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Groundwater Monitoring
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E.0 GROUNDWATER MONITORING

Section E, including associated appendices, is intended to provide a complete reference on the site characteristics as required by IDAPA 58.01.05.012 [40 CFR 270.14], as well as data relevant to developing and implementing the Groundwater Monitoring requirements of IDAPA 58.01.05.008 [40 CFR Part 264.97] for the US Ecology Idaho, Inc.(USEI) facility.

E.0.a. General Background

The USEI Site B facility is a commercial hazardous waste treatment, storage, and disposal facility (TSDF) in southwestern Idaho, 10.5 miles west of the town of Grand View in Owyhee County (Figure E-1). The site was formerly a U.S. Air Force Titan Missile Complex constructed during the cold war in the early to mid-1960s. The Air Force constructed three identical bases, sites A, B, and C, in southern Idaho during this period. The Air Force site designations for these parcels have been retained even though the missile bases were deactivated in the late 1960s and the sites were sold for salvage. In 1972, Site B was purchased by Western Containment Corporation (WesCon), which used the underground missile silos, ancillary structures, and shallow unlined trenches and pits for disposal of hazardous wastes. In 1981, EnviroSource purchased the site and in 2001 USEI purchased the site and continued to operate the site as a Resource Conservation and Recovery Act (RCRA) Subtitle C TSDF.

E.0.b. Permit History

In 1981, ESII submitted a Part A application to the U.S. Environmental Protection Agency (EPA), providing the facility information required and indicating they intended to continue to operate the site and would therefore be applying for a Part B permit under Subtitle C of RCRA.

Between 1983 and December 1985, ESII conducted extensive site investigations and hydrogeologic characterization studies. Numerous borings and wells were installed and chemical and physical testing was conducted to describe the subsurface conditions and to develop an effective groundwater monitoring program for the site. The original Section E (Groundwater Monitoring) of the RCRA Part B permit application for the site was submitted in 1983. In February 1986, the agencies accepted the site characterization efforts and the last revision of the Site Characterization Report for Section E (Appendix E.11) of the application was submitted (CH2M HILL, February 1986). Between 1986 and 1988 there were several submittals and revisions to Section E.6 of the application that described in detail the proposed Groundwater Monitoring System for the site. On December 15, 1988, the EPA and the Idaho Department of Environmental Quality (IDEQ) of the Idaho Department of Health and Welfare granted a RCRA Part B permit for USEI Site B. Permit Renewal Applications were submitted in 1998 and 2003 respectively. USEI is currently operating under a RCRA Part B Permit issued November 12, 2004. The current Permit Renewal Application was submitted on May 1, 2014.

E.0.c. Additional Information Not Included in the 1986 Site Characterization Document

In support of the pending Part B permit, considerable work was completed from March 1986 to December 1987 on characterizing the vadose zone (unsaturated interval from land surface to the uppermost aquifer). This work culminated in computer simulations of potential waste migration through the vadose zone and simulated potential groundwater plumes. This analysis was used by the EPA and IDEQ to establish the location, spacing, and sampling frequency of monitoring wells included in the RCRA Part B operating permit, effective December 15, 1988.

The Detection Monitoring section of the RCRA Part B operating permit required significant modifications to the existing monitoring well network. In 1988, 1989, and 1990, 20 new monitoring wells were installed

to complete the Detection Monitoring System required by the December 15, 1988, permit. Many of the new wells were installed to replace existing wells that were either not strategically positioned or were not constructed to the required monitoring well standards.

In 1993, additional characterization performed to support a proposed modification to the configuration of Cell 14 resulted in the installation of seven additional wells. In 1999, USEI installed a test well south of the existing facility for hydrogeologic characterization in support of siting Cell 15. This well was subsequently abandoned in 2003. In 2000, ESII installed four (4) multi-port soil vapor wells on the west side of the site. Several soil vapor investigations have been conducted (Appendix E.10). At present, of the 54 wells in the Groundwater Monitoring Program, water chemistry and water level data are collected on a semiannual basis from 40 monitoring wells, and 14 wells are used solely for the purpose of semiannual static water level measurements.

E.0.d. Relationship to Previous Documents

All of the detailed site characterization information, well installation, well abandonment, water chemistry, and water level data collected since the February 1986 Site Characterization Report has been submitted to the regulatory agencies and/or is in the permanent Operating Record at USEI Site B. This section combines this information with the pertinent data contained in the February 1986 report to provide a consolidated and updated description of the physical and aqueous chemical characteristics of the site. The information and analyses provide the technical basis for the proposed Groundwater Monitoring Program for the permit renewal period. Although existing pertinent data are presented, in order to keep this Section E document to a manageable size, extensive references have been made to the previous documents and to information contained in the operating record, instead of including those supporting documents in the appendices.

E.0.e. Facility Description

The USEI Site B facility occupies approximately 328 acres in the northern half of Section 19, Township 4 South, Range 2 East, as referenced to the Boise Baseline and Meridian (Figure E-2). USEI property surrounds the Site B facility.

Figure E-3 provides a detailed topographic and facilities map of the site. Pertinent site facilities identified in Figure E-3 consist of various active and closed waste disposal trenches and cells, waste receiving and treatment facilities, and administrative offices. The surface expressions of the three missile silos are identified in Figure E-3. Each of these silo complexes consists of a main missile silo about 40 ft. in diameter and 160 ft. deep and three ancillary smaller silos connected by tunnels about 60 ft. below grade. The three silo complexes are joined by a tunnel that extends to the southeast to two large subsurface structures known as the powerhouse and control room, which housed the crew and the support equipment for the missile base. A tunnel also extends to the southeast from the powerhouse to two smaller silos that contained the radar and communications antenna. A detailed description of the current and past waste disposal areas is provided in Section B.

E.1 GROUNDWATER WAIVER

USEI Site B is underlain by two low-yielding, water-bearing zones that are referred to as the Upper and Lower Aquifers. Both water-bearing zones are comprised of thin, fine-grained sand beds within a predominantly silty clay matrix. The Lower Aquifer is present beneath the entire facility and yields less than 0.5 gallon per minute (gpm). The Upper Aquifer is only present across the northern two-thirds of the site. Well yields in the Upper Aquifer range from five (5) gpm to less than 0.5 gpm. A detailed description of the hydrogeology of USEI Site B is provided in Section E.3.

The southern 1/3 of USEI Site B is underlain by a thick, dry, stratified sand, silt and clay vadose zone overlying the Lower Aquifer. For Cell 14 and future disposal areas with similar hydrogeology, a groundwater waiver demonstration meeting the requirements of IDAPA 58.01.05.008 [40 CFR 264.90(b)] could be presented, effectively demonstrating no contaminant migration within the active, closure, and post-closure periods. However, a waiver demonstration for the northern two-thirds of the site, where unlined pre-RCRA Units overlie the Upper Aquifer, could not be satisfactorily presented. Rather than propose a groundwater waiver for only the southern portion of the site, USEI has elected not to pursue a groundwater monitoring waiver demonstration for Site B in this Document.

E.2 HISTORICAL GROUNDWATER DATA

This portion of Section E contains the “Interim Status Data” required by IDAPA 58.01.05.012 [40 CFR 270.14]. USEI Site B has been a permitted RCRA Part B facility since December 1988. Therefore, for the purposes of this Document, pre-Permit RCRA “Interim Status Data” is groundwater monitoring data collected prior to December 1988. This information is contained in USEI’s original Part B permit application submitted in 1983 and in subsequent revisions and submittals made during the permit review process. This information is incorporated in this Document by reference only, with the exception of pertinent common-ion and aquifer test data, which help to describe site characteristics.

For historical reference, it is important to note that some of the interim status data presented in the 1983 application and subsequent revisions may be potentially misleading because of inappropriate well construction on some wells. Several wells installed during the early stages of the characterization process bridged the confining bed separating the two minor water-bearing zones that were subsequently differentiated into the Upper and Lower Aquifers. This resulted in erroneous water levels and mixed water quality samples.

The report entitled “ESII Site B Site Characterization and Groundwater Monitoring Program” CH2M HILL (February 1986) was the last revision to the site characterization portions of Section E of the 1983 Part B permit application. This report provided characterization of both aquifers and identified those wells that spanned both water-bearing zones. Data from the invalid wells were not used in the characterization presentation and those wells have been plugged and abandoned. The data acquired from the remaining monitoring well system and new wells installed since 1986 are representative of the two-aquifer system.

This portion of Section E, while still entitled Historical Groundwater Data, briefly describes the groundwater data collected from April 1989 through October 2013 in accordance with the Groundwater Monitoring Program as described in Section IX of USEI’s current Part B operating permit.

The USEI monitoring well network consists of 55 wells that are properly located for effective monitoring and data collection as described in Section E.6.a. The wells were designed, constructed, documented and maintained as described in Section E.7.b. The Groundwater Monitoring Program under which the data were collected is described in Section E.6.b, which specifies overall responsibilities that USEI has in collecting the data. Section E.6.d specifies the list of detection monitoring parameters, indicator parameters, and field sampling parameters. Section E.6.d also lists the sampling and analysis requirements, including the sampling, preservation, and handling procedures, chain-of-custody control, and quality assurance/quality control procedures. Sections E.7 and E.8 provide the data evaluation requirements, including the statistical monitoring criteria for data evaluation and required responses to the detection of statistically significant levels of the detection monitoring parameters in the groundwater at Site B.

The data presented in this section were collected and accepted by IDEQ under the auspices of the current RCRA Part B operating permit pursuant to IDAPA 58.01.05.008 [40 CFR 264.97 and 264.98]. Therefore, the information requirements of IDAPA 58.01.05.012 [40 CFR 270.14] regarding the presentation of these data under the heading of “Interim Status Data” are assumed to be satisfied. With

this assumption, the section will present the water quality data collected from the USEI Site B monitoring wells since the Part B RCRA Permit was issued. This data base represents nearly 13 years of semiannual water levels, field water chemistry data, and analysis for 28 specific volatile organic compounds, and from previous (pre-1998) permit sampling and analysis requirements, total organic carbon, and total organic halides. These data comprise the basis for much of the site characterization and for the groundwater monitoring programs for this Document.

The 1986 revision to Section E of the initial Part B permit application (CH2M HILL, February 1986) provides significant additional data on the geology, hydrogeology, and general water chemistry of Site B. These data were collected from valid wells for the two-aquifer system and from several of the old wells that were incorporated directly into the current Groundwater Monitoring System. Pertinent data contained in the February 1986 report and prior permit issuance are also included in this Document. Since these data help describe the general site characteristics, including geologic properties and general (noncontaminant-related) water chemistry, they are not considered “Interim Status” data.

The hydrogeologic and general water chemistry data collected from the monitoring wells during this period are discussed in Section E.3. Section E.5 presents the specific monitoring data collected pursuant to IDAPA 58.01.05.008 [40 CFR 264.97 and 264.98]. Sections E.6, E.7, and E.8 address the proposed groundwater monitoring systems and programs based on the current monitoring data.

E.2.a. Description of Wells

Since the 1988 permit was issued, USEI collected water quality data from the permitted well network as required in the permit. New monitoring wells installed in accordance with the requirement of the Part B permit, and in response to subsequent data needs and supplemental site characterization efforts, have been incorporated into the Groundwater Monitoring System. The present groundwater monitoring network at USEI Site B consists of 54 wells that are further differentiated as follows: 41 monitoring wells (24 in the Upper Aquifer and 17 in the Lower Aquifer) and 14 piezometers (eight (8) in the Upper Aquifer and six (6) in the Lower Aquifer). The locations of the monitoring wells and piezometers are shown in Figure E-4. Well numbers beginning with the letter “U” are completed in the Upper Aquifer and those beginning with the letter “L” are completed in the Lower Aquifer. Section E.3.b describes the existing monitoring well network and provides details on the Upper or Lower Aquifer systems at Site B.

The piezometers (UP and LP designations) are used for water level measurement, although periodically water samples may be collected from them for limited analyses of pertinent constituents, depending on the purpose of the special sampling. Water levels are measured in piezometers on a semiannual basis in the Spring and Fall.

In late 1999, a test boring (D-40) and adjacent lower aquifer piezometer LP-40 were installed south of Cell 14 for the purposes of site characterization data on the geology and lower aquifer groundwater in support of the permit modification to allow construction of new Cell 15. LP-40 was never formally included in USEI’s site B permit as it was installed offsite (prior to siting approval which expanded the site to include this area). In March 2003, well LP-40 was abandoned as it was within the construction footprint of Cell 15. Aside from periodic water levels collected from Spring 2000 through Fall 2002, and an initial water quality sample for common ion data, there is no additional data from this well to incorporate into this application.

E.2.b. Description of Sampling/Analysis Procedures

Sampling procedures and analytical requirements for monitoring from 1989 to 2013 are outlined in USEI’s current RCRA Part B operating permit. Section E.3.b. provides additional details on the sampling methods used. Following the completion of the semiannual sampling events and receipt of the analytical results, USEI submits a copy of the analytical results to IDEQ in accordance with the Sections E.6, E.7,

and E.8 of this document. The field sampling logs and laboratory results are maintained as part of the operating record at Site B and are not included in this Document.

E.2.c. Monitoring Data

E.2.c.(1) Summary of Groundwater Monitoring Activities

Table E-1 provides a summary of the water quality sampling events that have been conducted at each monitoring well at Site B. The table presents data beginning with April 1989, the first semiannual sampling event after the current Part B operating permit was issued, and includes all annual, semiannual, confirmation, and Appendix IX samples collected under the Detection Monitoring and Compliance Monitoring Programs through October 2013. As new wells were installed and completed, they were included in the monitoring program in accordance with Part B permit requirements. Installation dates of wells currently in the Groundwater Monitoring System range from October 1984 to June 2012. Consequently, as shown in Table E-1, not all wells have data for the entire time period from April 1989 to October 2013.

Table E-2 identifies the organic and inorganic analytes and field parameters collected from the network of detection and compliance groundwater monitoring wells at Site B. To address site water quality characteristics requirements in this Document, specific sampling results from April (Spring) 1989 to October (Fall) 2013 data are used. The results of the specific VOC, and from pre-1999 data total organic halides (TOX), and total organic carbon (TOC) analytical data are summarized in this section. Section E.3, which describes the hydrogeology of Site B, provides a more rigorous examination of the water levels, and general water chemistry parameters (temperature, pH, and specific conductance) collected during the current Detection and Compliance Monitoring Programs at Site B. Section E.5 provides additional discussion and analysis of the VOCs and elevated TOX levels detected in the Upper Aquifer at Site B.

E.2.c.(2) VOC Results

Between April 1989 and October 2002, 15 of the 27 VOCs for which samples were analyzed have been detected in six monitoring wells at Site B. All of the impacted wells were in the Upper Aquifer in the northwest portion of the site. The occurrence of VOCs in groundwater at Site B is discussed in detail in Sections E.5 and E.7.

E.2.c.(3) TOX Results

TOX data was collected from most wells through Spring 1999. TOX was detected in all Site B monitoring wells except L-32. TOX concentration ranged from 3.0 µg/L at U-3 (April 1990) to 2,953.3 µg/L at L-37 (April 1989). Routine sampling and analysis for TOX was discontinued in 1998. TOC and TOX was replaced with superior measurement techniques that identify specific compounds per EPA approved methods.

E.2.c.(4) TOC Results

TOC was detected in all monitoring wells at Site B. TOC concentrations range from 0.25 mg/L at U-5 (April 1991 and April 1992) to 15.5 mg/L at L-36 (September 1996). Sampling and analysis for TOC was discontinued in 1998. TOC was replaced with superior analysis that identifies specific compounds per EPA approved methods.

E.2.d. Statistical Methods

For monitoring events prior to 1998 the combined Shewhart-CUSUM control chart statistical methodology (EPA, April 1989) was used to perform the analysis of the TOC and TOX data.

The use of control charts provides a means to monitor a constituent within a single well for trends, drifts, or abrupt changes in concentration level. To construct the control charts, the upper and lower control limits for TOX and TOC at each well were established based upon up to the first three (3)years of data collected from that specific well. Subsequent samples were then plotted and compared to the control limits to determine if a significant change in groundwater chemistry had occurred.

A discussion of the results of the control charts is provided in Section E.5. The use of control charts to monitor TOX and TOC levels in individual wells as required by the past permit is discussed in Section E.5.

E.2.e. Groundwater Assessment Plan

Computer modeling (CH2M HILL, April 1993) was conducted to simulate the fate and transport of selected organic constituents (carbon tetrachloride, chloroform, and chloromethane) in the Upper Aquifer at Site B. The analysis was conducted in response to the October 1991 detection of these compounds in well U-21 at concentrations above the levels allowed in USEI's Part B permit. The source of the detected volatile organic compounds (VOCs) was assumed to be vapor transfer to the groundwater in the vicinity of Silo 2.

The analytical model MYGRT (Migration of Organic and Inorganic Chemicals in Groundwater) [Tetra Tech, Inc., 1989]), was used to evaluate the fate and transport of the compounds from the source area to the downgradient boundary. Although Silo 2 was the only pre-RCRA Unit where these compounds were detected in 1993, the modeling effort used Silo 3 as the source. Silo 3 was chosen because groundwater velocities are faster from Silo 3 to the boundary than they are from Silo 2 to Silo 3 and Silo 3 is closer to the downgradient boundary of Site B. This combination of higher velocity and shorter migration pathway added additional conservatism to the analysis.

The objective of the model was to calculate the concentration of each compound that would need to be detected onsite (at U-21) to trigger the implementation of a corrective action plan. To determine groundwater concentration levels at U-21 that would constitute a potential health concern at the facility boundary, a risk assessment was conducted for each VOC. The risk assessment identified the concentration of each VOC that would produce a 10^{-4} and 10^{-6} cancer risk. The risk-based numbers were independent of the MYGRT model results and represented typical risk assessment scenarios of lifetime cancer risk using both an industrial and residential setting. Using the residential 10^{-6} cancer risk scenario at the site boundary as the maximum allowable concentration, attenuation factors developed from the MYGRT model were used to "back calculate" what the maximum permissible concentration at Silo 3 should be to trigger implementation of any corrective action.

The fate and transport analysis, MYGRT model, and risk assessment conducted for USEI Site B indicated that, based on the highest VOC concentration detected and the lowest reasonable attenuation factor, groundwater leaving the site would not exceed the 10^{-6} residential cancer risk level. Furthermore, the modeled VOC concentrations at U-21 that would cause the VOC concentrations at the facility boundary to exceed the risk-based boundary concentrations were several thousand times the maximum concentration of each respective VOC detected at well U-21. Based on this study, an alternate concentration limit (ACL) was established for U-21 and incorporated into USEI's RCRA Part B permit in April 1993.

In April 1999 a site wide ACL demonstration report was prepared to address the detection of VOC's in several wells at Site B including well U-1, an upgradient background Upper Aquifer well (CH2M Hill, 1999). The ACL demonstrated that the low part per billion levels of VOC's being detected in this well and others in the northwestern portion of the site were from vapor transport and not indicative of a liquid

release. Consistent with the fate and transport modeling completed in the 1993 ACL, the April 1999 ACL assigned each of the monitoring wells to one of three different categories for purposes of allowable concentrations if VOC's were detected. The categories of wells are based on risk and groundwater flow paths and include upgradient background wells, Level 1 compliance wells and Level 2 compliance wells. Level 1 wells included those wells interior to the site and have higher allowable concentrations than do the Level 2 wells which are the downgradient and northern facility boundary wells. Appendix E-14 provides the ACL which describes the well categories.

In response to DEQ concerns regarding the conclusions reached in the 1993 ACL and 1999 ACL that a soil vapor transport mechanism was responsible for the detection of VOC's, a soil vapor work plan was completed in 1999 and four (4) multi-port soil vapor wells were installed and tested by CH2M HILL in early 2000. The results of CH2M HILL's soil vapor investigation were subsequently submitted by Brown and Caldwell, (Brown and Caldwell, 2001). This work confirmed the conclusion that soil vapor transfer to the groundwater was responsible for the detections of VOCs in the impacted Upper Aquifer wells. In late 2002, USEI completed a follow-up soil vapor study in response to continued DEQ concerns regarding the soil vapor mechanism. This study collected additional soil vapor samples from the vapor wells and head space on existing monitoring wells. The results were reported in February 2003 (Brown and Caldwell, 2003) and the same conclusion was reached. The confirmation of the transfer mechanism supports the concept and application of the 1999 ACL which acknowledges the presence of the vapors and sets appropriate concentration limits for interior wells while establishing much lower concentration limits for the perimeter downgradient wells.

E.3 GENERAL HYDROGEOLOGIC INFORMATION

Section E.3, including associated appendices, presents the regional setting, site characterization methods, and site hydrogeologic characteristics for USEI Site B. This information has been assembled pursuant to IDAPA 58.01.05.012 [40 CFR 270.14(c)].

E.3.a. Regional Setting

E.3.a.(1) Introduction

The following is a summary of the Physiographic Setting and Regional Hydrogeology of USEI Site B presented in the 1986 Site Characterization Report (CH2M HILL, February 1986). This information has been assembled pursuant to IDAPA 58.01.05.012 [40 CFR 270.14(c)(2)].

E.3.a.(2) Physiography

USEI Site B is situated in the western portion of a 20,000-square-mile physiographic unit known as the Snake River Plain. The plain extends from the vicinity of Ashton, Idaho, to north of Ontario, Oregon. The Snake River Plain is approximately 350 miles in length and varies in width from 25 to 75 miles. USEI Site B lies within the lowland area of the Owyhee subunit of the Snake River Plain at an elevation of between 2,525 ft. and 2,635 ft.

Figure E-5 shows the location of Site B relative to major surface water drainages in the area. The Snake River, which flows to the northwest, lies approximately three (3)miles east of the site and is the most prominent water resource of the area. The site is approximately 250 ft. higher than the Snake River flood plain, which locally extends outward up to one mile along either side of the river. Castle Creek, a perennial stream that flows northward to the Snake River, lies approximately one mile west of Site B. Cloudburst Wash, a small ephemeral (intermittent) stream, lies about two (2) miles to the east of Site B and also empties into the Snake River. The facility straddles the Castle Creek and Cloudburst Wash

drainage basins. However, since the facility contains all run-off from active areas, it does not contribute run-off to either drainage.
Figure E-2 depicts the topographic setting of the Site B area. The area is characterized by badlands-type topography and exhibits varied relief. Major topographic features of the area include several prominent buttes, remnant basaltic cinder cones, and canyons cut by the Snake River.

Vegetation in the area is typical of a semiarid environment. The lowland area within which the site is located is inhabited by low brush and grasses, including sagebrush, rabbit brush, wheat grass, and cheat grass. Land use in the area consists of undeveloped rangeland and some limited irrigated agriculture. Irrigation water in the area is derived from the Snake River, Castle Creek, and from the deep, regionally extensive, geothermal groundwater system. The area is sparsely populated with isolated farms and ranches being the dominant habitation.

E.3.a.(3) Climate

The semiarid western portion of the Snake River Plain has one of the highest annual average temperatures in the state. For a 64-year period (1933 to 1996) at the Grand View U.S. Weather Bureau Station, located ten (10) miles east of the site, the average temperature was 52.2 degrees Fahrenheit (EarthInfo, Inc., 1997). The range in temperature during the winter months of December through February was -1 degree Fahrenheit to 58 degrees Fahrenheit. From March to November, the temperatures ranged from 12 degrees Fahrenheit to 101 degrees Fahrenheit.

The site is influenced by prevailing westerly maritime winds via the Columbia River and Snake River valleys; consequently, most precipitation falls during the winter. Over the same 64-year period at the Grand View U.S. Weather Bureau Station, the average annual total precipitation was 7.1 inches. The precipitation in this area is evenly distributed from November through June, with only a minor amount falling during the summer, usually associated with isolated thunderstorms. The mean annual pan evaporation for the Grand View area is approximately 53 inches (U.S. Weather Bureau, 1959).

E.3.a.(4) Regional Well Inventory

A records search of the well log files at the Idaho Department of Water Resources (IDWR) in spring 2014 turned up 54 logs for wells installed within a 3-mile radius of Section 19. There were 23 new wells drilled in this search area between the 2003 and current submittals of this permit application document. Ten (10) of these wells were monitoring wells associated with operations at the US Ecology facility.

Figure E-6 shows the approximate location of the wells based on the location information included on the log. Included in Figure E-6 is a table showing the well depth, date drilled, and stated use. Eighteen (18) of the well logs were for USEI monitoring wells and there were two duplicate logs filed for the same well (well No. 13). The plugged and abandoned water well exploratory well drilled west of Site B by USEI to a depth of 800 ft. is shown as well No. 18 and the plugged and abandoned deep artesian well drilled by the U.S. Air Force in 1958 is shown as well No. 14. Appendix E.1 provides copies of the well logs as filed with IDWR.

As shown in Figure E-6, there are five existing wells in the immediate vicinity of Site B that are of interest because they may be hydraulically downgradient of the facility. Three (3) of these wells, Nos. 12, 21, and 22, are domestic wells that probably cannot be impacted by shallow groundwater at Site B because they are deep artesian wells (greater than 600 ft. deep) and either flow at the surface or have very shallow static water levels (less than 12 ft. bgs). Well No. 23, was drilled for stock watering and draws water from sands and gravels with a reported yield of over 50 gallons per minute. The location provided on the Well Drillers Report places this well about 1.5 miles west of the Snake River (one mile east of Site B) in an area where saturated gravel deposits are not expected. However, in a telephone interview with the owner of the well, the actual location of the well is approximately ½ mile west of the Snake River and 50 ft. northwest of the Grand View Irrigation Canal. This places the well approximately 2.0 miles east of Site B

in the NW ¼ NE ¼ of Section 21 as shown in Figure E-6, not NW ¼ NE ¼ of Section 20 as stated on the Well Driller's Report. Based on well No. 23's proximity to the Snake River and the irrigation canal, and the lithology provided in the Well Drillers Report, this well apparently draws water from saturated gravels that are recharged by the Snake River and possibly the canal. Thus, well No. 23 will not likely be impacted by shallow groundwater at Site B. Well No. 50 is a 450 foot deep well located in the NE ¼ SE ¼ of Section 18. The well log indicates that this will is for domestic use and stock watering. The well is not likely to be impacted by shallow groundwater at USEI due to its depth.

E.3.a.(5) Regional Geology

Several investigators have been active in the delineation of the geology of the area at the regional scale. Malde and Powers (1962), Littleton and Crosthwaite (1957), Anderson (1965), and Ralston and Chapman (1969) have all contributed to establishing the geology of southwestern Idaho, including the general area of Site B. The information from these researchers is summarized and synthesized in this section to provide an overview of the geologic setting. The intent of this section is not to provide a definitive and detailed examination of the geology of the area, but only to place the site in the regional geologic framework as a basis for the detailed site geology and hydrogeology presented in Section E.3.c.

E.3.a.(5)(a) Stratigraphy

The regional stratigraphy of the area is dominated by the Idaho Group of Miocene to Pleistocene Age. This depositional sequence consists of up to 5,000 ft. of sedimentary and interspersed basaltic lava deposits that accumulated in the Snake River Plain over a basement of thick, older silicic volcanic rocks, primarily rhyolites.

The sedimentary deposits of the Idaho Group were laid down under three distinct episodes of lava damming (and subsequent dam breaking) of the ancestral Snake River. These episodes resulted in the formation of large lakes across the region. Fine-grained (silt and clay) lacustrine (lake bed) deposits are frequently intertongued with coarser-grained (silt and sand) of fluvial (river) and flood plain deposits throughout the area. These discontinuous and interbedded sand, silt, and clay beds form complex stratigraphic relationships on a regional scale. As a general rule, the deposits are unconsolidated except for some minor sandstone and freshwater limestone and localized, discontinuous, basaltic lava beds. Generally, however, the lacustrine deposits predominate and form the most contiguous sedimentary beds across the Snake River Plain and the Site B area. The lacustrine and fluvial sediments of the Glenns Ferry Formation of the Idaho Group are the primary strata of concern at Site B.

The several-hundred-foot-thick Snake River Basalt forms a cap rock over the Idaho Group sediments throughout much of the area and is the youngest formation in the regional sequence. Locally, the Snake River has eroded through the Snake River Basalt and into the underlying Idaho Group sediments. The Idaho Group sediments north of the Snake River, north of Site B, are capped by the resistant Snake River Basalt that forms steep cliffs adjacent to the river. The Idaho Group sediments south of the river (and within the vicinity of Site B) generally lack the protective basalt cap and have been eroded, forming the badlands topography characteristic of the area.

E.3.a.(5)(b) Structure

The Snake River Plain appears to be a downdrop fault-block basin, or graben, bounded by normal faults to the northeast and the southwest. Subsidence in the center of the basin was greatest and, consequently, the Idaho Group sediments are thickest near the center. The regional dips (angle from horizontal that the strata slopes) of the Idaho Group sediments range from near horizontal near the center of the basin to a maximum of about ten (10) degrees toward the margins of the basin. In the vicinity of Site B, regional dips of 2 to 4 degrees have been reported, with strike directions (perpendicular to direction of dip) approximately north 70 degrees west.

As a result of the structural attitude (dip) of the Idaho Group strata, older units tend to be exposed at a considerable distance south of the Snake River, with younger units exposed progressively nearer the river. Faults are apparent throughout the region because of differential settlement of sedimentary beds and movements along the principal regional faults that border the Snake River Plain. Minor faults locally cut older units of the Idaho Group; the younger units, however, are generally unaffected since they were deposited after the faulting occurred. The faults typically parallel the plain; faulting transverse to the plain is not common.

E.3.a.(6) Local Geology

This section focuses on the characteristics of the Idaho Group sediments present in the vicinity of Site B. This information is presented as background and support for the detailed site-scale findings and observations that are discussed in Section E.3.c. of this report.

E.3.a.(6)(a) Local Stratigraphy

In ascending order (deepest and oldest first), the localized formations are the Poison Creek (600+ feet thick); the Banbury Basalt (200+ feet thick); the Chalk Hills (200+ feet thick); the Glenns Ferry (1,500+ feet thick); and the Bruneau (0 to 100+ feet thick). A detailed stratigraphic column prepared from the driller's log for the artesian well drilled in 1958 at Site B illustrates the stratigraphic sequence at Site B.

The Chalk Hills and Poison Creek Formations represent two individual lacustrine periods affecting the central and western portions, respectively, of the Snake River Plain. In some reports, particularly in many of the older geologic reports concerning the area and on numerous deep-drilling logs, the Poison Creek Formation is shown as occurring stratigraphically above the Banbury Basalt. This is due to lithologic similarities between the Chalk Hills and Poison Creek Formations and the volcanism responsible for the deposition of Banbury Basalt into the lacustrine environments present.

The Glenns Ferry and Bruneau Formations are of prime interest to the site; the Glenns Ferry is the unit where groundwater is first encountered and the Bruneau forms the uppermost geologic unit beneath Site B. Together, these two units form a composite thickness of about 1,600 ft.. The deeper Banbury Basalt and Poison Creek Formations are of secondary importance to site-scale hydrogeology only because of their depth. However, these formations provide a regional source of deep-flowing artesian groundwater, generally obtained from depths in excess of 2,000 ft. to 3,000 ft. beneath Site B. The artesian aquifer discussion is provided in Section E.3.a.(7) below. Because of the importance of the Bruneau and Glenns Ferry Formations to the Site B characterization, these units are discussed in detail below.

E.3.a.(6)(b) Glenns Ferry Formation

The Glenns Ferry Formation is of interest since the uppermost zone of saturation beneath Site B exists within the upper portions of this formation. Although the Glenns Ferry Formation is approximately 1,500 ft. thick in the site area, the following discussion focuses on roughly the upper 800 ft. The Glenns Ferry Formation was deposited in the area under three ancestral depositional environments: lacustrine, fluvial, and flood plain. The three stratigraphic facies, each representing a different energy of deposition that is reflected in the typical grain size of the sediments, differ from one another in lithologic composition and areal persistence and tend to grade vertically from one facies to the next. The overall sedimentary pattern in the upper few hundred feet of the Glenns Ferry Formation is of upward coarsening, reflecting the climate and drainage pattern changes that ultimately led to the complete disappearance of the Glenns Ferry lake.

For discussion purposes, the Glenns Ferry Formation has been divided into two units. The lower unit of the Glenns Ferry Formation consists of a lower lacustrine facies that upwardly becomes increasingly interbedded with fine-grained fluvial sands. The upper unit of the Glenns Ferry Formation consists of

predominantly fluvial sands grading vertically into flood plain facies. The lacustrine facies is the most extensive and areally persistent sedimentary body in the Glenns Ferry Formation. Because of the structural dip of the beds in the Snake River Plain, all three facies are exposed at the land surface within the general area.

The extensive lacustrine facies consists of a thick-bedded, silty clay to clayey silt that grades with depth into a massive clay. Within the lacustrine facies are discrete intervals of thin lenses of very fine, tuffaceous sand interbedded with thicker, clayey, silt beds. These intervals represent periods of unstable lake margins. As water levels fluctuated, lake margin and fluvial sands were deposited farther into the lake. When the lake levels rose again, the sand lenses were covered with additional fine-grained lacustrine sediments. Where these sand zones are saturated, they represent the water-bearing portions of the lacustrine facies of the Glenns Ferry Formation. The water-bearing zones being monitored at Site B consist of two groups of these thin sand beds sand beds interbedded in the lacustrine sediments. At some exposures, the thick-bedded silt unit is overlain by several feet of very fine sand, alternately interbedded with additional silt. In many exposures, the fine sands are cross-bedded and show the presence of ripple marks. The fine sands generally denote the regional top of the lacustrine facies.

A less extensive fluvial facies overlies the lacustrine deposits, and generally consists of a fine- to medium-grained sand reaching a thickness of about 60 ft. Frequently, a 1” thick, tuffaceous, fine-grained sandstone is found at the top of the fluvial sand. Some cross-bedding is evident in the fluvial facies and, on a local scale, the sand unit intertongues laterally with the lacustrine facies.

The flood plain facies, where present, overlies the fluvial facies and denotes the top of the Glenns Ferry Formation; it consists of an interbedded sequence of clay, silt, and sand. sand beds. Individual beds vary in thickness from about two (2) to four ft. (4’) in the general area and laterally persist for several hundred feet. The flood plain sediments are areally discontinuous, however, and range from being absent to about 200 ft. thick. Plant fragments and other detritus are evident in the flood plain facies. Texturally, the flood plain deposits appear banded (that is, possessing thin, laminae-like alternating beds) compared to the more homogeneous underlying fluvial and overlying Bruneau Formation sediments.

E.3.a.(6)(c) Bruneau Formation

The Bruneau Formation consists of a variety of lithologic types ranging from unconsolidated lake deposits that contain basalt flows and tuff beds to high energy river gravels. In the vicinity of Site B, the formation is approximately 100 ft. thick, but the thickness varies greatly and the formation is absent in some locations. The Bruneau Formation is generally more coarse-grained than the underlying Glenns Ferry Formation and has been divided regionally into a basal gravel unit (approximately 40 ft. thick), an overlying lower unit (approximately 70 ft. thick), followed by an upper unit (approximately 20 ft. thick). A 10- to 15-foot tuff layer separates the upper and lower units.

The basal gravel unit is composed of rounded pebbles, cobbles, and coarse-grained, cross-bedded sand lenses. The origin of the unit is interpreted as a river and beach deposits of ancestral Lake Bruneau. The lower unit, which overlies the basal gravel, consists of a thin, basaltic, cinder bed, an intervening mottled clay, and a fine-grained tuffaceous sand. The upper unit of the Bruneau is lithologically similar to the lower unit, but regionally occurs above the 10- to 15-foot-thick tuff layer. Locally, the thicknesses and lithologic characteristics of the Bruneau units can vary considerably. Only the basal gravel unit of the Bruneau Formation is present at USEI Site B.

Minor recent and Pleistocene surficial deposits are also intermittently present in the local area and consist of Snake River terrace gravels, colluvium, and stream alluvium. The stream alluvium exists along the margins of permanent drainages, and the colluvium consists of random slope debris. These minor deposits are difficult to distinguish from the unconsolidated coarse-grained Bruneau Formation deposits on a local scale. For purposes of classification in this report, all surficial deposits in the vicinity of Site B are considered to be part of the Bruneau Formation, even though they may be of more recent geologic origin.

E.3.a.(7) Regional Hydrogeology

The groundwater resources of the area have been examined at the regional scale by several investigators. Mundorff, Crosthwaite, and Kilburn (1964) prepared a report on the occurrence of groundwater within the entire Snake River Plain. Ralston and Chapman (1969) investigated the groundwater resources of northern Owyhee County, and Young and Lewis (1982) examined the hydrology of deep thermal groundwater in southwestern Idaho. Several other groundwater availability and geothermal resource studies have been performed in the region, most notably by Brott, Blackwell, and Mitchell (1978) and Young, Lewis, and Bracken (1979). On the basis of these principal research studies, an overview of the groundwater resources of the region is presented in the following sections.

E.3.a.(7)(a) Principal Groundwater Systems

The regional studies indicate that three groundwater systems are present in the area of Site B. These systems are as follows:

1. A deep groundwater system found primarily within the silicic volcanics, Banbury Basalt and the Poison Creek Formation. Groundwater is found at depths ranging from 600 to more than 3,000 ft. in this system. Water in this system is under considerable artesian pressure and geothermally heated. Many wells tapping the aquifer are capable of flowing at the land surface. Several flowing geothermal wells in the Castle Creek drainage are used for irrigation and contribute to the general water resources available in that area. In the 3,000-foot-deep water supply well drilled by the U.S. Air Force (USAF) at Site B, the first significant water was encountered at 2,980 ft. The USAF test well flowed at over 300 gpm at a temperature of 170 degrees Fahrenheit. The USAF geothermal well was plugged and abandoned in 1986 by USEI (CH2M HILL, June 1986). The geothermal aquifer system, herein referred to as the deep artesian aquifer, is the most important groundwater resource in the area. Recharge to the deep artesian system in the area is believed to originate in the Owyhee Mountains, where precipitation exceeds 50” annually.
2. A local veneer of saturated alluvium exists along Castle Creek. The alluvium and the creek are reported to be hydraulically connected. Some shallow domestic wells have been installed in the alluvium, generally to depths not exceeding 50 ft. Most of this alluvial system development occurs approximately eight (8) miles southwest and upstream of Site B (Ralston and Chapman, 1969). As Castle Creek flows northeastward from this area to the Snake River, it passes to within one (1) mile of Site B. It can reasonably be assumed that a veneer of saturated alluvium exists along Castle Creek in this downstream area as well. Recharge to this system is primarily by surface water run-off derived locally from precipitation and from the Owyhee Mountains.
3. Groundwater is found within the fine-grained sand beds and interbedded silts of the upper parts of the Glenns Ferry Formation at depths on the order of 140 to 350 ft. below ground level. Well yields and water quality in this system vary greatly. The Glenns Ferry Formation provides water to scattered low-yielding stock watering and domestic wells in the general vicinity of the site. In the area of the town of Oreana, seven (7) miles southwest of Site B, numerous wells provide groundwater for small irrigation and domestic uses from the Glenns Ferry Formation (Ralston and Chapman, 1969). In this area, local leakage from the Catherine Creek alluvial system probably contributes significantly to the recharge and well yields from the Glenns Ferry Formation. Recharge to the shallow Glenns Ferry aquifer comes from direct precipitation on exposed permeable beds, infiltration where the formation is exposed to surface water sources, and by vertical leakage from underlying artesian zones on a broad regional scale. The potential for recharge to the Glenns Ferry Formation from Site B is minimal because all site run-off is directed to lined collection ponds.

The water-bearing intervals being monitored at USEI Site B are in the upper portion of the shallow Glenns Ferry Formation. At Site B, however, the formation is not very permeable and most wells yield less than 0.5 gallon per minute. The shallow Glenns Ferry aquifer as it exists at Site B is not a true aquifer in the context of water resources because of low yield. The detailed characterization of the water-bearing properties and geochemical properties of the shallow Glenns Ferry system beneath Site B is provided in Section E.3.c.

E.3.a.(7)(b) Regional Flow Characteristics

Deep Artesian System

Groundwater in the deep artesian system generally moves from the mountains toward the Snake River, which is the regional hydrologic base level and therefore the likely discharge point for at least a portion of the groundwater in the deep artesian system. The observed northeast direction of flow in this system is consistent with the generalized orientation of the landscape, the trend of regional surface water drainages, and the regional trend of the Owyhee Mountains relative to the position of the Snake River. Strong upward gradients exist between the deep artesian system and shallower systems over most of the area. Where intervening confining strata are thin, more permeable, or breached by faults or wells, the deep artesian system also has a vertical flow pattern and contributes water to shallower systems. This is particularly noted to be occurring in the Castle Creek drainage area southwest of Site B where uncased or uncontrolled artesian wells are contributing to the base flow of Castle Creek and therefore also to the localized alluvial groundwater system in communication with the creek.

Shallow Glenns Ferry Groundwater

Because of the remoteness and sparsely populated nature of the area, coupled with the limited and sporadic groundwater resource potential of the Glenns Ferry Formation, there is insufficient information available to make definitive regional interpretation of flow directions and rates for the Shallow Glenns Ferry system. In general, the shallow groundwater system flows toward, and probably discharges into, the Snake River. However, smaller scale flow directions are expected to be highly variable because of localized points of recharge from surface waters and vertical leakage from the deeper system, and from localized discharge points such as wells and natural drainages. Locally, southeasterly, northeasterly, and easterly flow directions have been identified in the shallow Glenns Ferry groundwater system at Site B. All of these flow directions are generally toward the Snake River where it either discharges directly or enters the local alluvial groundwater system along the Snake River.

E.3.a.(7)c Relationship of the Deep Artesian System to Site B

A deep artesian well was drilled on Site B by the USAF in 1958 as a water supply well (Shannon and Wilson, 1959). The artesian well was plugged and abandoned by USEI in 1986 (CH2M HILL, June 1986). The well abandonment was completed methodically and thoroughly using oil-field cementing techniques and cementing service contractors. There have been no data suggesting any vertical leakage from the deep artesian well, either before or after plugging. Although the well was abandoned, because of the location of the artesian well in the center of Site B and because much of the understanding of the deeper geologic formations beneath Site B came from the artesian well records, it is appropriate to preserve the documentation of the well in this application. Pertinent information regarding the deep artesian well is summarized below. Appendix E.2 provides narrative information from the original report by Shannon and Wilson, the USAF construction contractor, regarding the construction of the deep artesian well as well as the well construction report filed with the State Engineer's Office in 1959. In addition, important information on the nature of the deep regional flow system can be gained by a review of the characteristics of this well. Figure E-7 provides a detailed stratigraphic column prepared from the drillers log recorded when the artesian well was drilled in 1958. As shown in this figure, the geologic section beneath Site B is dominated by blue clays and shales. The aquifers of interest at Site B occupy a very small portion of the uppermost geologic formation shown in this figure. Selected details regarding the deep artesian well are presented in Table E-3.

The shut-in pressure of 70 psi at the wellhead reported in 1958 was confirmed in 1986 prior to well abandonment. This value represents a head approximately 160 ft. above the land surface at Site B and approximately 335 ft. above the heads observed in the shallow Glenns Ferry Formation at Site B. These data confirm that a strong upward hydraulic gradient exists between the deep artesian system and the shallow Glenns Ferry system immediately beneath Site B. The drillers log of the artesian well did not report any major aquifer zones between the shallow Glenns Ferry system and the deep artesian zone,

spanning an interval of several thousand feet. This was confirmed at the 800-foot-deep exploratory borehole that was drilled by USEI as an exploratory water well west of the site in 1984 (well 18 in Figure E-6). Drilling logs from this well indicate that strata below 300 ft. are predominantly blue clay and shale, which is consistent with the drillers log recorded for the artesian well (Figure E-7). This hydrogeologic setting and head relationship indicates it is not possible for waste constituents from the site to migrate downward to the deep artesian aquifer. Therefore, the shallow water-bearing zones within the Glenns Ferry Formation are the primary “aquifers” of interest in this Document, and the remainder of this section is devoted to describing, in detail, the characteristics of these two groundwater systems.

E.3.b. Site Characterization Methods

E.3.b.(1) Introduction

The data necessary to describe the hydrogeologic framework and to identify and characterize the Upper and Lower Aquifers at USEI’s Site B were obtained by numerous iterative investigations. This section describes the scope and methods used in the investigations at the site conducted to meet the requirements of IDAPA 58.01.05.012 [40 CFR 270.14(c)(2)].

The first subsurface geologic investigation of the site was conducted in 1958 by Shannon and Wilson for the U.S. Air Force before Lemley Road was built. Most of the drilling conducted during this preconstruction period focused on the geotechnical properties of the shallow (less than 150 ft.) sediments. Hollow-stem auger and fluid rotary drilling techniques were used. Although four (4) of the ten (10) Shannon and Wilson borings were extended to 200 ft., no groundwater was reported.

In 1981 and 1982, Northern Testing and Engineering drilled seven shallow geotechnical borings, 17 ft. to 152 ft. deep, using hollow-stem augers. The purpose of these boreholes was to identify the shallow stratigraphy and obtain geotechnical foundation information for USEI. Additional shallow (41 ft. to 140 ft.) geotechnical information was obtained at seven hollow-stem auger borings drilled by CH2M HILL in September and October 1983.

Shallow groundwater was first reported in boring D-2, drilled by CH2M HILL in 1983 in the northeast corner of the site. The original purpose of this boring was to provide additional information for preparation of a groundwater monitoring waiver demonstration since groundwater had not been reported above 1,600 ft. at this site. Following the discovery of groundwater at 183 ft., numerous borings, test wells, and monitoring wells were installed between 1983 and 1985 to characterize the hydrogeology of the site. These activities were reported in the Site Characterization Report (CH2M HILL, February 1986) prepared in support of USEI’s Part B permit application.

Between 1985 and 1993, 26 additional wells were installed at the site by CH2M HILL as part of the Site Characterization and RCRA Detection Monitoring Programs pursuant to USEI’s Part B Permit No. IDD 073114654. In September and October 1986, two boreholes, D-33 and D-34, were also drilled to obtain detailed information on the stratigraphy and hydraulic properties of the vadose zone soils at the site. The information was used to perform predictive numerical modeling of hypothetical contaminant transport through the vadose zone.

In late 1999, a test boring (D-40) and adjacent lower aquifer piezometer LP-40 were installed south of Cell 14 for the purposes of site characterization data on the geology and lower aquifer groundwater in support of the permit modification to allow construction of new Cell 15. LP-40 was never formally included in the USEI’s site B permit as it was installed offsite (prior to siting approval which expanded the site to include this area). In March 2003, well LP-40 was abandoned as it was within the construction footprint of Cell 15.

A total of 123 test borings, test wells, monitoring wells, and piezometers are known to have been drilled at and around Site B, beginning with Shannon and Wilson's work. Table E-4 provides the coordinate location, dates drilled, depths, and current disposition of all wells and borings drilled in the study area. Figures E-8 and E-8a show the well and boring locations.

Forty of these wells are presently used as monitoring wells and 14 are used as piezometers. As shown in Table E-4, some of the original site characterization wells that remain in use as monitoring wells or piezometers have been renamed pursuant to USEI's Part B permit. The remaining 69 wells and boreholes have been plugged and abandoned.

Table E-4 identifies the wells and boreholes that were drilled after submittal of the 1986 Site Characterization Report (CH2M HILL, February 1986). Detailed descriptions of borehole drilling, well completion and development, sampling, and testing techniques for these wells and borings have previously been reported in numerous specific well construction and geologic reports. Table E-4 identifies the applicable reports.

Drilling, well completion and development, sampling, and testing techniques used to obtain hydrogeologic data on the site are described in the following sections. For boreholes and wells that were installed prior to 1986 and were included in the 1986 Site Characterization Report (CH2M HILL, February 1986), relevant drilling and well completion information is summarized in Table E-5. Detailed information on the drilling, well completion and development, sampling, and testing techniques at the pre-1986 wells and boreholes is provided in CH2M HILL, February 1986. For boreholes and wells installed after 1985, detailed descriptions of the techniques are provided below. Investigative methods used on this site include standard field and laboratory procedures and new drilling techniques that were developed for this project in response to formation and depth limitations of the conventional methods.

E.3.b.(2) Well Construction

E.3.b.(2)(a) Drilling Methods

Air Rotary

Most of the monitoring wells installed since USEI's Part B permit was issued in 1988 were drilled using conventional air rotary drilling methods. An auxiliary air compressor was used to ensure enough air circulation in the borehole to remove drill cuttings. The boreholes were drilled using a 7-7/8" in.-diameter drag bit from ground surface to the total depth drilled, except at UP-26, LP-27, and L-31. At UP-26 and LP-27, a 5-7/8" bit was used to drill the borehole from ground surface to the total depth drilled. At L-31, a 9-7/8" in. bit was used to drill the borehole from ground surface to 101.2 ft. below top of the steel casing (btsc) and a 7-7/8" in.-diameter bit was used to drill the remaining section of borehole. At most wells, well cuttings and split spoon soil samples were routinely screened for VOCs using an HNu organic vapor detector.

In some wells, it was necessary to use water and Quik Foam or straight water injection to clear cuttings from the borehole. Quik Foam is a non-ionic, foaming surfactant used in the drilling industry to clear drill cuttings from wells. It is approved for use in potable wells by the National Safety Foundation. Quik Foam has been used sparingly at USEI Site B since 1983 and no spurious chemical effects have ever been noted in subsequent water samples.

Welded steel surface casing was driven downward as each hole was advanced. A tophead drive air rotary drill rig with pneumatic casing driver was used to drill and drive the steel surface casing. The surface casings were 8-1/8" in. inside-diameter (ID) 0.250" in. wall steel casing fitted with a nine in.(9")-long, 9-3/4" in. outside-diameter (OD) drive shoe except at UP-26, LP-27, and L-31. At UP-26 and LP-27, six in. (6") ID steel casing fitted with a 7-3/4" ID drive shoe was used and at L-31 a ten in. (10") ID

steel casing with 11-3/4” in. OD drive shoe was used. The annulus outside of the steel casing was filled with dry granulated bentonite as the casing was driven.

When the surface casing was set, the inside of the casing was scrubbed using an eight in. (8”) steel wire brush and blown clean with air, except at L-28, L-29, L-30, L-35, and L-39 where the inside of the casing was scrubbed using a steel wire brush, Quik Foam, and water. After scrubbing, the casings at L-28, L-29, L-30, L-35, and L-39 were rinsed with water and blown dry. The tops of the steel casings are about two (2) ft. above the ground surface and are the permanent reference datum for all measurements presented in Table E-5. The surface casing depths are also shown in Table E-5.

At Upper Aquifer boreholes, an open borehole was drilled from the bottom of the steel casing to the anticipated depth of the top of saturation in the Upper Aquifer. One or more split spoon samples were then obtained to confirm the presence of water-saturated sand seams. When water was encountered, the borehole was allowed to equilibrate for an extended period of time (up to several days). After allowing the well to equilibrate, the borehole was advanced to the top of the confining bed that separates the Upper and Lower Aquifers, with the exception of UP-28, where the borehole was advanced through the Lower Aquifer to obtain detailed stratigraphic information in this portion of the site. At the Lower Aquifer boreholes, the boreholes were advanced to the total depth of the borehole. The drilling depths for each well are shown in Table E-5.

Special Drilling Methods

At UP-6 (SW-3-2) and UP-8 (SW-1-2), special drilling methods were used because these wells are proximal to a silo or a silo access tunnel, which were suspected sources of organic and potentially explosive vapors. At both wells, conventional air rotary techniques were used in combination with a modified bucket auger technique. The bucket auger method was primarily used to minimize worker exposure to potentially hazardous vapors and cuttings discharged out the borehole during air rotary drilling.

At UP-8, the well is of telescopic construction, having butt-welded steel casing diameters of ten in.(10”), eight in. (8”), and six in. (6”) ID. Initially, a 9-7/8” tricone bit was used to drill the borehole from ground surface to 39.9 ft. btsc. A ten in.(10”) -diameter bucket auger was then used to advance the hole from 39.9 ft. btsc to 81.9 ft. btsc. A 7-7/8”-in. diameter drag bit was then used to drill the remaining portion of the borehole to the total depth drilled. Welded steel surface casing was driven downward as the hole was advanced. At the bottom of each section of ten in (10”), eight in. (8”), and six in. (6”) steel casing, the hole was underreamed to widen the borehole, neat cement was tremied into the bottom of the borehole, and the bottom of the steel casing was driven and seated in the cement grout plug.

At UP-6, the drilling method from ground surface to 172.4 ft. btsc was conventional air rotary using a 7-7/8”-diameter drag bit. Welded steel surface casing was driven downward as each hole was advanced. A bucket auger was used to drill the borehole from 172.4 ft. to the total depth drilled.

Two (2) boreholes, D-33 and D-34, were drilled to obtain detailed information on the stratigraphy and hydraulic properties of the vadose zone soils at the site. The boreholes were located 100 ft. west from USEI’s eastern property boundary as shown in Figures E-8 and E-8.a. The boreholes are located in the downgradient direction of saturated groundwater flow beneath disposal trenches. Boreholes D-33 and D-34 were drilled with eight in. (8”) -diameter hollow-stem augers to depths of 155 ft. and 153.5 ft. bgs, respectively. At both boreholes, split spoon and cutting samples were routinely screened for VOCs using an HNu organic vapor detector.

In March and April 2000, four soil vapor wells were installed in the northwest portion of the site. These wells were drilled using eight (8) in. nominal diameter hollow stem augers. The bore holes were advanced until auger refusal halted progress.(137.5 to 165.3 feet). The soil vapor wells were completed using an emerging technique (FLUTe) where an inverted flexible liner was installed into the auger and inflated as

the auger was removed. Each well has five (5) discrete porous sections connected by tubing to the surface.

E.3.b.(2)(b) Well Construction

Table E-5 summarizes the well construction details for all existing monitoring wells, piezometers and soil vapor monitoring wells at the site. All boreholes drilled after 1985, with the exception of D-33 and D-34, were completed as monitoring wells or piezometers. All monitoring wells constructed since USEI's Part B permit was issued in 1988 consist of threaded, flush-jointed, 4" ID, Schedule 40 PVC casing joined with a four in. (4") stainless steel riser and four in. (4") stainless steel, continuous wire-wound well screen. At the piezometers, threaded, flush-jointed, two in. (2") or four in. (4") ID, Schedule 40 PVC casing is joined with two in.(2") – or four in. (4") Schedule 40 PVC slotted well screen. Screen slots are 0.010 inch.

In the Upper Aquifer wells, the entire saturated thickness was screened and the screens were placed to extend approximately ten ft. (10) above the static water level. For Lower Aquifer wells, a fixed screen length of 30 ft. was used. Site characterization efforts prior to 1986 established that the Lower Aquifer consists of a number of discrete, thin, very fine sand beds with a typical cumulative thickness of only two ft. (2') to four ft. (4'). These sand beds occur over an interval of silty clay that ranges from approximately 20 ft. to 40 ft. and that the bottom of the Lower Aquifer is difficult to identify as it grades into the underlying basal confining bed. As a result, a fixed screen length of 30 ft. was established in the 1988 permit to allow screening (plus sand pack) across all sand beds in the Lower Aquifer to maximize the potential for detection of contaminants in any individual sand bed and to obtain enough water for effective groundwater sampling.

At all wells constructed since USEI's permit was issued in 1988, a sump ranging in length from 0.8 ft. to 2.0 ft. was placed on the bottom of the screen in all wells. The final well screen and casing were installed in the open hole and extended up through the steel casing to the surface. Stainless steel centralizers were used to center the well screen and casing inside the borehole. In 1988, the four in. (4") -diameter PVC screen in well L-35 failed and the well was reconstructed using threaded, flush-jointed, two in. (2") ID, Schedule 40 PVC, a two in.(2") stainless steel riser, and two in. (2") stainless steel, continuous wire-wound well screen.

All wells were installed with a filter pack extending from two ft. (2) to five ft. (5) above the top of the screen and consisting of 20-40 mesh clean silica sand that was pumped with water around the well screen using a one in. (1")-diameter tremie pipe. A bentonite plug was placed in the annulus between the borehole and well casing immediately above the filter pack. In Upper Aquifer wells, the bentonite plug consists of granulated bentonite or pellets that was tremied dry on top of the filter pack and hydrated in place. In Lower Aquifer wells, the bentonite plug consists of bentonite pellets or a Benseal high solids bentonite grout slurry that was tremied on top of the filter pack. At some Lower Aquifer boreholes, a neat cement grout plug was placed immediately above the bentonite plug. The remaining annulus between the borehole and well casing and the well casing and the steel surface casing were sealed with a bentonite and cement grout that was tremied into place, with the exception of UP-6 and UP-8, where dry granulated bentonite was used as the annular seal. The amount of annular fill was determined by periodically sounding the annulus as the seal material was being placed.

Table E-5 provides a summary of the pertinent well construction information on all wells at Site B. Well completion diagrams and geologic logs for all currently active wells are provided in Appendix E.3.

E.3.b.(2)(c) Well Surveying

Each existing well was surveyed for north and east coordinates to within 0.1 ft. and recorded using the Idaho State Plane Coordinate system. The top of the steel surface casing and the water level measuring point were surveyed to within 0.01 ft. and the top of the concrete pad was measured to within 0.1 ft. based on the site vertical elevation datum.

E.3.b.(3) Testing, Sampling, and Analysis

E.3.b.(3)(a) Soil Sampling Methods

Soil samples at boreholes drilled since USEI's Part B permit was issued in 1988 were collected using several methods. The methods were chosen based on practical applicability and on the objectives of the sampling. These methods are described below.

E.3.b.(3)(b) Soil Sampling at Monitoring Wells and Piezometers

Grab samples of the cuttings were taken for lithologic descriptions. These samples were disturbed and represent a homogenized sample over several feet. Bulk lithology changes were detected, but thinly bedded sequences may not have been distinguishable. Grab samples were retained as composites of 5-foot intervals.

Standard two in. (2") OD steel split spoons were used to obtain soil samples at particular horizons at most borings. At most Upper Aquifer monitoring wells and piezometers, one or more split spoon samples were obtained to confirm the presence of water-saturated sand seams. At UP-6, nine split spoon samples were collected for geotechnical analysis and laboratory analysis of potential contaminants. At UP-8, numerous split spoon samples were collected to obtain better geologic logs. Split spoon samples were collected from some portions of some Lower Aquifer boreholes to identify water-bearing zones and obtain detailed stratigraphic information. Each split spoon sample was also screened for VOCs using an HNu organic vapor detector. The HNu logs, soil analysis, and geotechnical results are presented in the respective individual well reports referenced in Table E-4.

E.3.b.(3)(c) Soil Sampling for Hydraulic Properties

Soil samples collected from D-21, D-22, and D-23 were laboratory tested for their hydraulic properties. The results were originally presented in CH2M HILL (February 1986). Samples were collected from each borehole representing the vadose zone, Upper and Lower Aquifers, the inner confining beds, and the lower confining beds. The data are used in this report to evaluate the degree of containment afforded by the clays and other sediments found above, below, and between the aquifers and to supplement in situ hydraulic conductivity values provided by aquifer testing. Standard two (2") OD and three in. (3") OD steel split spoons samples were collected at five (5)-foot intervals. A total of 79 samples were tested for dry unit weight, moisture content, specific gravity, percent saturation, vertical coefficient of permeability, and porosity.

E.3.b.(3)(d) Soil Sampling at Vadose Zone Boreholes

Soil samples were obtained during the drilling of D-33 and D-34 by split spoon sampling and continuous sampling. The purpose of the soil sampling was to obtain detailed information on the stratigraphy and hydraulic properties of the vadose zone soils at the site. Split spoon samples were obtained with a standard two in. (2") OD steel split spoon sampler driven with a 140-pound hammer. Continuous core sampling was accomplished with a three in. (3") OD x five (5)-foot-long sampler that was advanced with the auger. In both methods, soil samples were collected inside clear plastic liners. Standard laboratory procedures were used to determine grain size distribution, moisture content, moisture retention relation, unsaturated hydraulic conductivity, bulk density, and porosity of the vadose zone samples.

Each of the five, multi-port vadose wells were continuously cored as the boreholes were advanced. The cores were retrieved in clear plastic liners which were sealed and labeled. These cores are stored at USEI's off-site storage facility.

E.3.b.(3)(e) Water Sampling

Three different groundwater chemistry sampling programs have been conducted at the USEI site. These include a RCRA Detection Monitoring Program, a RCRA Compliance Monitoring Program, and a Site Characterization Program. Data collected under the RCRA Detection Monitoring Program have been collected on a semiannual basis since USEI's Part B permit was issued in 1988. Section E.2 c and Table E-1 describe the various samples collected under the groundwater monitoring requirements of USEI's Part B permit from 1989 through 2013 . Data collected under the site characterization program include common-ion data collected at several monitoring wells and piezometers between the years 1984 and 1997.

RCRA Detection and Compliance Monitoring Program

The methods and procedures used to sample the RCRA detection and compliance monitoring wells are summarized below.

On arrival at each wellhead, a photoionization organic vapor detector (PID) was used to determine if organic vapors are present in the breathing zone or in the wellhead. Immediately after monitoring for organic vapors at a well, the depth to groundwater from an established measurement point was measured using an electronic water-level measuring tape.

Each well was equipped with a dedicated stainless steel piston pump (Hydrostar™) and dedicated discharge fittings and sampling tube, eliminating the potential for cross-contamination. Each monitoring well was checked for the presence of immiscibles by collecting the initial purge water into a glass container and allowing any immiscibles to separate from the water. Four field parameters—temperature, visual turbidity, pH, and specific conductance—are recorded during purging. The wells were purged of standing water in the casing with the dedicated, permanently installed sampling pumps. Each well was purged of three casing volumes (including the sand pack volume) or until dry. Wells purged to dryness were sampled as soon as they had sufficiently recovered to pump enough water to purge the pump column and collect all samples and field parameters. A determination of the sustainable yield of each well was made when the wells were drilled, reworked, or incorporated into the monitoring well network.

Groundwater sampling and analysis conformed to the protocols of *EPA SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 1986). Dedicated pumps and discharge fittings and sampling tubes were used to collect the groundwater samples. Samples were collected in the following order: VOCs, TOX, TOC (TOX and TOC analysis was discontinued in 1999), and inorganics (pH, specific conductivity). The samples were placed in sample shuttles with frozen packets of blue ice and shipped via overnight delivery to a qualified laboratory with chain-of-custody paperwork.

In conjunction with each monitoring event, water levels at all site piezometers were also measured. At each piezometer, the depth to groundwater from an established measurement point was determined using an electronic water-level measuring tape. The water levels in all monitoring wells and piezometers were measured on the same day at the beginning of a sampling event.

Prior to use, the PID and field parameter meters were calibrated by personnel following the manufacturer's instructions. Each device was calibrated daily or when conditions indicate that re-calibration is necessary. Calibration results were recorded in the sampling event field log. Sample field books are maintained in the Operating Record at Site B.

Site Characterization Program

Site hydrochemical data was collected to characterize the hydrochemistry of the USEI site. The hydrochemical data are used to describe the Upper and Lower Aquifers, to describe the differences between the two aquifers, and to evaluate any potential impacts on the aquifer's general chemistry by

facility operations. The data include temperature, specific conductance, pH, common-ions, and TOC. Groundwater temperature, specific conductance, and pH data were collected as described above for the Detection and Compliance Monitoring Programs.

Common-ion data were collected at several monitoring wells and piezometers between the years 1984 and 2000. The methods used to collect the common-ion data before 1986 were previously reported in CH2M HILL (February 1986). After 1986, common-ion data were collected at selected wells, including U-4, U-7, U-10, U-17, U-21, U-26, UP-26, UP-28, UP-29, L-29, L-32, L-33, L-38, and , LP-40. At wells U-4, U-7, U-10, U-21, L-29, L-32, L-33, and L-38 the common-ion samples were collected in conjunction with the April 1992, April 1993, or October 1993 detection monitoring events. The methods used to collect groundwater samples are described in Section E.3.b.(3). At wells U-17, U-26, UP-26, UP-28, UP-29, and LP-40, the groundwater samples were collected separately from a detection monitoring event. These wells are very low-yielding wells and are easily dewatered by bailing or pumping. Piezometers U-26, UP-26, UP-28, and UP-29 were bailed to collect the water samples. The water samples were collected from the middle of the screened interval. At U-17, the well was pumped to dryness with a dedicated pump and then allowed to recover prior to sampling.

After the required samples were collected at a well, the sample bottles were placed in the sample shuttle with frozen packets of blue ice with the chain-of-custody paperwork and shipped to a qualified laboratory. All Laboratory Analytical Reports for common-ion data collected between 1984 and 2000 are provided in Appendix E.4.

E.3.b.(3)(f) Geophysical Logging

Most of the boreholes drilled prior to the 1988 permit issuance and all wells installed since the permit was issued were logged using downhole geophysical methods to aid in formation identification and geologic correlation. The typical suite of geophysical logs consisted of natural gamma radiation, single-point resistivity, spontaneous potential, and three-arm caliper. Prior to geophysical logging, most wells were partially filled with clean water to facilitate the single-point resistivity logging. Standard truck-mounted geophysical wire-line methods were used. All logs were recorded by a geophysical logging contractor. The geophysical logs are shown along with the lithology logs in Appendix E.3. Single-point resistivity logs are the most useful in identifying the significant water-bearing sand beds and for providing a stratigraphic signature of the Upper Aquifer, Lower Aquifer, and intermediate confining bed that separates the two water-bearing zones.

E.3.b.(3)(g) Aquifer Testing

Site permeability data were collected to characterize the groundwater hydraulics of the USEI site. The data are used to describe the Upper and Lower Aquifers, to describe the differences between the two aquifers, and to evaluate the potential for contaminant migration beneath the site. Slug tests, pumping recovery, and specific capacity tests were performed at 45 locations. The methods used to collect and analyze the various types of hydraulic property data are described below.

Definition of Terms

There are three basic properties of water-bearing materials that affect the movement of groundwater through and between aquifers: hydraulic conductivity (K), hydraulic gradient (I), and the area (A) across which flow occurs. In addition to these fundamental properties, three other characteristics are used to describe the hydraulic properties of aquifers: transmissivity (T), storativity (S), and specific capacity (Q/s). These terms are further defined as follows:

- Hydraulic conductivity (K) is defined as the volume of water that a one square unit area of the aquifer will transmit under a unit (1:1) hydraulic gradient per unit of time. Hydraulic conductivity is essentially the same term and concept as permeability. Throughout this report K is expressed and primarily reported in terms of feet per day (ft/d).

- Hydraulic gradient (I) is the relative water level difference or hydraulic head (pressure) difference between points in an aquifer, or between aquifers, divided by the distance between the two water level measurement points. Gradient measurements in this report are provided in terms of feet per foot (ft/ft), which reduces to a unitless number. Horizontal gradients used in the description of groundwater flow at Site B were determined from potentiometric maps (maps showing the water surface elevation) across the site. Vertical gradients were determined from specific locations where Upper and Lower Aquifer water levels can be measured in adjacent wells.
- Area (A) is the cross-sectional area across which flow occurs. In this report, flow areas in square feet (ft^2) are used.
- Transmissivity (T) is a measure of the ability of an aquifer to transmit a volume of water with time. It is defined as the amount of water transmitted through a unit width of the complete saturated thickness of the aquifer under a unit gradient. Transmissivity is further defined as the hydraulic conductivity (K) times the saturated thickness (b): T=K*b. In this report, transmissivity is reported in ft^2/day.
- Storativity (S) or storage coefficient is the amount of water released from storage in an aquifer per unit drop in head or water level. Storage is a unitless term since it is measured in volume per volume. In unconfined water table aquifers, S is essentially the specific yield of the formation materials, which typically ranges from 0.01 to 0.2. In confined aquifers, storativity values typically range from 0.001 to 0.00001.
- Specific Capacity (Q/s) is a measured value indicating the ability of a well to produce a volume of water (Q) per unit time, i.e., gallons per minute (gpm) per feet of drawdown (s) in the well. Specific capacity data are typically obtained on existing wells equipped with pumps that can be pumped at sustained pumping rates. As will be discussed under the Methods section below, specific capacities can be used to estimate the aquifer transmissivity.

The hydraulic properties and groundwater flow descriptions for Site B presented in this report all use the feet-day units. Where necessary, those calculations and procedures providing characteristics in other typical units such as gallons per day per foot (gpd/ft) or centimeters per second (cm/sec) have been converted to the feet per day system using the following conversions:

- ft^2/day = gpd/ft ÷ 7.48 gallons/ft^3
- ft/day = cm/sec x 2834.6

Scope of Available Aquifer Properties Data

The available data used to characterize the hydrologic properties of the groundwater system at USEI Site B consist of the following:

- 18 single-well constant discharge pumping tests in which both water level drawdown and recovery were measured
- 10 slug tests
- 58 specific capacity determinations of individual wells
- 29 grain-size analyses of aquifer materials
- 23 packer testing of selected drill holes during initial well installation
- 33 laboratory permeability tests on cores representing Upper and Lower Aquifer sand seams and confining silt and clay zones
- Routine water-level monitoring and subsequent construction of potentiometric surface maps
- Geologic strata distribution from geologic and geophysical logs

The packer tests, grain-size analyses, laboratory permeability tests, and 14 single-well tests were previously reported in CH2M HILL (February 1986). The new data were collected over the past ten (10) years as new wells were installed and on new and existing wells in response to specific permit conditions or data needs.

The slug recovery, pumping recovery, and specific capacity tests provided the most meaningful data from which to estimate T. An estimated T, based on slug tests, pumping recovery, and specific capacity tests, was determined at 43 locations. A total of ten (10) pumping tests, four (4) slug tests, and 36 specific capacity tests conducted on the Upper Aquifer, and five (5) pumping tests, six (6) slug tests, and 22 specific capacity tests conducted on the Lower Aquifer were determined to be valid. Ten (10) of the single-well tests (MW-1[UP-7], MW-3, MW-5, MW-6, MW-10[UP-5], MW-11, MW-12, D-17, D-18, and D-27[L-36]) that were previously reported in CH2M HILL (February 1986) are included as part of the current groundwater characterization. The well numbers in brackets [ ] are existing wells that were retained and renumbered from the pre-permit site characterization efforts. Wells without a new number have been plugged and abandoned.

The methods used to collect and analyze the various types of hydraulic property data are described below. The aquifer testing data included in the current groundwater characterization are summarized in Table E-6. Field data, graphic plots, and calculation sheets for the aquifer tests conducted at Site B are provided in Appendix E.5.

Slug Test Procedures

Slug injection and withdrawal test methods as described by Cooper et al. (1967) and Bouwer and Rice (1976) were used at Site B. In these methods, the pressure recovery in a well was monitored following the instantaneous injection or removal of a known volume of water (slug). In concept, the slug test can be viewed as a drawdown/recovery test in which the pumping duration is zero and the only aquifer discharge occurring during the test is after-flow to the well bore during recovery.

In general, the slug removal test is considered to be the most accurate slug test method because of the ease with which a slug can be removed from the well. In addition, for unconfined conditions where the borehole is screened above the water table, the slug withdrawal method is required. Therefore, only the slug removal results are reported for this study.

Slug tests were conducted by recording the time-recovery curve as water levels rose following the removal of a solid slug or a bailer of water of known volume. Water level recovery was monitored at regular intervals with an electric water level probe or a Hermit 1000B data logger and pressure transducer. The time required to monitor water level recovery varied from 0.9 to 4.2 days, depending on permeability of the aquifer.

Curve-matching procedures and generation of a value for T were accomplished using the aquifer test analysis program AQTESOLV, Version 2.0, by Geraghty and Miller Environmental Services. The Cooper et al. curve-matching method was applied to the confined wells of the Lower Aquifer, and the Bouwer and Rice method was applied to unconfined/semiconfined wells of the Upper Aquifer. The curve-matching analyses and a summary sheet of the reference and solution methodology are contained in Appendix E.5.

Pump Test Procedures

The pump tests were conducted as single-well constant discharge tests in which the water level recovery was monitored following the cessation of pumping. Because of the general low-yield characteristics of both the Upper and Lower Aquifers, eight (8) of the 15 wells pumped were readily dewatered during the tests. The pumping or bailing of these eight wells was performed until the well bore was fully evacuated, at which point water-level recovery measurements were initiated. Typical times to evacuate these wells ranged from 1.7 to 8.0 minutes.

The remaining wells with sustainable yields were pumped at constant rates until sufficient drawdowns from which to measure well recoveries were achieved. Table E-6 denotes the eight wells that were dewatered and the seven wells for which pumping rates could be maintained.

The drawdown and recovery of water levels in the wells were measured at regular intervals using an electric probe or a pressure transducer. The pumping or bailing rate was measured using a calibrated bucket and stopwatch. Average discharge rates were calculated based on total volume evacuated over the total time period of pumping or bailing. Appendix E.5 contains the discharge and recovery field data generated during the tests.

Methods for analyzing single-well pumping and recovery test data presented by Cooper and Jacob (1946) and McWhorter (1981) were used. At wells that were able to maintain a constant pumping rate for an adequate period of time, Cooper and Jacob's adaptation of the Theis (1935) Standard Recovery Test method was used. The Cooper-Jacob method uses a semi-log plot of residual drawdown versus a time function. This method assumes that the effects of well bore storage can be neglected during pumping and recovery.

McWhorter found that the Theis recovery test has limited application in situations where water-bearing strata exhibit low permeabilities and associated transmissivities (McWhorter, 1981). The Standard Recovery Test inherently assumes that the effects of well bore storage can be neglected during pumping and recovery. McWhorter demonstrated that well bore storage effects are important in the investigation of low permeability materials and that the assumptions present in the Theis recovery test are no longer valid. He presents an analytic solution to the Theis flow equation that gives full consideration to the complicating effects of well bore storage during pumping and aquifer after-flow to the well bore during well recovery.

The McWhorter method is also applicable to situations where instantaneous drawdown conditions are approximated by rapidly evacuating the water in the well using either a pump or a bailer. McWhorter considers the slug test (where pumping duration equals zero) as a limiting case to his family of solutions. McWhorter's method was used for analyzing data from those "hybrid" tests conducted on low-yielding wells at Site B for which the limiting assumptions of instantaneous drawdown and casing storage effects fall between true slug tests and pumping-recovery tests.

Specific Capacity Test Procedures

Specific capacity of a well is its yield per unit of drawdown. The specific capacities of several monitoring wells and piezometers in the Upper and Lower Aquifers were measured using drawdown and discharge data collected during well development and groundwater sampling events. The specific capacities of the tested wells are shown in Table E-6. For several wells, multiple specific capacity measurements have been recorded over time. In higher yielding wells, pumping rates were held constant until water levels in the well stabilized. If the well was not pumped long enough to obtain a stable water level, the specific capacity test was determined to be invalid and is not included in the analysis or in Table E-6. In lower-yielding wells, the well bore was rapidly evacuated and a constant pumping rate was established by determining the sustained pumping rate with the water level at the level of the pump.

The transmissivity of the aquifer at each well where a specific capacity was measured was estimated using the empirical equation relating transmissivity and specific capacity developed from Jacob's modified non-equilibrium equation. This procedure is presented in several groundwater texts, including Driscoll (1986). When the following typical aquifer properties and test parameters of T=30,000 gpd/ft, S = .001, time (t) = 1 day, and well radius (r) = 0.5 ft. are used, this method results in the following widely published "rules of thumb":

- T (gpd/ft) = 1,500 * Q/s for unconfined aquifers
- T (gpd/ft) = 2,000*Q/s for confined aquifers (Driscoll, 1986)

However, the typical aquifer properties and test parameters for the Upper and Lower Aquifers at Site B do not compare with the values used to generate the above relationships. Therefore, to estimate the transmissivity from the specific capacity data for Site B, two new empirical relationships were developed

by substituting typical Site B aquifer and test properties into the Jacob equation. The values used are provided in Table E-7.

The T values shown in Table E-7 are the average T derived from the pumping and slug tests for each aquifer. The unconfined and confined storage coefficient values shown in Table E-7 are typical values for S, as discussed below. From this exercise, two equations were developed, one for the Upper Aquifer and one for the Lower Aquifer. In the feet-day system of units, these equations are as follows:

- $T(ft^2/day) = Q/s * 58$ (unconfined Upper Aquifer)
- $T(ft^2/day) = Q/s * 106$ (confined Lower Aquifer)

Appendix E.5 provides the calculations and equations used to generate the empirical relationships that were used to estimate transmissivity from the specific capacity data at Site B.

As discussed above, typical values for S were used to calculate the transmissivity based on the specific capacity of a well. Single-well aquifer tests do not allow for a reliable calculation of the aquifer storage coefficient, as stated by Cooper et al. (1967) and Kruseman and deRidder (1970). Therefore, the aquifer storage coefficients for the Upper and Lower Aquifers were estimated from published information. The unconfined storage value is known as specific yield and is defined as the volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in the water table. The usual range of specific yield is 0.01 to 0.30 (Freeze and Cherry, 1979). Fetter (1980) reports specific yield values of 4×10^{-2} to 3×10^{-1} for aquifers composed of clayey silts to silty sands. Domenico and Schwartz (1990) reports specific yield values of 3.0×10^{-2} to 2.3×10^{-1} for aquifers composed of fine sands, silt, and clay. Driscoll (1986) reports the typical value for specific yield is 7.2×10^{-2}. For the Upper Aquifer, Driscoll's reported value for S was used to calculate transmissivity from the specific capacity of a well.

The confined storage value is known as specific storage and is defined as the volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in the hydraulic head. Freeze and Cherry (1979) and Todd (1980) report specific storage values of 10^{-5} to 10^{-3}. McWhorter (1981) bases his single-hole method for confined aquifers on a storage coefficient of 10^{-4}.

The specific storage of the lower confined aquifer can be estimated using Equation E.3-1 (Domenico and Schwartz, 1990):

Eq. E.3-1

$$S = \rho g b(\alpha + n\beta)$$

where:
ρg=specific weight of water at 25 degrees Celsius, in lb/ft^2
b=average thickness of the sand bed portion of the aquifer, in ft
α=compressibility of the aquifer matrix, in ft^2/lb
n=porosity of the aquifer
β=compressibility of water at 25 degrees Celsius, in ft^2/lb

Estimated values for each variable in Equation 5 are α = 1E-6 ft^2/lb and β = 2.3E-8 ft^2/lb (Domenico and Schwartz, 1990), n = 0.43 (CH2M HILL, February 1986), ρg = 62.4 lb/ft^2, and b = 4.0 ft. (the average sandbed thickness of the Lower Aquifer wells). The estimated value for specific storage in the lower confined aquifer is 2.5×10^{-4} and was used above to calculate T based on a confined well's specific capacity.

E.3.b.(3)(h) Gyroscopic Directional Survey

Gyroscopic directional surveys were performed on piezometers U-26, UP-28, and UP-29 on July 26, 1993, and monitoring well L-28 on December 4, 1990, to determine the plumbness of the boreholes at these locations. The gyroscopic surveys were performed because anomalies in the water surface elevations in the Upper Aquifer and Lower Aquifer in the vicinities of UP-28 and L-28, respectively, were indicated on potentiometric surface maps prepared for the site. The gyroscopic surveys were performed by Strata Data, Inc. of Casper, Wyoming.

E.3.b.(4) Borehole and Well Abandonment

All wells and boreholes that have been plugged and abandoned at the site are identified in Table E-4. A total of 69 wells and boreholes have been plugged and abandoned at the site. For wells and boreholes plugged and abandoned prior to 1986, a brief description of the plugging and abandonment procedures is included in Table E-4. For wells and boreholes plugged and abandoned after 1985, the abandonment procedures described below were followed.

Twenty-six wells were plugged and abandoned in 1986 or thereafter. In general, the wells were reentered and drilled out using conventional air rotary methods with water injection and plugged with Benseal and dry bentonite. Quik-Foam was used in some boreholes to help lift the cuttings from the borehole. Each well was drilled to the original borehole depth or the bottom of the sand pack interval, then subsequently filled with Benseal and dry bentonite up to the ground surface. At most wells, the steel surface casing was cut off at or below the ground surface and welded shut with the well number and the date of abandonment inscribed on the top plate of the well. At D-31, the steel casing was cut off approximately 60 ft. bgs and pulled out to avoid any interference with the future expansion of Cell 14.

In March 2003, well LP-40 was plugged and abandoned. The well was filled with cement grout to full depth to fill the screen and sand pack. After the initial cement had set, the PVC casing was drilled out to a depth of 134 feet, approximately 14 feet below the 8” steel surface casing. The surface casing was then filled with 4% bentonite-cement grout and pulled out allowing the cement to flow into the exposed borehole. All surface casing was removed and the upper part of the borehole was filled with granulated bentonite.

Specific plugging procedures for each well abandoned in 1986 or thereafter are described in the abandonment reports referenced in Table E-4.

The two uncased boreholes, D-33 and D-34, were also abandoned. After obtaining hydraulic characterization samples of the vadose zone, the boreholes were plugged with a bentonite-cement slurry pumped down the inside of the augers as the augers were retracted.

