.U.		EPA 150.1	12/13/96	MBM
VOC			* SCAN	ug/L		EPA 502.2	12/14/96	DMB

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UNITED WATER

ANALYTICAL LABORATORIES, INC.
1804 N. 33rd Street
Boise, Idaho 83703
Phone # (208) 342-5515

LABORATORY ANALYSIS REPORT
SAMPLE NUMBER - 9628554

Attn. ED SQUIRES

UNITED WATER
8248 W VICTORY RD
BOISE ID,

P.O.# 4034

Time of Collection: 11:00
Date of Collection: 12/13/96

Date Received: 12/13/96
Date Reported: 12/30/96

Submitted by:

Source of Sample: STATE ST TEST WELL ZONE #1 Deepest

Lab Comment: FIELD PH 7.03 TEMP 15.0c

*VOC SCAN:

BENZENE	<0.5	ug/L
VINYL CHLORIDE	<0.5	ug/L
CARBON TETRACHLORIDE	<0.5	ug/L
1,2-DICHLOROETHANE	<0.5	ug/L
TRICHLOROETHENE	<0.5	ug/L
1,4-DICHLOROBENZENE	<0.5	ug/L
1,1-DICHLOROETHENE	<0.5	ug/L
1,1,1-TRICHLOROETHANE	<0.5	ug/L
CHLOROFORM	<0.5	ug/L
BROMODICHLOROMETHANE	<0.5	ug/L
DIBROMOCHLOROMETHANE	<0.5	ug/L
BROMOFORM	<0.5	ug/L
trans-1,2-DICHLOROETHENE	<0.5	ug/L
CHLOROBENZENE	<0.5	ug/L
1,3-DICHLOROBENZENE	<0.5	ug/L
DICHLOROMETHANE	<0.5	ug/L
cis-1,2-DICHLOROETHENE	<0.5	ug/L
1,2-DICHLOROBENZENE	<0.5	ug/L
DIBROMOMETHANE	<0.5	ug/L
1,1-DICHLOROPROPENE	<0.5	ug/L
TETRACHLOROETHENE	<0.5	ug/L
TOLUENE	<0.5	ug/L
p-XYLENE	<0.5	ug/L
o-XYLENE	<0.5	ug/L
m-XYLENE	<0.5	ug/L
1,1-DICHLOROETHANE	<0.5	ug/L
1,2-DICHLOROPROPANE	<0.5	ug/L
1,1,2,2-TETRACHLOROETHANE	<0.5	ug/L
ETHYLBENZENE	<0.5	ug/L
1,3-DICHLOROPROPANE	<0.5	ug/L
STYRENE	<0.5	ug/L
CHLOROMETHANE	<0.5	ug/L
BROMOMETHANE	<0.5	ug/L
1,2,3-TRICHLOROPROPANE	<0.5	ug/L
1,1,1,2-TETRACHLOROETHANE	<0.5	ug/L
CHLOROETHANE	<0.5	ug/L
1,1,2-TRICHLOROETHANE	<0.5	ug/L
2,2-DICHLOROPROPANE	<0.5	ug/L
2-CHLOROTOLUENE	<0.5	ug/L
4-CHLOROTOLUENE	<0.5	ug/L

(continued)

