STATE OF NEVADA

AGENCY FOR NUCLEAR PROJECTS/ NUCLEAR WASTE PROJECT OFFICE

NWPO-TR-010-89

GROUND-WATER SAMPLING OF THE NNWSI WATER TABLE TEST WELLS SURROUNDING YUCCA MOUNTAIN, NEVADA

by:

Nancy A. Matuska
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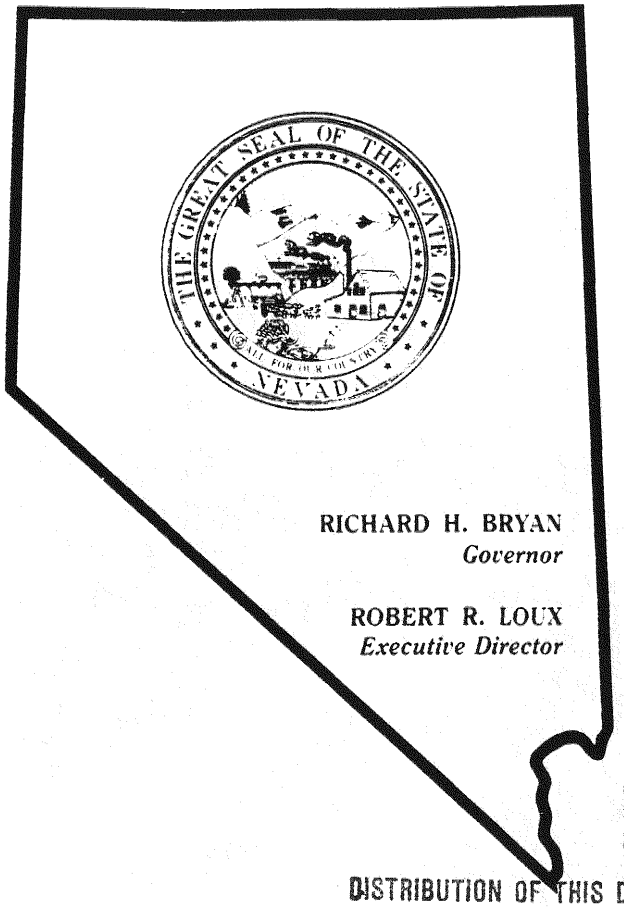

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The Nevada Agency for Nuclear Projects/Nuclear Waste Project Office was created by the Nevada Legislature to oversee federal high-level nuclear waste activities in the state. Since 1985, it has dealt largely with the U.S. Department of Energy's siting of a high-level nuclear waste repository at Yucca Mountain in southern Nevada. As part of its oversight role, NWPO has contracted for studies of various technical questions at Yucca Mountain.

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INTRODUCTION

The U.S. Geological Survey (USGS), as part of the Nevada Nuclear Waste Storage Investigation (NNWSI) study of the water table in the vicinity of Yucca Mountain, completed 16 test holes on the Nevada Test Site and Bureau of Land Management-administered lands surrounding Yucca Mountain. These 16 wells are monitored by the USGS for water-level data; however, they had not been sampled for ground-water chemistry or isotopic composition. As part of the review of the proposed Yucca Mountain high-level nuclear waste repository, the Desert Research Institute (DRI) sampled six of these wells. The goal of this sampling program was to measure field-dependent parameters of the water such as electrical conductivity, pH, temperature and dissolved oxygen, and to collect samples for major and minor element chemistry and isotopic analysis. This information will be used as part of a program to geochemically model the flow direction between the volcanic tuff aquifers and the underlying regional carbonate aquifer.

WELL DESCRIPTIONS

The NNWSI water-table test wells are located to the east and south in the basins surrounding the Yucca Mountain block. Figure 1 shows the locations of the wells.

The wells are completed in Tertiary ash-flow and bedded tuffs which erupted eight to sixteen million years ago from the Timber Mountain and other older calderas to the north and west. The predominant sequence for the members of the volcanic formations present at Yucca Mountain are multiple ash-flow sheets which constitute one compound cooling unit. Generally, the top and base of the flows are nonwelded, vitric and may contain pumice, glass

