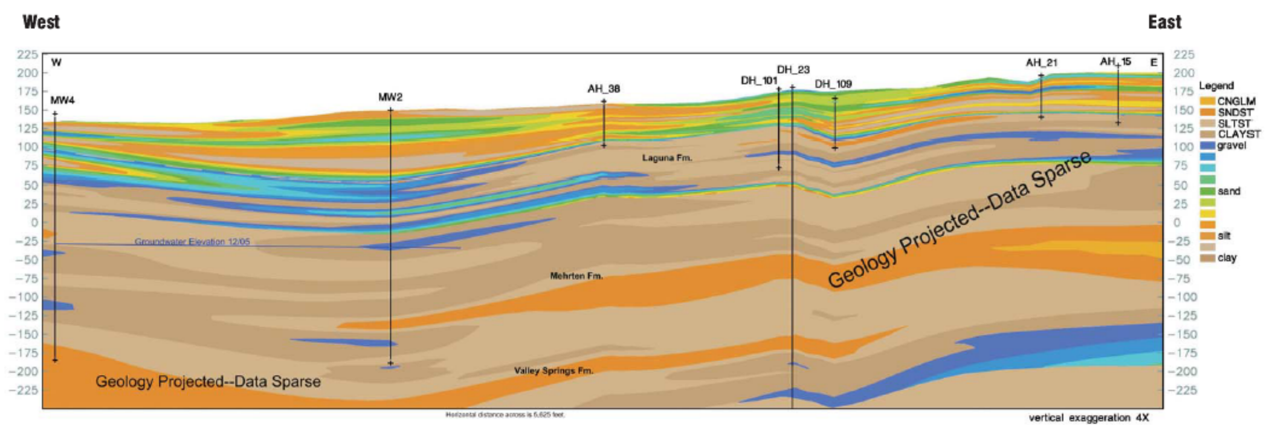
Rancho Seco Nuclear Generating Station

Groundwater Monitoring Report

Third Quarter 2005 through Second Quarter 2006



SMUD

Sacramento Municipal Utility District

Rancho Seco Nuclear Generating Station

Groundwater Monitoring Report

Revision 0

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1.0 INTRODUCTION

The purpose of this Groundwater Monitoring Report is to provide the results of implementing the guidance contained in NUREG-1757, Vol. 2, Appendix F, "Ground and Surface Water Characterization," [Reference 8-1] for groundwater characterization of the Rancho Seco site. Groundwater under the Rancho Seco site is a part of the regional aquifer, with the top of the aquifer approximately 183 feet below ground surface (bgs) in the Mehrten Formation under the Industrial Area of the site and the bottom of this aquifer at approximately 2,000 feet bgs, where the Ione Formation is in contact with much denser rocks.

The hydrogeological characterization of the site is described in detail in the Hydrogeological Characterization of the Rancho Seco Nuclear Generating Station prepared by the URS Group, Inc. [Reference 8-2], which was previously submitted to the Nuclear Regulatory Commission in support of the License Termination Plan submittal and is summarized in this Groundwater Monitoring Report. The hydrogeological characterization of the site is based on the initial siting investigation conducted from June 1967 until August 1967; a geotechnical investigation of a proposed evaporation pond site performed in the summer and fall of 1985; and an update investigation conducted in 2005 to support development of the License Termination Plan [Reference 8-3].

As part of the update investigation, nests of monitoring wells were constructed at four locations between potential sources of contamination (Turbine Building, Spent Fuel Pool, Retention Basin) and the Rancho Seco property boundary. Each nest included three monitoring wells constructed within one boring. The monitoring wells were constructed such that the well screens were emplaced at three different depths within the boring to allow characterization of the groundwater aquifer. The results of this Groundwater Monitoring Program are based on samples taken from these new monitoring wells and pre-existing potable water wells that serve as up-gradient, background wells.

The Groundwater Monitoring Program consisted of samples collected over four calendar quarters to represent the four seasons of a yearlong period. Samples were collected in the summer and fall of 2005 and the winter and spring of 2006. The results of the Groundwater Monitoring Program conclude that licensed radioactive materials, including tritium, resulting from the operation and decommissioning of Rancho Seco, have not contaminated the regional aquifer under the Rancho Seco site.

2.0 SITE DESCRIPTION

2.1. Site Location

The Rancho Seco site is located in the southeast part of Sacramento County, California as shown in Figure 1. It lies either wholly or partly in Sections 27, 28, 29, 32, 33, and 34 of Township 6 North, Range 8E. The site is approximately 26 miles north-northeast of Stockton and 25 miles southeast of Sacramento. The Rancho Seco nuclear reactor unit and independent spent fuel storage installation (ISFSI) lie wholly within Section 29.

More generally, the site is located between the Sierra Nevada mountains to the east and the Coast Range along the Pacific Ocean to the west in an area of flat to lightly rolling terrain at an elevation of approximately 200 feet above mean sea level (msl). To the east of the site the land becomes more rolling, rising to an elevation of 600 feet at a distance of about seven miles, and increasing in elevation thereafter approaching the Sierra Nevada foothills.

The site area is almost exclusively agricultural and is presently used as grazing land or for growing wine grapes. The climatology of the Rancho Seco site is typical of the Great Central Valley of California. Cloudless skies prevail during summer and much of the spring and fall seasons due to the Pacific anticyclone off the California coast, which prevents Pacific storms from entering inland. The rainy season usually extends from December through March. Atmospheric dispersion factors for the site are considered favorable.

The owner-controlled site is approximately 2,480 acres as shown in Figure 2 with all acreage being owned by the District. Within the owner-controlled area is an approximately 87-acre fence-enclosed Industrial Area containing the nuclear facility.

Groundwater in the site area occurs under unconfined or semi-confined conditions. It is stored chiefly in the Mehrten Formation and formations below it. Groundwater movement in the area is to the southwest with a slope of about ten feet/mile.

There is no indication of faulting beneath the site. The nearest fault system, the Foothill Fault System, is about ten miles east of the site and has been inactive since the Jurassic Period, some 135 million years ago.

The soils at the Rancho Seco site can be categorized as hard to very hard silts and silty clays with dense to very dense sands and gravels.

2.2. Site Geology

The surface geology from the Rancho Seco site to the city of Galt, California, is shown on Figure 3. The youngest alluvial deposits occur farthest west, near the City of Galt and Interstate 5. The deposits exposed at the surface are older as one moves east toward Rancho Seco.

The stratigraphy of the Rancho Seco site consists of the following deposits:

- Recent alluvium consisting of stream-deposited gravel, sand, and silt. This material is confined to present drainage courses and ranges in depth from 0 to 5 feet bgs.

- Older alluvium consists of old stream and terrace deposits of gravel, sand, and silt. This material covers the floodplains in the southwestern portion of the site and deposits of well-rounded cobbles, pebbles, and sand derived chiefly from pre-Cretaceous sediments on pediment surfaces. This category includes the equivalents of the Modesto and Riverbank formations. The thickness on site is 0 to 20 feet.

- The Laguna Formation consists of sand, silt, and some gravel; it may or may not contain clay. It is made up of poorly bedded materials of silicic volcanic origin. This formation occurs at the surface across much of the site; its bottom boundary has been encountered at depths of approximately 130 feet bgs.

- The Mehrten Formation consists of fluviatile sandstone, siltstone, and conglomerate composed primarily of andesitic detritus. Locally, it contains horizons of coarse andesitic agglomerate of mudflow origin. This formation is encountered at the surface west of the Industrial Area and has an approximate thickness of 225 feet beneath the site.

- The Valley Springs Formation consists of pumice and fine siliceous ash, with much greenish-gray clay and some vitreous tuff, glassy quartz sand, and conglomerate. It is commonly well bedded. It derived largely from rhyolithic material thrown out from the high Sierra Nevada. This formation has no surface exposures on the site, and an estimated thickness of 250 feet beneath the site.

- The Ione Formation is composed of clay, sand, sandstone, and conglomerate. It may have a thickness of 200 to 400 feet beneath the site, and it is not exposed anywhere on the District property. Lying beneath the Valley Springs Formation, the Ione Formation is likely to be the deepest sedimentary deposit above the metamorphic basement rocks; however, its depth and thickness are not known because none of the site borings penetrated through the Valley Springs Formation. The approximate depth of the metamorphic basement rocks beneath the site is 2,000 feet bgs.

No faults have been identified within 10 miles of Rancho Seco, and the only structure in the sedimentary rocks is identified by gentle westerly dips of 1 to 3 degrees caused by the gradual uplift of the Sierra Nevada relative to the basin receiving the sediments.

2.3. Site Hydrology

Runoff from the Industrial Area of the Rancho Seco site drains into a seasonal unnamed creek, which is tributary to Clay Creek, which empties into Hadselville Creek. Hadselville Creek is a tributary of Laguna Creek South, which flows into the Cosumnes River, which joins the Mokelumne River upstream from its confluence with the San Joaquin River. A portion of the flow in the unnamed creek originates below the dam constructed to create the Rancho Seco Reservoir, approximately 1 mile southeast of the Industrial Area. The remainder of the flow in the creek originates from runoff in the area of its catchment west of the dam and from releases of water from Rancho Seco. Water, most of which is conveyed to the site from the Folsom South Canal, is consistently released to the creek from the Rancho Seco Industrial Area at an average rate of 6,000 gallons per minute.

Recharge to the groundwater occurs primarily by the infiltration of surface water along the active channels of streams, such as the Cosumnes River, Dry Creek, and Mokelumne River, and by deep percolation of applied irrigation water [Reference 8-4]. Some recharge also occurs from the direct infiltration of precipitation; however, direct infiltration is limited by the relatively low (18-inch) annual rainfall, relatively high (50-inch or more) evapotransporation rate, the moderate to low permeability (0.07 to 0.08 inch per hour) of surface soil, and the deep (greater than 180 feet bgs) water table.

Widening of the unnamed creek occurs at the District's western property boundary in an area where the gradient decreases. Most of the flow into the unnamed creek originates from the Folsom South Canal and is discharged from the site in the liquid effluent pathway downstream of the site retention basins. Since the investigation of Rancho Seco began in the 1960s, no flooding or inundation from storm runoff has occurred within the site boundaries. The Industrial Area of the site would not be flooded during a 100-year storm event. The topography of the site and the soil types promote runoff away from site buildings. However, seasonal marshes and vernal pools develop west of the Industrial Area in shallow surface depressions during and after the December through March rainy season.

3.0 GEOLOGICAL INVESTIGATIONS

3.1. Initial Siting Investigation

A soil and foundation investigation program was conducted to establish the suitability of the site and to provide the basic criteria for design of Rancho Seco. The drilling and sampling program began on June 28, 1967 and was concluded on August 25, 1967. Preceding the drilling and sampling program, a geologic reconnaissance and mapping program was performed by Bechtel geologists in consultation with Roger Rhoades, consultant geologist to Bechtel Corporation. Borings drilled on the Rancho Seco site included 71 exploratory holes and one domestic water supply well as shown on Figure 4. The results of the initial siting evaluations are summarized in the Rancho Seco Final Safety Analysis Report [Reference 8-5].

Geophysical logging techniques were employed in DH-23, the deepest geologic boring drilled at the site. These techniques provided a continuous geophysical log of materials with depth between sampling intervals and indicated changes of materials, density, and firmness with depth. Refraction seismograph traverses also were run in the general area of the proposed site using a portable seismic device. The seismic velocities obtained were used to interpret the densities or changes in the properties of subsurface materials with depth.

Bechtel Corporation supervised the entire investigation program; the drilling was carried out under a subcontract with Boyles Bros. from Auburn, California, and Myren Drilling of Sacramento, California. Selected soil samples were tested by the Soil Mechanics and Foundation Engineers, Inc., soils laboratory in Palo Alto, California, and supplemented by classification and other testing performed by the District's soils laboratory facility near Placerville, California.

3.2. Geotechnical Investigation for Proposed Evaporation Ponds

A geotechnical investigation of a proposed evaporation pond site at Rancho Seco was performed in the summer and fall of 1985. The site is located about 0.25 miles southwest of the Industrial Area, in an area of gently rolling topography underlain by unconsolidated alluvium and poorly consolidated sedimentary rocks. The purpose of the geotechnical investigation was to collect subsurface geologic and soils data for use in evaluating the suitability of the site for the proposed evaporation ponds and to establish a baseline groundwater and soil pore water monitoring system. The ponds were not constructed.

The fieldwork included soil sampling, permeability testing, installation of observation wells and lysimeters, water sampling, and measurement of groundwater levels. Four permeameter holes were drilled for testing permeability of near-surface soils. Four observation wells and two lysimeters were installed. Four test pits were dug for bulk soil samples and 10 soil borings were drilled to collect soils samples for laboratory testing. The water table at this location is at a depth of approximately 165 feet bgs.

Using data from the field program, the effect of a hypothetical pond liner failure on downgradient groundwater quality was analyzed. Based on conservative distribution coefficient assumptions, and considering the effects of adsorption, a travel time of over 20,000 years was calculated for a radiological contaminant (Cs-137) to reach the nearest offsite, downgradient well 2,200 feet southwest of the proposed evaporation pond site.

3.3. 2005 Update Investigation

To reduce uncertainties in the hydrogeological conceptual model, an investigation was undertaken in 2005. The investigation plan was presented to a group of Nuclear Regulatory Commission personnel in Washington, D.C. in November 2004 to gain preliminary approval of the investigatory approach.

In the investigation, nests of monitoring wells were constructed at four locations between potential sources of contamination (Turbine Building, Spent Fuel Pool, Retention Basin) and the Rancho Seco property boundary. Each nest contained three monitoring wells constructed within one boring. The monitoring wells were constructed such that the well screens were emplaced at three different depths within the boring. Drilling and construction of wells were permitted by the Environmental Management Department of the County of Sacramento. Table 1 lists the drilling and construction details of each of the well locations. Table 1 also lists details for two of the proposed evaporation pond monitoring wells and two site potable water supply wells.