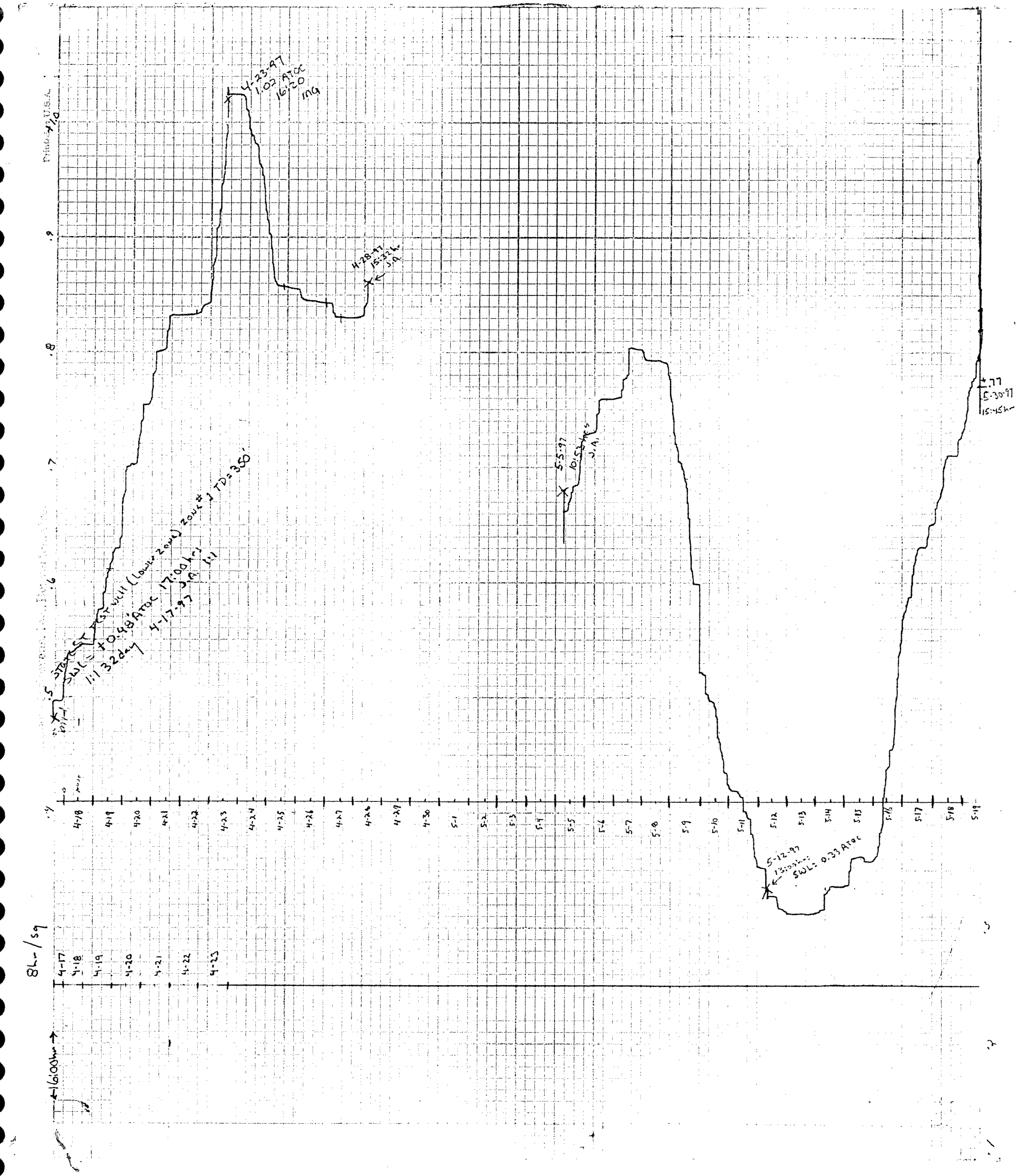
BROMOBENZENE	<0.5	ug/L
1,3-DICHLOROPROPENE	<0.5	ug/L
1,2,4-TRICHLOROBENZENE	<0.5	ug/L