In addition to the abandonment of the wells and boreholes discussed above, the 3,080-foot-deep artesian well at the site was plugged. Because the well was very deep and was under artesian pressure, a variety of oil field services, equipment, and techniques were required to successfully plug the well. The well and annulus were filled with 2,806 cubic feet (ft^3) of cement and grout mixes, which is equal to 2.9 times the calculated volume of the well. A detailed description of the abandonment procedures for the artesian well is presented in CH2M HILL (June 1986).

E.3.b.(5) Decontamination Procedures

To minimize the potential of cross-contamination between drill holes and samples, common equipment used between holes or wells was decontaminated before and after each use. High-pressure hot water and steam were used to clean the drilling and testing equipment. All down-hole tools, drill pipes, geophysical logging equipment, development pumps, and well construction materials were steam-

cleaned rigorously between holes. Any petroleum products visible after rig maintenance or seepage during operations were removed. Leaking hydraulic lines were repaired or replaced as soon as they were noticed.

Because all wells are fitted with dedicated sample pumps and tubing, decontamination of these materials is not required. Before using the electronic water-level tape for the first time each day, the probe and the first 100 ft. of tape are decontaminated. After measuring each well, the probe is washed with isopropanol, then rinsed with distilled water.

E.3.c. Site Hydrogeologic Characteristics

E.3.c.(1) Introduction

The regional and local hydrogeologic setting for the Site B area was presented in Section E.3.a. In this section, the results of the site-specific hydrogeologic investigations conducted at Site B are presented in detail. The goal of the hydrogeologic investigations to date has been to characterize the geologic and hydrogeologic properties of the uppermost aquifer and any aquifer hydraulically connected to it. At Site B this involved a detailed investigation of the upper 400 ft. of unconsolidated sediments beneath the site. This information has been assembled pursuant to IDAPA 58.01.05.012 [40 CFR 270.14(c)(2)].

The uppermost water-bearing zone beneath Site B actually consists of two discrete, low-yielding, finely bedded sand zones that are separated by a 20- to 30-foot-thick confining clay bed. Under the nomenclature used in this report, these two zones are called the Upper and Lower Aquifers, respectively. Both zones occur in the Glenns Ferry Formation.

An unsaturated zone, ranging from 140 ft. to 200 ft. in thickness, overlies the uppermost aquifer and consists of silts and clays of the Glenns Ferry Formation overlain by coarser-grained sands, silty sands, dense clay beds, and sandy gravels of the Bruneau Formation.

The following sections develop in detail the generalized concepts presented above. A description of the site-specific subsurface geology is provided, followed by a detailed examination of the hydraulic and hydrochemical aspects of the uppermost aquifer system. The system is complex as a result of subtle stratigraphic differences within the Glenns Ferry Formation and the effect of dipping strata. To orient the reader, an overview of the uppermost aquifer concept is presented in Section E.3.c.(3), following the site-specific geology discussion below.

E.3.c.(2) Site Geology

E.3.c.(2)(a) Formation Identification

Quaternary and Tertiary sediments of the Bruneau and Glenns Ferry Formations directly underlie the site. The veneer of surficial gravels present over much of the site is interpreted as basal conglomerate of the Pleistocene-Age Bruneau Formation (Benfer, 1984). Fine-grained sediments of the Pliocene- to Pleistocene-Age Glenns Ferry Formation underlie the Bruneau Formation gravels. The Glenns Ferry then persists throughout the remaining depth of the investigation.

E.3.c.(2)(b) Stratigraphy

Throughout the remainder of this section, references will be made to the observed thicknesses of various geologic strata penetrated. Qualitative descriptive terms have been numerically classified according to Krumbein and Sloss (1963), and are shown in Table E-8. Unless an actual numeric thickness is reported in the text, the reader should use Table E-8 to identify the thickness ranges represented by the qualitative

descriptive terms.

Geologic and geophysical logs have been used to construct several geologic cross sections depicting the stratigraphy at USEI Site B. Previous reports and submittals on file with DEQ contain these large cross section plates which are not reproduced in this application.

Cross section A-A', located in Figure E-9 and shown in Figure E-10, is a stratigraphic section based on continuous rotary coring at coreholes D-21, D-22, D-23, and D-32. Cross section A-A' provides detailed stratigraphic characterization of the upper Glenns Ferry Formation beneath Site B. The reader should examine Figure E-10 to become familiar with the stratigraphy and lithology at Site B. The line A-A' is drawn along the predominant structural attitude.

With two minor exceptions, the basal gravels of the Bruneau overlie the entire site. The exceptions are where the basal gravels are thinly covered by recent soil or ash layers, or where they have been removed by site construction activities. Typically, the gravels are present only to about 50 ft. bgs but were found to extend to approximately 100 ft. in the southeast and northeast corners of the site.

The Glenns Ferry is present beneath the Bruneau gravels and represents sedimentary deposition in a large lake system with peripheral and capping fluvial and flood plain facies (Smith et al., 1982). As such, the Glenns Ferry consists of lake-margin deposits containing fluvial deposits (stream and beach shoreline sands and near-shore silts). Underlying the fluvial deposits are the lacustrine facies (lake deposits) of the Glenns Ferry. The entire sequence exhibits upward coarsening (finer grained with depth). As such, this represents a period of lake regression (a lowering of the water level in the ancient lake [Selley, 1972]). Lithologic and facies contacts are gradual and are controlled by the predominance of grain size and bedding.

The upper (fluvial) sequence of the Glenns Ferry Formation contains very thick-bedded (greater than ten (10) ft.) fine sands and silts containing a few clay seams. Typically, the sands are well sorted, moderately indurated, and thickly bedded. Calcite cementing predominates. The clay seams distributed within the sand are generally thin-bedded (several inches to one (1) ft. thick) and are plastic (soft and moldable). Near the base of the sequence, thin-bedded carbonates (limestone) occur. These sedimentary sequences are representative of lake margin environments (Selley, 1972). This section persists to approximately 130 ft. in depth at the center of the site, where the finer grain size and thinner bedding exists. Where the predominance of finer grain size and thinner bedding exists, this facies change is interpreted as the bottom contact of the fluvial facies overlying lacustrine sediments of the Glenns Ferry Formation.

The lacustrine facies consists of thick-bedded clays and silts containing very thin beds of silt, sand (generally less than one ft. (1) thick), and sand-silt lamina. The sequence expresses cyclic sedimentation for the depth investigated. The formation transcends through thick-bedded sequences of clay and silts containing discrete, thinly bedded sands (one ft. (1) thick or less) and reflects deposition representative of a lacustrine environment as the lake waters rose and fell. The sands and silts (linear and lense-like in form) represent near-shore and shoreline deposits. Portions of this sequence are deltaic in nature and contain abundant plant debris. Sheet-like clay and finer silts are representative of offshore and deeper lacustrine deposition.

The first sequence of shoreline and near-shore deposits underlying the fluvial facies occurs at an approximate depth of 160 ft. at the center of the site. In the northwest portion of the site, the sequence contains numerous thin-bedded silty sands and lamina that are separated by thin- to thick-bedded silts and clays. These sand beds appear to pinch and thin toward the south and east, forming thickly bedded clay and silt in those directions. Although a continuous zone exists, individual sand beds appear discontinuous across the site. This may indicate that the source of the sands was from the northwest, where increased bedding and coarser grain sizes would be expected. This may also be a result of a lateral facies change, such as a transition to a flood plain or deltaic sequence, occurring within the northern portion of the site, or may represent younger deposition upon paleo-erosional surfaces. It is this

zone of thin, discontinuous, and laterally variable sands and silts that represents the Upper Aquifer. Within the upper portion of the sequence, the unit changes color from brown to gray, which may represent a change from oxidizing to reducing conditions at the time of deposition.

These near-shore deposits transcend downward into offshore (deep lake) deposits consisting of thickly bedded clay containing silt. This clay unit is approximately 20 ft. thick at the center of the site, extending to a depth of approximately 230 ft. This zone thickens from approximately 20 ft. thick in the northwest portion of the site to more than 30 ft. thick in the southeast portion of the site. This unit is the confining bed separating the Upper and Lower Aquifers.

This offshore deposit transcends into another shoreline and near-shore sequence, generally comprising thick-bedded silt and thin-bedded clay that contains thin-bedded sands and sand lamina. This zone (the Lower Aquifer) is continuous across the site, although individual sand beds gradually thin and pinch out. This unit extends to a depth of approximately 250 ft., where again, deposition transcends into deeper offshore deposits of thick-bedded clay and fine silt, which provide the basal confinement of the Lower Aquifer. It appears from the limited information and from the deep borings that this facies again transcends into another sequence of near-shore sands and silts at approximately 290 ft. in depth. These sands are very thin-bedded and have not been investigated.

The drilling logs of the deep artesian well onsite and the 800-foot-deep exploratory water well (WWI) west of the site indicate that the strata below 300 ft. are predominantly blue clay and shale to at least 1,770 ft. A stratigraphic column for the artesian well showing the deep strata beneath Site B is provided in Figure E-7.

E.3.c.(2)(c) Structure

Units of the Glenns Ferry Formation at the site strike north 69 degrees west, and dip approximately 3.5 degrees to the northeast. Gradual differences have been noted within the formation and reflect changes in depositional environment reflective of lacustrine sedimentation and Snake River Plain downwarping. The upper near-shore sequence (i.e., the Upper Aquifer measured at its base) strikes north 70 degrees west and dips 1.8 degrees northeast. The next near-shore sequence (i.e., the Lower Aquifer measured at its center) strikes north 70 degrees west and dips 2.4 degrees northeast, as measured from Coreholes D-32, D-22, and D-21.

No evidence of faulting exists within the depths of the investigation at the site as determined by surface mapping of existing trenches and analysis of geologic cores. Units can be traced across the site using geophysical logs and direct core logs, all of which conform to measured strike and dips. No indications of faulting (such as displacement, associated fracturing, or alteration) have been witnessed throughout the entire geologic section investigated.

E.3.c.(3) Site Hydrostratigraphy

Section E.3.a. of this report described the geologic framework of the upper 3,000 ft. of sediments. This section, E.3.c.(3), will describe in detail the hydrologic and hydrochemical properties of two interbedded sand zones that have been defined as uppermost aquifer(s) beneath the site pursuant to IDAPA 58.01.05.012 [40 CFR 270.14(c)(2)].

E.3.c.(3)(a) Overview

Two low-yielding, water-bearing zones denoted as the Upper and Lower Aquifers have been identified within the shallow Glenns Ferry Formation beneath Site B. Although neither zone would be classified as an aquifer for water resources development because of the definition of the uppermost aquifer in the regulatory context, they represent the uppermost aquifer(s) of concern for groundwater monitoring

purposes. The Upper Aquifer at Site B consists of finely bedded, fine, silty sand in 80 ft. to 90 ft. of silt and clay. The top of the Upper Aquifer sequence is a gradational contact with the overlying fluvial facies of the Glenns Ferry Formation. The top of the Upper Aquifer section is 120 to 160 ft. below ground level. A massive clay, 20' to 30 ft. thick, hydraulically separates the Upper Aquifer from another group of fine, silty, and clayey sands referred to as the Lower Aquifer. The top of the Lower Aquifer is 220 ft. to 275 ft. below ground level and the aquifer section is 30 ft. to 40 ft. thick. Because of structural dip, both aquifers slope to the northeast at approximately 2 to 4 degrees.

As a result of the northeasterly structural dip, the Upper Aquifer sands gradually emerge out of the water from north to south across the site. The entire Upper Aquifer becomes unsaturated along a general east-west trend that crosses the south-central portion of the site. South of this emergence, the sands comprising the Upper Aquifer are present but they are above the potentiometric surface and are not saturated. Conversely, the saturated thickness of the Upper Aquifer increases from south to north as more sands become saturated.

The potentiometric surface of the Upper Aquifer varies from 140 ft. to about 200 ft. below ground level. Groundwater in the Upper Aquifer flows into the site all along the northern border, but most enters from the northwest corner. Flow in the Upper Aquifer is to the east and southeast. The permeabilities of the Upper Aquifer are low, and sustained well yields are generally less than 1.0 gpm.

The Lower Aquifer consists of two (2') ft. to nine (9') ft. of thinly bedded, very fine sand and silty sand seams in a 30- to 40-foot-thick section of silts and clays. Most sand beds are found within a 15-foot-thick interval. The Lower Aquifer is saturated beneath the entire site. The permeabilities of the Lower Aquifer are low, and well yields are generally less than 0.5 gpm. Water in the Lower Aquifer is under moderate artesian pressure. Along the northern edge of the site, water levels rise 60 ft. to 80 ft. above the top of the aquifer. Groundwater in the Lower Aquifer flows to the northeast.

Figure E-11 is a diagrammatic cross section showing the Upper and Lower Aquifers at the site. The two aquifers are described and characterized in detail in the following sections.

E.3.c.(3)(b) Upper Aquifer

The Upper Aquifer sequence consists of thinly bedded sands and sand lamina separated by thin- to thick-bedded silts and clays. The individual sand seams range from less than 1.5 ft. thick to partings less than 1/16 of an inch thick. Most are between 0.5ft. and 0.1 ft. thick and consist of very fine-grained, silty sand. Lateral continuity of individual sands is difficult to demonstrate, but the aquifer sequence is present across the entire site. The total cumulative thickness of the sand beds changes laterally east and west because of depositional variations.

In the northwest portion of the site, the cumulative thickness of saturated sand beds in the Upper Aquifer ranges from about eight ft. (8) ft. to 36 ft., occurring over approximately 70 ft. of fine- to thick-bedded silts and clays. The individual sand beds thin and pinch-out toward the east and south. Therefore, the Upper Aquifer contains less sands and does not yield as much water to the east and south. The cumulative thickness of bedded sands underlying the water table in the eastern portion of the site is approximately two (2') ft. to 12 ft., occurring over approximately 20 ft. to 50 ft. of fine- to thick-bedded silts and clays.

The bottom of the aquifer sequence is represented by a relatively rapid gradational change from bedded silts and silty clay to the massive silty clay and clay of the underlying confining bed. The bottom of the Upper Aquifer section ranges from 185 ft. to 250 ft. below ground level.

The top of the Upper Aquifer is also a gradational contact. As discussed earlier, the Upper Aquifer is developed in the lacustrine facies of the Glenns Ferry Formation. The contact between the lacustrine and overlying fluvial sediments is a gradational facies change represented by a thinning of beds and dominance of silts and clays from fluvial to lacustrine. The top of the lacustrine facies (top of the Upper Aquifer sequence) ranges from 120 ft. below ground level in the northwest corner to about 160 ft. below

ground level in the northeast corner; across the central portion and eastern sides it is 120 ft. to 140 ft. below ground level. Thickness of the sequence ranges from 80 ft. to 90 ft.

The top of the saturated water-bearing portion of the Upper Aquifer is a function of the intersection of the dipping stratigraphic sequence and the potentiometric surface. Because of the dip, the section rises above the potentiometric surface and becomes unsaturated across the southern portion of the site. From south to north, the dip causes progressively more sand seams to intercept the potentiometric surface and become saturated. Consequently, the saturated thickness of the aquifer increases to the north and the top of saturation is found progressively higher in the geologic section comprising the Upper Aquifer.

Each individual saturated sand seam is probably under confined conditions as a result of the adjacent silt and clay beds. Given the scale of the bedding, it is impossible to isolate individual sand seams to verify this assumption. Taken as a whole, however, there appears to be little evidence of vertical gradient within the Upper Aquifer section, and, therefore, the aquifer is considered to be unconfined.

E.3.c.(3)(c) Intermediate Clay Bed

The inner confining clay between the Upper and Lower Aquifers ranges from 20 ft. to 30 ft. thick across the site. As discussed in the previous section, the top of the inner confining clay is gradational with the silts of the bottom of the Upper Aquifer. A similar transitional contact exists between the bottom of the confining clay and the top of the Lower Aquifer. In both cases, the gradational contact occurs within about five ft. (5). This clay consists of blue-gray, massive to thickly bedded clay. In Corehole D-23, in the northwest corner, there are seven (7) to ten (10) silty sand lamina (less than 1/8” thick) within the 20 ft. thick clay, while along the east side, no sand lamina are found in the entire 20 ft. thick section.

This clay unit is persistent and consistent across the site and hydraulically separates the Upper and Lower Aquifers. This hydraulic separation is evidenced by differences in water level, flow directions, and water chemistry between the Upper and Lower Aquifers. These indicators of hydraulic separation are discussed in more detail in subsequent sections.

E.3.c.(3)(d) Lower Aquifer

The Lower Aquifer is a sand sequence within silts and clays of the Glenns Ferry Formation. Although the persistence and thickness of individual thinly bedded sands varies laterally, the aquifer is present and saturated everywhere beneath the site.

The bedded sands occur within a 30 ft. to 40 ft. thick sequence of thick-bedded silts and clays. The majority of sands occur within a 10 ft. to 15 ft. interval. Coreholes and geophysical logs of borings indicate that the bedded sands pinch and thin toward the west and south, forming very thin-bedded sands and sand lamina less than ¼” thick. Some sands are discontinuous and pinch out. The total cumulative thickness of bedded sands in the western portion of the site is less than four (4) ft.

Along the east side of the site, the individual beds range from sand lamina (less than ¼ inch thick) to one ft. (1) thick bedded sands, the latter consisting of fine- to very fine-grained silty sand. Most of the water is probably being carried in the upper portion of the sequence, where greater sand thickness and persistence exist. The total cumulative thickness of bedded sands in the Lower Aquifer along the eastern side is less than nine (9) ft. The top of the Lower Aquifer section is 205 ft to 275 ft. below ground level, and the bottom is 305 ft. to 250 ft. below ground level. The Lower Aquifer section generally ranges from 30 ft. to 40 ft. thick.

E.3.c.(3)(e) Basal Confining Clay

Underlying the Lower Aquifer is a massive to thickly bedded clay at least 25 ft. thick. This clay was penetrated in only a few borings, and it has not been tested extensively. Visual descriptions indicate it to

be massive (does not contain sand lamina) and “fat,” having high plasticity. Properties of this clay are expected to be similar to the inner confining clay.

E.3.c.(4) Hydraulic Properties

E.3.c.(4)(a) Introduction

Pursuant to IDAPA 58.01.05.012 [40 CFR 270.14(c)(2)], the hydrogeologic regime at USEI Site B was characterized as part of the initial permit application process (CH2M HILL, February 1986). Subsequent to the issuance of the permit, considerable additional information has been developed on the hydraulic properties of the Upper and Lower Aquifers at Site B. This portion presents a complete reexamination of the hydrologic properties of Site B, using both previously presented information and new information. The objectives of the hydrologic characterization program were to 1) examine the factors that influence the rate and direction of groundwater movement; 2) evaluate overall groundwater availability; 3) evaluate the degree of hydraulic separation of the Upper and Lower Aquifers; and 4) estimate the degree of containment afforded by the clays and other sediments found above, below, and between the aquifers.

Information from the available data were used individually and conjunctively to determine the hydraulic characteristics that define the groundwater flow properties at USEI Site B. The aquifers at Site B consist of finely bedded, fine sand and silt beds in a predominantly silty clay matrix. Because most groundwater flow, and therefore most of the potential contaminant migration, would occur in the sand beds, the ultimate aquifer property being sought from the aquifer test data was the hydraulic conductivity (K) of the sand beds, as opposed to a composite hydraulic conductivity of the entire saturated thickness. Most of the test data available, however, provided either an estimate of the composite K or the transmissivity (T) of the entire saturated thickness of the aquifer.

To estimate the K of the sand beds, the T and/or K values from the aquifer tests described in Section E.3.b. were adjusted to reflect only the cumulative thickness of sand beds identified in the wells as estimated from review of the geologic and geophysical logs for each well. Once a K was determined, an estimated groundwater velocity was calculated. Aquifer transmissivities were also used to compare the relative water flux across the site through and between aquifers.

To evaluate the degree of containment afforded by the clays and other sediments found above, below, and between the aquifers, laboratory testing was performed on soils collected from the Upper and Lower Aquifers and the inner and lower confining units. Grain-size analyses and permeability testing were performed on 79 samples of materials from three (3)borings, D-21, D-22, and D-23, at the USEI site. These data were previously reported in CH2M HILL (February 1986) as part of USEI’s 1985 Part B permit application. The locations of D-21, D-22, and D-23 are shown in Figure E-8.

E.3.c.(4)(b) Results

Table E-9 summarizes the results of all available testing data used to estimate the hydraulic properties for the Upper and Lower Aquifer at USEI Site B. Usable data are not available on all wells but the large amount of data that was available provides valuable information on both aquifers beneath all portions of the site. Table E-10 summarizes the results of all laboratory hydraulic testing for site soils. The complete data sets and results of the single-well and specific capacity tests and selected grain-size analyses are presented in Appendix E.5. Soil hydraulics testing data are presented in CH2M HILL (February 1986).

In Section E.3.b., a transmissivity value was estimated for each pumping and recovery test, slug test, and specific capacity test (Table E-9). Based on the individual tests, an average T value for each well was calculated as shown in Table E-9. The average T value is the average of all aquifer tests performed over the lifespan of the well. Additionally, if an individual test was analyzed by more than one analytical technique and more than one analytical technique provided a valid solution, then all valid solutions are included in the calculation of the average T value.

Table E-9 also summarizes the hydraulic conductivity (K) values obtained from the aquifer tests. K values were calculated from the average transmissivity data through the relationship K = T/b where b = the saturated aquifer thickness. Representative thickness values were obtained for 22 of 28 test wells in the Upper Aquifer and 14 of 15 test wells in the Lower Aquifer where successful transmissivity values were obtained. Representative thickness values were determined via an interpretation of subsurface conditions at each respective test site. Information from all geologic and geophysical logs were used to estimate the actual thickness of sandbeds present within each test interval. This was done to adjust the aquifer test results under the premise that most of the aquifer response during the tests occurs from the sandier aquifer zones, and not the adjacent confining zones, a portion of which is generally included in the test interval. This resulted in a conservative reduction in the thickness values and an associated conservative increase in hydraulic conductivities.

As a supplement to the in situ determination of hydraulic conductivity provided by the aquifer tests, hydraulic conductivity values were also calculated from grain-size distribution information by the Hazen Method. Thirteen (13) of the 79 samples shown in Table E-10 had grain-size analysis performed on the most permeable beds in the Upper and Lower Aquifers. Table E-11 summarizes the calculated hydraulic conductivity estimates for these 13 soil samples based on the Hazen Method. The Hazen Method is one of several predictive equations that relate hydraulic conductivity values to the grain-size distribution of representative aquifer materials. The techniques are approximation methods, but generally provide useful estimates of hydraulic conductivity (Freeze and Cherry, 1979). Todd (1980) cautions that the empirical formulas may not give reliable results because of the difficulty of including all possible variables in porous media. Therefore, field and laboratory methods are preferable as a general rule.

The Hazen Method estimates K through the following relationship (Equation E.3-2):

$K = A (d_{10})^2$
where:

K is the hydraulic conductivity, A is a conversion factor (equal to 1.0 when K is reported in cm/sec and grain size in millimeters [mm]), and d_{10} is the grain-size diameter at which ten (10) percent by weight of the particles are finer.

Upper Aquifer

For the Upper Aquifer, transmissivity values were obtained from 28 test wells. Average T values ranged from a low of 0.1 ft^2/day for U-26 to a high of 51.1 ft^2/day for D-18 (abandoned). The mean transmissivity for the Upper Aquifer is 7.0 ft^2/day, based on an average of the average T values. Figure E-12 denotes the average transmissivity values obtained for each Upper Aquifer test site. Figure E-12 also shows the distribution of T values in the Upper Aquifer. The highest T values of the Upper Aquifer occur beneath the north/northwest portions of the facility and generally decrease toward the south and east.

To understand the significance of these transmissivity values, they can be compared to minimum values required for a domestic water supply. The U.S. Bureau of Reclamation (USBR) has investigated and published the transmissivity values necessary for water supply development purposes (USBR, 1977). Transmissivity values below one (1) ft^2/day are considered infeasible for domestic well purposes, while transmissivity values between one (1) ft^2/day and 10 ft^2/day are considered poor. Fair well potential can be achieved with transmissivity values between 10 and 100 ft^2/day. Thus, the transmissivity values obtained for the test sites are generally in the infeasible to poor well potential range, with only five (5) average T values of the Upper Aquifer test locations falling in the fair range. As shown in Figure E-12, the five higher-yielding wells are located in the north/northwest portion of the Upper Aquifer.

Table E-9 shows that the calculated hydraulic conductivity values derived from the average T for the Upper Aquifer materials range from a minimum of 4.0×10^{-2} ft/day (1.4×10^{-5} cm/sec) at U-26 to a maximum of 4.2 ft/day (1.5×10^{-3} cm/sec) at UP-7. These values are representative of very fine sands and mixtures of sand, silt, and clay, which are reported to have conductivity values ranging from 10^{-}

^{3} cm/sec to 10^{-6} cm/sec (Todd, 1980). Consistent results were observed between the geologic classification of subsurface materials and their calculated conductivity values. From Table E-11 it can be seen that the range of empirically derived hydraulic conductivity values (Hazen Method) in the Upper Aquifer is significantly lower than the range determined with the pump tests (Table E-9). For the Upper Aquifer, empirically derived hydraulic conductivity values ranged from 2.6 x 10^{-2} ft/day (9.0 x 10^{-6} cm/sec) to 0.5 ft/day (1.69 x 10^{-4} cm/sec). The hydraulic conductivity values obtained from the grain-size analyses may include finer-grained materials from the confining zones that are adjacent to the sandier aquifer zones. This could account for the somewhat lower values observed. It is important to note that the hydraulic conductivity values obtained from the grain-size analyses were not used in the computation of groundwater velocities. Rather, they have been included for exemplary purposes and as an additional check on pumping test-derived hydraulic conductivities.

Lower Aquifer

For the Lower Aquifer, transmissivity values were obtained from 22 test wells. Average T values ranged from a low of 0.03 ft^2/day for L-45 to a high of 3.3 ft^2/day for MW-5 (abandoned). The mean transmissivity for the Lower Aquifer is 1.0 ft^2/day, based on an average of the average T values. Figure E-13 denotes the average transmissivity values obtained for each Lower Aquifer test site. T values in the Lower Aquifer are low and do not appear to follow a discernible distribution pattern. Based on the USBR criteria discussed above, the transmissivity values obtained from the Lower Aquifer test sites are in the infeasible to poor well potential range for a domestic water supply.

The calculated hydraulic conductivity of the Lower Upper Aquifer materials range from a minimum of 6.9 x 10^{-2} ft/day (2.4 x 10^{-5} cm/sec) at L-38 to a maximum of 8.3 x 10^{-1} ft/day (2.9 x 10^{-4} cm/sec) at MW-5 (abandoned). Similar to the Upper Aquifer, these values are representative of very fine sands and mixtures of sand, silt, and clay, which are reported to have conductivity values ranging from 10^{-3} cm/sec to 10^{-6} cm/sec.

From Table E-11, it can be seen that the range of empirically derived hydraulic conductivity values (Hazen Method) in the Lower Aquifer is lower than the range determined with the pump tests (Table E-9). For the Lower Aquifer, empirically derived hydraulic conductivity values ranged from 2.8 x 10^{-3} ft/day (1.0 x 10^{-6} cm/sec) to 0.6 ft/day (1.96 x 10^{-4} cm/sec). As noted above, the hydraulic conductivity values obtained from the grain-size analyses may include materials from the confining zones that are adjacent to the sandier aquifer zones. This could account for the somewhat lower values observed. It is important to note that the hydraulic conductivity values obtained from the grain-size analyses were not used in the computation of groundwater velocities. Rather, they have been included for exemplary purposes and as an additional check on pumping test-derived hydraulic conductivities.

Intermediate (Inner) and Basal Confining Layers

Soil samples collected from D-21, D-22, and D-23 that represent the inner and basal confining zones are identified in Table E-10. The vertical coefficient of permeability was determined for ten (10) of the confining material samples. The range in vertical permeabilities for the two confining zones was 1.1 x 10^{-4} to 1.4 x 10^{-1} ft/day (4 x 10^{-8} to 5.0 x 10^{-5} cm/sec). The single sample (boring D-22, sample S-31) with the 5.0 x 10^{-5} cm/sec value is probably due to bedding fractures within the clay as noted on the well log (CH2M HILL, February 1986) or may represent a silty or sandy seam in the confining bed. Without including this sample, the vertical conductivity of the confining beds ranges from 5.7 x 10^{-3} ft/day (2 x 10^{-6} cm/sec) to 1.1 x 10^{-4} ft/day (4 x 10^{-8} cm/sec) and the mean value is 2.8 x 10^{-4} ft/day (1 x 10^{-7} cm/sec).

As shown in Table E-10, the moisture content for the soil samples collected from the inner and lower confining zones ranged from 23.0 % to 31.0 % and averaged 28.1 %, and the degree saturation ranged from 89.4 % to 98.7 % and averaged 93.7 %. These data indicate that moisture was present in the confining zones at near-saturated field conditions. According to the field drilling logs, the moisture content within the inner and upper confining zones ranged from dry to moist, supporting the presence of some

moisture in the soils in the confining zones. However, the moisture content in soils below 100 ft. may have been affected by water used in rotary drilling.

E.3.c.(5) Groundwater Flow Properties

E.3.c.(5)(a) Water Level and Hydraulic Gradient

Depth to Water Level Measurement Corrections

The results of gyroscopic surveys at piezometers U-26, UP-28, and UP-29 and monitoring well L-28 indicate that UP-28, UP-29, and L-28 significantly deviate from vertical, and U-26 does not significantly deviate from vertical. As a result, the depth to water measurements at UP-28, UP-29, and L-28 have been corrected based on regression analysis. The equations used to correct the depth to water measurements at UP-28, UP-29, and L-28 are shown in Table E-12. The regression analysis and the uncorrected and corrected depth to water measurements are provided in Appendix E.6.

Based on the corrected depth to water measurements, the water level elevation anomaly indicated on potentiometric surface maps of the Upper Aquifer in the vicinity of UP-28 does not appear to be directly associated with the inclination of the piezometer off of vertical. However, the water level elevation anomaly indicated on potentiometric surface maps of the Lower Aquifer in the vicinity of UP-28 does not appear to be directly associated with the inclination of the piezometer off of vertical.

Potentiometric Data

Groundwater levels at USEI Site B are measured semiannually in the monitoring wells and piezometers included in the permitted Detection and Compliance Monitoring Systems. The period of record for each well varies according to when the individual well was installed. Some of the wells in the groundwater monitoring system were installed as test wells for site characterization prior to USEI receiving the permit. Consequently, they have periods of record extending back to 1984. Most of the active monitoring wells were installed after the Part B permit was issued and, therefore, the effective period of record begins in 1989

The pre-1989 data sets tend to have more scatter than the post-1989 wells for several reasons:
1) insufficient water level re-equilibration time between frequent sampling and testing activities;
2) variable wellhead configurations and therefore various measure points between wells and over time for the same well; and 3) non-standardized equipment. As the new and existing wells were brought into the permitted Groundwater Monitoring System, wellheads and measuring points were standardized, dedicated water level probes were used and written field procedures and data recording formats were adopted. These measures significantly reduced the data scatter in these records.

Water level data and hydrographs for the pre-1989 period are presented in CH2M HILL (February 1986). As discussed in the next section, water levels have been rising at Site B. In 1999 a Rising Groundwater Study was completed (CH2M HILL,1999b). As required by the permit, the rising groundwater was re-evaluated every two years until 2005. In 2006, DEQ approved a request by the Permittee to change to a five (5) -year interval for evaluation of the rising groundwater.. The 2010 re-evaluation report is provided as Appendix E.6. Appendix A of the 2010 re-evaluation report provides updated data and hydrographs for the on-site wells through October 2010. The next scheduled re-evaluation of the rising groundwater at Site B will be completed in 2015. The rising groundwater study is further discussed in the next section.

From April 1989 through the October 1996 sampling event, all water levels were measured with the same water-level probe. Prior to the October 1997 water-level measurements, however, the original probe failed and could not be repaired. Consequently, a new water meter was used for the October 1997 water-level data set. Calibrating the new probe or establishing a measurement offset by collecting comparison water levels from several wells using both probes could not be completed before the old probe failed.

In comparing the October 1996 to October 1997 water levels, many wells exhibited a significant decline in recorded water-level elevations between the two events. Because a correlation could not be established between the two probes, the observed declines in water levels between the successive October water levels are not considered reliable.

Water levels are tabulated after each sampling event and included in the sampling reports contained in the operating record. These reports document the water level data collected between April 2001 and October 2013. The October 2013 water levels are included on Table E-13 and the period of water level record from October 1989 to October 2013 is used in this section to describe the water level trends, potentiometric surfaces, hydraulic gradients, groundwater velocities, and the groundwater flux and water balance for the Upper and Lower Aquifers at Site B.

Water Level Trends

Water levels in the monitoring wells and piezometers at Site B have been generally rising over the period of record. The rate of rise for each well is variable and not consistent between wells or over the period of record for any individual well as illustrated by the hydrographs provided in Appendix E.6

In 1999 a rising groundwater study was completed (CH2M HILL, 1999b). This study examined flow paths, water chemistry and age dating in an effort to determine the source of the rising groundwater. The rising groundwater study determined that the water in the Lower Aquifer water and eastern portions of the Upper Aquifer were of similar ages but that the water in the Upper Aquifer in the extreme northwest corner of the site was much younger. This suggests that the water coming into the site in the Upper Aquifer was being recharged by Castle Creek about one (1) mile to the west. This incoming water is displacing the older water in the Upper Aquifer. The rising hydraulic head in the Upper Aquifer is also affecting the pressure head in the Lower Aquifer, especially where the two aquifers overlap. Because of the potential impacts of rising water levels on groundwater flow rates and directions, monitoring well screen placement and concerns over possible impacts to water quality as the rising groundwater encounters vapors or the missile silos, DEQ required the rising groundwater trends to be re-evaluated every two years. In 2006, DEQ approved a request by the Permittee to change to a five (5) -year interval for evaluation of the rising groundwater

The 2001 re-evaluation report, used regression analysis to predict future water level elevations based on the assumption that the rising water level trends continue at current rates. In summary, these projections indicate the Upper Aquifer water levels will contact the bottom of the missile silos in 36 to 53 years (year 2039 to 2056), again, assuming past trends continue unchanged into the future. In many wells the hydrographs show an initial steeper trend followed by a distinct flattening trend beginning in about 1993 so these predictions must be used with caution. The re-evaluation report also concluded that rising water would not seriously impact well construction or placement as the groundwater flow directions have not changed.

Table E-13 summarizes the water level differences for those wells with 1989 and 2013 data. As shown on this table, the average rise in the Upper Aquifer wells is 7.4 ft. for the period from October 1989 to October 2013. The maximum change has been an increase of 12.41 ft. in piezometer UP-4 and the minimum rise is 4.11 ft. in piezometer UP-6. In general, water levels in the Upper Aquifer on the east side of the site have risen faster than those on the west side. This has resulted in a gradual decrease in the west-to-east gradients across the site, although groundwater flow paths have not significantly changed. A contour map showing the change in water levels in the Upper Aquifer between October 1989 and October 2013 is provided in Figure E-14.

Water levels in the Lower Aquifer wells have also risen over this same period. The average rise in the Lower Aquifer is 10.1 ft. and the range is from 1.52 ft. in well L-38 to 15.62 ft. in well LP-29. In general the wells with the highest water level change, are overlain by the Upper Aquifer. Since the Lower Aquifer is confined, the water levels in these wells are believed to be responding primarily to the increase in loading

from the water level rise in the Upper Aquifer. A contour map showing the change in water levels in the Lower Aquifer between October 1989 and October 2013 is provided in Figure E-15.

Well L-38 in the extreme southwest part of the study area experienced a sudden water level increase of approximately ten ft. (10) in 1993 that is believed to be caused by surface loading of earth materials stockpiled in the vicinity during the excavation of Cell 14. Since 1993, the water level has been gradually declining back to the trend line that existed prior to the “spike.” Similar, but smaller, spikes occurred in wells L-35 and LP-14 during this same time. These wells are also near the soil stockpile area. Well L-36, in contrast, experienced a drop of approximately three ft. (3) in the water level during this same time, apparently in response to the decrease in loading as the nearby Cell 14 trench was excavated. Since 1993, the water level in L-36 has been gradually rising back to the trend line that existed before the sudden drop in water levels. Water level changes in the Lower Aquifer have not significantly affected the groundwater flow paths.

Potentiometric Surface

Lower Aquifer. Potentiometric surface maps for the Upper and Lower Aquifers for October 1989 and October 2013 are provided as Figures E-16 through E-19. Flow lines showing the horizontal direction of flow across the site are also shown pursuant to IDAPA 58.01.05.012 [40 CFR 270.14(c)(2)].

Comparing Figures E-16 and E-17 for the Lower Aquifer, October 1989 and October 2013, respectively, indicates little change in the direction of groundwater flow over this period. Groundwater in the Lower Aquifer moves into the site from the southwest and flows northeasterly across the southern end of the site. The equipotential lines on the figures are equally spaced and trend uniformly northwest-southeast. The consistency of the equipotential lines is also another indication that geologic matrix and hydraulic properties of the Lower Aquifer of the site are uniform across the southern and southwestern portions of the site. This uniform flow field characteristic is consistent with the geologic descriptions and hydraulic property characterization data presented earlier in this section.

The potentiometric surface in the Lower Aquifer changes character radically northeast of Cell 14. Because the piezometers in this area are linearly aligned along the northeastern side of the site (LP-12, LP-13 and LP-15), it is difficult to determine true flow patterns. However, the data suggest that groundwater flow in the Lower Aquifer changes to an easterly direction and that the gradients flatten out in this area.

Geologic coring, hydraulic property testing, and geophysical logging of the Lower Aquifer sediments in this area do not indicate any changes in the geologic framework or hydrogeologic properties that would account for these flow direction changes. The apparent distortion of the consistent northeasterly flow pattern exhibited by the Lower Aquifer to the southwest appears to be coincidental with the southern limit of saturation in the overlying Upper Aquifer. These data indicate the potentiometric head in the Lower Aquifer is influenced by the overlying Upper Aquifer. This influence is believed to be primarily related to hydraulic pressure, as opposed to leakage. The hydraulic communication between the Upper and Lower Aquifer is discussed in more detail in Section E.3.c. below.

Based on the October 2013 potentiometric map in Figure E-17, horizontal gradients in the southern part of the Lower Aquifer (that portion not overlain by the Upper Aquifer) range from 0.0110 to 0.0440 ft/ft and average 0.0261. It is not possible to establish a gradient for the Lower Aquifer north of the Cell 14 monitoring wells (where it is overlain by the Upper Aquifer) because of insufficient data points.

Upper Aquifer

Water table maps for the Upper Aquifer for the October 1989 and October 2013 periods are provided in Figures E-18 and E-19. Although, as discussed previously, water levels in the Upper Aquifer wells have

risen 5.0 ft. to 12.4 ft. over the 1989 to 2013 time period, the overall pattern of groundwater flow has not changed. Water in the Upper Aquifer flows across the site from northwest to southeast. As can be seen in Figure E-19 (2013 Water Level map), water also flows into the site all along the northern boundary. This water flows diagonally across the northeastern corner and exits the site along the eastern boundary.

The additional water level data provided by wells UP-28 and UP-29, installed in 1993 along the west central side of the site, suggests a radical and unexplained gradient change in this area as shown on the October 2013 potentiometric map, Figure E-19. The data from these wells indicate that along the west central side of the site, water in the Upper Aquifer is flowing from southwest to northeast, which is almost perpendicular to the predominant flow direction in the Upper Aquifer. However, as shown in Figure E-19, the groundwater flowing from the area of UP-28 and UP-29 eventually converges upon and joins the rest of the system. Detailed site characterization efforts in this area, including a discussion of the high water levels in wells UP-28 and UP-29, are reported in CH2M HILL (June 1993).

Well UP-28 was drilled into the Lower Aquifer to verify the stratigraphy prior to well construction. Although the Lower part of the borehole was plugged with bentonite grout prior to installing the well, upward leakage of Lower Aquifer water cannot be ruled out. It is unlikely, however, that the high water level at UP-28 represents a mounding effect since the Upper Aquifer sediments should be able to accommodate any minimal leakage past the bentonite seal that could be occurring. There are insignificant chemistry differences between the Lower part of the Upper Aquifer and the Lower Aquifer; therefore, there is not a distinctive chemistry profile that can be used to determine if the high water levels represent leakage up the borehole (see Section E.3.c.(6)). Well UP-29 was not drilled into the Lower Aquifer, yet water levels in this well are also higher than expected. This suggests a natural cause for the elevated heads that cannot be explained by the existing data. At this point, the water levels in well UP-28, and to a lesser extent in UP-29, represent the only deviation in the overall northwest-southeast flow direction in the Upper Aquifer.

The irregular spacing and curved equipotential lines for the Upper Aquifer are an indication of the variable Aquifer hydraulic properties of the Upper Aquifer as described previously in Section E.3.c.(4). There are two hydrologic gradient regimes in the Upper Aquifer, illustrated by the distinct spacing of the equipotential lines in Figure E-19. The western 1/2 of the aquifer displays gradients in the range of 0.0049 to 0.0089 ft/ft. The eastern 1/2 has much steeper gradients that range from 0.0140 to 0.0235 ft/ft. The demarcation between the two gradient regimes appears to extend from slightly west of U-26 on the southern extent of the aquifer to between U-5 and UP-7 on the northern site boundary. The area of low gradients in the north and northwest parts of the site coincides with the areas of high hydraulic conductivity and transmissivity described in Section E.3.c.(4) and shown in Figure E-12. Aquifer properties and well yields are Lower along the eastern side and southern extent of the aquifer. The pattern of hydraulic gradients illustrated in Figure E-19 mirrors and supports the distribution of aquifer properties.

E.3.c.(5)(b) Groundwater Flux and Velocities

Lower Aquifer

The cluster of sand and silty sand seams comprising the Lower Aquifer occurs over an interval 20 ft. to 40 ft. thick. Recalling that aquifer transmissivity, T, is defined as the hydraulic conductivity times saturated thickness, groundwater flux, or the volume of groundwater moving with time through the Lower Aquifer beneath the southern portion of the site, can be estimated by Q = T x I x width, where T = the average aquifer transmissivity, I = the average horizontal gradient, and width is the width of the aquifer parallel to the equipotential lines. The average T for the Lower Aquifer determined in wells around Cell 14 is 1.0 ft/d (Table E-9). The average gradient for the southern portion of the site using the October 2013 water level data is 0.0261 ft/ft as discussed previously. The cross-sectional width of the aquifer beneath Cell 14 is approximately 2,000 ft.. Based on these variables, there is about 57 cubic feet (ft^3) per day or 20,958 ft^3/year of water moving through the entire width and thickness of the Lower Aquifer. To put this flow rate in perspective, a typical household uses 400 gallons per day or 19,600 ft^3/year. Because the cross-sectional area, hydraulic conductivity, and hydraulic gradient in the Lower Aquifer do not change

significantly across the site, flux into the site from the west side and flux leaving the site on the east side are approximately equal.

Most groundwater movement and, therefore, contaminant transport, will occur through the sand seams making up the aquifer. Groundwater velocities for the sand seams can be estimated by Velocity = (K x I)/n_e where K is the hydraulic conductivity, I is the gradient, and n_e is the effective porosity. Effective porosity is defined as that portion of the total porosity through which flow occurs. Effective porosity is almost impossible to determine because of the difficulty in obtaining undisturbed samples. As presented in the 1986 Section E document (CH2M HILL, February 1986), the average porosity of the fine sands in the Upper and Lower Aquifers at Site B was 0.43. Also, as discussed in the 1986 Section E, researchers have concluded that for groundwater flow through granular media, the total porosity can be used in the velocity calculation with little effect. Therefore, velocity calculations for Site B made since 1986 have used the porosity value of 0.43. The K and porosity of the sand beds, as discussed in the Aquifer Properties section, were used in the velocity calculations. Calculated seepage velocities for the Lower Aquifer range from 2.6 ft. to 11.2 ft. per year and average 5.2 ft. per year. Calculated velocities vary with the K and I at each well. Table E-9 provides the calculated velocity at each Lower Aquifer well for which a K and I value have been determined.

Upper Aquifer

Flux calculations for the Upper Aquifer are more complicated than for the Lower Aquifer because the Upper Aquifer is unconfined, the gradients across the site are highly variable, and the saturated thickness varies from about 70 ft. along the north facility boundary to zero feet across the northern edge of Cell 14 where the last of the aquifer sediments emerge. Consequently, a wedge-shaped, cross-sectional area was used to compute the flux, and separate fluxes were calculated for the west and east sides.

From this exercise, the estimated flux into the site from the west is about 43,122 cubic feet (ft^3) per year and the flux leaving the east side of the site is 5,193 cubic feet (ft^3) per year. The difference between the two values is a net inflow of 37,929 cubic feet (ft^3) per year that must be accounted for. These issues are presented in the Water Balance section (Section E.3.c.(5)(d)), which follows the Upper Aquifer groundwater velocity discussion.

The same approach and assumptions presented earlier for the Lower Aquifer were also used to estimate velocities in the Upper Aquifer sand beds. Calculated seepage velocities for the Upper Aquifer range from 0.2 ft. per year at well U-2 to 81.6 ft. per year at well UP-7. The average for all Upper Aquifer wells is 8.3 ft. per year.

Calculated velocities vary with the K and I at each well. Table E-9 provides the calculated velocity at each Upper Aquifer well for which a K and I value have been determined. Although the composite hydraulic conductivities on the east side of the site are lower than those for the northwest corner, the gradients are higher. Therefore, there are no large and consistent east-west differences in the calculated groundwater velocities in the Upper Aquifer across the site. However, as shown in Table E-9, the three wells with the highest velocities (UP-7, UP-5 and U-6) are all located in the northeast corner of the site.

E.3.c.(5)(c) Vertical Gradients and Flux

Separating the two aquifers is the inner confining bed, a strata of clay and silty clay 20 ft. to 40 ft. thick. The hydraulic head relationship between the Upper and Lower Aquifers across the inner confining bed varies across the site. Near the southern limit of saturation in the Upper Aquifer north of Cell 14, the hydraulic head in the Lower Aquifer is higher than the water table in the overlying Upper Aquifer. Across a narrow band in the middle of the site there is no significant head difference between the two aquifers, and across the northern 1/2 of the site water levels in the Upper Aquifer are higher than the head in the Lower Aquifer.

Using the October 2013 water level data, there are five Upper Aquifer-Lower Aquifer well pairs available to quantify the gradient across the inner confining bed. The upward gradient, as measured in two well pairs (U-26/L-33 and UP-26/LP-27) averages 0.0378 ft/ft with .77 ft. to 1.5. ft. of actual water level difference. There are much greater water level differences between the Upper and Lower Aquifers across the northeast side of the site. Downward gradients in the three well pairs in this area (U-7/LP-13, UP-4/LP-12, and U-12/LP-15) average 0.1231, with actual water level differences ranging from 1.63 ft. at U-12/LP-15 to 6.77 ft. at U-7/LP-13.

Laboratory tests conducted on geologic cores of the inner confining bed and from similar formations within and beneath the Lower Aquifer provided estimates of vertical hydraulic conductivities of $1x10^{-7}$ to $1x10^{-8}$ cm/sec. (CH2M HILL, February 1986). Vertical flow occurs across strata, as opposed to along strata for horizontal flow. Therefore, it is appropriate to assume that in a bedded sedimentary sequence, vertical movement will be controlled by the material having the lowest hydraulic conductivity. To evaluate leakage between the Upper and Lower Aquifers, a vertical conductivity of 10^{-8} cm/sec was used.

Applying Darcy's law and using an average vertical hydraulic conductivity of 10^{-8} cm/sec, the gradients discussed previously, and an upward gradient zone 500 ft. wide by the width of the site (2,000 ft.) results in a flux of 391 cubic feet (ft^3) of water per year moving from the Lower to the Upper Aquifer in the southern part of the site. Doing the same calculation for the area with downward gradients across the northern part of the site indicates a downward flux of 3,822 cubic feet (ft^3) per year moving from the Upper Aquifer to the Lower Aquifer.

Comparing the calculated vertical flux into the Lower Aquifer beneath the northern part of the site to the horizontal flux in the Lower Aquifer south of the area overlain by the Upper Aquifer indicates that about 1/4 as much water is moving vertically into the Lower Aquifer as is coming in horizontally from the southwest. As discussed previously, the horizontal gradients in the Lower Aquifer beneath the northern part of the site appear to flatten and change directions to roughly parallel that in the Upper Aquifer. This gradient change is probably due to a combination of the flux of water coming vertically into the Lower Aquifer and the effect of the hydraulic head imposed by the overlying Upper Aquifer.

As discussed in Section E.3.c.(6), there are distinct water chemistry differences between the Upper Aquifer and the Lower Aquifer wells in the northern parts of the site. In addition, data presented in Section E.3.c.(6) also indicates the water chemistry in all Lower Aquifer wells is similar. If leakage from the Upper Aquifer is a significant source of water for the Lower Aquifer as the Darcy flux indicates, then the Lower Aquifer water chemistry beneath the northern part of the site should also reflect the influx of Upper Aquifer water.

In summary, although there are strong downward gradients and therefore by Darcy's law a calculable net flux of water from the Upper Aquifer into the Lower Aquifer, water chemistry data suggest that the actual flow is much less than the calculations indicate.

E.3.c.(5)(d) Water Balance Calculation

To synthesize the elements affecting the movement of water though the Upper Aquifer at USEI Site B, a water balance was prepared. One of the most significant benefits of conducting a water balance analysis is to check the validity of the estimated physical and hydrogeologic characteristics of the aquifer and the overall conceptual model of the system. If it is impossible to achieve an approximate level of water balance by applying the site characterization data, then either the characteristics are not correct or the conceptual model is not correct. As will be presented in the following section, the water balance for the Upper Aquifer at Site B indicates that the site characterization data are both correct and reasonable and that the overall conceptual model is correct.

The elements of a water balance for the Upper Aquifer are: lateral inflow, lateral outflow, vertical inflow from the Lower Aquifer, vertical outflow to the Lower Aquifer, infiltration of precipitation, groundwater pumpage, and change in storage. To examine the water balance at Site B, the 13-year period from

October 1989 to October 2013 was used. Table E-14 summarizes the results from each element and Appendix E.7 contains the complete water balance calculation sheet. Each of the elements of the water balance discussed independently in the preceding sections is briefly presented below.

Lateral Inflow and Outflow in the Upper Aquifer

As mentioned previously, in the Upper Aquifer there is approximately 43,122 cubic feet (ft^3) per year coming into the site from the northwest and 5,193 cubic feet (ft^3) per year leaving along the eastern side. This results in a net influx of 37,929 cubic feet (ft^3) per year or a total net gain of approximately 498,265 cubic feet (ft^3) over the 1989 to 2013 period.

Vertical Inflow from the Lower Aquifer

The vertical flux calculations provided above account for an influx of 391 cubic feet (ft^3) per year from the Lower Aquifer to the Upper Aquifer over the southern portion of the Upper Aquifer. From 1989 to 2013, this added approximately 5,089 cubic feet (ft^3) of water to the Upper Aquifer.

Vertical Outflow to the Lower Aquifer

Over the northern portion of the Upper Aquifer, the calculated flux from the Upper Aquifer to the Lower Aquifer was about 3,822 cubic feet (ft^3) per year, or 49,683 cubic feet (ft^3) over the 1989-2013 period.

Precipitation Infiltration

There is no direct evidence of the infiltration of precipitation at Site B. In fact, the only hard evidence, very dry moisture contents in the vadose zone determined during the vadose zone characterization, suggests no infiltration is occurring. However, infiltration of precipitation occurs under very arid conditions given the right set of circumstances. Therefore, an infiltration component was included. The percentage of annual precipitation that actually infiltrates and reaches the groundwater is highly speculative and in arid ranges may range from essentially zero to about two percent (2 %) of annual precipitation. An infiltration rate of 0.05 inches per year (0.7 % of annual precipitation) was applied to the total square footage of the Upper Aquifer (about 4,000,000) and equates to about 16,667 cubic feet (ft^3) per year, or 216,967 cubic feet (ft^3) from 1989 to 2013. This calculated amount is intuitively much too large for Site B, especially given the dry vadose sediments present. At Site B where compacted clayey surface soils are prevalent and surface water run-off is channeled into lined ponds, infiltration rates are expected to be very low. The rising groundwater study conducted in 1999 (CH2M HILL, 1999) found no evidence of recent precipitation water in the Upper Aquifer through either water chemistry or tritium age dating and it is probable that the effective recharge from precipitation is essentially zero at this site. However, for the purposes of the water balance, a low infiltration rate was used. The conclusions of the water balance evaluation are not affected by the inclusion, or exclusion, of precipitation.

Pumpage

The Upper Aquifer wells are sampled twice per year and pre-sample purging removes 15 to 200 gallons from each well. Approximately 1,800 gallons is removed during each sampling event, resulting in the net removal of approximately 11,551 cubic feet (ft^3) of water from 1989 to 2013.

Change in Storage

As shown in Table E-13, the average water level increase in the Upper Aquifer from 1989 to 1996 was 5.7 ft. Based on the aquifer properties discussed in Section E.3.b.(3), the specific yield of the Upper Aquifer was estimated to range from 0.01 to 0.07. Specific yield is defined as the amount of water released from or taken into storage in one cubic foot (1 ft^3) of aquifer material for every one ft. (1) rise in

water level. The specific yield of the Upper Aquifer is used to equate the observed change in storage to the calculated net volume of water added to the Upper Aquifer from 1989 to 2013.

Water Balance Summary

A water balance calculation is the culmination of all the individual hydrogeologic and hydraulic characteristics presented in Section E.3. It is a final check that the site characteristics can be combined to form a comprehensive model of the hydrodynamics of the site.

The water balance summary is shown in Table E-14. As can be seen, there was a net inflow of approximately 1,100,000 cubic feet (ft^3) between 1989 and 2013. This amount of water must be accounted for as a net increase in storage. To accommodate the observed 7.4 ft. average water level rise in the Upper Aquifer over this period, the calculated specific yield of the Upper Aquifer is 0.029, which is essentially a direct match with the estimated specific yield presented in Section E.3.b.(3).

The two parameters with the most uncertainty, vertical flow from the Upper Aquifer to the Lower Aquifer and infiltration of precipitation, have canceling effects on each other. If a threshold hydraulic conductivity prevents the exchange of water between aquifers and infiltration of precipitation is essentially nil, both of which are quite possible given the data, the net result is still the same. The lateral influx minus the lateral outflux results in approximately the same volume of water to be accounted for with the same resultant specific yield.

Thus, the water balance calculation presented in this section confirms that the hydrogeologic conceptual model developed for Site B is correct and reasonable and that the overall hydraulic properties of the site are well understood and adequately characterized.

E.3.c.(6) Hydrochemistry

E.3.c.(6)(a) Introduction

The purpose of this section is to present available site hydrochemical data and to characterize the hydrochemistry of the USEI site. The hydrochemical data are used to describe the Upper and Lower Aquifers, to describe the differences between the two aquifers, and to evaluate any potential impacts on the aquifer's general chemistry by facility operations.

Three different groundwater chemistry sampling programs have been conducted at the USEI site. These include a RCRA Detection Monitoring Program, the RCRA Compliance Monitoring Program, and a Site Characterization Program. Data collected under the RCRA Detection and Compliance Monitoring Programs include the field parameters (Ph, temperature, and specific conductance), total organic carbon (TOC), total organic halides (TOX), and analysis for 28 specific volatile organic compounds (VOCs). These data were collected on a semiannual basis between April 1989 and October 2013 (except for TOC and TOX which were discontinued in 1999) for background wells and wells monitoring Regulated Units. Wells monitoring pre-RCRA Units were sampled annually. Compliance monitoring wells are sampled semiannually. Data collected under the Site Characterization Program includes common-ion data collected at a number of monitoring wells and piezometers between the years 1984 and 1997. The VOC and TOX data are discussed in Section E.5. Hydrochemical data collected under both programs were used for the hydrochemical characterization presented in this report. This section only addresses the field parameters, common-ions, and TOC characteristics.

E.3.c.(6)(b) Field Parameters.

Groundwater temperature, specific conductance, and pH were measured in the Upper and Lower Aquifer monitoring wells as part of the RCRA Detection Monitoring Program. Between April 1989 and October 2002, 21 Upper Aquifer monitoring wells and 11 Lower Aquifer monitoring wells were sampled on

a semiannual basis. In addition to the semiannual samples, follow-up confirmation samples were also collected at specified monitoring wells when RCRA statistical monitoring criteria were exceeded. Graphs showing the temperature and field and laboratory measurements of pH and specific conductance for each sample event for each well between April 1989 and October 2013 are also presented in Appendices E-8.a. and E-8.b

A summary of the temperature, specific conductance, and pH data is presented in Table E-15. The temperature and pH data summaries in Table E-15 are based on data collected in the field at the time the sample was collected. The specific conductance summary in Table E-15 is based on the laboratory measurement of specific conductance of the groundwater samples. Laboratory conductivity values were used because the field-generated specific conductance measurements appeared to contain significantly more data scatter because of variable field conditions, equipment, personnel and field procedures. Table E-15 includes the minimum, maximum, and mean values for temperature, pH, and specific conductance.

Beginning in 1999 USEI began collecting dissolved oxygen (DO), oxygen reduction potential (ORP) and turbidity measurements during the pre-sample purging process as a means of evaluating these parameters for use in determining when adequate purge volumes had been removed. The data and evaluation of these field parameters are presented in Appendices E.-8.a and E-8.b. USEI has found through this study that DO, ORP and turbidity are not reliable indicators of groundwater equilibrium prior to sampling.

Temperature–Upper Aquifer

Between April 1989 and October 2013, the mean temperature in the Upper Aquifer was 18.2 degrees Celsius and temperatures ranged from a minimum of 15.7 °C at U-49 to a maximum of 21 °C at U-3 and U-4 (Table E-15). Background temperatures at upgradient wells U-1, U-2, U-3, and U-4 ranged from 15.9 °C to 21.0 °C. Regression analysis of the temperature trend graphs of Appendix E.8 indicates no Upper Aquifer well had a statistically significant ($r^2 > 0.6$) temperature change during the study period. However, the temperature trendlines shown in Appendix E.8.a indicate all Upper Aquifer wells, except wells U-20, U-21, and U-22, generally exhibited a downward trend in groundwater temperature between April 1989 and October 1997. At wells U-20, U-21, and U-22, which are adjacent to the missile silos, a general upward trend in groundwater temperature during the same period is indicated.

Temperature–Lower Aquifer

Between April 1989 and October 2013 (Table E-15), the mean temperature in the Lower Aquifer was 18.0 °C and temperatures ranged from a minimum of 15.7 degrees Celsius at L-29 to a maximum of 21.0 °C at L-35. Temperatures at upgradient wells L-38 and L-35 ranged from 16.8 degrees Celsius to 21.0 °C. Regression analysis of the temperature trend graphs of Appendix E.8.b indicates none of the Lower Aquifer wells had a statistically significant trend ($r^2>0.6$) change during the study period. However, the temperature trendlines indicate all Lower Aquifer wells, except for L-35 and L-33, exhibited a general downward trend in groundwater temperature between April 1989 and October 2013. At L-35, the groundwater temperatures exhibited an upward trend and at L-33 no trend in temperature change with time was evident.

pH–Upper Aquifer

Between April 1989 and October 2013, the mean pH in the Upper Aquifer was 7.1 and the pH ranged from a minimum of 5.5 at U-5 to a maximum of 8.7 at U-20 (Table E-15). Background pH at upgradient wells U-1, U-2, U-3, and U-4 ranged from 6.5 to 7.8. Regression analysis of the groundwater pH data provided in Appendix E.8.a indicates that no Upper Aquifer well had a statistically significant trend ($r^2>0.6$) in pH over time. However, the pH trendlines shown in Appendix E.8.a indicate that the pH in the Upper

Aquifer wells increased slightly over time, except at U-3, U-7, U-10, U-20, U-21, and U-23 where the pH decreased slightly.

pH–Lower Aquifer

Between April 1989 and October 2013, the mean pH in the Lower Aquifer was 7.2 and pH ranged from a minimum of 6.3 at L-29 to a maximum of 8.0 in L-32 (Table E-15). Background pH at upgradient wells L-38 and L-35 ranged from 6.6 to 7.8. Regression analysis of the groundwater pH data provided in Appendix E.8.b indicates that no Lower Aquifer well had a statistically significant trend (r^2>0.6) in pH over time. However, the pH trendlines shown in Appendix E.8.b indicate that most Lower Aquifer wells had a slight increase in groundwater pH over time.

Specific Conductivity–Upper Aquifer

Between April 1989 and October 2013 (Table E-15), the mean specific conductance in the Upper Aquifer was 1,472 umhos/cm and specific conductance ranged from a minimum of 480 umhos/cm at U-4 to a maximum of 2,790 umhos/cm at U-23 (Table E-15). Background specific conductance at upgradient wells U-1, U-2, U-3, and U-4 ranged from 480 to 1,580 umhos/cm.

Regression analysis of the specific conductance trend graphs of Appendix E.8.a indicates statistically significant (r^2>0.6) changes in specific conductance occurred at two Upper Aquifer wells, U-7 and U-22, between April 1986 and October 2013. The trendlines shown in Appendix E.8.a indicate the specific conductance also increased at several other wells, including background wellU-4, and downgradient wells U-10, U-17, U-18, U-19, U-20, U-23, and U-25, though these increases were determined to not be statistically significant. Wells exhibiting a downward trend included U-5, U-8, U-12, and U-21, and wells exhibiting little or no trend included U-3, U-6, U-9, U-11, U-21, and U-24. A zone of higher specific conductance is located within the central portion of the facility and extends west to east from about wells U-23/U-25 to well U-12.

Specific Conductivity–Lower Aquifer

Between April 1989 and October 2013 , the mean specific conductance in the Lower Aquifer was 1,410 and specific conductance ranged from a minimum of 620 umhos/cm at L-38 to a maximum of 1,740 umhos/cm at L-29 (Table E-15).

Background specific conductance at upgradient wells L-38 and L-35 ranged from 620 to 1520 umhos/cm. Regression analysis of the specific conductance trend graphs of Appendix E.8.b indicates no Lower Aquifer wells had a statistically significant (r^2>0.6) change during the study period. However, all Lower Aquifer wells, except for L-31, exhibited a general upward trend in specific conductance between April 1989 and October 2013. At L-31, specific conductance decreased slightly during the study period.

E.3.c.(6)(c) Common-Ion Hydrochemistry

The site characterization sampling program included the analysis of site common-ion hydrochemistry. The sample results for the Upper and Lower Aquifers are summarized in Tables E-16 and E-17, respectively. These tables contain chemistry data of all water samples obtained from existing wells and piezometers and selected samples from previously abandoned wells and piezometers. The laboratory data sheets for the common-ion data from April 1989 to June 2000 (last common ion sample collected during this period) are provided in Appendix E.4. Laboratory data sheets for the pre-1989 period are provided in CH2M HILL (February 1986). The common-ion data shown in Tables E-16 and E-17 have been separated into Upper and Lower Aquifer designations, based on the zone of well completion. These tables include the chemistry data for water samples obtained from existing small-diameter piezometers and do not include data from abandoned, small-diameter piezometers. Common-ion data from the latter group of piezometers are provided in CH2M HILL (February 1986). Although the piezometers were not designed

for water quality sampling purposes, samples were obtained from them in an attempt to provide a more complete data base. However, normal aquifer development and proper resampling purging could not be accomplished in the piezometers because of their depth and small diameter. For this reason, sample data from the following stations may not be representative of aquifer conditions and will not be used for water chemistry interpretation: D-4s, D-4d, D-8s, D-9s, D-10s, D-10d, UP-26, and LP-12 (D-21).

Interpretation of the common-ion data began with data quality verification. Data were checked for anion/cation imbalances, and ion imbalances of greater than ten (10) % were considered unacceptable. Only the U-23 imbalance of 11.8 % exceeded the ten (10) % imbalance criteria. Thus, the common-ion data from U-23 are also not included in the following analysis.

Differences and similarities between water chemistry of samples from different aquifers are shown graphically by Piper diagram in Figure E-20. The Piper diagram uses the percentage of the major cation and anion milliequivalents per liter on a trilinear diagram to graphically show the differences in water type. Only the most recent samples collected from each well were used to construct the Piper diagram.

E.3.c.(6)(d) Lower Aquifer

The data plotted on Figure E-20 are divided into two water types. The Lower group, which contains the Lower Aquifer wells, indicates a sodium-bicarbonate to sodium-calcium-magnesium-bicarbonate-type water. Groundwater in wells in the upgradient (western) portion of the Lower Aquifer are typically sodium-bicarbonate type waters and groundwater in wells in the downgradient portion of the aquifer tend toward a sodium-calcium-magnesium-bicarbonate-type water. Along the flow path, calcium and magnesium increased and sodium decreased without exhibiting a significant change in total dissolved ion or bicarbonate concentrations. These trends suggest that cation-exchange, where sodium is exchanged for calcium and magnesium, may be occurring along the groundwater flow path.

E.3.c.(6)(e) Upper Aquifer

The upper grouping in Figure E-20 contains most of the Upper Aquifer wells and indicates a calcium-magnesium-bicarbonate- to a calcium-magnesium-bicarbonate-sulfate-type water. However, samples collected from the Upper Aquifer at wells U-26, UP-28, and UP-29 were sodium-bicarbonate-type waters, thus more closely resembling the water chemistry of the Lower Aquifer. Each of these three wells is located along the southwestern portion of the property and generally coincides with the southern limit of the Upper Aquifer. The limit of saturation generally extends east-west along the southern edge of expansion Cell 14 (CH2M HILL, June 1, 1993). Other wells that are close to the Upper Aquifer's southern limit of saturation, U-17 and U-22, also plot toward the Lower portion of the diamond of the Piper diagram, indicating they are also sodium-bicarbonate-type waters. However, groundwater in U-17 and U-22 are characteristically higher in magnesium and calcium and appear to be intermediate between the sodium-bicarbonate-type waters of U-26, UP-28, and UP-29 and the calcium-magnesium-bicarbonate\calcium-magnesium-bicarbonate-sulfate-type water of the northern portion of the Upper Aquifer. This suggests that groundwater within the Upper Aquifer is generally a sodium-bicarbonate-type water along the south-southwestern portion of the aquifer and grades to a calcium-magnesium-bicarbonate or calcium-magnesium-bicarbonate-sulfate-type water toward the north.

E.3.c.(6)(f) Major Ion Distribution

The following discussion is based on the available common-ion analysis shown in Tables E-16 and E-17 for all existing and abandoned wells for samples collected between 1984 and 2000.

Upper Aquifer

The sodium, chloride, and bicarbonate ion distribution in the Upper Aquifer all have a similar character, each forming a ridge of increased concentrations beneath the south-central portion of the facility. This

ridge generally extends west to east from the western boundary of the facility at upgradient wells U-1, UP-28 and UP-29 to the eastern border of the facility between Cell 14 and the northern edge of the Evaporation Pond. North and south of the ridge, the chemical gradients are perpendicular to the groundwater flow path. The chemical gradient along the ridge varies for the different common ions; for sodium and bicarbonate, the highest concentrations on the ridge occur upgradient toward the western side of the facility and decrease toward the east, whereas for chloride, the highest concentrations on the ridge occur downgradient toward the eastern side of the facility.

The calcium, magnesium, and sulfate ion contour maps of the Upper Aquifer all have a similar character, each forming a ridge of increased concentrations beneath the north-central portion of the facility. This ridge generally extends west to east from the northwestern side of Cell 5 in the vicinity of wells UP-3 and UP-24 to the southern border of the facility between the Evaporation Pond. West of wells UP-3 and UP-24, the chemical gradient away from the ridge appears to quickly decline in the upgradient direction. North and south of the ridge, chemical gradients away from the ridge are perpendicular to the groundwater flow path.

The common-ion distribution of the Upper Aquifer is probably controlled by a combination of factors, including: 1) the bedding attitude; 2) the geochemical composition of the aquifer materials; 3) the availability of oxygen; and 4) the hydraulic properties of the aquifer. A south-to-north change in the Upper Aquifer's hydrochemistry is caused, to some degree, by the bedding attitude and the variable geochemical composition of the Lower part of the aquifer. The shallow north-northeast dip of the beds of the Upper Aquifer causes the Upper Aquifer to become unsaturated as the individual sand seams cross the potentiometric surface. The Lower part of the Upper Aquifer is in the lacustrine deposits while the upper part is present in fluvial sands. The combination of the aquifer's bedding attitude and geochemical variability causes monitoring wells in the southern portion of the Upper Aquifer to generally represent the lacustrine depositional environment of the bottom of the Upper Aquifer and monitoring wells to the north to generally represent a combination of lacustrine and fluvial depositional environments. Thus, a south-to-north shift in hydrochemistry that is perpendicular to the direction groundwater flow is consistent with the structure and geochemistry of the Upper Aquifer.

The hydrochemistry of the Upper Aquifer is also believed to be affected by active oxidation-reduction (redox) cells within the Upper Aquifer. A detailed description of a redox cell and the formation of redox zones or cells beneath the site was presented in USEI's 1985 Part B permit application (CH2M HILL, February 1986). The general premise of the redox cell model is that oxygen comes in contact with disseminated pyrite within the sand seams and forms redox cells at various locations. As a result of the dip of the sand seams, there are many places beneath the facility where oxygen can contact and enter the aquifer and produce redox cells. In the redox cells, the oxidation of pyrite produces acids that liberate calcite and sulfate and decreases alkalinity.

Several factors can affect the redox cells in both the lateral and vertical directions. One factor is that oxygen can migrate down under osmotic pressure from the unconfined areas into more confined areas. Another factor is the placement of wells within the aquifer. Wells in the southernmost portion of the Upper Aquifer are generally screened against sand seams that are probably unconfined and under oxidizing conditions, whereas wells to the north probably include semi-confined to confined sand seams that are more reduced. Another factor is the influence of the aquifer's hydraulic properties on the highly variable flow velocities within the individual sand seams that affect the spread of redox products in the direction of groundwater flow. Another influence is the ongoing rising groundwater situation beneath USEI. Water-level fluctuations associated with the rising groundwater combined with the dip of the sand seams probably affects the lateral movement of groundwater within redox zones.

Finally, some consideration must be given to the possibility that elevated levels of sodium, magnesium, sulfate, or chloride beneath portions of the site are possible indicators of a subsurface release. The absence of VOCs at several wells where common-ion concentrations appear to be elevated within the Upper Aquifer indicates that the common-ion distributions are not related to a release at the facility. For instance, sulfate is apparently high in the vicinity of wells U-9, U-10, U-11, U-12, and U-19; magnesium is

apparently high in the vicinity of wells U-8, U-9, U-10, U-11, U-12, U-18, and U-19; chloride is apparently high in the vicinity of wells U-11, U-12, U-17, U-18, and U-19; and sodium is apparently high in the vicinity of wells U-9, U-10, U-11, U-12, U-18, and U-19 (Plate E-10). However, VOCs are absent in all of these wells.

Lower Aquifer

The common-ion data for the Lower Aquifer are limited to the southern and eastern portions of the site. Basic ionic water chemistry in the Lower Aquifer is variable and shows no consistent spatial pattern.

Aquifer Comparisons

Based on comparisons along the northeastern section of the site where maps overlap, there is little correlation between Upper and Lower Aquifer chemical contours and ion concentrations. This indicates there is probably no mixing of water between the aquifers in this area. Magnesium and sulfate concentrations are higher in the Upper Aquifer, chloride and calcium concentrations are lower in the Upper Aquifer, and bicarbonate and sodium concentrations are similar in both aquifers. It is also apparent that all common ions in the Upper Aquifer are spatially related, probably as a result of the structural, geochemical, hydrochemical, and hydraulic properties of the Upper Aquifer. Common-ion distributions within the Lower Aquifer do not appear to be spatially related.

E.3.c.(6)(g) TOC

TOC Data

TOC samples were collected from April 1989 to October 1997 on most wells. From October 1997 until June 1999, when the TOC and TOX samples were phased out, only partial sets of data are available. Therefore the discussion of the aerial distribution of the TOC in the Upper and Lower Aquifers and between the aquifers uses the data through 1997 because it provides a more consistent data set. .

Upper Aquifer

Between April 1989 and ending in October 1997, the mean TOC in the Upper Aquifer was 1.67 mg/L and TOC ranged from a minimum of 0.25 mg/L at U-4 and U-5 to a maximum of 5.98 mg/L at U-11. Background concentrations at upgradient wells, U-1, U-2, U-3, and U-4, ranged between 0.25 mg/L to 2.65 mg/L. A significant trend in TOC over time in the Upper Aquifer is not indicated except at silo well U-20. Between April 1989 and October 1997, TOC concentrations at U-20 remained relatively low at 1.80 mg/L or less. However, in October 1997, TOC concentrations increased to 4.7 mg/L at U-20.

TOC concentration gradients are generally perpendicular to the direction of groundwater flow with TOC increasing toward the south. As discussed in the previous section, monitoring wells in the southern portion of the Upper Aquifer represent saturated conditions along the bottom of the Upper Aquifer. Drillers' logs indicate that the organic matter content in the Upper Aquifer increases in the lacustrine beds at the bottom of the aquifer and is abundant within the completion zone of wells located on the south side of the facility. Therefore, monitoring wells toward the southern portion of the facility are likely to have higher TOC concentrations.

Lower Aquifer

Between April 1989 and October 1997, the mean TOC in the Lower Aquifer was 5.45 mg/L and TOC ranged from a minimum of 0.72 mg/L at L-29 to a maximum of 15.50 mg/L at L-36 Background TOC at upgradient wells L-38 and L-35 ranged from 4.05 mg/L to 7.86 mg/L.

No significant trend in TOC over time in the Lower Aquifer is indicated with the exceptions of wells L-32 and L-36. At L-32, TOC concentrations decreased from 10.83 mg/L in October 1993 to 6.3 mg/L in October 1997. At L-36, TOC concentrations have generally increased since April 1989, increasing from 4.5 mg/L in April 1989 to 8.5 mg/L in June 1997.

No VOCs have been detected in any Lower Aquifer monitoring wells, indicating that these comparatively high TOC concentrations are not related to releases of organic materials from USEI. The absence of VOCs in the Lower Aquifer also indicates that the steady rise in TOC levels in L-36 is probably the result of some process other than the introduction of VOCs into groundwater. The most probable source of the high TOC in L-36 is the continued growth of bacteria in the well (TOC includes particulate organic matter which includes bacteria). The probable source of the comparatively high concentrations of TOC throughout the rest of the Lower Aquifer is the organic-rich lacustrine sediments of the Lower Aquifer.

Aquifer Comparison

Based on the comparison, the TOC of the Lower Aquifer appears to be significantly higher than the Upper Aquifer TOC. A comparison of the TOC contour maps for the Upper and Lower Aquifers is not possible because the contoured areas do not overlap.

E.3.c.(7) Vadose Zone

E.3.c.(7)(a) Introduction

A vadose zone investigation was conducted in support of the 1985 Part B permit application. Drilling, sampling, and laboratory testing of the vadose zone were performed to obtain detailed information on the stratigraphy and hydraulic properties of unsaturated soils at Site B. The information gained from this effort, in conjunction with existing well logs and previous soils analysis, was used to perform predictive numerical modeling of hypothetical contaminant transport through the vadose zone at Site B. In 2000 a soil vapor investigation was conducted involving the installation and testing of four (4), multi-port soil vapor wells installed west of the site near well U-1 and along the east side of Cell 5. In 2003, a focused examination of soil vapor in the vadose zone was completed on these vadose wells and other existing wells along the west side of the site. The drilling, sampling, testing, analysis and computer modeling investigations of the vadose zone at Site B are summarized below. For more detailed information on these investigations, the reader is referred to the following reports:

- Vadose Zone Characteristics at USEI Site B Grand View, Idaho (CH2M HILL, December 1986)
- Computer Modeling Results for the Part B Permit Application, USEI Site B Grand View, Idaho (CH2M HILL, December 1987)
- Simulation of Hypothetical Leachate Plumes from Disposal Trenches at USEI Site B: A Preliminary Report (CH2M HILL, October 31, 1986)
- A Diffusion/Dispersion Analysis for the Vadose Zone and uppermost aquifer at USEI Site B (CH2M HILL, 1986)
- Draft Soil Vapor Study (CH2M HILL, 2000)
- Soil Vapor Report (Brown and Caldwell, 2001)
- Soil Vapor Report (Brown and Caldwell, 2003)

The 2003 (Brown and Caldwell) report is included as Appendix E.10.

E.3.c.(7)(b) Vadose Zone Drilling and Sampling

Two boreholes, D-33 and D-34, were drilled as part of the vadose zone drilling and sampling program. The locations, depths, and drilling and sampling techniques for these two boreholes are described in Sections E.3.b.(2) and E.3.b.(3). The geologic logs for the two boreholes are shown in Appendix E.3.

Table E.10 summarizes the results of the laboratory analyses performed on 40 vadose zone soil samples from D-33 and D-34. The laboratory data were also grouped by geologic formation to determine the average properties of the different soil types encountered in the two boreholes; Table E.10 indicates which samples were assigned to each geologic formation and soil type, and summarize the average properties calculated for each soil type. A total of seven soil types are identified: the Bruneau Formation soils, Glenns Ferry fluvial facies sand/silty sand soils, Glenns Ferry fluvial facies clayey silt soils, Glenns Ferry sandy silt soils, Glenns Ferry lacustrine sand/silty sand soils, Glenns Ferry lacustrine clayey silt soils, and Glenns Ferry blue-gray clayey silt soils.

Two geologic cross sections of the vadose zone at Site B were prepared from available soil boring logs. Figure E-21 shows the location of the two cross sections relative to the site. Cross section K-K', shown in Figure E-22, runs north to south along the eastern edge of the site. Cross section L-L', shown in Figure E-23, cuts diagonally across the site from the northeast to the southwest corner. Both cross sections show the interpreted locations of geologic formations and facies beneath the site. It should be noted that these cross sections have a large vertical exaggeration and the actual dip of the various geologic units if drawn to scale would appear almost horizontal.

The following is a summary of the results of the vadose zone drilling and sampling program.

1. Auger drilling and continuous sampling provide effective methods for obtaining detailed stratigraphic information on the vadose zone at Site B to depths of approximately 150 ft.
2. Laboratory data indicate the presence of four distinct soil types: 1) sands and gravels of the Bruneau Formation; 2) sands/silty sands of the fluvial and lacustrine facies of the Glenns Ferry Formation; 3) sandy silts of the fluvial and lacustrine facies of the Glenns Ferry; and 4) clayey silts of the fluvial and lacustrine facies of the Glenns Ferry Formation.
3. Saturated hydraulic conductivities of Bruneau Formation soils show the largest variation and range from 10^{-5} to 10^{-2} cm/sec. Saturated hydraulic conductivities of the Glenns Ferry fluvial and lacustrine sand/silty sand soils are on the order of 10^{-3} cm/sec. Saturated hydraulic conductivities of the Glenns Ferry clayey silt soils are on the order of 10^{-6} cm/sec. Saturated hydraulic conductivities of Glenns Ferry soils at the site differ by three to four orders of magnitude between the sand/silty sand and the clayey silt soils.
4. Cross sections prepared with existing soil boring logs and correlations with grain-size distribution data from Shannon and Wilson indicate that the geologic facies described in D-33 and D-34 are horizontally continuous beneath the site. The ranges of hydraulic conductivity found for soil types in D-33 and D-34 describe the range of hydraulic conductivity for similar soil types at the site.
5. Vadose zone strata dip to the north-northeast between 1.5 and 3.4 degrees. The north-northeast dip direction is consistent with the dip of deeper formations in the area that are known to dip toward the Snake River.
6. The most prominent stratigraphic marker in the vadose zone at Site B is the blue-gray clayey silt layer shown in the cross sections in Figures E-22 and E-23. The change from a light brown to blue-gray color is interpreted as a transition from oxidizing to reducing conditions within the soils. The blue-gray color contact does not parallel the present day potentiometric surface in the uppermost aquifer. Instead, the blue gray contact is located between 11 ft. and 75 ft. above the potentiometric surface and appears to parallel the strata in the vadose zone. This indicates the contact may be due to a change in the depositional environment as, or soon after, the sediments were deposited or is related to a paleo-potentiometric surface in the area.
7. Based on soil boring logs from D-33 and D-34, clayey silt layers comprise 8.6 to 11.0 % (6.5 ft. to 9.4 ft.) of the Glenns Ferry fluvial facies section. Clayey silt layers comprise 67.5 to 75.6 % (28.7 ft. to 36.9 ft.) of the Glenns Ferry lacustrine facies section. The total accumulated thickness of clayey silt layers in D-33 was 43.4 ft. over 155 ft. of borehole. The total thickness of clayey silt layers in D-34 was 38.2 ft. over 153.5 ft.

In situ moisture contents for Site B soils at depths less than 30 ft. are very low and are probably close to the residual value. At these moisture contents, the unsaturated hydraulic conductivity of these soils is also

very low, indicating there is a low potential for infiltration and moisture recharge via precipitation at the site.

E.3.c.(7)(c) Computer Modeling

Computer modeling (CH2M HILL, December 1987) was conducted to simulate a release from the bottom of a disposal unit and the movement of a hypothetical leachate plume through the unsaturated zone at Site B. The emphasis was on examining the amount of vertical and lateral movement of leachate through the unsaturated zone. The modeling effort also provided insight into the question of potential leachate plume widths and therefore appropriate monitoring well spacing.