Table 1

Well Drilling and Construction Details

Well ID	Northing	Easting	Screen Interval (feet bgs)	Water Use
MW1A	1888419.45	6813523.57	160 - 170	Monitoring
MW1B	1888419.16	6813522.97	210 - 220	Monitoring
MW1C	1888419.56	6813522.92	290 - 300	Monitoring
MW1D	1888419.29	6813537.01	200 – 220	Monitoring
MW2A	1887946.55	6812353.12	200 - 210	Monitoring
MW2B	1887945.27	6812352.87	265 - 275	Monitoring
MW2C	1887946.21	6812353.24	320 - 340	Monitoring
MW3A	1888224.36	6810988.02	200 - 210	Monitoring
MW3B	1888224.00	6810987.93	265 - 275	Monitoring
MW3C	1888224.13	6810988.28	310 - 320	Monitoring
MW4A	1887086.40	6810770.31	195 - 205	Monitoring
MW4B	1887086.44	6810770.72	251 - 261	Monitoring
MW4C	1887086.10	6810770.56	310 - 320	Monitoring
OW-2	1886349.74	6910826.33	168 - 177	Monitoring
OW-3	1887127.52	6811602.60	177 - 187	Monitoring
SW-1	NA	NA	156 - 400	Water supply
SW-2	NA	NA	254 - 295	Water supply

NA – Not available

The 12-inch-diameter borings were drilled with mud rotary drilling equipment. The subsurface materials being penetrated by the drill were described by an on-site geologist using the drill cuttings brought to the surface by the drilling mud. Drilling logs and construction details were provided in the Hydrogeological Characterization Report.

The first boring was drilled into dense sandstone or siltstone at 400 feet bgs. The nature of the rocks penetrated below 320 feet bgs in that boring indicated that vertical migration of any contaminants would be slowed, if not stopped, by the condition of the rock. Subsequent borings were drilled to 300 to 340 feet bgs after penetrating the top of the same dense rock that would impede contaminant migration. After drilling of each boring, the construction of the three monitoring wells in the boring was decided by the on-site geologist in consultation with a California Certified Hydrogeologist. Between the screen intervals in adjacent wells are at least 35 feet of less permeable material than that in the screen interval. After the screen decision was made, the wells were constructed with clean, low-carbon steel casing and screen. Following construction of each well nest, each well in the nest was developed to assure groundwater would flow into the screen. All of the wells were developed and water flowed into the screen, with the exception of MW1A, the well with the shallowest well screen at location MW1. The shallowest well in each nest is labeled "A;" the "B" and "C" wells are successively deeper in the boring.

Nine months after construction, well MW1A had not provided any water level information or groundwater samples. The well screen at 160 to 170 feet bgs has been above the groundwater level since the well was completed. During drilling, it was not possible to confirm that groundwater was present at 160 feet bgs because, when drilling with the mud rotary technique, water containing drilling mud is added to the boring during drilling. Little loss of drilling mud occurred while the drill penetrated through the 140 to 170 feet bgs because the material was a plastic clay; therefore, the penetrated material seemed to be water saturated. Previous work at the site and water-level measurements in existing wells indicated that the groundwater surface would be approximately 140 to 150 feet bgs. Groundwater depths in Wells MW1B and MW1C were greater than 182 feet bgs in December 2005. MW1B has sampling equipment stuck in the casing and cannot be sampled. A new well (MW1D) was constructed near the MW1A location in February 2006.

4.0 SITE HYDROGEOLOGY

The Rancho Seco site is located within the Cosumnes Subbasin of the San Joaquin Valley Groundwater Basin. The subbasin consists of the unconsolidated and semi-consolidated sedimentary deposits that may hold groundwater between the Cosumnes River on the north and the Mokelumne River on the south. All of the sedimentary deposits in the Cosumnes Subbasin, and possibly the basement rocks if they are fractured, may contain groundwater. Thirteen borings on the site have penetrated the water table; four of those borings were completed as potable water supply wells, and geologic information was not saved for two of them. Three observation borings, each to a depth of 200 feet bgs, one boring drilled to 602 feet bgs, four 2005 borings, and one 2006 boring for monitoring well nests provide the geologic information about the aquifer.

Subsurface deposits beneath Rancho Seco are dominated by fine-grained deposits of clay and silt with interbedded thin sands and gravels to a depth of approximately 120 to 130 feet bgs; above that depth interval, deposits become more indurated with depth, such that some intervals can be considered claystone and siltstone. Beneath 130 feet, the deposits are siltstone and claystone with thin (10 feet or less) interbedded sandstone and conglomerate; this interval is mostly within the Mehrten Formation. At approximately 290 to 330 feet bgs in all of the deeper borings, drilling became very difficult as the drill penetrated gray to green well-indurated siltstones with thin sandstones and claystones. This change in drilling and lithology of deposits is interpreted as the top of the Valley Springs Formation.

The upper groundwater surface beneath the site now occurs at depths greater than 180 feet bgs (December 2005) in the sediments of the Mehrten Formation. Therefore, groundwater may be present from approximately 180 feet bgs in the Mehrten Formation to perhaps 2,000 feet bgs, where the Ione Formation is in contact with much denser rocks. The sand and gravel zones of these formations yield water readily to wells predominantly west of the facility in the Central Valley. The Mehrten Formation is known for yielding large volumes of water to wells. Beneath the site, however, the Mehrten Formation consists predominantly of siltstones and claystones that are likely to have lower hydraulic conductivity values (1.0E-07 to 1.0E-04 centimeters per second (cm/sec) from permeability tests [Reference 8-6]) than the typical Mehrten Formation, which is sand/sandstone dominated. The sediments of the Laguna Formation are above the water table and, therefore, do not produce groundwater to wells. However, the hydraulic conductivity range of samples collected in the unsaturated Laguna Formation is 2.8E-07 to 5.8E-04 cm/sec. The Valley Springs and Ione formations are considered small-yield aquifers because of low hydraulic conductivity values caused by claystone and siltstone layers. Figure 5 graphically depicts the geological conditions under the Rancho Seco site.

In the Cosumnes Subbasin, groundwater flows to the west from the foothills and the Rancho Seco area. For at least 40 years (since the initial investigation of the site), a groundwater depression has been caused by the pumping of municipal and agricultural wells in the Galt area. Figure 6 shows contours of groundwater elevations in southern Sacramento County [Reference 8-7]; the top part of the figure shows contours for Spring 2003, and the bottom part shows contours for Fall 2003; the 2003 maps are the most recent contour maps available from the county. On both figures, a groundwater depression is roughly centered on the town of Herald, which lies between the site and Galt. The depression had an elevation approximately 10 feet lower in Fall 2003 than in Spring 2003. The shape and values of the groundwater elevation contours on the figures indicate that groundwater beneath the site will flow southwesterly toward the depression.

Groundwater levels in the four new well nests suggest that there is one aquifer between the water table and 300 feet bgs, that the horizontal gradient is southwesterly, and the vertical hydraulic gradient is upward. A potentiometric surface map, constructed with data collected in the monitoring wells on December 6, 2005, is shown in Figure 7. The contours support the hypothesis of southwesterly gradient beneath Rancho Seco. The average hydraulic gradient calculated from potentiometric data for the wells is 0.0028 feet per foot. Only one potentiometric surface map was prepared because the data suggest that the horizontal gradients are similar in all depth intervals from 170 to 300 feet bgs. Vertical gradients were upward from the deepest screen interval (approximately 300 feet bgs) toward the shallower screen depths, except between MW4C and MW4B. However, the gradient is upward from MW4B to MW4A. Therefore, an upward gradient averages 0.0028 feet per foot among six pairs of wells. This vertical gradient value is essentially identical to the average horizontal gradient among the wells.

With site-specific data obtained in the 2005-2006 investigation and previous investigations, an estimate of the migration speed of a water particle can be made. Assuming the highest hydraulic conductivity measured (2.0E-04 cm/sec) and a travel distance of 165 feet from a near-surface source to groundwater, a particle would require approximately 80 years to reach groundwater. Once the particle reached groundwater, and again assuming the highest hydraulic conductivity of 2.0E-04 cm/sec and a distance of 3,100 feet, the travel time to the Rancho Seco property boundary is estimated at approximately 1,500 years. However, the hydraulic conductivities of deposits vary above the groundwater and below the groundwater surface. Therefore, it is likely that migration to groundwater will require more than 80 years and migration to the property boundary will require more than 1,500 years.

Long-term hydrographs for 23 wells in the Cosumnes Subbasin indicate that water levels declined from the mid-1960s until approximately 1980, unless the wells were in the recharge area of the Cosumnes River, which is several miles north of the site. From 1980 until 1986, water levels in most wells recovered as much as 10 feet from pre-1980 levels. Water elevations again decreased approximately 10 to 15 feet during the drought years of 1987 to 1992 and recovered 15 to 20 feet from 1993 to 2003 [Reference 8-8].

5.0 GROUNDWATER CHEMISTRY

The 2005 update investigation of Rancho Seco was also conducted to evaluate hydrology and hydrochemistry that would affect migration of any contaminants migrating in groundwater. Water samples were collected in 10 new wells and 3 water supply wells to evaluate groundwater chemistry and water quality.

Groundwater samples were collected from 10 of the 12 monitoring wells constructed in 2005 and analyzed for a suite of analytes that characterize the natural constituents in groundwater that originate from the atmosphere and from the soluble anions and cations from soil and aquifer material. Well MW1A did not produce sufficient water for a sample and well MW1B became obstructed with sampling equipment. Sometimes referred to as "general minerals," the analytes in the suite are used to determine differences between groundwater bodies that may be vertically separated. Near-surface groundwater may have a different geochemical composition than deeper groundwater because of constituents dissolved from soil and anthropological sources. In addition to the general mineral constituents, analyses were performed for the total boron because boric acid was added to the reactor's primary coolant water and would be an indicator that leakage of water from the reactor area reached groundwater.

In addition to the 10 samples from monitoring wells, a sample from one groundwater supply well in the Industrial Area, SW-2; a sample from the site supply well, SW-1, just east of the Industrial Area; and one sample from a well at Rancho Seco Park (RSPW), approximately a mile southeast of the Industrial Area, were also sampled for the suite of analytes. Results from the two wells located east of the Industrial Area are representative of "background conditions" because the groundwater moving through those wells has not been affected by any discharges from Rancho Seco activities. Groundwater at SW-1 and RSPW can be considered unaffected by any contaminants from the Industrial Area because groundwater has been flowing from northeast to southwest for at least 38 years.

Table 2 lists the results of the general minerals results for groundwater samples. It is readily evident that borate is not a contaminant in the samples analyzed because it was detected in only one sample, from well MW2A, at a concentration equal to the reporting limit of 0.05 milligrams per liter (mg/L). Furthermore, the results are notable for the similarity of values among the wells sampled. The only readily identifiable differences in the table are the variations in total iron concentration, higher level of total dissolved solids, presence of detectable concentrations of nitrate nitrogen, and pH 1.5 to 2.1 units lower in wells SW-1, SW-2, and RSPW than in most of the monitoring well samples.

The similarity of most parameters among all monitoring well locations and all depths indicate that groundwater is not stratified with large differences in constituent concentrations vertically. Graphical techniques that show the similarity or difference in general mineral concentrations between waters were used to confirm that groundwater up hydraulic gradient from the Industrial Area, beneath the Industrial Area, and down hydraulic gradient from the Industrial Area are the same. Piper and Stiff diagrams were prepared with concentrations of the major cations and anions occurring in groundwater: calcium, magnesium, potassium, sodium, bicarbonate, carbonate, chloride, and sulfate concentrations (Figures 8 and 9).

In the Piper diagram, each of the 13 well samples is represented by one dot on each of the three diagrams. For this diagram, concentrations of the major cations and anions are converted to milliequivalents (meq) and totaled. The location of dots representing wells is determined by the percentages of the total that each cation or anion (or a combination such as sodium and potassium) contributes. The close clustering of all the dots representing monitoring well samples as well as the three supply wells indicates that no great difference occurs in the groundwater from 1 mile upgradient to 3,500 feet downgradient of the Industrial Area. Furthermore, groundwater from 300 feet bgs from the "C" depth monitoring wells is not distinguishable from the groundwater in the "A" and "B" depth wells.

Stiff diagrams use the same meq/L data. However, they are arrayed in a different plot. Stiff diagrams are made for rapid pattern recognition to classify a groundwater and determine similarities from location to location and shallow to greater depths. Figure 9 illustrates a series of Stiff diagram plots that further support the similarity of groundwater among all of the wells sampled. These diagrams also indicate that the groundwater beneath the Rancho Seco site is a sodium-bicarbonate type.

Two wells up hydraulic gradient from the Industrial Area (SW-1 and RSPW) tap groundwater that has the same composition and similar concentrations of general mineral constituents as groundwater beneath and down hydraulic gradient from the Industrial Area. Therefore, the two wells can be used as indicators of background quality to compare with any wells that are suspected of being contaminated.

The general mineral constituents at 190 feet bgs in the groundwater beneath the Rancho Seco site are essentially the same as at 320 feet bgs. This condition and the upward hydraulic gradient from greater depth to shallower suggests that sampling of most of the "B" and "C" depth wells for contaminants will not be necessary because contamination, if any is suspected in the "A" depth wells, is unlikely to migrate downward against the gradient.