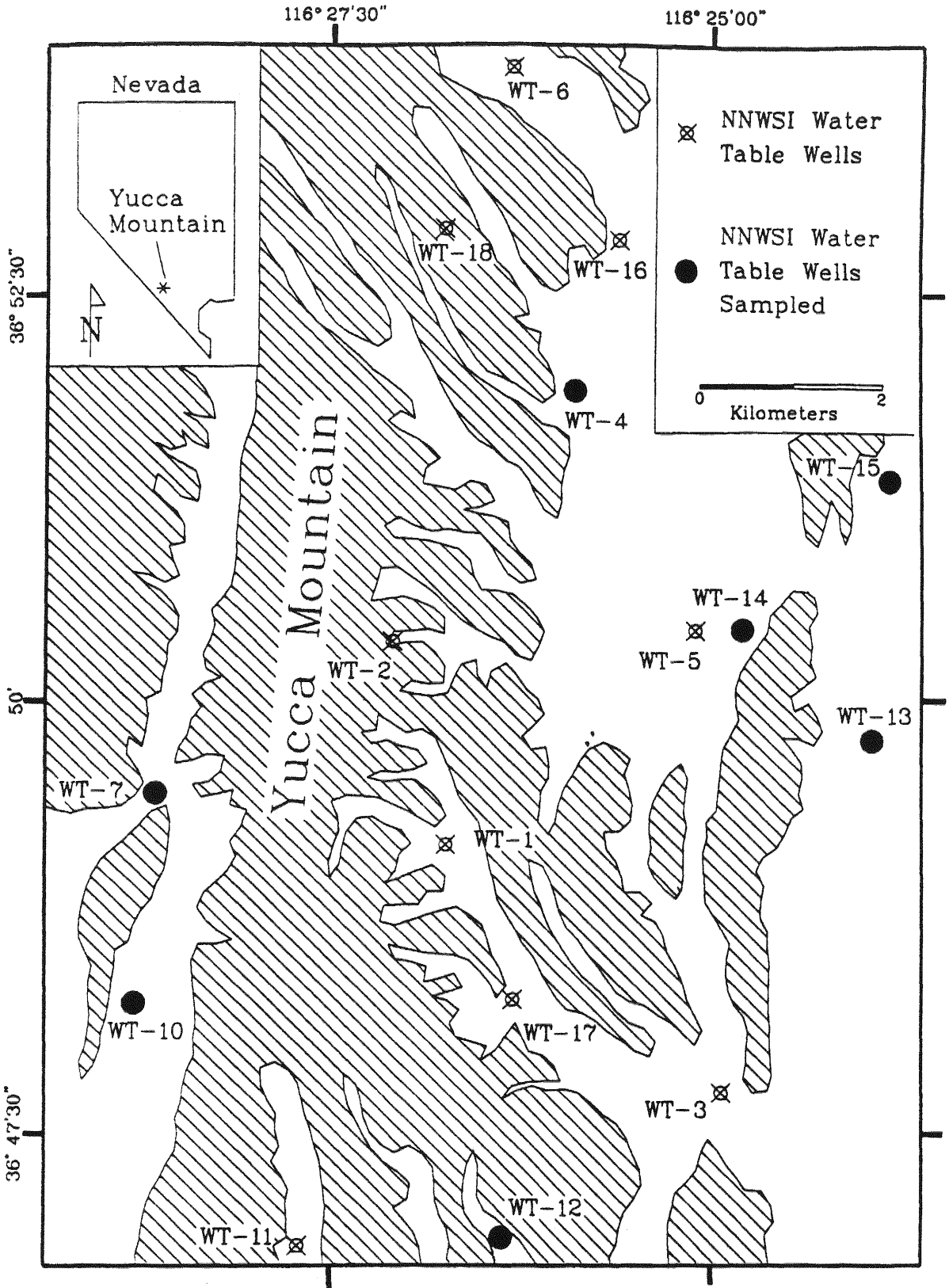

Figure 1: Location of NNWSI Water Table test wells on Yucca Mountain, southern Nevada.

shards and lithic fragments. The interiors of the flows are generally welded and devitrified, and may have vapor phase crystallization. Diagenetic alteration is best developed in the groundmass and phenocrysts in the nonwelded zones and in fractures of the welded zones, and consists of zeolites, smectites and authigenic feldspars.

The principal aquifers that the wells penetrate are the unconfined tuffaceous aquifers in the Topopah Spring Member of the Miocene Paintbrush Tuff, and underlying Crater Flat Tuff. The Topopah Spring Member is generally welded and transmits water along fractures, while the Crater Flat Tuff is nonwelded, zeolitic and transmits water by matrix flow.

The 16 test holes were drilled in 1983 to depths of between 348 meters and 628 meters using conventional rotary methods. A LiBr tracer was added to the air-foam. The boreholes are 22.2 cm in diameter at depth and are cased with steel casing (O.D. 7.3 cm) that is screened over the last four meters. Prior to emplacement of the tubing, various geophysical logs, including caliper, were conducted (Fenix and Scisson, 1986).

USGS water-level monitoring transducers were installed in six of the water-table test wells which prevented sampling, and four others were unsuitable for study because they were dry or too deep for proposed sampling methods. Table 1 lists the locations of the six sampled wells, while Table 2 gives their lithologies and hydrologic units.