The model SUTRA (Saturated and Unsaturated Transport), developed by the U.S. Geological Survey (Voss, 1984), was used to simulate quasi-3D vertical plume migration in the unsaturated zone. Hydraulic properties of the unsaturated strata underlying Site B used in these simulations were determined in the laboratory on samples collected by continuous coring during the vadose zone drilling and sampling investigation, as described above. The model included 43 separate layers consisting of nine (9) different lithologies based on the cores and vadose zone hydraulic properties analysis.

Simulations were conducted to analyze the effect of both “falling head” (catastrophic release) and “continuous leak for two (2) years” (slow leak based on infiltrating precipitation). The effect on plume spreading of variable leachate source depths and dimensions was also examined. The following represent the relevant conclusions that can be drawn from the simulation results:

1. The results from both simulated scenarios indicate that the unsaturated subsurface beneath Site B acts to completely halt the downward migration of large volumes of source fluid before it can reach the water table. This occurs primarily because the unsaturated zone is thick, relatively dry, and comprised of many low-permeability stratigraphic units that tend to retard and spread out the infiltrating liquids.
2. Simulated dissolved-solute contaminant releases from trenches at Site B, as large as 300,000 gallons and released over a period of two (2) years at a depth of 40 ft., did not reach the water table. A steady-state distribution of concentration for this particular scenario was reached in 15,000 years. At that point in elapsed time, the maximum depth of infiltration was about 130 ft., roughly 50 ft. above the water table.
3. The scale of the leak discussed in item 2 above is the largest leak considered likely to occur through the particular source-area diameter selected (10 ft.). However, should this scale of leak underestimate the size of potential contaminant sources, the results imply that for contamination to reach the water table, and to do so in less than 100 years, it would have to originate from a substantially larger source than the volume of the largest scenario simulated in this investigation.
4. Monitoring well spacing cannot be based solely on the simulation results because the hypothetical plume did not reach the depth of the Upper Aquifer at Site B. Therefore, other criteria must be used to establish appropriate monitoring well spacing and locations. These include location of waste disposal units and aquifer flow rates and flow directions.

E.3.c(7)(d) Soil Vapor Investigation

At four locations on the west side of the site multi-port soil vapor borings were installed to investigate the migration of soil vapors to the groundwater. These borings were installed by hollow stem auger. Continuous cores were collected from near ground surface to auger refusal which varied from 140 to 165 feet. This investigation provided details on the vadose zone stratigraphy of this part of the site and on the distribution of soil vapors at depth and laterally between the test wells. The dry, fine sand which underlies the entire site is present to a depth of approximately 100 ft. below ground surface and the highly stratified sands and clays of the lacustrine section extend to depth. No vadose zone hydraulic properties were obtained from this investigation.

E.4 TOPOGRAPHIC MAP REQUIREMENTS

The required topographic map at the prescribed scale and showing site features as required by IDAPA 58.01.05.012 [40 CFR 270.14(b)] is provided as Drawing PRMI-T01. A smaller scale topographic map is also provided as Figure E-3. In addition, the general topography around Site B, as depicted on the U.S. Geological Survey (USGS) 7.5" topographic quadrangle maps, is shown in Figure E-2.

E.5 CONTAMINANT PLUME DESCRIPTION

E.5.a. VOC Detections

Synthetic organic compounds have been detected in five Upper Aquifer monitoring wells, U-1, U-20, U-21, U-22, U-23, and U-24 at Site B. A total of 14 volatile organic compounds (VOCs) have been identified in the groundwater from these wells. The dates and concentrations for all VOC detections are listed in Table E-18.

The apparent source of the VOCs is soil vapors, which, because of variable concentration gradients and vadose zone properties, have come in contact with the Upper Aquifer. The conceptual model for the contaminant transfer mechanism does not suggest that groundwater contamination in any specific well is part of a contiguous plume but, rather, each well represents localized areas where the vapors have contacted the groundwater. Therefore, no attempt has been made to map the extent, boundaries, and concentration distributions of the individual VOCs. Instead, Plate E-10 shows the maximum concentration of each VOC detected at each well. The detection of chloroform in the November 2000 samples from well U-5 and U-6 were not confirmed, therefore these results are not included in Plate 10.

The location of a geologic cross section, M-M', which runs from east to west across the west-central portion of the facility where groundwater has become impacted by VOCs, is shown in Figure E-24. The cross section is shown in Figure E-25. Figure E-25 illustrates the well construction in the areas where groundwater is contaminated. The five (5) wells included in cross section M-M' (U-1, U-20, U-21, U-22, U-23, and U-24) are the only wells known to be in contact with contaminated groundwater.

E.5.b. TOX Detections

TOX concentrations were also measured in groundwater samples from April 1989 through June 1999. TOX reflects the gross presence of halogenated compounds and could not be used to quantify concentrations of specific compounds as anticipated. .

A comparison of the specific VOCs detected and the TOX values indicates that in wells with detectable VOCs, TOX is also present. However, TOX was detected in numerous wells without any associated detection of VOCs. For instance, several wells, including U-1, U-2, U-3, U-4, U-20, U-21, and U-22, have been sampled for Appendix IX compounds, and no other organic compounds were detected that would indicate what the TOX analyses were detecting. It appears that TOX analysis was detecting naturally occurring halogenated compounds as well as synthetic VOCs. Numerous naturally occurring halogenated compounds, especially brominated and iodated compounds, may be present in the organically rich, volcanically derived sediments forming the Upper and Lower Aquifers.

E.5.c. TOC Detections

The occurrence of TOC in the Upper and Lower Aquifers is discussed in Section E.3.c.(6)(g).

E.5.d. TOX and TOC Control Charts

TOC and TOX data were collected until June 1999 for each of the monitoring wells at Site B, a combined SHEWHART-CUSUM control chart was developed for TOC and TOX (EPA, 1989). The control charts developed and used in the past is provided below.

E.5.d.(1) TOX Control Charts

Monitoring wells, U-1, U-2, U-8, U-11, U-12, U-20, U-21, U-23, L-32, and L-33, had one or more out-of-control TOX results between April 1992 and June 1999. Among the 11 wells, there were a total of 14 TOX out-of-control measurements. However, only two wells, U-21 and U-23, had more than one out-of-control TOX measurement. Nine of the 13 TOX out-of-control results occurred between September 1996 and October 1997.

A comparison of the TOX out-of-control results with the VOC results indicates there is little or no correlation between the two measurements. The only wells that exhibited both out-of-control TOX measurements and measurable quantities of VOCs were U-1, U-20, U-21, and U-23. In contrast, several wells - U-2, U-5, U-8, U-11, U-12, L-32, and L-33 - had out-of-control TOX measurements but did not have measurable VOCs; and two wells, U-22 and U-24, had measurable quantities of VOCs but did not have out-of-control TOX measurements. As noted above, the probable cause of these discrepancies is the presence of naturally occurring halogenated compounds that may be present in the organically rich, volcanically derived sediments that form the Upper and Lower Aquifers.

E.5.d.(2) TOC Control Charts

Nine (9) wells, U-1, U-2, U-3, U-10, U-21, U-22, U-24, L-29, and L-36, had one or more out-of-control TOC results between April 1992 and October 1997. Among the eight wells, there were a total of 31 TOC out-of-control measurements. Four wells, U-3, U-21, L-29, and L-36, had more than one out-of-control TOC measurement.

A comparison of the TOC out-of-control results with the VOC results indicates there is little or no correlation between the two measurements. The only wells that exhibited both out-of-control TOC measurements and measurable quantities of VOCs were U-1, U-21, and U-24. In contrast, wells U-2, U-3, U-10, L-29, and L-36 had out-of-control TOC measurements but did not have measurable VOCs, and wells U-20, U-22, and U-23, had measurable quantities of VOCs but did not have out-of-control TOC measurements. As discussed in Section E.3.c.(6), the probable source of TOC in groundwater beneath Site B is the naturally occurring organic matter in the lacustrine beds of the Upper and Lower Aquifers. At L-36, the steady rise in TOC measurements and the absence of VOCs suggest the out-of-control TOC measurements are probably the result of some process that is unrelated to the introduction of VOCs. The probable source is the growth of bacteria in the well (TOC includes particulate organic matter, which includes bacteria).

It is important to note that at U-21, the TOC out-of-control limits were established based on two samples, whereas EPA guidance (EPA, 1986) recommends a minimum of four samples. Furthermore, TOC concentrations at U-21 have been comparatively low throughout the period of study. Therefore, the TOC control chart results for U-21 may be statistically invalid. In November 1994, Well U-21 was placed in the compliance monitoring program and control chart analysis was no longer required.

E.6 GENERAL MONITORING PROGRAM REQUIREMENTS

E.6.a. Description of Wells

IDAPA 58.01.05.008 [40 CFR 264.97(a)] regulations specify that a Groundwater Monitoring Program be established for the uppermost aquifer and any lower aquifers that are hydraulically connected to the uppermost aquifer beneath the waste disposal facility. Site B is underlain by two independent water-bearing zones, described as the Upper and Lower Aquifers.

Pursuant to IDAPA 58.01.05.008 [40 CFR 264.97(a)], USEI maintains a groundwater monitoring network at Site B. The wells and piezometers are divided between the Upper Aquifer and Lower Aquifer. Two aquifers are being monitored because they are each classified as the “uppermost” aquifer beneath separate portions of the site. Figure E-26 shows where each of the two water-bearing zones constitutes the uppermost aquifer beneath the site. As shown in this figure, the Lower Aquifer is the uppermost aquifer of regulatory concern for the southern 1/3 of the site, including Cell 14, Cell 15, and a portion of Cell 16. The Upper Aquifer is the “uppermost” aquifer for the northern two-thirds of the site, including all of the pre-RCRA Units and Regulated Units: Trench 10, Trench 11, Trench PCB 4, Trench 5, the Evaporation Pond, and a portion of Cell 16. Section E.3.c.(3) provides a detailed description of the two-aquifer system at USEI Site B.

E.6.a.(1) Number of Wells

The monitoring well network includes 24 wells in the Upper Aquifer including four (4) upgradient background monitoring wells, 20 wells that monitor the Regulated Units and pre-RCRA Units, and eight (8) piezometers. The Lower Aquifer has a total of seventeen (17) wells consisting of three (3) upgradient background monitoring wells, fourteen (14) downgradient monitoring wells, and six (6) piezometers. A total of 55 monitoring wells and piezometers comprise the groundwater monitoring system.

E.6.a.(2) Location of Wells

The locations of the existing monitoring wells are based on the location and orientation of existing and planned Regulated Units and on the groundwater flow directions for the overlying “uppermost” aquifer determined during the site characterization study presented in Section E.3. Figure E-27 shows the typical groundwater flow direction in the Upper Aquifer and the Upper Aquifer monitoring well network including Upper Aquifer detection monitoring wells for Cell 16 (U-48, U-49, and U-54). Figure E-28 shows the typical groundwater flow directions in the Lower Aquifer and the Lower Aquifer monitoring well network including proposed Lower Aquifer detection monitoring wells for Cell 16 (L-50, L-51, L-52, and L-53).

E.6.a.(3) Depths of Wells

The existing monitoring wells range in depth from approximately 201 ft. below ground surface (Upper Aquifer well U-23) to 304 ft. below ground surface (Lower Aquifer well L-38). The depth of the wells varies by the aquifer being monitored, position across the site with respect to the dipping geologic strata, the saturated thickness of the aquifer, and by ground surface elevation.

Table E-5 provides complete well depth and completion information on all of the existing groundwater monitoring wells and piezometers.

E.6.a.(4) Well Construction

The current monitoring well network includes both two (2”) in. diameter and four (4”) in. diameter wells. Casing materials include Schedule 40 PVC, type 304 stainless steel, and low carbon steel. Well screen

materials include both Schedule 40 PVC and type 304 stainless steel. Well construction materials vary based on the purpose of the well when it was installed and construction details specified in the December 1988 Part B permit. Section E.3.b.(2) provides a narrative of the well construction techniques used for the existing wells, and Table E-5 provides details on the construction materials used in each well. Appendix E.3 provides well construction diagrams for each existing well.

Construction techniques that will be used for new wells or replacement wells installed during the duration of the permit are described in the following section. All wells installed at USEI Site B will meet the requirements of IDAPA 58.01.05.008 [40 CFR 264.97(c)] regarding materials used, construction techniques, and procedures to maintain integrity of the borehole and subsequent samples. USEI will construct wells that are of sufficient diameter and adequately sealed to provide valid samples. Available site characterization data will be used to guide well construction activities based on the specific well location and target aquifer.

The ultimate objective is the construction of a four (4”) in. diameter well that is protected from surficial contaminant sources, is adequately sealed from subsurface contaminant sources, and allows the collection of valid water samples and water level data from the target aquifer. Figure E-29 shows the typical well construction and screen placement for monitoring wells at Site B with regard to the Upper Aquifer and Lower Aquifer and site geology. This general construction approach and objective will be followed for new and replacement wells for this permit.

E.6.a.(4)(a) Drilling Method and Borehole Sizes

In general, air rotary drilling methods are used to advance an eight (8”) in. nominal steel casing through the dry, loose, upper 120 ft. to 140 ft. of strata and 7-7/8” open hole is extended into the aquifer. However, variations of these methods may be necessary depending on subsurface conditions at each well site and the target depths.

For most Upper Aquifer wells, the successfully proven well construction approach has been to use dry air rotary methods to drill and drive steel casing to a depth of about 140 ft. From 140 ft. to the total depth, dry air rotary is attempted. If cuttings removal is not possible with dry air below 140 ft., water or Quik Foam and water injection is used to about 20 ft. above the aquifer. All water used during drilling and well construction is obtained from a source tested periodically and certified to be free of synthetic organic compounds.

Quik Foam is a National Sanitary Foundation (NSF)-approved drilling additive for drilling potable water wells. It is a non-ionic, foaming surfactant containing phosphate and isopropyl alcohol. Quik Foam has been used sparingly on wells at USEI because the low-yielding aquifers at Site B do not yield enough water during development to quickly remove the effects of the foam. However, in many instances the Quik Foam injection must be used because sticky moist clays penetrated by the borehole could not be removed with straight air or air-water injection. Low concentrations of Quik Foam and water injected into the drilling air, and subsequently out the drill bit, produce thick lather that wets and disseminates and allows the removal of the otherwise plastic clay adhering to the bit, drill pipe, and inside the surface casing.

Quik Foam has been used on numerous piezometers and monitoring wells at Site B since 1984 and has never been found to contribute to or alter any subsequent chemical analysis, including common-ions, VOCs, and Appendix IX constituents. The only drawback is the increased development time, which cannot be avoided. Therefore, USEI proposes to continue to use Quik Foam injection as a last means of clearing drill cuttings from boreholes.

From 20 ft. above the anticipated top of the aquifer to the first saturated sand, and for an additional 20 ft. (if possible), a combination of dry air rotary drilling and split spoon sampling will be used. These detailed dry drilling and sampling methods will be used so that the first saturated sand can be positively identified.

Alternatively, or in conjunction with the split spoon sampling, after the well bore has penetrated into the top five (5') ft. of suspected saturated sediments, the well bore may be left open for 12 to 48 hours. This will allow water to reenter the hole, thus providing direct confirmation of the top of saturation.

For wells installed into the Lower Aquifer where the Upper Aquifer sediments are also saturated, alternative construction approaches may be needed in order to advance the borehole through the Upper Aquifer. Two approaches may be used depending on the thickness and water-bearing properties of the overlying Upper Aquifer and the location of the borehole relative to known areas with wastes or Upper Aquifer contamination.

If the Upper Aquifer is saturated but not contaminated, the eight inch (8") nominal borehole will be advanced through the Upper Aquifer as open hole. This is generally possible where the saturated thickness of the Upper Aquifer is approximately 20 ft. or less. In most locations where the Upper Aquifer is saturated, portions of the confining clay between the Upper and Lower Aquifers are too moist and sticky to be removed with dry air. If the cuttings cannot be effectively removed from the borehole, water injection or a water-Quik Foam mixture will be used.

If a Lower Aquifer well is installed through known or suspected surface contaminants, multiple permanent and temporary strings of steel casing will be used to isolate the surface contaminants prior to penetrating into the Lower Aquifer. Typically, this requires 12", 10" and 8" steel casing sizes. Because of the plastic clays penetrated, it is usually necessary to cut off and leave in place the drive shoe of any casing that is to be withdrawn. Water or water/Quik Foam injection is also usually required to clear moist plastic clays from larger boreholes.

All bits will be 7-7/8 in. except if hole instability or contaminant issues require the use of multiple casings, in which case bit sizes will be adjusted accordingly. Monitoring wells will be completed as four (4") in. diameter wells. Piezometers may be completed as either four (4") in. or two (2") in. diameter wells. The minimum borehole size for two (2") in. completion is six (6") in.; a four (4") in. completion requires a minimum eight (8") in. borehole to provide sufficient annular space to install and verify placement of filter pack and annular seals.

E.6.a.(4)(b) Geophysical Logging

All new and replacement wells will be geophysically logged after the borehole is extended to the total designed depth and before the well screen and casing are installed. The minimum suite of logs that will be recorded are: natural gamma radiation, spontaneous potential, and single-point resistivity. On a case-by-case basis, the borehole may be filled with clean water prior to logging so the single-point resistivity log can be recorded for the entire open hole interval instead of just that portion that naturally fills with groundwater prior to logging. The distinctive log signature provided by the single-point resistivity log is crucial to documenting and delineating the Upper and Lower Aquifers, which cannot be differentiated by drill cuttings alone.

E.6.a.(4)(c) Surface Casing

For a typical monitoring well without special contaminant considerations, as the 7-7/8"-diameter borehole is advanced, 8-5/8" OD (8-1/8" ID) Schedule 40 steel surface casing with welded joints will be driven to approximately 140 ft. The casing will be equipped with a 9-3/4"-diameter drive shoe. The annulus above the drive shoe will be kept full with bentonite. To avoid vertical cross-contamination after the surface casing has been set, it will be scrubbed with casing brushes and compressed air to remove soil particles that adhere to the inside walls.

E.6.a.(4)(d) Well Screen and Casing Materials

All new and replacement monitoring wells will be nominal four (4") in. ID. The well screen, ten (10") in. long dense phase cup, and bottom end plate will be 304 stainless steel. For Upper Aquifer wells, a riser

consisting of a single joint of type 304 stainless steel casing 20 ft. long will be attached to the top of the well screen. Because the Lower Aquifer is under artesian conditions and rises above the top of the aquifer, two joints of stainless steel riser (40 ft.) will be installed above the screen. Schedule 40 PVC casing will extend from the top of the stainless steel casing to the top of the well, typically two ft. (2) above ground surface. Schedule 40 PVC was selected because at the installation depths at Site B it is sufficiently strong to prevent well collapse and the threaded joints are strong enough to allow installation without separation. In addition, the inside diameter of Schedule 40 PVC is slightly greater than four (4") in. and is approximately the same inside diameter as the adjoining stainless steel, as opposed to Schedule 80 PCV, which is stronger because it has a greater wall thickness. However, to retain the same outside diameter for compatibility with other PVC fittings, the inside diameter of Schedule 80 PVC is reduced to about 3.5" to achieve the greater wall thickness. Therefore, Schedule 80 PVC should not be used because it will not allow the use of standard four (4") inch diameter pumps and drilling tools which may be needed for maintenance and testing (well disinfections, redevelopment and aquifer testing for example). All casing sections will be joined by watertight, factory-manufactured, flush-joint threaded couplings.

E.6.a.(4)(e) Well Screen Length and Placement

Each new or replacement Upper Aquifer monitoring well will have a maximum of a 20 ft. screen length unless prior approval is obtained for longer screened intervals.

Water level data collected by USEI since 1984 reveal a gradual rise in water levels in most Upper Aquifer wells. As described in Section E.3.c.(5), observed water level rises over the period from 1990 to 1996 across the site range from 2.2 ft. to 8.4 ft. and average 4.1 ft. In recognition of the rising water levels, the screens of new or replacement Upper Aquifer wells will be extended to ten (10') ft. above the static water level encountered when the well is installed. The exposed screen plus a stainless steel riser 20 ft. long above the screen will provide 30 ft. of stainless steel above current water levels for Upper Aquifer wells.

As discussed in Section E.3.c.(3), the interbedded clay, silt, and thin, fine sand beds comprising the Lower Aquifer extend over a 20- to 40-foot interval. The top of the Lower Aquifer is readily identifiable by geophysical logs (see Section E.3.c.(3)). The bottom of the aquifer is also identifiable by geophysical methods, provided the boreholes are extended well below the depth of the Lower Aquifer so the logging tool can record the subtle transition from clay below the aquifer to the silty clay matrix that denotes the Lower Aquifer. Significant overdrilling of the boreholes requires them to be backfilled with bentonite, which may cause problems with well construction and water chemistry and requires increased well development.

Consequently, since only the top of the aquifer is critical, Lower Aquifer wells will be drilled 40 ft. below the anticipated top of the aquifer. After the top of the Lower Aquifer is identified by geophysical logging, if necessary, the borehole will be reentered and drilled deeper to allow placement of the screen at the required position. In Lower Aquifer wells, 30 ft. of screen will be installed with the top of the screen three (3') ft. to five (5') ft. below the bottom of the inner confining clay. The remainder of the borehole below the screen, if any, will be filled with the silica sand filter pack.

The Lower Aquifer is confined, which causes the water level in the well to rise above the top of the aquifer when the well is completed. Consequently, water levels in the Lower Aquifer wells will be 20 ft. to 30 ft. above the top of the screen. Several Lower Aquifer wells have been affected by the long-term rising water level trend seen in the Upper Aquifer wells. Consequently, 40 ft. of stainless steel casing will extend above the well screen to accommodate the artesian water level rise and future water level rises.

Figure E-29 shows the intended well construction with regard to the Upper and Lower Aquifers and site geology. Figures E-30 and E-31 provide more details on the screen placement in the Upper Aquifer and Lower Aquifer, respectively.

E.6.a.(4)(f) Screen Slot Size and Filter Pack

Screen slot size for all wells will be 0.010", and a filter pack of grade size 20-40 Colorado silica sand will be used. The screen slot and filter pack sand were sized for the aquifer sand grain-size distributions. There is only minimal difference between aquifer sand grain-size distribution characteristics at any location of the site or between the Upper and Lower Aquifers. The use of a 0.010" slot and 20-40 sand for the very fine to silty sands at Site B is supported, based on successful experience at Site B and was confirmed by grain-size analysis. Colorado Silica 20-40 sand was determined to be the best overall sand (coupled with screen slots of .010 inch) to minimize the development of formation washouts and lengthy development periods, minimize the siltation of the wells and allow maximum water flow into the wells. The water bearing zones at Site B consist of individual sand/silt seams in a predominantly silty clay matrix. A single size, coarser (larger) grained, filter pack (No. 16 for example) will result in longer development time, and more siltation.

The same filter pack and screen slot size will be used in all wells.

The filter pack will extend from no more than two (2') ft. below the bottom of the dense phase cup to two (2') ft. to five (5) ft. above the top of the screen. The filter pack will be placed through a tremie pipe, and the well will be bailed during placement to settle the filter pack. The temporary steel casing, if used, will be pulled back as the filter pack is placed. The top of the filter pack will be tagged periodically during placement and as the temporary casing is pulled to ensure its proper position. In the Upper Aquifer wells the top of the sand pack will extend about 12 ft. to 15ft. above the water table in the borehole determined at the time of drilling. In the Lower Aquifer wells, the filter pack will extend up to but not into the bottom of the inner confining bed.

E.6.a.(4)(g) Annular Seals

Several types of sealants will be used to correctly seal the annulus of the monitoring wells. In the Upper Aquifer wells, approximately four (4) ft. of bentonite pellets will be poured from the surface on top of the filter pack and hydrated in place with water. After the pellets have hydrated, the annulus outside the 4" casing will be filled to the surface with four (4) % bentonite (by weight) cement grout. The grout will be placed from the bottom up by using a temporary steel tremie pipe. To prevent distortion of the PVC casing because of the heat of hydration from the cement curing, a temporary packer will be set in the stainless steel riser and the well will be filled with clean water prior to cementing. The casing will be kept full of water and no work will resume on the well for a minimum of 24 hours after the cement is placed.

The annular seal in Lower Aquifer wells will be similar to the Upper Aquifer's with one exception: the bentonite pellets will not be used if there is more than five (5) ft. of standing water above the top of the filter pack. If standing water cannot be removed by bailing prior to placing the pellets, a volume of high solids bentonite grout sufficient to provide approximately four (4) ft. of seal will be placed by tremie pipe. The annulus from the top of the bentonite to ground surface will then be filled with four (4) % bentonite (by weight) cement grout placed via tremie pipe. The same precautions to avoid casing distortion mentioned previously will be followed. Work will not resume until the cement has set for a minimum of 24 hours.

For both Upper and Lower Aquifer wells, concrete mix will be used to form a sloped pad approximately four (4) in. thick around the base of the wellhead to promote drainage away from the wellhead and to provide a clean working area around the well. The concrete pads will be triangular with approximately 4-foot sides. Protective bollards consisting of steel pipes embedded in the ground, but not in the concrete, will be installed at each corner of the concrete pad. Triangular well pads are used because they allow closer access to the well for the pump service truck when installing and servicing the sampling pumps.

E.6.a(4)(h) Development

All wells will be developed by a combination of methods, as necessary. In their approximate order of use, these methods are: bailing with a stainless steel bailer; pumping and jetting with a temporary, electric

submersible stainless steel pump; followed by final pumping after installation of the dedicated sampling pump. Piezometers will not receive the final pumping since dedicated pumps will not be installed in these wells.

Water removed from the well during development will be monitored for specific conductivity, temperature, pH, and turbidity. Stabilization of the measured values will be used as a guide to determine when the well has been thoroughly developed. Turbidity will be determined by visual examination. The total volume of water removed during development will be recorded.

E.6.a.(4)(i) Determination of Well Yield and Aquifer Properties

Each new or replacement well will be tested to determine the well yield and to estimate aquifer properties. Qualitative testing and yield information will be obtained during the development process by recording the recovery of water levels after pumping or bailing. For higher-yielding monitoring wells, well yield information, including specific capacity (gpm per foot of drawdown) and maximum sustained pumping rates, will be determined when the dedicated sampling pump is installed. Low-yielding monitoring wells and piezometers will be slug-tested to provide estimates of aquifer properties and to establish a baseline well response. Low-yielding monitoring wells will also be tested to document sustainable pumping rates and water level recovery rates for use in establishing well specific sampling procedures. See Section E.7.b.(2) for the procedures to be used to document well yields.

E.6.a.(4)(j) Security Covers and Seals

Each well will be equipped with a locking steel cover. The top of the primary well casing inside the security cover will be fitted with a tight-fitting, vented seal to prevent dust or other foreign material from entering the well. The well seals will be compatible with the dedicated sampling equipment installed in monitoring wells. Piezometers will be fitted with a secure, vented cap.

E.6.a.(4)(k) Surveying and Labeling

Each well will be surveyed for north and east coordinates to within 0.1 ft. using the existing grid system established for Site B. The top of the steel surface casing will be surveyed to within 0.01 ft. elevation, and ground level elevation will be determined to within 0.1 ft. based on the existing site vertical elevation datum. The top of the steel surface casing will become the permanent elevation datum for each well. Water-level measure points will be established after sampling equipment is installed, and measure point elevations will be determined from the permanent well datum. Both the permanent well datum point and the measure point will be clearly marked on all wells.

All wells will be labeled by welded number on the surface casing and security cover and by indelible marker on the well casing or well seal.

E.6.a.(4)(l) Equipment Decontamination and Disinfection

Well completion material (casing and well screen) delivered pre-cleaned and sealed in plastic directly from the manufacturer will not be re-cleaned prior to installation unless needed, based on visual inspection. All other equipment, including steel surface casing(s), drill bits, drill pipe, tremie pipe, bailers, test pumps, pump discharge pipe, test probes and the surfaces of the drill rig and support vehicle that may introduce foreign material into the well during construction, will be decontaminated before use, as necessary during use, and between wells by high pressure hot water.

The low-yielding, iron- and sulphur-rich aquifers at Site B provide favorable conditions for bacteria growth, and bacteria are known to have heavily colonized some of the existing wells at Site B. Therefore, all downhole drilling and completion equipment will be disinfected with a calcium or sodium hypochlorite solution during the high pressure-hot water cleaning process prior to use in each well. These procedures

will be employed in an attempt to minimize the potential introduction and spreading of iron and sulphur bacteria colonies in the wells.

E.6.a.(4)(m) Well Abandonment

In the event that a monitoring well or piezometer must be abandoned, the following procedures will be used depending on whether the well is constructed with PVC casing and screen (some existing piezometers and older monitoring wells), PVC casing and stainless steel screen and riser (monitoring wells installed as part of the existing permit), or steel casing and stainless steel screen (monitoring wells at missile silos).

In wells with PVC screens, the well screen will be broken and the filter pack material will be removed by jetting with air and water. Once the filter pack has been removed, the entire well will be filled with bentonite grout placed via tremie pipe filling the well from the bottom to the surface. Once the screen has been broken and the well has been completely filled with bentonite, a drill rig will be used to remove as much of the casing as possible. The remainder of the casing will then be drilled out to the original depth or as deep as possible if the drill bit wanders off the PVC casing and starts cutting new hole. Once the PVC is removed, the well will be sealed with four (4) % bentonite (by weight) cement grout placed from the bottom via tremie pipe. The grout will fill the entire borehole to approximately two (2) ft. from the surface. At two (2) ft. below grade, the steel surface casing will be cut off and a steel plate will be welded over the casing with the well number and date abandoned scribed by weld beads.

Wells with stainless steel screens and PVC casings will be abandoned by filling the screen section and the stainless steel riser pipe with neat cement grout placed by tremie pipe. The PVC casing will be pulled or drilled out and the hole filled with four (4) % bentonite (by weight) cement grout to within two (2) ft. of the surface. The top of the steel surface casing will be cut off and welded shut with the well number and date abandoned scribed by weld beads.

If it becomes necessary to abandon any of the three silo wells (UP-6, U-21 and U-22) or nearby piezometer (UP-8) (see Figure E-27), USEI will prepare and submit a specific abandonment plan for IDEQ approval. The proximity of these wells to the waste-filled missile silo structures dictates that the abandonment procedures be conducted thoroughly and safely. At a minimum, the wells will be filled with cement grout that is squeezed out the screens and into the filter pack and borehole walls by the application of hydraulic pressure.

E.6.a.(4)(n) Installation of Dedicated Sampling Equipment

If a new or replacement monitoring well is installed, it will be equipped with a dedicated positive displacement sampling pump of equal or superior performance/design to the existing dedicated sampling pumps. The dedicated pumps will be selected from commercially available models and be constructed of modern materials meeting industry standards for obtaining water samples for analysis of the monitoring parameters. Pump columns will be equipped with a check valve to prevent backflow of water in the pump column. The pump will be positioned within one (1’) ft. of the bottom of the sump below the well screen.

If a dedicated sampling pump fails in an existing well, the pump will be repaired or replaced as soon as possible. A pump that fails during a semiannual sampling event will be removed immediately. In order to allow the well to be sampled during the regularly scheduled sampling event, the pump will either be repaired and replaced, or a temporary pump or other approved sampling device will be used. The failed pump will be repaired or replaced and reinstalled in the monitoring well prior to the next scheduled sampling event. Temporary or replacement pumps will meet the standards provided in the first paragraph of this section. Section E.6.b.(1) provides procedures for using a bailer to sample a well if the pump fails during a sampling event.

E.6.a.(4)(o) Well Construction, Well Abandonment, and Pump Installation Documentation

Within 60 days after new wells are installed, completed, and developed, or within 60 days after any well is plugged and abandoned, USEI will submit a report to the Director documenting the well construction or the well abandonment procedures and place a copy of the report in the Operating Record at Site B. The well construction report shall follow IDEQ and IDWR requirements.

Sampling pump operation, including failure and removal, as appropriate, will be documented in the field sampling log (Section E.6.b.(4)). If a pump has to be removed and repaired or replaced USEI will prepare a report documenting the removal and replacement of the pump. The pump record document will be placed in the Operating Record at Site B.

E.6.a.(5) Assurance of Unaffected Background Groundwater Measurement

USEI Site B is underlain by two discrete aquifers, the Upper Aquifer and the Lower Aquifer, as described in Section E.3.c. The groundwater flow direction in the Upper Aquifer is from northwest to southeast and the flow direction in the Lower Aquifer is from southwest to northeast as discussed in Section E.3.c.(5) and as shown in Figures E-27 and E-28, respectively. Annual determinations of flow rate and direction made by USEI and submitted to IDEQ as part of the current permit conditions indicate the flow patterns of the two aquifers have not changed significantly over the period of record. As indicated by the well inventory provided in Section E.3.a.(4), there are no known high-capacity pumping wells in the vicinity of the site that affect the flow directions in the two aquifers. Consequently, the upgradient-downgradient relationships for the wells relative to the site do not change seasonally or annually.

The upgradient background wells for the Upper Aquifer are U-13, U-14, U-15, and U-4 (Figure E-27). As presented in Section E.5, Well U-1 was impacted by carbon tetrachloride, a volatile compound. There are no known sources of synthetic compounds in the subsurface upgradient of Site B. Therefore, the carbon tetrachloride in well U-1 is believed to be the result of subsurface vapor migration from pre-RCRA disposal of wastes at Site B. Additional discussion of the implications of well U-1 becoming impacted by the site is presented in Sections E.7 and E.8. Well U-1 was plugged and abandoned in July 2012. As presented in Section E.5, the other upgradient background wells in the Upper Aquifer have not been impacted by the site.

The upgradient background wells for the Lower Aquifer are L-35, L-36, and L-38. Well L-38 is approximately 500 ft. upgradient of the site. Wells L-35 and L-36 are located along the upgradient perimeter of the site and along the southern edge of Cell 14 (Figure E-28). Monitoring data for these wells summarized in Section E.5 and contained in the Operating Record at the site indicate that none of the Lower Aquifer background wells has been impacted by site activities.

As discussed in Section E.3.b.(2) and shown in Appendix E.3, all Upper and Lower Aquifer wells were constructed using materials and sealing techniques to maintain the integrity of the well. Consequently, the groundwater samples from these wells are considered valid and accurately represent the background water quality in the two aquifers.

E.6.a.(6) Assurance of Compliance Point Groundwater Measurement

As presented in Section E.3, groundwater flow directions in the aquifers have not varied appreciably over the period of record. As shown in Figures E-27 and E-28, the compliance wells are properly located in the downgradient position of the waste management unit they were designated to monitor. Well construction data on the wells discussed in Section E.3.b. and provided on Table E-5 and in Appendix E.3 show that the wells are properly constructed to provide valid water samples of their respective aquifers.

E.6.b. Description of Sampling and Analysis Procedures

Pursuant to IDAPA 58.01.05.008, [40 CFR 264.97(d)] USEI has developed sampling procedures designed to collect representative samples from the groundwater aquifer under the site. The sampling procedure includes the following elements:

- Sample collection
- Sample preservation and handling
- Chain-of-custody control
- Analytical procedures
- Field and laboratory quality assurance/quality control

Prior to implementing the sampling and analysis plan, a sampling procedures manual will be prepared that gives specific detailed instructions for each well. This manual will contain information developed during the well installation procedure, including information on well construction, water level, well yield, casing volume storage, and specific procedures for each well. The sampling procedures manual will be updated at least annually to reflect any changes in the status of wells, sampling equipment, sampling methods, or when laboratory analytical schedules are refined or modified. The sampling procedures manual is a working document prepared to guide well sampling activities and is not considered part of this Document.

E.6.b.(1) Sample Collection Methods

E.6.b.(1)(a) Wellhead Inspection and Organic Vapor Screening

At wells that have a high potential for the presence of organic vapors and/or a history of organic constituents within the groundwater, the sampling team will determine background organic vapor levels in the breathing zone and at the level of the wellhead with a photoionization detector (PID) or equivalent. The PID will be calibrated to known standards and will be maintained in accordance with manufacturer recommendations. The wellhead will be visually inspected for signs of tampering and needed maintenance while the background organic vapor levels are being recorded.

The wellhead will be opened and the PID probe tip inserted into the well at the top of the water-level measurement tube or inside the well casing, depending on the final well construction and dedicated sampling equipment in the well. The organic vapor monitoring point will be open to the top of the static water column in the well.

Background and wellhead organic vapor values, along with observations of wellhead conditions, will be entered into the sampling log. Certain atmospheric conditions, notably wind, temperature, dust, and humidity, can affect the reliability and accuracy of instrument readings. Weather conditions will be recorded in the sampling log to help interpret PID readings.

Organic vapor monitoring will be used primarily to screen for contamination that may impact sampling crew safety. The presence of VOCs in the headspace of a well would also be detected in the subsequent water samples.

E.6.b.(1)(b) Presample Purging

In low-flow aquifers such as those at USEI Site B, it is necessary to remove water from the well, filter pack, and formation in the immediate vicinity of the borehole prior to sampling. Removal of this stagnant water is critical to proper sampling because it removes water that may not be representative of formation water as a result of interaction with the atmosphere, well casing, filter pack, sealing materials, or biological (bacteria) processes in or near the borehole.

Most of the wells at Site B do not yield sufficient water to sustain practical pumping rates. With the exception of Upper Aquifer wells in the northern 1/3 of the site, the maximum sustainable pumping rate for most of the monitoring wells at Site B is less than 1.0 gpm.

USEI will “purge to dry” those wells that that have been determined to produce less than 1.0 gpm Those wells that are purged to dry will be sampled when an adequate amount of groundwater is available within the well to fill the sample containers. In all cases, the sample will be taken within 24 hours of purging the well.

Wells that yield more than 1.0 gpm are purged of at least three borehole volumes and field parameter stabilization, then sampled without shutting off the pump.

The selection of 1.0 gpm as the cutoff between those wells continuously pumped versus those wells evacuated to dryness was based on the practicalities of operating the positive displacement piston pumps at low flows with the high lifting heads (140 ft. to 280 ft.), the ability to sample each well consistently between sampling events, and the need to complete each sampling event within a reasonable time frame. Under the current sampling protocols, a sampling event takes five (5) to seven (7) days.

Specifically, the pre-sample purging process for the Detection Monitoring Program consists of the following:

- Dedicated Hydrostar, positive displacement piston pumps, or approved equals, will be installed and maintained in all monitoring wells.
- A determination of the sustainable yield of each well will be made when it is drilled, reworked, or incorporated into the monitoring well network for the first time.
- The pump intake will be set within one (1) ft. from the bottom of the sump below the well screen to ensure that stagnant water in the well is fully evacuated prior to sampling.
- Purge rates will be established on a well-by-well basis. Wells capable of yielding more than 1.0 gpm without dewatering will be pumped at a sustainable pumping rate. Wells incapable of yielding 1.0 gpm will be pumped to dryness as quickly as possible.
- Wells evacuated to dryness will be sampled within twenty-four (24) hours or as soon as sufficient water has reentered the well to allow purging of the pump column and collection of the required sample volumes.
- Since purge water disposal is not a significant imposition, high-yielding wells will be pumped until three casing volumes have been removed or field parameters stabilize. The collection of field parameter data is addressed in Section E.6.b.(1).
- Samples will be collected by decreasing the pump rate to the lowest sustainable rate. An adjustable valve system will be used as necessary to divert a portion of the pump discharge for sample collection so that the sample bottles can be filled with a minimum of agitation.
- The sustained yield will be determined for all wells biennially.
- For wells estimated to produce less than 1.0 gpm, the sustainable yield will be confirmed by recording the total gallons pumped in five (5) minutes after the borehole storage has been evacuated.
- For wells that produce 1.0 gpm or more, the sustainable pumping rate will be determined by measuring the pumping rate and the pumping water level in the well for a 5-minute period. The pumping rate used will be well- and pump-specific with the intention of establishing specific capacity for the well, which implies the pumping rate and drawdown are stable.
- The casing storage volume of the well will be calculated after the wells are constructed and will be adjusted based on the amount of water in the well at the time of sampling. The casing storage calculation will include water in the sand pack, assuming a 20 % porosity.

- The pumping rate(s) and the amount of time necessary to purge up to three well volumes for wells with sustainable rates of 1.0 gpm or greater will be based on the maximum well volume and the sustainable yield for each well.
- All purge water will be collected in labeled 55-gallon drums or other watertight containers at each well. USEI will dispose of the purge water onsite as allowed by their permit.

E.6.b.(1)(c) Field Measurements

The dedicated sampling pumps in the monitoring wells at Site B have an effective pumping rate range of 0.5 to five (5) gpm. However, the pumps are not equally efficient and some cannot maintain the 0.5 gpm pumping rate. Below 0.5 gpm, the pump seals and check valves cannot maintain a steady discharge rate because of the high lift (>200 ft in most wells). All of the lower aquifer wells and most of the upper aquifer wells at Site B are low yielding and cannot be pumped slow enough to maintain a steady pumping water level during the pre-sample purge. The water removed from these low yielding wells prior to sampling is almost entirely casing storage. In those wells capable of yielding greater than 0.5 gpm (at full drawdown – water level at or near the pump intake) the percentage of casing storage versus fresh aquifer water gradually changes during the pre-sample purge until near the end of the purge process most of the discharge water is formation water from the aquifer immediately surrounding the well. However, continued pumping of higher yielding wells draws water from progressively more distant parts of the aquifer which has slightly different chemistry. If these wells were pumped long enough, eventually stabilization of all parameters would be expected. Field water chemistry parameters collected during the purge process reflect the mix of casing storage and formation waters removed during the purging process.

Prior to 1999, low yielding wells were purged to dryness and re-sampled after sufficient recovery to allow re-purging the pump column and filling the required bottles. High yielding wells (>0.5 gpm) were purged of three casing volumes prior to sampling, providing the field parameters of temperature, SC and pH were stable. In 1999, USEI began measuring the field parameters of dissolved oxygen (DO), Oxygen Reduction Potential (ORP) and turbidity, (in addition to Temperature, SC and pH) to determine if other parameters would provide confirmation of water quality stability during the purge process. The intent was to pump at the slowest rate possible and permit sampling after smaller purge volumes had been removed and to avoid dewatering low yielding wells over the DEQ's concern with loss of volatiles from cascading water.

Review of this data, provided in Appendices E.8.a and E.8.b indicates that temperature, SC and pH stabilize quickly, typically within the first ten (10) gallons removed. The parameters DO, ORP and turbidity sometimes reach reasonably stable values much later in the purging process but often do not stabilize, even when purge volumes approach two (2) casing volumes in those wells capable of being pumped at sustained rates. No single parameter is either consistent among all wells or singularly robust enough to indicate when a well has been adequately purged.

Dissolved oxygen and turbidity probes are prone to fouling and calibration instability during the sampling process which degrades their usefulness over the sampling event and for use in comparison between events. ORP readings appear to change the most during the purging process, always becoming progressively smaller (when starting as a positive number) or becoming more negative when starting as a negative number. In some wells the ORP crosses from positive to negative and becomes increasingly more negative during the purge process. ORP readings are sensitive to dissolved oxygen and since the dissolved oxygen in the groundwater is low, ORP should be a useful indicator of when the oxygenated water in the casing storage has been removed. Reviewing the field parameter data however indicates that this is not a consistent response suggesting that the water in casing storage can also be low in oxygen. Therefore ORP by itself is not a singularly reliable measure of when formation water is being discharged.

Based on the above discussion the field water quality parameters of temperature, pH, and specific conductivity will be measured and recorded during the purging and sampling of each well.

Normal laboratory and manufacturer-recommended procedures will be followed in measuring field parameters. All meters will be allowed to warm up before being used. The pH meter will be standardized with pH 7 and 10 buffers. All field equipment will be calibrated in accordance with manufacturers' recommendations. All readings will be recorded as read and noted as to whether they were automatically temperature-corrected.

Pump discharge will be directed into a barrel and measured using a calibrated staff rod. Field parameters will be recorded at a minimum of every well casing volume of purge water discharge or for the low yielding wells every three (3) to five (5) gallons.

Low yielding wells(< 0.5 gpm) will be purged to dryness and sampled when an adequate volume is available to fill the required sample containers. All wells that purge to dryness will be sampled within 24 hours of purging. Higher yielding wells (>0.5 gpm) will be pumped continuously until at least three (3) casing volumes have been removed and parameter stabilization has been achieved.

After the well is purged and the sample is being collected, four independent measurements of temperature, pH, and specific conductance will be measured. This information will be recorded in the sampling log.

Sample Collection

Pursuant to IDAPA 58.01.05.008 [40 CFR 264.97(d)(1) and (2)], sample collection procedures are described below. All monitoring wells will be sampled directly from the dedicated sampling pump. The only material that will come in contact with the sample will be stainless steel or Teflon. Each well will have a dedicated pump and Teflon sample tubing to eliminate potential cross-contamination.

For low-yielding wells purged to dryness, the sample will be collected as soon as the well has sufficiently recovered, or within 24 hours of purging. For those wells capable of being pumped continuously at 0.5 gpm or greater, sampling will begin as soon as purging is completed.

The pump discharge rate will be reduced prior to sampling; and through the use of a by-pass valve sampling tee, discharge rates out the Teflon sampling hose will be reduced to a low, controlled rate. All samples will be collected in a way that minimizes agitation or aeration to prevent loss of the constituent.

If a pump fails during the sampling event, the pump will be removed and repaired or replaced as described under Installation of Dedicated Sampling Equipment in Section E.6.a.(4). If the pump cannot be repaired, or replaced, and reinstalled in time to collect the required sample during the sampling event, a Teflon or stainless steel bailer with a bottom check valve and bottom emptying device will be used. The sampling techniques to be used if it is necessary to use a bailer will follow industry standards and are as follows:

- The bailer will be triple cleaned. The initial wash will use de-ionized water and a laboratory grade surfactant such as Alconox. After rinsing with de-ionized water, the bailer will be washed with isopropanol. Following the alcohol wash, the bailer will be washed with de-ionized water and allowed to air dry before use in the well.

- The bailer will be attached to new polypropylene rope and lowered into the well. When the bailer is about 25 ft. above the water column, the rate of descent will be slowed so that the bailer entry into the water column does not result in significant surging of the well. The bailer will then be allowed to sink to the bottom of the well. It will be raised slowly through the water column. Once above the water column, the bailer will be retrieved as quickly as possible and the contents dumped into the purge water containers. This process will be repeated a minimum of ten (10)

times. As the bailer and rope are removed from the well, they will not be allowed to contact the ground or other potential sources of contaminants.

- After the tenth bail is removed, the bailer will be used to collect the sample by repeating the bailing procedure as many times as necessary to fill the required sample volumes. The bailer will be lowered to the center of the remaining water column in the well. Particular emphasis will be placed on gently lowering the bailer into the water column and gently pulling it out of the column. When the bailer is free of the water column, it will be extracted as quickly as possible. When filling the samples bottles, the initial discharge from the bottom emptying device from each bailer will be discarded. Sample bottles will be filled in the same sequence as described above.

- After sampling, the bailer will be rinsed with de-ionized water, isopropanol, and de-ionized water and stored for reuse. The polypropylene rope will be discarded.

Alternatively, due to the depth of certain wells, USEI may check to replace or repair the pump and collect the sample within a 45 day period.

Sample bottles will be filled in decreasing order of volatility depending on the analytes being sampled for. Sample vials for VOCs will be filled first, followed, in order, by , semi-volatiles, metals, and common ions.

E.6.b.(2) Sample Preservation and Shipment

Once all of the samples specific to an individual sample shipping shuttle are collected, the chain-of-custody forms will be completed and the samples will be prepared for shipment. The sample containers will be packed with insulation inside the shipping shuttles along with the chain-of-custody forms. Frozen ice-packs or double bagged water ice will be placed in the shuttle to chill and maintain the samples at the recommended target temperature of 4 degrees Celsius. The shuttle lids will be secured and sealed with chain-of-custody seals. The shuttles will be shipped by express delivery to the contract laboratory for analysis. The sample analysis request form will be provided directly to the contract laboratory by USEI or its sampling contractor.

Well sampling sequences will be coordinated so that all samples specific to each shuttle are collected in one day. Sample shuttles will normally be shipped on the same day that the samples are collected.

The sampling procedures described above will be consistent throughout the sampling program. In addition to the well samples, the sampling will also include the use of field blanks, equipment blanks, and trip blanks. These are discussed in Section E.6.b.(5).

E.6.b.(3) Analytical Procedures

Parameter-specific analytical procedures as specified in the most current version of EPA SW 846 will be followed.

E.6.b.(4) Chain-of-Custody Control

As required by IDAPA 58.01.05.008 [40 CFR 264.97(d)(4)], the Groundwater Monitoring Program will include chain-of-custody control to maintain integrity of samples. USEI will use chain-of-custody record forms that are equivalent to the chain-of-custody form found in SW 846.

The sequence of events for controlling chain-of-custody will be as follows: When the sample bottles are delivered from the laboratory, the sender will sign and date the chain-of-custody form and specify on the form what has been shipped. From that point on, each time the sample bottles, whether empty or full,

change hands, both parties will sign and date the transfer. The shipping bills and receipt of delivery will satisfy the chain-of-custody requirements for transfer of the sealed shuttles from shipper to receiver. When samples are delivered to the laboratory and received into custody, a copy of the chain-of-custody form will be retained in the Operating Record at USEI.

The following information will be included on the chain-of-custody sample form:

- Sample number (that includes well ID for lab reporting purposes, e.g. U-1 then the sample number)
- Signature of sampler
- Date of collection (time logged in field log)
- Place and address of collection
- Type of sample
- Number and type of container
- Inclusive dates of possession
- Signature of receiver

In addition to the chain-of-custody form, other components of chain of custody will include sample labels, sample seals, field log, sample analysis request sheet, and the laboratory log. These are further described as follows:

- Sample Label. A sample label will be affixed to each sample bottle to provide the sample number.
- Custody Seals. A seal will be affixed to each sample shipping container (not each bottle). This seal will be signed and dated by the individual packing the samples. The seal will be secured across the lid of the shipping container in such a manner that the lid cannot be opened without breaking the seal.
- Field Log. A field log will be kept for each sampling event. A copy of the field logs will be kept at the facility and will be available for inspection. The format for the field log is as follows:

    1. Facility name and address
    2. Name and signature of sample collector(s)
    3. Purpose of sample and type (for example, required analyses for initial background data, routine detection monitoring, re-sampling, etc.).
    4. Time and date of sampling
    5. Meter and equipment model numbers and serial numbers
    6. Organic vapor screening in breathing zone, at wellhead, and in wellhead space
    7. Pertinent well data (such as depth, water surface elevation, pumping schedule, and method)
    8. Sampling method
    9. The unique number of each sample
    10. Appearance of each sample (such as color, turbidity, sediment, sheens, and immiscible liquids
    11. Field observations/sampling weather conditions
    12. Field parameters during purging and at time of sample collection
    13. Field meter calibration dates, times, results, and calibration solution or gas identification and lot numbers
    14. Analyses performed in the field (such as pH, temperature, specific conductance, and others).
    15. Other pertinent observations regarding the purging and sampling of the wells such as pump operation or pumping disruptions
    16. Name and address of laboratory performing analyses
    17. Sampler’s printed name(s) and signature
    18. Reviewer’s printed name and signature

19. Locations(s) or source of sampling (such as the monitoring well number)

- Sample Analysis Request Sheet. Analysis request sheets will be provided to the laboratory, with a copy kept with the field log.
- Laboratory Log. Laboratory control records will be attached to the chain-of-custody form, and a copy will be kept at the facility.

Upon receipt of the samples at the contract laboratory, the security of the shuttles (chain-of-custody seals) will be checked. Any shuttles that have broken or missing chain-of custody seals will be noted and reported to the facility contact. The following procedures will be followed on opening the sample shuttles:

- The condition of the samples and temperature of the samples will be determined.
- The sample and seal information will be checked to ensure that they match the chain-of-custody record.
- The chain-of-custody record will be checked for a signature.
- The laboratory services request form from USEI's facility contact will be cross-checked against the chain of custody to confirm the analyses requested.
- A laboratory sample number will be assigned.
- The sample will be stored in a secure area to await analysis.

E.6.b.(5) Documentation of Proper Sampling and Analysis Procedures

USEI will follow industry standards for quality assurance and quality control (QA/QC) to assure that groundwater analytical results represent groundwater chemical and physical composition from groundwater sampling through analytical report preparation. Overall quality assurance will be the responsibility of USEI. The sampling, analysis, and reporting of data to IDEQ will be the responsibility of USEI or its designated agents. Actual coordination of QA/QC activities will be through USEI.

Components of the QA/QC program will follow recommendations in SW 846 and are as follows:

- Laboratory: The analytical laboratory will provide all shipping containers, sampling containers and preservatives, chain-of-custody forms, labels, and seals. The contract laboratory will follow all laboratory QA/QC procedures as specified in SW 846. A full laboratory QA/QC report will accompany each data report and will be kept on file at the facility, this may be in the form of hard copies of electronic formats.
- Sample Collection: QA/QC procedures for sample collection will be accomplished by the sampling team under the supervision of the USEI facility contact. A standardized field log will be kept for each sampling event following the format described in the preceding chain-of-custody section. The log will include all label and seal numbers and documentation of all QA/QC procedures related to sample collection. It will be standard procedure to include field, lab, and trip blanks, and replicate samples in each sampling event for appropriate parameters.

Sample Blanks and Duplicates:

- Field blanks: Field blanks will be submitted at USEI's discretion, however, at least one field blank will be collected per day when well samples are being collected. Field blanks will be prepared by filling a separate set of sample containers with water provided by the laboratory. After the regular samples have been collected, and with the sampling pump turned off (but with any mechanical equipment still operating such as the air compressor or generator used to power the sampling equipment), the water containers will be opened and used to fill sample containers. The field blanks samples will be filled at the wellhead and under the same conditions as the actual samples. Field blanks, exposed to ambient conditions to which the groundwater samples were subjected, will be used to assess the potential for externally introduced error factors during the sampling event. Field blanks will only be submitted for VOC analysis.

- Trip blanks: Trip blanks will accompany each sealed sample container if that container holds volatile samples. They will be analyzed for the same list of VOCs as the actual groundwater samples to assess the level of potential contamination that may have occurred during sample transport.
- Lab blanks: Analysis of the water used to prepare the field and trip blank containers will be completed. This water has never left the laboratory. Lab blank data are used to establish the baseline quality of water used in all of the QA/QC blanks.
- Equipment blanks: If non-dedicated sampling equipment must be used, analysis of water from the laboratory poured through sampling equipment will be used to detect potential equipment contamination.
- Duplicate samples. USEI may elect to send duplicate samples to different laboratories at its discretion. These samples would be used to evaluate competitive laboratories or as needed to verify or confirm sample results. Results of duplicate samples sent to other laboratories will not be included with the regular sample report to the Director after each sampling event.
- QA/QC of Analytical Data: The raw data will be reviewed by the laboratory QA/QC Director to determine that it is correctly and accurately reported. Upon receipt of the written laboratory report, USEI will review the data to identify any irregular results and to determine if any hazardous constituents are present that require response.

Additional QA/QC data evaluation procedures will be performed and documented in the facility files as needed. These activities include review and modification of sampling procedures, analysis, data reporting, and data reduction such as graphical trend line analysis and statistical variation assessment.

E.6.b.(6) Determination of Groundwater Elevation

As required by IDAPA 58.01.05.008 [40 CFR 264.97(f)], prior to purging or sampling the well, the elevation of the groundwater will be determined. An electronic water-level measuring device will be used to determine the depth to groundwater.

On the first day of a groundwater sampling event, the water level in all monitoring wells and piezometers will be measured. Three separate, consecutive measurements will be taken at each well. The water-level probe will be pulled up out of the water before it is re-lowered to take the next measurement. This will help ensure the tape is hanging straight and the measurements are accurate and to help prevent erroneous readings from being incorporated into the data base. The individual water levels will be recorded and the average measurement will be used as the representative measurement for that well on that date.

Before use each day, the lower 50 ft. of the water-level probe and wire will be washed with a phosphate free detergent and rinsed with distilled water. Between wells, the bottom ten (10') ft. of the probe will be rinsed with distilled water. Groundwater elevations will be measured to the nearest 0.01 ft.

The water-level measurement point elevation relative to mean sea level will be determined for each well based on a fixed reference point elevation datum established on the well casing (see Section E.6.a.(4)). The water-level measure point will be marked on the well and described in the field log.

E.6.c. Procedures for Establishing Background Quality

As described in Section E.6.a.(1), both aquifers being monitored at USEI Site B have four designated background wells. Some annual water level data collected and resultant groundwater flow directions for these wells indicate the wells are consistently upgradient from the facility. All of these wells are currently sampled semiannually for VOCs . In addition, several of the Upper Aquifer upgradient wells have also been sampled for Appendix IX parameters as discussed in Section E.5.

This data base establishes background concentrations for the monitoring parameters. Based on the results of these samples, the background concentrations of synthetic organic contaminants in the Upper and Lower Aquifers are below detection limits. Based on the existing data base, background concentrations for the monitoring parameters is non-detect and no statistical evaluation sampling or data evaluation procedures are necessary.

In April 1996, carbon tetrachloride was detected in Upper Aquifer well U-1. As indicated in Sections E.5 and E.7, the detection of this VOC in an upgradient background well is believed to be the result of vapor migration from the site. Well U-1 is no longer considered an unimpacted upgradient well. The detection of a synthetic contaminant in well U-1 does not alter the conclusion reached from the other seven wells, which have established that the background concentration of VOCs at Site B is essentially zero. Well U-1 was plugged and abandoned in July 2012.

E.6.d. Statistical Procedures

E.6.d.(1) Detection Monitoring Parameters

No statistical procedures are required to evaluate the concentrations of synthetic organic compounds detected in any downgradient compliance well at Site B. Since the background concentration of these compounds is zero, any detection above the Estimated Quantification Limit (EQL) for the detection monitoring compounds is assumed statistically significant.

Section E.7.d.(3) provides a discussion of the EQL and laboratory reporting limits for the VOCs on the detection monitoring parameter list.

E.6.d.(2) Other Analyses

USEI will collect samples for analysis of common ions for general water chemistry evaluation on the first sampling event for any new or replacement wells installed during this permit. On receipt of the common ion analyses, USEI will perform ion balance calculations to establish the reliability of the data. The data will also be compared to previous data from the same well to check for outliers or significant changes in water chemistry

Since these data are being collected for long-term site characterization and ancillary issues, no reporting or action levels are proposed. USEI will maintain the common-ion analyses in the Operating Record at Site B.

E.6.d.(3) Field Parameters

Field sampling parameters will be logged into the sample log, This information may be used as trending information as appropriate. Field parameters will consist of temperature, conductivity and pH.

E.7 DETECTION MONITORING PROGRAM

Regulations IDAPA 58.01.05.008 [40 CFR 264.98] and 16.01.05.012 [40 CFR 270.14(c)] specify the conditions that must be met by the owner/operator to develop a Groundwater Monitoring Program. If hazardous constituents are detected and confirmed in the uppermost aquifer at the point of compliance and are reasonably expected to be in or derived from waste contained in the Regulated Units, the owner may need to institute a Compliance Monitoring Program. If the groundwater protection standard under IDAPA 58.01.05.008 [40 CFR 264.98(g)] is exceeded, or if concentration limits are exceeded between the point of compliance and the property boundary, a Corrective Action Program is required under

IDAPA 58.01.05.008 [40 CFR 264.98(g)]. In all other cases, a Detection Monitoring Program under IDAPA 58.01.05.008 [40 CFR 264.98] is appropriate.

To select the appropriate monitoring program for the USEI facility, it is necessary to assess which of the conditions defined above are applicable. Subpart F Rules and Regulations adopted by IDAPA 58.01.05.008 [40 CFR 264.98(a)] state that for compliance monitoring to be instituted, the monitoring well analytical data must indicate that any hazardous constituents detected are "... reasonably expected to be derived from a Regulated Unit."

Hazardous constituents have been detected in samples from several point of compliance monitoring wells and one upgradient background well that are monitored under the current Groundwater Monitoring Program at USEI Site B. Table E-18 summarizes the detection of VOCs in the wells at USEI Site B and Plate E-10 shows the locations of the impacted wells.

Prior to October 1991 low levels of chloroform and carbon tetrachloride were sporadically detected in several wells in the northwest portion of the site. In October 1991, chloroform was detected at a concentration of 30 μg/L and low levels of carbon tetrachloride (4.0 μg/L) and chloromethane (21μg/L) were detected in well U-21, monitoring well installed near Silo 2, a pre-RCRA Unit. As a result of the detection of these VOCs, the well was sampled for the complete Appendix IX list of analytes in December 1991 and February 1992. These samples confirmed the presence of the initial VOCs but did not detect any other compounds. This event triggered an evaluation of the source of the VOCs. An alternate concentration limit (ACL) demonstration and a corrective measures study was completed for well U-21 (CH2M HILL, April 1993). The corrective measures study concluded that the chloroform, carbon tetrachloride and chloromethane detected in well U-21 was from fugitive soil vapors coming from Silo 2 and not from a liquid release of contaminants. Fate and transport analysis, including computer modeling, conducted for the ACL demonstration indicated that the slow groundwater velocities, high carbon content of the aquifer materials, and the chemical properties of chloroform effectively precluded significant migration of the compound; therefore, very high concentrations could be present at U-21 without exceeding risk-based levels at the downgradient facility boundary.

The results of this study were used by IDEQ and USEI to establish the action level for triggering corrective action at well U-21 as the 10^{-4} cancer risk or Hazard Index of one (1) under an industrial exposure scenario. A Compliance Monitoring Program for well U-21, including the risk-based corrective action trigger level, was adopted by permit modification on November 24, 1993. The Compliance Monitoring Program for U-21 consisted of semiannual sampling for the 28 specific VOCs required under the Detection Monitoring Program plus methylene chloride and annual sampling for Appendix IX constituents (except for dioxin).

In September 1996, carbon tetrachloride (CTET) was detected in upgradient well U-1 (Plate E-10) at 14 μg/L, and at a concentration of 71 μg/L in Well U-23, a designated downgradient well for Regulated Unit Trench 5. In July 1997, CTET was detected at 29 μg/L in U-1. USEI conducted an analysis of the data pertinent to U-23 and U-1 (CH2M HILL, June 1997).

The U-21 and U-1/U-23 studies both suggest soil vapors are present in the subsurface at Site B and that penetration of the vapors to groundwater is responsible for the VOCs detected in these wells. The specific source of the vapors could not be identified but solvent waste disposal practices in unlined shallow trenches prior to USEI ownership is the probable source.

The presence of soil vapors presents a situation whereby monitoring in a well may not indicate a release from the specific solid waste management unit for which the well is dedicated.

In April 1999 a site wide ACL demonstration report was prepared to address the detection of VOC's in several wells at Site B including well U-1, an upgradient background Upper Aquifer well (CH2M Hill, 1999). The ACL demonstrated that the low part per billion levels of VOC's being detected in this well and

others in the northwestern portion of the site were from vapor transport and not indicative of a liquid release. Consistent with the fate and transport modeling completed in 1993 for Well U-21, in support of the first ACL, the April 1999 site-wide ACL assigned each of the monitoring wells to one of three different categories for purposes of allowable concentrations if VOC's were detected. The categories of wells are based on risk and groundwater flow paths and include upgradient background wells, Level 1 compliance wells and Level 2 compliance wells. Level 1 wells included those wells interior to the site and have higher allowable concentrations than do the Level 2 wells which are the downgradient and northern facility boundary wells. Appendix E.14 provides the 1999 ACL.

In response to DEQ concerns regarding the conclusions reached in the 1993 ACL and 1999 ACL that a soil vapor transport mechanism was responsible for the detection of VOC's, a soil vapor work plan was completed in 1999 and the four (4) multi-port soil vapor wells were installed and tested by CH2M HILL in early 2000. The results of CH2M HILL's soil vapor investigation were subsequently submitted by Brown and Caldwell, (Brown and Caldwell, 2001). This work confirmed the conclusion that soil vapor transfer to the groundwater was responsible for the detections of VOCs in the impacted Upper Aquifer wells. In late 2002, USEI completed a follow-up soil vapor study in response to continued DEQ concerns regarding the soil vapor mechanism. This study collected additional soil vapor samples from the vapor wells and head space on existing monitoring wells. The results were reported in February 2003 (Brown and Caldwell, 2003) and the same conclusion was reached. Based on these investigations there is no evidence for liquid release and the low part-per-billion levels of VOC's detected in the groundwater in a small group of Upper Aquifer wells in the northwest portion of the Site is the result of soil-vapor transfer. The confirmation of the transfer mechanism supports the concept and application of the 1999 ACL which acknowledges the presence of the vapors and sets appropriate concentration limits for interior wells while establishing much lower concentration limits for the perimeter downgradient wells.

On the basis of this history, the Groundwater Monitoring Program at USEI Site B includes both a Detection Monitoring Program for all non-impacted wells and a Compliance Monitoring Program for specific wells presently impacted and a general description of a Compliance Monitoring Program to be used if other wells exceed the Detection Monitoring Program concentration limits. The Detection Monitoring Program, including a description of the well network, sample collection, data analysis, reporting and responses, is included in this section. Details of the Compliance Monitoring Program are presented in Section E.8.

E.7.a. Indicator Parameters, Waste Constituents, and Reaction Products to be Monitored

As required under IDAPA 58.01.05.008 [40 CFR 264.98(a)], this section presents the list of parameters to be monitored in order to provide a reliable indication of the presence of hazardous constituents in groundwater.

The selection of analytes for the RCRA Part B permit process is addressed in IDAPA 58.01.05.008 [40 CFR 264.98(a)], which states "The owner or operator must monitor for indicator parameters (specific conductance, total organic carbon, or total organic halogen), waste constituents, or reaction products that provide a reliable indication of the presence of hazardous constituents in ground water." The regulations also state that the Regional Administrator will specify the monitoring parameters after considering the following factors:

- The types, quantities, and concentrations of constituents in wastes managed at the facility
- The mobility, stability, and persistence of waste constituents or their reaction products in the unsaturated zone beneath the waste management area
- The detectability of indicator parameters, waste constituents, and reaction products in the groundwater

- The concentrations or values and coefficients of variation of proposed monitoring parameters or constituents in the groundwater background

The list of analytes for the Detection Monitoring Program at Site B includes 28 specific VOCs and general chemistry field parameters. Justification for the specific organic constituents and field parameters is presented in the following sections.

E.7.a.(1) Volatile Organic Constituents

Table E-19 provides the list of volatile organic constituents for which USEI will sample under the RCRA Detection Monitoring Program at Site B. This list meets the intended purpose of detection monitoring for the following reasons:

- These are mobile, persistent, synthetic organic compounds representative of waste constituents and their principal reaction products in both the pre-RCRA Units and in the Regulated Units.
- All of these compounds are included in Method 8260b, which replaces Method 8240 in EPA SW 846; therefore, analysis can be performed using standard laboratory methods.
- A historical data base of semiannual sample results for these compounds has been established.

- The positive detection of several of the compounds in some wells at Site B confirms their value as detection monitoring analytes.
- Subsequent sampling for the entire list of Appendix IX volatiles, semi-volatiles, and metals in those wells that had detectable detection monitoring VOCs has not detected any other compounds present. This further supports the position that the current list of these compounds provides a sensitive suite of compounds for detection monitoring purposes.
- Site B is in an isolated, non-industrialized setting; therefore, there is no natural background groundwater concentration of synthetic organic constituents.
- As a result of the arid location and dry subsurface conditions at Site B, vapor transport of volatile synthetic compounds from near-surface waste disposal to the groundwater is more likely than liquid transport.

Under current land disposal regulations, high levels of VOCs may no longer be disposed and the waste streams entering USEI Site B are increasingly dominated by inorganics, notably metals, and pesticides. Metals and pesticide are not included in the detection monitoring list because they are not mobile in the vadose zone and groundwater pathways at the site. However, trace levels of VOCs are still commonly present in the waste streams coming to USEI. As presented in the Compliance Monitoring Program, Section E.8, if VOCs are confirmed to be present in detection monitoring groundwater samples, analysis will be performed for additional parameters, including pesticides and metals. VOCs are more mobile in the subsurface environment than the other categories of wastes in the current waste streams; therefore, they are valid detection monitoring parameters representing past and current waste streams at USEI Site B.

E.7.a.(2) Other Parameters

USEI began sampling all monitoring wells for major anions and cations during the Spring 2008 semiannual sampling event and will continue sampling for those constituents every five (5) years . The samples are analyzed for total dissolved solids and the following anions and cations:

Anions	Cations
Chloride (Cl^-)	Calcium (Ca^+)
Carbonate (CO_3^{-2})	Magnesium (Mg^{+2})
Bicarbonate (HCO_3^-)	Sodium (Na^+)
Sulfate (SO_4^{-2})	Potassium (K^+)

Fluoride (F^-)	Iron (Fe^{+2} , Fe^{+3})
Nitrate (NO_3^-)	Manganese (Mn^{+2})
	Silica (SiO_2)

USEI will collect this information to bolster the existing data presented in Section E.3.c.(6) and to establish a long-term record of the general water chemistry in both aquifers at Site B. Potential uses of the common-ion data include additional characterization and comparison of the fundamental chemistry of each aquifer, evaluating the water resource potential of the aquifers, site certification and characterization for future expansion, and site-specific studies, including the rising groundwater and soil vapor investigation.

These data will not be part of the detection monitoring criteria for the site. However, since the common-ion samples will be collected during a semiannual RCRA Detection Monitoring sampling event, a description of their usage is included in this Document. The common-ion analyses will be by current SW 846 methods for the individual analytes.

E.7.b. Groundwater Monitoring System

The Detection Monitoring well system will consist of three “categories” of wells: existing pre-1988 permit wells, existing post-1988 permit wells, and new or replacement wells. Note: these categories are not related to the classification of wells presented in the Compliance Monitoring program.

E.7.b.(1) Monitoring Well Location and Construction

In compliance with IDAPA 58.01.05.008 [40 CFR 264.97(c)], all existing wells were installed using materials and construction methods that maintain the integrity of the monitoring wells. Section E.3.b. describes the well construction techniques and materials that were used on existing wells. Table E-5 provides tabulated construction dimensions and details and indicates the aquifer designation for each well. The construction techniques for new or replacement wells required during the permit period are provided in Section E.6.a.(4).

The locations of the proposed detection monitoring wells for Cell 16 (L-50, L-51, L-52, and L-53) are shown in Figure E-32. The locations of the existing monitoring wells are based on the location and orientation of existing and planned Regulated Units and on the groundwater flow directions for the overlying “uppermost” aquifer determined during the site characterization study presented in Section E.3 and as shown in Figures E-27 and E-28. The first alpha character designates into which aquifer the well is installed: L = Lower Aquifer and U = Upper Aquifer. LP and UP wells are piezometers and L and U wells are monitoring wells, with the exception of UP-6 and U-26. UP-6 is currently used as a groundwater monitoring well and U-26 is currently used as a piezometer. Depths and construction details of the detection monitoring wells are provided in Sections E.6.a.(3) and E.6.a.(4), in Table E-5, and in Appendix E.3.

For existing and permitted, but not yet constructed landfill Cells, wells are located downgradient from the leachate detection sumps, which are assumed to be the logical points at which a liquid release may occur. For the lined surface impoundment, the Evaporation Pond, a well is located downgradient from the central axis of the impoundment. The Evaporation Pond has a sump located on the north side of the impoundment. The sump for the reconstructed Evaporation Pond remains in the same location as the previous sump.

A line of monitoring wells is located along the northeast side of the site to monitor general releases from the northern 1/3 of the facility where numerous shallow pre-RCRA (and pre-USEI) Units reportedly exist. In addition, four wells are located around the northeast end of Trenches 10 and 11, which are unlined and consequently do not have sumps.

Wells U-17, U-18, and U-19 are generally along the same groundwater flow lines that pass through the impacted area around wells U-21 and U-23.

Well U-26, at the extreme south-central extent of the Upper Aquifer, was installed as a future monitoring well for proposed Cell 14 Subcell 7. Construction of this subcell will not occur and, consequently, well U-26 will be maintained as a piezometer. USEI proposes to continue to maintain well U-26 as a piezometer for the Detection Monitoring Program.

Wells U-13, U-14, and U-15 were installed in the 4th Quarter of 2010 (U-13, U-15) and 1st Quarter of 2011 (U-14) and are upgradient of Cell 16.

As discussed in Section E.5 and addressed in the 1999 ACL, well U-1 became impacted by soil vapors. Well U-1 was upgradient of the site and groundwater flow from this area is back into the facility. Since well U-1 was no longer a viable upgradient, unimpacted background well, it was plugged and abandoned in July 2012.

Table E-20 provides the regulatory designation for each Upper Aquifer well based on the regulatory status of the well or waste management unit being monitored. Figure E-27 shows the groundwater flow direction for the Upper Aquifer and the Upper Aquifer detection monitoring network including Upper Aquifer detection monitoring wells for Cell 16 (U-48, U-49, and U-54).

The Lower Aquifer has a total of 23 wells consisting of 17 monitoring wells and six (6) piezometers. With the exception of well L-31, which monitors the pre-RCRA Unit radar silo, all of the Lower Aquifer monitoring wells are associated with a specific sump of Regulated Unit Cell 14 or Cell 15. Figure E-32 shows the monitoring wells for the site. Wells L-41, L-42, L-43, L-44, L-45, L-46, and L-47 were installed in coordination with construction of Cell 15. The initial group consisted of L-41, L-42 and L-46. Well L-41 is a general downgradient well for Cell 15 and L-42 is the dedicated downgradient well for sump 15-1. Wells L-41 and L-42 are equipped with dedicated sampling equipment and were incorporated into the Detection Monitoring System in the 3rd quarter 2003. Well L-46 was installed during the initial construction phase of Cell 15 as a general downgradient well for Cell 15 primarily to provide groundwater level control. Well L-46 was abandoned in the 1st quarter 2009 as part of the construction of Cell 15, Phase 4 and was replaced by well L-47. Well L-47 was installed in the 1st quarter of 2009 and is equipped with dedicated sampling equipment and has been incorporated into the Detection Monitoring system at USEI Site B.

Table E-20 provides the designation for each Lower Aquifer well. Figure E-28 shows the groundwater flow direction for the Lower Aquifer and the Lower Aquifer detection monitoring network including proposed Lower Aquifer detection monitoring wells for Cell 16 (L-50, L-51, L-52, and L-53).

E.7.b.(2) Well Maintenance Program

Detection monitoring wells should be disturbed as little as possible and only as needed when the condition of the well or pump affects the collection of valid water samples. A Well Maintenance Program will be conducted as part of the Groundwater Monitoring Program for the site. The Well Maintenance Program will provide periodic documentation of the condition of the wells and to maintain well yields, if necessary, by periodic re-development. All existing wells onsite and off-site, whether part of the RCRA Part B monitoring or not, may be subject to periodic maintenance. Piezometers will be subject to wellhead inspection but unless anomalous water level readings are observed, will not be re-developed or otherwise disturbed.

The Well Maintenance Program is designed to maintain the operation and integrity of the monitoring wells while minimizing the disturbance, risk of damage, and disruption of downhole conditions in the wells. The primary elements of the Well Maintenance Program consist of wellhead maintenance, well yield

determinations made during each sampling event and periodic well re-development if well yields or pump efficiency decrease such that it interferes with the collection of consistent, valid groundwater samples.

E.7.b.(2)(a) Wellhead Inspection

Visual inspection of the protective steel cover and guard posts will be performed during each sampling event. Any necessary repairs will be initiated promptly. Evidence that the locked security cover has been tampered with will be reported immediately to USEI. Visual inspection of the interior wellhead seals will be done every time the well is opened. Loose bolts, foreign material, etc. will be corrected at the time of discovery.

E.7.b.(2)(b) Pump Performance Assessment

During each sampling event the sampling team will observe the performance of each dedicated pump relative to its ability to provide an adequate discharge for purging and sampling the well. Pumps requiring service will be identified and USEI will arrange to have the pump pulled and serviced prior to the next sampling event.

E.7.b.(2)(c) Well Yield Determination

Every two years, during the fall sampling event, USEI will attempt to collect specific capacity information from each well capable of being pumped at a sustained rate of >1.0 gpm. This will be accomplished by measuring water levels in the well during the pre-sample purge. Specific capacity information is not required to be collected from well U-48. The diameter of the well changed in 2015 and the specific capacity test can no longer be conducted on this well.

E.7.b.(2)(d) Well Re-development and Disinfection

Well re-development will be completed by surging and bailing the well with a stainless steel bailer. Any time a pump is pulled from a well for service, the well will be re-developed with a bailer before the repaired pump is re-installed.

If bacterial growth develops in a well to the point that sampling is affected and mechanical re-development cannot restore the well yield, chemical well disinfection may be applied. Introduction of chemical well disinfectants into detection monitoring wells is problematic because of the potential impact on long term monitoring trends and the potential for introduction or generation of trace levels of detection monitoring compounds. In the event that well disinfection is required a plan will be submitted to the Department for concurrence.

E.7.c. Background Groundwater Concentration Values for Monitoring Parameters

Based on the site characterization data and groundwater flow directions presented in Section E.3, and in Figures E-27 and E-28, the initial upgradient background wells for the Upper Aquifer were U-2, U-3, and U-4. With the construction of Cell 16, wells U-2 and U-3 have been replaced with wells U-13, U-14, and U-15. U-4 remains an upgradient background well for the Upper Aquifer. The upgradient background wells for the Lower Aquifer consist of L-35, L-36, and L-38. Groundwater flow directions have not changed seasonally or temporally over the period of record. Therefore, these wells are consistently upgradient of the site. The wells are correctly constructed in accordance with the requirements of IDAPA 58.01.05.008 [40 CFR 264.97(c)] and provide representative samples of their respective aquifers and the groundwater entering the site.

The upgradient background wells will be sampled semiannually using the procedures presented in Section E.6.b.

A data base extending back to 1989 indicates none of the detection monitoring parameters has been detected in the background wells. Based on these data and the rural, non-industrialized setting for the site, the background concentration of VOCs in these wells is essentially zero.

E.7.d. Sampling and Analysis Procedures

E.7.d.(1) Documentation of Proper Sampling and Analysis Procedures

The sampling and analysis procedures presented in Section E.6.b. will be followed.

Sample logs as described in Section E.6.b.(4) will be maintained for all sampling events conducted at Site B. The completed logs for each sampling event are maintained in the Operating Record at Site B. Complete laboratory reports, including the required presentation of laboratory analytical methods and laboratory QA/QC procedures, are maintained in the Operating Record at USEI Site B.

The QA/QC procedures specified in Sections E.6.b.(4) and E.6.b.(5) will be followed.

The VOC detection monitoring parameters (Table E-19) will be analyzed by Method 8260b or the method recommended by the most current version of SW 846 as adopted by the laboratory performing the sample analyses.

E.7.d.(2) Procedure of Determination of Groundwater Elevation

The elevation of the measure point used for water-level measurements has been determined by a registered surveyor. Measure point elevations for all existing wells at Site B are provided in Appendix E.3 and in Table E-5.

The static water level will be measured in each monitoring well prior to sampling. On the first day of each semiannual sampling event, water levels will be measured in all monitoring wells and piezometers following the procedures provided in Section E.6.b.(6). This information will be used in the annual determination of groundwater flow directions and velocities as required by IDAPA 58.01.05.008 [40 CFR 264.98(e)] and as discussed in Section E.7.d.(5).

E.7.d.(3) Procedures for Determining Statistical Increase of Constituents

As presented in Section E.5 and Section E.7.a., the VOCs, as determined by EPA Method 8260b, are demonstrated to be reliable indicator parameters for the Detection Monitoring Program. Analytical data collected to date indicate that no VOCs are present in the upgradient background wells. In the remote hydrogeologic setting of USEI Site B, background levels of the VOC compounds are considered to be zero. Therefore, USEI proposes to use the trigger-level approach for data evaluation. The trigger level for any single VOC will be set at the EQL as recommended by SW 846.
Single spike laboratory method detection limits (MDLs) for Method 8260b VOCs range from 0.03 μg/L (chloroform) to 0.21 μg/L (carbon tetrachloride) (see SW 846, Table 1). The actual method detection limit for environmental samples with matrix effects and other interferences is established for each sample by the laboratory at the time of analysis following protocols specified in SW 846. SW 846 indicates that actual MDLs are typically five (5) to ten (10) times the listed MDLs but will vary based on the same and specific compounds present.

Using the 10x criteria, the sample MDLs for the VOCs may range from 0.3 to 2.1 μg/L depending on the actual sample matrix effects. In recognition of the variability of MDLs for each compound and for each sample, EPA SW 846, Table 3 proposes a standardized reporting limit of 1 μg/L, which is referred to as

the EQL. The EQL is defined in SW 846 as the "lowest concentration that can be readily achieved within specified limits of precision and accuracy during routine laboratory operations."

USEI proposes to use an EQL of 1 μg/L for all detection monitoring VOCs.