Table 2
General Minerals Results from Analyses of Groundwater

Well Sample	Alkalinity, Total mg/L	Alkalinity, Bicarbonate mg/L	Alkalinity, Carbonate mg/L	Chloride mg/L	Magnesium mg/L	Nitrogen, Total Nitrate-N mg/L	Sulfate mg/L	Iron mg/L
MW1C	86	57	29	7.1	2	<0.05	<0.50	17
MW2A	86	86	<5	14.0	3	<0.05	4.20	23
MW2B	64	64	<5	9.6	4	<0.05	1.40	73
MW2C	62	36	26	6.7	2	<0.05	<0.05	36
MW3A	53	42	11	5.0	<2	<0.05	<0.05	38
MW3B	49	42	7	4.6	<2	<0.05	<0.05	37
MW3C	49	38	11	3.7	2	<0.05	<0.05	4.65
MW4A	49	45	<5	5.6	2	<0.05	1.10	203
MW4B	51	40	11	5.2	<2	<0.05	<0.50	5.3
MW4C	58	51	7	5.7	3	<0.05	<0.05	6.4
SW-1	52	52	<5	4.0	3	1.80	3.50	<0.05
SW-2	55	55	<5	4.1	3	1.80	4.80	<0.05
RSPW	65	65	<5	5.8	5	0.64	1.40	0.24
Quantification Limit	5	5	5	1	2	0.05	0.50	0.05

Meq = milliequivalents
mg/L = milligrams per liter

Table 2 (Cont.)
General Minerals Results from Analyses of Groundwater

Well Sample	Potassium mg/L	Boron-Total mg/L	Calcium mg/L	Hardness mg/L	Sodium mg/L	Total Dissolved Solids mg/L	pH pH Units	Cation/Anion Balance meq
MW1C	3.86	<0.05	5.9	24	34	126	9.5	2.04/1.92
MW2A	3.34	0.05	4.0	24	42	151	7.6	2.36/2.20
MW2B	3.46	<0.05	4.7	28	26	101	8.9	1.78/1.58
MW2C	4.03	<0.05	4.7	20	24	88	9.6	1.55/1.43
MW3A	2.41	<0.05	3.2	16	20	70	9.3	1.09/1.20
MW3B	2.50	<0.05	3.2	16	18	71	9.3	1.01/1.11
MW3C	3.09	<0.05	4.0	20	16	71	9.3	1.14/1.08
MW4A	2.69	<0.05	4.0	20	19	69	9	1.26/1.16
MW4B	2.97	<0.05	3.2	14	18	72	9.4	1.02/1.17
MW4C	3.16	<0.05	4.0	22	21	81	9.2	1.44/1.32
SW-1	3.90	<0.05	3.2	20	22	168	7.7	1.46/1.35
SW-2	3.80	<0.05	4.7	24	20	165	7.6	1.45/1.44
RSPW	3.70	<0.05	6.3	35	20	180	7.4	1.69/1.54
Quantification Limit	0.05	0.05	3.0	5	5	10	0.1	NA

Meq = milliequivalents
mg/L = milligrams per liter

6.0 GROUNDWATER MONITORING

6.1. Radiochemical Monitoring Of Groundwater

6.1.1 Licensed Radionuclides

The shallowest available well at each of the new monitoring well locations down hydraulic gradient from the Industrial Area was sampled (unfiltered) for radiochemical analysis during the third and fourth quarters of 2005 and first and second quarters of 2006. Monitoring well MW1A did not produce water during the first and second sampling periods and MW1B became obstructed during the first sampling period. A new monitoring well MW1D was constructed adjacent to the MW1 well nest with a screen interval of 200 to 220 feet bgs. This well was used as the shallow location for the first and second quarter 2006 monitoring at the MW1 well nest location. Each of the first and second period groundwater samples was analyzed by General Engineering Laboratories (GEL) for the 26 site-specific radionuclides identified in the License Termination Plan (Pu-242 was inadvertently omitted from the list of radionuclides for GEL analysis for the third and fourth quarters of 2005 and only the first period sample from MW1D was analyzed by GEL for all 26 radionuclides). The remaining samples were analyzed onsite by Rancho Seco personnel using liquid scintillation spectrometry for tritium analysis and gamma spectrometry for gamma isotopic analysis. Analytical results for licensed radionuclides are provided in Table 3 [Reference 8-9].

For the most part, sample analysis results were less than the minimum detectable activity (MDA) for the sample analysis. Water samples had positive results identified two times for gross alpha activity and five times for gross beta activity out of the nine samples analyzed for gross alpha and gross beta activity. In each case of positive results identified, the concentrations were below the California Title 22 Division 4 Chapter 15 Article 5 maximum contaminant level concentrations of 15 pCi/L for gross alpha and 50 pCi/L for gross beta. Also, as discussed in Section 6.1.2, naturally occurring radionuclides were identified by gamma spectroscopy analysis; therefore, the positive gross alpha and gross beta activity results are likely due to naturally occurring radionuclides. Since the groundwater samples were not filtered, the presence of sediment at the time of sample analysis may also have led to an overestimation of detectable activity in water.

The hard-to-detect radionuclide, Ni-63 was identified in the fourth quarter 2005 MW4A sample with activity statistically greater than the *a posteriori* calculated MDA value, 2.64E+01 pCi/L, for the sample analysis at the 99 percent confidence level. However, Ni-63 was not detected in the third quarter 2005 sample with an MDA lower than the fourth quarter statistically positive identified value. Therefore, it is concluded that the reported statistically present Ni-63 value was a false positive result. None of the other radionuclides in the site-specific suite were identified in any samples with activity statistically greater than the *a posteriori* calculated MDA value for the sample analysis at the 99 percent confidence level.

The site-specific radionuclide omitted from analysis during the third and fourth quarters of 2005, Pu-242, has not been detected in contaminated soil samples above the MDA values for the sample analyses. The first quarter 2006 MW1D sample was analyzed for Pu-242 with the result being less than the MDA for the sample analysis. Therefore, it is unlikely that Pu-242 would be present in groundwater samples without detecting any of the 25 other radionuclides in the site-specific suite of radionuclides for Rancho Seco.

Table 3
Groundwater Monitoring Radiochemical Results

Analyte	3rd Quarter 2005 Results (pCi/L)				4th Quarter 2005 Results (pCi/L)			
	MW1C	MW2A	MW3A	MW4A	MW1C	MW2A	MW3A	MW4A
Alpha	<1.14+00	4.53E+00	<1.38E+00	<1.18E+00	<1.13E+00	7.07E+00	<3.61E+00	<1.25E+00
Beta	5.21E+00	8.02E+00	2.89E+00	2.24E+00	<3.71E+00	1.71E+01	<4.30E+00	<4.38E+00
H-3	<2.57E+02	<2.62E+02	<2.58E+02	<2.53E+02	<3.59E+02	<3.59E+02	<3.62E+02	<3.65E+02
C-14	<3.09E+01	<3.15E+01	<3.48E+01	<3.47E+01	<2.66E+01	<2.66E+01	<2.67E+01	<2.67E+01
Na-22	<6.67E+00	<2.86E+00	<5.23E+00	<4.21E+00	<3.14E+00	<3.01E+00	<3.82E+00	<3.49E+00
Fe-55	<8.20E+01	<8.05E+01	<7.94E+01	<7.86E+01	<5.66E+01	<5.02E+01	<5.07E+01	<5.89E+01
Ni-59	<1.95E+01	<1.54E+01	<1.68E+01	<1.61E+01	<1.66E+01	<1.57E+01	<1.56E+01	<1.56E+01
Co-60	<7.15E+00	<3.32E+00	<5.90E+00	<3.74E+00	<3.32E+00	<3.12E+00	<3.38E+00	<3.35E+00
Ni-63	<2.18E+01	<1.24E+01	<2.44E+01	<2.69E+01	<2.51E+01	<2.89E+01	<2.67E+01	2.76E+01
Sr-90	<1.24E+00	<1.37E+00	<1.43E+00	<1.05E+00	<1.27E+00	<1.03E+00	<9.64E-01	<9.55E-01
Nb-94	<6.00E+00	<2.80E+00	<5.23E+00	<3.52E+00	<3.01E+00	<2.95E+00	<3.44E+00	<3.02E+00
Tc-99	<3.01E+01	<3.01E+01	<2.98E+01	<3.05E+01	<7.06E+00	<2.01E+01	<2.23E+01	<2.10E+01
Ag-108m	<6.93E+00	<2.96E+00	<6.23E+00	<3.39E+00	<2.95E+00	<3.18E+00	<4.13E+00	<3.53E+00
Sb-125	<1.79E+01	<8.36E+00	<1.66E+01	<1.01E+01	<8.24E+00	<9.01E+00	<1.05E+01	<9.30E+00
Cs-134	<7.35E+00	<3.35E+00	<6.04E+00	<4.45E+00	<3.30E+00	<3.26E+00	<3.87E+00	<3.67E+00
Cs-137	<6.02E+00	<3.15E+00	<7.59E+00	<4.16E+00	<2.99E+00	<2.75E+00	<3.48E+00	<3.99E+00
Pm-147	<7.53E+00	<7.63E+00	<6.77E+00	<7.12E+00	<7.06E+00	<8.64E+00	<7.83E+00	<7.82E+00
Eu-152	<1.99E+01	<9.78E+00	<1.79E+01	<1.03E+01	<9.76E+00	<9.34E+00	<1.23E+01	<1.03E+01
Eu-154	<1.85E+01	<7.93E+00	<1.45E+01	<1.17E+01	<8.72E+00	<8.40E+00	<1.07E+01	<9.72E+00
Eu-155	<2.18E+01	<1.24E+01	<2.30E+01	<1.02E+01	<1.13E+01	<1.28E+01	<1.37E+01	<1.21E+01
Np-237	<3.03E-01	<4.58E-01	<4.24E-01	<3.50E-01	<4.39E-01	<2.17E-01	<5.27E-01	<7.03E-01
Pu-238	<4.98E-01	<4.33E-01	<3.57E-01	<3.89E-01	<2.24E-01	<8.37E-01	<1.05E+00	<8.56E-01
Pu-239/240	<4.32E-01	<3.06E-01	<3.35E-01	<2.33E-01	<5.51E-01	<8.36E-01	<6.21E-01	<6.91E-01
Pu-241	<9.26E+00	<1.24E+01	<1.17E+01	<1.11E+01	<1.22E+01	<5.79E+01	<1.07E+01	<9.75E+00
Am-241	<4.50E-01	<3.14E-01	<3.53E-01	<3.59E-01	<3.28E-01	<2.72E-01	<4.32E-01	<3.10E-01
Pu-242	NA	NA	NA	NA	NA	NA	NA	NA
Cm-244	<6.00E-01	<5.16E-01	<4.01E-01	<5.95E-01	<4.39E-01	<5.01E-01	<4.32E-01	<3.10E-01

NA – Not Analyzed

Note: "Less Than" numbers are the *a posteriori* calculated MDA value for the sample analysis. Detected concentration values are statistically positive at the 99.9% confidence level (greater than three times the one sigma uncertainty).

Table 3 (Cont.)
Groundwater Monitoring Radiochemical Results

Analyte	1st Quarter 2006 Results (pCi/L)				2nd Quarter 2006 Results (pCi/L)			
	MW1D	MW2A	MW3A	MW4A	MW1D	MW2A	MW3A	MW4A
Alpha	<6.44E-01	NA	NS	NA	NA	NA	NA	NA
Beta	<2.14E+00	NA	NS	NA	NA	NA	NA	NA
H-3	<2.84E+02	<2.77E+02	NS	<2.83E+02	<2.70E+02	<2.75E+02	<2.57E+02	<2.75E+02
C-14	<4.43E+01	NA	NS	NA	NA	NA	NA	NA
Na-22	<1.01E+01	NA	NS	NA	NA	NA	NA	NA
Fe-55	<4.06E+01	NA	NS	NA	NA	NA	NA	NA
Ni-59	<1.22E+01	NA	NS	NA	NA	NA	NA	NA
Co-60	<5.70E+00	<6.51E+00	NS	<5.75E+00	<6.26E+00	<7.35E+00	<5.47E+00	<5.47E+00
Ni-63	<3.47E+01	NA	NS	NA	NA	NA	NA	NA
Sr-90	<1.11E+00	NA	NS	NA	NA	NA	NA	NA
Nb-94	<8.95E+00	NA	NS	NA	NA	NA	NA	NA
Tc-99	<2.90E+01	NA	NS	NA	NA	NA	NA	NA
Ag-108m	<5.65E+00	<5.26E+00	NS	<5.83E+00	<5.96E+00	<6.56E+00	<6.82E+00	<6.80E+00
Sb-125	<2.40E+01	NA	NS	NA	NA	NA	NA	NA
Cs-134	<5.20E+00	<5.53E+00	NS	<6.21E+00	<5.98E+00	<5.80E+00	<6.04E+00	<6.04E+00
Cs-137	<6.03E+00	<6.46E+00	NS	<6.43E+00	<6.87E+00	<6.56E+00	<7.69E+00	<7.69E+00
Pm-147	<6.28E+00	NA	NS	NA	NA	NA	NA	NA
Eu-152	<2.56E+01	NA	NS	NA	NA	NA	NA	NA
Eu-154	<2.80E+01	NA	NS	NA	NA	NA	NA	NA
Eu-155	<2.63E+01	NA	NS	NA	NA	NA	NA	NA
Np-237	<4.58E-01	NA	NS	NA	NA	NA	NA	NA
Pu-238	<1.24E+00	NA	NS	NA	NA	NA	NA	NA
Pu-239/240	<9.41E-01	NA	NS	NA	NA	NA	NA	NA
Pu-241	<1.14E+01	NA	NS	NA	NA	NA	NA	NA
Am-241	<4.34E-01	NA	NS	NA	NA	NA	NA	NA
Pu-242	<6.83E-01	NA	NS	NA	NA	NA	NA	NA
Cm-244	<4.34E-01	NA	NS	NA	NA	NA	NA	NA

NA – Not Analyzed

NS – Not Sampled (well not accessible)

Note: "Less Than" numbers are the *a posteriori* calculated MDA value for the sample analysis. Detected concentration values are statistically positive at the 99.9% confidence level (greater than three times the one sigma uncertainty).

6.1.2 Naturally Occurring Radionuclides

Background radiation is comprised of four major sources (or components) of ionizing radiation; terrestrial radiation, cosmic, cosmogenic and man-made radiation sources. Of these four sources, naturally occurring terrestrial radionuclides may be found in groundwater. Some of these naturally occurring radionuclides are readily observed using gamma spectrometry for gamma isotopic analysis. Rancho Seco personnel performed gamma spectrometry analysis on all groundwater samples obtained. The positive results of naturally occurring radionuclides observed are presented in Table 4.