** WATER WAS MODERATELY AGGRESSIVE.

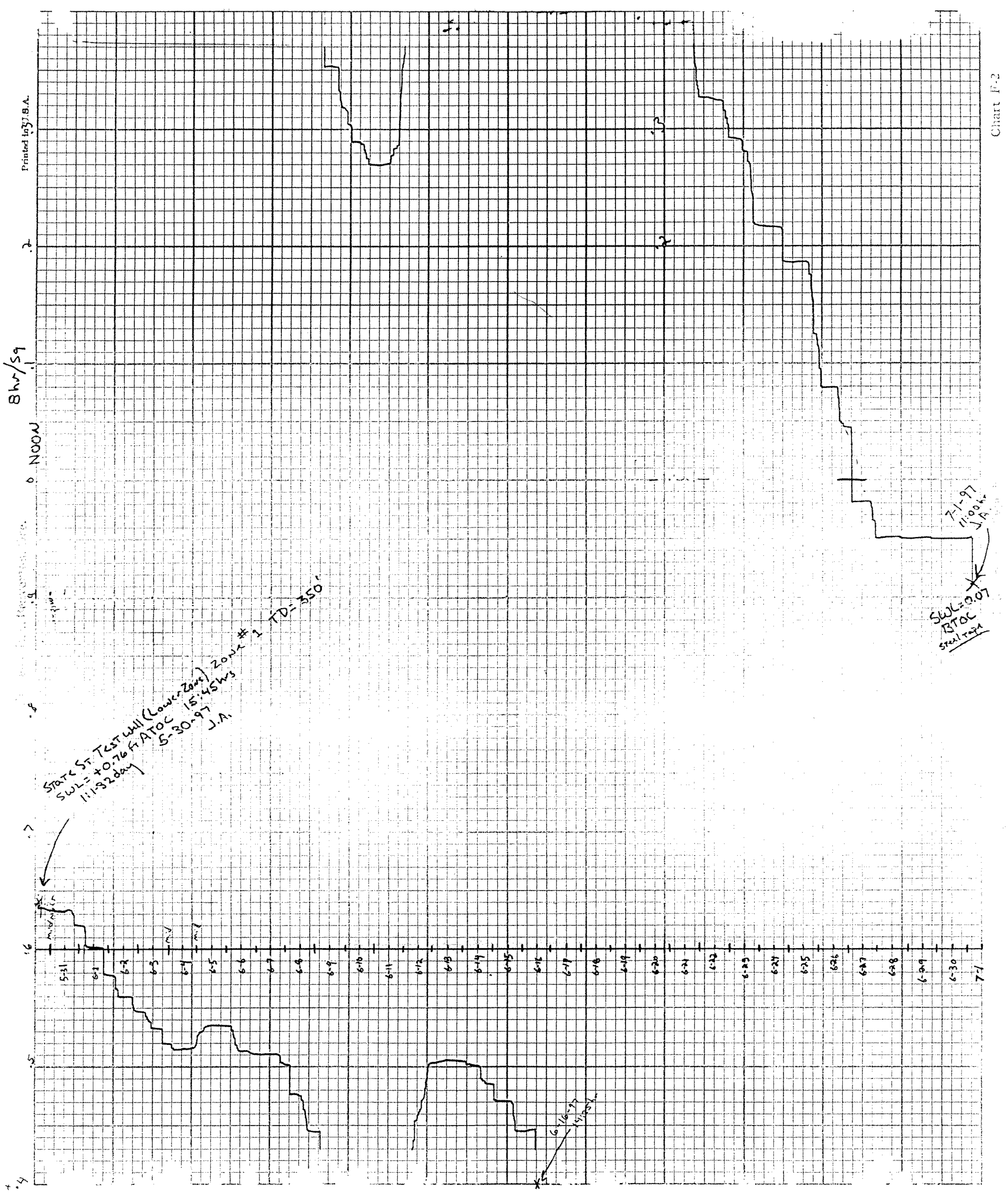
Test Requested	FRDS #	MCL	Analysis Result	Unit	MDL	Method	Date Completed	Analyst Initials
CHLORIDE	1017		2	mg/L	1.0	EPA 300.0	12/23/96	JAL
FLUORIDE DIRECT	1025	4.0	0.57	mg/L	0.05	SM 4500F-C	12/22/96	KAI
NITRATE N	1040	10.0	0.16	mg/L	0.10	EPA 300.0	12/23/96	JAL
SODIUM	1052		15.8	mg/L	0.10	EPA 200.7	12/19/96	DDB
SULFATE	1055		14	mg/L	1.0	EPA 300.0	12/23/96	JAL
CALCIUM	1016		29.2	mg/L	0.10	EPA 200.7	12/19/96	DDB
IRON	1028		<0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
POTASSIUM	1042		1.58	mg/L	0.10	EPA 200.7	12/19/96	DDB
MAGNESIUM	1031		4.58	mg/L	0.10	EPA 200.7	12/19/96	DDB
MANGANESE	1032		<0.05	mg/L	0.05	EPA 200.7	12/18/96	DDB
SILICON → Si			14.6	mg/L × 2.139 = 29.9 (SiO_2) Silica		EPA 200.7	12/19/96	DDB
ALKALINITY	1927		114	mg/L		EPA 310.1	12/19/96	JH
CONDUCTIVITY	1926		255	umhos	2.0	EPA 120.1	12/13/96	MBM
CORROSIVITY	1997		-1.1 **			LANGELIER	12/27/96	DMB
SULFIDE	1027		0.07	mg/L		EPA 376.1	12/30/96	MDM
HARDNESS	1915		99.9	mg/L	2.0	SM 2340	12/19/96	JH
PHOSPHATE P, TOTAL			0.07	mg/L	0.05	EPA 365.4	12/19/96	JAL
TOTAL DISSOLVED SOLIDS	1930		182	mg/L	1.0	EPA 160.1	12/18/96	MS
pH	1925		7.6	S.U.		EPA 150.1	12/13/96	MBM
VOC			* SCAN	ug/L		EPA 502.2	12/14/96	DMB