E.7.d.(4) Sampling Frequency

Pursuant to IDAPA 58.01.05.008 [40 CFR 264.98(d)], groundwater monitoring data will be collected and analyzed to determine whether there are indications that waste constituents have migrated to the uppermost aquifer or both aquifers. These evaluations are designed to provide an indication of potential migration of hazardous constituents at the downgradient monitoring wells located on the point of compliance.

Each upgradient well and the downgradient detection monitoring wells designated to Regulated Units will be sampled semiannually. Since statistical evaluations are not appropriate, each sample will consist of a single sample collected according to the sampling and analysis procedures specified in Section E.6.b. Detection monitoring wells downgradient of pre-RCRA Units will be sampled at least semi-annually. A sample consists of a single sample collected according to the sampling and analysis procedures specified in Section E.6.b. Table E-20 provides a summary of each well in the Detection Monitoring Program, the Solid Waste Management Unit (SWMU) it is designed to monitor, and the sample schedule.

E.7.d.(5) Annual Determination of Groundwater Flow Rate and Direction

Pursuant to IDAPA 58.01.05.008 [40 CFR 264.98(e)], water level elevations will be determined before each well is sampled. The water-level data collected during the last sampling event for each calendar year will be used to prepare updated potentiometric surface maps for the Upper and Lower Aquifers similar to the ones presented as Figures E-27 and E-28. Water levels measured in all monitoring wells and piezometers will be used to construct the potentiometric surface map, pursuant to IDAPA 58.01.05.008 [40 CFR 264.98(e)].

Once a potentiometric surface map has been prepared for each aquifer representative flow lines will be drawn to show the direction of groundwater flow, as illustrated in Figures E-27 and E-28.

A groundwater flow velocity will be calculated for both aquifers along a representative flow line using Darcy's Law. Average hydraulic conductivities for the Upper and Lower Aquifers determined during site characterization and presented in Table E-9 and the effective porosity of 0.43 as discussed in section E.3.c.(5)(b) will be used. A representative hydraulic gradient calculated for each flow line will be used for the velocity calculations. The methodology and values for the hydraulic properties to be used for the annual determination of groundwater flow rate are as follows:

Velocity = K *I/n

where:	**Upper Aquifer**	**Lower Aquifer**
V = Average linear velocity (ft/day)	Calculated	Calculated
K = Average hydraulic conductivity (ft/day)	0.57 ft/day	0.29 ft/day
I = Hydraulic gradient along representative flow line (ft/ft)	Varies*	Varies*
n = Effective porosity	0.43	0.43

* Hydraulic gradients are determined annually using the measured water levels for wells at either end of the flow line drawn for that year.

The potentiometric map, flow directions, and groundwater velocities will be updated once each year.

E.7.e. Response to Statistically Significant Increase of Detection Monitoring Constituent at Any Compliance Point

If VOCs are detected above the EQL (i.e., 1 µg/L) in any monitoring well, USEI will notify the Director within seven (7) calendar days. Within 30 calendar days of receipt of all the data, USEI will collect two independent confirmation samples using the dedicated sampling equipment installed in the affected well. The confirmation samples will be collected by following the same protocols used to collect the original sample, as specified in Section E.6.b. After the first sample is collected, the well will be allowed to recover to pre-sampling static conditions and the second sample will be collected following the identical sampling protocol as was used on the original sample and for the first confirmation sample. For some wells, it may take several days for water levels to recover after the first confirmation sample before the second confirmation sample can be taken.

Within 30 calendar days of receipt of all analytical results, USEI will submit the analytical data from each sampling event to the Regional Administrator along with a report that identifies whether, in the opinion of USEI, hazardous constituents have been detected in the “uppermost” aquifer.

If VOCs are detected above the statistically significant criteria in either confirmation sample, USEI will sample the affected well for Appendix IX constituents. Within 90 calendar days of receipt of all Appendix IX data USEI will submit to the Regional Administrator either of the following:

- A report summarizing the results of the analysis, as described in the Permit, and the notification that the affected well(s) is being removed from Detection Monitoring and is being placed in Compliance Monitoring; or

- A report demonstrating that a source other than a regulated unit or past practice unit, caused the increase, or that the increase resulted from an error in sampling, analysis, or evaluation.

If the report submitted by the Permittee in accordance with the Permit is not approved by the Director, then the Permittee shall remove the affected well from the Detection Monitoring Program and place the affected well in the Compliance Monitoring Program.

If either one of the confirmation samples confirms the presence of VOCs above the EQL, USEI will investigate the cause of the discrepancy by repeating the confirmation sampling as described above and performing other tasks as required, such as laboratory and sampling QA/QC reviews.

Within 90 days of conducting the re-analysis, USEI will submit a report to the Director detailing the findings of this investigation and, if necessary, notification that the affected well(s) is being removed from Detection Monitoring and is being placed in Compliance Monitoring. If neither confirmation sample contains VOCs above the EQL, USEI will resume detection monitoring as described in this Document. Figure E-33 provides a decision tree for the Detection Monitoring Program.

E.8 COMPLIANCE MONITORING PROGRAM

USEI is currently under both a Detection Monitoring Program and a Compliance Monitoring Program. Therefore, this section provides the information required by IDAPA 58.01.05.008 [40 CFR 264.99] and IDAPA 58.01.05.012 [40 CFR 270.14(c)] for the Compliance Monitoring Program.

As discussed in Section E.7, in response to the detection of chloroform in well U-21, a pre-RCRA Unit monitoring well for Silo 2, in 1993 USEI conducted fate and transport analysis to support Alternate Concentration Limits (ACLs) and completed a corrective measures study. Fate and transport modeling conducted in support of the well U-21 ACL demonstration and Compliance Monitoring Program (CH2M

HILL, April 1993a) concluded that the low groundwater velocities and fine-grained, organic-rich Upper Aquifer combine to provide significant natural attenuation of synthetic organic compounds.

This study concluded that concentrations of solvents approaching, or in some cases mathematically exceeding, their solubility limits in interior point of compliance wells were required before a 10^{-5} cancer risk or a hazard quotient of 1 was exceeded at the downgradient facility boundary.

In September 1996, well U-23, and in July 1997, U-1 also exceeded the detection monitoring criteria for carbon tetrachloride. In addition, in September 1996, the corrective action trigger, hazard quotient equal to 1, established for U-21 was met when 71 μg/L carbon tetrachloride was detected in well U-23.

In the Fall 1997 sampling event, well U-20 also triggered the detection monitoring criteria with the detection of 26 μg/L chloroform. However, no VOCs were detected in either confirmation samples collected from U-20 in December 1997. Since 1997 these same VOC's, have been detected in wells U-23 and U-24, in addition to continued, but inconsistent detections in U-20 and U-21.

The source of this limited list of VOC contaminants was evaluated and it was determined that the likely source was soil gas vapors associated with widespread pre-USEI disposal of solvents in pre-RCRA Units. All of the impacted wells are completed in the Upper Aquifer in the northwest quarter of the site as shown in Plate E-10. The contamination at well U-1 was attributed to lateral migration of soil vapors from the site and not background contamination. Because the source of the vapors was not specific to a single regulated unit USEI developed a site wide ACL (CH2M HILL, 1999). The site wide ACL classifies the wells at Site B depending on their position and use. Interior wells are allowed higher concentrations than perimeter wells for the purposes of the Compliance Monitoring program. The Compliance Monitoring program, described in the 1999 ACL and as subsequently modified with regard to the status of well U-1 is presented in this section.

E.8.a. Description of Monitoring Program

E.8.a.(1) Waste Description

Appendix E.13 provides a description of the volume, types, and chemical composition of wastes placed in units in the waste management areas.

E.8.a.(2) Characterization of Contaminated Groundwater

Table E-18 of this application provides a summary of the groundwater contamination detected in monitoring wells at Site B. Section E.3 provides the available characterization data on the wells currently in the Compliance Monitoring Program. All of the wells that exceeded the detection monitoring criteria established in the existing permit, and the upgradient Upper Aquifer background wells U-2, U-3, and U-4 have been sampled for Appendix IX constituents. Other than the constituent that triggered, and low levels of other VOC's, no organic constituents have been detected in the Appendix IX samples from the impacted wells. No non-VOC Appendix IX constituents were detected in any well that had not been impacted by VOCs. This information is provided in Section E.5 and in the Operating Record maintained at Site B.

E.8.a.(3) Hazardous Constituents to be Monitored in the Compliance Program

When a well is placed into the Compliance Monitoring Program, on the next regularly scheduled semiannual sampling event, the impacted well and the nearest upgradient background well(s) will be sampled for Appendix IX constituents. The upgradient background well will be selected based on groundwater flow lines estimated from the potentiometric surface map prepared for the previous semiannual sampling event. Deferring the Appendix IX sampling until the next regularly scheduled

semiannual sampling will not result in significant delay between samples because of the time required to get the initial sample results, collect the confirmation samples, and obtain those results.

If any new compounds are detected in the Appendix IX samples, they will be added to the compliance monitoring constituent list for subsequent samples. After the initial Appendix IX sample, the well will be sampled in accordance with the schedule and analytes found in Section E.8.a.(9)(c).

Concentration limits presented in Section E.8.a.(4) are based on “synthetic organic compounds,” which is defined as any synthetic organic compound on the Appendix IX list of analytes.

E.8.a.(4) Concentration Limits

E.8.a.(4)(a) Compliance Monitoring Well Classification

The Compliance Monitoring Program divides the monitoring wells at Site B into three categories: Upgradient Background Wells, Level 1 Compliance Wells, and Level 2 Compliance Wells. These well classifications are as follows:

- **Upgradient Background Wells**. Upgradient Background Wells (UGB) are all hydraulically upgradient, non-impacted background wells.
- **Level 1 Compliance Wells**. Level 1 Compliance Wells (L1C) include all interior wells downgradient of designated solid waste management units.
- **Level 2 Compliance Wells**. Level 2 Compliance Wells (L2C) include all wells on the east and northern site boundaries where groundwater flow paths will potentially carry impacted groundwater off the facility. Groundwater flow paths at wells U-5 and U-6 along the northwest facility are actually into the northwest corner of the site. However, since USEI does not own the adjoining property to the north, these two wells are designated L2C wells.

Figure E-34 shows the existing wells at Site B and their classification under the Compliance Monitoring Program.

E.8.a.(4)(b) Concentration Limits for Compliance Monitoring Wells

As presented in Section E.3, and Appendix E.14 the aquifers at Site B consist of thinly bedded, very fine-grained sand to silty sand, in a predominantly silty clay organic and mineral rich matrix. Well yields are generally less than ½ gallon per minute and groundwater velocities are slow. Fate and transport monitoring conducted during the U-21 ACL analysis (CH2M HILL, April 1993a) indicates natural attenuation and degradation rates for synthetic organic compounds in this environment are very high; therefore, the potential for significant migration of organic contaminants is low.

Evidence for the presence of widespread soil vapors at Site B was presented in the U-23/U-1 ACL analysis, (CH2M HILL, June 1997).

The Compliance Monitoring and ACL Program allows higher concentrations in interior wells for which there is no risk of exposure and significant attenuation and degradation potential. The program establishes lower concentrations for wells along the facility boundary, where shorter travel times reduce the potential for attenuation and degradation and increase the risk of exposure if contaminated groundwater leaves the facility.

Section E.8.a.(3) describes the Compliance Monitoring parameters. With this background and basis, the Compliance Monitoring Program and ACLs for Site B are as follows:

- **Detection Monitoring Criteria, All Wells**. Detection levels for detection monitoring will be the EQL of 1 µg/L, except for Freon 113 which is 2.1 µg/L (Section E.7.d.(3)) for the specific VOCs analyzed by Method 8260b (see Section E.7.a.(1)). A well will trigger from Detection Monitoring to Compliance Monitoring if the presence of any VOC above the EQL is confirmed in either of the

two independent samples collected after the initial detection. If any one of the confirmation samples are above the EQL, the impacted well will be included in the Compliance Monitoring Program. Section E.7.e. describes the sample confirmation procedures and Figure E-33 provides a decision tree illustrating the evaluation criteria used to determine when a well enters the Compliance Monitoring Program.

- **Upgradient Unimpacted Background Wells**. Detection monitoring criteria will apply. The stipulated background concentration for the detection monitoring VOCs is zero. If any of the Upper Aquifer upgradient background wells U-13, U-14, U-15, and U-4 or Lower Aquifer upgradient background wells L-35, L-36, or L-38 (Figure E-32) become impacted by monitoring constituents above the detection monitoring criteria, they will be temporarily reclassified as an "Other Well" because they are upgradient of the site, but outside of the current facility boundary. Reclassification of "Other wells" to either Level 1 or Level 2 Compliance wells will be established on the basis of an investigation into the source and extent of the impacting constituent. If any of the UGB wells become impacted, new UGB wells may be installed.

- **Level 1 Compliance Wells**. If the following ACLs are exceeded in a Level 1 Compliance Well, Corrective Action Requirements of IDAPA 58.01.05.008 [40 CFR 264.99(h)] will apply: Any single synthetic organic compound equal to 1/2 % (0.5 %) of its solubility in water, or, if multiple constituents are present, a cumulative total of 1/2 % solubility based on the summation of solubility percentages represented by the concentration of each constituent detected.

- **Level 2 Compliance Wells**. If the following ACLs are exceeded in a Level 2 Compliance Well, Corrective Action Requirements will apply. If a maximum concentration limit (MCL) has been established by the EPA for drinking water, the MCL will apply. If an MCL has not been established, a concentration equal to $1x10^{-5}$ industrial cancer risk for carcinogenic constituent, or if multiple carcinogenic compounds are present, a cumulative cancer risk of $1x10^{-5}$ industrial for carcinogenic synthetic organic contaminants will apply. For hazardous constituents, the limit shall be a hazard quotient of one (1) based on an industrial scenario or a cumulative hazard quotient of one (1) if multiple hazardous constituents are detected.

The distinction between Level 1 and Level 2 Compliance Wells, and therefore the difference in allowable concentrations, is based on the fact that there is very little exposure risk at a Level 1 Compliance Well. Since the L1C wells are locked, dedicated monitoring wells, there is no potential exposure except to trained samplers who are wearing personal protective equipment during the periodic, infrequent sampling events. Furthermore, the L1C wells are all located interior to the site. Groundwater flow paths from L1C wells to the downgradient facility boundary involve long distances and slow times, allowing adequate time for implementing a Corrective Action Program.

Level 2 Compliance Wells are also locked and dedicated monitoring wells offering no exposure at the wellhead or to groundwater in the well. However, given the proximal location of these wells either to private property (U-5 and U-6) or to the downgradient facility boundary, a slight potential for offsite exposure risks is assumed and low concentration criteria are applied.

Figure E-34 shows the existing monitoring wells at USEI Site B and their classification. Carbon tetrachloride, a VOC, was detected in upgradient well U-1 beginning in October 1995 (see Section E.5) It was determined that U-1 was no longer a valid upgradient non-impacted background well for VOC's and was re-classified as a Level 1 Compliance well. In July 2012, well U-1 was plugged and abandoned.

Table E-21 provides a list of all 51 VOCs on the current Appendix IX list of analytes and their respective ½ % solubility levels, which apply to Level 1 Compliance Wells.

E.8.a.(4)(c) Compliance Monitoring Sampling Frequency

The sampling frequency for compliance monitoring wells is semi-annually, as described in Section E.8.a.(3). Because statistical sampling and data analysis are not proposed, each sample will consist of a single sample collected after the well is purged following procedures described in Section E.6.b.

E.8.a.(5) Alternate Concentration Limits

The justification for establishing ACLs is provided in Section E.8.a.(4). The concentration trigger levels presented in Section E.8.a.(4) represent the concentration limits included in the 1999 ACL which was incorporated into USEI's RCRA Part B permit. The ACL is provided as Appendix E-14.

E.8.a.(6) Adverse Effects on Groundwater Quality

USEI conducted significant efforts to characterize the vadose zone at USEI (CH2M HILL, December 1986) and to simulate the movement of liquids through the vadose zone (CH2M HILL, December 1987). These studies concluded that transport of liquid wastes from solid waste management units at Site B were unlikely to reach the groundwater because of the high assimilative capacity of the thick, highly layered, and relatively dry subsurface strata. When low levels (part per billion) of VOCs were detected in well U-21, USEI conducted and investigated the likely source of VOCs (CH2M HILL, April 1993b). This study concluded that the most probable source of the VOCs in the groundwater, given the low concentrations and limited compounds present, was the penetration of soil vapors to the groundwater. Additional evaluation of the likely transport mechanism of VOCs to the groundwater was also completed after VOCs were detected in wells U-1 and U-23. This study (CH2M HILL, June 1997) concluded that widespread soil vapors likely existed as a result of past practice disposal of VOCs in unlined trenches and the sandy nature of the upper 100 ft. of sediment. Subsequent soil vapor investigations in 2000 and 2001 (CH2M HILL 2000, Brown and Caldwell, 2001 and Brown and Caldwell, 2003) confirmed the soil vapor transport hypothesis first identified in the studies conducted in 1993 and 1997 in response to the detection of VOCs in U-21 and U-23. The 2003 Brown and Caldwell Soil Vapor Study is provided as Appendix E-10.

Extensive fate and transport modeling of VOCs in the groundwater (CH2M HILL, April 1993) and the initial ACL analysis for U-1 and U-23 (CH2M HILL, June 1997), indicate that the groundwater system at Site B provides significant attenuation and degradation potential, which greatly limits the migration of VOCs by advective flow in the groundwater. This is due to the high mineral content and high carbon content of the aquifer matrix and slow groundwater velocities in the thin silty sand comprising the water-bearing zones.

As shown in Section E.3, the shallow groundwater systems at USEI Site B are marginal water producers and, except for a sandy zone limited to the northwest corner in the Upper Aquifer, are not capable of supplying usable quantities of water to wells. In addition, the natural water chemistry is high in total dissolved solids and exceeds secondary drinking water standards for sulfate. Consequently, the Upper and Lower Aquifers at Site B are not viable resources. The well inventory presented in Section E.3.a.(4) indicates the closest downgradient shallow well to Site B is a stock well approximately two (2) miles to the northeast. This well is completed in shallow sand and gravel along the Snake River and yields more than 50 gpm. The high yield and high dilution potential of the river gravels will preclude any possible adverse effects from synthetic organic compounds in the Upper Aquifer at Site B. The other wells within two (2) miles of the site are all deep and penetrate far enough into the regional artesian system that they either flow at the surface or have static waters less than 20 ft. below ground surface. The high hydraulic heads in these wells will prevent any possible impact from contaminants in the aquifers at Site B. The fate and transport studies completed by USEI indicate that the attenuation and degradation of VOCs over approximately 1/4 mile from the northwest upgradient side of the site where the VOCs have intercepted

the groundwater to the downgradient facility is sufficient to completely degrade the compounds to below detectable levels.

Since USEI Site B is in an isolated rural area, there are no other sources of VOCs in the groundwater. This is demonstrated by the background water quality in which no VOCs have been detected. Consequently, cumulative or additive effects are not significant.

Groundwater flow directions in the Upper Aquifer are from the facility onto property also owned by USEI. There are no potential receptors (well users) in the area, given the limited usefulness of the aquifers based on quality and yield. Therefore, the potential adverse health risks presented by contaminated groundwater on Site B are negligible to nonexistent.

The aquifers do not yield sufficient water for irrigation or any commercial use. Therefore, there are no adverse impacts or potential damage to crops. Minor use of the aquifers for stock watering may occur as noted above. Given the low levels of contaminants present or allowed to be present under the Compliance Monitoring and ACL Program and the high degradation and attenuation capacity of the aquifers, the threat to livestock in the area is also considered negligible.

E.8.a.(7) Potential Adverse Effects on Surface Water

The depth to water at Site B ranges from about 140 ft. to 280 ft. below ground level. There are no springs or other surface discharges of the Upper or Lower aquifer groundwater to surface water within at least a three mile radius of the site. The nearest surface water body is Castle Creek, about 1 mile west and hydraulically upgradient from the site. Castle Creek appears to be a source of recharge to the shallow aquifers at Site B. The aquifers at USEI Site B may be hydraulically connected to the Snake River approximately three (3) miles to the east. However, the rate of groundwater flow, the small volume of groundwater flow compared to the Snake River, and the degradation potentials discussed in the previous section make it extremely unlikely that contaminated groundwater at USEI will have any detectable impact on surface water resources in the area. There have been no studies quantifying potential impacts of the contaminated groundwater present in the Upper Aquifer at Site B because they are effectively nonexistent.

E.8.a.(8) Groundwater Monitoring System for Compliance Monitoring

E.8.a.(8)(a) Groundwater Monitoring Wells

No new monitoring wells are specifically proposed for the Compliance Monitoring Program.
Any new or replacement well will be installed and constructed in accordance with the well construction details provided in Section E.6.a.(4). As required, existing wells currently in the Detection Monitoring Program at Site B will be incorporated into the Compliance Monitoring Program, as needed. Sections E.2, E.3, and E.6 describe the existing wells at Site B and the construction techniques and design criteria for new or replacement wells to be installed under the permitted monitoring programs.

Wells currently in the Compliance Monitoring Program consist of both Level 1 and Level 2 wells. Level 1 Compliance Wells consist of interior monitoring wells located downgradient of Regulated and Past Practice Units. Level 2 Compliance Wells consist of downgradient wells on the eastern and northern site boundaries where groundwater flow could potentially carry impacted groundwater off of the facility.

E.8.a.(8)(b) Representative Groundwater Quality

Detection monitoring wells that are incorporated into the Compliance Monitoring Program will provide representative groundwater samples for both background and downgradient compliance monitoring points. The location and construction of the wells with respect to waste management units, groundwater flow directions, and aquifer properties has been described in detail in Sections E.3 and E.6.

E.8.a.(9) Sampling and Statistical Analysis Procedures for Groundwater Data

E.8.a.(9)(a) Compliance Period

If the data evaluation indicates that concentrations have fallen to below the detection monitoring criteria, the impacted wells will remain in compliance monitoring. After the sixth consecutive semiannual sample below the detection monitoring criteria, USEI will advise IDEQ that the impacted well and the associated upgradient background well are being taken out of the Compliance Monitoring Program and placed back into the Detection Monitoring Program.

E.8.a.(9)(b) Sampling Methods and Procedures

Compliance Program groundwater sampling will be conducted using the same sampling equipment and sampling procedures and will follow the same internal and laboratory QA/QC procedures as specified in Sections E.6.b.(4) and E.6.b.(5).

E.8.a.(9)(c) Compliance Monitoring Constituents and Sampling Frequency

Compliance monitoring sampling schedule events will coincide with the semiannual detection monitoring sampling program. Compliance Monitoring wells will be monitored for the constituents in Table E-19 during these semiannual events. Laboratory analysis on all compliance monitoring samples will follow methods and protocols required by the most current version of EPA SW 846 as adopted by the laboratory.

Groundwater monitoring wells in the Compliance Monitoring Program shall be monitored annually for the constituents listed in Appendix IX of 40 CFR Part 264 per IDAPA 58.01.05.008 [40 CFR 264.99(g)].

E.8.a.(9)(d) Background Water Quality

Synthetic organic compounds are not naturally present in background upgradient wells at Site B. Therefore, there is no value in establishing a statistical data base or conducting statistical analysis to establish background concentrations of organic compounds in the detection monitoring or compliance monitoring wells. Under any statistical approach using a background concentration of zero, the confirmed presence of any synthetic organic compound in a monitoring well at Site B will fail any statistical method applied. Since there is no advantage to statistical evaluation of the background data on organic compounds, none is proposed.

If any of the metals or other organic and inorganic compounds are detected above the groundwater protection standards listed in Table 1 in 40 CFR 264.94, as adopted by IDAPA 58.01.05.008, USEI will establish statistical background concentrations in the upgradient background wells for that aquifer. Table E-22 provides the constituents and the groundwater protection standards for metals, selected inorganic non-metals, and pesticides and herbicides for which EPA has codified groundwater protection standards. These constituents are not highly mobile, nor are they likely to spread via vapor transport and their presence above these groundwater protection standards is not likely. Therefore, until any of these compounds is detected in concentrations exceeding the groundwater protection standards in the impacted compliance monitoring well, their concentration in the background, upgradient well(s) will not be statistically established.

If necessary to statistically establish concentrations of the constituents in Table E-22, USEI will collect samples from all impacted compliance wells and associated upgradient wells as follows:

- Four independent samples will be collected from each well semiannually for one (1) year. This will result in a total of eight independent samples covering two seasonal periods.
- The wells will be allowed to recover between each independent sample.

- Purging and sampling techniques established for each well as described in Section E.6.b. will be followed.
- Samples for metal analysis will be filtered with an appropriate media in the field or the off-site laboratory and analyzed for dissolved metals analysis.

E.8.a.(9)(d)(1) Background Metals Study Conclusions

Metals data has been collected from some site monitoring wells at Site B beginning in 1989, In 2005, USEI initiated a Background Metals Study and began collecting additional metals data from selected background wells in both aquifers to be compared with data from the compliance wells. These wells were initially sampled semi-annually for the eight RCRA metals. Gradually additional wells were included and beginning in 2012 and continuing through the fall 2019 sampling event all wells were sampled for Appendix IX metals semi-annually.

Metals data collected from all wells for the period from 2012 through 2019 was used to determine the average arsenic concentrations in the background wells for both aquifers. Additional data exists prior to 2012, but was not used for the determination since not all wells were sampled on the same frequency and several of the wells used initially were abandoned prior to 2012.

Based on the data collected, the average concentration of arsenic in the background wells is 0.02 mg/L for the upper aquifer and 0.063 mg/L for the lower aquifer. It was determined that arsenic in both aquifers is from naturally occurring sources within the sedimentary deposits underlying Site B. In the case of the upper aquifer, the most likely cause of elevated arsenic in several CMP wells is the presence of soil vapors of VOCs in the sandy un-saturated zone immediately above water. The soil vapors are apparently creating oxygen deficient (reduced) conditions in the upper part of the aquifer by several possible mechanisms, including directly displacing oxygen, accumulation of carbon dioxide as the VOCs degrade and by consumption of oxygen by bacteria feeding on the organic compounds. The net result is mobilization of arsenic from the aquifer sediments as conditions change from oxidized to reduced. The lower aquifer has abundant mobile natural arsenic because the sediments are already reduced.

E.8.a.(9)(e) Annual Determination of Groundwater Flow Rate and Direction

As part of the Detection Monitoring Program sampling protocols, water levels are measured in all Site B monitoring wells as the initial task of the sampling event. Section E.6.b.(6) provides details on the methods and procedures to be used. These data will be used to document the groundwater flow direction and rate annually as required for the Compliance Monitoring Program. Section E.7.d.(5) provides hydraulic conductivity and porosity values for this calculation.

E.8.a.(9)(f) Data Reporting and Evaluation

USEI will evaluate the data from each compliance monitoring sample as follows. The composite impacts of multiple constituents will be calculated by adding either the cumulative solubilities for Level 1 Compliance Wells or summing the cancer risks or hazard quotients for the Level 2 Compliance Wells. Table E-23 provides the procedure to be used to calculate the Hazard Quotient and the cancer risk for any synthetic organic compound detected in a Level 2 Compliance Well. The resultant values will be compared to the allowable concentration limits described in Section E.8.a.(4). Figures E-35 and E-36 provide flowcharts for evaluating the compliance monitoring data from Level 1 Compliance Wells and Level 2 Compliance Wells, respectively.

If the evaluation of the compliance monitoring data indicates that one or more of the constituents listed in Table E-22 has exceeded the groundwater protection standards, within seven (7) days of making such a determination USEI will notify IDEQ of the exceedance. Beginning with the next scheduled semiannual sampling event, USEI will collect the first four independent samples of the impacted well and associated

background well. The second set of four independent samples will be collected during the next semiannual sampling event.

Within 30 days of receiving the sample results on the second set of four independent samples, USEI will establish control limits for the background wells and compare the results to the downgradient wells; USEI will report the results to IDEQ. If the downgradient wells are not out of control compared to the upgradient background wells, no action is necessary and compliance monitoring will continue. Because of natural occurrences and spatial variations resulting from geochemical processes and aquifer matrices unrelated to site activities, exceeding groundwater protection standards for inorganic parameters will not automatically require USEI to begin corrective action. If the downgradient wells are out of control for inorganic constituents, within 60 days, USEI will submit a plan to evaluate the cause of the exceedance.

E.8.a.(10) Groundwater Protection Standard Exceeded at Compliance Point Monitoring Well

USEI will respond to the compliance monitoring data based on the compliance monitoring criteria. If the results of this evaluation indicate the concentration limits of the synthetic organic compounds included in the Compliance Monitoring Program (Table E-23) are exceeded, USEI will do the following:

- Provide IDEQ with a written evaluation of the compliance monitoring sample results within seven (7) days of receipt of the final written laboratory report.
- Submit an application for a permit modification to establish a Corrective Action Program meeting the requirements of IDAPA 58.01.05.008 [40 CFR 264.99(h)], as described in Section E.9, within 180 days.

If the data evaluation indicates that concentrations are within the compliance monitoring concentration limits, the affected wells will remain in compliance monitoring.

E.9 CORRECTIVE ACTION PROGRAM

None of the impacted compliance wells at Site B have exceeded concentration limits that would require corrective action. No hazardous constituents have been detected in any of the downgradient facility monitoring wells. Therefore, corrective action requirements provided in IDAPA 58.01.05.008 [40 CFR 264.100 and 264.101] are not applicable and a Corrective Action Program has not been implemented.

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Table E-1 - Summary of Sample Events for VOCs or Appendix IX, April 1989 Through October 2013

Well ID	Apr-89	Aug-89	Oct-89	Apr-90	Oct-90	Apr-91	Oct-91	Dec-91	Feb-92	Mar-92	Apr-92	July-92	Oct-92	Mar-93	May-93	Oct-93	May-94	Oct-94	May-95	Oct-95	Apr-96	Sep-96	Jun-97	Oct-97	May-98	Oct-98	Jun-99	Oct-99	Jan-00	Jun-00	Nov-00	Mar-01	Apr-01	Dec-01
Upper Aquifer																																		
U-1	X		X	X	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V9	A9
U-2	NA		X	X	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-3	X		X	X	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-4	X		X	X	X	X	X			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-5	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	V	V
U-6	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	V	V
U-7	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-8	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-9	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-10	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-11	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-12	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-13	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
U-14	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
U-15	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
U-17	NA		X	X			X				X		X		X	X	X	X	X	X	X		X		X		X			X			V
U-18	NA		X	X			X				X		X		X	X	X	X	X	X			X		X		X			X			V
U-19	NA		X	X			X				X		X		X	X	X	X	X	X			X		X		X			X			V
U-20	X		X		X		X				X		X		X	X	X	X	X	X			X		X		X		X	X		V9	A9
U-21	X		X		X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V9	A9
U-22	X				X		X						X			X		X		X			X		X		X						V
U-23	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V9	A9
U-24	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V9	V
U-25	NA		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
U-48	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
U-49	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
UP-6*	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
Lower Aquifer																																	
L-28	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-29	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-30	X		X	X	X		X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-31	NA		NA	NA	NA		X				X		X		X	X	X	X	X	X	X		X		X		X			X			V
L-32	NA		NA	NA	NA	NA	NA				NA		NA		NA	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-33	NA		NA	NA	NA	NA	NA				NA		NA		NA	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-35	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-36	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-37	X	X	X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-38	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-39	X		X	X	X	X	X				X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		V	V
L-40	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-41	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-42	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-43	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-44	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-45	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-46	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA
L-47	NA		NA	NA	NA	NA	NA				NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA	NA

Well ID	May-02	Sep-02	May 03	Jul-03	Oct 03	Jan-04	May 04	Jul-04	Aug-04	Oct 04	Jan-05	May-05	Oct 05	May-06	Oct 06	Jan-07	May 07	Nov 07	Feb-08	May 08	Nov 08	May 09	Oct 09	May 10	Jul-10	Oct 10	May 11	Oct 11	May 12	Jun-12	Oct 12	May 13	Oct 13	Well ID
Upper Aquifer																																	**Upper Aquifer**
U-1	V9	A9	V9		A9		V9			A9		V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		PA	PA	PA	U-1
U-2	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		PA	PA	PA	U-2
U-3	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		PA	PA	PA	U-3
U-4	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	U-4
U-5	V	V	V		V		V			V		V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-5
U-6	V	V	V	V	V	V	V			V	V	V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-6
U-7	V	V	V		V		V			V		V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-7
U-8	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	U-8
U-9	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	U-9
U-10	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	U-10
U-11	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	U-11
U-12	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	U-12
U-13	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	NA	NA	NA		NA	NA	NA	NA		V	V	V	U-13
U-14	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	NA	NA	NA		NA	NA	NA	NA		V	V	V	U-14
U-15	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	NA	NA	NA		NA	NA	NA	NA		V	V	V	U-15
U-17		V			V					V			V	V	V		V	V		V	V	V	V			V	V	V			V	V	V	U-17
U-18		V			V					V			V	V	V		V	V		V	V	V	V			V	V	V			V	V	V	U-18
U-19		V			V					V			V	V	V		V	V		V	V	V	V			V	V	V			V	V	V	U-19
U-20	V9	A9	V9		A9		V9			A9	A9	A9	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		UTS	UTS	PA	U-20
U-21	V9	A9	V9		A9		V9			A9		V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-21
U-22		V			V					V		V	V	V	V	V	V	V	V	V	V	V	V	V		V	V	V	V	V	V	V	V	U-22
U-23	V9	A9	V9		A9		V9			A9		V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-23
U-24	V	V	V		V	V	V	V	A9	A9	A9	V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-24
U-25	X	V	V		V		V			V		V	A9	V	A9		V	A9		V	A9	V	A9	V		A9	V	A9	V		A9	V	A9	U-25
U-48	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	NA	NA	NA		NA	NA	NA	NA		NA	V	V	U-48
U-49	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	NA	NA	NA		NA	NA	NA	NA		NA	V	V	U-49
UP-6*	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	NA	NA	NA		NA	NA	NA	NA		NA	V	V	UP-6
Lower Aquifer																																	**Lower Aquifer**
L-28	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-28
L-29	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-29
L-30	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-30
L-31		V			V					V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-31
L-32	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-32
L-33	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-33
L-35	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-35
L-36	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-36
L-37	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-37
L-38	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-38
L-39	V	V	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-39
L-40	NA	NA	V		PA		PA			PA		PA	PA	PA	PA		PA	PA		PA	PA	PA	PA	PA		PA	PA	PA	PA		PA	PA	PA	L-40
L-41	NA	NA	V		V		V			V		V	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-41
L-42	NA	NA	NA		V		V			V		V	V	V	V		V	V		V	V	V	V	V	V	V	V	V	V		V	V	V	L-42
L-43	NA	NA	NA		NA		NA			NA		NA	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-43
L-44	NA	NA	NA		NA		NA			NA		NA	V	V	V		V	V		V	V	V	V	V		V	V	V	V		V	V	V	L-44
L-45	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		V	V	V	V	V		V	V	V	V		V	V	V	L-45
L-46	NA	NA	NA		V		V			V		V	V	V	V		V	V		V	V	PA	PA	PA		PA	PA	PA	PA		PA	PA	PA	L-46
L-47	NA	NA	NA		NA		NA			NA		NA	NA	NA	NA		NA	NA		NA	NA	V	V	V		V	V	V	V		V	V	V	L-47

Table E-2 - List of Organic and Inorganic Parameters in Pre-ACL Detection Monitoring Program

Constituent	CAS No.
Benzene	71-43-2
Bromodichloromethane	75-27-4
Bromoform (tribromomethane)	75-25-2
Bromomethane	74-83-9
Carbon Tetrachloride	56-23-5
Chlorobenzene (monochlorobenzene)	108-90-7
Chloroethane (ethyl chloride)	75-00-3
2-chloroethylvinyl ether	110-75-8
Chloroform	67-66-3
Chloromethane (methyl chloride)	74-87-3
cis-1,3-Dichloropropene	10061-01-5
Dibromochloromethane	124-48-1
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethene	75-35-4
1,2-Dichloropropane	78-87-5
Ethylbenzene	100-41-4
Methylene Chloride	75-09-2
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethene	127-18-4
Toluene	108-88-3
Trans-1,2-Dichloroethene	156-60-5
Trans-1,3-Dichloropropene	10061-02-6
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethene	79-01-6
Vinyl chloride	75-01-4
Total Organic Carbon (TOC)	-----
Total Organic Halides (TOX)	-----
pH	-----
Specific Conductance	-----
Temperature	-----
Note: Refer to Table E-19 for current requirements.	

Table E-3 - Deep Artesian Well Data

• The well was drilled to a depth of 3,080 feet and was completed in 1958.
• The driller's log indicates that the Glenns Ferry Formation underlies the site to a depth of 1,666 feet.
• The upper 173 feet of the Glenns Ferry Formation was identified as coarse-grained, compared to the underlying interbedded clay and shale layers below 173 feet.
• The Poison Creek Formation, beneath the Glenns Ferry, occurs as approximately 600 feet of alternating gray shale, clay, and cinder characterized by a low yield of warm artesian water.
• At a depth of 2,291 feet, the Banbury Basalt was penetrated and occurs as approximately 225 feet of alternating black basalt and gray shale. It is an important source of hot artesian water in the area.
• Underlying the Banbury Basalt are the Tertiary silicic volcanics identified as alternating rhyolite and gray shale grading into black and red sands and sandstones. The silicic volcanics are considered the basement rocks of the Snake River Plain.
• The deep artesian well at Site B was cased to a depth of 2,515 feet and completed as open-hole from 2,515 to 3,080 feet.
• Artesian water was found at a depth of 2,400 feet.
• 50 gpm flow at the surface with the well at a depth of 3,000 feet.
• 335 gpm flow with the bottom of the well at 3,080 feet.
• Temperature was 170 degrees Fahrenheit.
• Shut-in pressure was 70 psi at ground surface.

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
Upper Aquifer Monitoring Wells								
U-4	2/15/89 - 2/23/89	361932.6	511444.7	0 - 207.0	AR	CH2M	Mon well	CH2M HILL, May 1989
U-5	2/27/89 - 3/3/89	362947.4	511436.5	0 - 257.5	AR	CH2M	Mon well	CH2M HILL, Jun 1989a
U-6	3/15/89 - 3/17/89	363417.7	511436.7	0 - 268.5	AR	CH2M	Mon well	CH2M HILL, Jun 1989b
U-7	6/22/89 - 6/28/89	363773.0	511300.5	0 - 237.0	AR	CH2M	Mon well	CH2M HILL, Aug 1989a
U-8	6/15/89 - 6/20/89	363793.2	511127.1	0 - 237.0	AR	CH2M	Mon well	CH2M HILL, Aug 1989b
U-9	3/21/89 - 3/24/89	363818.4	510888.3	0 - 242.0	AR	CH2M	Mon well	CH2M HILL, Jun 1989c
U-10	3/29/89 - 4/6/89	363806.7	510518.1	0 - 232.0	AR	CH2M	Mon well	CH2M HILL, Jul 1989a
U-11	4/14/89 - 4/19/89	363815.1	510343.0	0 - 217.0	AR	CH2M	Mon well	CH2M HILL, Jul 1989b
U-12	4/20/89 - 4/25/89	363809.4	510184.7	0 - 217.5	AR	CH2M	Mon well	CH2M HILL, Jul 1989c
U-13	11/19/10 - 12/14/10	361209.8	511469.5	0 - 203.9	AR	Feast	Mon well	Feast, April 2011
U-14	1/4/11 – 1/12/11	360699.9	511469.1	0 - 196.9	AR	Feast	Mon well	Feast, April 2011
U-15	11/8/10 - 11/16/11	360489.4	510809.8	0 - 219.4	AR	Feast	Mon well	Feast, April 2011
U-17	5/9/89 - 5/19/89	363237.9	509847.1	0 - 217.0	AR	CH2M	Mon well	CH2M HILL, Oct 1989b
U-18	5/22/89 - 5/25/89	363241.7	510124.0	0 - 227.0	AR	CH2M	Mon well	CH2M HILL, Aug 1989c
U-19	6/8/89 - 6/13/89	363245.1	510352.5	0 - 239.0	AR	CH2M	Mon well	CH2M HILL, Aug 1989d
U-21 (SW-2)	2/21/85 2/22/85 - 4/12/85	362727.4	510684.5	0 - 27.7 27.7 - 211.7	AR MBA	CH2M	Mon well	ESII, Feb 1986
U-22 (SW-1)	7/25/84 - 11/1/84	362539.6	510311.6	0 - 228.1	MCT	CH2M	Mon well	ESII, Feb 1986
U-23 (PCB-1)	6/19/85 - 7/9/85	362238.6	510305.9	0 - 199.0	AR	CH2M	Mon well	ESII, Feb 1986
U-24	7/18/89 - 7/25/89	362247.8	511018.1	0 - 226.0	AR	CH2M	Mon well	CH2M HILL, Oct 1989c
U-25	7/11/89 - 7/14/89	362294.2	510543.3	0 - 224.0	AR	CH2M	Mon well	CH2M HILL, Oct1989d

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
U-48	6/12/12 – 6/26/12	361897.3	510995.3	0 – 195.5	AR	Feast	Mon well	Feast August, 2012
U-49	6/12/12 – 6/26/12	361909.4	510568.3	0 – 202.8	AR	Feast	Mon well	Feast August, 2012
UP-6 (SW 3-2)	1/8/86 - 1/21/86	363035.7	510541.6	0 - 172.4 172.4 - 199.4	AR MBA	CH2M	Mon-well	CH2M HILL, Aug 1986
U-54	12/16 – 12/28/16	361906.2	510038.1	0 – 210.0	AR	Feast	Mon well	Feast June, 2017
Upper Aquifer Piezometers								
U-26	3/7/93 - 3/12/93	362768.2	509642.2	0 - 237.8	AR	CH2M	Piezometer	CH2M HILL, Jun 1993
UP-1 (D-19)	1/9/85 - 1/15/85	363536.7	510998.5	0 - 252.0	AR	CH2M	Piezometer	ESII, Feb 1986
UP-3 (PCB-2)	7/9/85 - 7/18/85	362237.6	510491.1	0 - 202.2	AR	CH2M	Piezometer	ESII, February 1986
UP-4 (D-21)	3/16/85 - 3/17/85 3/18/85 - 3/22/85	363792.2	510625.3	0 - 111.4 111.4 - 302.9	HSA WRC	CH2M	Piezometer	ESII, February 1986
UP-5 (MW-10)	4/5/84 - 4/16/84	363767.8	511186.6	0 - 252.0	AR	CH2M	Piezometer	ESII, February 1986
UP-7 (MW-1)	12/8/83 - 12/9/83	363186.0	511494.9	0 - 235.8	AR	CH2M	Piezometer	ESII, February 1986
UP-8 (SW 1-2)	6/20/86 - 9/10/86	362593.6	510309.6	0 - 39.9 39.9 - 81.9 81.9 - 201.9	AR MBA AR	MK	Piezometer	MKE, November 1986
UP-26	3/2/92 - 3/5/92	362345.0	510079.7	0 - 233.5	AR	CH2M	Piezometer	CH2M HILL, June 1993
Lower Aquifer Monitoring Wells								

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
L-28	10/11/88 - 10/17/88	363802.8	509307.8	0 - 252.5	AR	CH2M	Mon well	CH2M HILL, Feb 1989a
L-29	9/22/88 - 9/28/88	363800.2	509499.1	0 - 252.0	AR	CH2M	Mon well	CH2M HILL, Feb 1989a
L-30	9/13/88 - 9/20/88	363649.1	509530.1	0 - 262.0	AR	CH2M	Mon well	CH2M HILL, Feb 1989a
L-31	12/1/90 - 12/7/90	363223.3	509560.9	0 - 277.0	AR	CH2M	Mon well	CH2M HILL, Feb 1991a
L-32	7/20/93 - 8/10/93	362973.1	509508.6	0 - 277.5	AR	CH2M	Mon well	CH2M HILL, Oct 1993a
L-33	7/23/93 - 7/29/93	362793.0	509603.3	0 - 282.2	AR	CH2M	Mon well	CH2M HILL, Oct 1993a
L-35 (D-30)	9/30/85 - 10/11/85 1/23/88 (reconstructed)	361877.4	508929.0	0 - 289.0	AR	CH2M	Mon well	CH2M HILL, Feb 1989a
L-36 (D-27)	9/17/85 - 10/8/85	362303.8	508871.0	0 - 301.3	AR	CH2M	Mon well	ESII, February 1986
L-37 (D-28)	9/20/85 - 10/9/85	363121.9	508872.5	0 - 301.8	AR	CH2M	Mon well	ESII, February 1986
L-38 (MW-13)	10/01/84 - 10/03/84	361372.5	508653.5	0 - 301.7	AR	CH2M	Mon well	ESII, February 1986
L-39	12/1/88 - 12/09/88	363121.5	509435.2	0 - 274.0	AR	CH2M	Mon well	CH2M HILL, Feb 1989a
L-41	7/28/03 - 7/31/03	362784.1	508870.5	0 – 257.0	AR	Feast	Mon well	Feast, Dec. 2003
L-42	7/22/03 - 7/25/03	363484.1	508872.3	0 – 276.0	AR	Feast	Mon well	Feast, Dec. 2003
L-43	7/14/05 - 7/18/05	363990.2	508938.3	0 - 270.0	AR	Feast	Mon well	Feast, Nov. 2005
L-44	7/19/05 - 7/22/05	364368.3	508905.4	0 - 280.0	AR	Feast	Mon well	Feast, Nov. 2005
L-45	8/21/07 -8/24/07	364704.8	508607.5	0 - 260.0	AR	Feast	Mon well	Feast, Dec. 2007
L-47	1/14/09 – 1/20/09	365046.1	508301.7	0- 260.0	AR	Feast	Mon well	Feast, June 2009
Lower Aquifer Piezometers								
LP-11	2/26/85 - 10/10/85	363681.0	508873.9	0 - 301.5	AR	CH2M	Piezometer	ESII, February 1986

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
(D-29)								
LP-12 (D-21)	3/16/85 - 3/17/85 3/18/85 - 3/22/85	363792.2	510625.3	0 - 111.4 111.4 - 302.9	HSA WRC	CH2M	Piezometer	ESII, February 1986
LP-13 (MW-25)	8/26/85	363784.6	511248.3	0 - 291.6	AR	CH2M	Piezometer	ESII, February 1986
LP-14 (MW-14)	10/3/84 - 10/5/84	361427.3	509484.9	0 - 292.0	AR	CH2M	Piezometer	ESII, February 1986
LP-15 (MW-24)	4/12/85 - 4/18/85	363809.2	510124.3	0 - 282.1	AR	CH2M	Piezometer	ESII, February 1986
LP-27	2/17/92 - 2/28/92	362370.4	510051.5	0 - 303.5	AR	CH2M	Piezometer	CH2M HILL, June 1993
Abandoned Wells and Boreholes								
M2-A1	8/27/58 - 8/29/58	362885	510703	0 - 200.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-B1	8/23/58 - 8/27/58	362440	510383	0 - 200.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-B	12/17/58 - 1/9/59	362805	510688	0 - 200.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-C1	8/26/58	362890	510393	0 - 50.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-D1	8/28/58 - 9/1/58	363340	510408	0 - 200.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-E1	8/23/58, 8/25/58	362595	510243	0 - 50.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-F1	8/20/58 - 8/22/58	363185	510243	0 - 50.0	Core	S&W	Assumed	ESII, February 1986

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
							plugged	
M2-H1	8/20/58 - 8/22/58	362905	509438	0 - 50.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-J	1/3/59 - 1/9/59	362885	510023	0 - 140.0	Core	S&W	Assumed plugged	ESII, February 1986
M2-L	12/19/58 - 1/3/59	363055	509618	0 - 60.0	Core	S&W	Assumed plugged	ESII, February 1986
DH-1	10/8/81 - 10/12/81	362915	511243	0 - 120.0	HSA	NT&E	Plugged in 1981	ESII, February 1986
DH-2	10/12/81	361920	511483	0 - 40.0	HSA	NT&E	Plugged with drill cuttings in 1981	ESII, February 1986
DH-3	10/13/81 - 10/22/81	363835	508868	0 - 131.4	HSA	NT&E	Plugged in 1981	ESII, February 1986
DH-4	10/22/81 - 10/23/81	363835	508973	0 - 60.0	HSA	NT&E	Plugged with drill cuttings in 1981	ESII, February 1986
DH-5	10/23/81 - 10/28/81	363705	508868	0 - 49.5	HSA	NT&E	Plugged with drill cuttings in 1981	ESII, February 1986
DH-6	10/27/81 - 10/29/81	361875	508883	0 - 152.1	HSA	NT&E	Plugged in 1981	ESII, February 1986
DH-7	11/16/82	362505	510548	0 - 17.0	HSA	NT&E	Plugged with drill cuttings in	ESII, February 1986

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
							1982	
DH-8	11/16/82	362425	510488	0 - 21.5	HSA	NT&E	Plugged with drill cuttings in 1982	ESII, February 1986
DH-9	11/16/82	362445	510433	0 - 22.0	HSA	NT&E	Plugged with drill cuttings in 1982	ESII, February 1986
B-1	9/19/83 - 9/20/83	361940	510543	0 - 126.3	HSA	CH2M	Plugged in 1983	ESII, February 1986
B-2	10/4/83	362255	509813	0 - 121.5	HSA	CH2M	Plugged in 1983	ESII, February 1986
B-3	9/7/83	362125	509183	0 - 105.0	HSA	CH2M	Plugged in 1983	ESII, February 1986
B-4	9/10/83 - 9/12/83	363305	509173	0 - 109.67	HSA	CH2M	Plugged in 1983	ESII, February 1986
B-5	9/16/83	363445	509733	0 - 41.5	HSA	CH2M	Plugged in 1983	ESII, February 1986
B-6	9/21/83 - 9/23/83 9/23/83 9/24/83	363635	510083	0 - 107.0 107.0 - 122.0 122.0 - 139.8	HSA WRB WRC	CH2M	Plugged in 1983	ESII, February 1986
B-7	9/16/83 - 9/17/83	363745	510903	0 - 61.4	HSA	CH2M	Plugged in 1983	ESII, February 1986
D-1	10/1/83 - 10/3/83 10/3/83 - 10/19/83	362790	508983	0 - 105.5 105.5 - 237.9	HSA AR	CH2M	Plugged in 1983	ESII, February 1986
D-2	9/8/83 - 9/9/83 9/10/83	363215	511488	0 - 30.0 30.0 - 75.0	AR HSA	CH2M	Plugged in 1983	ESII, February 1986

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
	9/10/83 - 9/22/83 9/22/83 - 10/1/83			75.0 - 285.0 285.0 - 430.0	AR WRC			
D-3	10/11/83 - 10/12/83 4/11/84 - 4/19/84	362925	508960	0 - 303.0 303.0 - 407.0	AR WRC	CH2M	Plugged in 1987	CH2M HILL, Feb 1988b
D-4 (s and d)	10/12/83 - 10/14/83 5/9/84 - 5/14/84	361998	511462	0 - 254.0 254.0 - 400.0 254.0 - 400.0	AR WRC AR	CH2M	Plugged in 1989	CH2M HILL, Jun 1989d
D-8 (s and d)	5/11/84 - 5/15/84 5/17/84 - 5/21/84	362938	510302	0 - 195.0 195.0 - 400.0	AR WRC	CH2M	Plugged in 1991	CH2M HILL, Feb 1991b
D-9	5/16/84 5/22//84 - 5/29/84	363801	510017	0 - 195.0 195.0 - 401.5	AR WRC	CH2M	Plugged in 1988	CH2M HILL, Feb 1989b
D-10 (s and d)	5/16/84 - 5/17/84 5/31/84 - 6/2/84	363696	511485	0 - 190.0 190.0 - 401.5	AR WRC	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
D-16	10/22/84 - 10/23/84 11/20/84 11/29/84 - 12/3/84	362238	510953	0 - 100.0 100.0 - 125.0 125.0 - 301.0	AR WRC WRC	CH2M	Plugged in 1985	ESII, February 1986
D-16A	1/24/85 - 2/4/85	362239	511045	0 - 260.0	AR	CH2M	Plugged in 1985	ESII, February 1986
D-17	10/29/84 - 10/30/84	363077	509440	0 - 300.0	AR	CH2M	Plugged in 1988	CH2M HILL, Feb 1988b
D-18	10/30/84 - 11/5/84	362414	511429	0 - 260.0	AR	CH2M	Plugged in 1991	CH2M HILL, Feb 1991b
D-20	1/10/85 - 1/21/85	363539	510961	0 - 390.0	AR	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
D-22	3/27/85 - 3/28/85 3/28/85 - 4/2/85	363755	509645	0 - 110.0 110.0 - 300.0	HSA WRC	CH2M	Plugged in 1985	ESII, February 1986

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
D-31	10/3/85 - 10/7/85	362592	509438	0 - 253.0	AR	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
D-32	10/2/85 - 10/4/85	362583	509356	0 - 299.0	WRC	CH2M	Plugged in 1985	ESII, February 1986
D-33	9/19/86 - 9/24/86	363774	509890	0 - 155	HSA	CH2M	Plugged in 1986	CH2M HILL, December 1986
D-34	9/29/86 - 10/4/86	363786	510975	0 - 153.5	HSA	CH2M	Plugged in 1986	CH2M HILL, Dec 1986
MW-2 (D-5)	10/17/83 - 10/18/83	363682		0 - 300.0	AR	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
MW-3	12/2/83 - 12/3/83	363827	510855	0 - 240.0	AR	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
MW-4 (D-7)	10/25/83 - 10/26/83	363835		0 - 280.0	AR	CH2M	Plugged in 1989	CH2M HILL, Jun 1989d
MW-5	11/28/83 - 11/29/83	363816	509208	0 - 250.0	AR	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
MW-6 (D-6)	10/20/83 - 10/21/83	361924		0 - 280.0	AR	CH2M	Plugged in 1992	CH2M HILL, Feb 1993
MW-7	3/30/84 - 4/2/84	362319	511432	0 - 260.0	AR	CH2M	Plugged in 1986	CH2M HILL, Jul 1991
MW-8	3/30/84 - 4/3/84	362634	511422	0 - 260.0	AR	CH2M	Plugged in 1986	CH2M HILL, Jul 1991
MW-8A	4/19/84 - 4/20/84	362616	511421	0 - 165.0	AR	CH2M	Plugged in 1991	CH2M HILL, Feb 1991b
MW-9	4/17/84 - 4/18/84	363449	511436	0 - 260.0	AR	CH2M	Plugged in 1989	CH2M HILL, Jun 1989d
MW-11	3/29/84 - 3/30/84	363765	510493	0 - 265.0	AR	CH2M	Plugged in	CH2M HILL, Feb 1993

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
							1992	
MW-12	3/29/84 - 3/30/84	363753	509593	0 - 265.0	AR	CH2M	Plugged in 1988	CH2M HILL, Feb 1989b
MW-15 (D-15)	10/8/84 - 10/9/84	361922	511065	0 - 270.0	AR	CH2M	Plugged in 1987	CH2M HILL, Feb 1988b
MW-26	8/14/85 - 8/21/85	363208	511432	0 - 290.0	AR	CH2M	Plugged in 1988	CH2M HILL, Feb 1989b
PCB-3	7/19/85 - 8/3/85	362238	510997	0 - 195.0	AR	CH2M	Plugged in 1993	CH2M HILL, Oct 1993b
WW-1	10/3/84 - 10/26/84	361403	509499	0 - 800.0	AR	CH2M	Plugged in 1986	ESII, February 1986
Artesian Well	8/28/58 - 11/12/58	362937	510085	0 - 3080	R	S&W	Plugged in 1986	CH2M HILL, June 1986
D-40	11/01/99 – 12/20/99	362816	507966	0-120 120-220	HAS WRC	CH2M	Plugged in 1999	CH2M HILL, 2000
LP-40	12/23/99-12/30/99	362831	507966	0-210	AR	CH2M	Plugged in 2003	Feast March 2003
L-46	7/16-03 - 7/21/03	364363.3	507927.4	0 - 280.0	AR	Feast	Abandoned Feb. 2009	Feast, Dec. 2003
U-1 (MW-16)	8/15/85 - 8/19/85	361754.5	510610.9	0 - 201.7	AR	CH2M	Abandoned, July, 2012	ESII, Feb 1986
U-2	7/28/89 - 8/2/89	361711.5	510845.2	0 - 210.0	AR	CH2M	Abandoned, July, 2012	CH2M HILL, Oct 1989a
U-3	11/16/87 - 11/18/87	361645.1	511058.4	0 - 210.6	AR	CH2M	Abandoned, July, 2012	CH2M HILL, Feb 1988a
U-20	4/22/85 - 6/4/85	362983.4	510533.5	0 - 29.5	AR	CH2M	Abandoned,	ESII, Feb 1986

Table E-4 - Well and Borehole Inventory

Well/ Bore-hole ID	Drilling/ Completion Date(s)	Easting	Northing	Depth	Drilling Method	Engineer	Status	Reference
(SW-3)				29.5 - 212.0	MBA		August, 2013	
UP-2 (D-23)	4/11/85 4/12/85 - 4/17/85	361904.6	510838.6	0 - 111.1 111.1 - 331.1	HSA WRC	CH2M	Abandoned, October, 2014	ESII, Feb 1986
UP-28	2/1/93 - 2/11/93	361830.2	509807.5	0 - 282.3	AR	CH2M	Abandoned , October 2014	CH2M HILL, June 1993
UP-29	2/6/93 - 2/9/93	361830.8	510154.4	0 - 232.3	AR	CH2M	Abandoned, October, 2014	CH2M HILL, June 1993

*Drilling Methods:			Abbreviations and Remarks:		
AR	=	Air rotary	S&W	=	Shannon & Wilson
HSA	=	Hollow stem auger	NT&E	=	Northern Testing & Engineering
WRC	=	Wash rotary core	CH2M	=	CH2M Hill, Inc
MCT	=	Modified cable tool	MK	=	Morrison Knudsen Engineers
MBA	=	Modified bucket auger	Core	=	Core Drilling Inc.
WRB	=	Wash rotary rock-bit	Feast	=	Feast Geosciences, LLC
R	=	Rotary	( )	=	Denotes old well name/number

Unless otherwise noted, plugged means methodically abandoned with either cement or bentonite following industry standards

TABLE E-5

Well Construction Summary
USEI Site B

Current Well ID	Previous Well ID	Install. Date	Easting	Northing	Concrete pad elev. (ft msl)	Top of steel surface casing elev. (ft msl)[a]	Measure point elev. (ft msl)[b]	Steel surface casing length (ft btsc)[c,d]	Total depth drilled (ft btsc)	Total completed well depth (ft btsc)	Bottom of completed well (ft msl)	Well diam. (in.)	Casing type[e]	Casing bottom (ft btsc)	Riser type[e]	Riser bottom (ft btsc)	Screen type[e]	Slot size (in.)	Top of screen (ft btsc)	Bottom of screen (ft btsc)	Screen length (ft)	Top of screen (ft msl)	Bottom of screen (ft msl)	Sump type[e]	Sump length (ft)	Top of sand pack interval (ft btsc)	Bottom of sand pack interval (ft btsc)	Top of sand pack interval (ft msl)	Bottom of sand pack interval (ft msl)	October 2013 water level (ft msl)	October 2013 water level vs top of screen (ft)[f]
Upper Aquifer Wells																															
U-1[j]	MW-16	19-Aug-85	361754.5	510610.9	2567.07	2568.34	2568.56	121.0	201.7	196.7	2371.6	4.00	P	181.7	None	-----	P	0.010	181.7	191.7	10.0	2386.6	2376.6	P	5.00	178.7	197.7	2389.6	2370.6	NA	NA
U-2[j]	-----	2-Aug-89	361711.5	510845.2	2552.18	2553.83	2554.05	140.8	210.0	202.2	2351.6	4.00	P	128.0	SS	149.2	SS	0.010	149.2	201.4	52.2	2404.6	2352.4	SS	0.80	144.3	202.5	2409.5	2351.3	NA	NA
U-3[j]	MW-150	18-Nov-87	361645.1	511058.4	2547.96	2549.28	2549.51	141.0	210.6	207.5	2341.8	4.00	P	145.9	None	-----	SS	0.010	145.9	206.6	60.7	2403.4	2342.7	SS	0.90	142.3	210.6	2407.0	2338.7	NA	NA
U-4	-----	23-Feb-89	361932.6	511444.7	2528.15	2529.40	2529.62	120.8	207.0	202.0	2327.4	4.00	P	109.0	SS	129.0	SS	0.010	129.0	201.2	72.2	2400.4	2328.2	SS	0.80	125.3	203.0	2404.1	2326.4	2397.43	2196.2
U-5	-----	3-Mar-89	362947.4	511436.5	2571.25	2571.77	2572.00	160.8	257.5	249.5	2322.3	4.00	P	146.5	SS	166.5	SS	0.010	166.5	248.7	82.2	2405.3	2323.1	SS	0.80	164.3	250.5	2407.5	2321.3	2390.56	2141.9
U-6	-----	17-Mar-89	363417.7	511436.7	2573.14	2574.09	2574.36	186.8	268.5	262.0	2312.1	4.00	P	169.0	SS	189.0	SS	0.010	189.0	261.2	72.2	2385.1	2312.9	SS	0.80	186.5	262.0	2387.6	2312.1	2383.25	2122.1
U-7	-----	28-Jun-89	363773.0	511300.5	2543.20	2544.55	2544.77	140.8	237.0	230.1	2314.5	4.00	P	147.4	SS	167.6	SS	0.010	167.6	229.3	61.7	2377.0	2315.3	SS	0.80	162.6	232.6	2382.0	2312.0	2375.99	2146.7
U-8	-----	20-Jun-89	363793.2	511127.1	2541.43	2542.75	2542.97	140.8	237.0	226.2	2316.6	4.00	P	144.0	SS	164.2	SS	0.010	164.2	225.4	61.2	2378.6	2317.4	SS	0.80	159.8	234.0	2383.0	2308.8	2376.05	2150.7
U-9	-----	24-Mar-89	363818.4	510888.3	2548.74	2550.14	2550.35	160.8	242.0	227.0	2323.1	4.00	P	145.2	SS	165.2	SS	0.010	165.2	226.2	61.0	2384.9	2323.9	SS	0.80	163.2	230.0	2386.9	2320.1	2375.69	2149.5
U-10	-----	6-Apr-89	363806.7	510518.1	2553.54	2554.61	2554.83	160.8	232.0	223.3	2331.3	4.00	P	161.3	SS	181.4	SS	0.010	181.4	222.5	41.1	2373.2	2332.1	SS	0.80	177.5	230.2	2377.1	2324.4	2375.00	2152.5
U-11	-----	19-Apr-89	363815.1	510343.0	2555.51	2557.31	2557.52	160.8	217.0	212.8	2344.5	4.00	P	161.5	SS	181.5	SS	0.010	181.5	212.0	30.5	2375.8	2345.3	SS	0.80	176.5	216.0	2380.8	2341.3	2374.52	2162.5
U-12	-----	25-Apr-89	363809.4	510184.7	2557.43	2559.02	2559.24	160.8	217.5	212.6	2346.4	4.00	P	161.3	SS	181.3	SS	0.010	181.3	211.8	30.5	2377.7	2347.2	SS	0.80	176.5	216.7	2382.5	2342.3	2373.76	2162.0
U-13	-----	14-Dec-10	361209.8	511469.5	2549.91	2551.70	2552.31	140.0	212.0	203.9	2347.8	4.00	P	173.7	None	-----	SS	0.010	148.1	203.1	55.0	2403.6	2348.6	SS	0.80	144.1	206.0	2407.6	2345.7	2399.72	2196.6
U-14	-----	12-Jan-11	360699.9	511469.1	2553.98	2556.18	2556.78	140.0	207.0	196.9	2359.3	4.00	P	172.3	None	-----	SS	0.010	146.1	196.1	50.0	2410.1	2360.1	SS	0.80	142.8	201.5	2413.4	2354.7	2400.14	2204.0
U-15	-----	16-Nov-10	360489.4	510809.8	2593.21	2594.84	2595.28	140.0	224.0	219.4	2375.4	4.00	P	172.4	None	-----	SS	0.010	193.6	218.6	25.0	2401.2	2376.2	SS	0.80	186.2	224.0	2408.6	2370.8	2401.43	2182.8
U-17	-----	19-May-89	363237.9	509847.1	2573.53	2574.58	2574.81	160.8	217.0	215.2	2359.4	4.00	P	173.7	SS	193.9	SS	0.010	193.9	214.4	20.5	2380.7	2360.2	SS	0.80	189.9	215.8	2384.7	2358.8	2379.01	2164.6
U-18	-----	25-May-89	363241.7	510124.0	2574.87	2576.19	2576.40	160.8	227.0	223.8	2352.4	4.00	P	172.3	SS	192.5	SS	0.010	192.5	223.0	30.5	2383.7	2353.2	SS	0.80	188.8	224.0	2387.4	2352.2	2380.86	2157.9
U-19	-----	13-Jun-89	363245.1	510352.5	2573.93	2575.20	2575.40	180.8	239.0	234.5	2340.7	4.00	P	172.4	SS	192.6	SS	0.010	192.6	233.7	41.1	2382.6	2341.5	SS	0.80	188.8	235.0	2386.4	2340.2	2381.57	2147.9
U-20[k]	SW-3	4-Jun-85	362983.4	510533.5	2572.33	2573.09	2573.25	29.5	212.0	212.0	2361.1	4.00	ST	196.5	None	-----	SS	0.010	196.5	206.5	10.0	2376.6	2366.6	S	5.50	191.5	212.0	2381.6	2361.1	NA	NA
U-21	SW-2	12-Apr-85	362727.4	510684.5	2572.48	2573.46	2573.68	27.7	211.7	207.7	2365.8	4.00	SS	192.7	None	-----	SS	0.010	192.7	202.7	10.0	2380.8	2370.8	S	5.00	187.7	211.7	2385.8	2361.8	2392.41	2189.7
U-22	SW-1	1-Nov-84	362539.6	510311.6	2578.59	2579.71	2579.72	18.6	228.1	225.6	2354.1	4.00	SS	195.6	None	-----	SS	0.020	195.6	205.6	10.0	2384.1	2374.1	S	21.00	193.1	216.8	2386.6	2362.9	2390.62	2185.0
U-23	PCB-1	9-Jul-85	362238.6	510305.9	2568.29	2569.63	2569.85	140.8	199.0	193.0	2376.6	4.00	P	183.0	None	-----	P	0.010	183.0	193.0	10.0	2386.6	2376.6	None	-----	181.0	193.0	2388.6	2376.6	2391.71	2198.7
U-24	-----	25-Jul-89	362247.8	511018.1	2559.80	2561.26	2561.48	156.2	226.0	215.2	2346.1	4.00	P	140.2	SS	162.2	SS	0.010	162.2	214.4	52.2	2399.1	2346.9	SS	0.80	157.6	219.0	2403.7	2342.3	2395.17	2180.8
U-25	-----	14-Jul-89	362294.2	510543.3	2566.38	2567.97	2568.19	160.8	224.0	212.3	2355.7	4.00	P	150.3	SS	170.3	SS	0.010	170.3	211.5	41.2	2397.7	2356.5	SS	0.80	166.5	212.5	2401.5	2355.5	2392.04	2180.5
U-48	-----	26-Jun-12	361897.3	510995.3	2549.30	2550.92	2551.14	137.0	212.0	195.5	2355.4	2.00	P	144.7	None	-----	SS	0.010	144.7	194.7	50.0	2406.2	2356.2	SS	0.80	140.0	201.8	2410.9	2349.1	2396.62	2201.9
U-49	-----	26-Jun-12	361909.4	510568.3	2560.70	2562.54	2562.77	140.0	212.0	202.8	2359.7	4.00	P	157.0	None	-----	SS	0.010	157.0	202.0	45.0	2405.5	2360.5	SS	0.80	151.4	203.1	2411.1	2359.4	2394.75	2192.8
UP-6	SW-3-2	21-Jan-86	363035.7	510541.6	-	2566.25	2566.45	160.8	199.4	197.4	2368.9	4.00	P	172.4	SS	182.4	SS	0.010	182.4	192.4	10.0	2383.9	2373.9	SS	5.00	179.9	197.4	2386.4	2368.9	2388.94	2196.5
U-54	-----	27-Dec-16	361906.2	510038.1	2578.73	2580.74	2580.93	160.0	210.0	209.3	2371.4	4.00	SS	178.5	SS	160.0	SS	0.010	178.5	208.5	30.0	2402.2	2372.2	SS	0.80	141.0	206.0	2439.7	2374.7	NA	NA
Upper Aquifer Piezometers																															
U-26	-----	12-Mar-93	362768.2	509642.2	2586.46	2588.15	2588.34	140.4	237.8	225.0	2363.2	4.00	P	189.0	SS	194.0	SS	0.010	194.0	224.0	30.0	2394.2	2364.2	SS	1.00	190.3	228.5	2397.9	2359.7	2387.18	2163.2
UP-1	MW-19(D-19)	15-Jan-85	363536.7	510998.5	2559.01	2560.27	2560.42	120.8	252.0	242.0	2318.3	4.00	P	192.0	None	-----	P	0.010	192.0	232.0	40.0	2368.3	2328.3	P	10.00	182.0	252.0	2378.3	2308.3	2380.19	2148.2
UP-2[j]	D-23	17-Apr-85	361904.6	510838.6	-	2553.10	2553.43	21.1	331.1	178.1	2375.0	0.75	P	168.1	None	-----	P	0.010	168.1	178.1	10.0	2385.0	2375.0	None	-----	166.1	178.1	2387.0	2375.0	2395.45	2217.4
UP-3	PCB-2	18-Jul-85	362237.6	510491.1	2566.63	2567.73	2567.92	140.8	202.2	195.7	2372.0	4.00	P	185.7	None	-----	P	0.010	185.7	195.7	10.0	2382.0	2372.0	None	-----	182.7	198.7	2385.0	2369.0	2392.08	2196.4
UP-4	D-21	22-Mar-85	363792.2	510625.3	2553.10	2555.22	2555.38	120.8	302.9	222.9	2332.3	0.75	P	207.9	None	-----	P	0.010	207.9	217.9	10.0	2347.3	2337.3	P	5.00	191.9	222.9	2363.3	2332.3	2375.42	2157.5
UP-5	MW-10	16-Apr-84	363767.8	511186.6	2540.25	2541.47	2541.65	120.8	252.0	227.0	2314.5	4.00	P	177.0	None	-----	P	0.010	177.0	217.0	40.0	2364.5	2324.5	P	10.00	162.0	232.0	2379.5	2309.5	2376.06	2159.1
UP-7	MW-1	9-Dec-83	363186.0	511494.9	2558.47	2559.33	2559.68	140.8	235.8	214.8	2344.5	4.00	P	174.8	None	-----	P	0.010	174.8	194.8	20.0	2384.5	2364.5	P	20.00	154.8	216.8	2404.5	2342.5	2388.80	2194.0
UP-8	SW-1-2	10-Sep-86	362593.6	510309.6	-	2571.27	2571.69	166.7	201.9	200.4	2370.9	2.00	P	184.4	SS	189.4	SS	0.010	189.4	199.4	10.0	2381.9	2371.9	SS	1.00	188.4	201.9	2382.9	2369.4	2390.50	2191.1
UP-26	-----	12-Mar-93	362345.0	510079.7	2574.49	2576.22	2576.40	140.5	233.5	233.5	2342.7	2.00	P	201.5	None	-----	P	0.010	201.5	231.5	30.0	2374.7	2344.7	P	2.00	196.5	233.5	2379.7	2342.7	2391.03	2159.5
UP-28[m]	-----	10-Feb-93	361830.2	509807.5	2589.01	2590.97	2591.41	140.4	282.3	215.9	2375.1	4.00	P	193.9	None	-----	P	0.010	193.9	213.9	20.0	2397.1	2377.1	P	2.00	187.9	220.9	2403.1	2370.1	2400.07	2186.2
UP-29[n]	-----	9-Feb-93	361830.8	510154.4	2573.69	2575.39	2575.74	160.4	232.3	221.6	2353.8	4.00	P	189.6	None	-----	P	0.010	189.6	219.6	30.0	2385.8	2355.8	P	2.00	184.3	222.5	2391.1	2352.9	2395.78	2176.2
Lower Aquifer Wells																															
L-28	-----	17-Oct-88	363802.8	509307.8	2569.78	2571.61	2571.83	120.8	252.5	247.8	2323.8	4.00	P	187.0	SS	217.0	SS	0.010	217.0	247.0	30.0	2354.6	2324.6	SS	0.80	212.7	247.8	2358.9	2323.8	2378.80	2131.8
L-29	-----	28-Sep-88	363800.2	509499.1	2571.40	2572.86	2573.09	140.8	252.0	245.8	2327.1	4.00	P	185.0	SS	215.0	SS	0.010	215.0	245.0	30.0	2357.9	2327.9	SS	0.80	211.8	245.8	2361.1	2327.1	2376.69	2131.7
L-30	-----	20-Sep-88	363649.1	509530.1	2567.53	2568.89	2569.12	140.8	262.0	257.0	2311.9	4.00	P	186.2	SS	226.2	SS	0.010	226.2	256.2	30.0	2342.7	2312.7	SS	0.80	222.4	257.0	2346.5	2311.9	2376.94	2120.7
L-31	-----	7-Dec-90	363223.3	509560.9	2581.71	2583.25	2583.48	140.8	277.0	263.9	2319.4	4.00	P	212.0	SS	232.0	SS	0.010	232.0	263.1	31.1	2351.3	2320.2	SS	0.80	229.0	271.0	2354.3	2312.3	2381.10	2118.0
L-32	-----	10-Aug-93	362973.1	509508.6	2586.44	2588.72	2588.96	140.4	277.5	268.8	2319.9	4.00	P	208.0	SS	238.0	SS	0.010	238.0	268.0	30.0	2350.7	2320.7	SS	0.80	234.0	275.5	2354.7	2313.2	2385.74	2117.7
L-33	-----	29-Jul-93	362793.0	509603.3	2587.25	2589.01	2589.23	139.9	282.2	268.6	2320.4	4.00	P	207.8	SS	237.8	SS	0.010	237.8	267.8	30.0	2351.2	2321.2	SS	0.80	235.8	275.0	2353.2	2314.0	2388.32	2120.5
L-35	D-30(reconst.)	23-Nov-88	361877.4	508929.0	2613.54	2615.16	2615.16	100.8	289.0	223.6	2391.6	2.00	P	187.8	SS	207.8	SS	0.010	207.8	222.8	15.0	2407.4	2392.4	SS	0.80	202.3	223.6	2412.9	2391.6	2426.43	2203.6
L-36	D-27	8-Oct-85	362303.8	508871.0	2613.31	2614.43	2614.65	100.3	301.3	238.3	2376.1	4.00	P	223.3	None	-----	P	0.010	223.3	233.3	10.0	2391.1	2381.1	P	5.00	219.3	248.3	2395.1	2366.1	2418.95	2185.7
L-37	D-28	9-Oct-85	363121.9	508872.5	2603.82	2604.88	2605.11	100.0	301.8	240.8	2364.1	4.00	P	225.8	None	-----	P	0.010	225.8	235.8	10.0	2379.1	2369.1	P	5.00	220.8	250.8	2384.1	2354.1	2396.06	2160.3
L-38	MW-13	3-Oct-84	361372.5	508653.5	2632.57	2634.69	2634.90	160.8	301.7	266.7	2368.0	4.00	P	216.7	None	-----	P	0.010	216.7	256.7	40.0	2418.0	2378.0	P	10.00	190.7	266.7	2444.0	2368.0	2445.12	2188.4
L-39	-----	9-Dec-88	363121.5	509435.2	2591.74	2593.24	2593.47	104.8	274.0	268.9	2324.3	4.00	P	208.0	SS	238.0	SS	0.010	238.0	268.1	30.1	2355.2	2325.1	SS	0.80	234.1	268.9	2359.1	2324.3	2383.86	2115.8
L-41	-----	31-Jul-03	362784.1	508870.5	2607.74	2608.73	2608.94	157.0	257.0	240.3	2368.4	4.00	P	166.1	SS	208.3	SS	0.010	208.3	239.5	31.2	2400.4	2369.2	SS	0.8	202.0	246.0	2406.7	2362.7	2406.07	2166.6
L-42	-----	25-Jul-03	363484.1	508872.3	2586.91	2587.87	2588.08	137.5	276.0	233.5	2354.4	4.00	P	161.3	SS	201.5	SS	0.010	201.5	232.7	31.2	2386.4	2355.2	SS	0.8	193.9	239.0	2394.0	2348.9	2387.04	2154.3
L-43	-----	18-Jul-05	363990.2	508938.3	2570.84	2572.12	2572.72	160.4	270.0	241.5	2330.6	4.00	P	169.5	SS	209.5	SS	0.010	209.5	239.5	30.0	2362.6	2332.6	SS	2.0	203.9	247.8	2368.2	2324.3	2378.64	2139.1
L-44	-----	22-Jul-05	364368.3	508905.4	2557.78	2559.21	2559.71	140.4	280.0	232.4	2326.8	4.00	P	161.6	SS	201.6	SS	0.010	201.6	231.6	30.0	2357.6	2327.6	SS	0.8	196.0	245.0	2363.2	2314.2	2379.10	2147.5
L-45	-----	24-Aug-07	364704.8	508607.5	2554.58	2555.78	2555.94	140.4	261.5	226.0	2329.8	4.00	P	145.2	SS	195.2	SS	0.010	195.2	225.2	30.0	2360.6	2330.6	SS	0.8	188.0	232.5	2367.8	2323.3	2380.39	2155.2
L-46[i]	-----	21-Jul-03	364363.3	507927.4	2581.83	2583.32	2583.42	136.0	282.0	267.2	2316.1	4.00	P	195.0	SS	235.2	SS	0.010	235.2	266.4	31.2	2348.1	2316.9	SS	0.8	231.8	277.0	2351.5	2306.3	NA	NA
L-47	-----	16-Mar-09	365046.06	508301.71	2554.16	2555.80	2555.93	139.4	260.0	240.8	2315.0	4.00	P	170.0	SS	210.0	SS	0.010	210.0	240.0	30.0	2345.8	2315.8	SS	0.8	204.0	250.5	2351.8	2305.3	2394.35	2154.4
Lower Aquifer Piezometers																															
LP-11	D-29	10-Oct-85	363681.0	508873.9	2579.46	2580.64	2580.77	98.5	301.5	228.5	2352.1	4.00	P	213.5	None	-----	P	0.010	213.5	223.5	10.0	2367.1	2357.1	P	5.00	208.5	239.5	2372.1	2341.1	2383.09	2159.6
LP-12	D-21	22-Mar-85	363792.2	510625.3	2553.10	2555.22	2555.51	120.8	302.9	272.1	2283.1	4.00	P	257.1	None	-----	P	0.010	257.1	267.1	10.0	2298.1	2288.1	P	5.00	247.1	264.1	2308.1	2291.1	2374.85	2107.8
LP-13	MW-25	26-Aug-85	363784.6	511248.3	2542.47	2543.63	2543.80	120.8	291.6	279.6	2264.0	4.00	P	279.6	None	-----	P	0.010	264.6	274.6	10.0	2279.0	2269.0	P	5.00	256.6	284.6	2287.0	2259.0	2371.39	2096.8
LP-14	MW-14	5-Oct-84	361427.3	509484.9	-	2608.06	2608.26	160.8	292.0	237.0	2371.1	4.00	P	232.0	None	-----	P	0.010	212.0	232.0	20.0	2396.1	2376.1	P	5.00	207.0	237.0	2401.1	2371.1	2419.71	2187.7
LP-15	MW-24	18-Apr-85	363809.2	510124.3	2558.04	2559.56	2559.81	120.8	282.1	277.1	2282.5	4.00	P	276.1	None	-----	P	0.010	247.1	257.1	10.0	2312.5	2302.5	P	20.00	238.1	276.1	2321.5	2283.5	2375.16	2118.1
LP-27	-----	28-Feb-92	362370.4	510051.5	2575.26	2576.50	2576.63	140.5	303.5	270.5	2306.0	2.00	P	258.5	None	-----	P	0.010	258.5	268.5	10.0	2318.0	2308.0	P	2.00	250.5	280.0	2326.0	2296.5	2391.72	2123.2
LP-40[h]	-----	30-Dec-99	507966.0	362831.0	2628.00	2630.44	2630.44	118.1	212.3	210.5	2419.9	4.00	P	159.7	SS	179.7	SS	0.010	179.7	209.7	30.0	2450.7	2420.7	SS	1.00	175.0	210.5	2455.4	2419.9		

Notes:

a. Permanent elevation datum at each well.
b. Measure point for water levels and well sounding, May 1998 survey.
c. Length includes drive shoe of .4 to .8 feet.
d. Ft btsc = ft below top of steel surface casing.
e. P = PVC; ST = low carbon steel; SS = 304 stainless steel.
f. Negative numbers indicate water surface is below the top of the screen.
h. LP-40 Abandoned March 10, 2003
i. L-46 Abandoned, February 2, 2009
j. U-1, U-2, U-3 Abandoned, July 2012
k. U-20 Abandoned, August 2013
l. UP-2 Abandoned, October 2014
m. UP-28 Abandoned, October 2014
n. UP-29 Abandoned, October 2014

Table E-6 - Summary of Aquifer Testing Data

Current Well ID	Old Well ID	Date	Test Type[a]	Sustained Pump Rate (gpm)	Static WL (ft bmp)	Pumping WL (ft bmp)	Draw-down/Dis-placement (ft)	Q/s (gpm/ft)	T (ft^2/d)
Upper Aquifer									
U-1[b]	UMW-16	3/6/1986	PRM	1.0	183.00	190.25	7.25	-----	1.9
		3/6/1986	PRJ	1.0	183.00	190.25	7.25	-----	2.0
		7/28/1992	Specific Capacity	0.3	179.46	191.7	12.24	0.021	1.2
		10/12/1992	Specific Capacity	0.4	179.25	191.7	12.45	0.032	1.9
		9/9/1996	Specific Capacity	0.4	177.57	191.7	14.13	0.028	1.6
U-2[b]	-----	10/16/1989	Specific Capacity	0.5	164.45	201.70	37.25	0.012	0.7
		4/15/1991	Specific Capacity	0.5	163.73	201.70	37.97	0.013	0.7
		9/30/1991	Specific Capacity	0.5	163.44	201.70	38.26	0.013	0.8
		7/28/1992	Specific Capacity	0.4	163.20	201.70	38.50	0.011	0.6
		10/12/1992	Specific Capacity	0.5	163.14	201.70	38.56	0.012	0.7
		9/9/1996	Specific Capacity	0.5	161.45	201.70	40.25	0.011	0.6
U-4	-----	3/2/1989	Specific Capacity	5.6	136.70	151.95	15.25	0.367	21.3
		3/2/1989	PRJ	5.6	136.70	151.95	15.25	-----	32.7
		3/2/1989	PRM	5.6	136.70	151.95	15.25	-----	34.1
U-6	-----	3/23/1989	Specific Capacity	4.3	196.25	252.60	56.35	0.076	4.4
		3/23/1989	PRJ	4.3	196.25	252.60	56.35	-----	5.9
		3/23/1989	PRM	4.3	196.25	252.60	56.35	-----	30.5
U-7	-----	10/17/1989	Specific Capacity	2.5	174.86	229.50	54.64	0.046	2.7
U-8	-----	6/27/1989	PRM*	5.0	171.30	225.35	54.05	-----	No Fit
		6/27/1989	PRJ*	5.0	171.30	225.35	54.05	-----	6.8
		6/27/1989	Specific Capacity	2.6	173.10	225.60	52.50	0.050	2.9
U-9	-----	5/16/1989	Specific Capacity	1.4	183.80	226.21	42.41	0.033	1.9
U-10	-----	4/16/1991	Specific Capacity	0.4	188.36	222.90	34.54	0.012	0.7
		10/15/1992	Specific Capacity	0.4	187.23	222.90	35.67	0.012	0.7
		9/10/1996	Specific Capacity	0.5	184.31	222.90	38.59	0.012	0.7
U-11	-----	4/16/1991	Specific Capacity	0.3	192.14	212.30	20.16	0.015	0.9
		10/15/1992	Specific Capacity	0.3	191.17	212.30	21.13	0.014	0.8
		9/10/1996	Specific Capacity	0.3	188.42	212.30	23.88	0.013	0.7
U-12	-----	4/16/1991	Specific Capacity	0.4	194.83	212.30	17.47	0.023	1.3
		10/15/1992	Specific Capacity	0.3	194.07	212.30	18.23	0.014	0.8
		9/10/1996	Specific Capacity	0.4	191.55	212.30	20.75	0.019	1.1
U-13	-----	2/1/2011	PDJ	2.5	153.60	177.90	24.30	0.100	17.9
		2/15/2011	PDJ	1.4	152.78	163.04	10.26	0.150	22.9
		2/15/2011	PRJ	1.4	152.78	163.04	10.26	-----	16.8
U-14	-----	3/16/2011	Slug B	-----	156.42	-----	7.00	-----	2.2
U-15	-----	3/16/2011	Slug B	-----	194.17	-----	6.20	-----	0.03
U-17	-----	10/16/1992	Specific Capacity	0.1	203.30	214.20	10.90	0.011	0.6
U-18	-----	10/16/1992	Specific Capacity	0.3	203.26	223.00	19.74	0.013	0.7
		9/12/1996	Specific Capacity	0.3	201.06	223.00	21.94	0.011	0.7
U-19	-----	10/16/1997	Specific Capacity	0.3	200.78	234.00	33.22	0.009	0.5
		9/12/1996	Specific Capacity	0.4	198.61	234.00	35.39	0.010	0.6
U-20[b]	SW-3	9/13/1996	Specific Capacity	0.2	187.10	206.50	19.40	0.010	0.6

See footnotes at end of table.