Table 4

Groundwater Monitoring of Naturally Occurring Radionuclides

Analyte	3rd Quarter 2005 Results (pCi/L)							
	MW1C	**MW1D**	**MW2A**	**MW2B**	**MW2C**	**MW3A**	**MW3B**	**MW3C**
Natural								
K-40	3.56E+02	NS	4.12E+02	3.65E+02	3.06E+02	3.47E+02	2.53E+02	3.31E+02
Uranium-238 Series								
Pb-214	<MDA	NS	<MDA	<MDA	8.33E+01	<MDA	<MDA	<MDA
Bi-214	<MDA	NS	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Rn-222	2.66E+04	NS	2.83E+04	1.74E+04	<MDA	<MDA	1.59E+04	4.95E+04
Ra-226	2.32E+02	NS	2.00E+02	2.31E+02	<MDA	1.94E+02	1.48E+02	1.38E+02
Thorium-232 Series								
Ra-224	3.53E+02	NS	2.99E+02	1.13E+02	<MDA	1.79E+02	<MDA	<MDA
Actinium Series								
U-235	1.41E+01	NS	1.22E+01	1.40E+01	<MDA	1.18E+01	8.97E+00	8.38E+00
	MW4A	**MW4B**	**MW4C**	**SW1**	**SW2**	**RSPW**		
Natural								
K-40	2.97E+02	2.21E+02	3.09E+02	2.48E+02	4.18E+02	<MDA		
Uranium-238 Series								
Pb-214	<MDA	4.87E+01	<MDA	9.36E+01	<MDA	1.50E+02		
Bi-214	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA		
Rn-222	1.94E+04	<MDA	<MDA	<MDA	2.20E+04	<MDA		
Ra-226	1.98E+02	<MDA	2.99E+02	<MDA	2.09E+02	<MDA		
Thorium-232 Series								
Ra-224	1.71E+02	<MDA	<MDA	<MDA	<MDA	<MDA		
Actinium Series								
U-235	1.20E+01	<MDA	1.82E+01	<MDA	1.27E+01	<MDA		

NS – Not Sampled (well not accessible)

<MDA – Less than the *a posteriori* calculated minimum detectable activity for the analysis

Table 4 (Cont.)
Groundwater Monitoring of Naturally Occurring Radionuclides

Analyte	4th Quarter 2005 Results (pCi/L)							
	MW1C	**MW1D**	**MW2A**	**MW2B**	**MW2C**	**MW3A**	**MW3B**	**MW3C**
Natural								
K-40	2.92E+02	NS	4.67E+02	3.49E+02	2.54E+02	3.10E+02	3.54E+02	2.95E+02
Uranium-238 Series								
Pb-214	<MDA	NS	<MDA	<MDA	3.89E+02	< MDA	< MDA	3.90E+01
Bi-214	<MDA	NS	<MDA	<MDA	3.95E+02	< MDA	< MDA	2.80E+01
Rn-222	<MDA	NS	2.04E+04	<MDA	<MDA	6.40E+04	3.81E+04	1.70E+04
Ra-226	2.92E+02	NS	1.79E+02	1.57E+02	<MDA	3.00E+02	1.35E+02	1.88E+02
Thorium-232 Series								
Ra-224	2.93E+02	NS	3.39E+02	2.29E+02	<MDA	6.11E+02	3.99E+02	<MDA
Actinium Series								
U-235	1.78E+01	NS	1.08E+01	9.53E+00	1.08E+01	1.82E+01	8.20E+00	1.14E+01
	MW4A	**MW4B**	**MW4C**	**SW1**	**SW2**	**RSPW**		
Natural								
K-40	2.40E+02	3.51E+02	4.04E+02	3.50E+02	2.97E+02	2.45E+02		
Uranium-238 Series								
Pb-214	<MDA	<MDA	<MDA	< MDA	4.96E+01	3.11E+02		
Bi-214	<MDA	<MDA	<MDA	< MDA	< MDA	3.51E+02		
Rn-222	4.36E+04	3.45E+04	5.97E+04	< MDA	< MDA	< MDA		
Ra-226	1.69E+02	<MDA	3.19E+02	1.50E+02	< MDA	< MDA		
Thorium-232 Series								
Ra-224	7.45E+02	< MDA	1.49E+02	1.46E+02	< MDA	< MDA		
Actinium Series								
U-235	1.03E+01	<MDA	1.93E+01	9.10E+00	8.09E+00	< MDA		

NS – Not Sampled (well not accessible)

<MDA - Less than the *a posteriori* calculated minimum detectable activity for the analysis

Table 4 (Cont.)
Groundwater Monitoring of Naturally Occurring Radionuclides

Analyte	1st Quarter 2006 Results (pCi/L)							
	MW1C	**MW1D**	**MW2A**	**MW2B**	**MW2C**	**MW3A**	**MW3B**	**MW3C**
Natural								
K-40	2.35E+02	2.68E+02	2.03E+02	2.84E+02	2.67E+02	NS	NS	NS
Uranium-238 Series								
Pb-214	4.40E+02	6.02E+01	9.10E+01	6.35E+01	9.76E+01	NS	NS	NS
Bi-214	4.45E+01	6.24E+01	9.54E+01	<MDA	1.10E+02	NS	NS	NS
Rn-222	<MDA	<MDA	<MDA	<MDA	<MDA	NS	NS	NS
Ra-226	2.00E+02	1.25E+02	<MDA	<MDA	<MDA	NS	NS	NS
Thorium-232 Series								
Ra-224	<MDA	<MDA	<MDA	<MDA	<MDA	NS	NS	NS
Actinium Series								
U-235	1.21E+01	7.56E+00	<MDA	<MDA	<MDA	NS	NS	NS
	MW4A	**MW4B**	**MW4C**	**SW1**	**SW2**	**RSPW**		
Natural								
K-40	2.64E+02	2.77E+02	2.44E+02	2.04E+02	2.34E+02	2.38E+02		
Uranium-238 Series								
Pb-214	1.22E+02	9.42E+01	4.05E+01	4.89E+01	3.43E+01	9.10E+01		
Bi-214	1.24E+02	1.00E+02	4.18E+01	4.42E+01	<MDA	9.43E+01		
Rn-222	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA		
Ra-226	1.88E+02	<MDA	<MDA	<MDA	1.20E+02	<MDA		
Thorium-232 Series								
Ra-224	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA		
Actinium Series								
U-235	1.14E+01	<MDA	<MDA	<MDA	7.30E+00	<MDA		

NS – Not Sampled (well not accessible)

<MDA - Less than the *a posteriori* calculated minimum detectable activity for the analysis

Table 4 (Cont.)
Groundwater Monitoring of Naturally Occurring Radionuclides

Analyte	2nd Quarter 2006 Results (pCi/L)							
	MW1C	MW1D	MW2A	MW2B	MW2C	MW3A	MW3B	MW3C
Natural								
K-40	3.56E+02	2.11E+02	3.88E+02	4.22E+02	3.59E+02	2.04E+02	2.23E+02	2.93E+02
Uranium-238 Series								
Pb-214	<MDA	9.89E+01	<MDA	<MDA	<MDA	3.03E+02	1.77E+02	3.36E+02
Bi-214	<MDA	1.04E+02	<MDA	<MDA	<MDA	2.86E+02	1.78E+02	3.58E+02
Rn-222	<MDA	<MDA	2.03E+04	3.92E+04	4.00E+04	<MDA	<MDA	<MDA
Ra-226	<MDA	<MDA	1.69E+02	1.69E+02	2.33E+02	<MDA	8.89E+01	<MDA
Thorium-232 Series								
Ra-224	2.95E+02	<MDA	4.58E+02	<MDA	5.77E+02	<MDA	<MDA	<MDA
Actinium Series								
U-235	<MDA	<MDA	1.03E+01	1.02E+01	1.42E+01	<MDA	5.58E+00	<MDA
	MW4A	MW4B	MW4C	SW1	SW2	RSPW		
Natural								
K-40	1.98E+02	2.30E+02	2.84E+02	4.65E+02	3.82E+02	2.90E+02		
Uranium-238 Series								
Pb-214	2.93E+02	1.81E+02	3.30E+02	5.56E+03	<MDA	2.41E+02		
Bi-214	2.90E+02	1.77E+02	3.54E+02	<MDA	<MDA	2.69E+02		
Rn-222	<MDA	<MDA	<MDA	<MDA	2.66E+04	<MDA		
Ra-226	<MDA	9.74E+01	<MDA	2.53E+02	2.66E+02	<MDA		
Thorium-232 Series								
Ra-224	<MDA	<MDA	<MDA	2.14E+02	<MDA	<MDA		
Actinium Series								
U-235	<MDA	5.91E+00	<MDA	1.53E+01	1.62E+01	<MDA		

NS – Not Sampled (well not accessible)

<MDA - Less than the *a posteriori* calculated minimum detectable activity for the analysis

The variability in the results of groundwater monitoring was plotted as a "scatter plot" for each monitoring quarter for K-40, Ra-226 and U-235. These plots are presented in Figures 10, 11 and 12. The variability of the results from monitoring naturally occurring radionuclides presented in Table 4 and depicted in Figures 10, 11 and 12 supports the conclusions reached in Section 5.0 on the similarity of groundwater among all of the wells sampled and that the two wells up hydraulic gradient from the Industrial Area (SW-1 and RSPW) tap groundwater that has the same composition and similar concentrations of general mineral constituents as groundwater beneath and down hydraulic gradient from the Industrial Area.

6.2. Groundwater Level Monitoring

NUREG-1757, Vol. 2, Appendix F, states that groundwater levels should be measured on a quarterly basis for a minimum one year to determine temporal variations in the hydraulic gradient. Therefore, the surface elevation of the groundwater aquifer was measured each time the wells were sampled. This data is presented in Table 5 in terms of measured distance of groundwater surface below mean sea level (msl) for each well location sampled. The average groundwater surface elevation for each well nest is plotted in Figure 13.

Table 5
Groundwater Surface Elevations

Sampling Period	MW1A (ft from msl)	MW1B (ft from msl)	MW1C (ft from msl)	MW1D (ft from msl)	MW2A (ft from msl)	MW2B (ft from msl)	MW2C (ft from msl)
3rd Qtr 2005	DW	NS	-18.7	-	-20.9	-22.1	-22.1
4th Qtr 2005	DW	-18.8	-19.3	-	-22.5	-22.9	-22.9
1st Qtr 2006	DW	NS	-19.2	-18.7	-22.5	-22.6	-22.7
2nd Qtr 2006	DW	NS	-19.5	-19.0	-22.8	-22.9	-22.8
Sampling Period	**MW3A (ft from msl)**	**MW3B (ft from msl)**	**MW3C (ft from msl)**	**MW4A (ft from msl)**	**MW4B (ft from msl)**	**MW4C (ft from msl)**	
3rd Qtr 2005	-23.7	-24.0	-24.1	-28.3	-28.5	-28.4	
4th Qtr 2005	-24.6	-24.6	-24.7	-29.0	-29.1	-29.0	
1st Qtr 2006	NS	NS	NS	-26.7	-26.7	-26.7	
2nd Qtr 2006	-26.3	-26.4	-26.3	-27.0	-27.0	-27.0	

DW – Dry Well

msl – mean sea level

NS – Not Sampled (well not accessible)

Monthly Sacramento area precipitation[1] for this same groundwater level monitoring period is shown in Table 6 and plotted in Figure 14.

Table 6
Monthly Precipitation for Second Half of 2005 and First Half of 2006

Precipitation (inches)	2005					
	July	**August**	**September**	**October**	**November**	**December**
	0.00	0.00	0.10	0.16	0.90	9.47
Precipitation (inches)	**2006**					
	January	**February**	**March**	**April**	**May**	**June**
	3.07	2.07	6.02	3.42	0.42	0.00

As shown in Figures 13 and 14, there is very little temporal variation in the surface elevation of the groundwater aquifer and no correlation with monthly precipitation for this same monitoring period. There is a slight temporal variation of the surface elevation observed in the MW3 and MW4 nest locations; however, this variation does not correlate with monthly precipitation. MW3 and MW4 nest locations are on the western boundary of the Rancho Seco site and adjacent to a rather large wine grape vineyard. This vineyard is irrigated by water drawn from a number of wells at various locations in the vineyard. The monitoring well nest locations are shown on Figure 15, which is a satellite close-up photograph of the Rancho Seco Industrial Area.

These observations support the statement in Section 2.3 that recharge to the groundwater occurs primarily by the infiltration of surface water along the active channels of streams, such as the Cosumnes River, Dry Creek, and Mokelumne River, and by deep percolation of applied irrigation water.

7.0 CONCLUSIONS

Groundwater under the Rancho Seco site was monitored over four calendar quarters to represent the four seasons of a yearlong period. Samples were collected in the summer and fall of 2005 and the winter and spring of 2006. The results of the Groundwater Monitoring Program conclude:

1. Licensed radioactive materials, including tritium, resulting from the operation and decommissioning of Rancho Seco, have not contaminated the regional aquifer under the Rancho Seco site.
2. Groundwater under the Rancho Seco site is a regional aquifer, with the top of the aquifer approximately 183 feet bgs under the Industrial Area of the site and the bottom of the aquifer at approximately 2,000 feet bgs.
3. Groundwater levels in the four new well nests suggest that there is one aquifer between the water table and 300 feet bgs, that the horizontal gradient is southwesterly, and the vertical hydraulic gradient is upward.

[1] Data Source: National Weather Service, California Nevada River Forecast Center, http://www.cnrfc.noaa.gov/monthly_precip_2005.php and http://www.cnrfc.noaa.gov/monthly_precip.php.

4. With site-specific data obtained in the 2005-2006 investigation and previous investigations, an estimate of the migration speed of a water particle concludes it is likely that migration from the site surface to groundwater will require more than 80 years and migration to the property boundary will require more than 1,500 years.
5. Groundwater chemistry monitoring concludes that groundwater is not stratified with large differences in constituent concentrations vertically because of the similarity of most parameters among all monitoring well locations and all depths.
6. The groundwater chemistry monitoring indicates that the groundwater beneath the Rancho Seco site is a sodium-bicarbonate type.
7. There are no indications that boron from boric acid added to the reactor's primary coolant water has reached groundwater.
8. There is very little temporal variation in the surface elevation of the groundwater aquifer and no correlation with monthly precipitation for this same monitoring period.
9. Groundwater monitoring over the one-year period has adequately characterized groundwater under the Rancho Seco site and no further monitoring of water quality, radionuclide content or groundwater level will be performed.