EQUIPMENT

The pump used for this sampling program was a submersible double-piston type (model 1800-5) manufactured by the Robert Bennett Co. of Amarillo, Texas. The pump was designed to fit inside a five centimeter well casing and has a lift of 460 meters. At this depth, the pump can maintain a flow rate of 1.4 to

TABLE 1
NNWSI WATER TABLE TEST WELLS

Well Name	Longitude	Latitude	Elevation* (m)	Total Depth (m)
UE-25 WT-4	116 ° 26'08"	36 ° 51'50"	1167.1	482
USW WT-7	116 ° 29'05"	36 ° 49'47"	1197.0	491
USW WT-10	116 ° 29'09"	36 ° 48'21"	1123.2	430
UE-25 WT-12	116 ° 26'26"	36 ° 47'00"	1074.6	399
UE-25 WT-14	116 ° 24'43"	36 ° 50'29"	1076.1	399
UE-25 WT-15	116 ° 23'43"	36 ° 51'20"	1082.8	415

* meters above mean sea level

TABLE 2
HYDROLOGY OF WATER-TABLE WELLS

Well Name	Producing Unit	Screened Interval* (m)	Hydaulic Head* (m)	Date Measured (m/d/y)
UE-25 WT-4	Tuff of Calico Hills	690-693	728.3	4/11/88
USW WT-7	Topopah Spg/Calico H.	716-720	775.3	6/03/88
USW WT-10	Topopah Spring	720-724	775.9	5/09/88
UE-25 WT-12	Tuff of Calico Hills	686-691	729.2	4/25/88
UE-25 WT-14	Tuff of Calico Hills	679-683	730.0	3/22/88
UE-25 WT-15	Topopah Spring	676-680	728.6	4/18/88

* meters above mean sea level

1.9 liters per minute (l/m). The pistons are driven by compressed air supplied by an Ingersoll-Rand air compressor; however, no air contacts the sample in the tubing, thus preserving its intergrity. The pump, tubing reel and air compressor are all mounted on a trailer for mobility.

The down-hole logger and chemical sonde used for chemically logging the well for temperature (T) and electrical conductivity (E.C.) were designed by the Desert Research Institute. The sonde consists of an Omega temperature resistance cell and a Yellow Springs Instrument flow-through fluid conductivity cell that are connected to 1160 meters of four conductor cable. The electronic signal is transmitted to the surface and recorded by a YSI S-C-T meter and Tandy RS-80 portable computer.

GENERAL SAMPLING PROCEDURES

Ground-water sampling from the NNWSI water-table wells followed the quality assurance sampling program: "Technical Procedure for Ground-water Sampling and Hydrogeologic Data Acquisition, DTP-3.5", which was prepared by the Desert Research Institute. This document contains instructions on the collection of ground-water samples, the preparation of the samples for laboratory analysis, as well as the field measurement of unstable parameters.

Prior to sampling, the USGS measured water levels in the wells using steel tape, which had NaCl crystals applied to its lower end. After the USGS water-level measurements, the well was logged with the DRI chemical sonde. This served several purposes: 1) to insure that the well-bore was open and free of obstructions; 2) to determine water table levels; and, 3) to record temperature and electrical conductivity changes within the well.

The pump was then put into place and purging began. Samples were collected from the initial waters for tritium, LiBr and methylene blue active (MBA), which was a test for the detergent used in drilling. Samples for chemical and isotopic analysis (except carbon-14) were also collected from the initial waters from wells USW WT-10 and UE-25 WT-12. Purging the wells generally required several days of pumping, during which time field parameters such as pH, temperature, E.C., alkalinity and flow rate were measured every four to six hours.

After three well volumes, calculated from the caliper logs, were purged, and the field parameters had stablized for three successive readings taken 15 minutes apart, samples for chemical and isotopic analyses were collected. Chemical analysis was performed for major ion chemistry (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^-) plus laboratory analysis for alkalinity, SiO_2, MBA and the LiBr tracer. Isotopic samples were collected for tritium, $\delta^{18}O$, δD, $\delta^{13}C$ and carbon-14 analysis. The chemical and isotopic samples, except those for carbon-14, were randomly split with the USGS supervisor on site. The USGS collected their own carbon-14 samples. Quality assurance requirements were met through collection of blanks, duplicates and standards and maintenance of the prescribed chain-of-custody records.

SPECIFIC WELL SAMPLING PROCEDURES

WELL UE-25 WT-14

Well UE-25 WT-14 is located on the east side of Yucca Mountain and was sampled March 21 - 26, 1988. The lithology around the screened interval consists of of ash-flow nonwelded, zeolitic tuff from 381-397 m (Richard Spengler - USGS, written communication, May, 1988). Depth to water was 346 m and

total depth of the well is 400 m. One well volume was calculated to be 2420 liters.