Table E-6 - Summary of Aquifer Testing Data (continued)

Current Well ID	Old Well ID	Date	Test Type[a]	Sustained Pump Rate (gpm)	Static WL (ft bmp)	Pumping WL (ft bmp)	Draw-down/Dis-placement (ft)	Q/s (gpm/ft)	T (ft^2/d)
U-21	SW-2	2/5/1992	PRJ*	1.5	187.95	199.71	11.76	-----	34.8
U-22	SW-1	10/19/1992	Specific Capacity	0.4	194.23	205.60	11.37	0.035	2.0
		9/12/1996	Specific Capacity	0.5	192.18	205.60	13.42	0.034	1.9
U-24	-----	8/29/1989	Specific Capacity	2.8	172.00	212.70	40.70	0.069	4.0
U-25	-----	9/1/1996	Specific Capacity*	1.5	179.49	211.75	32.26	0.046	2.7
U-26	-----	4/30/1993	Slug B	-----	209.31	-----	7.10	-----	0.1
U-48	-----	7/20/2012	PDJ/PRJ	3.0	154.60	166.5	11.91	0.240	21.1
U-49	-----	7/20/2012	Slug B	-----	168.00	-----	4.23	-----	2.1
U-54	-----	4/5/2017	Slug B	-----	184.90	-----	6.30	-----	0.046
UP-5	MW-10	11/16/1984	PRM	1.5	177.20	200.30	23.10	-----	8.3
		11/16/1984	PRJ	1.5	177.20	200.30	23.10	-----	9.6
UP-6	SW-3-2	1/23/1986	PRM	-----	183.75	-----	9.30	-----	6.4
UP-7	MW-1	8/10/1984	PRM*	12.6	183.65	202.00	18.35	-----	21.0
UP-26	-----	4/29/1993	Slug B	-----	191.46	-----	9.20	-----	0.2
UP-28[b]	-----	4/30/1993	Slug B	-----	198.80	-----	6.30	-----	0.1
UP-29[b]	-----	4/30/1993	Slug B	-----	190.22	-----	3.75	-----	0.1
MW-11[b]	-----	11/16/1984	PRM	5.0	193.30	230.90	37.60	-----	2.1
		11/16/1984	PRJ	5.0	193.30	230.90	37.60	-----	2.5
D-18[b]	-----	11/17/1984	PRM	5.0	177.00	185.42	8.42	-----	33.0
		11/17/1984	PRJ	5.0	177.00	185.42	8.42	-----	69.1
Lower Aquifer									
L-28	-----	10/14/1992	Specific Capacity	0.2	211.35	246.80	35.45	0.006	0.6
		9/10/1996	Specific Capacity	0.3	209.60	246.80	37.20	0.007	0.7
L-29	-----	7/29/1992	Specific Capacity	0.2	210.90	244.80	33.90	0.007	0.8
		10/14/1997	Specific Capacity	0.3	210.92	244.80	33.88	0.008	0.9
		9/10/1996	Specific Capacity	0.5	208.91	244.80	35.89	0.013	1.3
L-30	-----	10/14/1992	Specific Capacity	0.3	204.48	256.00	51.52	0.005	0.5
		9/10/1996	Specific Capacity	0.4	202.76	256.00	53.24	0.008	0.8
L-31	-----	1/29/1991	PRM*	0.7	223.70	263.00	39.30	-----	2.8
		10/15/1992	Specific Capacity	0.4	210.42	263.15	52.73	0.008	0.8
L-32	-----	9/25/1993	Slug C	-----	212.46	-----	1.34	-----	0.1
		10/15/1993	Specific Capacity	0.4	212.34	268.50	56.16	0.007	0.7
		9/10/1996	Specific Capacity	0.3	209.81	267.80	57.99	0.005	0.5
L-33	-----	9/22/1993	Slug C	-----	211.11	-----	1.37	-----	0.1
		10/15/1993	Specific Capacity	0.4	210.57	268.40	57.83	0.007	0.7
		9/10/1996	Specific Capacity	0.3	207.54	267.60	60.06	0.005	0.5
L-35	LMW-30 (D-30)	11/13/1985	Slug C	-----	Unknown	-----	1.41	-----	0.4
		10/13/1992	Specific Capacity	0.2	194.46	224	29.54	0.005	0.5
		9/9/1996	Specific Capacity	0.3	192.61	224	31.39	0.008	0.8
L-36	LMW-27 (D-27)	11/20/1985	Slug C	-----	Unknown	-----	1.60	-----	0.2
		10/13/1992	Specific Capacity	0.2	205.82	237.3	31.48	0.005	0.5
		9/9/1996	Specific Capacity	0.3	205.23	237.3	32.07	0.009	1.0

Table E-6 - Summary of Aquifer Testing Data (continued)

Current Well ID	Old Well ID	Date	Test Type[a]	Sustained Pump Rate (gpm)	Static WL (ft bmp)	Pumping WL (ft bmp)	Draw-down/Dis-placement (ft)	Q/s (gpm/ft)	T (ft^2/d)
See footnotes at end of table.									
L-37	LMW-28 (D-28)	10/1/1985	Slug C	-----	Unknown	-----	1.41	-----	0.737
		11/14/1988	Slug C	-----	Unknown	-----	1.41	-----	0.335
		10/13/1992	Specific Capacity	0.2	220.32	235.8	15.48	0.010	1.0
		9/9/1996	Specific Capacity	0.4	219.15	235.8	16.65	0.024	2.5
L-38	LMW-13	10/13/1992	Specific Capacity	0.4	190.5	256.7	66.20	0.006	0.6
		9/9/1996	Specific Capacity	0.4	187.56	256.7	69.14	0.006	0.6
L-39	-----	10/14/1992	Specific Capacity	0.3	217.54	265.9	48.36	0.005	0.6
		9/10/1996	Specific Capacity	0.3	216.35	265.9	49.55	0.005	0.5
L-41	-----	12/10/2003	Slug B	-----	210.02	-----	9.90	-----	1.6
L-42	-----	12/10/2003	Slug B	-----	210.75	-----	10.60	-----	1.4
L-43	-----	10/3/2005	Slug B	-----	205.41	-----	2.84	-----	0.05
		10/10/2005	Slug B	-----	202.88	-----	2.85	-----	0.05
L-44	-----	10/3/2005	Slug B	-----	195.41	-----	3.05	-----	0.04
		10/10/2005	Slug B	-----	195.25	-----	3.01	-----	0.05
L-46[b]	-----	12/9/2003	Slug B	-----	191.01	-----	12.20	-----	0.1
L-45	-----	11/29/2007	Slug B	-----	181.72	-----	1.65	-----	0.03
L-47	-----	3/19/2003	Slug B	-----	171.05	-----	69.00	-----	0.02
		4/6/2009	Slug B	-----	171.05	-----	1.78	-----	0.04
LP-15	MW-24	3/6/1986	PRM*	1.0	201.10	252.50	51.40	-----	0.8
MW-5[b]	-----	8/10/1984	PRM*	11.7	206.45	228.50	22.05	-----	3.3
MW-6[b]	-----	8/10/1984	PRM*	1.6	205.00	229.50	24.50	-----	0.4
MW-12[b]	-----	11/24/1984	PRM*	Unknown	202.13	239.42	37.29	-----	2.5

[a] Test Types:

PDJ = Pumping drawdown by Jacobs Method.
PRM = Pumping recovery by McWhorter Method.
PRJ = Pumping recovery by Jacobs Method.
Slug C = Slug test analyzed by Cooper et al Method.
Slug B = Slug test analyzed by Bouwer et al Method.

[b] Abandoned well.

* Dewatered during pumping.

Table E-7 - Typical T, t, r, and S Values for the Upper and Lower Aquifers Used for Specific Capacity Calculations

Variable	Upper Aquifer	Lower Aquifer
T	133.6 gpd/ft	9.9 gpd/ft
t	0.021 days (30 minutes)	0.021 days (30 minutes)
r	0.5 ft	0.5 ft
S	7.2×10^{-2}	2.5×10^{-4}

Table E-8 - Definition of Bedding

4 ft to 32 ft	Very thick-bedded
2 ft to 4 ft	Thick-bedded
2 in. to 2 ft	Thin-bedded
¼ in. to 2 in.	Very thin-bedded
0.2 cm to ¼ in.	Laminated
0.1 cm to 0.2 cm	Thinly laminated

Source: Krumbein & Sloss, 1963.

Table E-9 - Summary of Hydraulic Properties

Well ID	Average T (ft^2/d)	Saturated Aquifer Test Section (ft)	Cumulative Sandbed Thickness (ft)	Avg. Sandbed K from Aquifer Tests (ft/day)	Avg. Sandbed K from Aquifer Tests (cm/sec)	Oct.2013 Gradient (ft/ft)	Avg. Linear Velocity (ft/day)	Avg. Linear Velocity (ft/year)
Upper Aquifer								
U-1	1.7	19.0	8.0	0.21	7.6E-05	P&A 2012	NA	NA
U-2	0.7	38.2	13.9	0.05	1.8E-05	P&A 2012	NA	NA
U-4	29.4	65.6	35.7	0.82	2.9E-04	0.0072	0.0138	5.05
U-6	13.6	65.7	8.6	1.58	5.6E-04	0.0203	0.0747	27.28
U-7	2.7	57.2	11.9	0.22	7.9E-05	0.0201	0.0104	3.80
U-8	4.8	60.9	11.1	0.44	1.5E-04	0.0165	0.0167	6.09
U-9	1.9	47.0	12.2	0.16	5.5E-05	0.0154	0.0056	2.05
U-10	0.7	41.0	7.4	0.09	3.2E-05	0.0145	0.0031	1.13
U-11	0.8	23.8	3.3	0.24	8.6E-05	0.0132	0.0075	2.73
U-12	1.1	20.8	4.7	0.23	8.1E-05	0.0130	0.0070	2.54
U-13	19.9	50.0	20.0	1.00	3.5E-04	0.0010	0.0023	0.84
U-14	2.2	40.0	7.0	0.31	1.1E-04	0.0026	0.0019	0.68
U-15	0.03	25.0	3.0	0.01	3.5E-06	0.0151	0.0004	0.13
U-17	0.6	11.4	2.3	0.28	9.8E-05	0.0178	0.0115	4.20
U-18	0.7	19.4	4.8	0.15	5.1E-05	0.0160	0.0054	1.97
U-19	0.5	44.7	4.6	0.12	4.2E-05	0.0268	0.0074	2.71
U-20	0.6	27.5	No SPR log	NA	NA	P&A 2013	NA	NA
U-21	34.8	26.4	No SPR log	NA	NA	0.0070	NA	NA
U-22	2.0	25.0	No SPR log	NA	NA	0.0114	NA	NA
U-23	1.8	8.0	No SPR log	NA	NA	0.0091	NA	NA
U-24	4.0	47.0	10.0	0.40	1.4E-04	0.0036	0.0033	1.20
U-25	2.7	29.6	5.0	0.54	1.9E-04	0.0074	0.0093	3.39
U-48*	16.1	53.0	25.0	0.64	2.3E-04	0.0072	0.0108	3.95
U-49*	2.1	35.0	12.0	0.18	6.2E-05	0.0060	0.0024	0.89
U-54*	0.046	25.0	1.5	0.03	1.1E-05	0.0058**	0.0004	0.15
U-26	0.1	19.2	1.5	0.04	1.4E-05	0.0117	0.0011	0.40
UP-5	9.0	47.0	5.0	1.79	6.3E-04	0.0324	0.1350	49.28
UP-6	6.4	11.4	No SPR log	NA	NA	0.0243	NA	NA
UP-7	21.0	22.0	5.0	4.20	1.5E-03	0.0237	0.2320	84.67
UP-26	0.2	42.0	2.0	0.08	2.9E-05	0.0124	0.0024	0.86
UP-28	0.1	21.9	1.5	0.07	2.3E-05	0.0167	0.0025	0.92
UP-29	0.1	32.3	1.5	0.07	2.4E-05	0.0082	0.0013	0.47
MW-11	2.3	46.0	3.0	0.77	2.7E-04	0.0133	0.0237	8.66
D-18	51.1	38.0	8.0	NA	NA	0.0062	NA	NA
max	51.1	65.7	35.7	4.2	1.5E-03	0.0324	0.2320	84.7
min	0.03	8.00	1.50	0.01	3.5E-06	0.0010	0.0004	0.13
avg	6.9	34.9	8.3	0.5	1.9E-04	0.0133	0.0228	8.3
Lower Aquifer								
L-28	0.7	35.1	2.0	0.33	1.2E-04	0.0083	0.0063	2.32
L-29	1.0	34.0	2.9	0.34	1.2E-04	0.0115	0.0091	3.31
L-30	0.7	34.6	3.2	0.20	7.2E-05	0.0137	0.0065	2.37
L-31	1.8	32.0	5.4	0.33	1.2E-04	0.0242	0.0188	6.85
L-32	0.5	30.0	3.0	0.16	5.5E-05	0.0350	0.0127	4.63
L-33	0.5	30.0	3.0	0.15	5.3E-05	0.0348	0.0122	4.47
L-35	0.6	30.0	No SPR log	NA	NA	0.0287	NA	NA
L-36	0.5	25.0	3.8	0.14	5.1E-05	0.0339	0.0114	4.16
L-37	1.2	30.0	3.8	0.31	1.1E-04	0.0316	0.0228	8.31
L-38	0.6	50.1	9.1	0.07	2.4E-05	0.0344	0.0055	2.01
L-39	0.6	34.8	3.4	0.16	5.7E-05	0.0161	0.0061	2.22
L-41	2.0	29.8	6.0	0.33	1.2E-04	0.0380	0.0294	10.74
L-42	1.8	20.3	4.0	0.45	1.6E-04	0.0196	0.0205	7.47
L-43	0.05	29.6	6.0	0.01	2.9E-06	0.0142	0.0003	0.10
L-44	0.04	30.0	8.0	0.01	1.8E-06	0.0080	0.0001	NA
L-45	0.03	30.0	4.0	0.01	2.6E-06	0.0049	0.0001	0.031
L-46	0.10	40.0	5.0	0.02	7.1E-06	P&A 2009	NA	NA
L-47	0.04	35.0	6.0	0.01	2.4E-06	0.0302	0.0005	0.17
LP-15	0.8	38.0	2.3	0.35	1.2E-04	0.0073	0.0059	NA
MW-5	3.3	23.0	4.0	0.83	2.9E-04	0.0160	0.0307	11.20
MW-6	0.4	22.0	4.0	0.10	3.5E-05	0.0308	0.0072	2.61
MW-12	2.5	46.0	4.0	0.63	2.2E-04	0.0177	0.0257	9.39
Max.	3.3	50.1	9.1	0.83	2.9E-04	0.0380	0.0307	11.20
Min.	0.03	20.3	2.0	0.01	1.8E-06	0.0049	0.0001	0.031
Avg.	0.9	32.2	4.4	0.23	8.3E-05	0.0218	0.0116	4.6

Notes:

Only wells with aquifer hydraulic data are shown.
Wells without Single Point Resistance (SPR) logs do not have an estimated sandbed thickness and therefore a K and velocity cannot be estimated.

NA = Not able to calculate without sandbed thickness and or gradient.

* Sand bed thickness estimated from boring log and nearby wells.

** Gradient for Fall 2017 between 2400 and 2390 water level contours.

Table E-10 Summary of Laboratory Results for Boreholes D-21, D-22, and D-23

Sample Number	Drill Hole Number	Depth in Feet	Stratigraphic Unit	Vertical Coefficient of Permeability (cm/sec)	Dry Unit Weight[a]	Moisture Content[b] (percent)	Specific Gravity	Degree of Saturation (percent)	Porosity (percent)
S-1	D-21	14.3-15.8	V			3			
S-2	D-21	24.2-25.0	V			4			
S-3	D-21	34.2-35.8	V			11			
S-4	D-21	44.2-45.4	V			21			
S-5	D-21	54.2-55.4	V			6			
S-6	D-21	64.2-65.6	V			7			
S-7	D-21	74.5-75.8	V			4			
S-8	D-21	84.2-85.1	V			7			
S-9	D-21	94.2-95.1	V			6			
S-11	D-21	138	UA			32			
S-12	D-21	146.3	UA			29			
S-13	D-21	156.0-156.8	UA			32			
S-14	D-21	163.4-164.9	UA	1×10^{-7}	97	26	2.691	91.9	
S-15	D-21	183.0-184.0	UA	2×10^{-6}	96	30	2.703	97.3	
S-16	D-21	204.2-205.0	UA	7×10^{-7}	92	29	2.703	95.8	
S-20	D-21	214.2-214.9	UA	1×10^{-6}	95	29	2.778	96.8	
S-21	D-21	224.0-224.7	IC	2×10^{-6}	98	23	2.609	89.9	
S-22	D-21	232.2-233.2	IC	2×10^{-7}	98	28	2.791	98.7	
S-23	D-21	250.5-251.7	LA	8×10^{-8}	98	27	2.743	99.9	
S-24*	D-21	256.2-256.5	LA	U N T E S T A B L E					
S-25	D-21	258.7-259.3	LA	2×10^{-7}	98	26	2.737	98.8	
S-29*	D-21	262.4-262.8	LA	1×10^{-5}	93	24	2.70 c	--	45
S-33	D-21	269.3-270.0	LA	1×10^{-7}	95	29	2.78	98.9	
S-35	D-21	278.0-278.5	LC	4×10^{-8}	94	30	--	--	
S-36	D-21	287.0-289.0	LC	5×10^{-8}	95	28	2.707	96.9	
S-1	D-22	10	V			6			
S-2	D-22	20	V			10			
S-3	D-22	30	V			4			
S-4	D-22	40	V			4			
S-5	D-22	50	V			3			
S-6	D-22	60	V			10			
S-7	D-22	70	V			4			
S-8	D-22	80	V			19			
S-9	D-22	90	V			3			
S-10	D-22	100	V			9			
S-11	D-22	110	V			17			
S-12	D-22	118.0-118.6	V			25			
S-13	D-22	144.0-144.6	UA		95	28	2.777	95.5	
S-14	D-22	152.5-153.4	UA	2×10^{-7}	95	28	2.758	95.8	

Table E-10 Summary of Laboratory Results for Boreholes D-21, D-22, and D-23

Sample Number	Drill Hole Number	Depth in Feet	Stratigraphic Unit	Vertical Coefficient of Permeability (cm/sec)	Dry Unit Weight[a]	Moisture Content[b] (percent)	Specific Gravity	Degree of Saturation (percent)	Porosity (percent)
S-15	D-22	159.0-160.6	UA	1×10^{-6}	98	19	2.771	69.6	
S-17	D-22	161.5-162.7	UA	2×10^{-6}	98	24	2.76	85.5	
S-20	D-22	176.4-177.6	UA	8×10^{-7}	95	26	2.764	87.2	
S-21	D-22	191.0-191.9	IC	2×10^{-7}	96	27	2.756	91.4	
S-22	D-22	216.5-217.4	IC	1×10^{-7}	94	29	2.785	94.1	
S-23	D-22	228.7-229.2	LA	$3x10^{-7}$	97	25	2.774	86.5	
S-24*	D-22	230.3-231.1	LA	8×10^{-6}	98	28	2.778	98.7	
S-25*	D-22	231.7-232.8	LA	1×10^{-5}	96	26	2.734	90.7	44
S-26*	D-22	233.3-233.5	LA	2×10^{-5}	92	25	2.709	81.8	45.6
S-27	D-22	233.7-234.2	LA	8×10^{-7}	98	26	2.725	95.3	
S-29	D-22	243.6-245.0	LA	1×10^{-7}	94	26	2.752	86.7	
S-30	D-22	275.0-276.5	LC	1×10^{-7}	95	26	2.728	89.4	
S-31	D-22	283.9-285.0	LC	5×10^{-5}	97	25	2.719	90.7	42.8
S-1	D-23	10	V			3			
S-2	D-23	20	V			4			
S-3	D-23	30	V			6			
S-4	D-23	40	V			7			
S-5	D-23	50	V			7			
S-6	D-23	60	V			28			
S-7	D-23	70	V			6			
S-8	D-23	80	V			4			
S-9	D-23	90	V			11			
S-10	D-23	100	V			7			
S-11	D-23	146.5-146.9	UA		86	32	2.66	90.9	
S-12	D-23	153.8-154.2	UA	3×10^{-7}	91	31	2.73	97.4	
S-13	D-23	161.5-162.0	UA	3×10^{-7}	95	29	2.79	96	
S-14*	D-23	168.2-168.8	UA	UNTESTABLE			2.70[c]		
S-15*	D-23	170.3-170.7	UA	1×10^{-4}	95	27	2.70[c]		43.4
S-16*	D-23	171.2-172.1	UA	5×10^{-5}	96	27	2.70[c]		43.1
S-17	D-23	176.8-177.2	UA		96	28	2.79	97.7	
S-18	D-23	193.6-194.0	UA		98	26	2.75	93.7	
S-19	D-23	208.0-208.4	IC		92	31	2.76	97.4	
S-20	D-23	211.4-212.8	IC	1×10^{-7}	92	29	2.74	93.1	
S-21	D-23	271.0-217.5	IC		92	30	2.76	95.3	
S-22	D-23	221.4-231.9	IC		93	29	2.76	93.5	
S-23	D-23	231.4-231.9	LA		96	29	2.75	96.3	
S-24	D-23	241.9-242.7	LA		94	29	2.75	94	
S-25	D-23	253.1-254.0	LC	8×10^{-8}	93	29	2.74	94.9	

Table E-10 Summary of Laboratory Results for Boreholes D-21, D-22, and D-23

Sample Number	Drill Hole Number	Depth in Feet	Stratigraphic Unit	Vertical Coefficient of Permeability (cm/sec)	Dry Unit Weight[a]	Moisture Content[b] (percent)	Specific Gravity	Degree of Saturation (percent)	Porosity (percent)
S-26	D-23	265.0-265.9	LC		92	30	2.72	96.8	
S-27*	D-23	192.7-193.1	UA	4×10^{-5}	96	23	2.70[c]		42.9
								Average	43.9

*Sandbed.

[a]Pounds per cubic foot.

[b]Moisture content for samples below 100 feet may have been affected by water used in rotary coring.

[c]Assumed value.

V =	Vadose	IC =	Inner confining zone	LC =	Lower confining zone
UA =	Upper aquifer	LA =	Lower aquifer	TS =	Third saturated zone

Table E-11 - Empirical Hydraulic Conductivity Values from Sieve Analyses

Well/Bore hole ID	Sample Depth	Matrix	d_{10} (mm)	K from Hazen Equation (cm/sec)	Average K (cm/sec)	Average K (ft/day)
Upper Aquifer						
D-21 (UP-4)	204.2-205.0	silt, sand, & clay	0.0030 *	9.00E-06	6.42E-06	0.018
	214.2-214.9	silt & clay	0.0020 *	4.00E-06		
	224.0-224.7	silt & clay	0.0025 *	6.25E-06		
D-22	159.0-160.6	sand & silt	0.0046	2.12E-05	1.51E-05	0.043
	161.5-162.7	sand & silt	0.0030 *	9.00E-06		
D-23 (UP-2)	170.3-170.7	sandbed	0.0060	3.60E-05	1.03E-04	0.291
	171.2-172.1	sandbed	0.0130	1.69E-04		
Lower Aquifer						
D-21 (LP-12)	256.2-256.5	sandbed	0.0037 *	1.37E-05	1.13E-05	0.032
	262.4-262.8	sandbed	0.0030 *	9.00E-06		
D-22	230.3-231.1	sandbed	0.0140	1.96E-04	7.67E-05	0.217
	231.7-232.8	sandbed	0.0030 *	9.00E-06		
	233.3-233.5	sandbed	0.0050	2.50E-05		
D-23	241.9-242.7	sand & clay	0.0010 *	1.00E-06	1.00E-06	0.003

* Projected value

Table E-12 - Water Level Correction Factors

Piezometer or Well I.D.	Correction Equation (feet)
UP-28*	Y= 0.9864(X) + 1.36
UP-29*	Y= 0.9484(X) + 5.39
L-28	Y= 0.9744(X) + 1.55

X= Measured depth to water
Y= True vertical depth to water

*Abandoned October 2014

Table E-13 - Water Level Differences, 1989-2013

USEI Site B

	Well ID	October-89 WL Elev. (ft msl)	October-13 WL Elev. (ft msl)	WL Diff. (ft)
Upper Aquifer				
	U-1	2387.86	P&A 5/2012*	na
	U-2	2389.71	P&A 5/2012*	na
	U-3	2390.59	P&A 5/2012*	na
	U-4	2392.75	2397.43	4.68
	U-5	2386.23	2390.56	4.33
	U-6	2379.14	2383.25	4.11
	U-7	2370.03	2375.99	5.96
	U-8	2369.09	2376.05	6.96
	U-9	2367.37	2375.69	8.32
	U-10	2365.55	2375.00	9.45
	U-11	2364.51	2374.52	10.01
	U-12	2363.70	2373.76	10.06
	U-17	2370.66	2379.01	8.35
	U-18	2371.63	2380.86	9.23
	U-19	2372.30	2381.57	9.27
	U-20	2383.00	P&A 8/2013*	na
	U-21	2384.51	2392.41	7.90
	U-22	2383.95	2390.62	6.67
	U-23	2384.74	2391.71	6.97
	U-24	2389.47	2395.17	5.70
	U-25	2385.42	2392.04	6.62
	UP-1	2371.10	2380.19	9.09
	UP-2	2389.66	2395.45	5.79
	UP-3	2385.40	2392.08	6.68
	UP-4	2363.01	2375.42	12.41
	UP-5	2369.16	2376.06	6.90
	UP-7	2384.48	2388.80	4.32
			Max.	12.41
			Min.	4.11
			Average	7.4
Lower Aquifer				
	L-28	2363.19	2378.80	15.61
	L-29	2361.07	2376.69	15.62
	L-30	2363.43	2376.94	13.51
	L-35	2421.36	2426.43	5.07
	L-36	2408.80	2418.95	10.15
	L-37	2382.78	2396.06	13.28
	L-38	2443.60	2445.12	1.52
	L-39	2374.12	2383.86	9.74
	LP-11	2370.68	2383.09	12.41
	LP-13	2363.23	2371.39	8.16
	LP-14	2418.14	2419.71	1.57
	LP-15	2360.71	2375.16	14.45
			Max.	15.62
			Min.	1.52
			Average	10.1

Only wells with 1989 and 2013 data shown. See Appendix E.6 for all data and for hydrographs.

Table E-14 - Water Balance Worksheet

Completed by C.Feast, 11/12/97
Last Revision: 1/25/14

LATERAL INFLOW AND OUTFLOW

Lateral flux in (West)

Wells	T (ft^2/d)	Sat. Thick for T	Avg. K (ft/d)	I
U-4	29.4	66.9	0.4388	0.0072
U-13	19.9	50.0	0.3980	0.0010
U-14	2.2	40.0	0.0550	0.0026
U-21	34.8	26.4	1.3182	0.0070
U-23	1.8	9.8	0.1809	0.0114
U-24	4.0	48.5	0.0823	0.0091
U-25	2.7	31.3	0.0862	0.0036
U-48	16.1	53.0	0.3038	0.0074
U-49	2.1	35.0	0.0600	0.0060
UP-26	0.2	42.0	0.0124	0.0089
Average	11.3		0.2623	0.0070

Lateral flux out (East)

Wells	T (ft^2/d)	Sat. Thick for T	Avg. K (ft/d)	I
U-7	2.7	58.2	0.0456	0.0201
U-8	4.8	62.3	0.0776	0.0165
U-9	1.9	49.0	0.0391	0.0154
U-10	1.9	62.3	0.0307	0.0145
U-11	0.8	49.0	0.0164	0.0132
U-12	1.1	43.8	0.0247	0.0130
U-17	0.6	26.6	0.0240	0.0178
U-18	0.7	43.8	0.0159	0.0160
Average	1.8		0.0343	0.0158

HORIZONTAL FLUX IN UPPER AQUIFER

Max Sat thickness	70	ft
Min. Sat thickness	0	ft
Width	2000	ft
Area	70000	ft^2

Flux Q = (K x I x A)

In (+, West)		Out (-, East)	
128	ft^3/day	(38)	ft^3/day
46,882	ft^3/year	(13,832)	ft^3/year
1,125,169	ft^3 1989-2013	(331,965)	ft^3/year

VERTICAL FLUX THROUGH INNER CONFINING BED

Vertical Gradients, I_v

Confining Bed Thickness 30 feet

Well pair	10/2013 WL	WL Delta	Gradient (+ is up)
U-26	2387.18		
L-33	2388.32	1.14	0.0380
UP-26	2388.94		
LP-27	2391.72	2.78	0.0927
U-12	2373.76		
LP-15	2375.16	1.40	0.0467
		Average	0.0653
U-7	2375.99		
LP-13	2371.39	-4.60	-0.1533
UP-4	2375.42		
LP-12	2374.85	-0.57	-0.0190
		Average	-0.0419

HORIZONTAL FLUX THROUGH LOWER AQUIFER

Q=T*I*A		
Transmissivity, T	0.9	ft^2/day
Gradient, I	0.0218	ft/ft
Width	2,000	ft
Flux	39	ft^3/day
Flux	14,323	ft^3/year
Flux	343,742	ft^3 1989-2013

VERTICAL FLUX SUMMARY

	Upward	Downward	
Limiting Kv		1.00E-08	cm/sec
K	2.84E-05	2.84E-05	ft/d
I	0.0653	-0.0419	ft/ft
Width	500	1500	ft
Length	2000	2000	ft
	2	(4)	ft^3/day
	676	(1,300)	ft^3/year
	16,225	(31,209)	ft^3 1989-2013

PRECIPITATION INFILTRATION

Precipitation	7.08	inches/year
Runoff	3	inches/year
Effective ppt	4.08	inches/year
Infiltration	1.00	% annual effective ppt
Infiltration	0.04	inches/yr
Width	2,000	feet
Length	2,000	feet
Area	4,000,000	ft^2
Infiltration	13,600	ft^3/year
Infiltration	326,400	ft^3 1989-2013

PUMPAGE

Assume	1800	gals. removed	per sample event
-1800	gals =	-241	ft^3 per event
2	events/yr	-481	ft^3/year
24	years	-11551	ft^3 1989-2013

WATER BALANCE SUMMARY

Lateral inflow	1,125,169	ft^3 1989-2013
Lateral outflow	(331,965)	ft^3 1989-2013
Vertical inflow	16,225	ft^3 1989-2013
Vertical outflow	(31,209)	ft^3 1989-2013
Pumping outflow	(11,551)	ft^3 1989-2013
Precipitation Infiltration	326,400	ft^3 1989-2013
Net inflow	1,093,069	ft^3 1989-2013

STORAGE CHANGE

Equivalent change in storage over 4,000,000 ft^2 area to accommodate net inflow of
1,093,069 ft^3 at a specific yield of 3.7% = 7.4 ft.

Typical specific yields: Clay 1-10%, Sand 10-20%.

CONCLUSION

Based on delta water level (Table E-13), avg wl rise across site is 7.4 feet (1989-2013).
Therefore water balance based on site characterization data is reasonable
indicating site characterization data is valid.

1/25/14 Update notes:
Added wells U-13, U-14, U-48 and U-49 on upgradient side
Broke all external spreadsheet links so data on table has to be manually adjusted from Tables E-9 and E-13.
Gradients were measured at each well using Fall 2013 Upper Aquifer Water Level map.

Table E-15 - Summary of Groundwater Temperature, pH, and Specific Conductance Data
April 1989 to October 2013
USEI Site B

Well ID	No. of Samples	Field Temperature (°C)			Field pH (units)			Field Specific Conductance (umhos/cm)		
		Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Upper Aquifer										
U-1	45	15.9	20.5	17.9	6.6	7.8	7.2	720	1580	1344
U-2	42	16.5	20.3	18.3	6.5	7.7	7.2	790	1520	1313
U-3	43	16.9	21.0	18.3	6.5	7.4	7.0	580	1230	1083
U-4	45	17.0	21.0	18.0	6.7	7.6	7.2	480	1000	869
U-5	43	16.3	19.1	18.0	5.5	7.9	7.3	500	964	848
U-6	43	15.8	19.7	18.4	6.4	7.8	7.0	660	1300	1105
U-7	44	17.2	19.8	18.5	6.4	7.3	6.8	816	2390	1545
U-8	43	17.5	19.7	18.5	6.5	7.4	7.0	820	1767	1360
U-9	44	16.5	20.5	18.5	6.4	7.6	7.0	770	1907	1453
U-10	44	16.3	20.9	18.4	6.2	7.3	7.0	940	1846	1575
U-11	44	16.5	20.3	18.2	6.3	7.4	7.0	950	2010	1681
U-12	44	16.1	20.5	18.1	6.2	7.4	6.9	1130	2068	1787
U-13	5	17.3	19.0	18.1	6.8	7.0	7.0	1114	1167	1140
U-14	5	16.3	19.3	18.2	6.8	7.1	7.0	1592	1730	1669
U-15	5	17.2	18.6	18.1	7.0	7.3	7.2	1154	1239	1191
U-17	31	16.5	19.5	18.2	6.8	7.5	7.1	1010	2000	1329
U-18	32	16.5	19.8	18.3	6.8	7.4	7.1	1120	2157	1740
U-19	32	16.8	19.6	18.2	6.6	7.3	7.0	1290	2293	1830
U-20	33	16.4	20.7	18.8	6.8	8.7	7.8	920	1950	1630
U-21	44	16.5	20.0	18.4	6.5	7.6	7.1	860	2537	1524
U-22	32	17.3	20.9	19.0	7.2	8.2	7.6	1380	2170	1780
U-23	47	16.0	20.3	18.0	6.4	7.7	7.0	1090	2790	1769
U-24	43	17.2	19.6	18.0	6.5	8.1	7.1	800	1378	1116
U-25	43	17.1	19.5	18.3	6.5	7.5	6.9	1300	2112	1745
U-48	3	16.9	18.0	17.6	6.9	7.2	7.0	1235	1282	1252
U-49	3	15.7	18.4	17.3	6.9	7.4	7.1	1530	1604	1559
UP-6	2	18.1	18.9	18.5	6.8	6.9	6.9	2497	2531	2514
Min.		15.7	18.0	17.3	5.5	6.9	6.8	480	964	848
Max.		18.1	21.0	19.0	7.2	8.7	7.8	2,497	2,790	2,514
Mean		16.7	19.8	18.2	6.6	7.5	7.1	1,039	1,797	1,472

Table E-15 - Summary of Groundwater Temperature, pH, and Specific Conductance Data April 1989 to October 2013 USEI Site B

Well ID	No. of Samples	Field Temperature (^{o}C)			Field pH (units)			Field Specific Conductance (umhos/cm)		
		Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Lower Aquifer										
L-28	45	16.0	20.0	17.9	6.6	7.7	7.2	810	1606	1416
L-29	46	15.7	20.4	17.9	6.3	7.7	7.2	830	1740	1440
L-30	44	16.7	20.3	18.3	6.5	7.7	7.2	860	1666	1452
L-31	29	16.5	19.4	18.2	7.0	7.6	7.2	1150	1656	1453
L-32	35	16.6	19.5	18.2	6.8	8.0	7.2	970	1600	1366
L-33	36	16.6	20.0	18.3	6.8	7.7	7.2	1050	1640	1384
L-35	44	15.9	21.0	18.1	6.6	7.7	7.2	780	1520	1332
L-36	43	16.2	20.1	17.9	6.5	7.6	7.2	690	1490	1288
L-37	45	16.1	21.0	17.9	6.6	7.9	7.2	760	1460	1290
L-38	42	17.6	21.0	19.0	6.6	7.8	7.3	620	1393	1255
L-39	44	16.4	20.0	18.3	6.6	7.8	7.2	830	1600	1372
L-41	21	16.4	19.1	17.9	7.0	7.5	7.3	1020	1340	1224
L-42	21	16.5	20.2	17.8	7.0	7.6	7.3	1090	1576	1407
L-43	17	16.9	18.8	17.6	7.0	7.4	7.2	1355	1650	1502
L-44	17	16.5	18.5	17.6	7.1	7.8	7.2	1445	1716	1558
L-45	12	16.5	17.7	17.3	7.2	7.6	7.3	1357	1595	1482
L-46	11	16.8	19.2	18.2	7.2	7.6	7.3	1500	1730	1621
L-47	10	17.1	17.8	17.4	7.1	7.4	7.2	1466	1683	1541
Min.		15.7	17.7	17.3	6.3	7.4	7.2	620	1,340	1,224
Max.		17.6	21.0	19.0	7.2	8.0	7.3	1,500	1,740	1,621
Mean		16.5	19.7	18.0	6.8	7.7	7.2	1,032	1,592	1,410

Table E-16 - Upper Aquifer Common-Ion Data
USEI Site B (mg/L)

Well ID	Old Well ID	Sample Date	Ca	Mg	Na	K	Cl	CO3	HCO3	SO_4
U-1	MW-16	11/1/1985	99.8	19.2	32.3	166.0	49.6	NR	600.0	65.0
U-4	-----	4/24/1992	81.4	26.0	76.0	25.5	21.0	0.0	328.0	134.0
U-6	MW-9	12/13/1984	89.0	36.0	77.0	26.0	17.3	0.0	376.0	223.0
		8/8/1985	91.8	39.2	71.0	25.0	14.8	0.0	362.0	180.0
U-7	-----	4/24/1992	84.2	46.0	88.0	29.0	19.0	0.0	440.0	152.0
U-10	MW-11	12/13/1984	153.0	64.0	150.0	34.0	57.7	0.0	391.0	423.0
		8/7/1985	159.0	77.5	150.0	30.0	48.0	0.0	594.0	390.0
		4/22/1992	149.0	67.0	139.0	31.5	57.0	0.0	603.0	247.0
U-17	-----	7/30/1990	93.7	48.5	121.0	22.0	109.0	NR	570.0	3.0
		4/29/1993	87.1	47.3	116.0	21.3	102.0	NR	589.0	12.0
U-20	SW-3	6/1/1985	163.0	75.1	NR	180.0	48.0	NR	590.0	340.0
		8/9/1985	157.0	75.3	140.0	33.0	35.6	0.0	575.0	420.0
		8/9/1985	136.0	89.5	140.0	33.0	37.1	NR	576.0	430.0
U-21	SW-2	6/1/1985	143.0	63.2	NR	145.0	36.0	NR	520.0	290.0
		8/9/1985	143.0	63.8	100.0	32.0	15.7	0.0	505.0	350.0
		4/27/1992	147.0	62.0	100.0	39.0	21.0	0.0	538.0	271.0
U-22	SW-1	3/8/1985	107.0	64.9	189.0	36.0	220.0	NR	NR	140.0
		6/28/1985	104.0	63.9	182.0	42.0	60.0	NR	680.0	180.0
U-23	PCB-1	8/8/1985	54.0	49.8	230.0	27.0	61.5	0.0	626.0	87.0
U-26	-----	8/8/1985	62.5	28.9	104.0	17.2	34.0	0.0	439.0	25.0
UP-1	D-19	2/6/1985	110.3	52.0	98.0	25.0	16.0	0.0	493.0	201.0
		8/8/1985	124.0	73.0	91.0	28.0	15.3	0.0	484.0	360.0
UP-3	PCB-2	8/8/1985	91.0	62.3	130.0	30.0	37.1	0.0	559.0	250.0
UP-5	MW-10	12/13/1984	178.0	0.0	93.0	26.0	21.0	0.0	421.0	210.0
		8/8/1985	93.6	50.0	86.0	24.0	12.7	0.0	433.0	210.0
UP-7	MW-1	1/4/1984	NR	NR	77.0	NR	22.0	NR	NR	143.0
		4/4/1984	75.0	31.0	93.0	22.0	9.2	NR	NR	140.0
		6/6/1984	81.0	33.0	77.0	22.0	20.0	NR	NR	110.0
		7/11/1984	80.0	140.0	77.0	24.0	26.0	NR	NR	132.0
		8/15/1984	78.0	150.0	72.0	23.0	39.0	NR	NR	140.0
		9/12/1984	71.0	30.0	70.0	21.0	240.0	NR	NR	140.0
		12/13/1984	64.7	40.0	78.0	21.0	16.7	0.0	322.0	225.0
		8/7/1985	72.5	35.3	76.0	22.0	16.9	0.0	308.0	160.0
UP-26	-----	4/29/1993	63.6	38.9	183.0	19.6	38.8	NR	740.0	18.0
UP-28	-----	4/30/1993	52.4	29.4	177.0	18.0	42.8	NR	596.0	49.0
UP-29	-----	4/30/1993	62.4	37.6	189.0	20.9	42.8	NR	737.0	15.0
-----	MW-3	1/4/1984	NR	NR	98.0	NR	40.0	NR	NR	228.0
		4/4/1984	67.0	61.0	110.0	28.0	21.0	NR	NR	300.0
		6/6/1984	140.0	66.0	110.0	22.0	22.0	NR	NR	270.0
		7/11/1984	140.0	140.0	120.0	30.0	26.0	NR	NR	210.0
		8/15/1984	140.0	140.0	110.0	29.0	40.0	NR	NR	270.0
		9/12/1984	3600.0	130.0	110.0	27.0	130.0	NR	NR	280.0
		12/13/1984	48.5	114.0	120.0	28.0	20.0	NR	548.0	400.0
		8/7/1985	100.0	73.4	120.0	28.0	17.3	0.0	477.0	295.0
-----	D-15	12/13/1984	79.3	32.0	86.0	22.0	17.8	NR	606.0	195.0
		8/1/1985	79.1	36.4	77.0	24.0	11.6	NR	365.0	138.0
-----	D-18	12/13/1984	56.6	29.0	78.0	19.0	14.6	NR	553.0	160.0
		8/8/1985	68.7	27.9	75.0	20.0	13.2	NR	302.0	140.0
-----	PCB-3	8/8/1985	130.0	53.2	120.0	29.0	15.3	NR	384.0	430.0
Min.			48.5	0.0	32.3	17.2	9.2	0.0	302.0	3.0
Max.			3600.0	150.0	230.0	180.0	240.0	0.0	740.0	430.0
Avg.			175.6	59.8	110.8	35.0	42.2	0.0	506.4	207.8

Table E-17 - Lower Aquifer Common-Ion Data
USEI Site B (mg/L)

Well ID	Old Well ID	Sample Date	Ca	Mg	Na	K	Cl	CO3	HCO3	SO_4
L-29	-----	4/23/1992	78.8	41.0	172.0	24.5	117.0	0.0	655.0	2.0
L-32	-----	10/7/1993	62.5	34.4	183.0	19.2	54.5	0.0	699.0	6.0
L-33		10/7/1993	60.8	34.9	203.0	18.8	35.8	0.0	767.0	9.0
L-35	D-30	11/1/1985	57.2	16.2	280.0	19.0	29.2	NR	686.0	117.0
L-36	D-27	11/1/1985	57.2	14.0	250.0	20.3	27.5	NR	654.0	67.0
L-37	D-28	11/1/1985	60.5	16.6	192.0	21.8	58.5	NR	527.0	28.0
L-38	MW-13	12/13/1984	52.6	19.0	160.0	18.0	34.5	0.0	522.0	110.0
		8/7/1985	51.0	27.9	190.0	16.0	39.0	0.0	566.0	68.0
		4/21/1992	49.0	27.0	190.0	20.0	42.0	0.0	671.0	5.0
LP-11	-----	11/1/1985	42.5	17.8	282.0	23.0	47.0	NR	682.0	93.0
LP-12	MW-21	4/23/1985	8.5	2.1	160.0	42.0	54.1	59.0	241.0	26.0
		8/1/1985	20.7	17.9	150.0	22.0	46.4	NR	410.0	22.0
LP-13	-----	11/1/1985	49.1	7.0	171.0	25.5	24.8	NR	536.0	16.0
LP-14	-----	8/8/1985	44.4	28.3	210.0	17.0	38.5	3.0	680.0	12.0
LP-15	-----	2/6/1985	61.7	27.0	135.0	21.0	78.0	33.0	454.0	10.0
		8/7/1985	51.5	30.8	160.0	22.0	66.4	0.0	535.0	18.0
-----	MW-5	1/4/1984	NR	NR	18.0	NR	83.0	NR	NR	14.0
		4/4/1984	67.0	36.0	170.0	22.0	60.0	NR	NR	0.0
		6/6/1984	72.0	39.0	170.0	22.0	92.0	NR	NR	0.0
		7/11/1984	74.0	40.0	180.0	21.0	100.0	NR	NR	0.0
		8/15/1984	74.0	40.0	160.0	21.0	110.0	NR	NR	0.0
		9/12/1984	70.0	39.0	160.0	18.0	120.0	NR	NR	0.0
		12/13/1984	64.7	42.0	180.0	20.0	58.3	0.0	613.0	4.0
		8/7/1985	67.5	45.4	180.0	20.0	99.1	0.0	615.0	7.0
-----	MW-6	1/4/1984	NR	110.0	200.0	NR	36.0	NR	NR	59.0
		4/4/1984	51.0	28.0	200.0	19.0	29.0	NR	NR	13.0
		6/6/1984	58.0	32.0	210.0	22.0	36.0	NR	NR	12.0
		7/11/1984	58.0	32.0	210.0	19.0	39.0	NR	NR	27.0
		8/15/1984	57.0	31.0	220.0	18.0	50.0	NR	NR	9.0
		9/12/1984	55.0	32.0	220.0	17.0	47.0	NR	NR	4.0
		12/13/1984	52.6	34.0	210.0	18.0	38.8	0.0	718.0	12.0
		8/7/1985	50.0	36.6	220.0	18.0	35.3	0.0	715.0	8.0
-----	MW-12	12/13/1984	64.7	32.0	170.0	21.0	111.0	0.0	492.0	75.0
		8/2/1985	67.7	41.4	190.0	21.0	114.0	0.0	611.0	17.0
-----	D-17	12/13/1984	38.8	12.0	70.0	16.0	30.2	0.0	513.0	36.0
		8/8/1985	55.0	37.5	110.0	20.0	73.8	0.0	503.0	22.0
		8/8/1985	59.5	45.9	110.0	19.0	74.9	NR	560.0	25.0
-----	D-31	11/1/1985	54.0	18.8	217.0	21.5	35.5	NR	655.0	16.0
LP-40		6/28/2000	44.1	20.5	99.1	16.3	30.9	0.0	421.0	24.1
Min.			8.5	2.1	18.0	16.0	24.8	0.0	241.0	0.0
Max.			78.8	110.0	282.0	42.0	120.0	59.0	767.0	117.0
Mean			55.7	31.2	178.5	20.5	58.9	5.0	581.5	25.5

Table E-18 - Summary of VOC Detections April 1989- October 2013

	Well	Apr 89	Oct 89	Apr 90	Oct 90	Apr 91	Oct 91	Dec 91	Feb 92	Mar 92	Apr 92	Jul 92	Oct 92	Mar 93	May 93	Oct 93	May 94	Oct 94	May 95	Oct 95	Apr 96	Sep 96	Jul 97	Oct 97	Apr 98	Oct 98	Jun 99	Oct 99	Jan 00	Jun 00	Nov 00	Mar 01	Apr 01	Dec 01	May 02	Sep 02	May 03	Jul 03	Oct 03	Jan 04	May 04	July 04	Aug 04	Oct 04	Jan 05	May 05	Oct 05	June 06	Oct 06	Jan 07	May 07	Nov 07	Feb 08	May 08	Nov 08	May 09	Oct 09	May 10	Jul 10	Oct 10	May 11	Oct 11	May 12	June 12	Oct 12	May 13	Oct 13
	U-1																																																																		
1,1,2,2-Tetrachloroethane	1,1,2,2-	ND	ND	ND	ND	ND	ND	-----	-----	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	-----	-----	-----
Carbon disulfide	CDS	ND	ND	ND	ND	ND	ND	-----	-----	4.0	ND	ND	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----
Carbon tetrachloride	CTET	ND	ND	ND	ND	ND	ND	-----	-----	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	5.0	12	14	29	14	ND	ND	3.1	14	-----	5.2	15	-----	1.5	ND	ND	1.4	140	-----	15	-----	30	-----	-----	15	-----	8.7	19	17	17	-----	26	15	-----	17	38	25	19	20	-----	31	29	23	31	-----	-----	-----	-----
Chloromethane	CM	ND	ND	ND	ND	ND	ND	-----	-----	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	-----	-----	-----
Methylene Chloride	MC	ND	ND	ND	ND	ND	ND	-----	-----	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	-----	-----	-----
4,4'- DDT	DDT	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.3	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND
Aldrin	ALD	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.1	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND
Dibromodichloromethane	DBA	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	1.3	ND	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Bromodichloromethane	BDA	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	4.4	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Chloroform	CF	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	43	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
	UP-6																																																																		
Methylene Chloride	MC	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.3	ND
	U-20																																																	-----			-----						-----								
(2,4-Dichorophenoxy) acetic ac	2,4-D	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	-----	-----	-----	ND	4.2	ND	ND	ND	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----
1,1,1-Trichloroethane	1,1,1-T	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	6.3	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
1,1,2,2-Tetrachloroethane	1,1,2,2-	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
1,1,2-Trichloro-1,2,2-trifluoroet	CFC-11	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	ND	ND	46	ND	2.3	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
1,1-Dichloroethane	1,1-DC	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	2.4	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
1,1-Dichloroethene	1,1-DC	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	1.2	-----	ND	ND	ND	ND	ND	-----	1.1	-----	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
2-Butanone	MEK	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	ND	ND	29.0	-----	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
Acetone	ACE	ND	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	ND	-----	ND	ND	6.8	ND	ND	-----	2.9	-----	2.8	-----	-----	ND	ND	ND	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	-----
Chloroform	CF	ND	-----	-----	6.0	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	26	170	24	ND	110	1100	110	1900	-----	14	70	60	50	3500	-----	330	-----	7.7	-----	-----	260	ND	1000	350	29	56	-----	820	500	-----	110	30	12	4.8	1.6	-----	1.3	1.0	6.8		-----	180	-----	-----
Chloromethane	CM	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
Endosulfan sulfate	ENDO	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	-----	-----	-----	0.1	ND	ND	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----
Methylene Chloride	MC	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	17	ND	ND	ND	ND	ND	ND	-----	1.3	ND	4.9	3.9	ND	-----	6.1	-----	ND	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	8.6	-----	-----
Tetrachloroethene	PCE	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	11	-----	ND	ND	ND	1.4	ND	-----	3.5	-----	ND	-----	-----	ND	ND	ND	12.0	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
Trichloroethene	TCE	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	23	-----	ND	ND	ND	1.6	ND	-----	4.9	-----	ND	-----	-----	ND	ND	ND	700	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	-----	-----
	U-21																																																																		
1,1,1-Trichloroethane	1,1,1-T	ND	-----	-----	ND	-----	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.1	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
1,1,2,2-Tetrachloroethane	1,1,2,2-	ND	-----	-----	ND	-----	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
1,2-Dichloroethane	1,2-DC	ND	-----	-----	ND	-----	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	5.9	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Carbon tetrachloride	CTET	ND	-----	-----	ND	-----	4.0	35	7.0	-----	ND	14	8.0	ND	14	14	10	ND	8.2	8.2	12	7.3	12	12	ND	ND	ND	1.3	-----	ND	3.2	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	1.5	ND	ND	-----	ND	ND	-----	ND	ND	ND	2.4	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Chloroethane	CA	ND	-----	-----	ND	-----	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	-----	ND	4.0	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Methylene Chloride	MC	ND	-----	-----	-----	-----	ND	39	ND	-----	ND	24	15	12	19	22	7.5	7.2	13	12	13	ND	12	6.3	ND	42	ND	39	-----	ND	ND	-----	58	130	32	12	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Trichloroethene	TCE	ND	-----	-----	ND	-----	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.9	-----	ND	15	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	1.0
	U-22																																																																		
1,1,2,2-Tetrachloroethane	1,1,2,2-	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	6.7	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	CF	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	5.1	ND	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	ND	1.4	ND	ND	ND	ND
Chloromethane	CM	ND	-----	-----	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	ND	-----	ND	-----	ND	ND	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	ND	ND	1.9	ND	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND
	U-23	ND																																																																	
1,1,2,2-Tetrachloroethane	1,1,2,2-	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
1,1,2-Trichloro-1,2,2-trifluoroet	CFC-11	ND	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	2.3	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Carbon disulfide	CDS	ND	ND	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	-----	-----	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND
Carbon tetrachloride	CTET	ND	ND	ND	ND	15	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	71	ND	16	10	ND	6.4	18	-----	6.5	40	-----	4.2	ND	ND	2.8	170	-----	170	-----	120	-----	-----	67	-----	97	46	230	80	-----	120	76	-----	19	27	10	26	28	-----	56	29	53	21	-----	68	25	48
Chloroform	CF	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Chloroform	CF	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.9	6.2	-----	1.3	5.2	-----	1.1	ND	ND	1.6	18	-----	9.8	-----	17	-----	-----	6.9	-----	10	7.2	40	6.8	-----	14	15	-----	3.2	6.0	1.9	3.2	6.3	-----	7.8	4.5	4.8	4.6	-----	8.8	4.6	5.3
Chloromethane	CM	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Methylene Chloride	MC	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Tetrachloroethene	PCE	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	1.0	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
	U-24																																																																		
1,1,2,2-Tetrachloroethane	1,1,2,2-	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Benzoic Acid	BENA	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	63	ND	-----	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND
Carbon disulfide	CDS	ND	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND
Carbon tetrachloride	CTET	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.3	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	2.4	2.8	ND	ND	ND	ND	ND	2.6	2.6	-----	5.7	ND	-----	2.1	1.4	5.6	1.1	1.2	-----	1.8	6.2	ND	5.5	-----	ND	1.6	ND
Chloroform	CF	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	5.0	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	2.0	ND	-----	1.0	1.1	2.3	ND	ND	-----	1.5	2.3	1.3	2.9	-----	2.0	2.3	1.4
Chloromethane	CM	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Methylene Chloride	MC	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	1.2	ND
Napthalene	NAPT	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	21	ND	-----	ND	ND	ND	-----	ND	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND	-----	-----	ND	-----	ND
	U-25																																																																		
Carbon tetrachloride	CTET	-----	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	1.9	1.9	-----	2.4	ND	-----	1.0	ND	2.5	ND	ND	-----	ND	2.9	ND	3.7	-----	ND	5.2	ND
Chloroform	CF	-----	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	1.1	-----	ND	1.1	ND
Chloromethane	CM	-----	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
Methylene Chloride	MC	-----	ND	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	-----	ND	-----	-----	ND	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	ND	-----	ND	ND	ND	ND	-----	ND	ND	ND
	L-43																																																																		
Benzene	B	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	ND	ND	ND	ND	-----	ND	ND	-----	ND	ND	ND	ND	1.1	ND	ND	ND	ND	ND	-----	ND	ND	ND

Compound Abbreviations:

(2,4-Dichorophenoxy) acetic acic	2,4-D	4,4'- DDT	DDT	Chloromethane	CM
1,1,1-Trichloroethane	1,1,1-TCA	Acetone	ACE	Dibromodichloromethane	DBA
1,1,2,2-Tetrachloroethane	1,1,2,2-PCA	Aldrin	ALD	Endosulfan sulfate	ENDO
1,1,2-Trichloro-1,2,2-trifluoroetha	CFC-113	Benzene	B	Methyl bromide	MB
1,1-Dichloroethane	1,1-DCA	Benzoic Acid	BENA	Methylene Chloride	MC
1,1-Dichloroethene	1,1-DCE	Bromodichloromethane	BDA	Napthalene	NAPT
1,2-Dichloroethane	1,2-DCA	Carbon disulfide	CDS	Tetrachloroethene	PCE
2,4-Dimethylphenol	2,4 DMP	Carbon tetrachloride	CTET	Toluene	T
2-Butanone	MEK	Chloroethane	CA	Trichloroethene	TCE
2-Methylnapthalene	2-MN	Chloroform	CF		

Notes:

All results in µg/L.

Only wells and sample dates with at least one compound detected are listed.

All detections are reported regardless of whether results were confirmed in subsequent samples or associated blank samples also had same constituents present.

(2,4-Dichorophenoxy) acetic acid	2,4-D	1,2-Dichloroethane	1,2-DCA	Aldrin	ALD	Chloroethane	CA	Methylene Chloride	MC
1,1,1-Trichloroethane	1,1,1-TCA	2,4-Dimethylphenol	2,4 DMP	Benzene	B	Chloroform	CF	Napthalene	NAPT
1,1,2,2-Tetrachloroethane	1,1,2,2-PCA	2-Butanone	MEK	Benzoic Acid	BENA	Chloromethane	CM	Tetrachloroethene	PCE
1,1,2-Trichloro-1,2,2-trifluoroethane	CFC-113	2-Methylnapthalene	2-MN	Bromodichloromethane	BDA	Dibromodichloromethane	DBA	Toluene	T
1,1-Dichloroethane	1,1-DCA	4,4'- DDT	DDT	Carbon disulfide	CDS	Endosulfan sulfate	ENDO	Trichloroethene	TCE
1,1-Dichloroethene	1,1-DCE	Acetone	ACE	Carbon tetrachloride	CTET	Methyl bromide	MB		

Table E-19 - Volatile Organic Compounds **USEI Site B Groundwater Monitoring Program**	
Monitoring Constituent	CAS No.
Benzene	71-43-2
Bromodichloromethane	75-27-4
Bromoform (tribromomethane)	75-25-2
Bromomethane	74-83-9
Cis- 1,2, Dichloroethene	540-59-0
Carbon Tetrachloride	56-23-5
Chlorobenzene (monochlorobenzene)	108-90-7
Chloroethane (ethyl chloride)	75-00-3
Chloroform	67-66-3
Chloromethane (methyl chloride)	74-87-3
Cis-1,3-Dichloropropene	10061-01-5
Dibromochloromethane	124-48-1
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethene	75-35-4
1,2-Dichloropropane	78-87-5
Ethylbenzene	100-41-4
Methylene Chloride (Dichloromethane)	75-09-2
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethene	127-18-4
Toluene	108-88-3
Trans-1,2-Dichloroethene	156-60-5
Trans-1,3-Dichloropropene	10061-02-6
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethene	79-01-6
1,1,2 Trichlor 1,2,2 Triflouroethane (CFC 113)	76-13-1
Vinyl chloride	75-01-4

Table E-20 Groundwater Monitoring Program Well Summary

Well ID	Designated Unit	Sample Schedule
U-4	Upper Aquifer Upgradient Background, Background Compliance well for U-21	Semiannual
U-5	Regulated Units Trench 11 and Collection Pond 1	Semiannual
U-6	Regulated Units Trench 11 and Collection Pond 1	Semiannual
U-7	Regulated Units Trench 11 and Collection Pond 1	Semiannual
U-8	Regulated Unit Trench 10	Semiannual
U-9	Regulated Unit Collection Pond 3 and pre-RCRA Units PCB 1, 2, and 3, Acid Disposal Pits, CHEM Area 1, CHEM-1, CHEM-2, CHEM-2B, CHEM-2C, CHEM-2D, CHEM-2E, CHEM-3, CHEM-4, CHEM-4B, CHEM-5, CHEM-5B, CHEM-6, CHEM-6A, CHEM-6B	Semiannual
U-10	Regulated Unit Collection Pond 3 and pre-RCRA Units PCB 1, 2, and 3, Acid Disposal Pits, CHEM Area 1, CHEM-1, CHEM-2, CHEM-2B, CHEM-2C, CHEM-2D, CHEM-2E, CHEM-3, CHEM-4, CHEM-4B, CHEM-5, CHEM-5B, CHEM-6, CHEM-6A, CHEM-6B	Semiannual
U-11	Regulated Unit Evaporation Pond	Semiannual
U-12	Regulated Units Evaporation Pond	Semiannual
U-13	Regulated Unit Cell 16	Semiannual
U-14	Regulated Unit Cell 16	Semiannual
U-15	Regulated Unit Cell 16	Semiannual
U-17	Pre-RCRA Unit Trench PCB-4, pre-RCRA Unit Control Center, pre-RCRA Unit Elevator Shaft, pre-RCRA Unit Electrical Vault, pre-RCRA Unit Area 9	Semiannual
U-18	Pre-RCRA Unit Trench PCB-4, pre-RCRA Unit Buried Drum Area 2 (near Silo 3), pre-RCRA Unit Elevator Shaft, pre-RCRA Unit Area 9	Semiannual
U-19	Pre-RCRA Unit Trench PCB-4, pre-RCRA Unit Buried Drum Area 2 (near Silo 3), pre-RCRA Unit Buried Drum Area 1 (near Silo 3)	Semiannual
UP-6*	Pre-RCRA Unit Silo 3	Semiannual
U-21	Pre-RCRA Unit Silo 2	Semiannual
U-22	Pre-RCRA Unit Silo 1	Semiannual
U-23	Regulated Unit Trench 5	Semiannual
U-24	Regulated Unit Trench 5	Semiannual
U-25	Regulated Unit Trench 5, pre-RCRA Unit Chem 7 and Chem 8	Semiannual
U-48	Regulated Unit Cell 16	Semiannual
U-49	Regulated Unit Cell 16	Semiannual
U-54	Regulated Unit Cell 16	Semiannual
L-28	Regulated Unit Cell 14 - Subcell 1	Semiannual
L-29	Regulated Unit Cell 14 - Subcell 2	Semiannual

Table E-20 Groundwater Monitoring Program Well Summary

Well ID	Designated Unit	Sample Schedule
L-30	Regulated Unit Cell 14 - Subcell 3	Semiannual
L-31	Pre-RCRA Unit Radar (Antenna) Silos	Semiannual
L-32	Regulated Unit Cell 14 - Subcell 5	Semiannual
L-33	Regulated Unit Cell 14 - Subcell 6	Semiannual
L-35	Lower Aquifer Upgradient Background	Semiannual
L-36	Lower Aquifer Upgradient Background	Semiannual
L-37	Lower Aquifer Upgradient Background	Semiannual
L-38	Lower Aquifer Upgradient Background	Semiannual
L-39	Regulated Unit Cell 14 - Subcell 4	Semiannual
L-41	Regulated Unit Cell 15 - Subcell 15-1	Semiannual
L-42	Regulated Unit Cell 15 - Subcell 15-1	Semiannual
L-43	Regulated Unit Cell 15 – Subcell 15-2	Semiannual
L-44	Regulated Unit Cell 15 – Subcell 15-2	Semiannual
L-45	Regulated Unit Cell 15 – Subcell 15-3	Semiannual
L-47	Regulated Unit Cell 15 – Subcell 15-4	Semiannual
LP	LP-11, LP-12, LP-13, LP-14, LP-15, LP-27	Semiannual water levels only
UP	UP-1, UP-3, UP-4, UP-5, UP-7, UP-8, U-26, UP-26	Semiannual water levels only

* Note: UP-6 replaced U-20 due to low flow.

Table E-21 - Preliminary Solubilities for Volatile Organic Compound

USEI Site B ACL

Organic Compound	CAS	0.5% Solubility (μg/L)
Benzene	71-43-2	8,900
Bromodichloromethane	75-27-4	22,500
Bromoform (tribromomethane)	75-25-2	16,000
Bromomethane	74-83-9	65,000
Carbon Tetrachloride	56-23-5	4,000
Chlorobenzene (monochlorobenzene)	108-90-7	2,440
Chloroethane (ethyl chloride)	75-00-3	28,700
Chloroform	67-66-3	46,500
Chloromethane (methyl chloride)	74-87-3	31,800
Total 1,3-Dichloropropene	542-75-6	0
Dibromochloromethane	124-48-1	20,000
1,1-Dichloroethane	75-34-3	27,500
1,2-Dichloroethane	107-06-2	43,450
1,1-Dichloroethene	75-35-4	2,000
1,2-Dichloropropane	78-87-5	13,500
Ethylbenzene	100-41-4	760
Methylene Chloride (Dichloromethane)	75-09-2	83,500
1,1,2,2-Tetrachloroethane	79-34-5	14,500
Tetrachloroethene	127-18-4	750
Toluene	108-88-3	2,575
Trans-1,2-Dichloroethene	156-60-5	3,000
Cis-1,2-Dichloroethene	156-59-2	0
1,1,1-Trichloroethane	71-55-6	22,000
1,1,2-Trichloroethane	79-00-5	22,500
Trichloroethene	79-01-6	5,500
Vinyl chloride	75-01-4	5,500
1,1,2-Trichlor-1,2,2-trifluoroethane (Freon 113)	76-13-1	0

Table E-21 - Preliminary Solubilitiesfor Volatile Organic Compound

USEI Site B ACL

Organic Compound	CAS	0.5% Solubility (µg/L)
1,1,1,2-Tetrachloroethane	630-20-6	1,000
1,2,3-Trichloropropane	96-18-4	9,500
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	5,000
1,2-Dibromoethane	106-93-4	58,500
2-Butanone (MEK, methyl ethyl ketone)	78-93-3	1,375,000
2-Hexanone (Methyl butyl ketone)	591-78-6	175,000
4-Methyl-2-pentanone	108-10-1	95,500
Acetone	67-64-1	5,000,000
Acrolien	107-02-8	1,040,000
Acrylonitrile	107-13-1	367,500
Allyl chloride	107-05-1	18,000
Carbon disulfide	75-15-0	14,500
Dibromomethane	74-95-3	21,500
Dichlorodifluoromethane (CFC-12)	75-71-8	1,400
Ethyl methacrylate	97-63-2	100
Iodomethane (Methyl iodide)	74-88-4	70,000
Methacrylonitrile	126-98-7	125,000
Methyl methacrylate	80-62-6	80,000
Propionitrile (Propanenitrile)	107-12-0	515,000
Styrene	100-42-5	1,500
Total-1,4-Dichloro-2-butene	764-41-0	0
Trichlorofluoromethane (CFC-11)	75-69-4	5,500
Vinyl acetate	108-05-4	100,000
Xylenes (total)	1330-20-7	9,950

Table E-22 - Compounds with Groundwater Protection Standards Established by 40 CFR 264.94 (Table 1)

Constituent	Maximum Concentration (mg/L)
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin (1,2,3,4,10,10-hexachlor-1,7-epoxy-1,4,4a,5,6,7,8, 9a-octahydro-1, 4-endo, endo-5,8-dimethano napthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenylethane)	0.10
Toxaphene ($C_{10}H_{10}Cl_6$) Technical chlorinated camphene, 67-69 percent chlorine)	0.005
2,4-D (2,4-Dichlorophenoxyacetic acid)	0.10
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.01

TABLE E-23

Procedures for Evaluating the Cumulative Hazard Quotient and Cancer Risk for Compliance Monitoring Wells

Non-Carcinogenic Hazard Quotient Cumulative Determination:

For each noncarcinogenic constituent detected in the same well at or above the EQL, calculate the Hazard Index as shown below and sum as follows:

$$\text{Hazard Index}=[(C_1/RSL_1) + (C_2/RSL_2) + (C_3/RSL_3) \ldots] \times 1$$

Where:

C = Chemical Concentration in the groundwater (µg/L) of the specific constituent
RSL = Tap Water Regional Screening Level at HQ =1 (see Table E-24)

The Hazardous Index must be less than one (1).

Calculating the Cumulative Carcinogenic Risk for Each Well:

$$\text{Cumulative Carcinogenic Risk} =[(C_1/RSL_1) + (C_2/RSL_2) + (C_3/RSL_3) \ldots] \times 10^{-5}$$

Where:

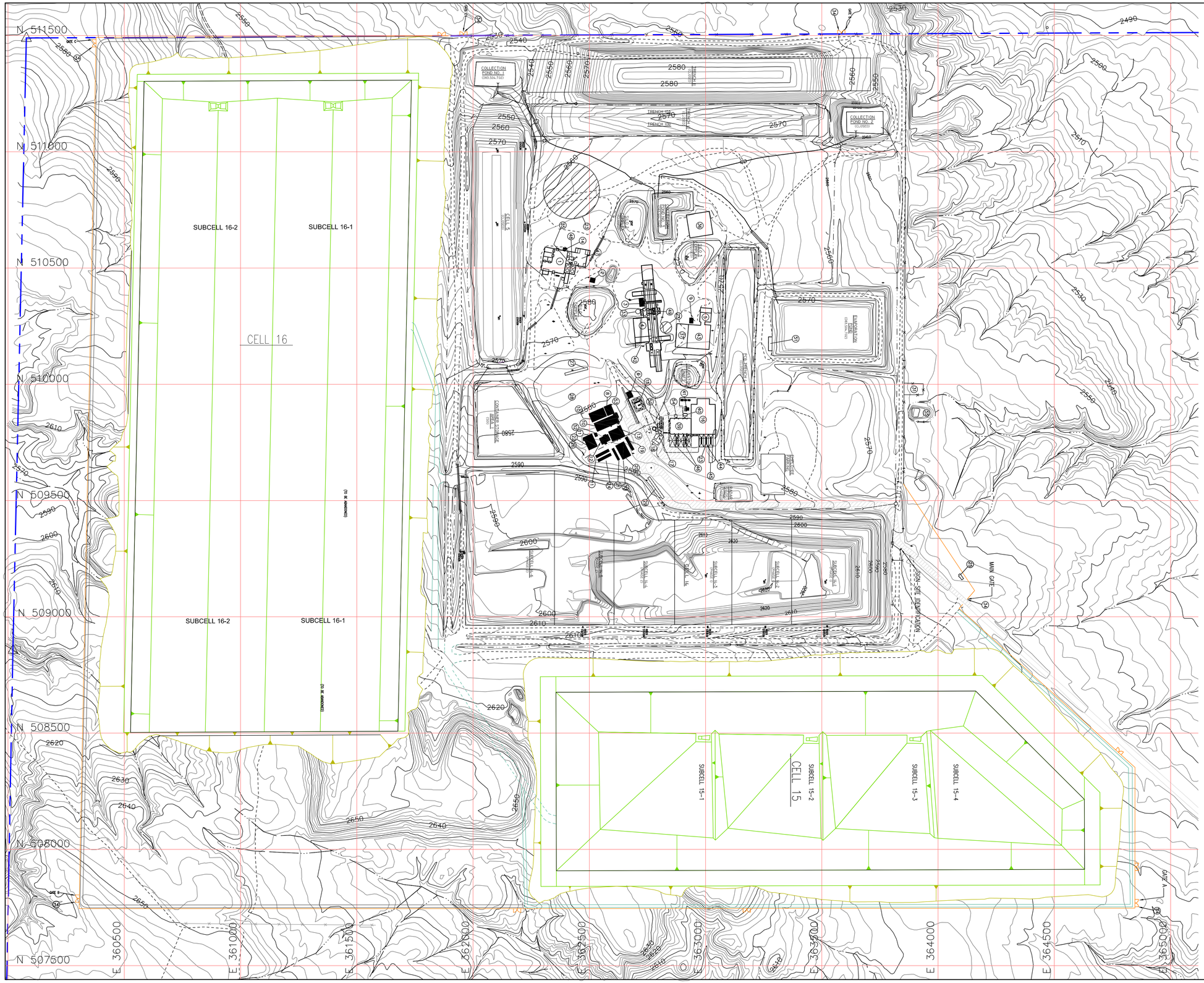
C = Chemical Concentration in the groundwater (µg/L) of the specific constituent
RSL = Tap Water Regional Screening Level at CR at $1x10^{-5}$ for the constituent (see Table E-24)

Calculating the Total Cancer Risk:
For each carcinogenic constituent detected at or above the EQL in the same well, calculate the Cancer Risk as shown above and sum as follows:

The Total Cancer Risk must be less than $1x10^{-5}$, as calculated by this methodology, using the stated, standard factors for each constituent detected as or above the EQL.