8.0 REFERENCES

8-1 U.S. Nuclear Regulatory Commission NUREG–1757, Vol. 2, "Consolidated NMSS Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria, Final Report," September 2003

8-2 URS Group, Inc., "Hydrogeological Characterization of the Rancho Seco Nuclear Generating Station," March 2006

8-3 Sacramento Municipal Utility District, Rancho Seco Nuclear Generating Station, "License Termination Plan," Revision 0, April 2006

8-4 California Department of Water Resources, 1978. "Evaluation of Ground Water Resources," Sacramento County. Bulletin 118-3

8-5 Sacramento Municipal Utility District, "Rancho Seco Nuclear Generating Station, Unit No. 1, Final Safety Analysis Report," 1971

8-6 Sacramento Municipal Utility District, "Geotechnical Investigation for Proposed Evaporation Ponds," ERPT-C0104, Rev.1, April 5, 1989

8-7 Sacramento County Department of Water Resources, 2003. Water Level Elevation Maps for Sacramento County

8-8 California Department of Water Resources, "San Joaquin Valley Groundwater Basin, Cosumnes Subbasin," Bulletin 118, 2004

8-9 Rancho Seco Decommissioning Technical Basis Document DTBD-06-004, Revision No. 0, "Analysis of RSNGS Groundwater Samples"

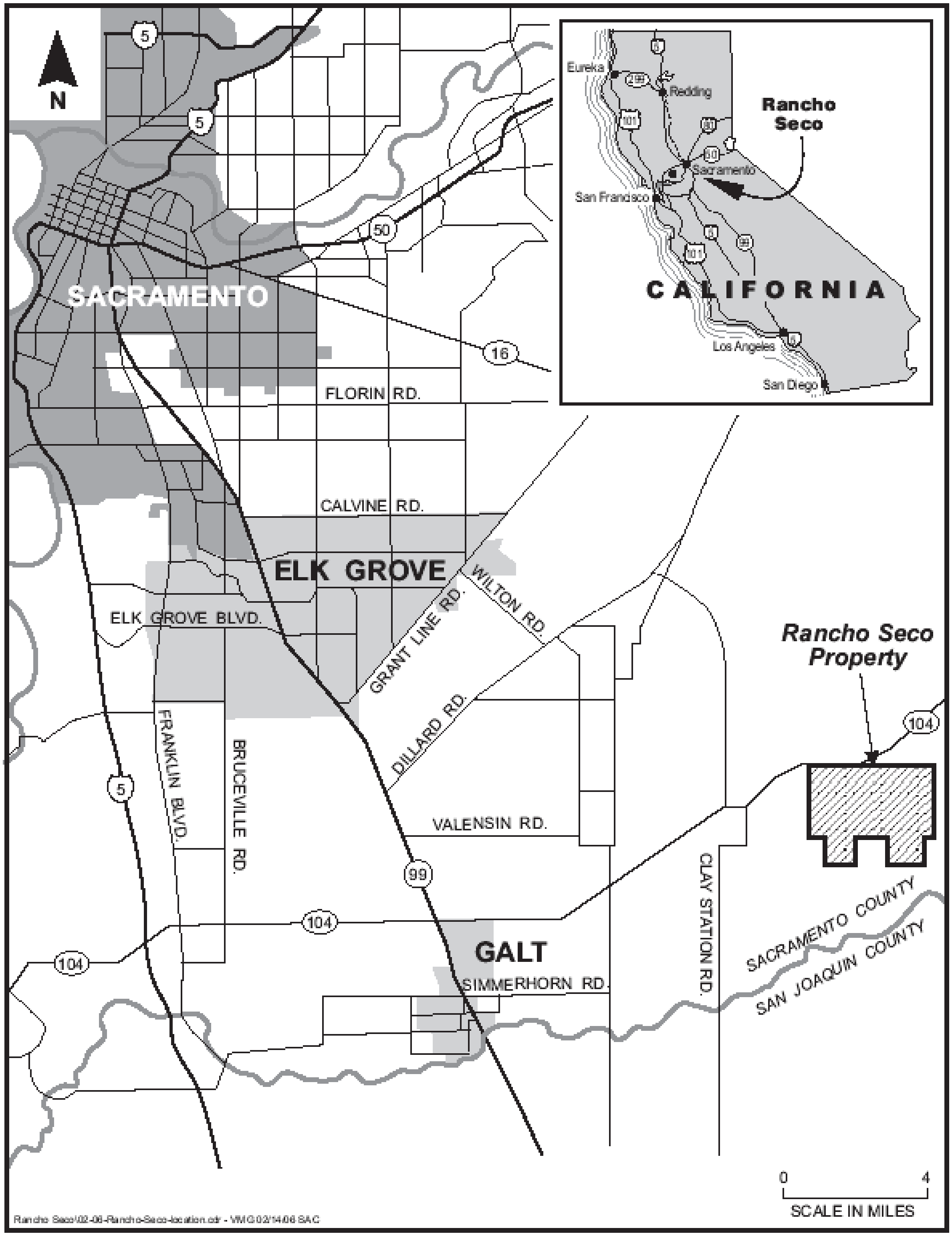

Figure 1

Location of Rancho Seco Nuclear Generating Station

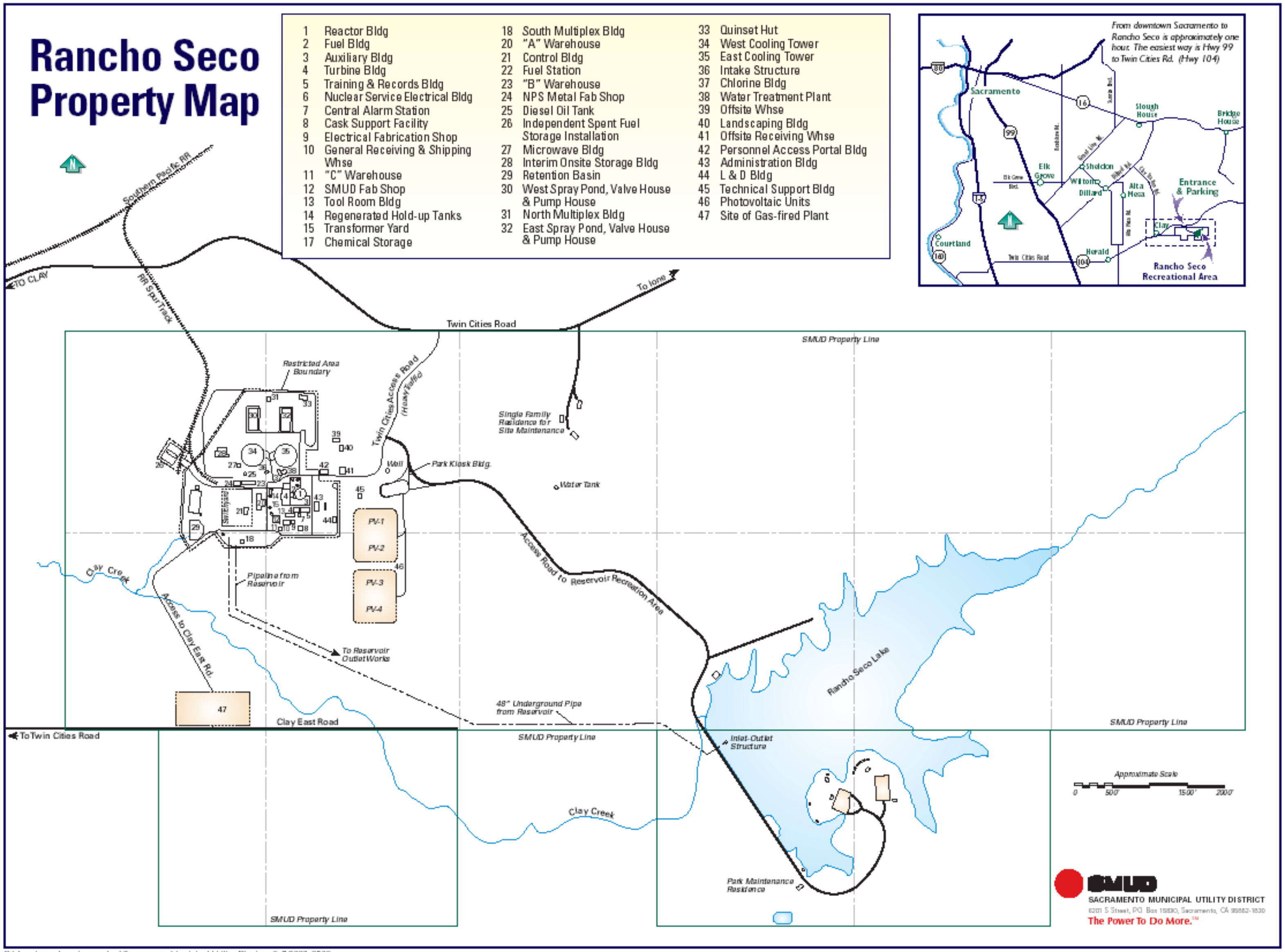

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Figure 2
Rancho Seco Site Layout