The well was logged for temperature and E.C. with the deep downhole logger on the morning of March 22, 1988. Temperature varied only slightly from 31.5 ° C at the water table to 30.0 ° C at the bottom of the well. Electrical conductivity varied greatly, from 1470 μmhos/cm at the water table to 400 μmhos/cm at the bottom of the well. This great difference was attributed to the USGS practice of using NaCl crystals on their water-level steel measuring tapes.

The pump was lowered to a depth of 393.5 m (0.6 m within screened interval) and purging started. Samples were taken from the initial waters for tritium and LiBr analyses. Purging of the well (three well volumes) took approximately 72 hours, from 3/22 to 3/25. Field parameters- T, E.C., pH and flow rate- were measured every 4-6 hours, and remained fairly stable throughout purging time. Electrical conductivity ranged from 250 to 270 μmhos while pH ranged from 7.05 to 7.20. Temperature values measured at the well head had a diurnal cycle, with peak temperatures of 28 ° C during the daytime, lower than the value found in logging the well. This was probably caused by cooling of the water sample to the ambient air temperature as it traveled through the 460 m of tubing. Flow rate increased from 1.4 l/m at the beginning of the purge, to an average of 1.8 l/m throughout. Water clarity changed from green and foamy initially to slighty cloudy with foam present when shaken.

Sample collection started the evening of March 25. Three carboys (50 liters each) were filled for carbon-14 analysis. The USGS then left a 208-liter drum to fill overnight for their carbon-14 sample. Samples for gross chemistry and isotope analyses were collected the following morning on March 26. Water chemistry at time of sampling was as follows: pH = 7.27, E.C. = 255 μmho/cm, D.O. = 2.1 mg/l and HCO_3 = 119 mg/l. Samples were labeled and taken to the

appropriate laboratories following the prescribed chain of custody. Total volume of water pumped from the well was 9180 liters. The pump was pulled from the well by hand until 230 m, at which point the winch motor was able to lift it the remainder of the way.

Well UE-25 WT-4

This well is located to the northeast of Yucca Mountain and was sampled April 11-15, 1988. It has a total depth of 482 m, is screened between 475-478 m, and has a well volume of 2170 liters. The lithology around the screened interval consists of lava and rhyolite which is devitrified and slightly zeolitic from 457 to 460 m, and nonwelded, zeolitic tuff from 460 to 482 m (Richard Spengler - USGS, written communication, May 1988).

The water table was located by the chemistry sonde at 438.3 m. Electrical conductivity decreased from 3810 μmho/cm at water table surface to 740 μmho/cm at 470 m. The pump was lowered to a depth of 448.6 m, approximately its maximum depth capability, but still 25 m above the screened interval.

Pumping was started at a flow rate of 1.2 l/m. LiBr, MBA and tritium samples were collected from initial waters. After the well was pumped for only three hours, the water level fell below the pump. The water level recovered to its original level within an hour and pumping resumed. However, again the water level fell below the pump. This cycle of pumping, running dry and recovery continued over the next three days. After 40 liters of well water was poured down the well a maximum pumping interval of 10 hours occurred; subsequent pumping intervals decreased rapidly to less than one hour durations before water levels were below the pump. Drawdown and recovery tests were performed to verify water levels.

On Thursday April 14, the intake screen became clogged, after only 3030 liters were pumped. The pump was then removed and no final water samples could be collected. The water was still foamy and very cloudy; the flow buckets were stained with rust and contained black sediment. Final water chemistry taken showed a pH = 7.61, E.C. = 345 μmho/cm and HCO_3 = 140 mg/l. However, these chemistry parameters had still not stabilized during the purging.

Two hypotheses proposed for the quick drawdown and slow recovery of the water in this well are:

1) The well screen became clogged, in which case the well should be jetted with air or nitrogen to clean the screen.

2) The permeability of the rock may be controlled by fractures which were dewatered during the 10-hour pumping interval and did not recover. The rock units affected by the well screen are a nonwelded, zeolitized tuff (Tuff of the Calico Hills) and a moderately to fully welded tuff (Topopah Spring Member) which is fractured.

Well UE-25 WT-15

This well is located just west of Fortymile Wash and to the northeast of Yucca Mountain and was sampled on April 18 - 23, 1988. The well is 414.5 m deep and has a screened interval between 403 and 407 m. The lithology around the screened interval is a densely welded, devitrified (slightly argillic or zeolitic) ash-flow tuff from 396 to 414.5 m (Richard Spengler - USGS, written communication May 1988). One well volume was calculated to be 2990 liters. Temperature and electrical conductivity measurements with the downhole logger showed that values were 27.8 °C and 1150 μmho/cm at water level and 28.6 °C and 485 μmho/cm at 405 m. The pump was installed and lowered to 404 m,

approximately 0.6 m into the screened interval. LiBr, MBA and tritium samples were collected from the initial water.