TABLE E-24. ALTERNATE CONCENTRATION LIMITS AND GROUND WATER PROTECTION STANDARDS, LEVEL 1 AND LEVEL 2 COMPLIANCE MONITORING WELLS

Compliance Monitoring Constituent	Level 1 Compliance Wells	Level 2 Compliance Wells Tapwater Regional Screening Levels			Applicable Criteria for Level 2 Compliance Wells
	Concentration @ 0.5% Solubility ug/L	Concentration @ HQ=1 ug/L	Concentration @ 1 x 10-5 Cancer Risk ug/L	MCL ug/L	
Benzene	8.90E+03			5E+00	MCL
Bromodichloromethane	2.25E+04			8E+01	MCL
Bromoform (Tribromomethane)	1.60E+04			8E+01	MCL
Bromomethane	6.50E+04	7.5E+00		N-A	HQ
Carbon Tetrachloride	4.00E+03			5E+00	MCL
Chlorobenzene	2.44E+03			1E+02	MCL
Chlorodibromomethane	2.00E+04			8E+01	MCL
Chloroethane (Ethyl chloride)	2.87E+04	2.1E+04		N-A	HQ
Chloroform	4.65E+04			8E+01	MCL
Chloromethane	3.18E+04	1.9E+02		N-A	HQ
1,1-Dichloroethane	2.75E+04		2.8E+01	N-A	CR
1,2-Dichloroethane (EDC)	4.35E+04			5E+00	MCL
1,1-Dichloroethene	2.00E+03			7E+00	MCL
Cis-1,2-Dichloroethene	3.00E+03			7E+01	MCL
Trans-1,2-Dichloroethene	3.00E+03			1E+02	MCL
1,2-Dichloropropane	1.35E+04			5E+00	MCL
Cis-1,3-Dichloropropene	1.40E+04		4.7E+00	N-A	CR
Trans-1,3-Dichloropropene	1.40E+04		4.7E+00	N-A	CR
Ethylbenzene	7.60E+02			7E+02	MCL
Methylene Chloride (Dichloromethane)	8.35E+04			5E+00	MCL
1,1,2,2-Tetrachloroethane	1.45E+04		7.6E-01	N-A	CR
Tetrachloroethene (PCE)	7.50E+02			5E+00	MCL
Toluene	2.55E+03			1E+003	MCL
1,1,1-Trichloroethane	2.20E+04			2E+02	MCL
1,1,2-Trichloroethane	2.25E+04			5E+00	MCL
Trichloroethene (TCE)	5.50E+03			5E+00	MCL
1,1,2-Trichlor-1,2,2-trifluoroethane (CFC-113)	8.5E+02	1.0E+04		N-A	HQ
Vinyl Chloride	5.50E+03			2E+00	MCL



LEGEND

- 5/8" IRON PIN W/ ALUMINUM CAP
- POWER POLE
- FENCE LINE
- PROPERTY BOUNDARY
- UNIMPROVED ROAD
- PAVED ROAD
- EXISTING TOPOGRAPHY (2500)
- RCRA UNIT BOUNDARY
- CULVERT
- DRAINAGE
- CARRIER PIPE
- POND WATER TRANSFER PIPE
- (34) FACILITY KEY NUMBER
- LEACHATE PIPE W/SLEEVE

FACILITY KEY AND PROCESS CODES

1 CONTAINER STORAGE PAD 4 (S01,T04)
2 COMPRESSOR/MCC BUILDING
3 STABILIZATION FACILITY OFFICE
4 STABILIZATION FACILITY (S01,T04)
5 PCB PROCESSING BUILDING
6 VEHICLE WASH FACILITY
7 "UNASSIGNED"
8 FIELD TECH/PPE BUILDING
9 STORAGE BUILDING
10 MAINTENANCE SHOP
11 DECONTAMINATION BUILDING
12 LAB OFFICES
13 RECEIVING OFFICE/LAB
14 PAD 4 OFFICE
15 FUEL STORAGE TANKS/FUELING STATION
16 CONTAINMENT BUILDING (S06,T01,T94)
17 PUMP HOUSE/WATER STORAGE TANKS
18 COMPRESSED GAS STORAGE AREA
19 ADMINISTRATION BUILDING
20 ADMINISTRATION/LUNCH ROOM
21 ADMINISTRATION BUILDING
22 RECORDS STORAGE BUILDING
23 REAGENT STORAGE
24 "UNASSIGNED"
25 SECURITY BUILDING
26 PROPANE TANK
27 SAMPLING PLATFORM
28 STAGING AREA
29 TRUCK SCALE
30 FLAG POLE
31 WEATHER STATION
32 "UNASSIGNED"
33 UNDERGROUND CLEAN WATER TANK
34 EVACUATION GATES
35 RCRA STORAGE TANKS-4 UNITS (S02,T01)
36 CONTAINER STORAGE PAD 5 (S01,T04)
37 PAD 6-RCRA/PCB STORAGE BUILDING APRON
38 "UNASSIGNED"
39 STABILIZATION BUILDING (S06,T01,T94)
40 BAG HOUSE
41 HEPA FILTER HOUSE AND FAN
42 YARD TRUCK SCALE
43 CONTAINER STORAGE PAD 7 (S01,T04)
44 CONTAINMENT BUILDING TRUCK UNLOADING APRONS 1,2 AND 3 (S01)
45 CONTAINMENT BUILDING TRUCK UNLOADING RAMP
46 STABILIZATION BUILDING TRUCK UNLOADING APRONS 1 AND 2 (S01)
47 PROCESS PLANT PAD
48 LEACHATE TREATMENT SYSTEM
49 STABILIZATION FACILITY ADDITIVE SILOS
50 STABILIZATION BUILDING ADDITIVE SILOS
51 EVAPORATION POND LOADING/UNLOADING AREA
52 OFFICE TRAILER SANITARY TANK
53 LAB WASTE HOLDING TANK
54 CONTROL HOUSE
55 ET CAP TEST PAD

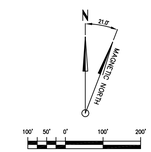


FIGURE E-3
USEI SITE B FACILITY

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654



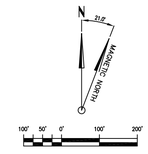
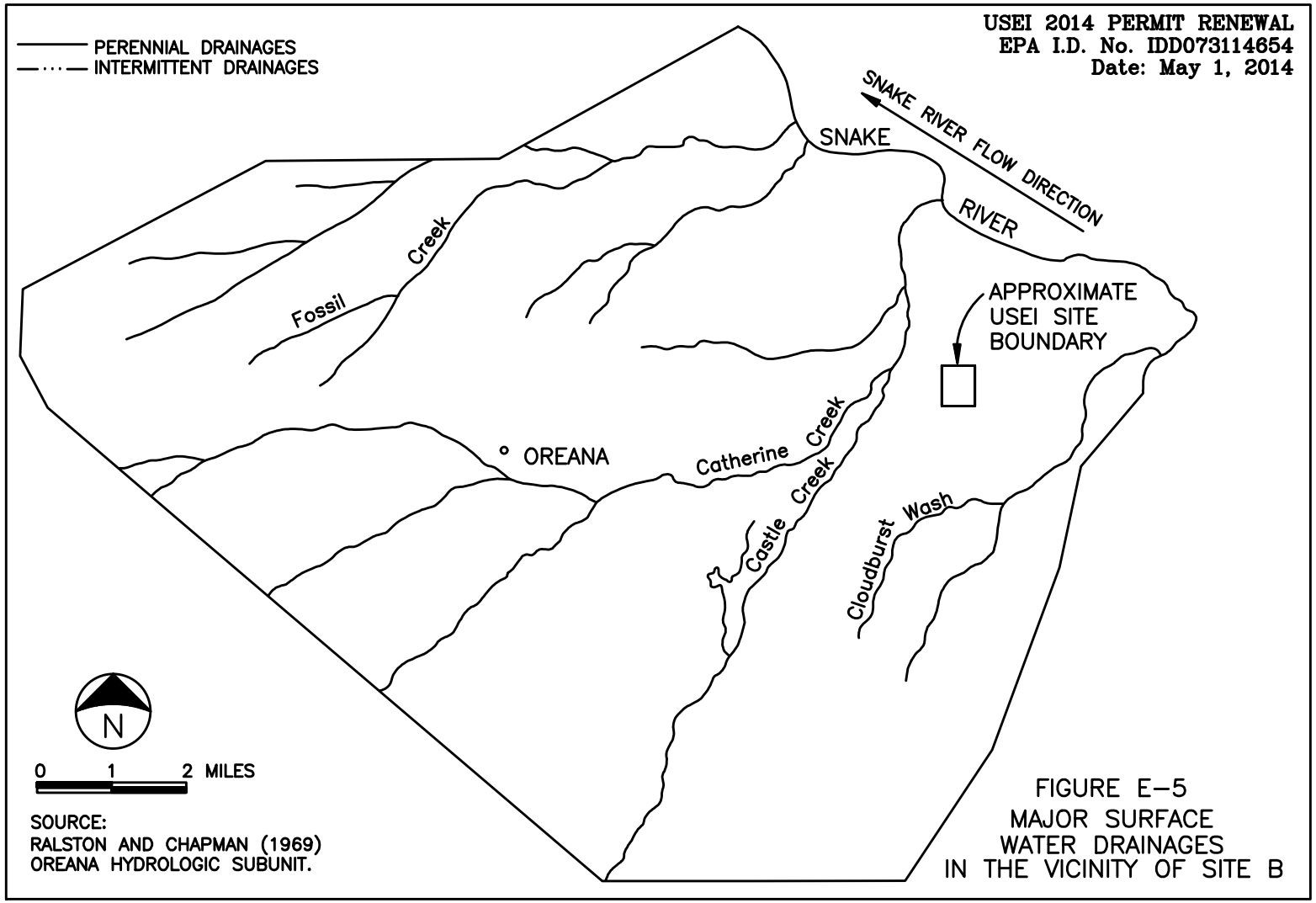


FIGURE E-4

Location of Existing Wells

US ecology

Revised: April 10, 2021


USEI 2014 PERMIT RENEWAL
EPA I.D. No. IDD073114654
Date: May 1, 2014
PERENNIAL DRAINAGES
INTERMITTENT DRAINAGES
SNAKE RIVER FLOW DIRECTION
SNAKE
RIVER
Fossil
Creek
APPROXIMATE
USEI SITE
BOUNDARY
OREANA
Catherine Creek
Castle Creek
Cloudburst Wash
N
0 1 2 MILES
SOURCE:
RALSTON AND CHAPMAN (1969)
OREANA HYDROLOGIC SUBUNIT.
FIGURE E-5
MAJOR SURFACE
WATER DRAINAGES
IN THE VICINITY OF SITE B

Index of Well Logs Within a 3-Mile Radius of Section 19, R2E, T4S (USEI Site B)[a]

Well Log Number	Township and Range	Section	Quarter - Quarter Section	Total Depth (ft)	Use	Date Drilled
1	R1E, T4S	11	SE of NE	1,115	D, S	11/4/1988
2	R1E, T4S	23	NE of NE	600	D	12/25/1969
3	R1E, T4S	24	NW of SW	200	S	10/20/1992
4	R1E, T4S	26	NW of NW	656	D	NI
5	R1E, T4S	26	NE of NW	840	S	1/30/1993
6	R1E, T4S	27	NE of NE	500	D	9/10/1997
7	R1E, T4S	34	NE of NE	2,980	I	7/8/1962
8	R1E, T4S	35	NE of SE	35	I	9/12/1966
9	R1E, T5S	3	SW of SW	130	I	9/5/1966
10	R2E, T4S	6	NE of SW	320	D	8/13/1967
11	R2E, T4S	15	SE of SW	100	D	12/22/1988
12	R2E, T4S	17	NW of NW	2,350	D	2/10/1979
13	R2E, T4S	19	NE of SE	1,608	D	6/1/1978
14	R2E, T4S	19	SW of NE	3,080	A	11/12/1958
15*	R2E, T4S	19	SW of NE	280	M	7/28/1993
16*	R2E, T4S	19	SW of NE	275	M	8/11/1993
17*	R2E, T4S	19	SW of NE	235	M	3/12/1993
18	R2E, T4S	19	SE of NW	800	A	10/26/1984
19*	R2E, T4S	19	SE of NW	280	M	2/5/1993
20*	R2E, T4S	19	SE of NW	230	M	2/9/1993
21	R2E, T4S	20	SW of NE	1,270	D	11/21/1975
22	R2E, T4S	20	NW of SW	620	D	4/18/1974
23	R2E, T4S	21	NW of NE	73	S	11/20/1996
24	R2E, T4S	22	NE of NW	220	D	10/11/1988
25	R2E, T4S	32	SW of NW	420	D	4/1/1987
26	R2E, T4S	34	NE of NE	238	D	3/28/1978
27*	R2E, T4S	19	SW of NE	207	M	12/30/1999
28	R1E, T4S	25	NE of SE	300	D	7/15/1980
29	R1E, T4S	35	NE of NE	680	D	6/5/2002
30	R1E, T4S	35	SE of NE	960	D	7/20/2002
31*	R2E, T4S	19	NW of SE	237	M	7/21/2003
32*	R2E, T4S	19	NW of SE	277	M	7/21/2003
33*	R2E, T4S	19	NW of SE	252	M	7/31/2003
34	R1E, T4S	25	SW of NW	600	D	2/2/2004
35	R1E, T4S	22	SE of SE	910	D	5/20/2004
36	R1E, T4S	35	SE of NE	710	D	6/10/2004
37	R1E, T4S	22	NE of SE	990	D	8/3/2004
38*	R2E, T4S	19	SE of NE	270	M	7/18/2005
39*	R2E, T4S	19	SE of NE	280	M	7/22/2005
40	R1E, T4S	22	SW of NE	875	D	5/11/2006
41	R1E, T4S	23	NW of NW	975	D, I	8/14/2006
42	R1E, T4S	23	NE of NW	990	D	10/28/2006
43	R2E, T4S	28	NW of NE	61	D	12/28/2006
44	R1E, T4S	23	NW of NE	940	D	4/24/2007
45*	R2E, T4S	19	NW of SE	260	M	8/24/2007
46	R2E, T4S	28	SW of NE	45	D	5/12/2008
47*	R2E, T4S	19	NE of SE	106	M	1/19/2009
48	R1E, T4S	35	SE of NE	120	D	9/13/2010
49*	R2E, T4S	19	NW of NW	224	M	11/16/2010
50	R2E, T4S	18	NE of SE	450	D	NI
51*	R2E, T4S	19	NW of NW	210	M	12/14/2010
52*	R2E, T4S	19	NW of NW	205	M	1/12/2011
53*	R2E, T4S	19	NE of NW	210	M	6/26/2012
54*	R2E, T4S	19	NE of NW	210	M	6/26/2012

[a] From Idaho Department of Water Resources

Notes:

D = Domestic	A = Abandoned
I = Irrigation	S = Stock Watering
M = Monitoring	NI = Not Indicated

LEGEND

EXISTING WELLS

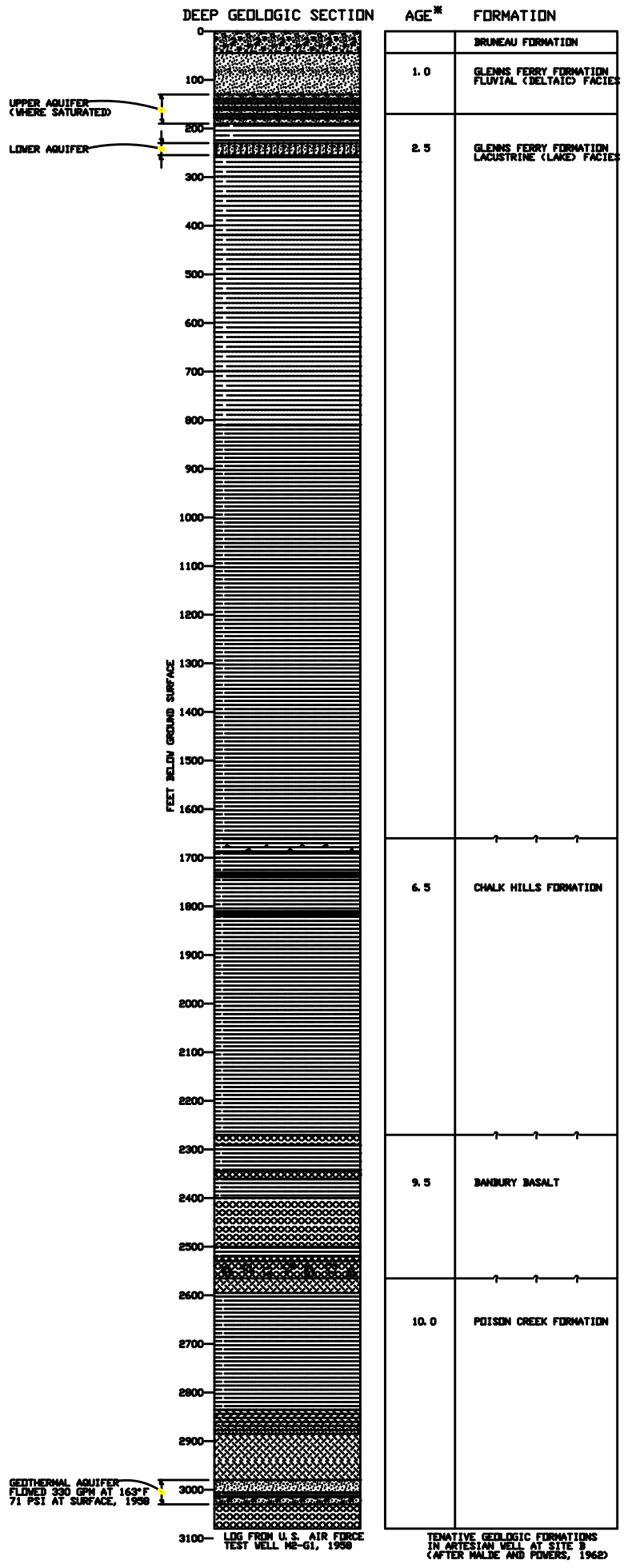
3-MILE RADIUS

N 21.0° MAGNETIC NORTH

2000' 1000' 0' 2000' 4000'

Figure E-6
Location Map of Known Water Wells

US ecology



LEGEND

- SAND AND GRAVEL
- SAND
- SILTY SAND
- SANDY SILT
- BEDDED SANDS, SILTS AND CLAYS
- CLAY
- SHALE
- CINDERS
- CINDERS AND SHALE
- BASALT
- BASALT BRECCIA
- RHYOLITE
- RHYOLITE WITH SHALE

*MILLIONS OF YEARS BEFORE PRESENT

FIGURE E-7
STRATIGRAPHIC COLUMN FROM ARTESIAN WELL

USEI RCRA PART B PERMIT
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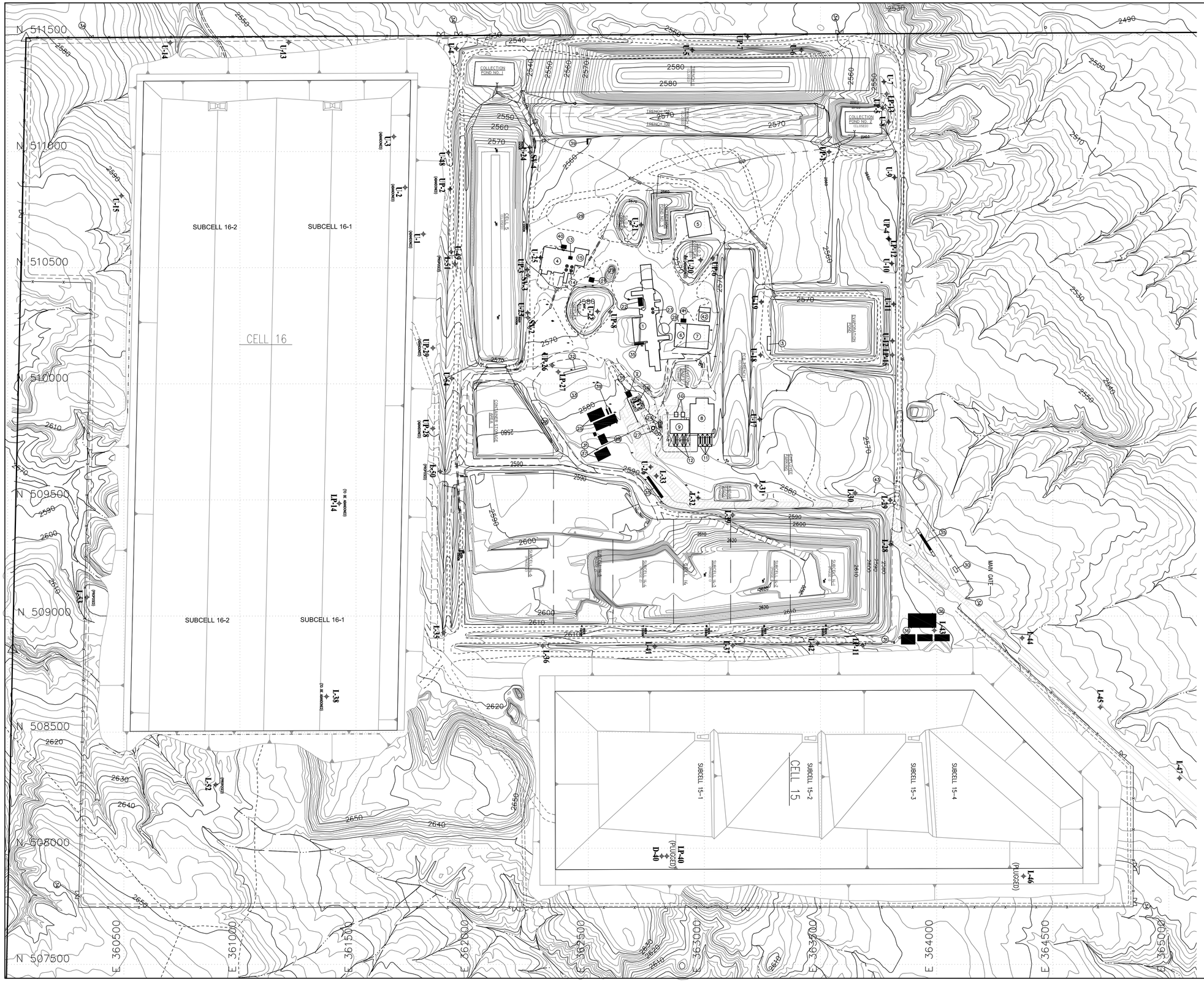


FIGURE E-8

Borehole & Well Locations

Revised: April 10, 2021

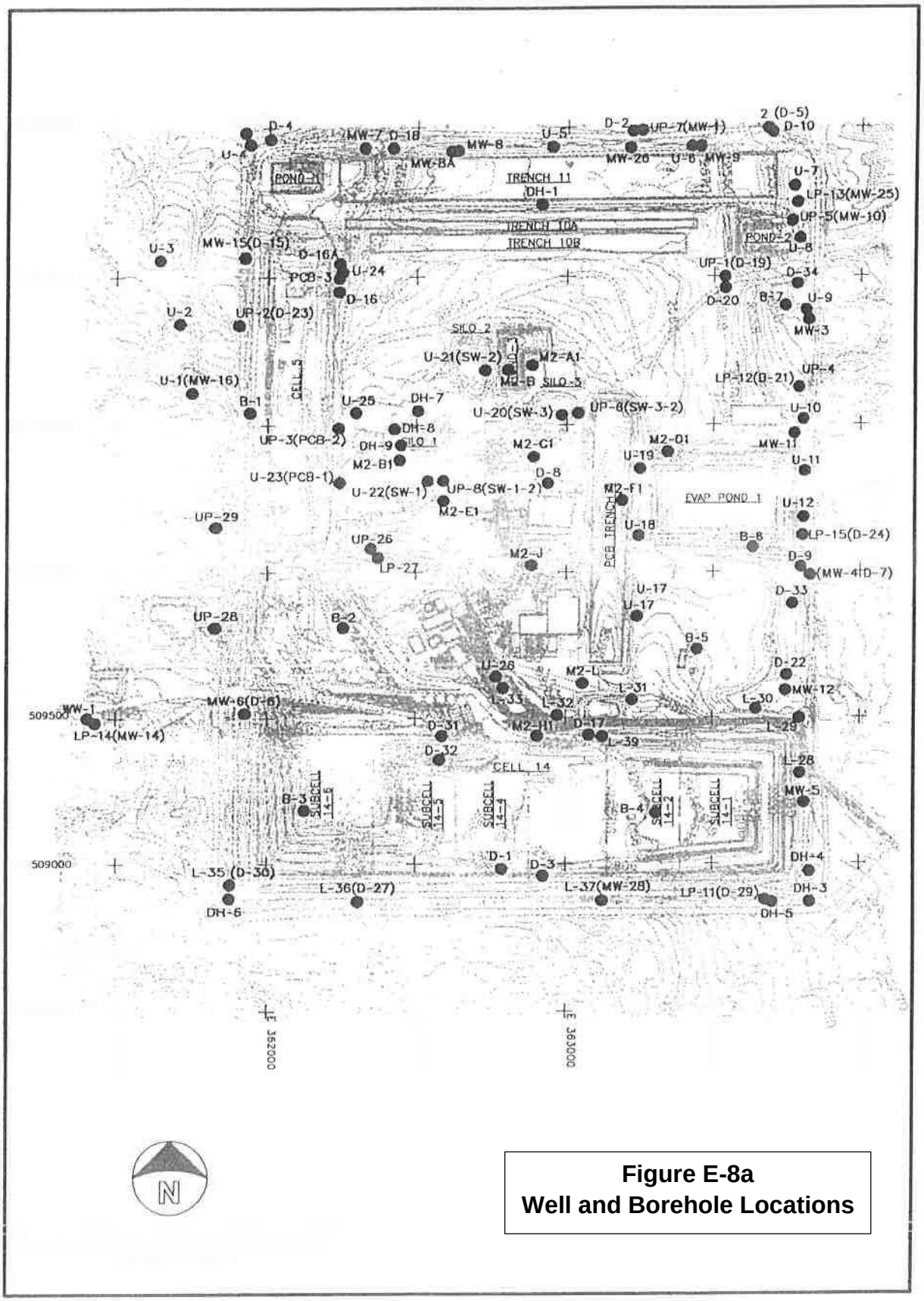


Figure E-8a
Well and Borehole Locations

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

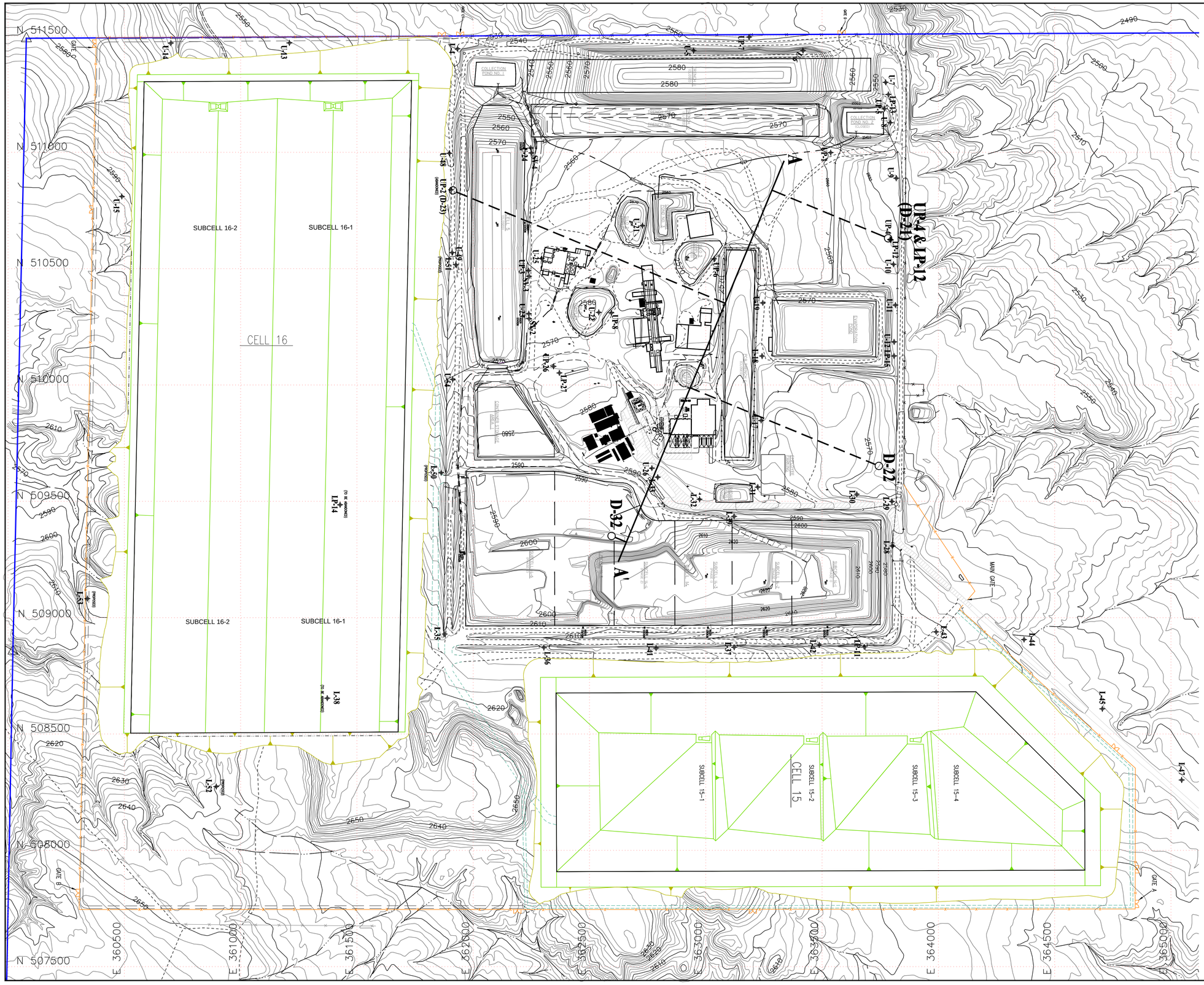
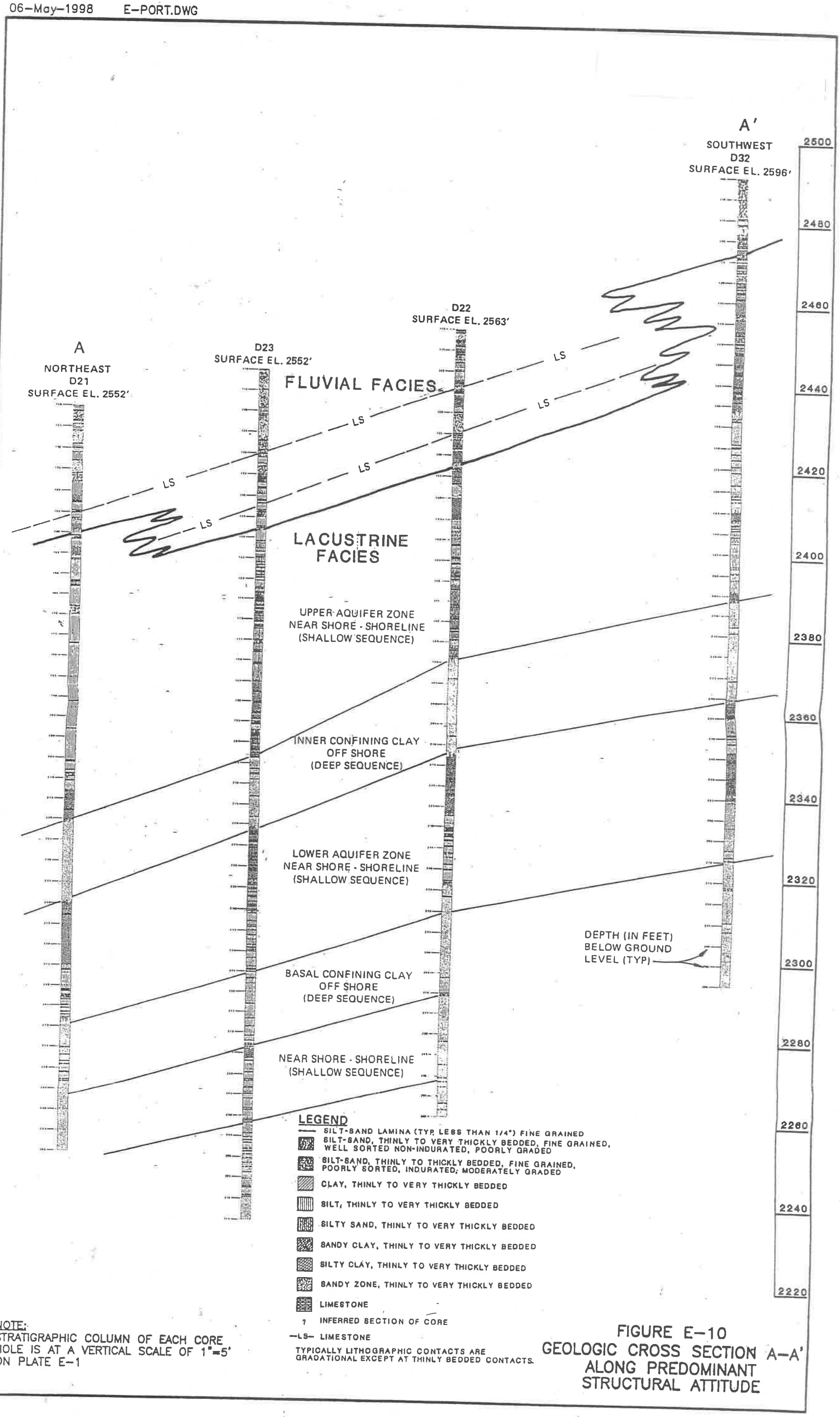


FIGURE E-9
LOCATION OF GEOLOGIC CROSS SECTION A-A'

US ecology

06-May-1998 E-PORT.DWG



LEGEND

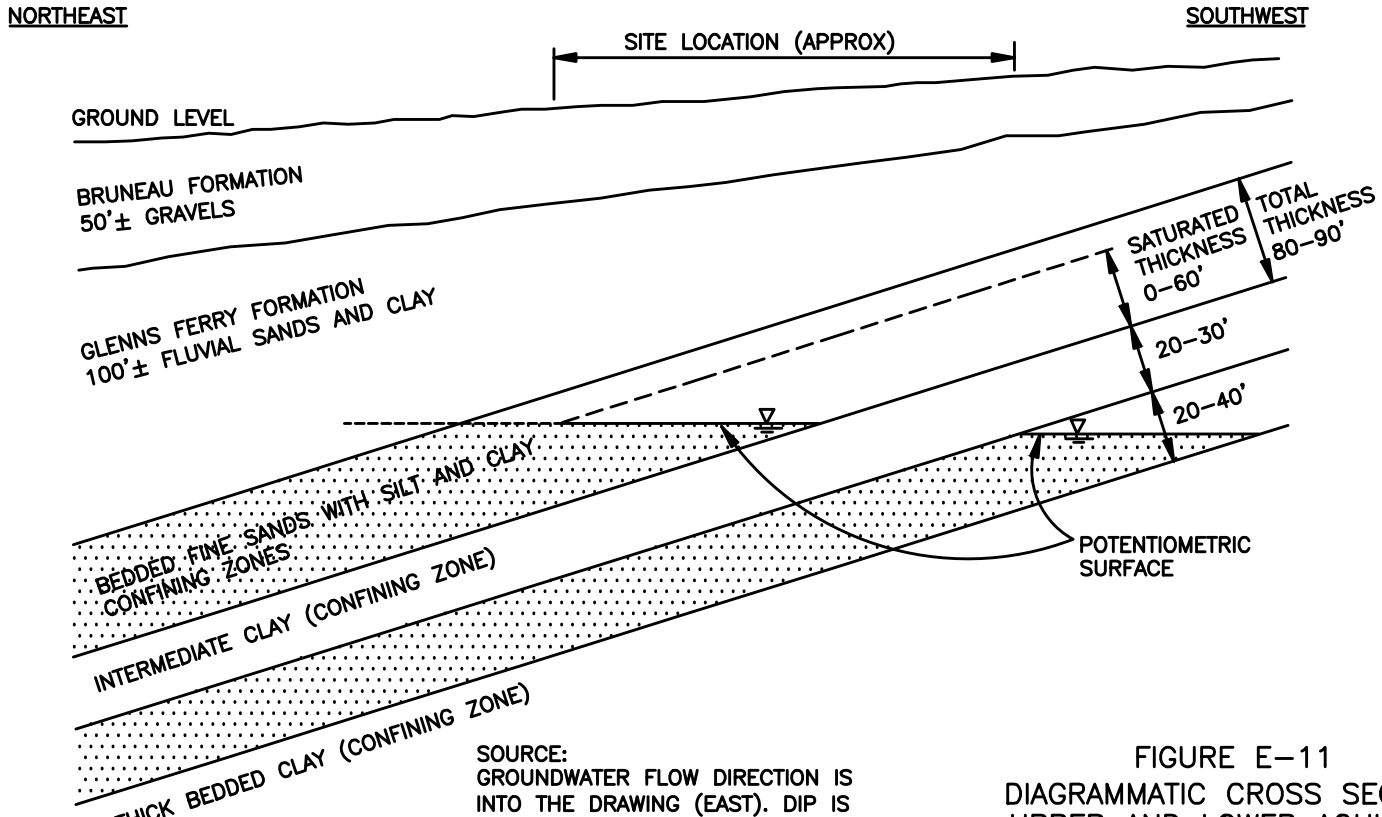
- SILT-SAND LAMINA (TYP LESS THAN 1/4") FINE GRAINED
- SILT-SAND, THINLY TO VERY THICKLY BEDDED, FINE GRAINED, WELL SORTED NON-INDURATED, POORLY GRADED
- SILT-SAND, THINLY TO THICKLY BEDDED, FINE GRAINED, POORLY SORTED, INDURATED, MODERATELY GRADED
- CLAY, THINLY TO VERY THICKLY BEDDED
- SILT, THINLY TO VERY THICKLY BEDDED
- SILTY SAND, THINLY TO VERY THICKLY BEDDED
- SANDY CLAY, THINLY TO VERY THICKLY BEDDED
- SILTY CLAY, THINLY TO VERY THICKLY BEDDED
- SANDY ZONE, THINLY TO VERY THICKLY BEDDED
- LIMESTONE
- ? INFERRED SECTION OF CORE
- —LS— LIMESTONE

TYPICALLY LITHOGRAPHIC CONTACTS ARE GRADATIONAL EXCEPT AT THINLY BEDDED CONTACTS.

NOTE:
STRATIGRAPHIC COLUMN OF EACH CORE HOLE IS AT A VERTICAL SCALE OF 1"=5' ON PLATE E-1

FIGURE E-10
GEOLOGIC CROSS SECTION A-A' ALONG PREDOMINANT STRUCTURAL ATTITUDE

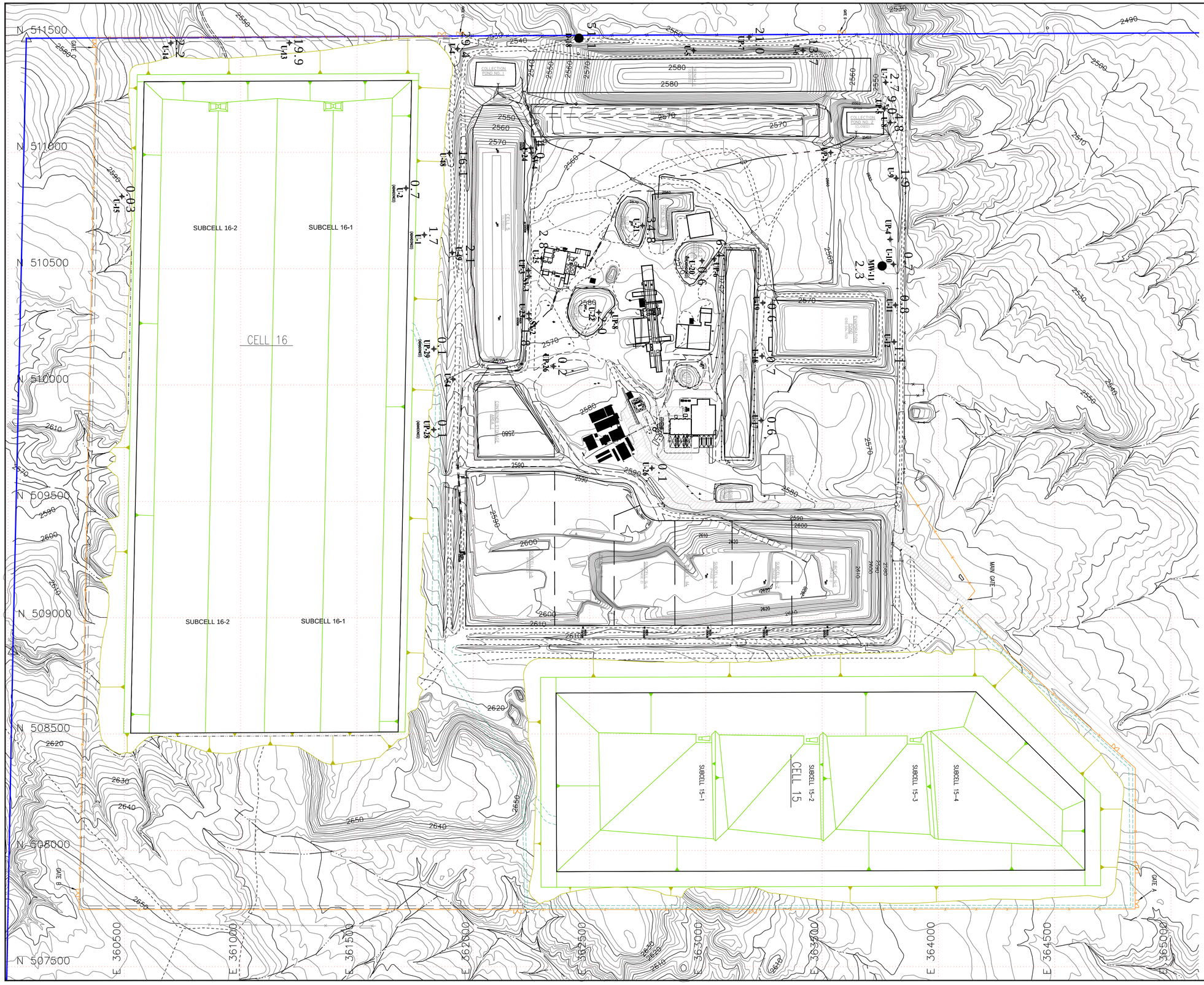
USEI 2014 PERMIT RENEWAL
EPA I.D. No. IDD073114654
Date: May 1, 2014



SOURCE:
GROUNDWATER FLOW DIRECTION IS INTO THE DRAWING (EAST). DIP IS EXAGGERATED FOR ILLUSTRATIVE PURPOSES.

FIGURE E–11
DIAGRAMMATIC CROSS SECTION
UPPER AND LOWER AQUIFERS
(NOT TO SCALE)

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017



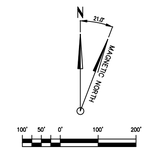


FIGURE E-12
UPPER AQUIFER AVERAGE TRANSMISSIVITIES (ft^2/DAY)

US ecology

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EPA ID. No. IDD073114654
Date: April 25, 2017

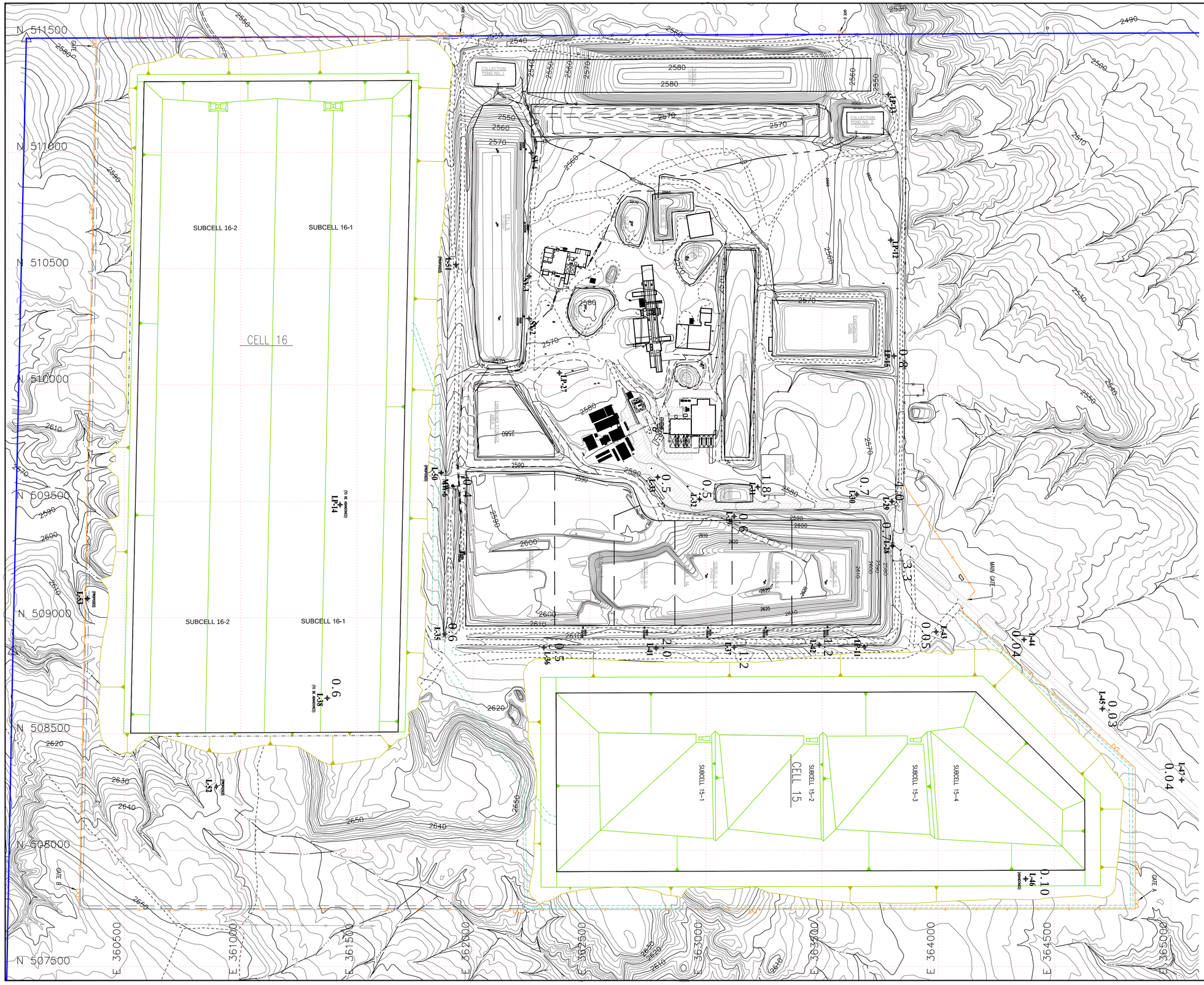


FIGURE E-13
LOWER AQUIFER AVERAGE TRANSMISSIVITIES (ft^2/DAY)

US ecology

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EPA ID. No. IDD073114654
Date: April 25, 2017

SUBCELL 16-2
SUBCELL 16-1
CELL 16
SUBCELL 15-1
SUBCELL 15-2
SUBCELL 15-3
SUBCELL 15-4
CELL 15
MAIN GATE
GATE B
GATE A

FIGURE E-14
UPPER AQUIFER WATER LEVEL CHANGE, 1989 - 2013 IN FEET

US ecology

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EPA ID. No. IDD073114654
Date: April 25, 2017

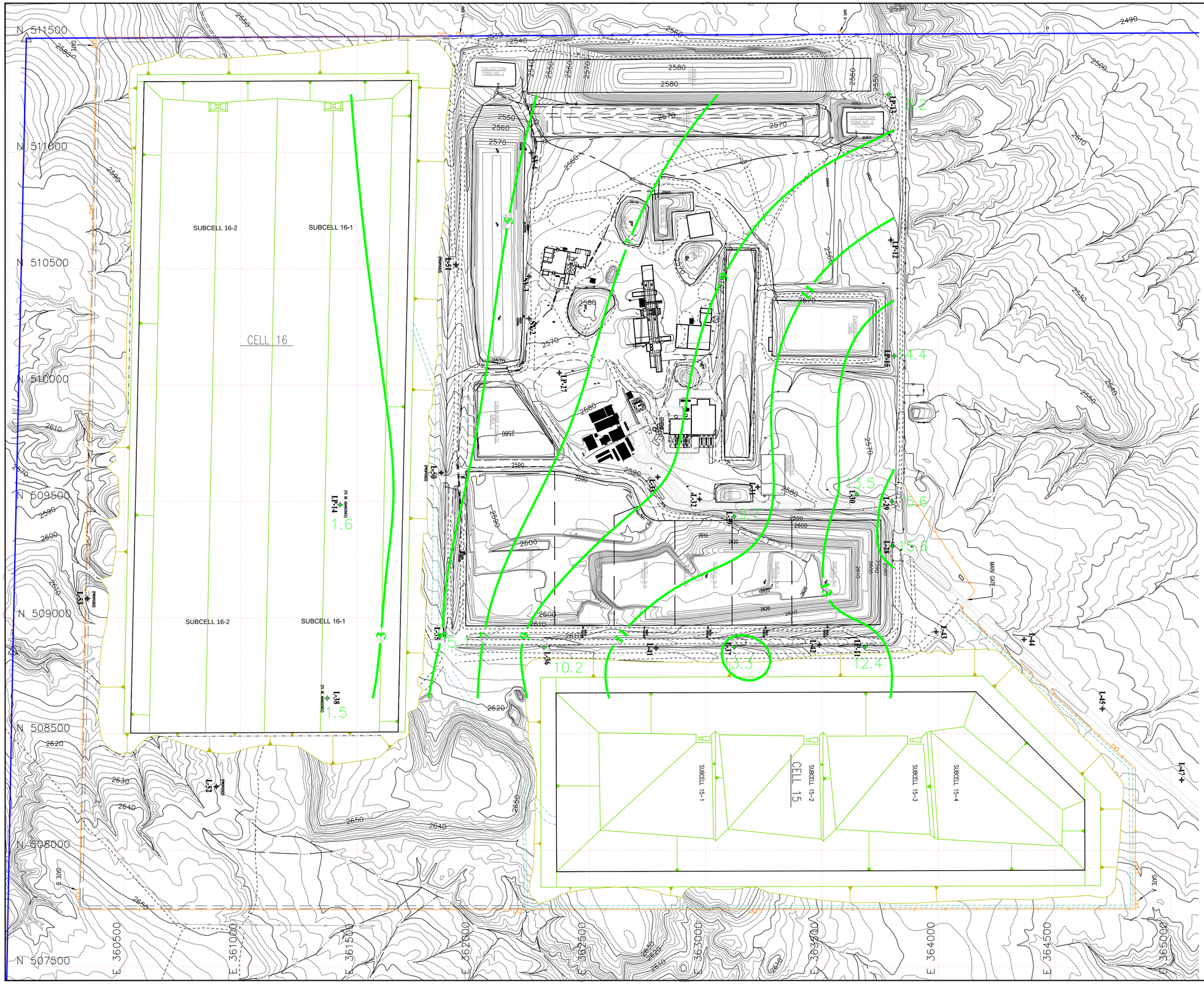
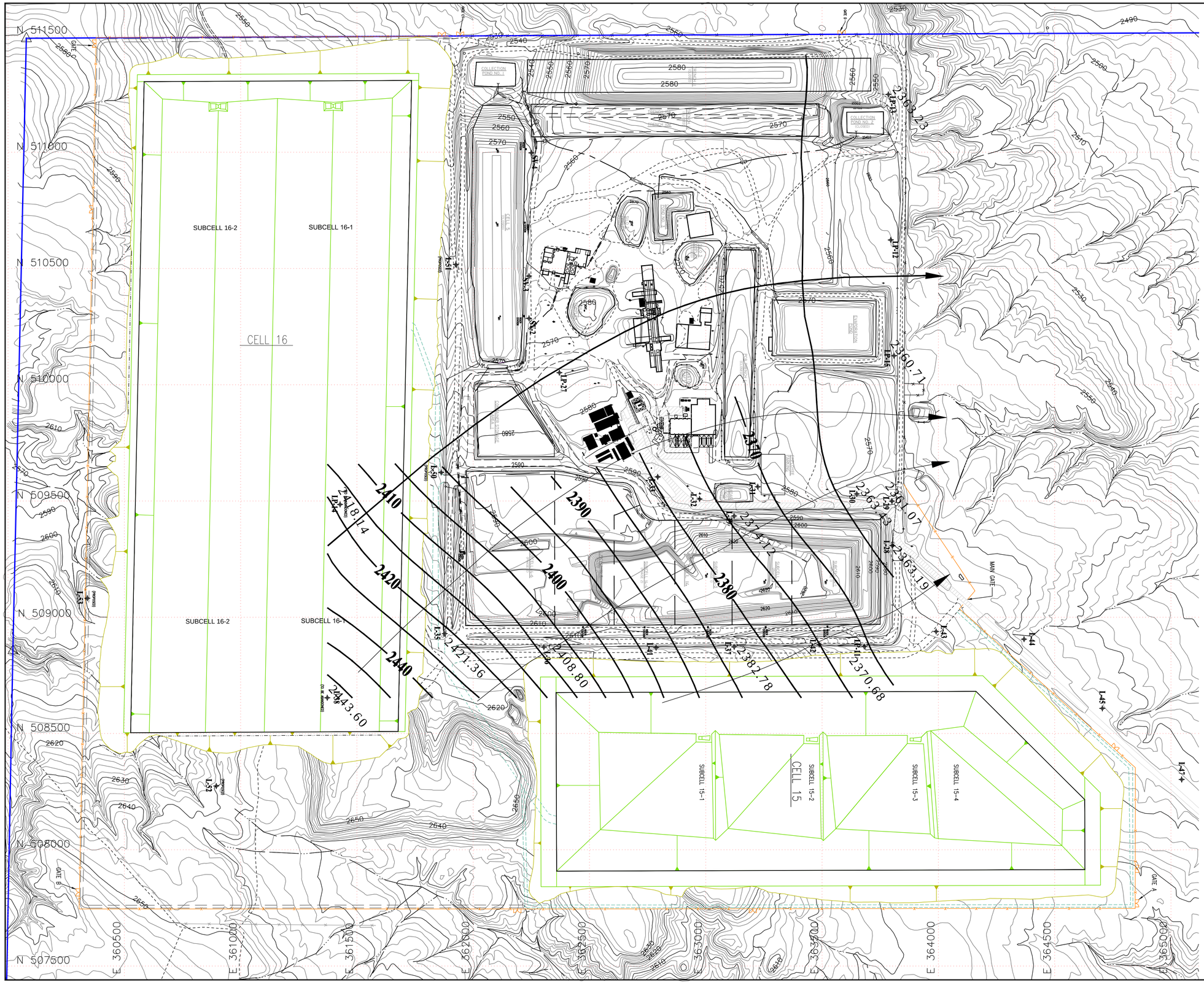


FIGURE E-15
LOWER AQUIFER WATER LEVEL CHANGE, 1989 - 2013 IN FEET

US ecology

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017



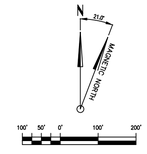


FIGURE E-16
LOWER AQUIFER POTENTIOMETRIC SURFACE (ft MSL), FALL 1989

US ecology

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

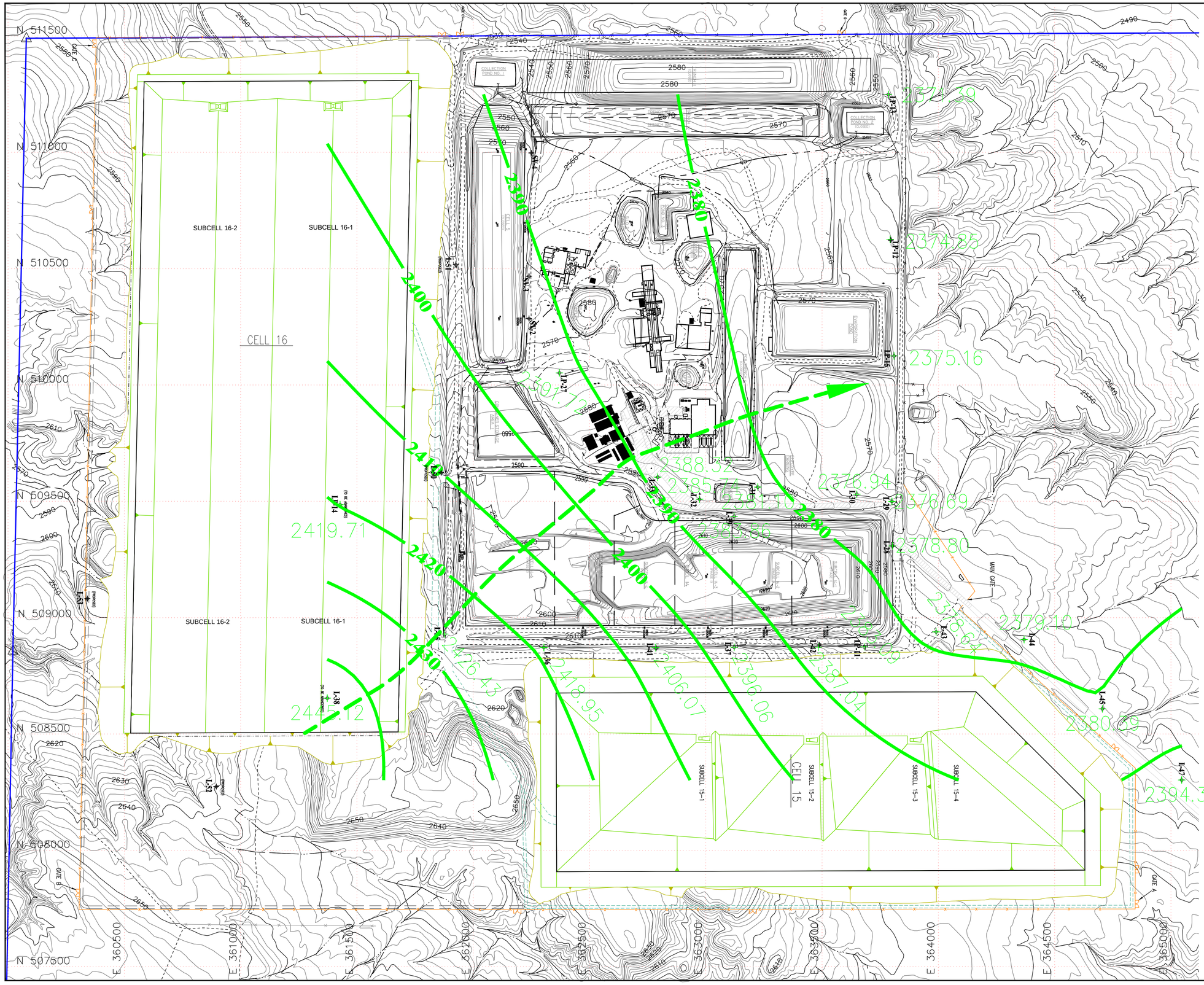
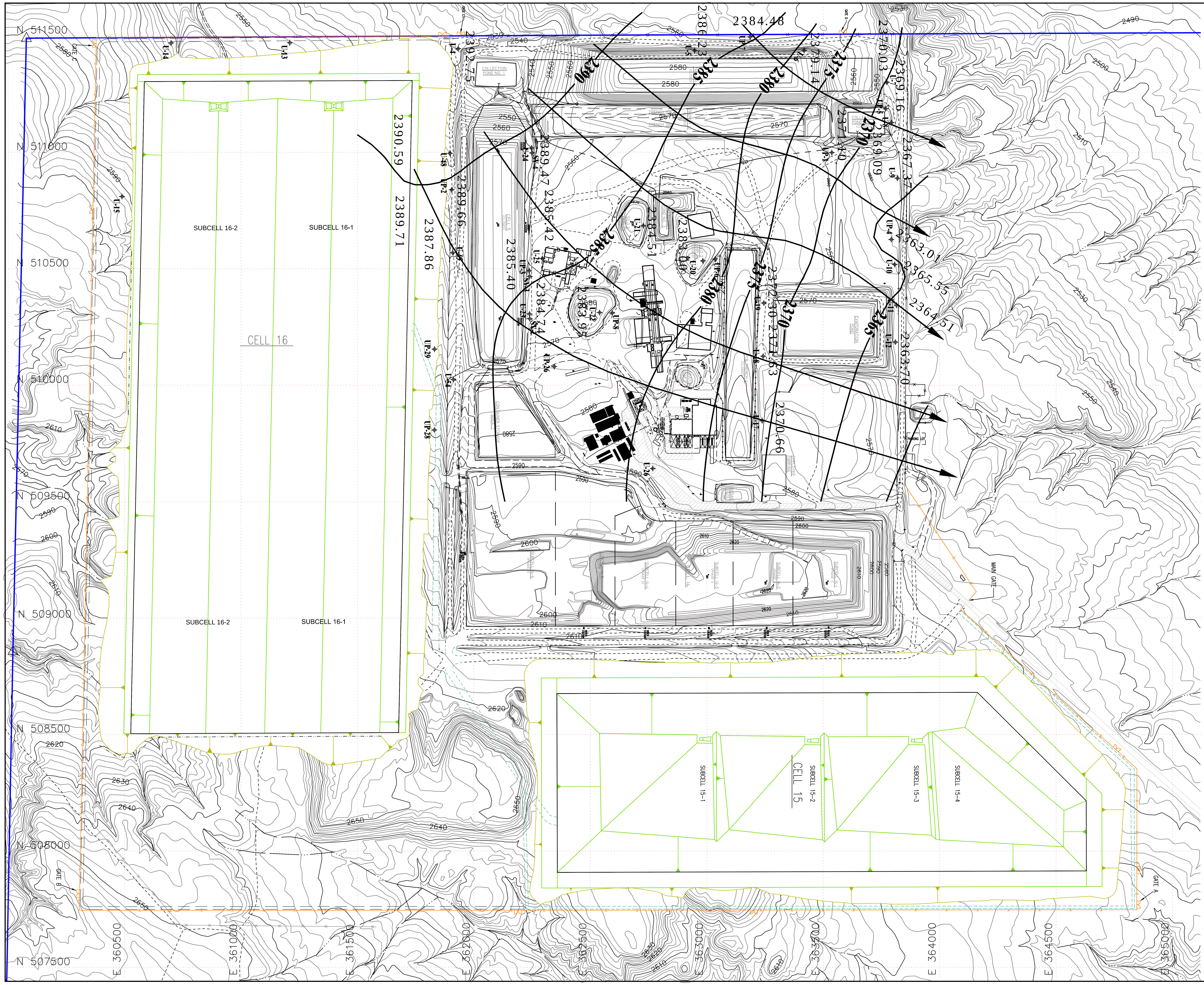


FIGURE E-17
LOWER AQUIFER POTENTIOMETRIC SURFACE(ft. MSL), FALL 2013

US ecology



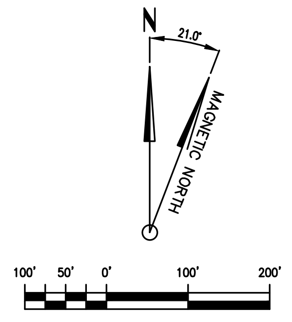


FIGURE E-18
UPPER AQUIFER WATER TABLE (ft MSL), FALL 1989

USEI RCRA Part B Permit
EPA ID. No. IDD073114654
Date: April 25, 2017

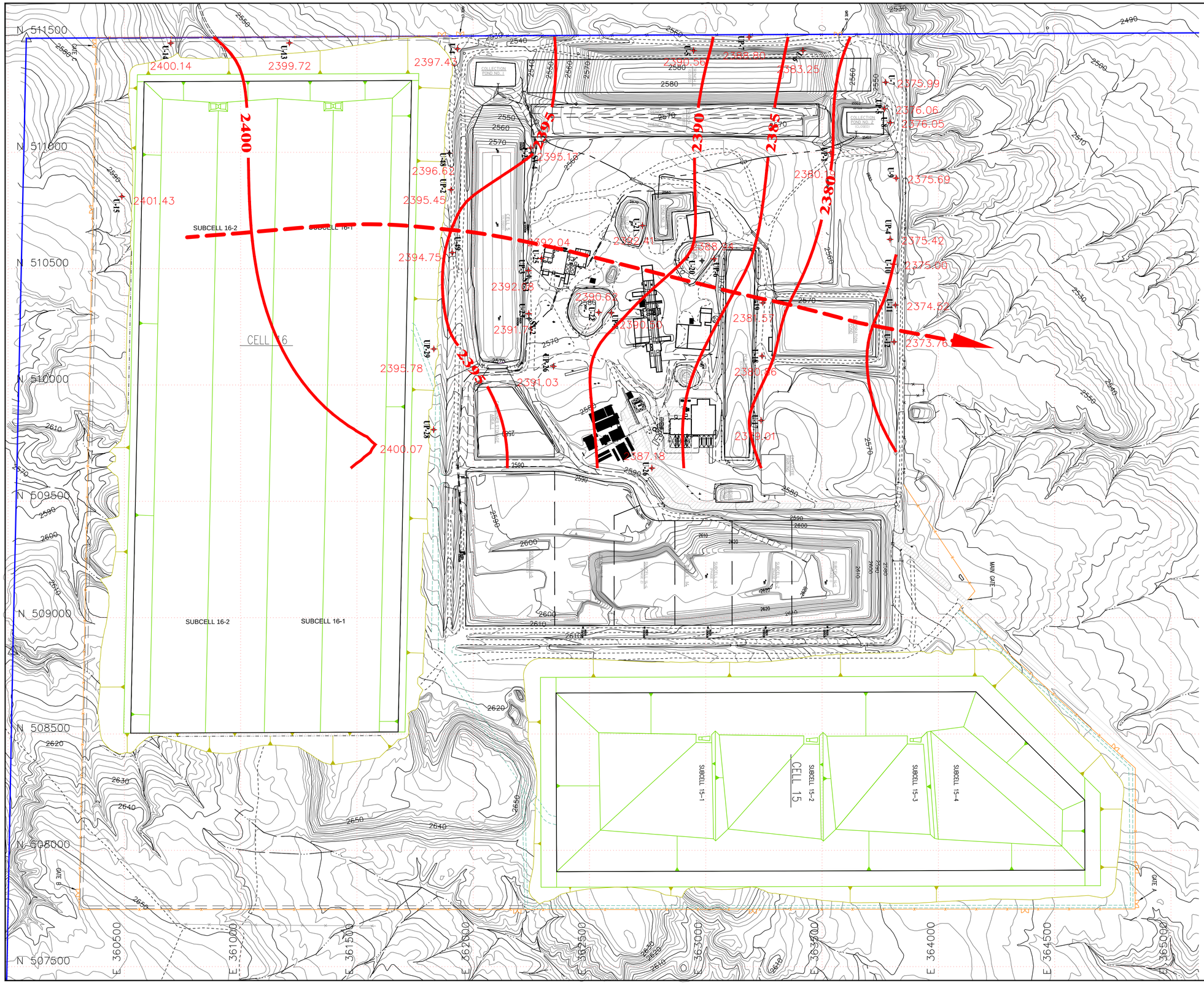


FIGURE E-19
UPPER AQUIFER WATER TABLE (ft MSL), FALL 2013

US ecology

Common Ion Water Chemistry
USEI Site B

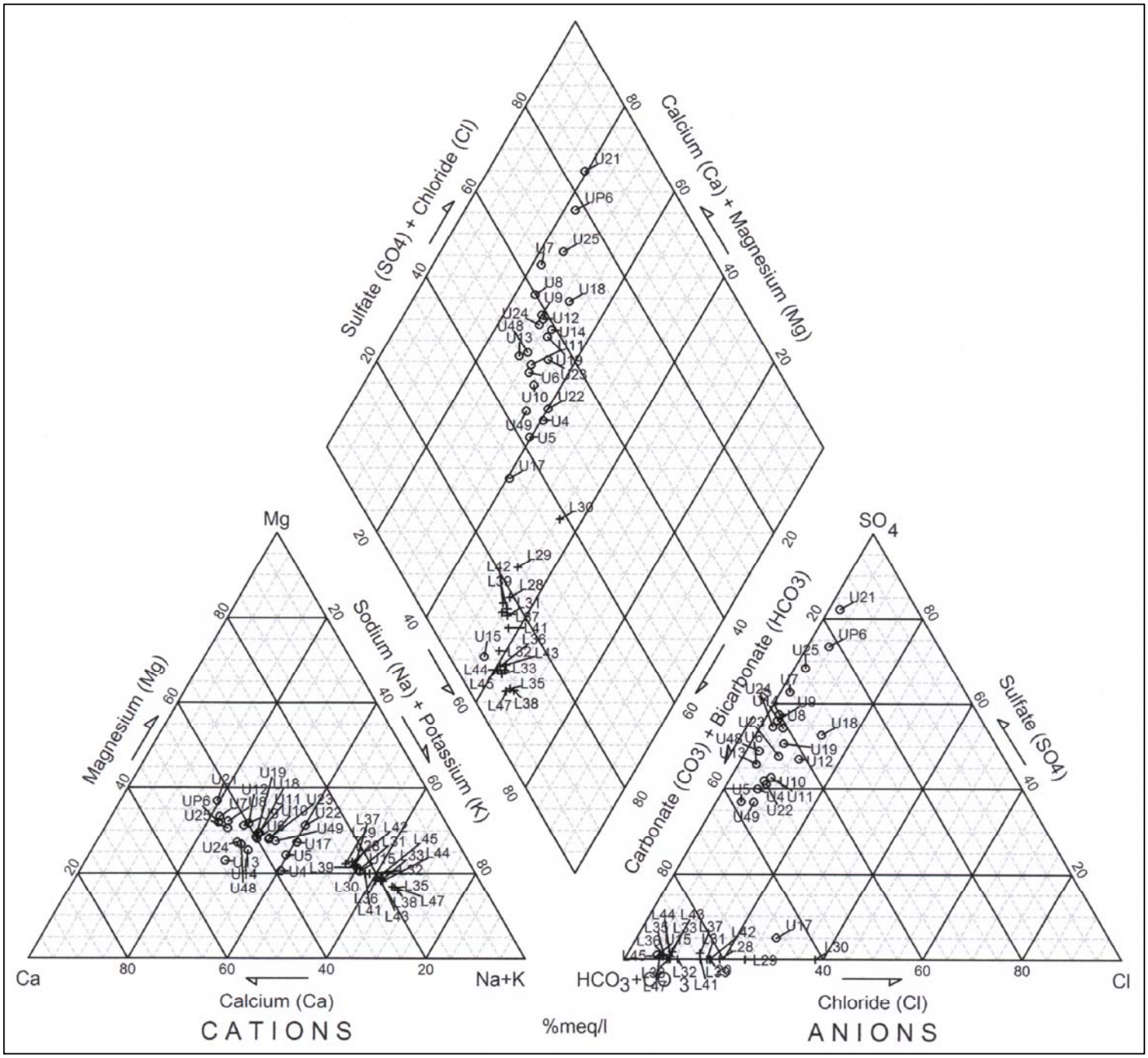


FIGURE E-20

PIPER DIAGRAM

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

SUBCELL 16-2
SUBCELL 16-1
CELL 16
SUBCELL 15-1
SUBCELL 15-2
SUBCELL 15-3
SUBCELL 15-4
CELL 15
MAIN GATE
GATE B
GATE A
COLLECTION POND NO. 1
COLLECTION POND NO. 2
EVAPORATION POND
CONTAINMENT STRUCTURE
N 511500
N 511000
N 510500
N 510000
N 509500
N 509000
N 508500
N 508000
N 507500
E 360500
E 361000
E 361500
E 362000
E 362500
E 363000
E 363500
E 364000
E 364500
E 365000

D-32
BOREHOLE INCLUDED IN CROSS-SECTION

N
21.6°
MAGNETIC NORTH
100' 50' 0' 100' 200'

FIGURE E-21
LOCATIONS OF VADOSE ZONE CROSS-SECTIONS K-K' AND L-L'

US ecology

APROXIMATE SCALE:
VERTICAL: 1"=36'
HORIZONTAL: 1"=300'

USEI 2014 PERMIT RENEWAL
EPA I.D. No. IDD073114654
Date: May 1, 2014

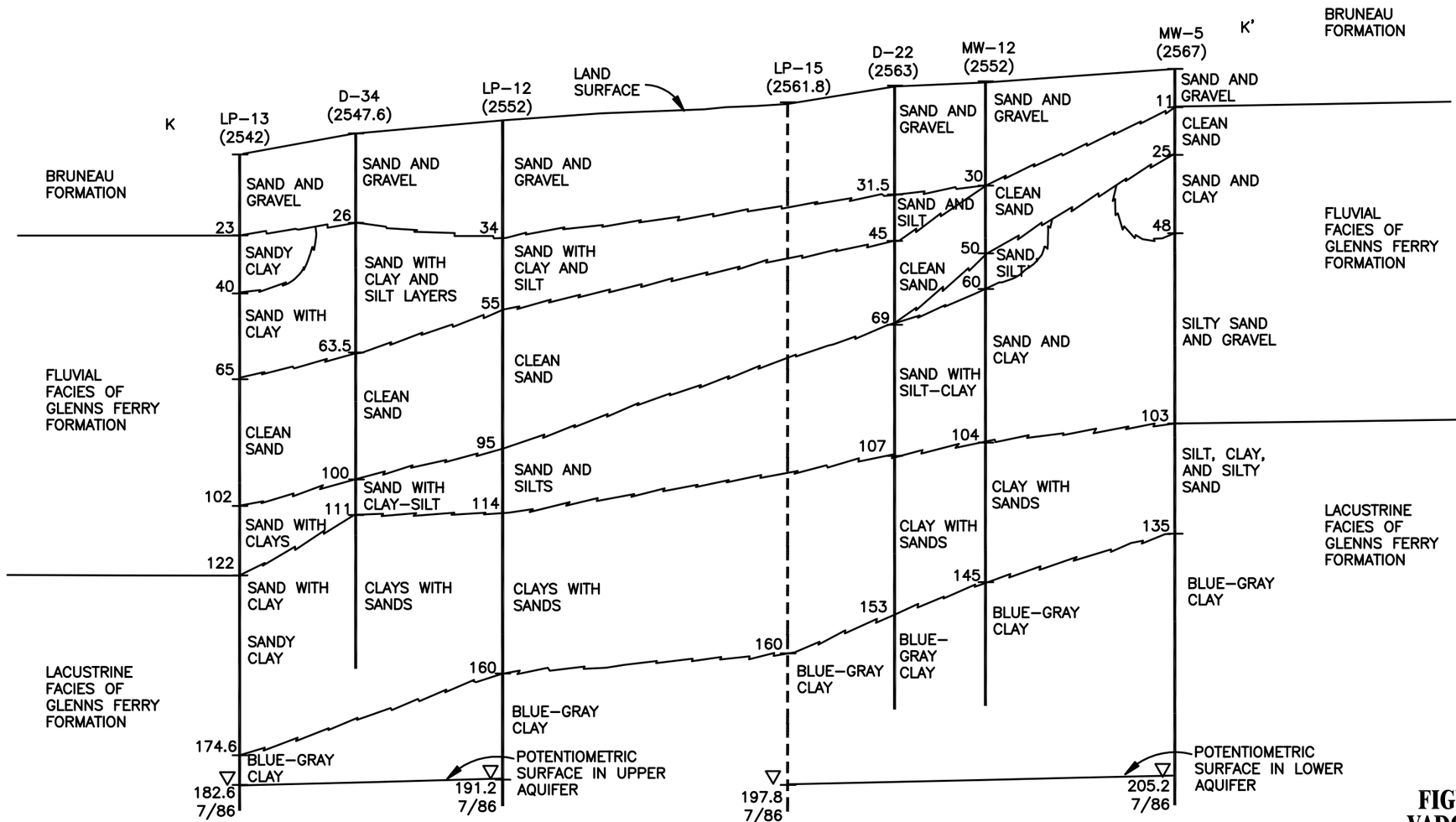


FIGURE E-22
VADOSE ZONE
CROSS SECTION K-K'

US Ecology Idaho

APROXIMATE SCALE:
VERTICAL: 1"=36'
HORIZONTAL: 1"=300'

USEI 2014 PERMIT RENEWAL
EPA I.D. No. IDD073114654
Date: May 1, 2014

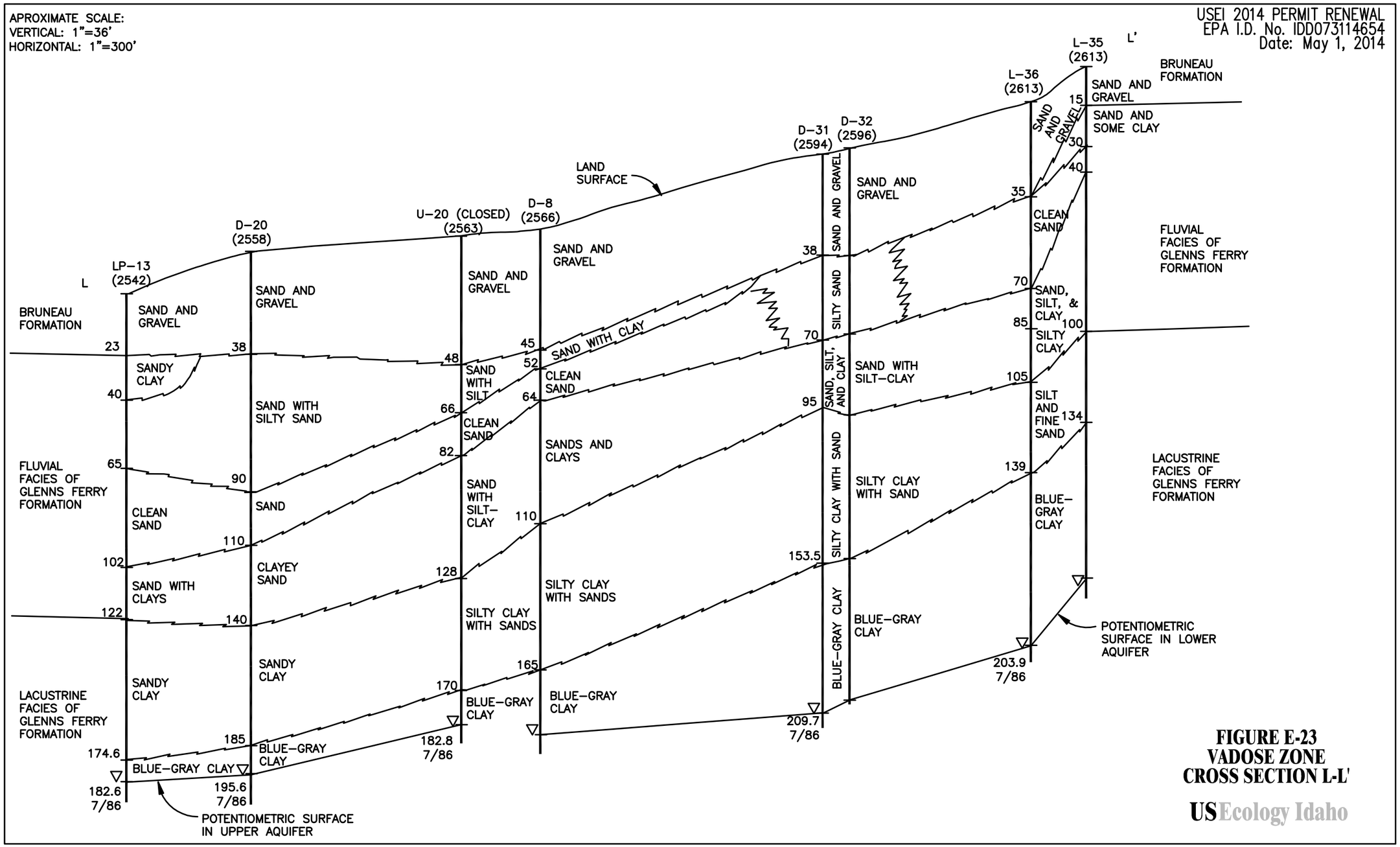


FIGURE E-23
VADOSE ZONE
CROSS SECTION L-L'

US Ecology Idaho

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

SUBCELL 16-2
SUBCELL 16-1
CELL 16
SUBCELL 15-1
SUBCELL 15-2
SUBCELL 15-3
SUBCELL 15-4
CELL 15
MAIN GATE
GATE A
GATE B
COLLECTION POND NO. 1
COLLECTION POND NO. 2
EVAPORATION POND
CONTAINMENT STRUCTURE
N 511500
N 511000
N 510500
N 510000
N 509500
N 509000
N 508500
N 508000
N 507500
E 360500
E 361000
E 361500
E 362000
E 362500
E 363000
E 363500
E 364000
E 364500
E 365000

O = BOREHOLE
INCLUDED IN CROSS-SECTION

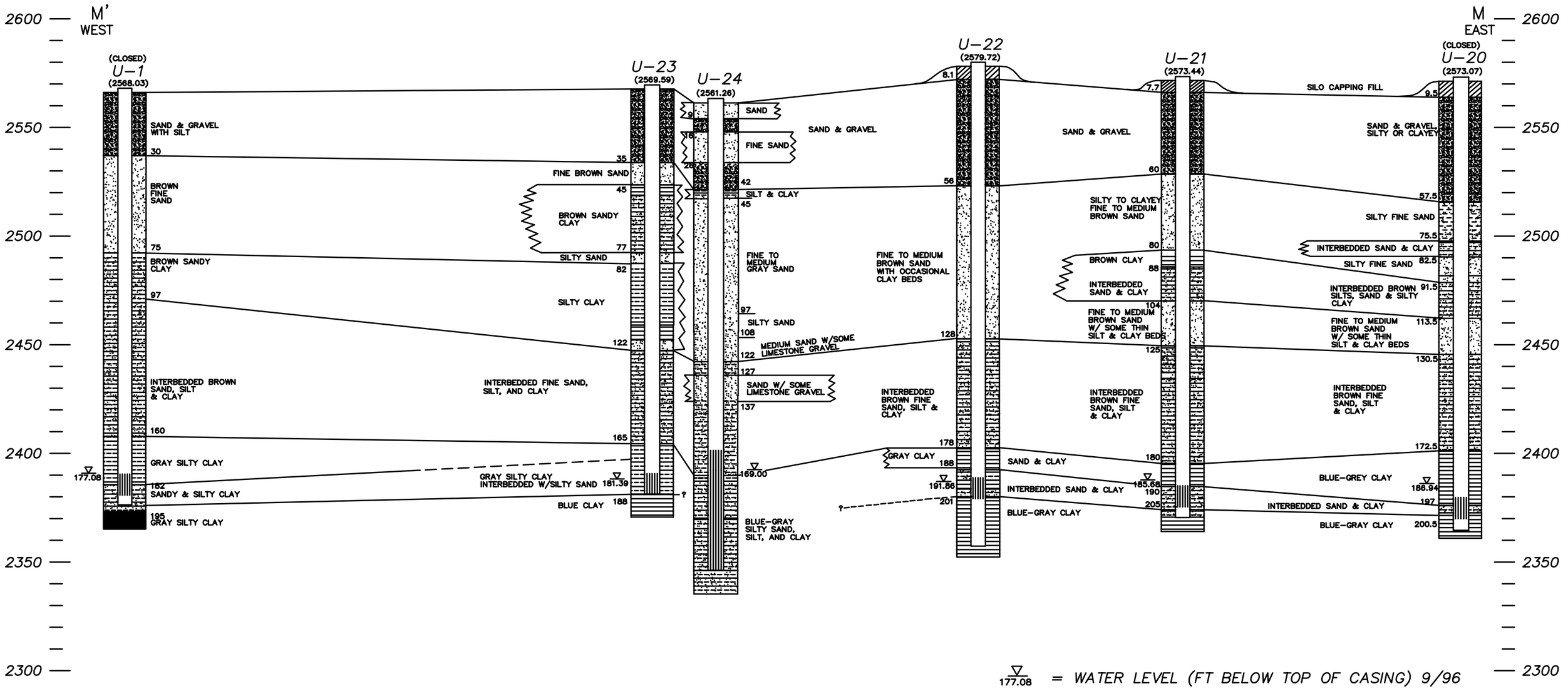
N
21.6°
MAGNETIC NORTH
100' 50' 0' 100' 200'

FIGURE E-24
LOCATION OF GEOLOGIC CROSS SECTION M-M'

US ecology

USEI 2014 PERMIT RENEWAL
EPA I.D. No. IDD073114654
Date: May 1, 2014

SCALE:
1" = 100' HORIZONTAL
1" = 50' VERTICAL



$\frac{\nabla}{177.08}$ = *WATER LEVEL (FT BELOW TOP OF CASING) 9/96*
(2580.3) = *STEEL SURFACE CASING ELEVATION (FTMSL)*

FIGURE E-25
GEOLOGIC CROSS SECTION M-M'