APPENDIX C

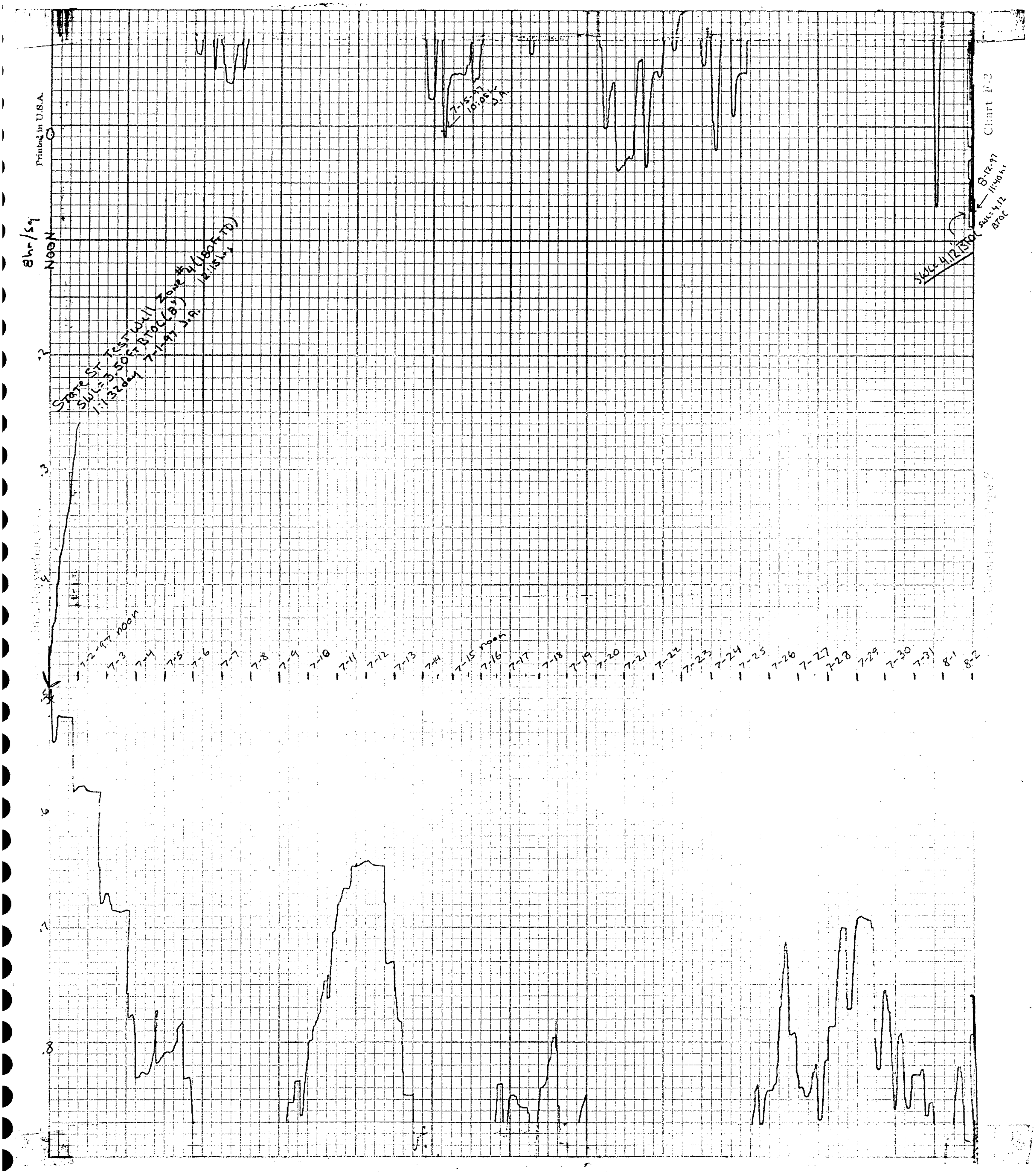
CHARTS FROM WATER-LEVEL RECORDERS



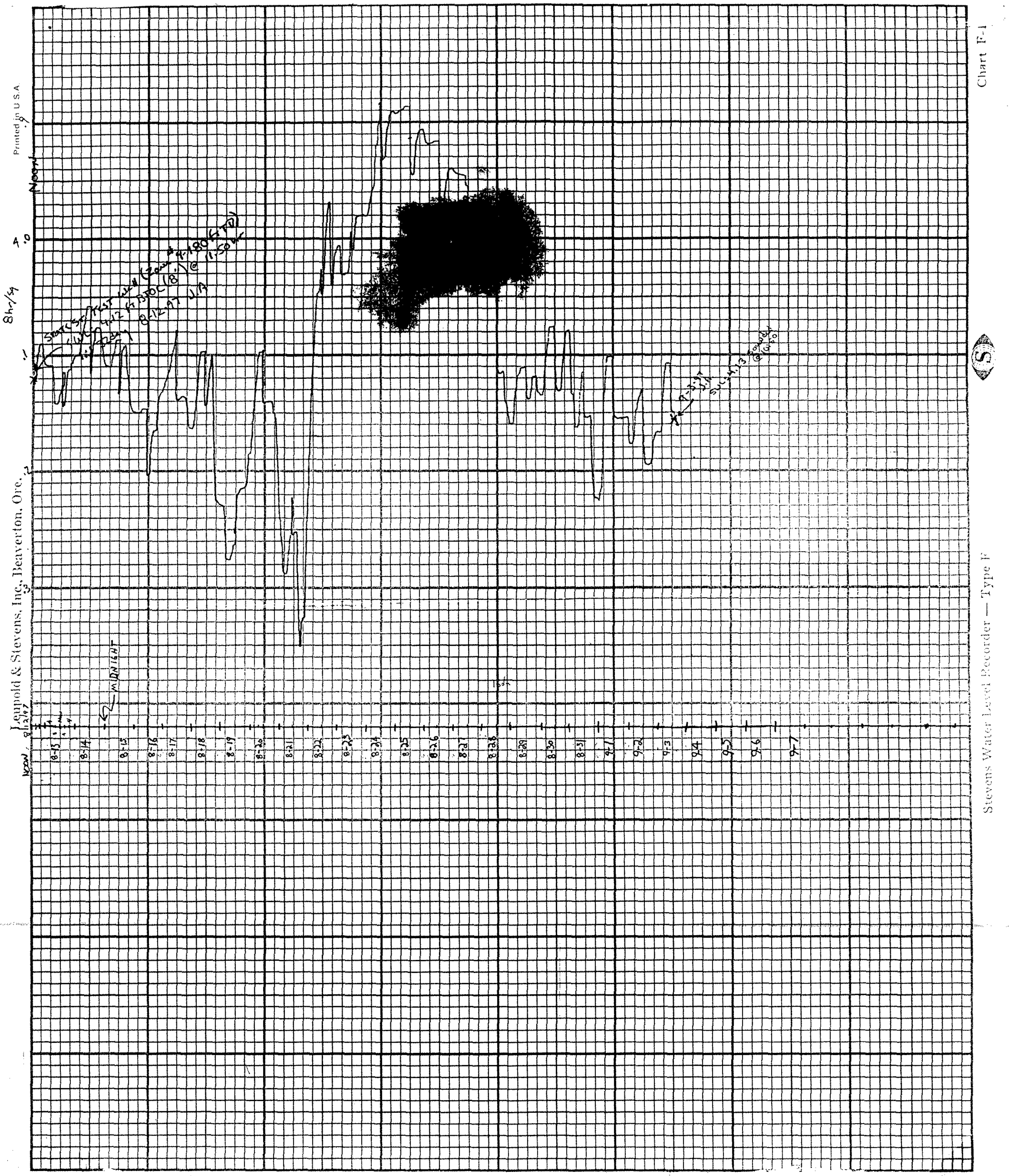