Temperature, E.C. and pH were measured every four to six hours and remained fairly stable throughout the purge time. However, as observed before, the temperature values produced a diurnal cycle. There were no problems with the pump or air compressor, and three well volumes were purged by 4/22/88, with an average pump rate of 1.66 l/m. The water quality at the end of purging was slightly foamy, especially if shaken, and exhibited a slight cloudiness. The water also had a distinct odor which might indicate anaerobic conditions. Samples for carbon-14 analysis were collected 4/22/88, and samples for gross chemistry and isotopic analyses were collected the following morning. The pH at time of sampling was 7.5, while E.C. = 350 μmho/cm, D.O. = 0.15 mg/l and HCO_3 = 166 mg/l. Total water volume pumped from well was 10,800 liters. The pump had black silty material clogging the screen and was coated with green organic matter when pulled from the well.

Well UE-25 WT-12

This well is located at the southern base of Yucca Mountain and was sampled on April 25 - 29, 1988. The well is 398.7 m deep and is screened between 385 - 389 m. The water table is at 345 m below ground surface. Lithology around the screened interval consists of partially to nonwelded, zeolitic (partially vitric) ash-flow tuff from 361 m to 381 m, ash-fall tuff dominantly composed of zeolitic (some vitric) pumice clasts from 381 m to 387 m and nonwelded, zeolitic ash-flow tuff from 387 m to 396 m (Richard Spengler - USGS, written communication May 1988). One well volume was calculated to be 2270 liters.

The well was logged for E.C. and temperature which ranged from 920 μmhos/cm and 33.1 °C at the water surface to 310 μmhos/cm and 35.0 °C at 387 m. The pump was installed at 384 m, which was within the screened interval. A complete suite of samples for chemical and isotope analysis (except carbon-14) was collected from the initial water. The water was fairly clear, with very little foam present. This may be due, in part, to the air-jetting the USGS performed on this well at 358 m during its construction in 1983.

Three well volumes were purged by April 28 with a pumping rate of 1.8 l/m. At the end of purging, the water was clear and no foam was present. Chemical parameters changed very little during purging. Samples for gross chemical and isotopic analyses were collected the afternoon of 4/28/88, and samples for carbon-14 analysis were collected that evening. The pH of the water at time of sampling was 7.58, the E.C. = 365 μmho/cm, D.O. = 1.7 mg/l and HCO_3 = 167 mg/l. A total of 9460 liters were pumped from the well.

Well USW WT-10

Well USW WT-10 is located at the southern end of Yucca Mountain, at the mouth of Solitario Canyon, and was sampled on May 9 - 16, 1988. Total depth of the well is 430 m. The water table was located at 347.5 m below land surface, and one well volume was calculated to be 5260 liters. Lithology of the screened interval is densely welded, devitrified ash-flow tuff which lies between 381 to 411 m (Richard Spengler - USGS, written communication, May 1988).

The well was logged with the downhole chemistry sonde for temperature and electrical conductivity, which ranged from 39.1 °C and 1110 μmho/cm at water table to 39.1 °C and 310 μmho/cm at 399 meters. The pump was lowered into place at 400 m and the well was purged. Samples for a complete chemical and isotopic suite (except for carbon-14) were collected from the initial water. The water was dark grey/green with a slight oil slick on top. No foam was

present, but the water contained black sediment and had a foul odor.

After seven days, three well volumes, approximately 17,200 liters, were purged at an average flow rate of 1.7 to 1.8 l/m. Water samples were collected for gross chemistry and isotope analyses. Water chemistry at time of sampling was pH = 8.28, E.C. = 415 μmho/cm, D.O. = 2.7 mg/l and HCO_3 = 202 mg/l. At the end of purging, water clarity had changed to having no foam or odor, and was fairly clear.

Well USW WT-7

Well USW WT-7, located at the mouth of Solitario Canyon at the southwestern edge of Yucca Mountain, was sampled between June 3-5, 1988. The well is 490.7 m deep, with a water table at 421.5 m from the surface and a screened interval between 477 - 481 m. One well volume was calculated to be 3260 liters. The lithology between 426 - 457 m is nonwelded, vitric (slightly silicified ?) ash-flow tuff from 426 to 433 m, ash-fall tuff composed of argillic and zeolitic pumice clasts from 433 to 438 m, and nonwelded, zeolitic ash-flow tuffs from 438 to 466 m (Richard Spengler - USGS, written communication, May 1988).