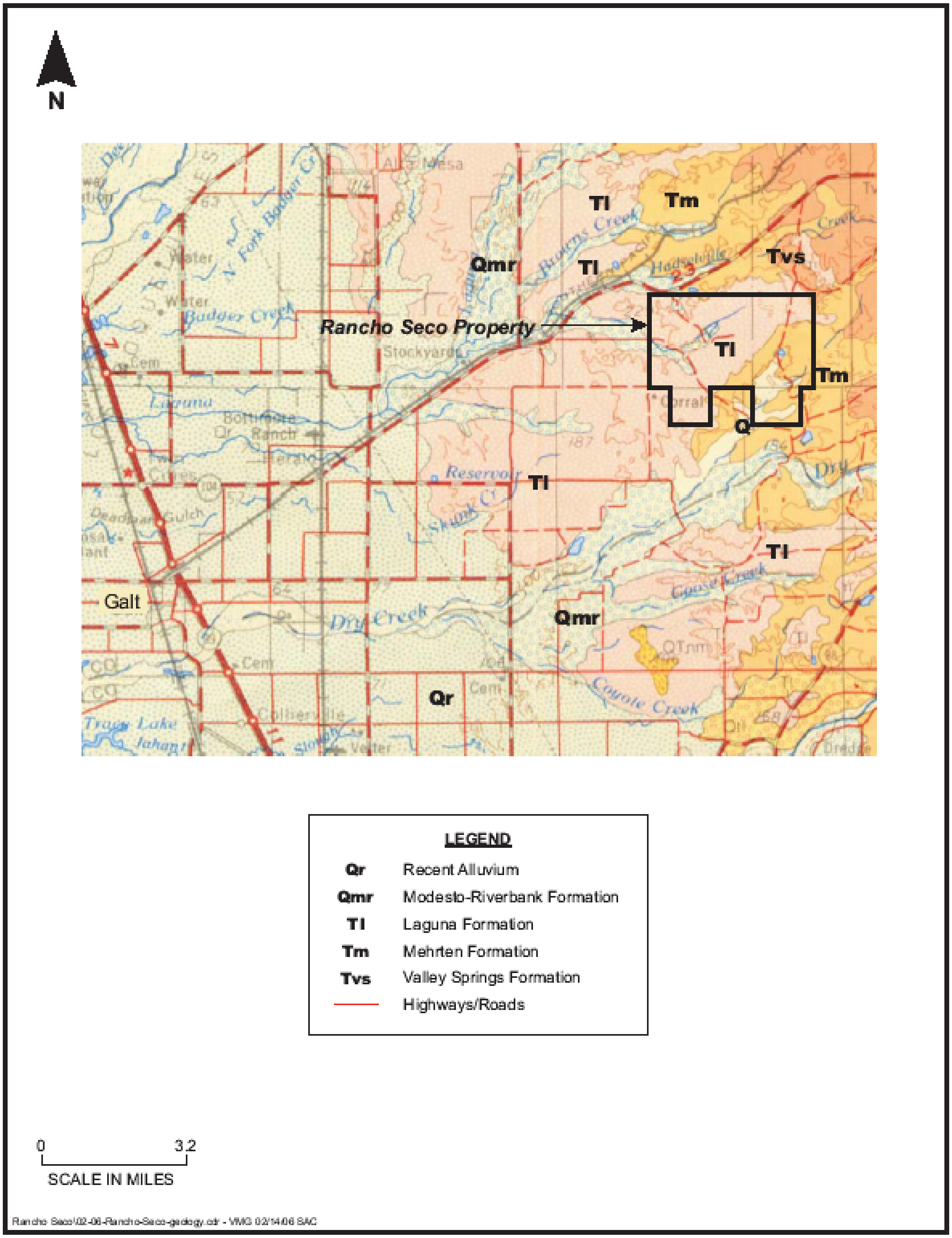


Figure 3

Geologic Map of Area from Rancho Seco to Galt, California

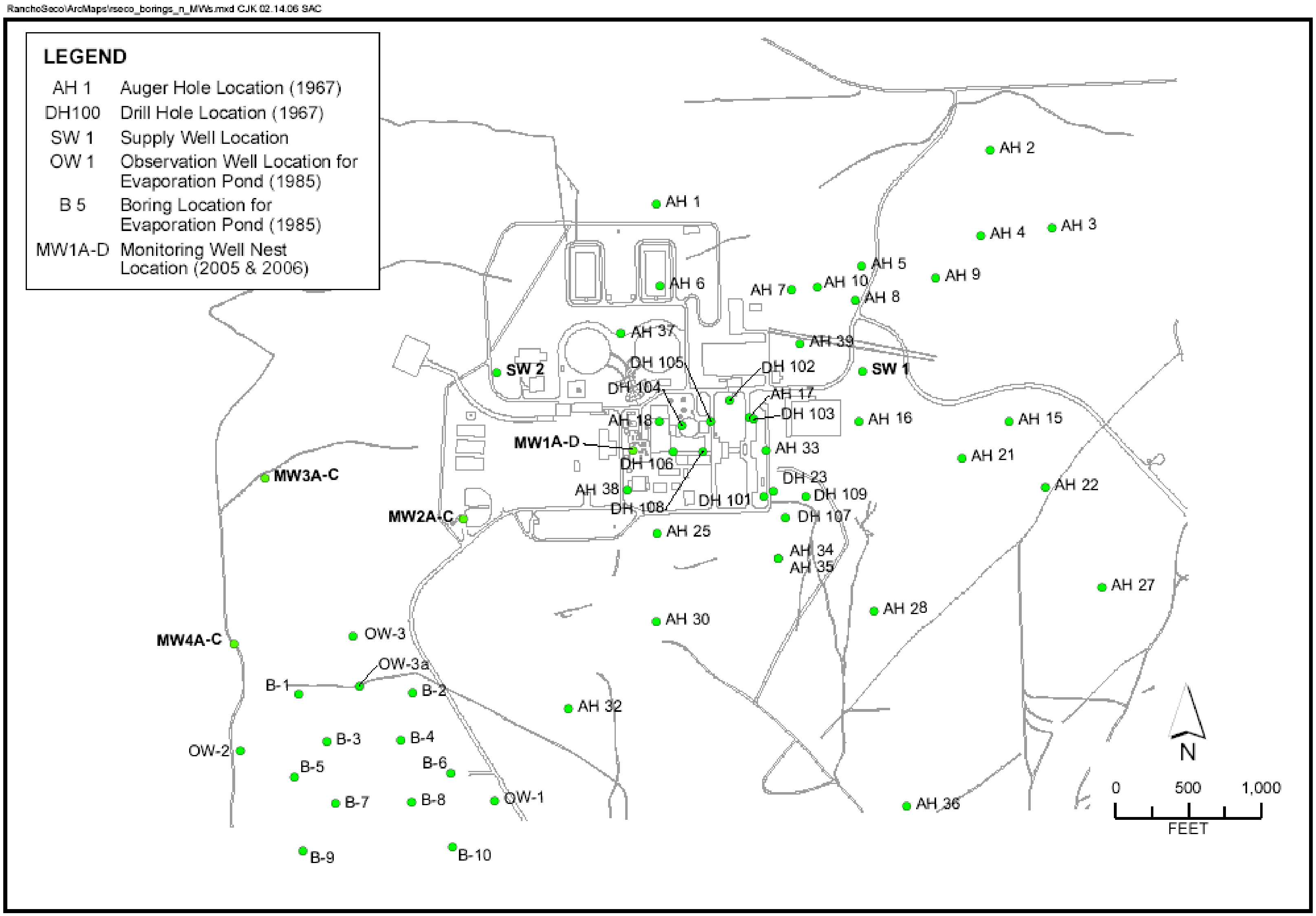


Figure 4

Locations of Borings Drilled and Sampled at Rancho Seco

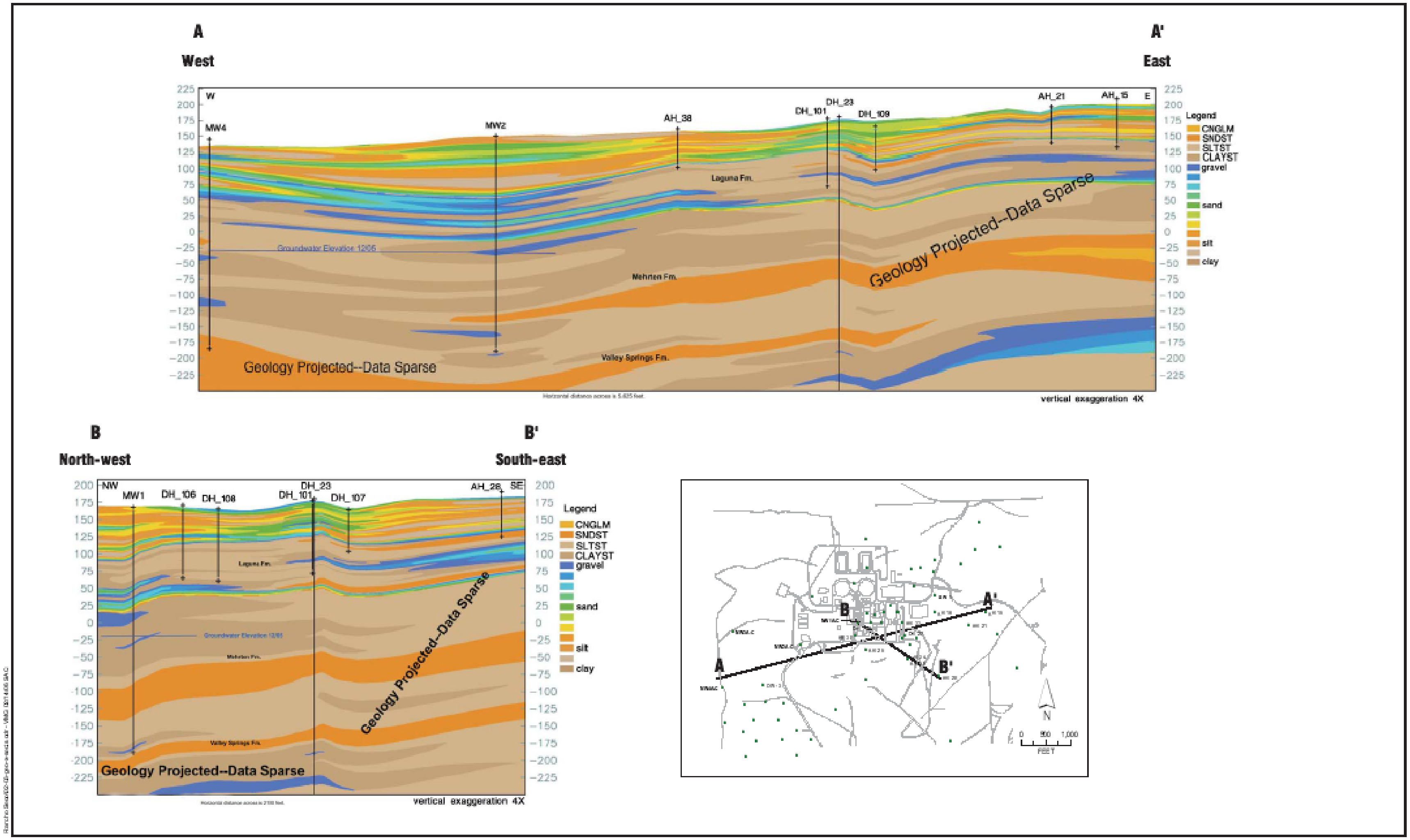
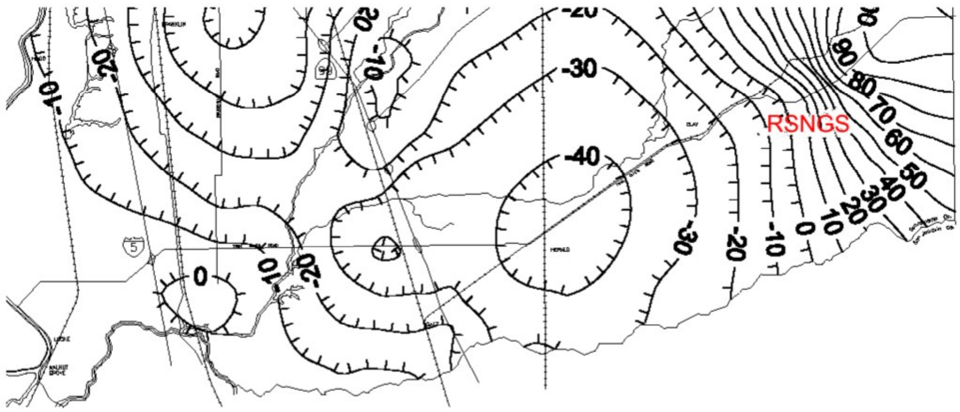
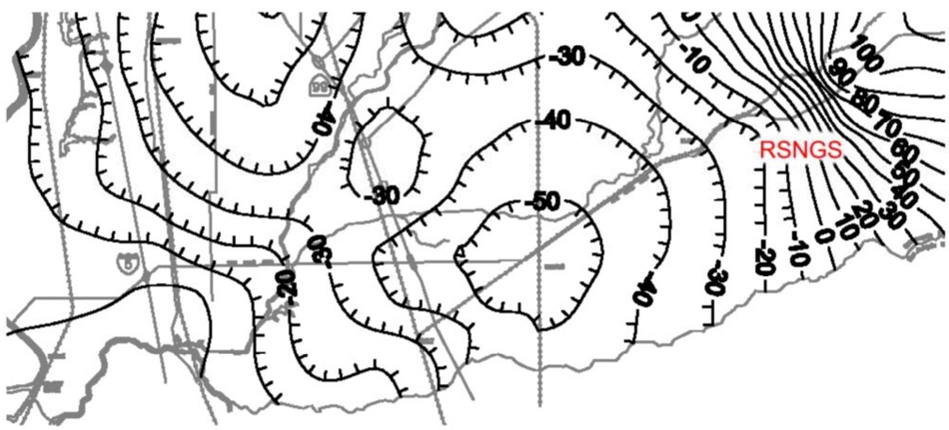


Figure 5
Geologic Cross Sections of the Rancho Seco Site



Groundwater Levels Southern Sacramento County
Spring 2003



Groundwater Levels Southern Sacramento County
Fall 2003

Figure 6
Groundwater Elevation Contours Measured in 2003,
Southern Sacramento County