Zone #1 piezometer 4/17/97 to 5/1/97



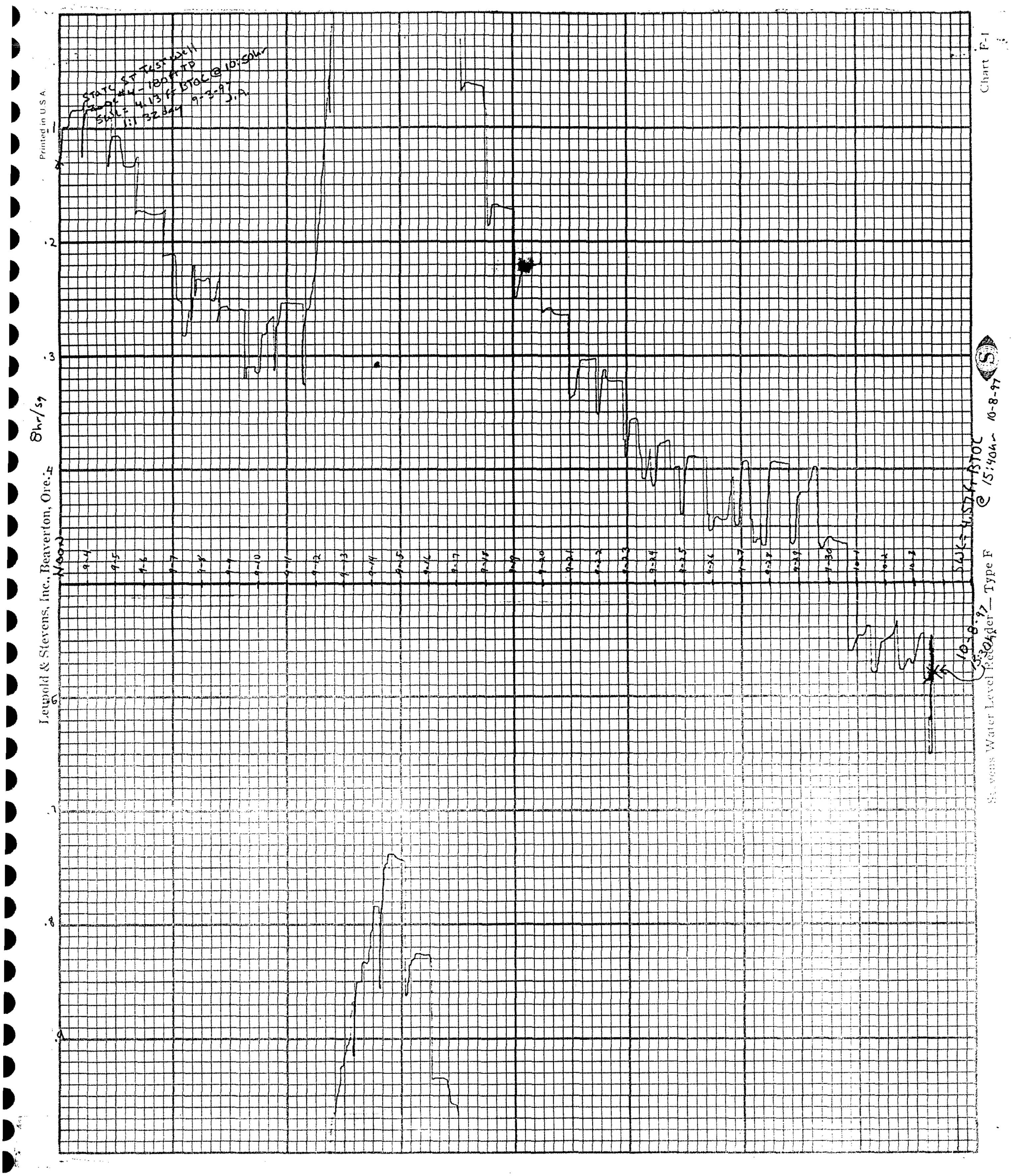
Zone #1 piezometer: 5/30/97 to 7/1/97



Zone #4 piezometer: 7/1/97 to 8/2/97



Zone #4 piezometer: 8/12/97 to 9/3/97



Zone #4 piezometer: 9/3/97 to 10/8/97