The well was logged with the downhole chemistry sonde. The E.C. at the water table, 421.4 m, was only about 300 μmho/cm. This was in sharp contrast to the E.C. values at the water table in previous wells which were usually over 1000 μmho/cm immediately after the USGS had taken a water level measurement using steel tape and NaCl crystals. A complete logging of the well was impossible because an obstruction was reached at approximately 431 m. Since the sonde was unable to pass this obstruction, the logging ceased. When removed, the chemical sonde had a rusty smudge along the edge of one side, indicating an encounter with a break or shear in the casing. Due to the

anomalously low E.C. values, the obstruction and the rust smudge on the sonde, it is believed that the casing has a shear at approximately 431 m.

The pump was lowered down the well to a depth of 428 m, just above the obstruction, and pumping began. The first water was slightly cloudy and produced foam and some rust-brown sedimentation. Samples for LiBr, MBA and tritum analysis were collected from the initial water. After only a few hours of pumping, the water table fell below the pump. The pump was shut off and the well was allowed to recover for an hour and a half. Pumping was then resumed and the well produced water for approximately another hour before the water table again fell below the pump. The pump was shut off and the well was allowed to recover overnight.

The next day, June 4, the well was pumped again, with the same results. As it appeared fruitless to try to purge three well volumes from this well, samples were taken at this time. Due to extremely high winds and blowing dust, two five-gallon cubitainers were filled at the pump and aliquots were taken for chemical and isotopic analysis (except for carbon-14) inside the trailer from this water. Field measurements at the time of collection was pH = 8.70, E.C. = 420 μmho/cm, and HCO_3 = 252 mg/l. Unfortunately, less than one well volume was pumped.

CHEMICAL AND ISOTOPIC RESULTS

Samples for chemical and isotopic analysis were collected from four of the wells after successfully purging three well volumes. Unfortunately, the other two wells could not maintain sufficient discharge to allow three complete well volumes to be purged, and only USW WT-7 was sampled. Samples collected

from the five wells were randomly split between DRI and the USGS and analyzed by their respective laboratories. In addition, samples were collected from the initial water produced in wells USW WT-10 and UE-25 WT-12. Table 3 lists all of the chemical analyses from the wells.

Field measurements of pH, E.C., temperature and alkalinity followed general trends. Electrical conductivity was anomalously high at the water table, due to the use of NaCl crystals on the steel tape for water level measurements. However, at the screened interval, E.C. decreased to approximately 300 μmhos/cm. Because of the long distance (460 m) the water traveled in the pump and tubing, water temperature measured at the well head reflected the ambient air temperature, rather than actual formation water temperature. Therefore, the temperature recorded during the downhole logging, about 30 ° C, is thought to be more representative of the true temperature. Water was slightly alkaline, with pH of 7.3 - 8.7, and alkalinity values of 140 - 250 mg/l.

Comparing the analyses of the first waters with those collected after three well volumes were purged, several trends in water chemistry may be noticed. The initial water samples are higher in Cl^- and Br^- and lower in SO_4^{2-}, NO_3^{2-} and SiO_2 than the later samples. These later samples are considered to be more representative of formation water. Although well USW WT-7 was not successfully pumped for three well volumes, the low E.C. values found when logging the well indicate that this well had some input of water into the well casing at the obstruction at 431 m. This water was considered to be more representative of the formation water than initial waters at previous wells. Unfortunately, samples could not be collected from UE-25 WT-4 due to purging problems discussed previously.

Chemically, the water from the WT wells is an $NaHCO_3$ type. There is a division of eastern (WT-12, WT-14, WT-15) wells and western (WT-7, WT-10)

TABLE 3
CHEMISTRY OF WATER TABLE WELLS

Well	Date (m/d/y)	Na^+	K^+	Ca^{2+}	Mg^{2+}	SiO_2	Cl^-	SO_4^{2-}	NO_3^{2-}
					(mg / l)				
USW WT-4[1]	4/11/88	-	-	-	-	-	-	-	-
USW WT-7[1]	6/4/88	96.6	2.07	2.63	0.18	20	12.5	7.2	<0.04
USW WT-10[1]	5/9/88	94.3	1.18	2.49	0.12	38	17.9	29.6	2.61
USW WT-10[2]	5/16/88	93.8	1.14	2.72	0.07	47	7.8	33.6	4.25
UE-25 WT-12[1]	4/25/88	67.2	2.15	11.70	0.25	33	14.7	14.1	0.04
UE-25 WT-12[2]	4/28/88	65.7	2.33	14.10	0.04	47	7.3	26.1	4.56
UE-25 WT-12[3]	4/28/88	66.0	2.60	15.00	0.30	47	7.9	28.0	-
UE-25 WT-14[2]	3/26/88	42.4	5.54	9.23	0.79	58	7.5	18.6	1.86
UE-25 WT-14[3]	3/26/88	45.0	5.00	10.00	0.80	57	8.2	22.0	-
UE-25 WT-15[2]	4/23/88	61.8	4.6	11.60	1.71	53	11.5	16.1	<0.04