RanchoSeco\ArcMaps\rseco_gw_contours_dec05.mxd CJK 02.23.06 SAC

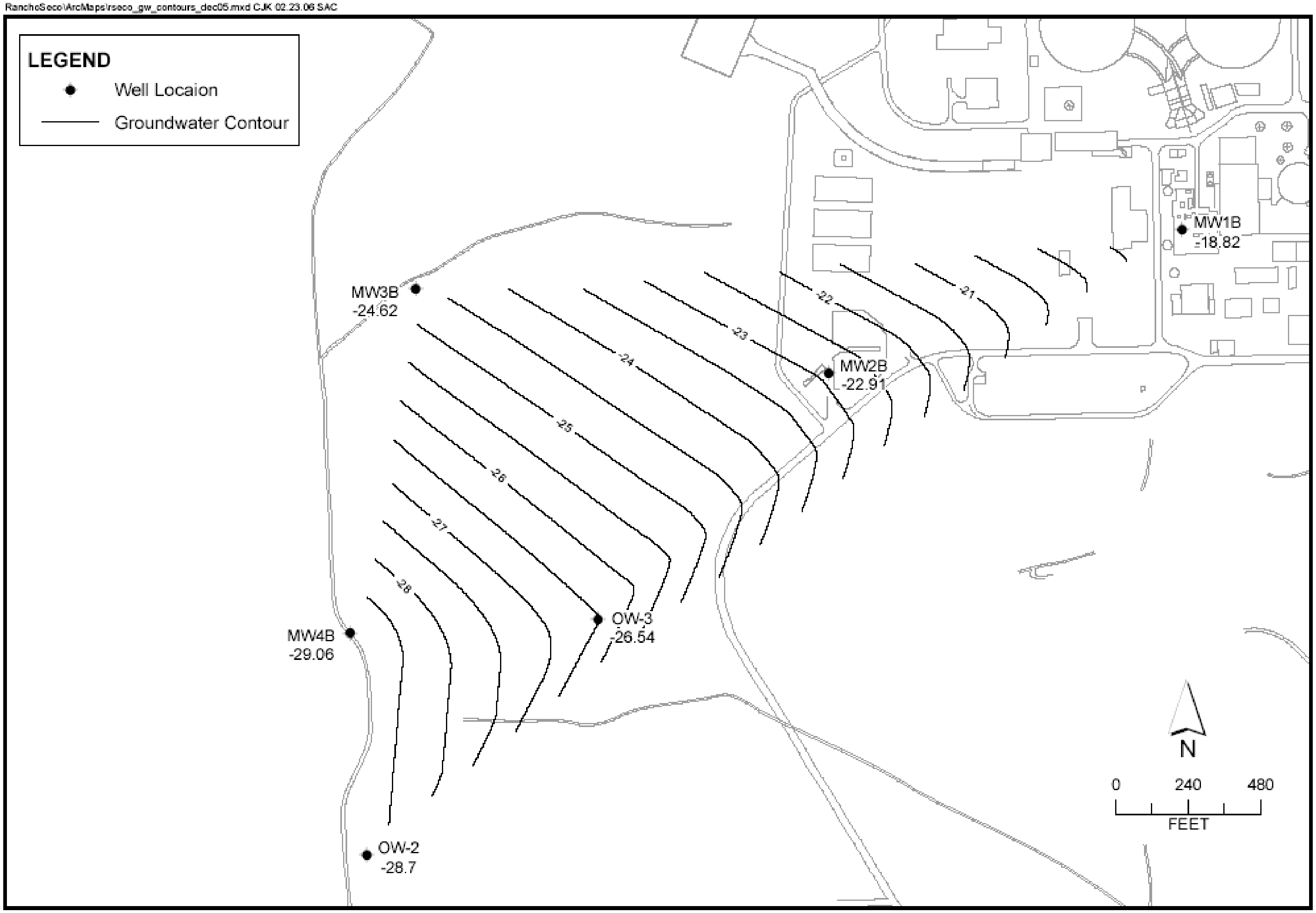


Figure 7
Potentiometric Surface Map for Groundwater Beneath Rancho Seco

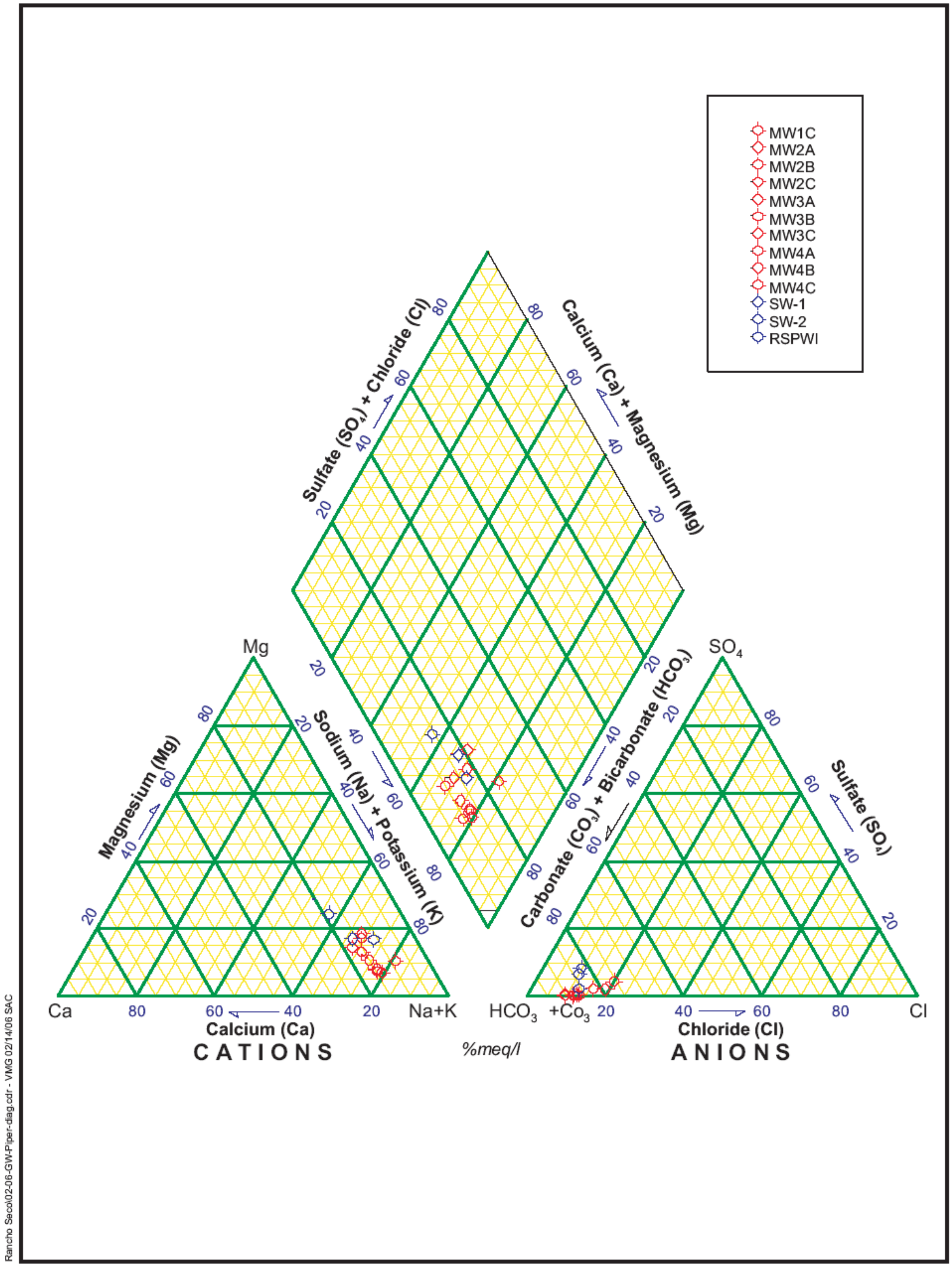


Figure 8
Piper Diagram for Groundwater Concentrations Beneath Rancho Seco

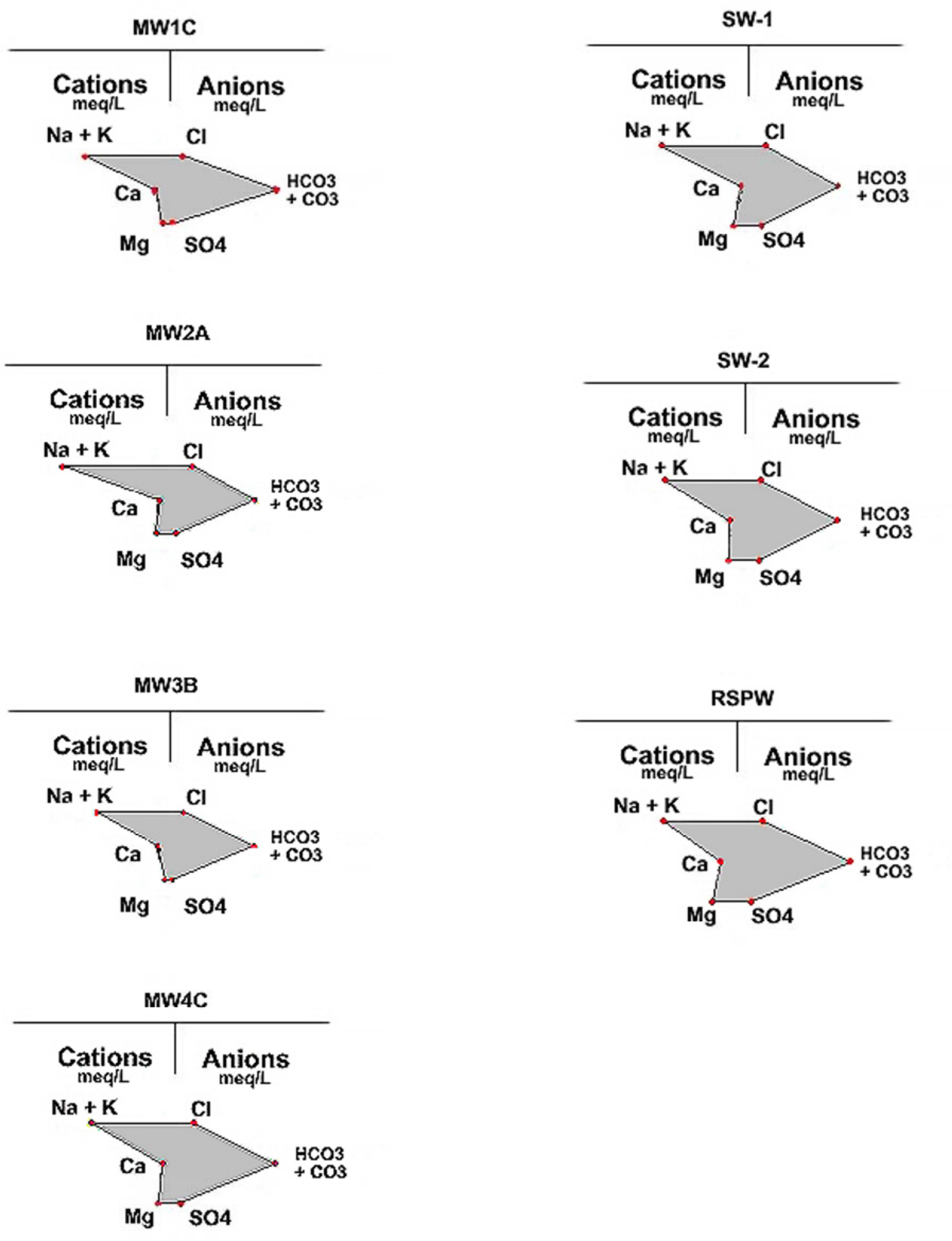


Figure 9
Stiff Diagrams of Cation and Anion Concentrations in Groundwater

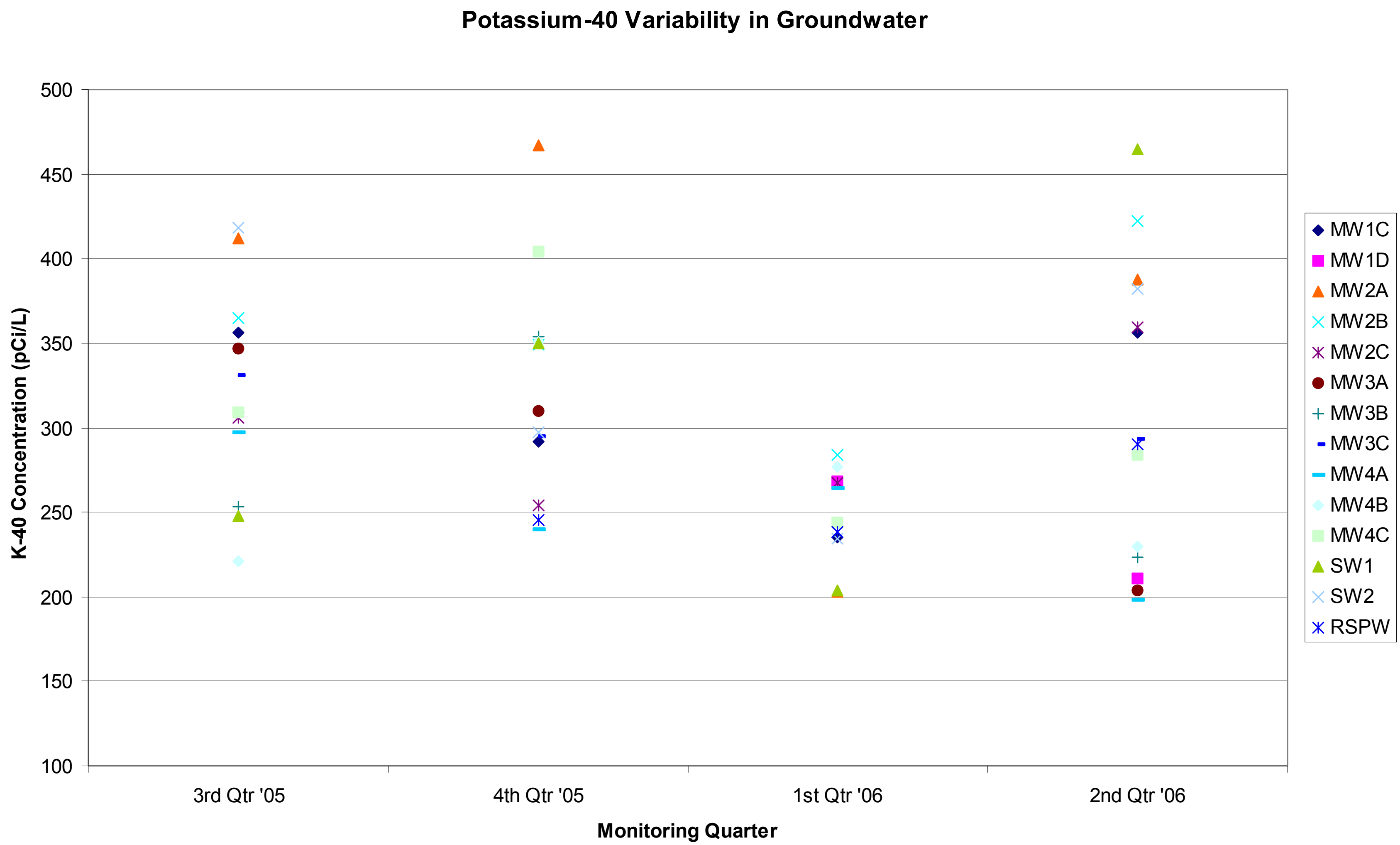

Potassium-40 Variability in Groundwater
K-40 Concentration (pCi/L)
500
450
400
350
300
250
200
150
100
3rd Qtr '05
4th Qtr '05
1st Qtr '06
2nd Qtr '06
Monitoring Quarter
MW1C
MW1D
MW2A
MW2B
MW2C
MW3A
MW3B
MW3C
MW4A
MW4B
MW4C
SW1
SW2
RSPW

Figure 10

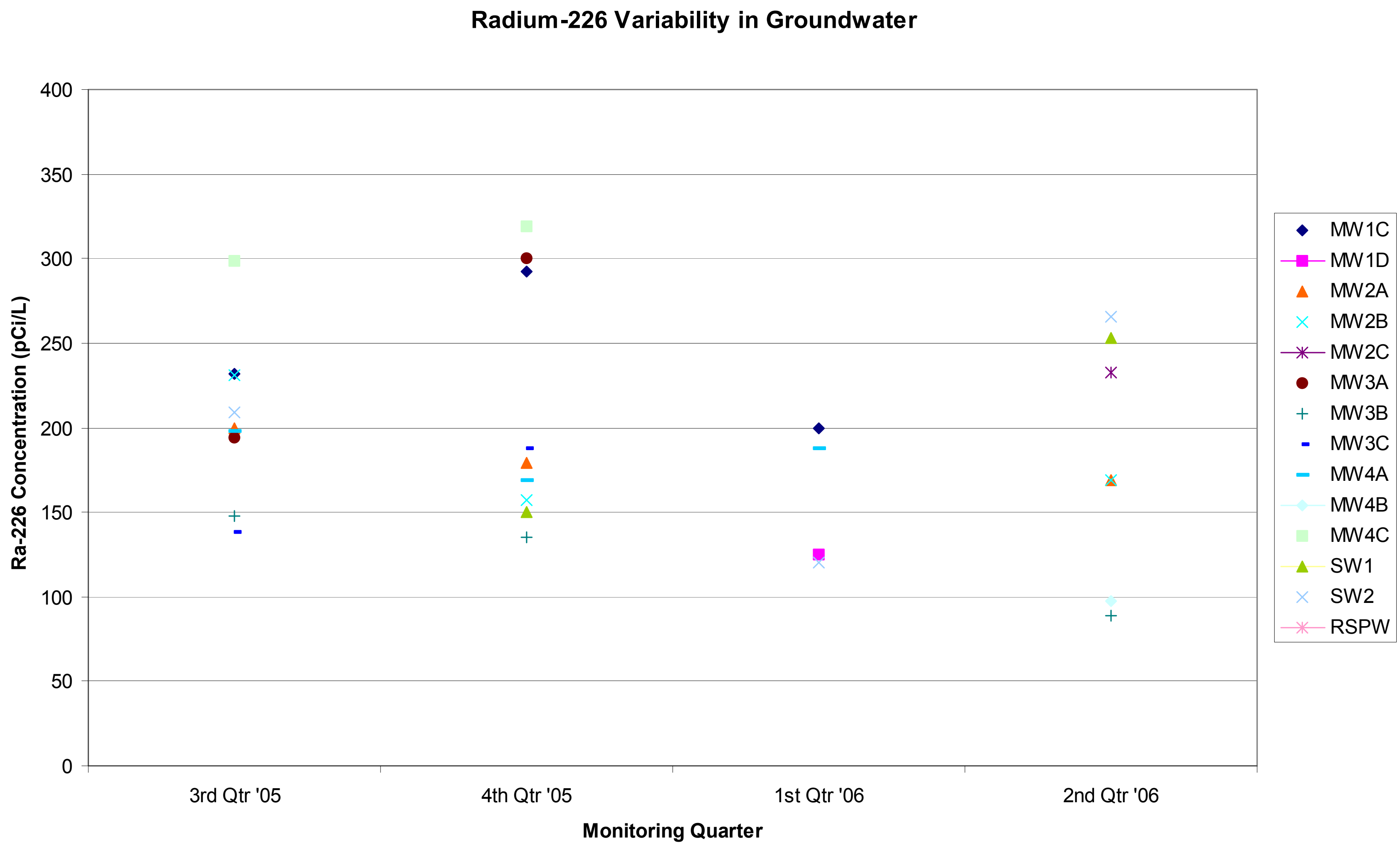

Radium-226 Variability in Groundwater
Ra-226 Concentration (pCi/L)
400
350
300
250
200
150
100
50
0
3rd Qtr '05
4th Qtr '05
1st Qtr '06
2nd Qtr '06
Monitoring Quarter
MW1C
MW1D
MW2A
MW2B
MW2C
MW3A
MW3B
MW3C
MW4A
MW4B
MW4C
SW1
SW2
RSPW