US ecology

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

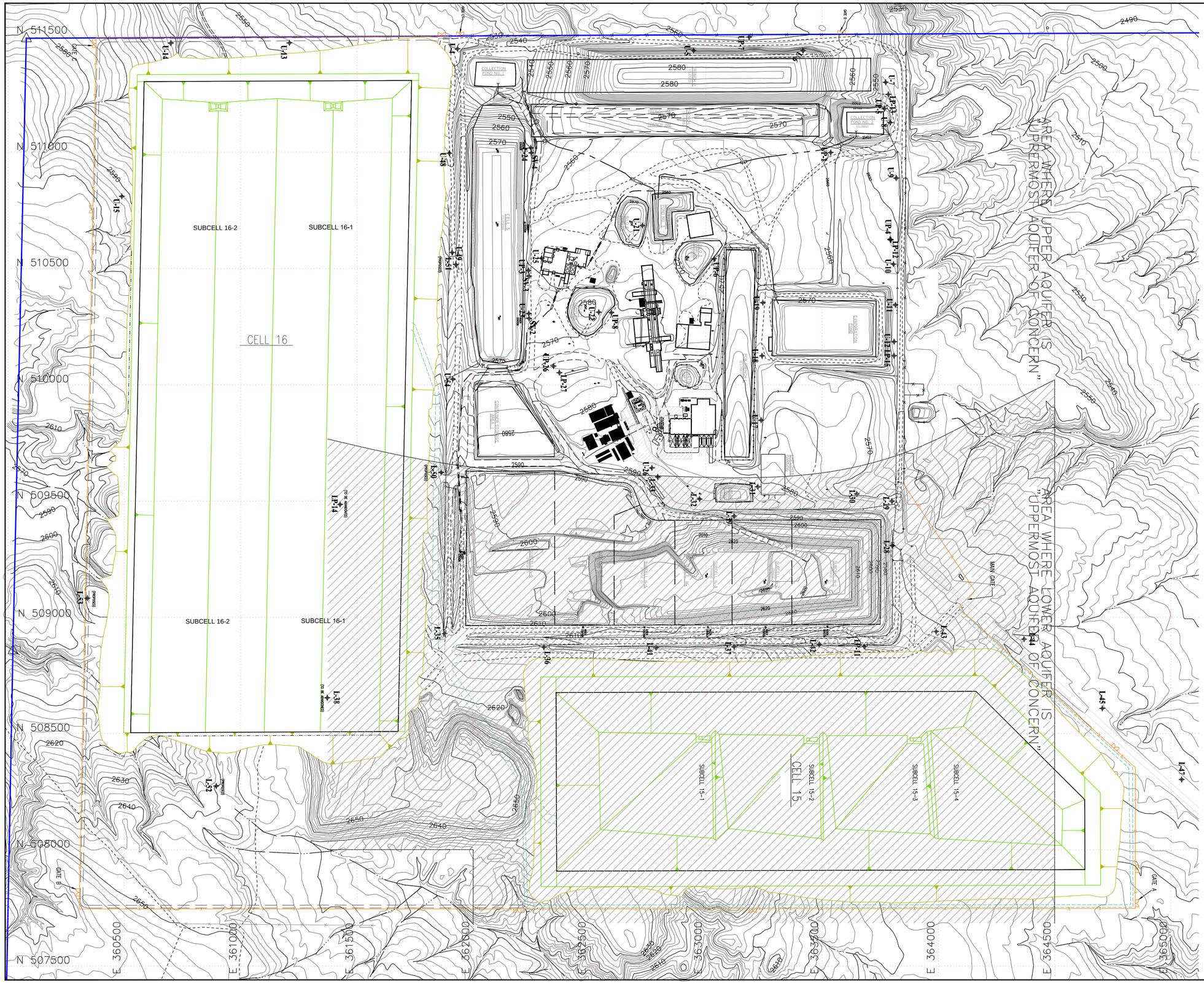


FIGURE E-26
UPPERMOST AQUIFER DELINEATION

US ecology

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

GROUNDWATER ELEVATIONS (FT MSL) = Fall 2013
+ = EXISTING DETECTION MONITORING WELLS
+ =ABANDONED DETECTION MONITORING WELLS

FIGURE E-27
UPPER AQUIFER GROUNDWATER FLOW DIRECTIONS AND DETECTION MONITORING WELLS

US ecology

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: April 25, 2017

GROUNDWATER ELEVATIONS (FT MSL) = OCTOBER 2013
+ = EXISTING DETECTION MONITORING WELLS

CELL 16
SUBCELL 16-2
SUBCELL 16-1

CELL 15
SUBCELL 15-1
SUBCELL 15-2
SUBCELL 15-3
SUBCELL 15-4

COLLECTION POND NO. 1
COLLECTION POND NO. 2
EVAPORATION POND
MAIN GATE
GATE A
GATE B

N 511500
N 511000
N 510500
N 510000
N 509500
N 509000
N 508500
N 508000
N 507500
E 360500
E 361000
E 361500
E 362000
E 362500
E 363000
E 363500
E 364000
E 364500
E 365000

2410
2420
2390
2400
2380
2370

FIGURE E-28
LOWER AQUIFER GROUNDWATER FLOW DIRECTIONS AND DETECTION MONITORING WELLS

US ecology

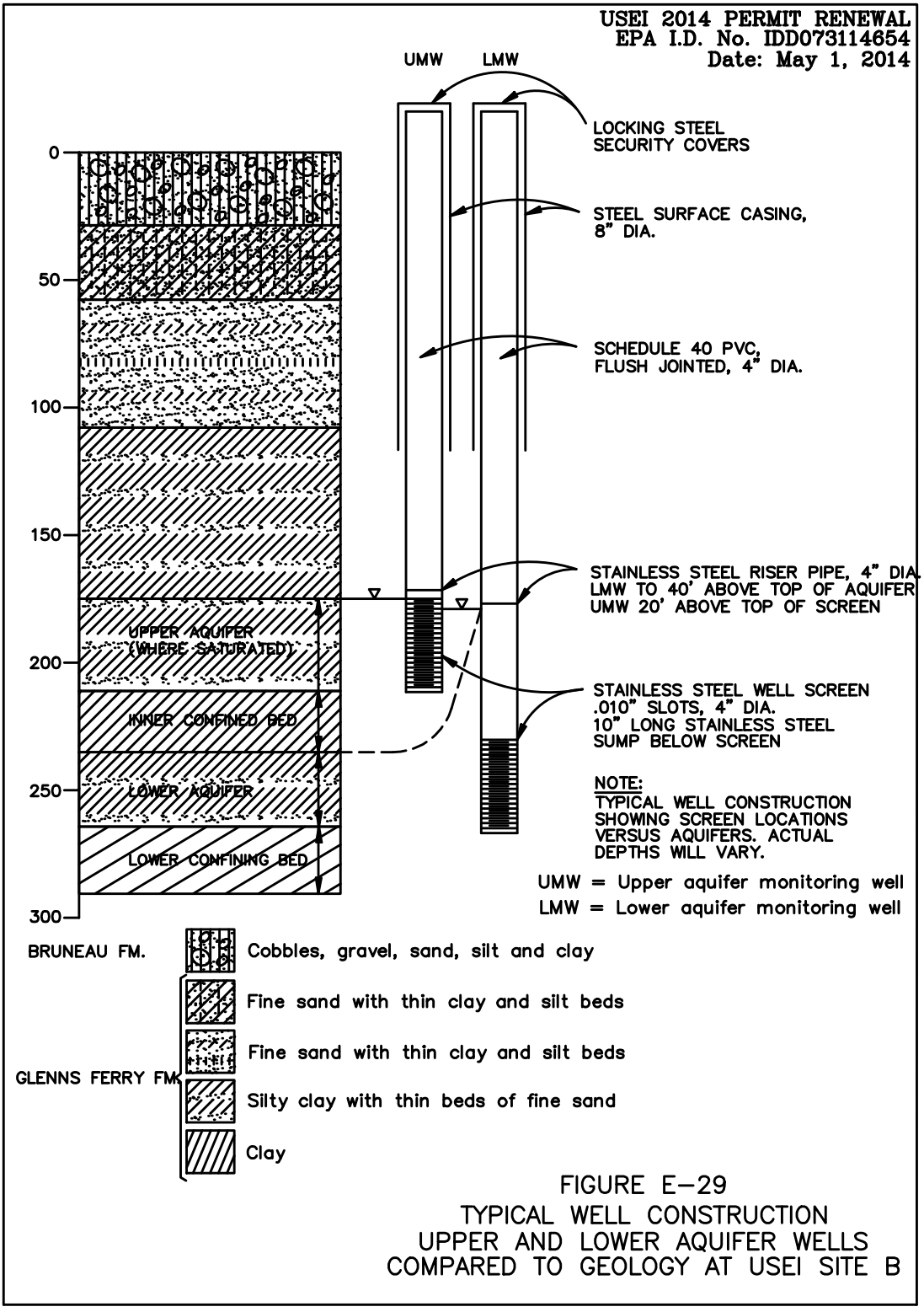


FIGURE E–29
TYPICAL WELL CONSTRUCTION
UPPER AND LOWER AQUIFER WELLS
COMPARED TO GEOLOGY AT USEI SITE B

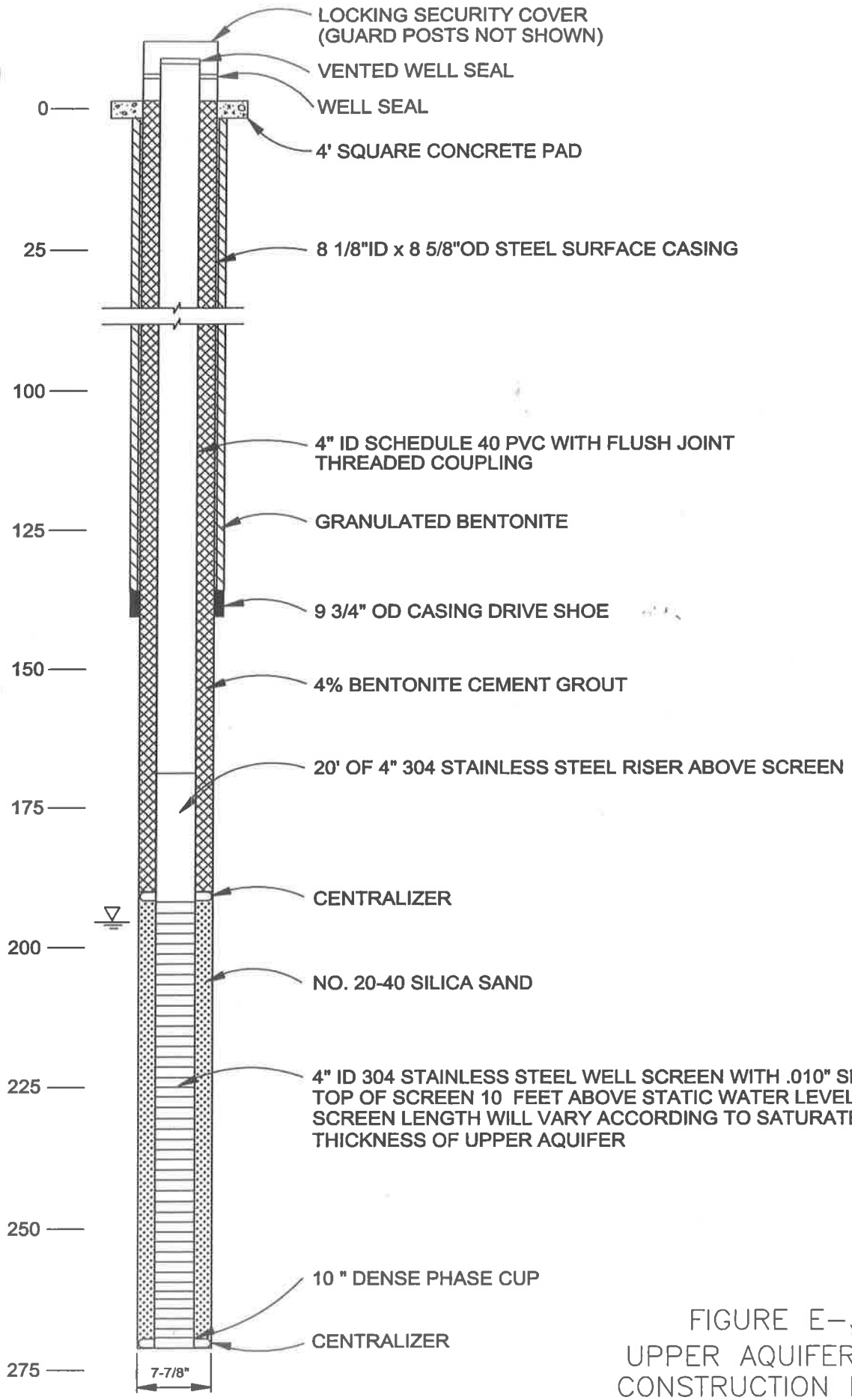


FIGURE E-30
UPPER AQUIFER WELL
CONSTRUCTION DETAILS

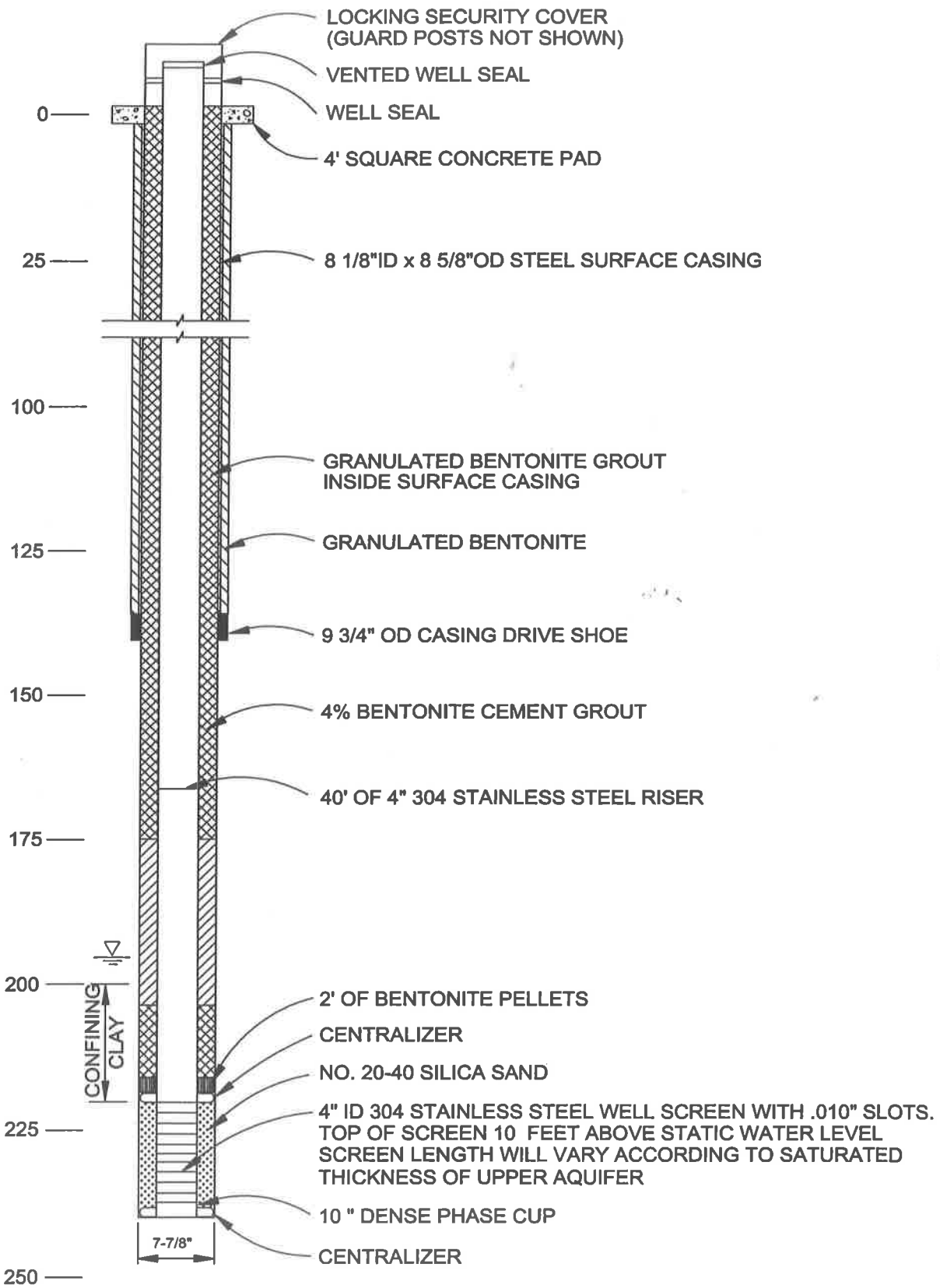


FIGURE E-31
LOWER AQUIFER WELL
CONSTRUCTION DETAILS

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654


FIGURE E-32

Detection Monitoring Wells

Revised: April 10, 2021

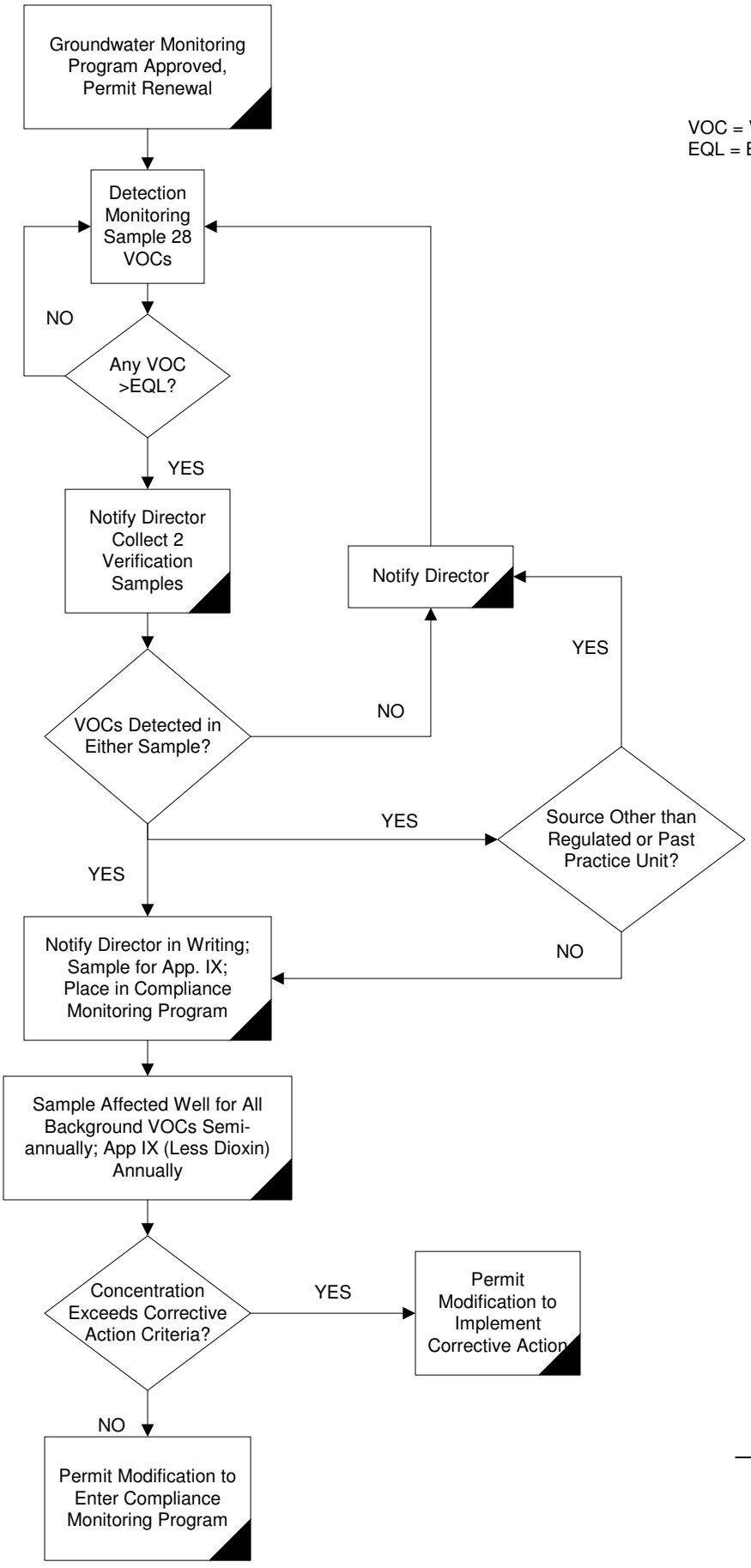


FIGURE E-33
DECISION TREE FOR THE GROUNDWATER DETECTION MONITORING PROGRAM

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654

UPGRADIENT BACKGROUND WELLS

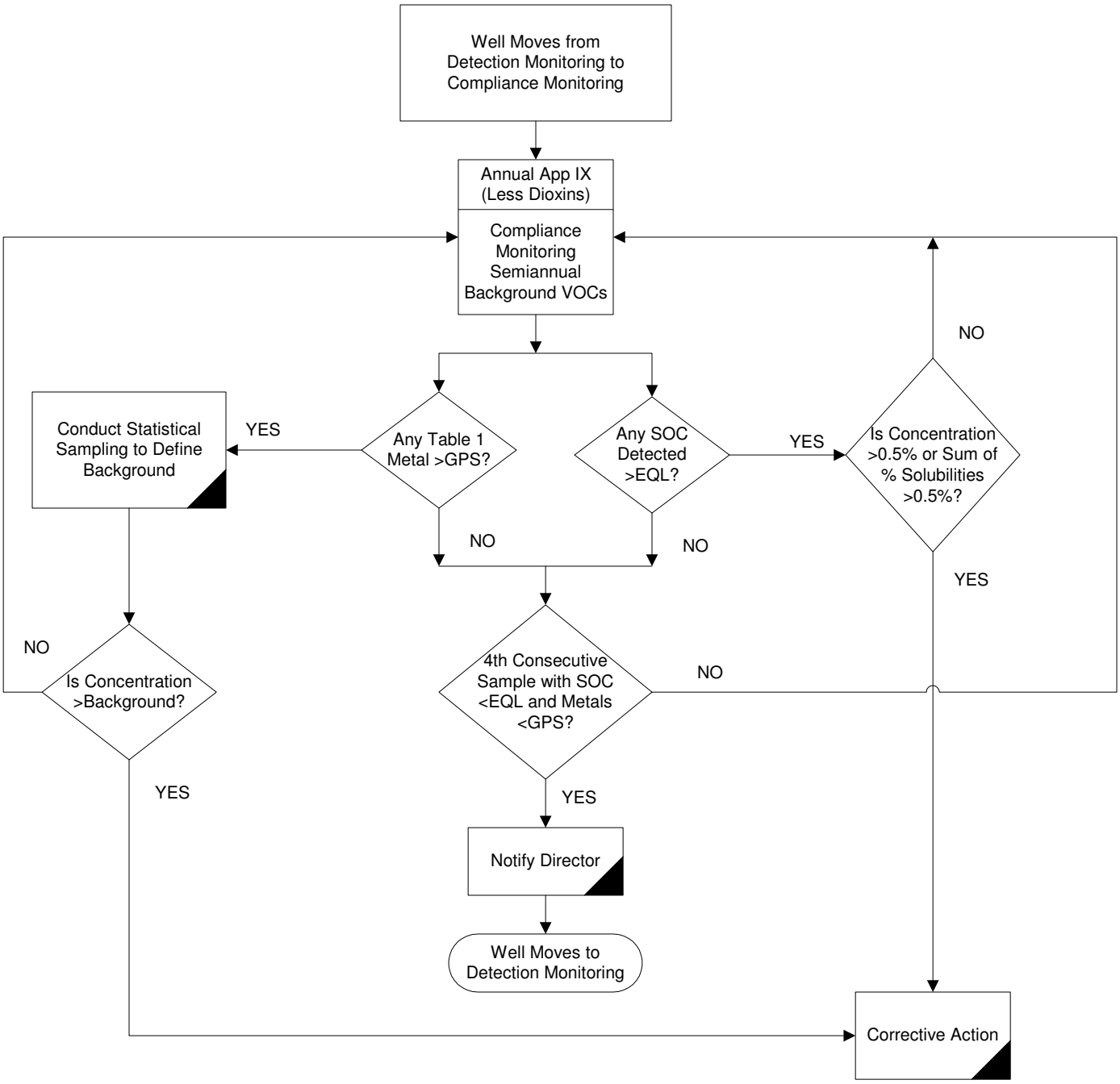
LEVEL 1 COMPLIANCE WELLS

LEVEL 2 COMPLIANCE WELLS

PIEZOMETERS

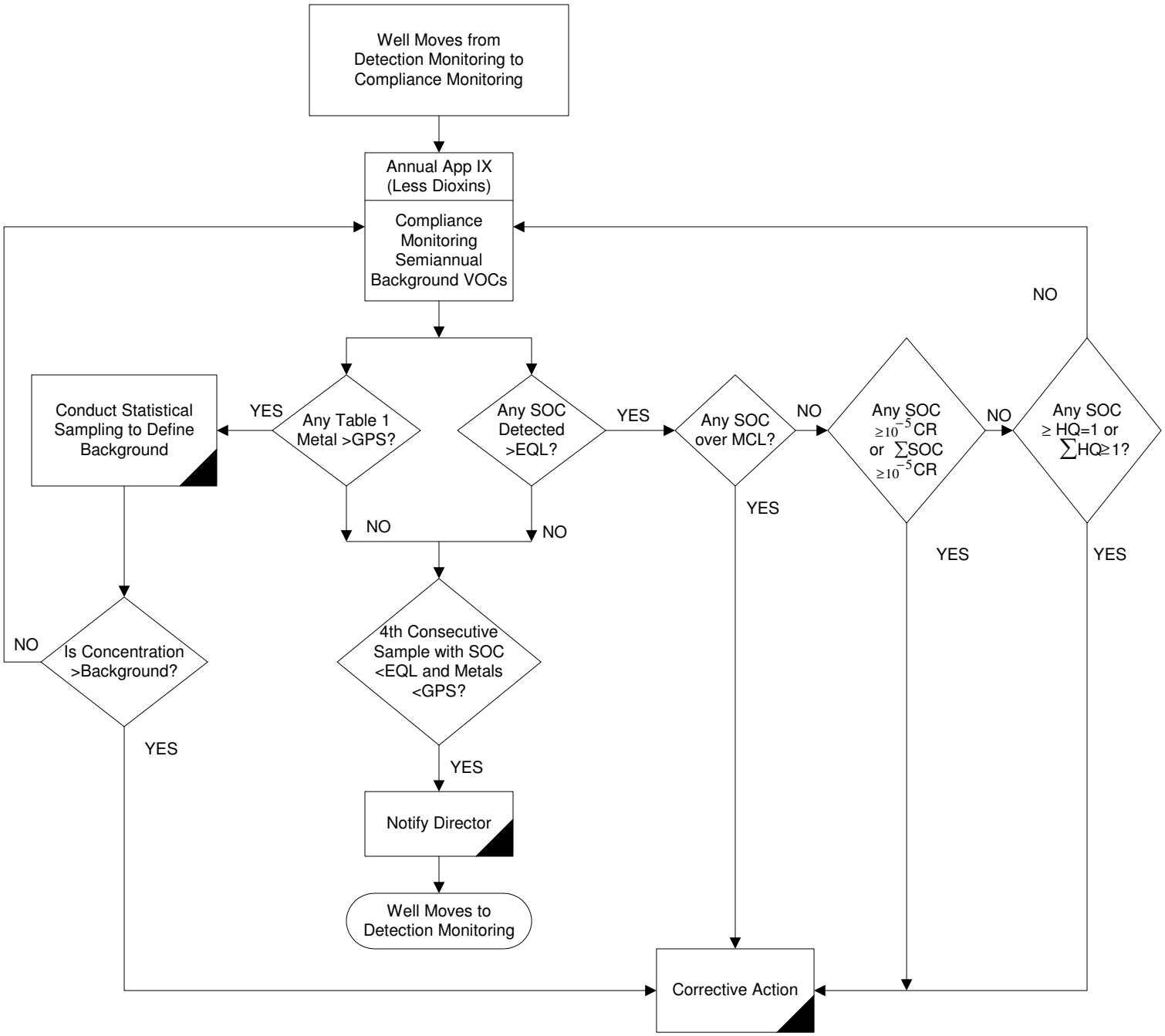
FIGURE E-34
Compliance Monitoring Well Designations

Revised: April 10, 2021



VOC = VOLATILE ORGANIC COMPOUNDS
SOC = SYNTHETIC ORGANIC COMPOUNDS
EQL = ESTIMATED QUANTITATION LIMIT
GPS = GROUNDWATER PROTECTION STANDARD

FIGURE E-35
DECISION TREE FOR
LEVEL 1 COMPLIANCE WELLS



VOC = VOLATILE ORGANIC COMPOUNDS
SOC = SYNTHETIC ORGANIC COMPOUNDS
EQL = ESTIMATED QUANTITATION LIMIT
CR = CANCER RISK
HQ = HAZARD QUOTIENT
GPS = GROUNDWATER PROTECTION STANDARD

FIGURE E-36
DECISION TREE FOR
LEVEL 2 COMPLIANCE WELLS

USEI RCRA PART B PERMIT
EPA ID. No. IDD073114654
Date: October 11, 2016

N 511500
N 511000
N 510500
N 510000
N 509500
N 509000
N 508500
N 508000
N 507500

E 360500
E 361000
E 361500
E 362000
E 362500
E 363000
E 363500
E 364000
E 364500
E 365000

SUBCELL 16-2
SUBCELL 16-1
CELL 16
SUBCELL 16-4
SUBCELL 16-5
SUBCELL 16-3
CELL 14
SUBCELL 15-1
SUBCELL 15-2
CELL 15
SUBCELL 15-3
SUBCELL 15-4
COLLECTION POND NO. 1
COLLECTION POND NO. 4
TRENCH 10A
TRENCH 10B
EVAPORATION POND
CONTAINER STORAGE AREA
MAIN GATE

U-6
TCE 1.5 May-11
CFC-113 7.0 Oct-05

U-21
CM 120.0 Dec-91
CF 1900.0 Dec-91
CTET 1700.0 Jun-98
PCE 8.3 Oct-97
MC 130.0 Nov-00
CF 1900.0 Dec-01
TCE 15.0 Nov-00
1,1-DCA 3.9 Nov-00
1,2-DCA 5.9 Nov-00
1,1-DCE 2.2 Nov-00
CEA 4.0 Nov-00
B 2.2 Nov-00

U-20
CF 1900.0 (11/00)
CTET 370.0 (11/00)
MC 17.0 (11/00)
PCE 23.0 (11/00)
TCE 11.1 (11/00)
1,1-DCA 2.4 (11/00)
1,1-DCE 1.2 (11/00)
1,1,1-TCA 6.3 (11/00)
CF 26.0 (10/97)

U-1
CTET 230.0 Jun-06
CF 15.0 Nov-07
PCE 1.0 May-02
CFC-113 2.3 Oct-06

U-2
CTET 5.2 May-13
CF 5.0 Jun-00
MC 1.5 Jun-14

U-3
CF 140.0 May-03
CDS 4.0 Mar-92
CF 4.2 Dec-00
CFC-113 1.9 May-11

U-4
CF 15.0 Jan-00
CTET 8.3 Oct-97

U-5
1,1,2,2-PCA 6.7 Oct-93
CF 5.1 Oct-93

U-7
CFC-113 5.0 May-12

KEY
B = BENZENE
CM = CHLOROMETHANE
MC = METHYLENE CHLORIDE
CF = CHLOROFORM
CTET = CARBON TETRACHLORIDE
1,1−DCA = 1,1,−DICHLOROETHANE
1,1−DCA = 1,1,−DICHLOROETHENE
1,2−DCA = 1,2,−DICHLOROETHANE
1,1,1−TCA = 1,1,1,−TRICHLOROETHANE
1,1,2,2−PCA = 1,1,2,2−TETRACHLOROETHANE
PCE = TETRACHLOROETHENE
TCE = TRICHLOROETHENE
CFC−113 = 1,1,2−Trichloro−1,2,2−trifluoroethane

N
31.6°
MAGNETIC NORTH
100' 50' 0' 100' 200'

PLATE E-10
MAP OF VOC MAXIMUM DETECTIONS (PPB) AS OF MAY 2015

US ecology

Appendix E.6
2010 Re-Evaluation of Rising Groundwater

Report

Re-Evaluation of Rising Groundwater at USEI, Site B

Prepared for

U.S. Ecology Idaho, Inc.

(U.S. EPA ID No. IDD073114654)

Prepared by

Feast Geosciences, LLC

February 2010

Feast Geosciences, LLC

Report

Re-Evaluation of Rising Groundwater at USEI, Site B

Prepared for

U.S. Ecology Idaho, Inc.

(U.S. EPA ID No. IDD073114654)

February 2010



Feast Geosciences, LLC

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6 Water Level Change in the Upper Aquifer October 2005 to October 2010
7 Water Level Change in the Lower Aquifer From 1990 to 2010
8 Water Level Change in the Lower Aquifer October 2005 to October 2010
9 Current Rate of Water Level Rise in the Upper Aquifer
10 Current Rate of Water Level Rise in the Lower Aquifer
11 Hydrographs for Upper Aquifer Wells along a Northwest to Southeast Flowpath across Site B
12 Hydrographs for Upper Aquifer Wells along a north-south line up the West Side of Site B
13 Hydrographs for Upper Aquifer Wells along A north-south line up East Side of Site B
14 Hydrographs for Upper Aquifer Wells along an west-east line across the North Side of Site B
15 Hydrographs for Upper Aquifer Wells along the Southern Extent of the Upper Aquifer
16 Hydrographs for the Silo Wells and Piezometers
17 Hydrographs for Silo Wells U-20 and UP-6
18 Hydrograph for Silo Well U-21
19 Hydrographs for Silo Wells U-22 and UP-8
20 Hydrographs for Lower Aquifer Wells along a Southwest to Northeast Flowpath across Site B
21 Hydrographs for Lower Aquifer Wells along the North Side of Cell 15
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24 Hydrographs for Upper and Lower Aquifer well pairs
25 Upper Aquifer Water Level Map, October 2005
26 Upper Aquifer Water Level Map, October 1990
27 Lower Aquifer Potentiometric Surface, October 2005
28 Lower Aquifer Potentiometric Surface, October 1990

Introduction

Background

U.S. Ecology Idaho, Inc. (USEI), owns and operates a commercial hazardous waste treatment, storage, and disposal facility (U.S. EPA ID No. IDD073114654) referred to as Site B, located about 10 miles west of Grand View in southwestern Idaho (see Figure 1). The northern part of Site B overlies an abandoned Titan missile base. Previous owners of the site used the three missile silos and other ancillary structures for hazardous waste disposal. The three main missile silos are 40 feet in diameter and 160 feet deep. The waste filled silos are capped and vented through activated carbon. Currently USEI operates two double-lined waste disposal cells across the southern portions of the site; Cells 14 and 15 (Figure 2).

Groundwater levels measured in monitoring wells and piezometers at USEI Site B have been rising gradually since the first sequential pairs of water level data were collected from the initial site characterization wells installed in 1984. U.S. Ecology and the Idaho Department of Environmental Quality (IDEQ) have tracked the rising groundwater and discussed possible reasons for the rises and potential ramifications of rising water levels on the groundwater monitoring system at Site B. The initial report on rising groundwater at Site B was issued in 1992 (CH2M HILL, 1992). Consequently, condition IX.J of USEI's RCRA Part B Permit required submittal of a work plan and an investigation of the rising groundwater. The work plan was prepared in 1998 (CH2M HILL, 1998) and the investigation was conducted and results submitted to IDEQ in September, 1999 (CH2M HILL, 1999).

In November 1999 IDEQ issued a conditional approval of the Rising Groundwater Study. The conditional approval required USEI to re-evaluate the rising groundwater situation at Site B every two years and stated that after the third re-evaluation USEI may request a five year interval between re-evaluations. In August 2001 the first report re-evaluating rising groundwater at Site B was submitted to IDEQ (CH2M HILL, 2001). The August 2001 report provided water level data through April 2001. In December 2003 the second re-evaluation of rising groundwater was completed and submitted to IDEQ (Feast Geosciences, 2003). The 2003 re-evaluation included water level data through October 2003. In 2005 rising groundwater conditions were evaluated again (Feast Geosciences, 2006). After the 2006 report was submitted USEI requested, and IDEQ granted, a request to go to a 5-year interval between subsequent re-evaluations of groundwater levels at Site B.

This report represents the fourth re-evaluation of rising groundwater at USEI Site B in accordance with permit condition IX.J. This report contains data collected through October 2010 in all the wells currently monitored at USEI Site B.

Hydrogeologic Setting

Detailed descriptions of the hydrogeology at Site B are provided in the numerous support documents prepared prior to and subsequent to the issuance of the Part B permit. The

general description and discussion in the following paragraphs is provided to familiarize the reader with the subsurface conditions relevant to the content of this report, and is not intended to provide a comprehensive presentation of the complex hydrogeology at Site B.

USEI Site B is underlain by two water-bearing units identified as the upper and lower aquifers. These hydrologic units consist of two distinct swarms or sets of thin beds of very fine, sand-to-silt-size grains embedded in a silty clay matrix. A confining layer of clay, 20 to 30 feet thick, separates the two aquifers.

The total saturated thickness of the upper aquifer ranges from less than 20 feet thick to about 80 feet. Within the aquifer section, the cumulative thickness of sand beds ranges from 1.5 feet to 35 feet, with an average of about 7 feet. Sand beds are thicker, and the cumulative sand bed thickness is greatest, in the northwest portion of the site. The number of sand beds and seams decrease and individual beds thin to the east and south. Well yields vary with sand content, and range from up to 5 gallons per minute in the northwest corner to less than 0.5 gallons per minute across the east and southern extents of the aquifer. The upper aquifer is under unconfined (water table) to semi-confined conditions and water levels range from 135 feet to 190 feet below ground surface. Water in the upper aquifer flows into the site from the northwest and exits across the eastern facility boundary. Figure 3 provides a map showing the water levels and typical groundwater flow line for the upper aquifer for October 2010.

The lower aquifer is generally 20 to 30 feet thick and contains fewer and thinner sand beds than does the upper aquifer; as such, the wells in this unit all yield less than 0.5 gallons per minute. Water in the lower aquifer enters from the southwest, flows to the northeast and also exits the site beneath the eastern facility boundary as shown on Figure 4. The lower aquifer is under confined conditions and the potentiometric surface ranges from 190 feet to about 220 feet below ground surface.

Water chemistry, geologic cores, and geophysical logging data collected during the site characterization process was use to differentiate the two aquifers, which appear geologically similar except in the northwest corner. The groundwater monitoring system established for the site as part of the permitting process has maintained the upper and lower aquifer distinction. The monitoring well system at USEI Site B consists of 33 wells and piezometers in the upper aquifer, and 23 wells and piezometers in the lower aquifer, as shown on Figure 2.

The upper aquifer section dips or slopes downward to the northeast at 2 to 5 degrees. The slight northeasterly dip is illustrated by the shape and spacing of the 2600 to 2500 foot elevation contour lines northwest of Site B shown on Figure 1. As a consequence of this dip, the sand beds that constitute the upper aquifer gradually rise above water and progressively become unsaturated from north to south across the site. The southern limit of saturation in the upper aquifer crosses the southern portion of the site from northwest to southeast, slightly north of the northern edge of Cell 14. The lower aquifer also dips to the northeast but is saturated beneath the entire facility.

Source of Rising Groundwater

This report does not address possible sources of the observed rising water levels in both aquifers at USEI Site B. The 1999 Rising Groundwater Study (CH2M Hill, 1999) concluded

that the upper aquifer water is about 1000 years old on the west side of the site and was being recharged from Castle Creek, approximately 3,800 feet west-northwest of the site. This relatively new water appears to be displacing and mixing with older water (5000 years) in the upper aquifer from west to east across the site. Lower aquifer water is approximately 12,000 years old. The lower aquifer is confined and is probably responding to hydraulic head influences from the Castle Creek drainage at a much greater distance to the southwest and over a much longer time period. The data on both aquifers are insufficient to determine why water levels are rising or how long they have been rising. There is no indication from water chemistry, temperature or water level (head) data to suggest any on-site recharge that could explain the rising water levels and heads. The heads in the lower aquifer are also clearly affected by changes in surface loading due to the large excavations and stock piling of spoils as Cell 14 and Cell 15 were constructed and subsequently filled well above previous grade. It is unknown what, if any, residual effect of soil loading may have occurred when the missile base was constructed in the early 1960's. Both aquifers are low yielding water bearing formations and both appear to be responding to changes in regional hydraulic heads and distant recharge sources that have occurred in recent geologic time. The lag time associated with a distant change in recharge or head as it relates to a response in the Site B wells is unknown. The rate of water level rise in the up-gradient wells for both aquifers is the slowest which suggests, at least for the short term, that away from the influence of site construction activities the aquifers are approaching equilibrium with the local and regional hydrologic conditions.

Rising Groundwater Issues and Structure of this Report

There are four primary concerns associated with the rising groundwater at Site B:

1. Are groundwater levels still rising and at what rate?
2. What is the effect of changing groundwater flow conditions (velocity and direction) on the groundwater monitoring program?
3. Have rising water levels impacted the effectiveness of monitoring wells by inundating well screens or by allowing water to come in contact with well construction materials that could affect the ability of the well to provide representative water samples?
4. When will the groundwater approach or inundate the bottom of the missile silos?

This report addresses each of these concerns and is organized in two sections. The first section, **Water Level Evaluation**, provides the basic water level data, presents and discusses the magnitude of water level changes seen since 1989 and provides representative hydrographs for individual wells and groups of wells organized by aquifer and site features of interest. The second section, **Effects of Rising Water Levels at Site B**, addresses the effects of the historical and projected water level changes on groundwater flow directions and flow rates, groundwater monitoring and well construction issues and on the projected time frames when water levels in the upper aquifer may reach the missile silos.

All tables and figures are provided sequentially following the text. Appendix A provides the historical water level data and hydrographs for all wells.

A single base map is used for all figures. This map shows all the wells at Site B. Please note the following abbreviations pertaining to the wells listed on the tables and shown on the map figures: U = upper aquifer monitoring well; UP = upper aquifer piezometer; L= lower aquifer monitoring well; LP = lower aquifer piezometer. With regard to the map figures, each map shows data specific to either the upper or lower aquifer. The specific data points used for the particular map are provided in small font near the well numbers. Although all wells are shown on all maps, only those wells with associated data points were used for that map.

Water Level Evaluation

This section provides a detailed evaluation of groundwater levels and water level trends in each well, by groups of wells, by areas of the site and for the upper and lower aquifers. This information is used in the next section of this report entitled **Effects of Rising Groundwater at Site B** to evaluate potential impacts and effects the rising groundwater may have on the monitoring well network and potential water quality.

Water Level Data

Repetitive groundwater level measurements at Site B began in 1984, when the first site characterization test wells were installed. In 1989, after the Part B permit was issued, new dedicated groundwater monitoring wells were installed, and water level measurements and groundwater sampling were conducted on a semi-annual basis using dedicated equipment and following standardized data measurement and reporting protocols. The standardized water-level-measuring equipment and procedures, together with the 6-month water level re-equilibrium period between sample events, significantly reduced the variations in reported water level elevations. Consequently, only water level data collected since 1989 are presented and used in this report. Tabulated water level data including measurement date, measure point elevation, water table elevation and hydrographs for all wells for the period from 1989 through 2005 are provided in Appendix A. To aid in scaling and comparison, select hydrograph figures and tables presented in this section include data beginning with October 1990. By using October 1990 as a starting date for these figures and tables, several instances of questionable data were avoided and since the most recent data used was for October 2010 this provided 20 years of seasonally comparative water level data.

Water level data for many of the upper aquifer wells show a distinct "flattening" of the upward water level trend beginning in the 1996-1997 time frame. This apparent slope change was noted in the 2001 Re-evaluation report. Additional water level data collected since 2001 has provided a better definition of this trend.

In the 2005 Re-evaluation report there was insufficient data points from the new lower aquifer wells installed along the northern side of Cell 15 to allow meaningful analysis of the water level trends in these wells. These wells, except L-47, now have 5 to 7 years of data and are included in the analysis. There is less than two years of data for Well L-47 which is insufficient to develop any meaningful water level trends.

Beginning with the May 2009 measurement, water level in well U-21 began rising much faster than the previous well-established trend for this well. These data and implications are further discussed in this report.

Water Level Change from 1990 to 2010

Upper Aquifer

Table 1 summarizes the historical water level differences for all upper aquifer wells from 1990 (or first data) to 2010. The maximum change over this period has been an increase of 8.80 feet in well U-12. The minimum rise over this same period is 2.70 feet in monitoring well U-6 and the average rise was 6.00 feet. Table 1 also shows the water level change from October 2005 to October 2010. From 2005 to 2010, water levels in the upper aquifer have risen an average of 1.04 feet. The right-hand column in Table 1 shows the differences in the rate of water level change, in feet per year, comparing the period from 1990-2005 to the period from 2005 to 2010. As shown on Table 1, with the exception of U-21, over the last 5 years compared with the previous 15 years, the average rate of water level rise in all upper aquifer wells has slowed from 0.33 to 0.21 feet per year, a decrease of approximately 33 percent.

Figure 5 is a contour map showing the feet of water level change in the upper aquifer between 1990 and 2010; only those wells with data for 1990 and 2010 were used in this figure. As shown on Figure 5, over the past 20 years water levels in the upper aquifer have increased the most across the southeast side the site.

Figure 6 provides a contour map of the water level rise in the upper aquifer from October 2005 through October 2010. As shown on this figure, water level changes over the past five years are still highest in the southeast portion of the site, except for the anomalously rapid rise in recent data for U-21.

As shown on Figures 5 and 6, the upper aquifer wells in the vicinity of the evaporation pond have the highest historical water level rises both from 1990 to 2010 and for the period from 2005-2010 (U-21 excepted as noted above). There have never been any volatile organic compounds (VOCs) detected in any of these wells, nor have there been any anomalous field parameters or common ion data that would suggest this pattern reflects a mounding effect caused by leakage from the evaporation pond.

It is possible that the water levels in these upper aquifer wells are responding to increased soil loading by the evaporation pond, similar to the effect seen in the lower aquifer wells associated with stock piling of spoils and construction of disposal cells.

Water levels across this portion of the site are also rising in response in the continuing influx of water (and rising water level heads) on the up-gradient side (north-northwest) of the site. The water level rises seen in the wells across the down-gradient side may reflect a delayed response as the water levels seek to maintain hydraulic equilibrium with the incoming recharge water.

Lower Aquifer

As shown in Table 1, the maximum water level change in the lower aquifer over the period from 1990 to 2010 has been an increase of 12.34 feet in L-29, and the minimum rise is 1.68 feet in well LP-14. It should be noted that the 1990-2010 comparison period does not include the data from new lower aquifer wells installed in October 2003 and October 2005 for Cell 15 (wells L-41, L-42, L-43 and L-44). From 2005 to 2010 the maximum (6.38 feet) and

minimum (0.26 feet) water level changes occurred at L-44 and L-38 respectively. Excluding the data from the new wells the maximum rise between 2005 and 2010 was 5.61 feet in well L-37. As shown on Table 1, the rate of water level rise (in feet per year) for the lower aquifer is greater for the period from 2005-2010 than for the period from 1990 to 2005. Based on the average water level changes, the rate of rise for the period from 2005 to 2010 is about 160 percent greater than the previous 15 years.

Figure 7 is a contour map showing the total water level change for wells in the lower aquifer between 1990 and 2010. Water level changes are generally greatest in the southeastern portions of the site, in the vicinity of the east end of Cell 14.

Figure 8 illustrates the water level change that has occurred in the lower aquifer from October 2005 to October 2010. As shown on Figure 8, water levels in the lower aquifer wells around the east end of Cell 14 and between Cell 14 and Cell 15 have increased the most. The water level increase in this area of the site is directly related to soil loading effects as a result of the excavation, stockpiling, construction and subsequent filling of Cells 14 and 15.

Hydrograph Trend Analysis

Appendix A provides the complete water level data set and hydrographs for all wells at Site B. Trend analyses of water levels were made by linear regression analysis of the hydrograph data to determine the slope of the water level trend.

Many wells exhibit distinct periods with steeper and flatter trends. In most of the upper aquifer wells from the center of the site northward, steeper rises occurred prior to 1996. However, this varies between wells and is more distinct in some wells than others. In many of the wells in the lower aquifer and southern portion of the upper aquifer the slope has been essentially constant since 1989. In addition, the data for several wells, notably L-38, L-35 and LP-14, and most of the wells between Cells 14 and Cell 15, exhibited rapid water level fluctuations attributed to localized impacts of soil loading changes. These data were not amenable to establishing trends in previous rising groundwater reports. However, the more recent data from these wells has been consistent enough to determine a trend as shown on their respective hydrographs.

As required by IDEQ, two slopes and subsequent rates of water level rise are presented and used in subsequent evaluations. A slope and rate of rise was determined for the entire period of record (POR). Since all wells do not have the same POR, the beginning date varies between wells. The second slope was determined for the last several years when a distinct new linear trend was evident. Although the hydrograph for each well is unique, the more recent trends for most wells began in about 1997. The regression equations and trend lines determined for all applicable wells are presented on the individual hydrographs provided in Appendix A.

Tables 2 and 3 provide the slope in feet per day determined from the regression analyses presented on the individual hydrographs provided in Appendix A and the calculated rate of water level rise in feet per year based on that slope for upper and lower aquifers respectively. The slope and rate of rise in feet per year for the POR and the latest trends are given on Tables 2 and 3. For comparison, the rate of rise in feet per year presented in the 2005 Rising Groundwater Re-evaluation is also provided. In addition, Tables 2 and 3 also

show the differences between the current (2010) rate of rise and the trends for the POR and the 2005 rates. Also shown on Tables 2 and 3 are the approximate dates when obvious changes (inflections) in the trends of the water level data for each well occurred. Most inflections occurred in 1997 in the upper aquifer wells with later changes occurring in 2003, 2004 and 2005 in a few wells. In the case of upper aquifer well U-21, a significant upward inflection began in October 2009 and this rapid water level rise has continued through October 2010. Most of the inflections in the lower aquifer wells have occurred since 2003. In about one-third of the lower aquifer wells there were no inflections observed.

As shown in Table 2, when comparing the long term trend over the POR to the most recent trends the rate of rise in the upper aquifer wells have decreased. Comparing the rate of rise determined in the 2005 report update to the current rate of rise indicates, with the exception of wells U-5 and U-6, the latest rates of rise are unchanged or slightly lower than the previous determination. At U-5 and U-6 the most recent trend analysis indicates a slight steepening in the most recent trend lines but this increase is only 0.01 to 0.04 feet per year higher than the 2005 slopes. On average, the latest slopes in the upper aquifer wells are still less than the average for 2005.

Table 3 provides the same trend data for the lower aquifer wells. The lower aquifer wells are split approximately evenly between those whose rate of rise has steepened (L-28, L-29, L-30, L-37, LP-11 and LP-15), those with no significant change or decreased rate of rise (L-31, L-32, L-33, LP-12 and LP-13 and LP-27). The new wells around Cell 15 do not have long enough data sets to reliably compare recent to previous trends.

In previous rising water level reports trend lines for wells L-35, L-38 and LP-14 were not considered valid due to rapid fluctuations in the data, apparently as a result of soil loading changes around Cell-14 and Cell-15. As shown on the individual hydrographs for these wells and on Table 3, a trend line has been established for these well in the last 6 years. The rates of rise for these three up-gradient wells are the slowest of the lower aquifer wells.

Water level trends in wells L-32, L-33 and LP-27 have flattened considerably since 2003 (see hydrographs in Appendix A). Site construction and activities affecting soil loading has generally moved away from these wells in the later years supporting the probable connection to the loading at Cell 14 and Cell 15 as causing the more rapid rise and variable water levels in the other lower aquifer wells. Wells LP-12 and LP-13, along the northeast side of the site away from the east end of Cell 14 and Cell 15, have also shown a significant decrease in the rate of rise in the later data. These wells are far away from the effects of increased loading around Cells 14 and 15 and the declining rates of rise in these wells are probably related to declining rates of rise in the overlying upper aquifer as discussed in the **Grouped Hydrographs** section of this report.

Note that the rate of rise provided on Tables 3 and 4 are based on regression analysis of the data, whereas the average change in feet per year provided on Table 1 is the total difference in water level at the beginning and end of the data sets divided by the elapsed time between first and last readings. The information in both sets of tables is similar, but the average change in feet per year on Table 1 is often skewed by early data points. This is best illustrated by review of the individual hydrographs provided in Appendix A.

Figures 9 and 10 illustrate the current rate of rise for the upper and lower aquifers, respectively, based on the regressed slopes of the hydrographs. These values, in feet per year, represent the overall trend of the data without variations caused by short term fluctuations in individual wells.

As can be seen in Figure 9, the rate of rise for the upper aquifer varies from 0.04 feet per year in the extreme northeast corner of the site to 0.35 feet per year in the southeast portion. The recent increased rate of rise in U-21 was not included in the trend line regression for this well. The rate of change in well U-20 is lower than the overall pattern suggested for the upper aquifer. This low value caused the contour lines to wrap around U-20 on Figure 9. If U-20 was not included, the 0.20 contour line would sweep smoothly around UP-6. The low rate of change in U-20 is probably directly associated with the extremely low well yield currently being experienced with this well as a result of well screen plugging. The hydrograph trends and rates of rise for U-20 and U-21 are discussed in more detail in the **Grouped Hydrographs** section of this report.

Figure 10 provides the recent rate of rise based on the trend graph regression analysis for the lower aquifer. As shown on Figure 10 the rate of rise in the lower aquifer varies from less than 0.20 feet per year across the west side of the site up over 1.0 feet per year on the southeast side. The rate of rise in the lower aquifer increases smoothly to the southeast, apparently in direct correlation with the impacts on water levels associated with the excavation, stockpiling of spoils and subsequent filling of Cells 14 and 15.

Grouped Hydrographs

The following section presents sets of hydrographs for the upper and lower aquifers grouped by geographic location or by pertinent orientation to geologic and groundwater patterns at Site B. These grouped hydrographs are presented to so that comparisons between wells are easier to see. However, combining groups of hydrographs on a single vertical scale often mutes characteristics of individual hydrographs, especially short term events and subtle changes in slope. In addition, note that grouped hydrographs in this section begin with October 1990 data whereas the individual hydrographs in Appendix A contain all data through April 1989. The individual hydrographs in Appendix A should be reviewed to note these important features and to see the pre-October 1990 data.

The rationale for each grouping and the results of visual examination of spatial and temporal data are discussed below. The figure title provides a summary of the hydrographs grouped in each figure and Figure 2 shows the location of specific wells. Groupings of upper aquifer wells are discussed first, followed by the lower aquifer well groups.

Upper Aquifer

Figure 11 - Upper Aquifer Wells along the Northwest-Southeast Groundwater Flowline (U-4, U-24, U-21, U-20, U-19 and U-12)

The wells included in Figure 11 progress down the typical upper aquifer groundwater flow line crossing Site B from northwest (U-4) to southeast (U-12). Several characteristics of the overall water level pattern in the upper aquifer can be seen from this set of hydrographs. The first significant characteristic is that although water levels have been rising over this entire period, the vertical relationship between wells has not significantly changed and

consequently there has not been any significant change in flow direction in the upper aquifer over this period. Although the hydrographs are approximately parallel, they have converged slightly over this period. As shown by the data on Table 1, the water level difference between U-4 and U-12 has decreased by 4.70 feet. The result is a decrease in the gradient and subsequent calculated groundwater velocity across the site of approximately 16 percent from 1990 to 2010.

Figure 12 – Upper Aquifer Wells along a North-South line on the West Side (U-4, U-24, U-25, U-23 and UP-26)

This set of wells shows the change in water levels occurring up the west side of the site from the northern boundary (U-4) toward the southern edge of the aquifer (UP-26). The hydrographs are converging with time as the rates of water level rise in the northern wells (U-4 and U-24) are slowing while the water levels in the southern wells continue to rise more steadily. The converging trend of water levels is a consequence of the slower response in the less transmissive lower part of the upper aquifer to the rising water levels occurring in the more highly transmissive upper and northwestern parts of the aquifer. In essence, the water coming into the site from the northwest is backing up against the less permeable parts of the upper aquifer. The lag effect caused by the transmissivity contrast east to west and north to south in the upper aquifer is the reason why water levels on the east and south side of Site B are still rising faster than on the northwest and north as shown in Figure 9.

Figure 13 – Upper Aquifer Wells along a North-South line on the East Side (U-7, U-8, U-9, U-10, U-11 and U-12)

The hydrographs for wells along a north-south line on the east side of the site, included on Figure 13, show the significant flattening of water level trends in wells U-7 and U-8 beginning in 2002. Since 2009 water levels in wells U-7 and U-8 are essentially unchanged. The same pattern of decreasing gradients from north to south seen on Figures 11 and 12 is even more clearly seen on Figure 13. The trend of rising water levels shown on the hydrographs for each well become progressively steeper from north to south. This pattern is also attributed to the progressive reduction in transmissivity of the upper aquifer as a result of decreasing saturated thickness and lower permeability.

Figure 14 – Upper Aquifer wells along the Northern Side of the Site (U-4, U-5, U-6 and U-7)

These wells are located along the northern margin of the site. Hydraulic gradients in the upper aquifer in this area are to the southeast and these wells represent the hydrologic conditions across the up-gradient northern boundary of Site B. As shown by the hydrographs, the rate of rise is similar in all wells. The parallel tracks of the hydrographs, especially since 1997, indicate there have been no significant changes in background hydraulic conditions over this period.

Figure 15- Upper Aquifer Wells along the Southern Limit of Saturation (UP-26, U-12, U-26, U-17)

These wells, located along the southern margin of the upper aquifer, were grouped because the water level trends in these wells affect the estimated southern limit of saturation in the upper aquifer. As shown in Figure 15, the hydrographs for this group are all similar. There was a minor change in slope in 1997 in well U-12 and in circa 2004 in wells UP-26 and U-26. There are no significant changes in slope over the period of record for U-17. Based on the smooth, consistent trend of these hydrographs, hydraulic conditions along the southern

edge of the upper aquifer have not changed significantly over the period of record. The effect of rising water levels on the southern limit of saturation is discussed more completely in the **Effects of Rising Water Levels** portion of this report.

Figures 16, 17, 18 and 19 - Missile Silo Wells (U-20, U-21, U-22, UP-6, UP-8)

These wells are grouped together in Figure 16 because of their proximity to the former missile silos in the center of the site. The pre-2001water level data set for this group of wells contains more variability in the data points than any other group of wells. The upward water level spike in U-20 (June 1997) and downward spike in U-22 (June 2000) have not been repeated and were most likely data recording or measurement errors rather than real events, although the true cause is not known. All three wells are accessed under Level C safety protocols and the added distraction and visual restrictions caused by wearing respirators may have contributed to the occasional data error. The similarity in water levels and scattering of data points causes the individual hydrographs to plot on top of each other. However, close review of the hydrographs reveal they are all similar except for late trends that appear to be developing in wells U-20 and U-21. The spacing between hydrographs has not changed significantly over the period of record, indicating hydraulic conditions in the center of the site have remained stable over the period of record. The individual hydrographs for wells at each silo wells are plotted and discussed separately on Figures 17, 18 and 19.

Figure 17 provides the hydrographs for well U-20 and nearby piezometer UP-6 at Silo 3. The source of the apparent "data noise" prior to 2001 cannot be determined, but does not affect the overall pattern shown by these hydrographs. In 1995, 1996, 1999, 2002 and 2003 water levels in both wells were essentially the same. From 2003 to 2008 the hydrographs were diverging, but since 2008 they are converging again. Since 2008, water levels in U-20 have essentially flattened out both in long term rise and short term seasonal fluctuations. The well yield in U-20 has fallen off significantly and the relatively featureless hydrograph since 2008 probably reflects the gradual sealing off of the well screen in this well. Well UP-6 provides a more reliable monitoring point for water levels at Silo 3.

Figure 18 provides the hydrograph for well U-21. Since the obvious break in slope that occurred in 1997, the hydrograph for well U-21 was reasonably smooth and consistent until the fall of 2009. Since October 2009, water level has risen 1.31 feet or approximately 5 times faster than the long term trend. The cause of this sudden increase in water levels is not known. There have not been any unusual contaminants or higher concentrations of previously detected VOCs in any of the semi-annual groundwater samples taken since 2009. During the fall 2009 groundwater sampling event, the well yield in U-21 was noted to have declined significantly from more than 1 gallon per minute to about one-quarter of a gallon per minute. The decline in well yield and sudden increase in water levels is probably related, but exactly how is not known. If a portion of the well screen became blinded off, the composite head (water level) in the well may be re-equilibrating to reflect new vertical gradients within the screened interval.

Figure 19 provides the hydrographs for wells U-22 and nearby piezometer UP-8. Since 2001 these hydrographs are almost identical, except for a consistent separation of about 0.10 feet in water level. An obvious change in slope occurred in about 1997 and a new linear trend

was re-established in about 2003. Otherwise these hydrographs indicate there has not been any change in the well or aquifer at this location over the period of record.

Water level trends in the silo wells are discussed in more detail the section of this report entitled **Projection of Water Levels versus Missile Silo Construction.**

Summary of Grouped Hydrographs for the Upper Aquifer

The rates of water level rise in the up-gradient wells across northwest and northern sides of the site have slowed considerably over the past 5 to 10 years and the rates of rise in these wells are lower than the water level rise in wells farther south and east. Consequently, gradients and calculated groundwater velocities are decreasing slightly. Most of the up-gradient wells along the northern end of the site have essentially stopped rising. The up-gradient and northern wells are completed in more productive parts of the aquifer and the increased head in these wells is continuing to be assimilated by the less productive portions of the aquifer across the southern and eastern parts of the site. Changes in water level trends for Silo Wells U-20 and U-21 since 2008 (U-20) and 2009 (U-21) appear to be coincidental with observed declining well yields, although the apparent relationship between water level trends and low well yields between the two wells is opposite. The hydrograph for U-20 suggests the well is becoming increasingly blinded off by mineralization on the well screen. At U-21, water levels are rising much faster than historical trends. The increasing rate of water level rise in U-21 is coincidental with a sudden loss of well yield, suggesting water levels in the well are reacting to a change in vertical inter-well gradients. There are insufficient data points to establish a new trend in water levels in U-21.

Lower Aquifer

Figure 20 – Lower Aquifer Wells along the Southwest to Northeast Flow line (L-38, L-35, L-33 and LP-15)

This series of wells follows down the up-gradient to down-gradient flow line for the lower aquifer. Well LP-14 was added to better illustrate up-gradient conditions in the lower aquifer. Disturbances in the hydrograph for L-38 and LP-14 in 1993 and in LP-14 and L-35 from 1998 to 2007 are due to soil loading changes as excavation and stock piling of spoils for Cells 14 and 15 were active in the vicinity of the wells. The effect of soil loading on the water levels in wells LP-14, L-35 and L-38 is more clearly seen on the individual hydrographs in Appendix A. Some of the variation in L-35 was due to difficulty in obtaining reliable water level measurements as a result of restricted access and the small diameter of this reconstructed well. Changes made to the well to improve access with the water level probe have improved the collection of reliable water levels since 2008. As can be seen from this series of wells, there has been very little effective change from up-gradient to down-gradient over the last 20 years. The down-gradient wells are rising faster than the up-gradient wells. This has the effect of slightly reduced gradients and calculated flow velocities over the past 20 years.

Figure 21 – Lower Aquifer Wells along the North Side of Cell 15 (L-38, L-35, L-36, L-41, L-37, L-42, LP-11, L-43 and L-44)

These wells are located sequentially from west to east along the north side of Cell 15. Although not as obvious on the nested hydrographs due to the vertical scale, each of these

wells shows effects of changes in soil loading; see the individual hydrographs in Appendix A. Apparent soil loading inflection points are as follows: L-38 - 1993 and 2003; L-35 - 1998 to 2007; L-36 – 1993 and 2003; L-41 – 2008; L-37 – 1998 and 2006; L-42 - 2006; LP-11 - 1997 and 2006. The hydrographs from the new Cell 15 wells (L-41, L-42, L-43 and L-44) illustrate that the water levels in these wells quickly equilibrated to, and are consistent with, the lower aquifer potentiometric surface established by the other nearby wells with longer periods of records such as LP-11, L-36 and L-37. This set of hydrographs also illustrates that although the water levels in the wells have been variably impacted by soil loading; overall there has not been any significant change in head relationships between the wells over the past 20 years.

Figure 22 – Lower Aquifer Wells along the North Side of Cell 14 (L-33, L-32, L39, L-31, L-30, L-29 and L-28)

These wells are located along an east-west line across the north side of Cell 14. The first four hydrographs (L-33, L-32, L-39 and L-31) all track identically until 2003. In 2003 the slope in the hydrograph for well L-33 flattens noticeably. There is also an inflection point to a flatter slope in the hydrograph for L-32 at this same time, but it is much less dramatic. Wells L-39 and L-31 do not show an inflection at this same time. The cause of the slope inflection in L-33 and L-32 is not known, but it did not change the hydraulic head relationships between these wells. Wells L-28, L-29 and L-30 at the east end of this line are all similar to each other, but not similar to the other four wells on this figure. All three wells have an upward inflection in 1998 and wells L-29 and L-30 have a second upward inflection in 2008. The slope increase in L-29 is of sufficient magnitude that water level in this well is now higher than L-28 and is approaching the head in L-30. These three wells are located around the northeastern corner of Cell 14 and are probably being affected by increased loading from continuing disposal and grading on Cell 14.

Figure 23 – Lower Aquifer Wells from North to South alone East Side (LP-13, LP-12, LP-15, L-29, L-28 and LP-11)

These wells are along a north-south line extending up the entire eastern side of Site B. As can be seen on Figure 23, the hydrographs for all wells tracked relatively consistently until 1998 when the first major inflection caused the hydrograph for LP-13 to flatten out. In subsequent years, as this flatter trend continued, the hydrograph for LP-13 cut across the hydrographs for wells LP-15, L-28 and L-29. This indicates the head relationship between LP-13 and these other wells became reversed between 2002 and 2006. The hydrograph for well LP-15 shows water levels in this well began to flatten out from about 2002 to 2009. In 2007, the head relationship between LP-12 and L-28 reversed. In 2008, the head relationship between LP-15 and L-29 reversed.

In 2006, water levels in LP-11 suddenly began to increase at a faster rate. Well LP-11 is located at the extreme south end of this line of wells and is located between Cells 14 and 15 (Figure 2). The increased slope in the hydrograph of this well since 2006 is a direct result of the increases in soil loading due to Cells 14 and 15.

Changes in the head relationships between these wells do not affect monitoring at the site because the wells are essentially along a single potentiometric line as illustrated by Figure 4. Changing head relationships within this group of wells is of interest because it illustrates that the head distribution in the lower aquifer is changing relatively quickly over the

southern half of the site. Figure 23 also illustrates the contrast between the head changes in the lower aquifer between the northern and southern portions of the site.

In the extreme northeast part of the site, the rate of water level rise is slowing down. The slow rate of rise in the northeast is probably associated with increased loading from the overlying upper aquifer. In the extreme southeast portion of the site, water levels are rising faster, apparently due to increased loading from Cell 14 and Cell 15.

Summary of Grouped Hydrographs for the Lower Aquifer

Most of the lower aquifer wells across Site B appear to be, or have been, impacted by changes in overburden soil loading as Cells 14 and 15 were constructed and are being filled. Up-gradient wells are rising slowly while down-gradient wells, especially those around the northeast corner of Cell 14, are rising much more quickly. The new Cell 15 monitoring wells have short term water level trends that are consistent with long term, well-established, water level trends in nearby wells. Head relationship changes evident in some hydrograph groupings illustrate the effect of temporal water level changes and variations between wells, but do not indicate a significant change in water level flow direction. Head relationships along the southwest to northeast groundwater flow line are unchanged.

Vertical Head Relationships

Figure 24 provides four sets of hydrographs for upper aquifer-lower aquifer well pairs. The top three hydrographs on this figure (U-7/LP-13, UP-4/LP-12 and LP-15/U-12) are located sequentially north to south along the east side of Site B. The UP-26/LP-27 well pair is located in the west central part of the site.

The U-7/LP-13 pair indicates that water levels in both the upper and lower aquifers have been rising in tandem and without significant deviation for the past 20 years. The head in the upper aquifer is about five feet higher than the lower. Given the similarities in the hydrographs and the geologic separation between the two wells, it appears the lower aquifer is responding to the increased head in the upper aquifer more through a loading or membrane effect rather that direct leakage of water. Beginning in 2008, the head in LP-13 began rising independently of U-7.

The UP-4/LP-12 well pair hydrographs shown on Figure 24 has an almost identical pattern to the U-7/LP-13 pair. In this well pair, the hydrographs show a uniform three feet of head difference and the same pattern of decreasing rate of rise in about 2000. As with LP-13, in 2008 the water level in LP-12 began to rise faster than UP-4 and by October 2010 there was only 0.60 feet of difference between the water levels in these wells.

The hydrographs for the U-12/LP-15 pair show the same roughly parallel tracking of water levels, including the decrease in slope in about 2000 and the increase in slope in the lower aquifer well in 2008. In this pair, the vertical head differences between the upper and lower aquifers has decreased from about 3 feet to zero over the last 20 years.

The cause of the increase in the rate of water level rise in wells LP-13, LP-12 and LP-15 since approximately 2008 is not known. It is possible that the head in these wells is also responding to the increased loading of the lower aquifer beneath Cells 14 and 15. In well LP-11 the rate of rise increased in 2007 and it may be that water levels in LP-13, LP-12 and

LP-15 also responded to this increased loading but that the response lagged and was muted by the distance from the cells.

The last well pair shown on Figure 24, UP-26/LP-27, present a completely different pattern than the first three pairs. As can be seen on this plot, the water levels in both wells were essentially the same until 2000 then the heads in the lower aquifer began to increase and the two hydrographs separated by about one foot. In 2002, the rate of water level rise in both wells flattened and from 2002 to 2010 the hydrographs for the wells are parallel and separated by about one foot.

Summary of Grouped Hydrographs for Well Pairs

The well pair hydrographs reveal that the vertical head differences between the upper and lower aquifers decrease from north to south. From about the center of the site to the south, the lower aquifer has a higher head than the upper aquifer. This pattern was identified early in the site characterization studies for Site B. However, the water level data collected over the past 20 years shows that beginning in about 2008, the heads in the lower aquifer across the eastern side of the site are increasing faster than the long term trend. Based on these data, it appears the transition from downward gradients to upward gradients has migrated northward from the historical transition point south of U-12 to an area between U-12 and UP-4.

Prior to 2008, the heads in the lower aquifer appeared to be directly correlated with the head in the overlying upper aquifer. There has never been any indication of direct leakage from the upper to the lower aquifers, which suggests the head in the lower aquifer is being influenced by the increased head in the upper aquifer through loading or by the membrane effect across the clay bed that separates the two systems. In 2008, hydraulic heads in the lower aquifer appear to have de-coupled from the upper aquifer and are responding to some other influence. The fact that all three of the lower aquifer wells across the east side of the site show this same pattern indicates that whatever changed was endemic to the aquifer and not a failure of the annular seal in each individual well. Many lower aquifer wells, particularly those around the east end of Cell 14 and associated with Cell 15, have an increase in the rate of water level rise circa 2007. This suggests that the changing water levels and head relationships, in the lower aquifer wells along the east side of the site, are also responding to the increased loading from the construction and filling of Cells 14 and 15.

Effects of Rising Groundwater at Site B

Velocity and Gradient Changes

In general, water levels in the upper aquifer on the down-gradient or east side of the site are still rising faster than those on the west and central portions of the site; although the rate of rise has decreased for both areas. This is illustrated by the different slopes of the hydrographs shown in Figure 11 and as noted in Tables 1 and 2. As discussed earlier, comparing water levels in wells U-4 and U-12 between 1990 and 2010 indicates the gradient along this flow path is about 16 percent lower in 2010 than it was in 1989. Because groundwater flow velocities are directly related to gradient, the overall velocity in the upper aquifer also has decreased 16 percent since 1990. The current rate of rise for the up-gradient wells is about one-half that of the rise in down-gradient wells, indicating gradients are continuing to decline.

Figure 20 provides hydrographs for a series of wells along a generally southwest-to-northeast (up-gradient to down-gradient) flow path across the site for the lower aquifer. The difference in rates of rise between up-gradient and down-gradient wells is evident on Figure 20 and has resulted in a decrease in gradient, and consequently, groundwater velocity across the site. Comparing water levels in wells L-38 and LP-15 between 1990 and 2010 indicates the gradient along this flow path is currently about 12 percent lower than in 1990. This implies the overall velocity in the lower aquifer also has decreased 12 percent.

Water Level Contour Maps and Flow Directions

Figures 3, 25 and 26 provide water level contour maps for the upper aquifer in 2010, 2005 and 1990, respectively. Comparison of these figures indicate that although water levels have come up over this interval, the general gradient directions and flow patterns have not changed significantly. The most significant changes have occurred over the northwestern one-quarter of the site, where gradients have flattened out, as evidenced by the larger spacing between contour lines. The other significant difference is the eastward shift of the contour lines as water levels across the site have risen. Some of the apparent differences in shape of the contours between the 1990 and later maps is due to addition of four wells (U-26, UP-26, UP-28 and UP-29), which provided additional detail to the southwest portion of the map.

Figures 4, 27 and 28 provide the water level contour maps for the lower aquifer in 2010, 2005 and 1990, respectively. Comparison of these figures reveals the overall groundwater flow direction in the lower aquifer has remained essentially the same. The additional wells installed for Cell 15 in 2003, 2005, 2007 and 2009 also provide more data on the southeast portion of the site than was available in 1990. The effect of these wells, especially L-45 and L-47 drilled in 2007 and 2009 respectively, has been to curve the water level contours across the southeastern side of the site as was suggested on Figure 27 and further confirmed and defined as shown on Figure 4. The position and shape of the 2370 contour line between

each figure illustrates the changes in the potentiometric surface for the lower aquifer over this 20 year period.

The difference in water table elevation across the site in the upper aquifer was about 24.2 feet in 2010 (25.2 feet in 2005; 28.9 feet in 1990). The elevation change in potentiometric surface across the site in the lower aquifer is currently about 72.8 feet; it was 75.66 feet in 2005 and 82.29 feet in 1990. Given these large water level differences and the relatively slow rate of water level rise in both aquifers, the general groundwater flow directions and gradients should remain stable for many years.

Comparison of Water Level Trends to Existing Well Construction

In this section projected water levels are compared to four different horizons that are potentially significant to maintaining the viability of the monitoring wells. The four well construction horizons of interest are the top of well screen, top of sand pack, bottom of steel surface casing, and bottom of PVC casing.

Top of Well Screen

The concern associated with water rising above the top of the well screen is that contaminants present at the top of the water surface will not enter the well during sampling, and therefore will not be detected. In addition, USEI's Part B permit requires the upper aquifer monitoring wells installed after the effective date of the permit (December 15, 1988) to have the well screen above the water table. The screens in the lower aquifer wells down-gradient of Cell 14 are currently fully submerged because the lower aquifer is confined and the potentiometric surface in the completed wells rises above the top of the well screen. The top of the screen in all of the new lower aquifer wells installed for Cell 15, except for L-42, are currently submerged.

Top of Sand Pack

The concerns with the sand pack becoming submerged in the upper aquifer wells is the same as for the screen; limited ability to detect potential contaminants at the top of the water column.

Bottom of Steel Surface Casing

Most wells at Site B have low carbon steel surface casing installed to various depths (typically 120 feet to 160 feet) to maintain hole stability during well construction. The wells constructed after the Part B permit was issued were designed to have only stainless steel in contact with the water. If rising groundwater contacts the steel surface casing, the release of iron may cause interference effects on the sensitive water quality analyses.

Bottom of PVC Casing

The monitoring wells installed after the permit was issued use schedule 40 PVC well casing above a section of stainless steel casing that is attached to the top of the well screen. If water levels come in contact with the PVC casing, the concern is either that contaminants may be absorbed into the casing and therefore will not be detected in the sample, or that the plastic

casing may leach compounds into the water, which interferes with or causes false positive analytical results.

Summary of Potential Impacts of Rising Water Levels on Monitoring Well Construction

Tables 4 and 5 provide the current water levels versus the identified pertinent upper aquifer and lower aquifer well construction horizons, respectively. Two projected dates are shown on Tables 4 and 5 when the water level will reach the horizon. The two projected dates are based on the regression analysis of the entire period of record and for the latest trend in data. The slopes for these projections are provided on Tables 2 and 3 and on the hydrographs in Appendix A. The actual impact to the monitoring effectiveness caused by inundation of these horizons is unknown. Several monitoring wells at Site B were pre-existing wells incorporated into the monitoring network when the Part B permit was issued. At these wells (U-1, U-20, U-21, U-22 and U-23, in addition to most of the piezometers) the water level was at or above the well screen when the well was installed.

As shown in Table 4, the first "event" affecting to upper aquifer well construction issues due to rising water levels occurred with the submergence of the well screen in well U-10 in October 2004. In October 2010, water level in U-10 was 1.5 feet above the top of the screen and 2.4 feet below the top of the sand pack. Water level is projected to reach the top of the sand pack in U-10 in 2017 to 2019, depending on the rate of rise used. Well U-10 yields just over 0.5 gallons per minute and is sampled by purging approximately 3 casing volumes before collecting the sample. During purging, the water level falls below the top of the well screen. Based on the sampling procedures required for well U-10, the current water level being slightly higher than the top of the well screen does not impact the effectiveness of this well.

As shown in Table 4, based on projections using the rate of rise over the POR, the next wells to be affected are U-7, U-11 and U-19, where the water level will rise to the level of the screen in 2015. If the more recent trends are used, the next wells in which water levels will rise above the screens are U-11 in 2016 and U-17 in 2017.

Organic compounds have been periodically detected in low part per billion levels in eight upper aquifer wells at Site B (U-1, U-6, U-20, U-21, U-22, U-23, U-24 and U-25, see Figure 2). Of these impacted wells, five have submerged screens and sand packs; U-6, U-24 and U-25 are not submerged. Based on the history of detection of organic compounds at Site B, it would appear that water level above the top of the screen and sand pack does not significantly impact the ability to detect trace levels of contaminants in the groundwater. Well U-20 is currently the most submerged with about 12.5 feet of water over the well screen and 7.5 feet of water over the sand pack.

Two of the wells with detectable organic compounds (U-1 and U-23) are constructed with PVC well screens and casing. Based on this data, water in contact with PVC does not significantly impact the effectiveness of these monitoring wells, and consequently, rising groundwater encountering this horizon does not appear to be significant.

Table 5 provides the same projections and key well construction horizons for the lower aquifer. The screen is currently submerged in all of the lower aquifer wells except L-42,

where it is 1.5 feet above the October 2010 water level. Based on projected water levels the screen in L-42 will become submerged in 2013.

Based on this analysis, it does not appear that rising water levels have had any significant effect on the ability to detect low level organic compounds in the groundwater at Site B. If water levels continue to rise and the screens become progressively more submerged, the ability to detect contaminants may be impacted in the future. However, given the slow rate of water level rise summarized on Tables 3 and 4, and the sample data that suggest wells with submerged well screens are still effective, rising water levels should not have a significant impact on the effectiveness of the Site B upper aquifer monitoring wells for many years.

It should be noted that the above projections are made from linear regression analysis of historical data and assume current straight line trends continue at the same slope into the future. As shown by the hydrographs, water level trends at Site B have changed with time. Therefore, the projected dates included in this and subsequent sections should only realistically be extended forward about 10 years.

Projections of Water Levels versus Missile Silo Construction

The three missile silos at Site B, adjacent to wells U-20, U-21 and U-22 (Figure 2), are approximately 160 feet deep. Current (October 2010) water levels are closest to the bottom of Silo 2 (9.3 feet) and farthest from Silo 1 (18.1 feet). This section of the report uses current and long term rates of water level rise in these wells to estimate the year in which water levels may reach the silos.

Two horizons were selected for analysis because of the primary concern of potential contaminant release associated with groundwater approaching and inundating the bottom of the missile silos. The bottom of the floor slab is roughly equivalent to the bottom of the construction excavation for the silo. It is likely that higher concentrations of vapors and contaminants are present in the disturbed envelope that exists around and beneath the silos. If water enters this horizon, it is likely that elevated levels of contaminants will be encountered which will likely impact groundwater quality. If water levels continue to rise until the top of the bottom slab is reached, it is possible that water will seep into the silos. If water levels rise above the bottom of the silo floor slab, water level fluctuations will create a pumping action that may significantly increase contaminant releases from the silos. Although the projected dates for water levels to reach the silos are still many years in the future, the implications of the bottom of the silos becoming inundated are significant.

Note that elevations of the bottom and top of the floor slabs in the silos used in this report were revised. The original 1999 Rising Groundwater Study did not report an elevation but gave a distance from the then current water level to these target horizons. Based on these numbers, the elevation of the top and bottom of the floor slabs were calculated and these numbers were used in subsequent updates. The previous elevations were approximately correct for the bottom elevation, but the top of the floor slab is several feet higher than was used in the previous reports. This report uses the as-built elevations provided in the original blue prints for the missile silos. The result is that it will take longer for water to reach the top of the floor slab in each silo.

Figures 17, 18, and 19 provide hydrographs for well U-20 (Silo 3), U-21 (Silo 2) and U-22 (Silo 1) respectively. Figures 17 and 19 also show the hydrographs for adjacent piezometers UP-6 at Silo 3 and UP-8 at Silo 1, respectively. The characteristics of the hydrographs for each well shown on these figures are discussed in the following paragraphs. The rate(s) of water level rise from each well is used in Table 6 to project the year when groundwater will reach the silos, assuming water levels continue to rise at current rates.

The projections provided in Table 6 were estimated by taking the difference in elevation between the October 2010 water level and pertinent silo elevations, and dividing by the rate of rise in the water table. The range of dates presented are based on using two rates of rise, one from the entire period of record (~1990-2010) and the second based on recent established trends.