TABLE 3 continued...
CHEMISTRY OF WATER TABLE WELLS

Well	pH field	pH lab	E.C. field (μmho/cm)	E.C. lab (μmho/cm)	HCO_3^- field (mg / l)	HCO_3^- lab (mg / l)	Li (mg / l)	Br (mg / l)	MBA (mg / l)
UE-25 WT-4[1]	7.6	-	346	-	140	-	0.08	2.99	107.00
USW WT-7[1]	8.7	8.1	422	413	252	228	0.15	0.35	30.20
USW WT-10[1]	8.4	7.8	-	416	175	183	0.10	0.66	<0.02
USW WT-10[2]	8.3	8.4	416	407	202	183	0.09	0.41	<0.02
UE-25 WT-12[1]	-	8.1	361	340	-	168	0.08	0.13	0.60
UE-25 WT-12[2]	7.6	8.0	365	347	167	163	0.07	0.09	<0.02
UE-25 WT-12[3]	7.6	7.8	365	358	167	166	0.07	0.01	<0.02
UE-25 WT-14[2]	7.3	7.3	256	251	119	116	0.05	0.45	-
UE-25 WT-14[3]	7.3	7.4	256	260	119	116	-	-	-
UE-25 WT-15[2]	7.5	7.6	347	344	252	228	0.39	0.05	14.00

[1] DRI analysis of initial water
[2] DRI split analysis after three well volumes purged.
[3] USGS split analysis after three well volumes purged.

wells with respect to Ca^{2+}. Eastern wells have more Ca^{2+}, with Na+K/Ca+Mg epm ratios of 3.8-4.0, compared to 28.0 in the western wells. This agrees well with previous work on Yucca Mountain wells by Kerrisk (1987), who suggested calcite solubility and ion exchange in smectites and zeolites as the cause of this division.

Isotopic analyses are given in Table 4. This table is still incomplete, pending sample analysis, but some general trends are apparent. Most of the water table wells are similar in their hydrogen and oxygen isotope ratios to the isotopic values reported for other Yucca Mountain wells as shown in Figure 2, and plot below the meteoric water line. In contrast, water from wells UE-25 WT-14 and UE-25 WT-15 are more enriched in both delta deuterium and delta ^{18}O than most of the Yucca Mountain wells, and thus are similar to water from wells J-12, J-13 and UE-29a#2 in Fortymile Wash.

Carbon-13 values range from -6.5 to -12.7, and are more enriched ($>$ -8.1 °/$_{oo}$) in wells USW WT-7, USW WT-10 and UE-25 WT-12, than in the wells to the north ($<$ -11.0 °/$_{oo}$).

Because of the similarity in chemical constituents and isotopic ratios between the initial and final water samples, and the generally low values of LiBr and MBA, it appears that most of the wells were fairly clean of drilling fluids prior to the purging. This indicates that there is ground-water flow through the wells. Flow through wells UE-25, WT-15 and USW WT-10, which had a foul odor and green coating on the pump during sampling, may not be as good as the other wells.

TABLE 4
ISOTOPIC ANALYSIS OF WATER TABLE WELLS

Well	Tritium (T.U.)	$\delta^{18}O$ ‰	δD ‰	$\delta^{13}C$ ‰	% Modern Carbon
UE-25 WT-4[1]	-	-	-	-	-
USW WT-7[1]	-	-13.7	-104	-	-
USW WT-10[1]	-	-13.4	-104	-6.5	-
USW WT-10[2]	-	-13.7	-103	-6.6	-
UE-25 WT-12[1]	-	-13.7	-101	-8.9	-
UE-25 WT-12[2]	-	-13.6	-102	-7.7	-
UE-25 WT-12[3]	0.96	-	-	-8.1	11.4
UE-25 WT-14[2]	-	-12.3	-96	-11.8	-
UE-25 WT-14[3]	0.96	-	-	-12.7	24.1
UE-25 WT-15[2]	-	-12.9	-97	-11.1	-
UE-25 WT-15[3]	1.3	-	-	-11.8	21.6

NOTE: Data with "-" = analysis not received from lab.
[1] DRI analysis of initial water.
[2] DRI split analysis after three well volumes purged.
[3] USGS split analysis after three well volumes purged.