Figure 11

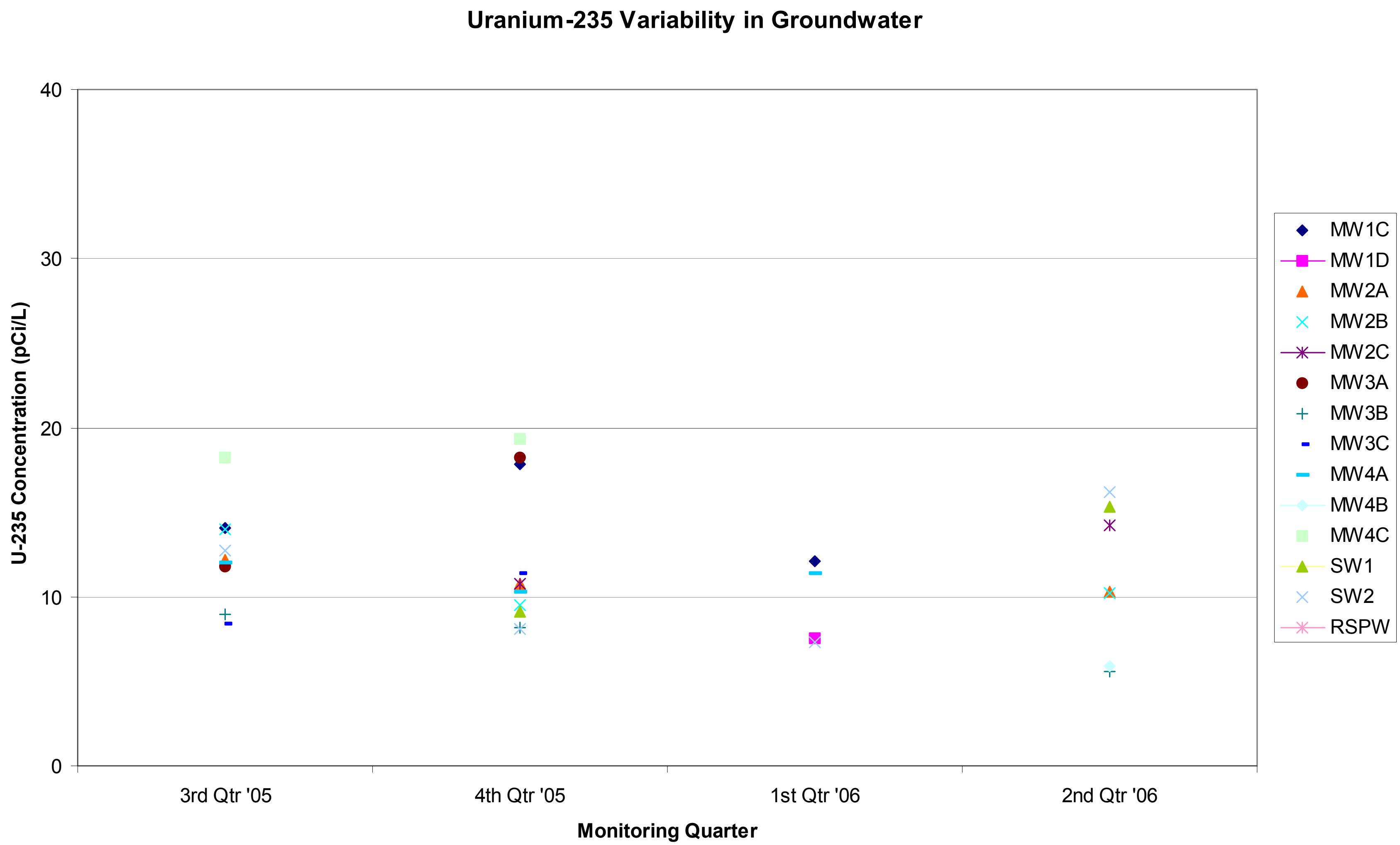

Uranium-235 Variability in Groundwater
U-235 Concentration (pCi/L)
40
30
20
10
0
3rd Qtr '05
4th Qtr '05
1st Qtr '06
2nd Qtr '06
Monitoring Quarter
MW1C
MW1D
MW2A
MW2B
MW2C
MW3A
MW3B
MW3C
MW4A
MW4B
MW4C
SW1
SW2
RSPW

Figure 12

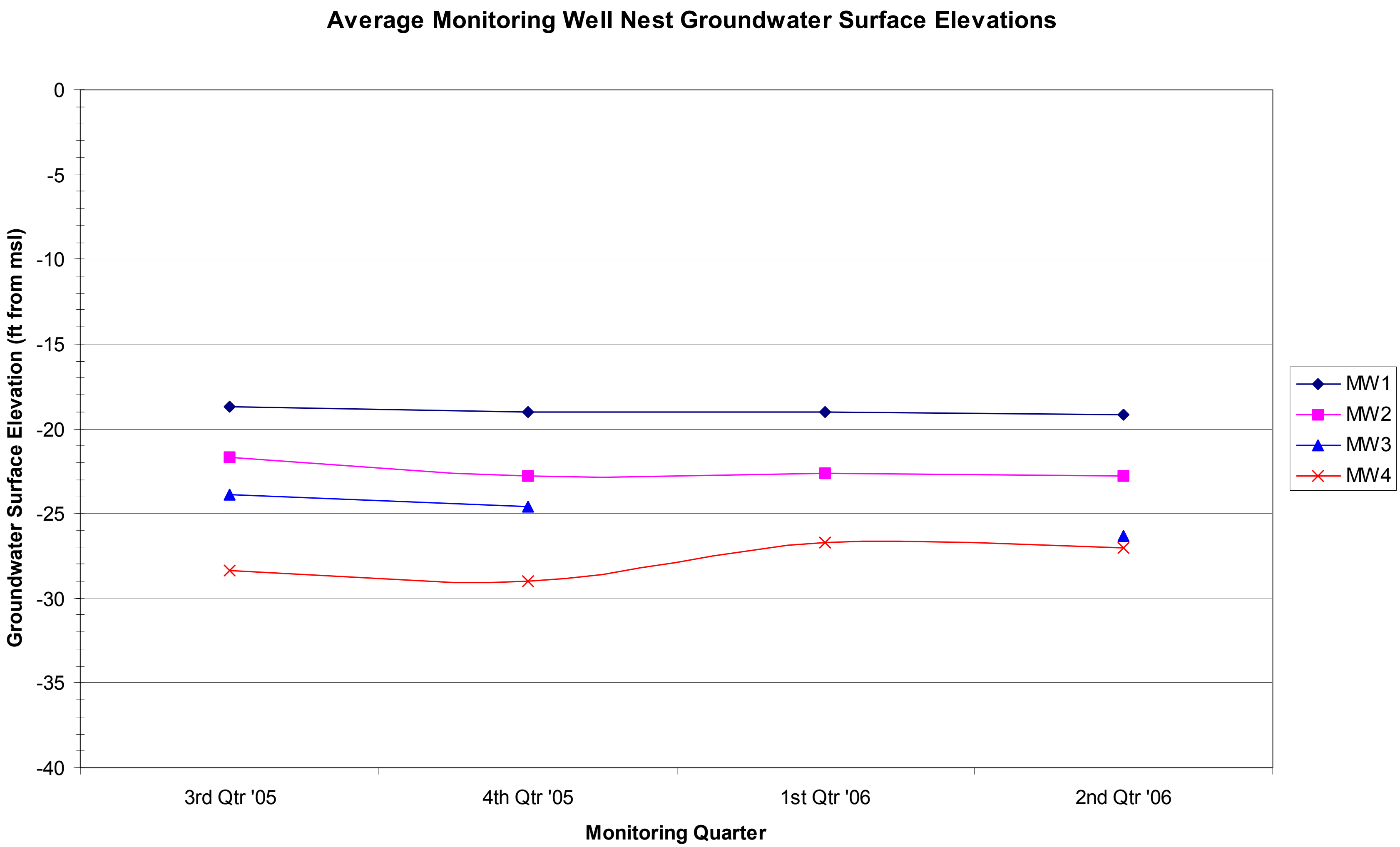

Average Monitoring Well Nest Groundwater Surface Elevations
Groundwater Surface Elevation (ft from msl)
0
-5
-10
-15
-20
-25
-30
-35
-40
3rd Qtr '05
4th Qtr '05
1st Qtr '06
2nd Qtr '06
Monitoring Quarter
MW1
MW2
MW3
MW4

Figure 13

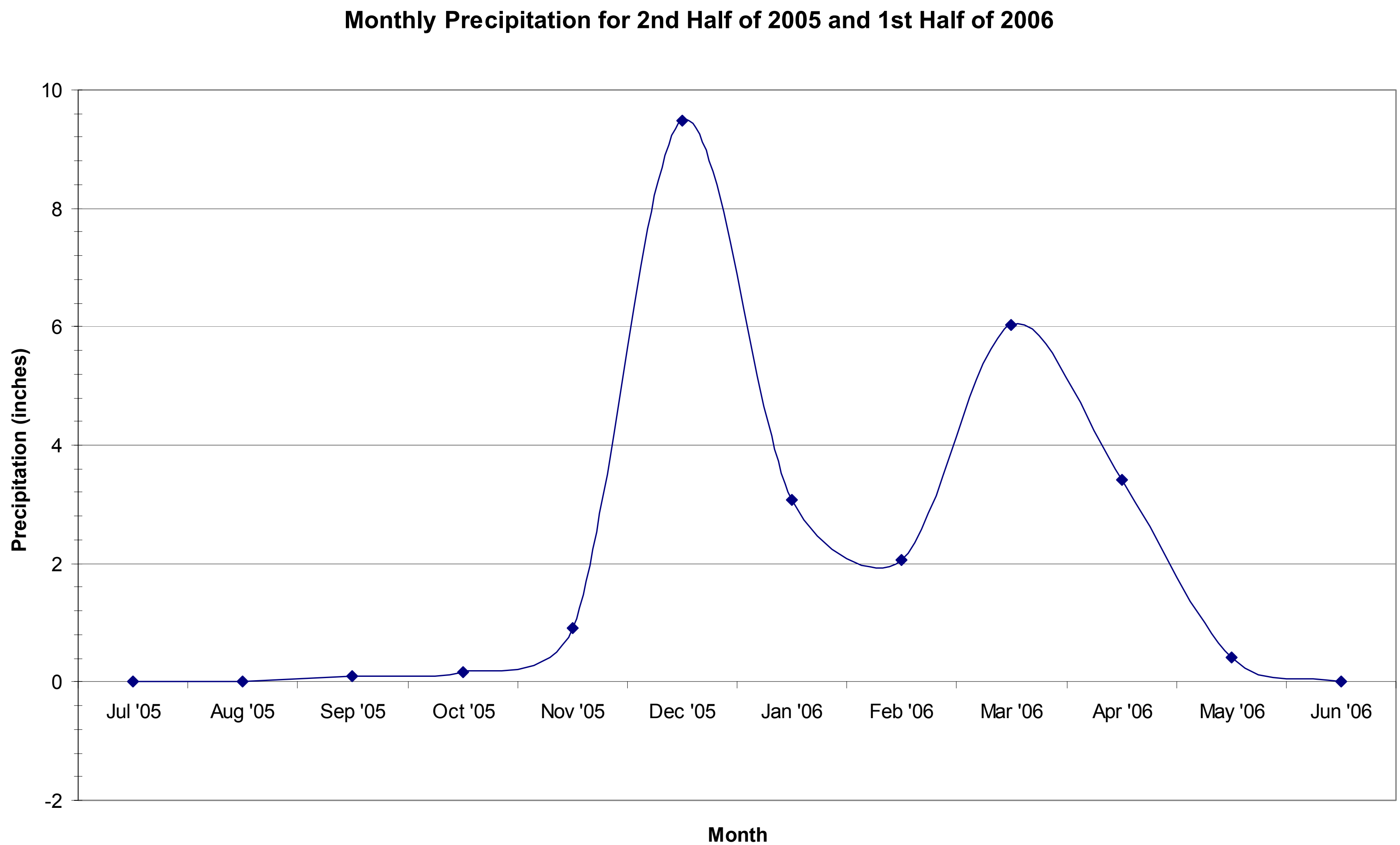

Monthly Precipitation for 2nd Half of 2005 and 1st Half of 2006
10
8
6
4
2
0
-2
Precipitation (inches)
Jul '05
Aug '05
Sep '05
Oct '05
Nov '05
Dec '05
Jan '06
Feb '06
Mar '06
Apr '06
May '06
Jun '06
Month

Figure 14

Figure 15

Monitoring Well Nest Locations