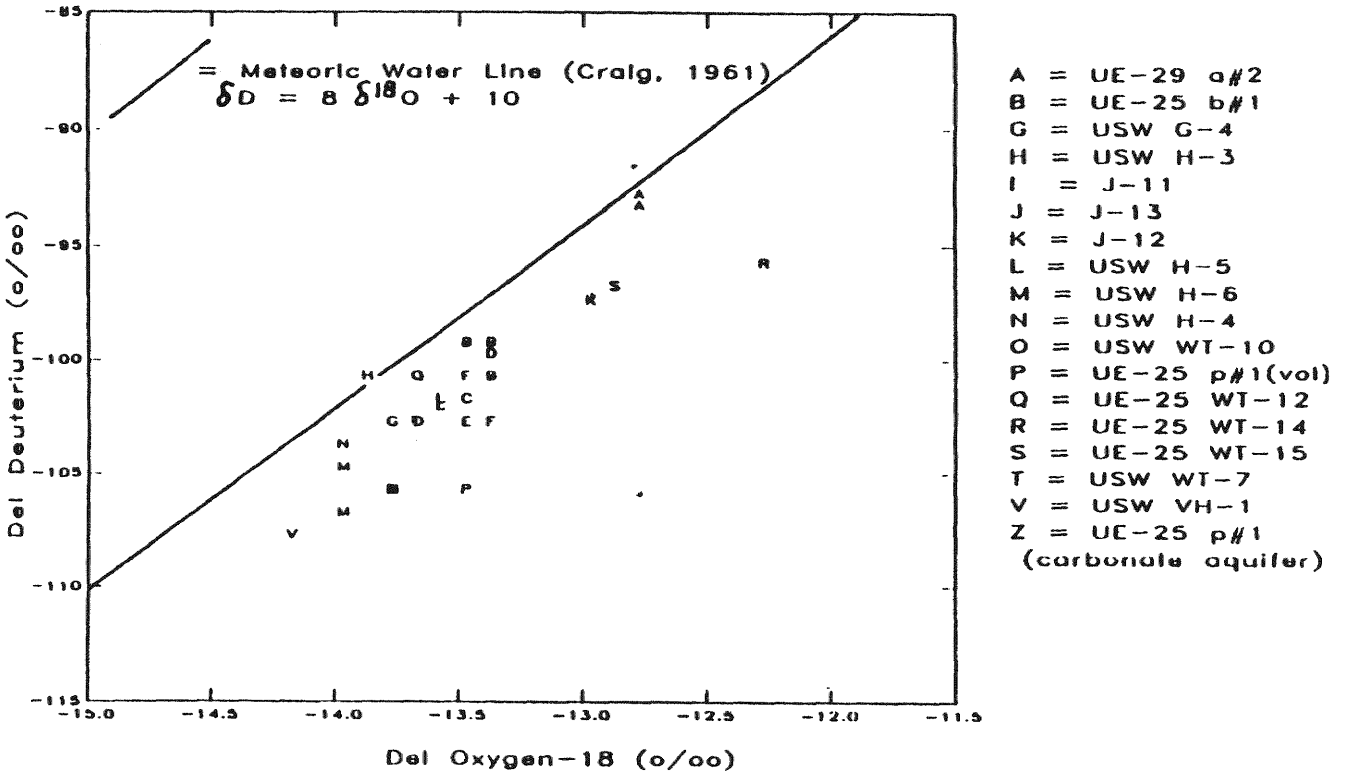

Figure 2: Del Deuterium and Del Oxygen-18 Values Of Yucca Mountain Wells (Benson and McKinley, 1985)

SUMMARY

The Desert Research Institute successfully purged and sampled four water table wells which surround Yucca Mountain. A fifth well, USW WT-7, was not completely purged due to an obstruction in the casing; however, comparisions of chemical samples between it and the other wells indicate that the sample collected may be considered fairly representative of formation waters. The attempt to sample UE-25 WT-4 was unsuccessful due to excessive drawdown; thus, the samples were collected after only one well volume was purged and were likely to still be contaminated with drilling fluid. The other wells appeared to be fairly free of drilling fluid prior to sampling, indicating ground-water movement. The data collected from this sampling program will be used in a geochemical model of ground-water flow between the volcanic tuffs and carbonate aquifer at Yucca Mountain.

Further work should include sampling of the remaining water table wells and resampling of the six sampled under this effort. Because of the importance aluminum has in geochemical modeling, collection of samples for aluminum species analysis is also recommended during resampling. It may be of interest to further study the obstruction in well USW WT-7, as this well is located at the mouth of Solitario Canyon, in close proximity to the Solitario Canyon fault.