The hydrographs for wells U-20 and UP-6 at Silo 3 are shown on Figure 17. The long term rate of rise for U-20, based on linear regression of all data from 1990 to 2010 is 0.0007 ft. per day (0.26 ft. per year). In 2008 the slope in U-20 decreased to about 0.04 ft. per year, but the slope in adjacent piezometer UP-6 appears unchanged. The slope in UP-6 established for the data since 2001 is 0.0005 ft. per day (0.18 ft. per year). Well U-20 is an extremely low yielding well and it is probable that the flat slope shown in the hydrograph since 2001 is related to the well screen and filter pack becoming plugged with precipitating minerals. Consequently, for the purposes of projecting future water levels in the vicinity of Silo 3, the long term slope for U-20 and the recent slope from UP-6 were used in Table 6.

Figure 18 provides the hydrograph for well U-21 at Silo 2. There are no piezometers installed at Silo 2. As can be seen from this figure, based on the overall period of record the rate of water level rise in U-21 is 0.0007 ft. per day (0.26 ft. per year). As can also be seen on this figure, from about 1997 to 2009 the hydrograph followed an approximate straight line with a slope of 0.0005 ft. per day (0.18 ft. per year). In 2009, the water level in U-21 inexplicably began to increase on a steep slope. Based on the limited data points for this period, the rate of rise since 2009 is approximately 1.4 feet per year. Well U-21 yielded more than one gallon per minute for most of its life until the spring of 2009 when yields began to fall. By the October 2009 groundwater sampling event, the yield was down to about one-quarter of a gallon per minute. The decline in yield appears to correlate with the increase in the rate of rise shown by the hydrograph on Figure 18. This relationship is counter-intuitive. It is possible that a portion of the well screen and filter pack have been blinded off by minerals and the water level in the well is establishing an equilibrium within the well bore between remaining open intervals with slightly different vertical heads. It is not likely that the recent steep water level trend in U-21 will continue, nor is it likely that water levels in the aquifer is rising this fast since no other upper aquifer wells in the area show any indication of an increased rate of water level rise. The projections shown on Table 6 use the long term rate of rise and the second slope from approximately 1997 to 2009. A separate set of projections are provided on Table 6 to illustrate the effect of using the short term rate of rise seen in well U-21 since 2009.

Figure 19 provides the hydrographs for wells U-22 and UP-8 at Silo 1. These two wells track closely together over the entire period of record. The long term rate of rise based on linear regression of the data is 0.0008 ft. per day (0.29 ft. per year). From about 2002 to present a slightly flatter trend is evident on the hydrographs for both wells. The slope for this period

is 0.0006 ft. per day (0.22 ft. per year). These two slopes are used in Table 6 to project water levels in the vicinity of Silo 1.

As shown on Table 6, assuming water levels continue rising at the same historical rate, upper aquifer water is projected to come into contact with the bottom of the floor slab in Silo 2 in 2047 if the slope for the period of record is used. If the more recent trends are used, water will reach the bottom of Silo 2 in 2075. If the steep trend evident in the last year of data continues, water levels may reach the bottom of the silo slab at Silo 2 in 2018. As discussed previously, it is likely that the relatively rapidly increasing water levels in U-21 reflect short term re-equilibration within the well and do not reflect the actual water level in the aquifer. However, there is no data available to confirm this. The earliest projected date when water will reach the bottom of the other silos is 2073 at Silo 1 and 2061 at Silo 3.

Water level will rise above the top of the floor slabs 20 to 30 years later. Except for projections based on the short term trend for water level in U-21, the projected dates shown on Table 6 when water will rise to the level of the silos are slightly farther out then the projections made in the 2005 rising groundwater update. Projections of when water levels will reach the top of the floor slab are much longer in this study than in previous reports due to the corrected floor slab elevations as discussed previously.

It is important to note that the same limitations and precautions regarding projecting forward dates from limited historical data discussed earlier also apply here. Although overall, the rate of water level rise in the upper aquifer has clearly declined, future water level trends may be significantly different than historical trends used in this analysis.

Southerly Extent of the Upper Aquifer and Cell 14 Monitoring Issues

The top of the confining bed between the upper and lower aquifer dips or slopes 2 to 5 degrees to the north-northeast. The southern limit of the upper aquifer is controlled by the intersection of the dipping stratigraphic sequences and the water table surface. Because of the dip, the water-bearing sands in the upper aquifer gradually rise above the water table and become unsaturated to the south. Currently the southern limit of saturation in the upper aquifer is projected to cross the southern portion of the site north of Cell 14. As a consequence, the lower aquifer is the "uppermost" aquifer of concern beneath Cell 14, and is therefore being correctly monitored with lower aquifer wells (See Figure 2 for the monitoring network around Cell 14).

The implication of the combination of the shallow dip of the confining bed and rising groundwater levels in the upper aquifer is that the southern limit of saturation in the aquifer migrates to the south 11 feet to 29 feet for each foot of water level rise. When well U-17 (Figure 2) was installed in 1989, the projected southern limit of the upper aquifer was about 260 feet south of the well, based on a dip of 2 degrees and 9 feet of water above the top of the confining bed reported when the well was completed. Since 1989, the water level in U-17 has risen 7.67 feet (Table 1), which implies that the southern limit of the upper aquifer has migrated about 223 feet farther south since the Part B permit was issued. At the current rate of rise in U-17 (0.37 feet per year) the southern limit of the upper aquifer is moving

Summary and Conclusions

The 2010 Re-evaluation of rising groundwater at USEI Site B was conducted in compliance with permit condition IX.J.

Water level data indicate the water surface in the upper aquifer and the potentiometric surface in the lower aquifer in general are continuing to rise although not uniformly. The range and variation in rate of rise in both aquifers is similar but not identical. In general, the rate of water level rise in the upper aquifer appears to be slowing down significantly in most wells. In the lower aquifer, water levels are steady to declining in most wells, but notably rising in several wells at the east and north central sides of Cells 14 and 15.

There has been no significant change in the direction of groundwater flow in either aquifer because of rising groundwater. Groundwater in the upper aquifer enters the site from the northwest and exits across the east side of the site. Flow in the lower aquifer comes in from the southwest and exits to the northeast.

Water levels in the more productive up-gradient wells in the upper aquifer are rising very slowly. The down-gradient wells are also still rising, but at slower rates than historical trends. This implies gradients, and therefore groundwater velocities, in the upper aquifer will continue to decrease as the down-gradient portion of the aquifer gradually equilibrates with the relatively stable up-gradient water levels.

Comparison of current water levels and projections of future water levels in the upper aquifer were used to evaluate whether, and when, rising water levels may impact the current monitoring wells. This analysis concluded that the well screen and sand pack in many of the existing wells incorporated into the monitoring well network when the Part B permit was issued have become submerged. With the exception of well U-10, monitoring wells installed after the permit was issued still have exposed screens. Water level rose above the well screen in U-10 in late 2004 and the sand pack will become submerged in 2017. Well U-10 yield slightly more than one-half gallon per minute and is pumped for three casing volumes prior to sampling. Water level in the well during pumping draws down below the top of the screen. Consequently a static water level slightly above the screen does not reduce the effectiveness of this well. Based on the current rate of water level rise, the screens in wells U-7, U-11 and U-19 will be submerged in 2015.

Five of the eight upper aquifer wells, in which organic compounds have been detected, have submerged screens. Based on this history, submerged screens do not appear to significantly impact the effectiveness of these wells. The screens in lower aquifer wells are submerged because the aquifer is confined. There are no impacts of rising potentiometric surface relative to the well screen or sand pack in these wells.

The water level trends in the monitoring wells near the missile silos were used to project when upper aquifer groundwater would reach the bottom and top of the floor slab in each silo. Based on the available data, water levels are projected to reach the bottom of the floor slab in Silo 2 in 2047 to 2075; and will reach the top of the slab 20 to 30 years later. The rate of water level rise in the silo wells has declined since 1997 and consequently these projected

dates are slightly farther into the future than those presented in the 2005 Rising Groundwater Re-evaluation or in the original 1999 rising groundwater report. In addition, the water level rise in the up-gradient upper aquifer wells has slowed considerably and the rate of rise in the silo wells should decrease in response to the flatter gradients developing across the northwest corner of the site. A significant increase in the rate of water level rise in well U-21 (Silo 2) beginning in 2009 is believed to be associated with plugging off of the well screen and filter pack with mineral precipitate and probably does not reflect the true water level in the aquifer. However, based on this rate of rise, the water level in U-21 will reach the bottom level of the bottom of the silo in 2018.

The limit of saturation in the upper aquifer theoretically moves southward 11 feet to 29 feet for each foot of rise. The southern portion of the upper aquifer has very low permeability however, and there may be a significant lag time between rising water levels and the actual migration of a saturation front. Currently, the southern limit of the aquifer is north of Cell 14. If water levels continue to rise, the southern limit of the upper aquifer may advance beneath the sumps in 15 to 95 years based on projections of water levels and geologic dips.

Conclusions from this re-evaluation of rising groundwater at Site B augment and agree with the September 1999 "Rising Groundwater Study", and the 2001, 2003 and 2005 re-evaluations of the rising groundwater at USEI Site B.

The conclusions from this report are:

- Water levels throughout most of Site B continue to rise, although not consistently with respect to each other or between aquifers.
- Water level trend data for the last 7 to 10 years indicate the rate of rise has slowed in most of the upper aquifer.
- Water levels in the lower aquifer around Cell 14 and Cell 15 appear to respond to surface loading phenomena from cell construction and filling.
- Water level trends in the lower aquifer wells range from essentially no rise to increasing rates of rise.
- The water levels in down-gradient wells in both aquifers have increased faster than the up-gradient wells, and consequently the overall gradient across the site in both aquifers has decreased 12 to 16% since 1989.
- The change in water levels has not significantly affected flow directions in either aquifer. Groundwater velocities have decreased slightly as the gradients in both aquifers have decreased. Therefore, the groundwater monitoring wells are still properly located to monitor designated waste disposal units and cell sumps.
- Overall groundwater velocities are decreasing and consequently the semi-annual sampling frequency is still appropriate.
- Groundwater may reach the bottom of missile silo 2 in 2047 to 2075 based on current projections. The projected dates for the other silos are 2061 and 2073.
- Based on recent measurements, water level in well U-21 at silo 2 is rising rapidly. At the current rate water level in the well will be at the level of the bottom of the silo in 2018. The recent rapid rate of water level rise in U-21 is probably associated with conditions in the well and not reflective of the upper aquifer at this location.

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Tables

2010 Rising Groundwater Report

Upper Aquifer Wells

Well	1st data	WL Elev.	Record (yrs.)	Feet change (POR)*	Water Level Elevations used in this Report			Feet change 1990-2010	Feet change 2005-2010	Rate of change 1990-2005 (ft/yr)	Rate of change 2005-2010 (ft/yr)	Difference in Rate of Change 2010-2005 (ft/yr)
					Oct-90	Oct-05	Oct-10					
U-1	Apr-89	2387.71	21.5	6.27	2388.36	2392.88	2393.98	5.62	1.10	0.30	0.22	-0.08
U-2	Oct-89	2389.71	21.0	5.46	2390.28	2394.20	2395.17	4.89	0.97	0.26	0.20	-0.07
U-3	Apr-89	2390.74	21.5	5.49	2391.58	2395.39	2396.23	4.65	0.84	0.25	0.17	-0.08
U-4	Apr-89	2392.45	21.5	4.88	2393.23	2396.66	2397.33	4.10	0.67	0.23	0.13	-0.09
U-5	Oct-89	2386.23	21.0	4.21	2387.23	2389.77	2390.44	3.21	0.67	0.17	0.13	-0.03
U-6	Oct-89	2379.14	21.0	4.24	2380.68	2382.98	2383.38	2.70	0.40	0.15	0.08	-0.07
U-7	Oct-89	2370.03	21.0	6.18	2371.53	2375.99	2376.21	4.68	0.22	0.30	0.04	-0.25
U-8	Oct-89	2369.09	21.0	7.08	2370.48	2375.76	2376.17	5.69	0.41	0.35	0.08	-0.27
U-9	Oct-89	2367.37	21.0	8.26	2368.60	2374.88	2375.63	7.03	0.75	0.42	0.15	-0.27
U-10	Oct-89	2365.55	21.0	9.13	2366.51	2373.47	2374.68	8.17	1.21	0.46	0.24	-0.22
U-11	Oct-89	2364.51	21.0	9.51	2365.27	2372.50	2374.02	8.75	1.52	0.48	0.31	-0.17
U-12	Oct-89	2363.70	21.0	9.40	2364.30	2371.33	2373.10	8.80	1.77	0.47	0.36	-0.11
U-17	Oct-89	2370.66	21.0	7.67	2370.82	2376.50	2378.33	7.51	1.83	0.38	0.37	-0.01
U-18	Oct-89	2371.63	21.0	8.64	2372.17	2378.70	2380.27	8.10	1.57	0.43	0.32	-0.12
U-19	Oct-89	2372.30	21.0	8.85	2373.09	2379.78	2381.15	8.06	1.37	0.44	0.28	-0.17
U-20	Oct-89	2383.00	21.0	6.11	2383.48	2388.22	2389.11	5.63	0.89	0.32	0.18	-0.14
U-21	Oct-89	2384.51	21.0	7.29	2385.01	2389.44	2391.80	6.79	2.36	0.29	0.48	0.18
U-22	Oct-89	2383.95	21.0	6.49	2384.52	2389.40	2390.44	5.92	1.04	0.32	0.21	-0.11
U-23	Apr-89	2384.81	21.5	6.71	2385.32	2390.34	2391.52	6.20	1.18	0.33	0.24	-0.10
U-24	Oct-89	2389.47	21.0	5.43	2389.99	2393.96	2394.90	4.91	0.94	0.26	0.19	-0.07
U-25	Oct-89	2385.42	21.0	6.29	2385.99	2390.63	2391.71	5.72	1.08	0.31	0.22	-0.09
U-26	May-93	2378.88	17.4	7.81		2385.32	2386.69	NA	1.37	NA	0.28	NA
UP-1	Apr-89	2370.18	21.5	9.99	2372.95	2379.60	2380.17	7.22	0.57	0.44	0.11	-0.33
UP-2	Apr-89	2389.43	21.5	5.78	2390.08	2394.12	2395.21	5.13	1.09	0.27	0.22	-0.05
UP-3	Apr-89	2385.29	21.5	6.49	2385.99	2390.68	2391.78	5.79	1.10	0.31	0.22	-0.09
UP-4	Apr-89	2362.66	21.5	12.33	2367.31	2374.13	2375.19	7.88	1.06	0.45	0.21	-0.24
UP-5	Apr-89	2368.46	21.5	7.76	2370.69	2375.88	2376.22	5.53	0.34	0.34	0.07	-0.28
UP-6	Apr-89	2382.64	21.5	6.19	2382.90	2387.85	2388.83	5.93	0.98	0.33	0.20	-0.13
UP-7	Apr-89	2383.70	21.5	5.11	2385.65	2388.00	2388.81	3.16	0.81	0.16	0.16	0.01
UP-8	Apr-89	2383.90	21.5	6.42	2384.11	2389.30	2390.32	6.21	1.02	0.34	0.21	-0.14
UP-26	Oct-92	2384.86	18.0	5.82		2389.56	2390.68	NA	1.12	NA	0.23	NA
UP-28	Oct-93	2395.36	17.0	4.49		2398.81	2399.87	NA	1.07	NA	0.21	NA
UP-29	May-93	2389.99	17.4	5.34		2394.31	2395.33	NA	1.01	NA	0.20	NA
							Maximum	8.80	2.36	0.48	0.48	0.18
							Minimum	2.70	0.22	0.15	0.04	-0.33
							Average	6.00	1.04	0.33	0.21	-0.12

Lower Aquifer Wells

Well	1st data	WL Elev.	Period of Record (yrs.)	Feet change (POR)*	Water Level Elevations used in this Report			Feet change 1990-2010	Feet change 2005-2010	Rate of change 1990-2005 (ft/yr)	Rate of change 2005-2010 (ft/yr)	Difference in Rate of Change 2010-2005 (ft/yr)
					Oct-90	Oct-05	Oct-10					
L-28	Apr-89	2362.93	21.5	12.69	2363.59	2371.51	2375.62	12.03	4.11	0.53	0.83	0.30
L-29	Apr-89	2360.95	21.5	12.86	2361.47	2369.96	2373.81	12.34	3.85	0.56	0.78	0.21
L-30	Apr-89	2363.17	21.5	11.40	2363.91	2371.35	2374.57	10.66	3.22	0.49	0.65	0.15
L-31	Apr-91	2372.25	19.5	7.73		2378.01	2379.98	NA	1.97	NA	0.40	NA
L-32	Oct-93	2376.62	17.0	8.31		2383.44	2384.93	NA	1.49	NA	0.30	NA
L-33	Oct-93	2378.66	17.0	9.09		2386.69	2387.75	NA	1.06	NA	0.21	NA
L-35	Apr-89	2421.87	21.5	4.62	2421.23	2423.42	2426.49	5.26	3.07	0.15	0.62	0.47
L-36	Apr-89	2409.40	21.5	9.41	2409.02	2417.11	2418.81	9.79	1.70	0.54	0.34	-0.20
L-37	Apr-89	2382.64	21.5	12.04	2383.61	2389.07	2394.68	11.07	5.61	0.36	1.13	0.77
L-38	Apr-89	2443.54	21.5	2.39	2443.65	2445.67	2445.93	2.28	0.26	0.13	0.05	-0.08
L-39	Apr-89	2373.76	21.5	9.09	2374.92	2380.96	2382.85	7.93	1.89	0.40	0.38	-0.02
L-41	Oct-03	2397.84	7.0	7.48		2400.74	2405.32	NA	4.58	NA	0.92	NA
L-42	Oct-03	2377.73	7.0	7.13		2380.13	2384.86	NA	4.73	NA	0.95	NA
L-43	Oct-05	2369.70	5.0	5.57		2369.70	2375.27	NA	5.57	NA	1.12	NA
L-44	Oct-05	2367.34	5.0	6.38		2367.34	2373.72	NA	6.38	NA	1.29	NA
L-45	Nov-07	2374.16	2.9	3.12			2377.28	NA	NA	NA	NA	NA
L-46 [Pa]	Oct-03	2383.26	7.0	NA		2399.24		NA	NA	NA	NA	NA
L-47	May-09	2388.60	1.4	1.97			2390.57	NA	NA	0.00	NA	NA
LP-11	Apr-89	2370.50	21.5	9.75	2371.22	2375.73	2380.25	9.03	4.52	0.30	0.91	0.61
LP-12	Oct-90	2364.23	20.0	9.45	2364.23	2371.99	2373.68	9.45	1.69	0.52	0.34	-0.18
LP-13	Apr-89	2362.80	21.5	8.00	2364.33	2370.00	2370.80	6.47	0.80	0.38	0.16	-0.22
LP-14	Apr-89	2418.34	21.5	1.42	2418.08	2418.91	2419.76	1.68	0.85	0.06	0.17	0.12
LP-15	Oct-89	2360.71	21.0	12.47	2361.36	2370.39	2373.18	11.82	2.79	0.60	0.56	-0.04
LP-27	Oct-92	2385.16	18.0	6.12		2390.45	2391.28	NA	0.83	NA	0.17	NA
							Maximum	12.34	6.38	0.60	1.29	0.77
							Minimum	1.68	0.26	0.00	0.05	-0.22
							Average	8.45	2.90	0.36	0.58	0.15

Notes:
POR= Period of record.
pa = Plugged and abandoned, Feb 2009.
NA = Data not available.

Table 1
Historical Water Level Change
in the Upper and Lower Aquifers
US Ecology Idaho - Site B

	Regression slope (ft/day)			Slope	Rate of Rise (ft/yr)***			Comparison of Latest ROR vs	
	POR*	2005 update	Latest**	Inflections	POR*	2005	Latest**	POR	2005
Upper Aquifer Monitoring Wells									
U-1	0.0008	0.0006	0.0006	1997	0.29	0.22	0.22	-0.07	0.00
U-2	0.0006	0.0005	0.0005	1997	0.22	0.18	0.18	-0.04	0.00
U-3	0.0006	0.0005	0.0004	1997	0.22	0.18	0.15	-0.07	-0.04
U-4	0.0006	0.0003	0.0003	1997, 2005	0.22	0.11	0.11	-0.11	0.00
U-5	0.0004	0.0002	0.0003	1997	0.15	0.07	0.11	-0.04	0.04
U-6	0.0003	0.0001	0.0001	1997	0.11	0.03	0.04	-0.07	0.01
U-7	0.0005	0.0001	0.0001	1997	0.18	0.04	0.04	-0.15	0.00
U-8	0.0007	0.0003	0.0003	1997	0.26	0.11	0.11	-0.15	0.00
U-9	0.0009	0.0006	0.0004	1997	0.33	0.22	0.15	-0.18	-0.07
U-10	0.0011	0.0009	0.0008	1997	0.40	0.33	0.29	-0.11	-0.04
U-11	0.0012	0.0011	0.0009	1997	0.44	0.40	0.33	-0.11	-0.07
U-12	0.0012	0.0011	0.0010	1997	0.44	0.40	0.37	-0.07	-0.04
U-17	0.0010	0.0011	0.0010	1997	0.37	0.40	0.37	0.00	-0.04
U-18	0.0011	0.0010	0.0009	1997	0.40	0.37	0.33	-0.07	-0.04
U-19	0.0011	0.0009	0.0008	1997	0.40	0.33	0.29	-0.11	-0.04
U-20	0.0008	0.0006	0.0001	2008	0.29	0.22	0.04	-0.26	-0.18
U-21****	0.0007	0.0005	0.0005	1997, 2009	0.26	0.18	0.18	-0.07	0.00
U-22	0.0007	0.0007	0.0006	1997	0.26	0.26	0.22	-0.04	-0.04
U-23	0.0008	0.0007	0.0006	1997	0.29	0.26	0.22	-0.07	-0.04
U-24	0.0006	0.0005	0.0005	1997	0.22	0.18	0.18	-0.04	0.00
U-25	0.0008	0.0006	0.0006	1997	0.29	0.22	0.22	-0.07	0.00
Upper Aquifer Piezometers									
U-26	0.0012	0.0014	0.0007	2005	0.44	0.51	0.26	-0.18	-0.26
UP-1	0.0010	0.0004	0.0004	1997	0.37	0.15	0.15	-0.22	0.00
UP-2	0.0007	0.0005	0.0005	1997	0.26	0.18	0.18	-0.07	0.00
UP-3	0.0008	0.0006	0.0006	1997	0.29	0.22	0.22	-0.07	0.00
UP-4	0.0012	0.0009	0.0006	2000	0.44	0.33	0.22	-0.22	-0.11
UP-5	0.0008	0.0003	0.0002	1997, 2003	0.29	0.11	0.07	-0.22	-0.04
UP-6	0.0008	0.0006	0.0005	1997	0.29	0.22	0.18	-0.11	-0.04
UP-7	0.0004	0.00008	0.0002	1997	0.15	0.03	0.07	-0.07	0.04
UP-8	0.0008	0.0006	0.0006	1997	0.29	0.22	0.22	-0.07	0.00
UP-26	0.0009	0.0011	0.0006	2004	0.33	0.40	0.22	-0.11	-0.18
UP-28	0.0008	0.0008	0.0005	2003	0.29	0.29	0.18	-0.11	-0.11
UP-29	0.0008	0.0008	0.0005	2004	0.29	0.29	0.18	-0.11	-0.11
				Maximum	0.44	0.51	0.37	0.00	0.04
				Minimum	0.11	0.03	0.04	-0.26	-0.26
				Average	0.30	0.23	0.19	-0.11	-0.04

* POR = Period of Record.

** = Slope and rate of rise based on last 5 to 15 years (see individual hydrographs).

*** = Regression slope x 365.25 days.

**** Water level in U-21 began rising rapidly in late 2009. Insufficient data to develop a trend or slope analysis. Latest slope and ROR for U-21 do not reflect this recent development.

Minus values in comparison columns indicate the rate of rise is less than earlier values.

Table 2
Rates of Water Level Rise
in the Upper Aquifer
US Ecology Idaho - Site B

	Regression slope (ft/day)				Rate of Rise (ft/yr)***			Comparison of Latest ROR vs	
	POR*	2005 update	Latest**	Slope Inflections	POR*	2005	Latest**	POR	2005
Lower Aquifer Monitoring Wells									
L-28	0.0016	0.0017	0.0018	1997	0.58	0.62	0.66	0.07	0.04
L-29	0.0016	0.0017	0.0028	1997, 2008	0.58	0.62	1.02	0.44	0.40
L-30	0.0014	0.0016	0.0021	2007	0.51	0.58	0.77	0.26	0.18
L-31	0.0011	0.0011	0.0011	none	0.40	0.40	0.40	0.00	0.00
L-32	0.0012	0.0005	0.0007	2003	0.44	0.18	0.26	-0.18	0.07
L-33	0.0014	0.00008	0.0005	2003	0.51	0.03	0.18	-0.33	0.15
L-35	0.0007	NT	0.0004	1998, 2007	0.26	NA	0.15	-0.11	NA
L-36	0.0016	0.0018	0.0010	1993, 2002, 2004	0.58	0.66	0.37	-0.22	-0.29
L-37	0.0013	0.0002	0.0020	1998, 2003, 2006, 2008	0.47	0.07	0.73	0.26	0.66
L-38	NT	NT	0.0001	1993, 2005	NA	NA	0.04	NA	NA
L-39	0.0011	0.0012	0.0011	none	0.40	0.44	0.40	0.00	-0.04
L-41	0.0030	NW	0.0013	2008	1.10	NA	0.47	-0.62	NA
L-42	0.0025	NW	0.0025	2006	0.91	NA	0.91	0.00	NA
L-43	0.0030	NW	0.0030	none	1.10	NA	1.10	0.00	NA
L-44	0.0035	NW	0.0035	none	1.28	NA	1.28	0.00	NA
L-45	0.0028	NW	0.0028	none	1.02	NA	1.02	0.00	NA
L-46	NA	NW, PA	NA	none	NA	NA	NA	NA	NA
L-47	0.0037	NW	0.0037	none	1.35	NA	1.35	0.00	NA
Lower Aquifer Piezometers									
LP-11	0.0010	0.0007	0.0028	1994, 2006	0.37	0.26	1.02	0.66	0.77
LP-12	0.0012	0.0008	0.0008	2000	0.44	0.29	0.29	-0.15	0.00
LP-13	0.0009	0.0003	0.0006	2000, 2007	0.33	0.11	0.22	-0.11	0.11
LP-14	NT	NT	0.0004	2004	NA	NA	0.15	NA	NA
LP-15	0.0016	0.0012	0.0017	2006	0.58	0.44	0.62	0.04	0.18
LP-27	0.0011	0.0013	0.0005	2003	0.40	0.47	0.18	-0.22	-0.29
				Maximum	1.35	0.66	1.35	0.66	0.77
				Minimum	0.26	0.03	0.04	-0.62	-0.29
				Average	0.65	0.37	0.59	-0.01	0.14

Notes:

* = Period of Record.

** = Slope and rate of rise based on last 5 to 7 years (see individual hydrographs).

NT = Data did not form defineable trend.

NA = Not available.

NW = New well, not available in 2005.

PA = plugged and abandoned, February 2009.

Minus values in comparison columns indicate the rate of rise is less than earlier values.

Table 3
Rates of Water Level Rise
in the Lower Aquifer
US Ecology Idaho - Site B

	Rate of Rise		Fall 2010 water level vs top of screen (ft)	Year water level reaches top of screen		Fall 2010 water level vs top of sand pack (ft)	Year water level reaches top of sand pack		Fall 2010 water level vs bottom of surface casing (ft)	Year water level reaches bottom of surface casing		Fall 2010 water level vs PVC to SS Joint (ft)	Year water level reaches PVC to SS Joint	
	POR	RT												
Upper Aquifer Wells														
U-1	0.29	0.22	7.3	UW	UW	4.3	UW	UW	-53.4	2194	2254	PVC	UW	UW
U-2	0.22	0.18	-9.5	2054	2063	-14.4	2077	2090	-17.9	2092	2109	-30.7	2151	2179
U-3	0.22	0.15	-7.2	2044	2060	-10.8	2060	2085	-12.1	2066	2093	-7.2	2044	2060
U-4	0.22	0.11	-3.1	2025	2039	-6.8	2042	2073	-11.3	2062	2114	-23.1	2116	2222
U-5	0.15	0.11	-14.8	2113	2146	-17.0	2128	2166	-20.5	2152	2198	-34.8	2249	2329
U-6	0.11	0.04	-1.7	2027	2058	-4.2	2049	2126	-3.9	2047	2118	-21.7	2209	2605
U-7	0.18	0.04	-0.7	2015	2031	-5.7	2042	2168	-27.5	2162	2765	-20.9	2126	2584
U-8	0.26	0.11	-2.4	2020	2033	-6.8	2036	2073	-25.8	2112	2246	-22.6	2099	2217
U-9	0.33	0.15	-9.3	2039	2075	-11.3	2045	2088	-13.7	2053	2105	-29.3	2100	2212
U-10	0.40	0.29	1.5	UW	UW	-2.4	2017	2019	-19.1	2059	2076	-18.6	2057	2075
U-11	0.44	0.33	-1.8	2015	2018	-6.8	2026	2032	-22.5	2062	2079	-21.8	2061	2077
U-12	0.44	0.37	-4.6	2022	2024	-9.4	2032	2037	-25.1	2068	2080	-24.6	2067	2078
U-17	0.37	0.37	-2.3	2017	2017	-6.3	2028	2028	-35.5	2108	2108	-22.6	2073	2073
U-18	0.40	0.33	-3.4	2020	2021	-7.1	2029	2033	-35.1	2098	2118	-23.6	2070	2083
U-19	0.40	0.29	-1.4	2015	2016	-5.3	2024	2029	-13.3	2044	2056	-21.7	2065	2085
U-20	0.29	0.04	12.5	UW	UW	7.5	UW	UW	-154.5	2540	6240	St	UW	UW
U-21	0.26	0.18	11.0	UW	UW	6.0	UW	UW	-154.0	2613	2854	St	UW	UW
U-22	0.25	0.22	6.3	UW	UW	3.8	UW	UW	-170.7	2679	2790	St	UW	UW
U-23	0.29	0.22	4.9	UW	UW	2.9	UW	UW	-37.3	2139	2181	PVC	UW	UW
U-24	0.22	0.18	-4.2	2030	2034	-8.8	2051	2059	-10.2	2057	2067	-26.2	2130	2154
U-25	0.29	0.22	-6.0	2031	2038	-9.8	2044	2056	-15.5	2064	2082	-26.0	2100	2129
Upper Aquifer Piezometers														
U-26	0.44	0.26	-7.5	2028	2040	-11.2	2036	2055	-61.1	2150	2250	-12.5	2039	2060
UP-1	0.37	0.15	11.9	UW	UW	1.9	UW	UW	-59.3	2173	2417	PVC	UW	UW
UP-2	0.26	0.18	10.2	UW	UW	8.2	UW	UW	-136.8	2546	2760	PVC	UW	UW
UP-3	0.29	0.22	9.8	UW	UW	6.8	UW	UW	-35.1	2131	2171	PVC	UW	UW
UP-4	0.44	0.22	27.9	UW	UW	11.9	UW	UW	-59.2	2146	2281	PVC	UW	UW
UP-5	0.29	0.07	11.8	UW	UW	-3.2	2022	2055	-44.4	2163	2619	PVC	UW	UW
UP-6	0.29	0.15	5.0	UW	UW	2.5	UW	UW	-16.6	2068	2102	SST	UW	UW
UP-7	0.15	0.07	4.3	UW	UW	-15.7	2119	2226	-29.7	2214	2418	PVC	UW	UW
UP-8	0.29	0.22	8.5	UW	UW	7.5	UW	UW	-14.3	2060	2076	3.5	UW	UW
UP-26	0.33	0.22	16.0	UW	UW	11.0	UW	UW	-45.0	2148	2217	PVC	UW	UW
UP-28	0.29	0.18	2.8	UW	UW	-3.2	2022	2029	-50.7	2185	2289	PVC	UW	UW
UP-29	0.29	0.15	9.5	UW	UW	4.2	UW	UW	-19.7	2078	2119	PVC	UW	UW

Notes:

Rate of Rise from Table 2 in feet per year

POR= Period of Record, RT = Recent trend, NT = No trend

Negative number is the feet water level is currently below the well construction interval of interest.

First date is based on rate of water level rise over period of record (~1989-2010); second date is based on rate of water level rise ~1997-2010.

UW (under water); water level is currently above the well construction interval of interest.

NA = not applicable.

PVC is all PVC construction.

SST is all stainless steel construction.

St is steel to stainless steel construction.

Table 4

Water Levels versus Construction of Upper Aquifer Wells

US Ecology Idaho - Site B

	Rate of Rise		Fall 2010 water level vs top of screen (ft)	Year water level reaches top of screen		Fall 2010 water level vs top of sand pack (ft)	Year water level reaches top of sand pack		Fall 2010 water level vs bottom of surface casing (ft)	Year water level reaches bottom of surface casing		Fall 2010 water level vs PVC to SS Joint (ft)	Year water level reaches PVC to SS Joint	
	POR	RT												
Lower Aquifer Wells														
L-28	0.58	0.66	21.0	UW	UW	16.7	UW	UW	-79.3	2147	2132	-9.0	2026	2025
L-29	0.58	1.02	15.9	UW	UW	12.8	UW	UW	-62.1	2117	2072	-14.1	2035	2025
L-30	0.51	0.77	31.9	UW	UW	28.1	UW	UW	-56.7	2122	2085	-8.1	2027	2022
L-31	0.40	0.40	28.7	UW	UW	25.7	UW	UW	-64.4	2171	2171	8.7	UW	UW
L-32	0.44	0.26	34.2	UW	UW	30.2	UW	UW	-64.9	2159	2265	4.2	UW	UW
L-33	0.51	0.18	36.5	UW	UW	34.5	UW	UW	-62.4	2133	2353	6.5	UW	UW
L-35	0.26	0.15	19.1	UW	UW	13.6	UW	UW	-90.9	2367	2633	-0.9	2014	2017
L-36	0.58	0.37	27.7	UW	UW	23.7	UW	UW	-97.0	2177	2277	PVC	NA	NA
L-37	0.47	0.73	15.6	UW	UW	10.6	UW	UW	-115.8	2255	2170	PVC	NA	NA
L-38	NT	0.04	27.9	UW	UW	1.9	UW	UW	-28.2	NA	2784	PVC	NA	NA
L-39	0.40	0.40	27.6	UW	UW	23.7	UW	UW	-107.5	2279	2279	-2.4	2017	2017
L-41	1.10	0.47	4.9	UW	UW	-1.4	2012	2014	-51.0	2058	2118	-37.3	2045	2090
L-42	0.91	0.91	-1.5	2013	2013	-9.1	2021	2021	-70.2	2088	2088	-41.7	2057	2057
L-43	1.10	1.10	12.7	UW	UW	7.1	UW	UW	-44.4	2052	2052	-27.3	2036	2036
L-44	1.28	1.28	16.1	UW	UW	10.5	UW	UW	-53.9	2053	2053	-23.9	2030	2030
L-45	1.02	1.02	16.8	UW	UW	9.7	UW	UW	-38.4	2049	2049	-33.2	2043	2043
L-47	1.35	1.35	44.8	UW	UW	38.8	UW	UW	-25.6	2030	2030	4.8	UW	UW
Lower Aquifer Piezometers														
LP-11	0.37	1.02	8.6	UW	UW	8.1	UW	UW	-106.4	2302	2115	PVC	NA	NA
LP-12	0.44	0.29	73.9	UW	UW	65.6	UW	UW	-62.4	2153	2225	PVC	NA	NA
LP-13	0.33	0.22	91.0	UW	UW	83.8	UW	UW	-52.8	2172	2252	PVC	NA	NA
LP-14	NT	0.15	22.9	UW	UW	18.7	UW	UW	-28.3	NA	2205	PVC	NA	NA
LP-15	0.58	0.62	57.9	UW	UW	51.7	UW	UW	-68.4	2128	2121	PVC	NA	NA
LP-27	0.40	0.18	72.5	UW	UW	65.3	UW	UW	-45.5	2124	2260	PVC	NA	NA

Notes:

Rate of Rise from Table 3 in feet per year

POR= Period of Record, RT = Recent trend, NT = No trend

Negative number is the feet water level is currently below the well construction interval of interest.

First date is based on rate of water level rise over period of record (~1989-2010); second date is based on rate of water level rise ~1997-2010.

UW (under water); water level is currently above the well construction interval of interest.

NA = not applicable.

PVC is all PVC construction.

SST is all stainless steel construction.

St is steel to stainless steel construction.

Table 5

Water Levels versus Construction of Lower Aquifer Wells

US Ecology Idaho - Site B

	Silo 1 (U-22)	Silo 2[3] (U-21)	Silo 2[4] (U-21)	Silo 3 (U-20)
Elev. of bottom of silo floor slab	2408.5	2401.1	2401.1	2402.0
Elev. of top of silo floor slab	2414.5	2407.0	2407.0	2408.0
October 2005 WL	2389.40	2389.44	2389.44	2388.20
October 2010 WL	2390.44	2391.80	2391.80	2389.11
Rate of Rise for the POR (ft/yr)[1]	0.29	0.26		0.26
Recent Rate of Rise (ft/yr)[2]	0.22	0.18	1.38	0.18
Fall 2010 water level vs bottom of silo floor slab (ft)	-18.1	-9.3	-9.3	-12.9
Year water level reaches bottom of silo based on POR	2073	2047	2018	2061
Year water level reaches bottom of silo based on Recent ROR	2098	2075	2019	2088
Fall 2010 water level vs top of silo floor slab (ft)	-24.1	-15.2	-15.2	-18.9
Year water level reaches top of silo floor slab[1]	2094	2070	2022	2084
Year water level reaches top of silo floor slab[2]	2126	2107	2024	2121

Notes:

1. Based on rate of water level rise over period of record (~1989-2010).
2. Based on rate of water level rise in last several years (see individual hydrographs)
3. Water level in U-21 began rising rapidly in late 2009. Insufficient data to develop a trend or slope analysis. Included in POR slope but recent ROR for U-21 does not reflect this recent development.
4. Based on water level measurements from Oct. 2009 through Oct. 2010 the rate of rise in U-21 is 1.38 ft./yr. This trend is not long enough to reliably establish a true rate of rise for projection into the future but the results are shown here because of the significant decrease in time before water rises to the silo if this trend continues.

POR = Period of Record, ROR = rate of rise.

Table 6
Rising Water Levels Compared to Missile Silo Construction
US Ecology Idaho - Site B

Figures

2010 Rising Groundwater Report

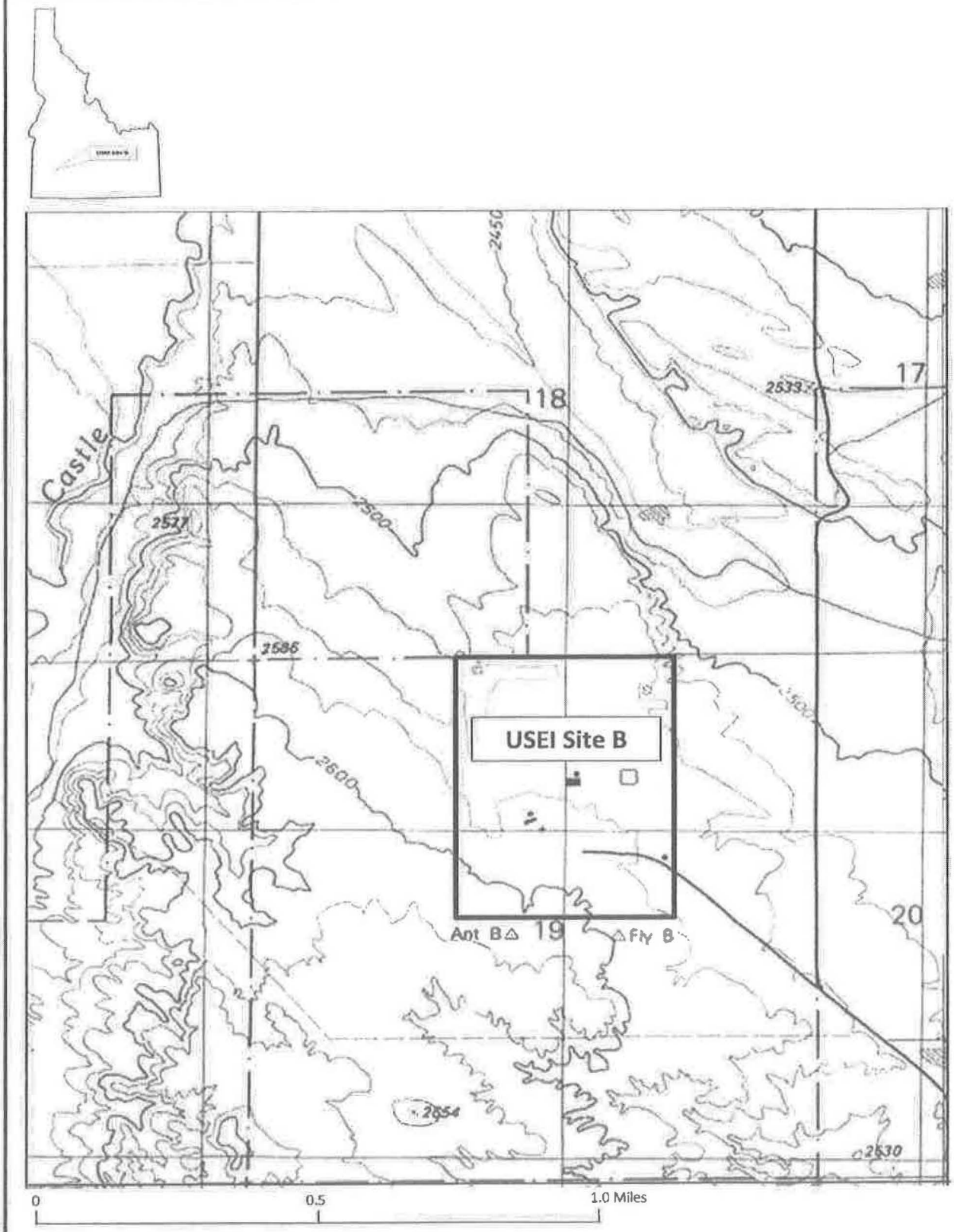


Figure 1
General Location and Local Topographic Features
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

Feast Geosciences, LLC

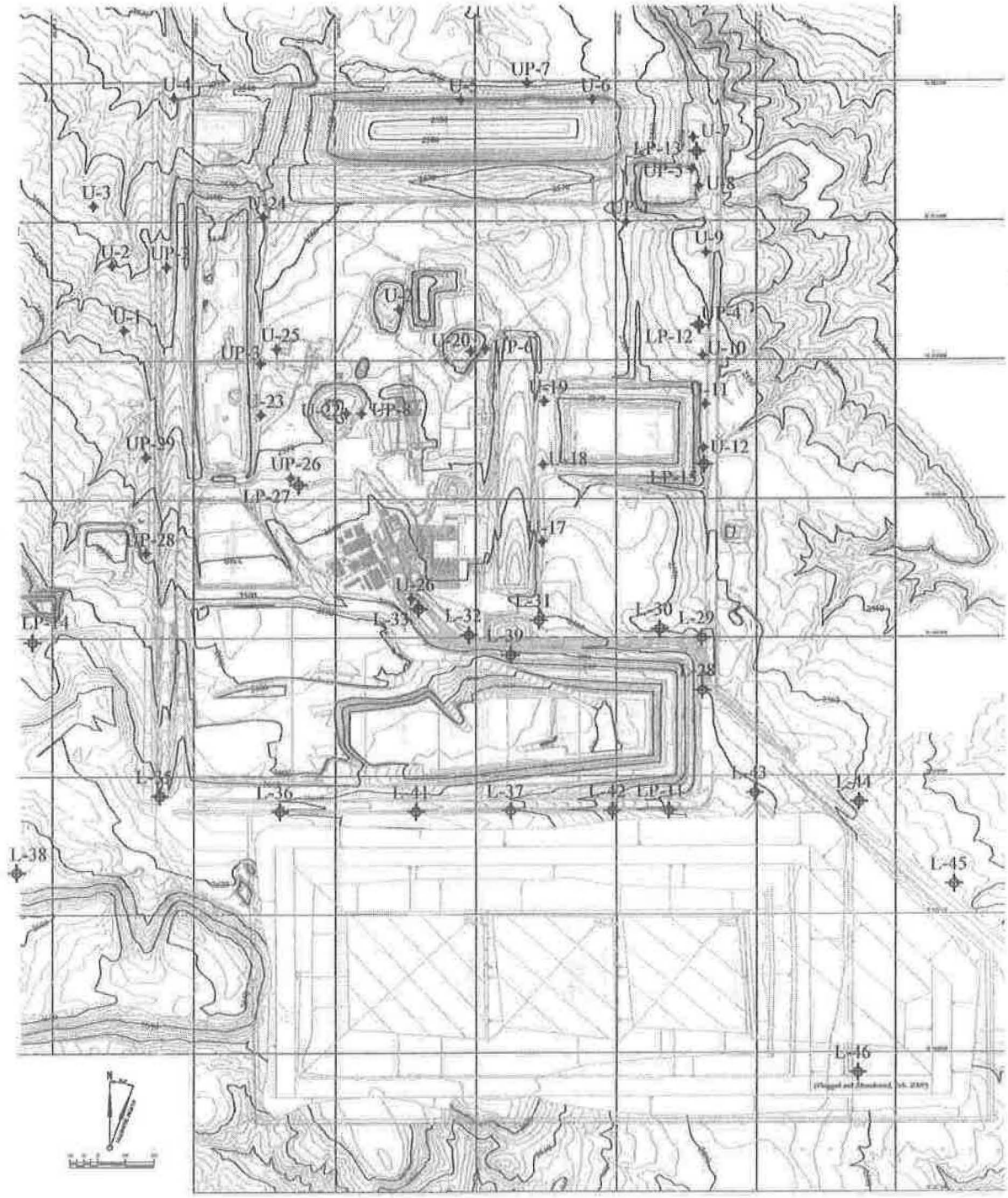


Figure 2
Location of Monitoring Wells and Piezometers at US Ecology Idaho, Site B
2010 Rising Groundwater Study

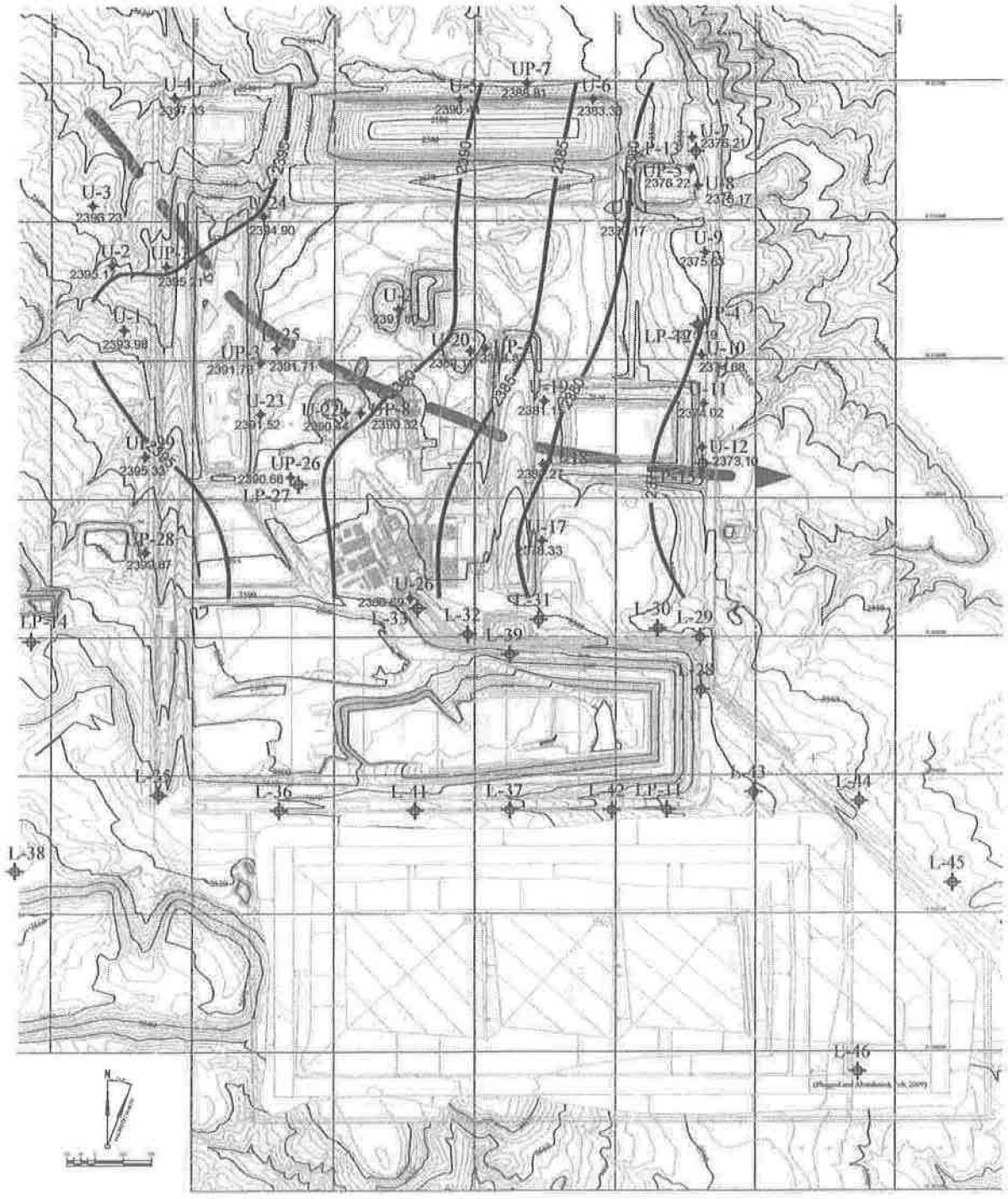


Figure 3
Upper Aquifer Piezometric Surface for October 4, 2010
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

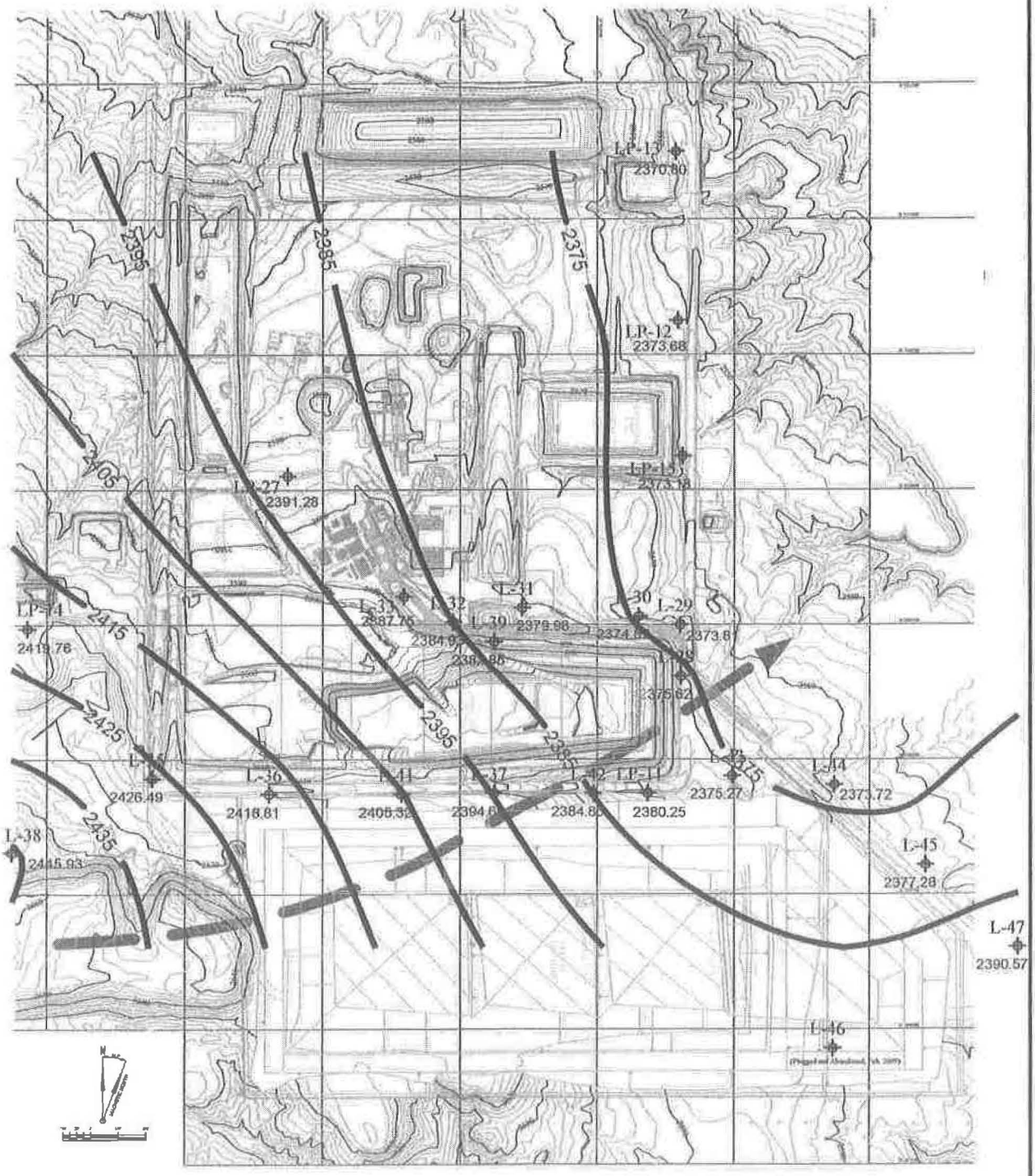


Figure 4
Lower Aquifer Potentiometric Surface for October 4, 2010
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

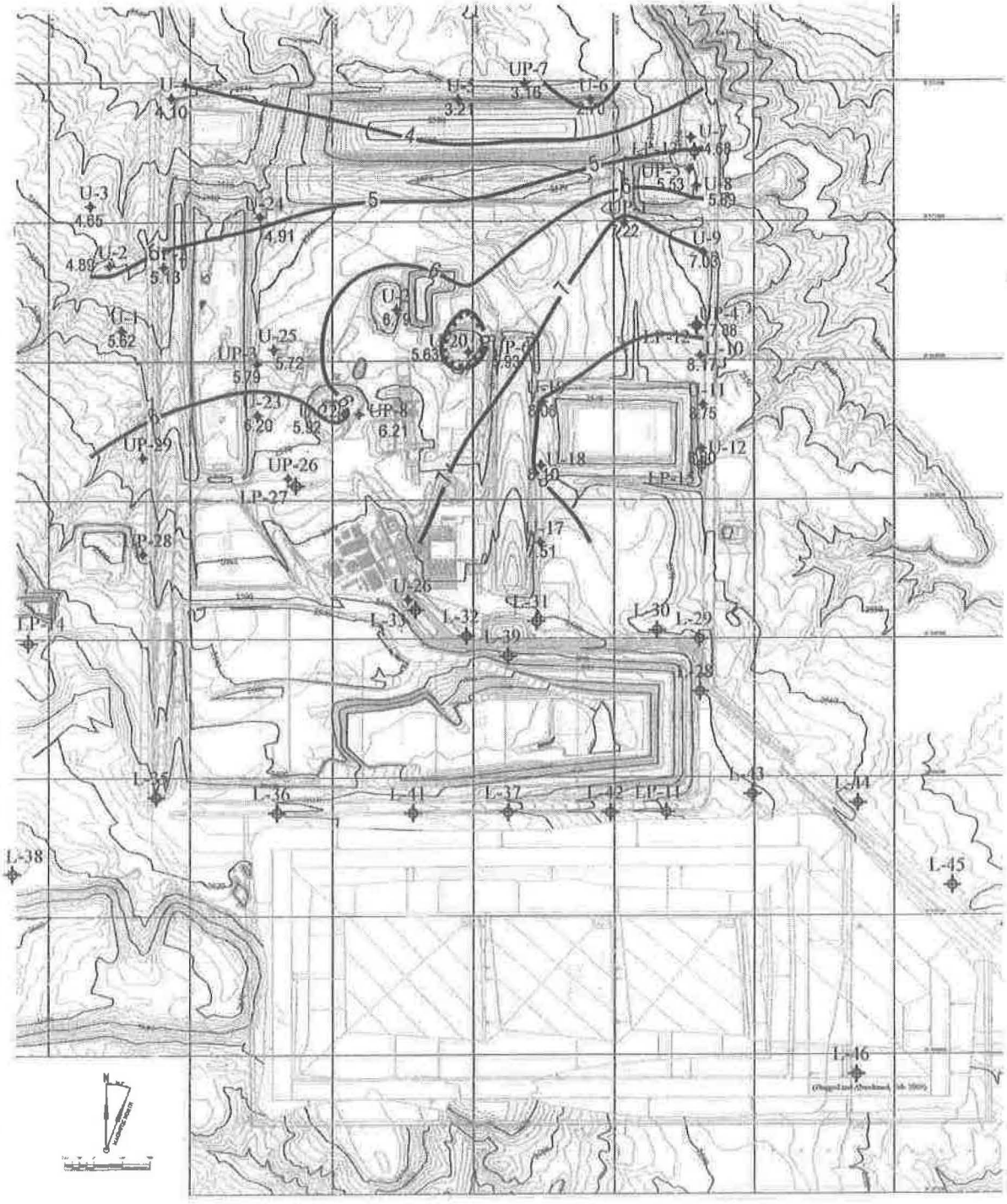


Figure 5
Water Level Rise in the Upper Aquifer
From Oct. 1990 to Oct. 2010 (in feet)
US Ecology Idaho, Site B
2010 Rising Groundwater Study

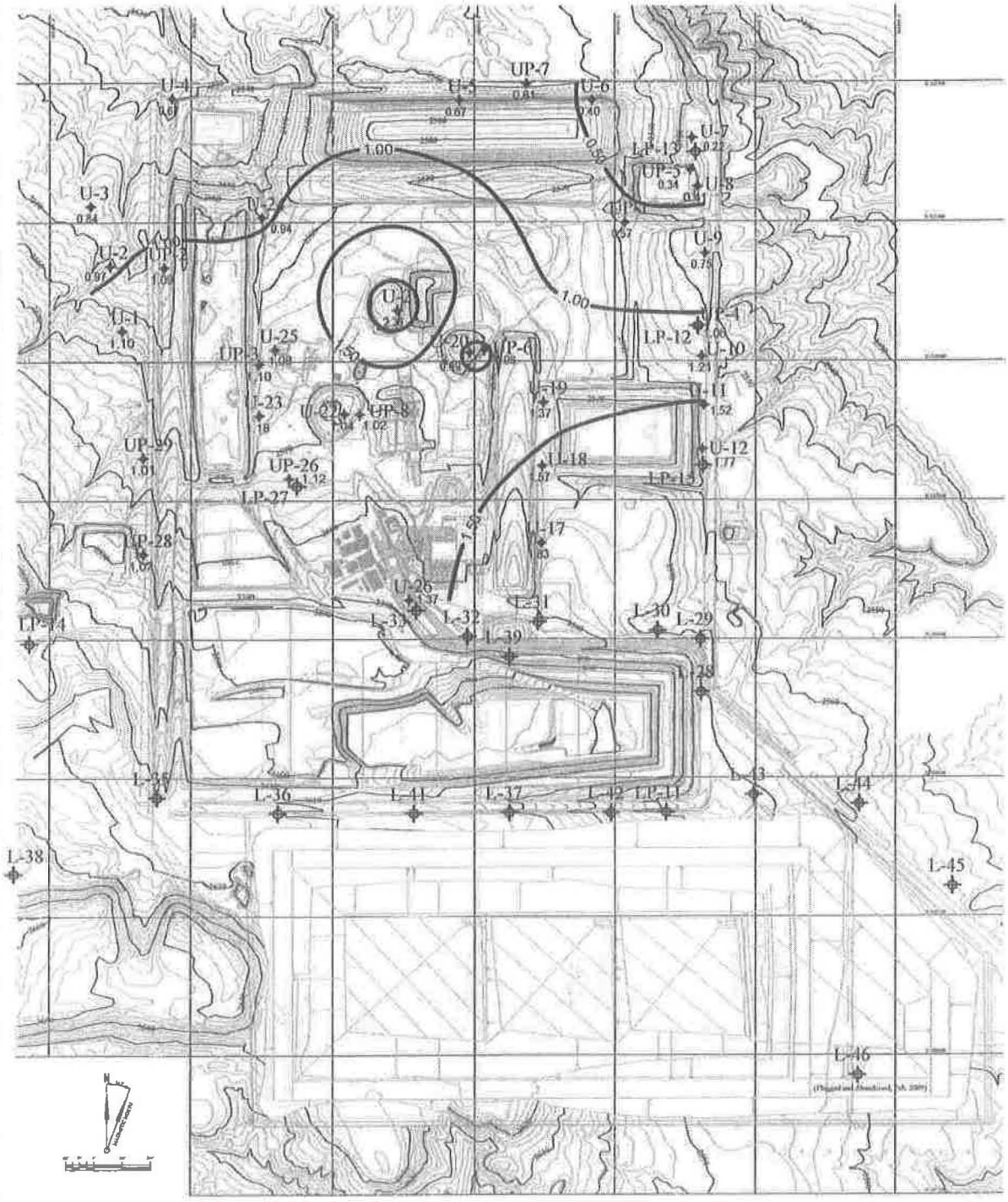


Figure 6
Water Level Rise in the Upper Aquifer
From Oct. 2005 to Oct. 2010 (in feet)
US Ecology Idaho, Site B
2010 Rising Groundwater Study

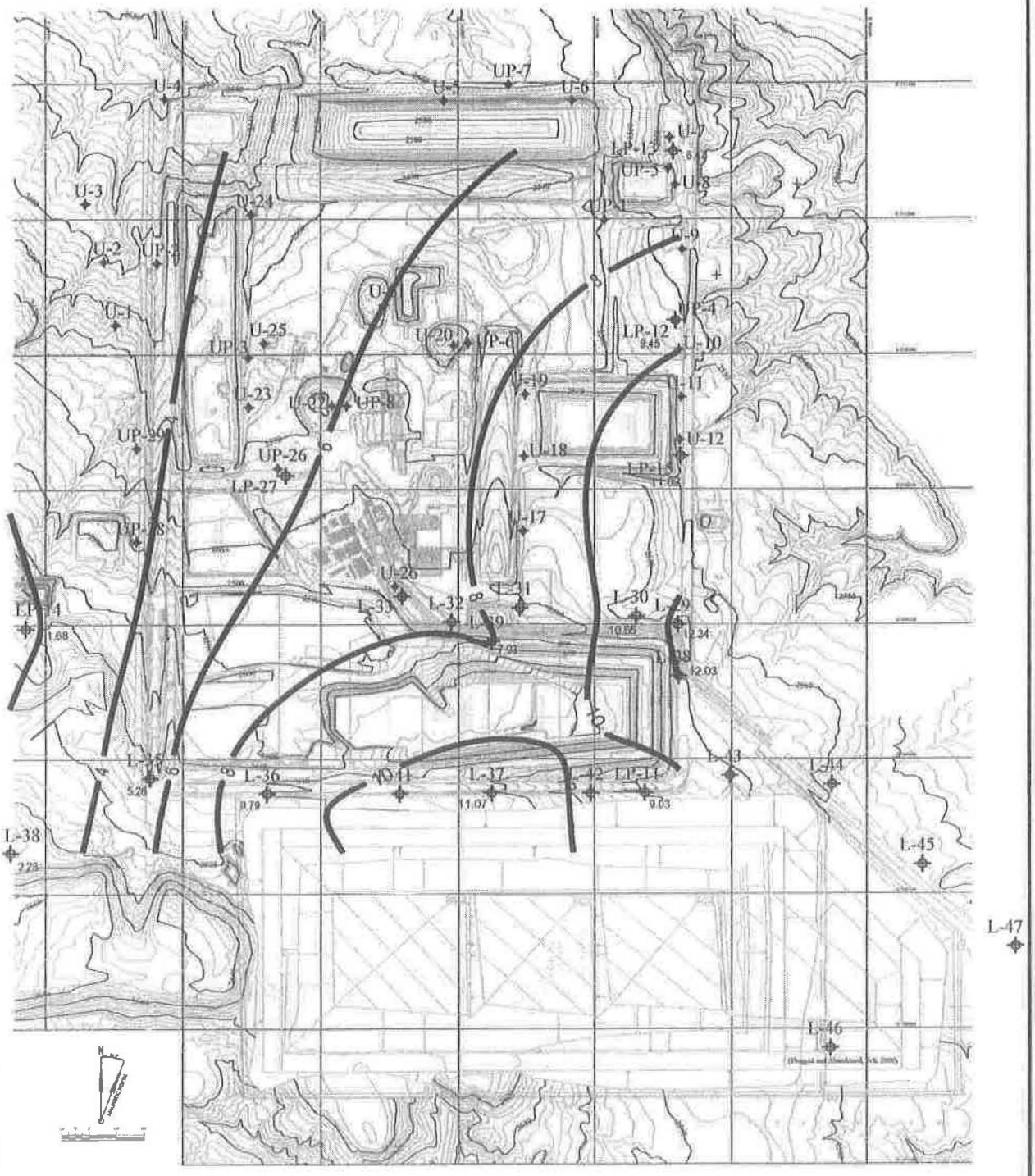


Figure 7
Water Level Rise in the Lower Aquifer
From Oct. 1990 to Oct. 2010 (in feet)
US Ecology Idaho, Site B
2010 Rising Groundwater Study

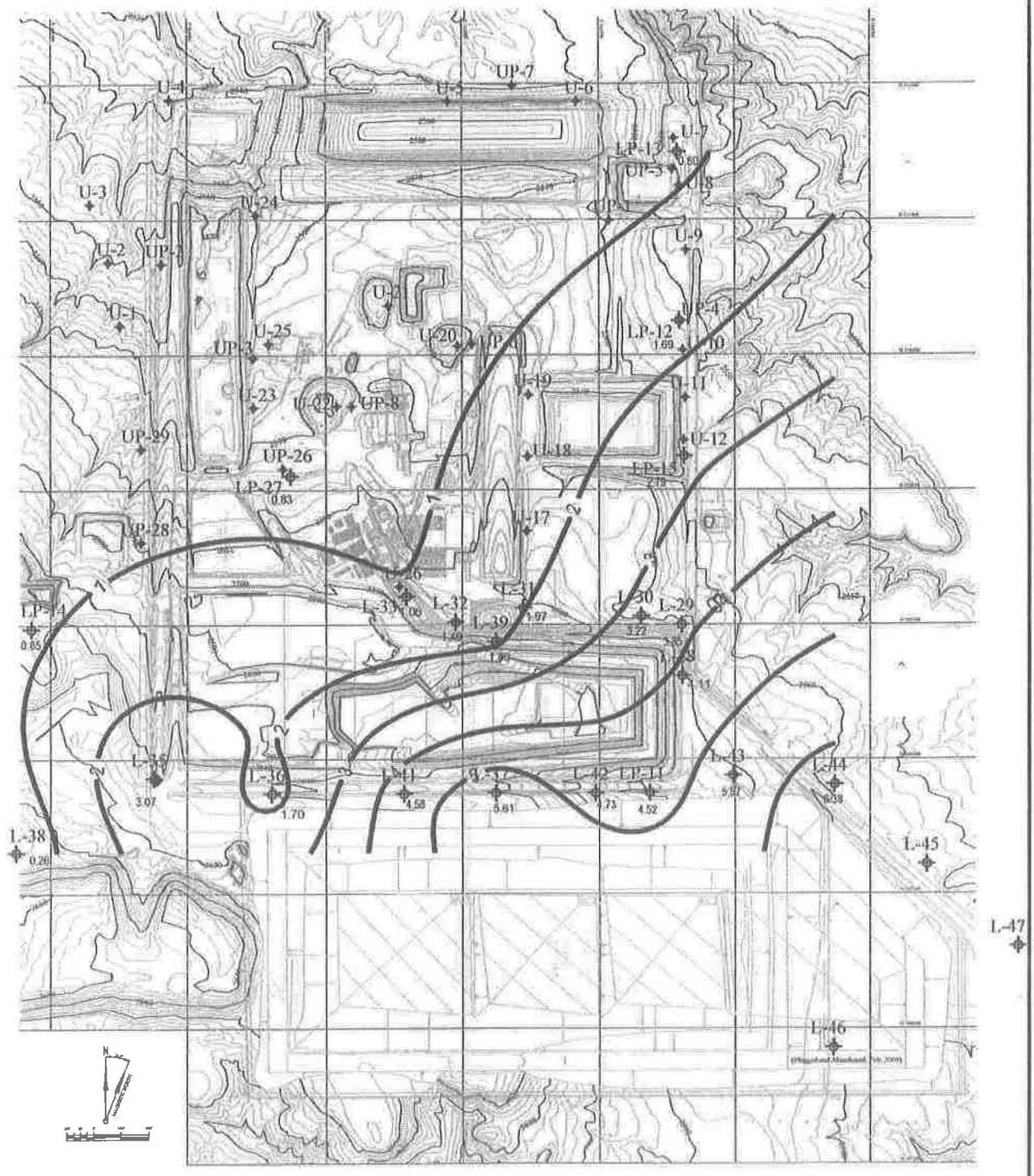


Figure 8
Water Level Rise in the Lower Aquifer
From Oct. 2005 to Oct. 2010 (in feet)
US Ecology Idaho, Site B
2010 Rising Groundwater Study

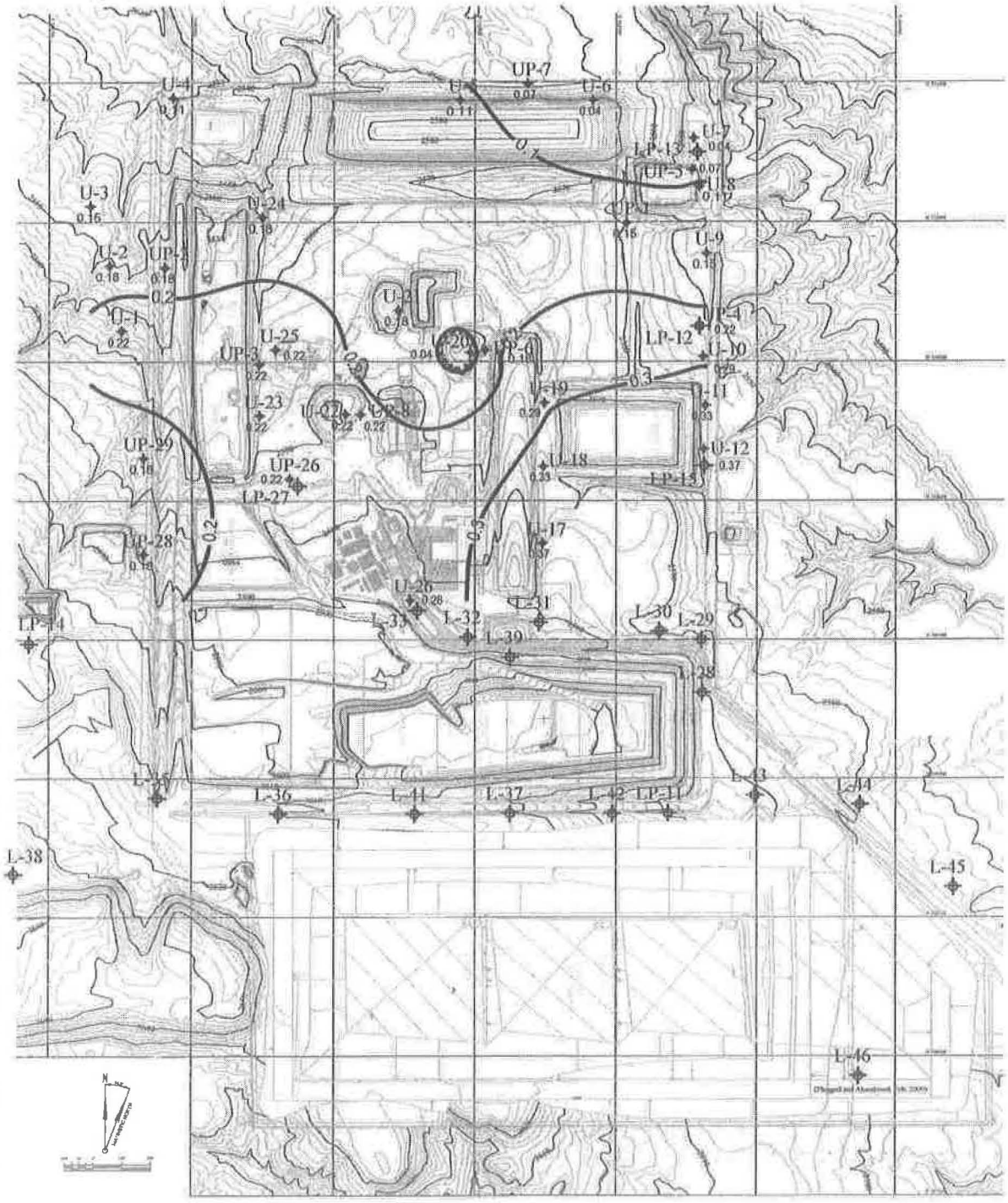


Figure 9
Rate of Water Level Rise in the Upper Aquifer
Based on Latest Sustained Trend (in feet per year)
US Ecology Idaho, Site B
2010 Rising Groundwater Study

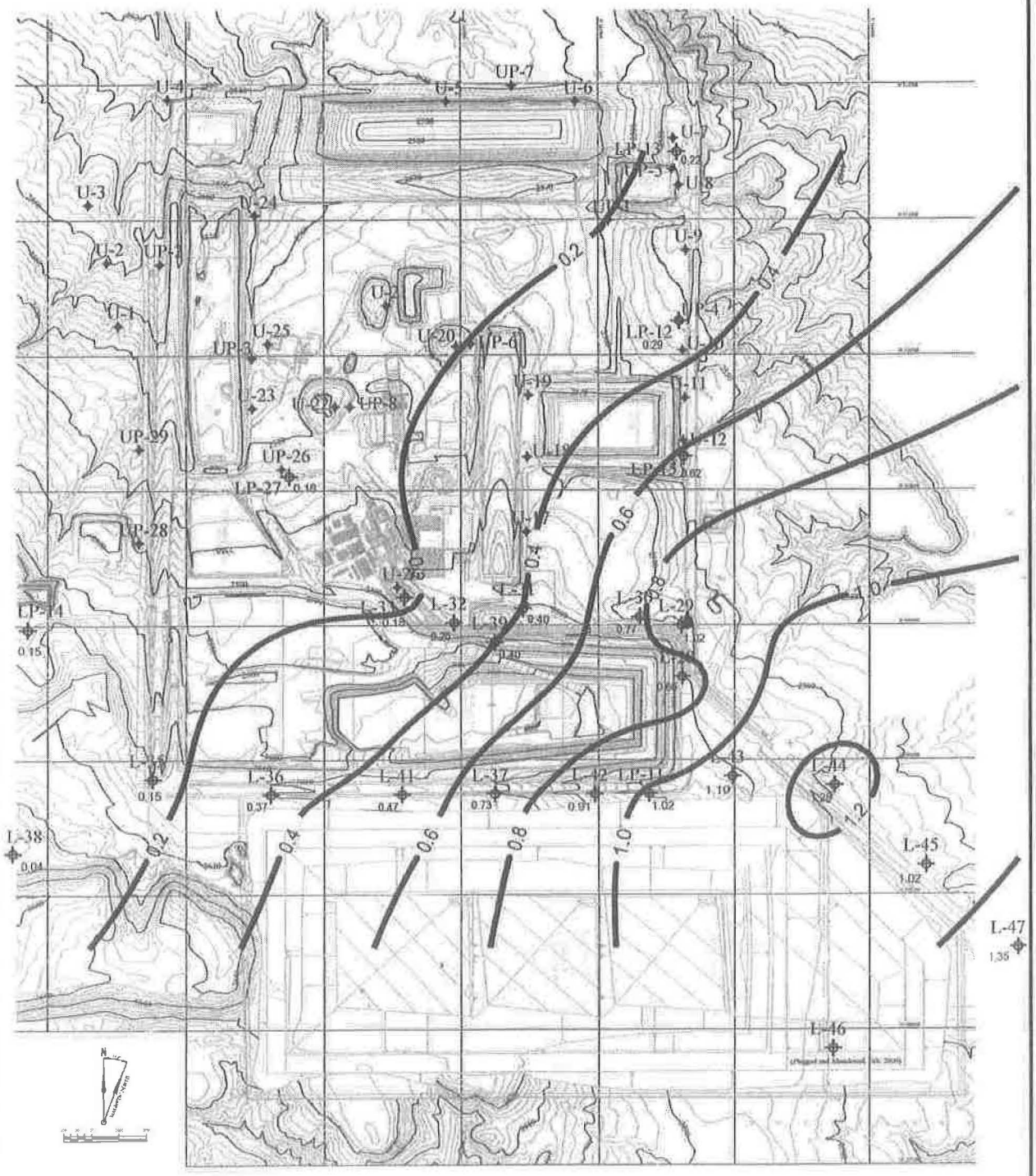


Figure 10

Rate of Water Level Rise in the Lower Aquifer
Based on Latest Sustained Trend (in feet per year)
US Ecology Idaho, Site B
2010 Rising Groundwater Study

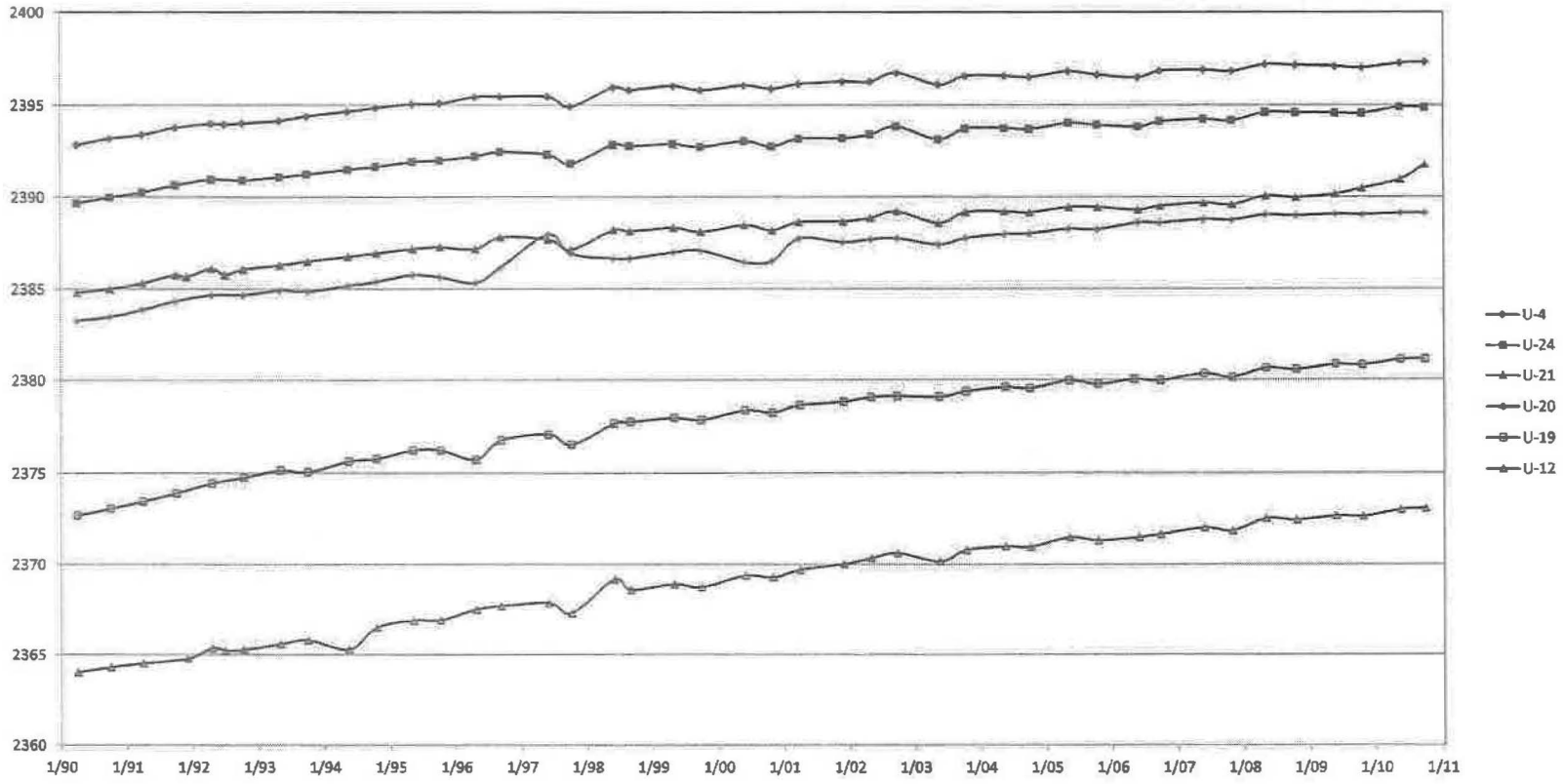


Figure 11
Hydrographs for Upper Aquifer Wells along NW-SE Flowline at US Ecology Idaho, Site B

2010 Rising Groundwater Study

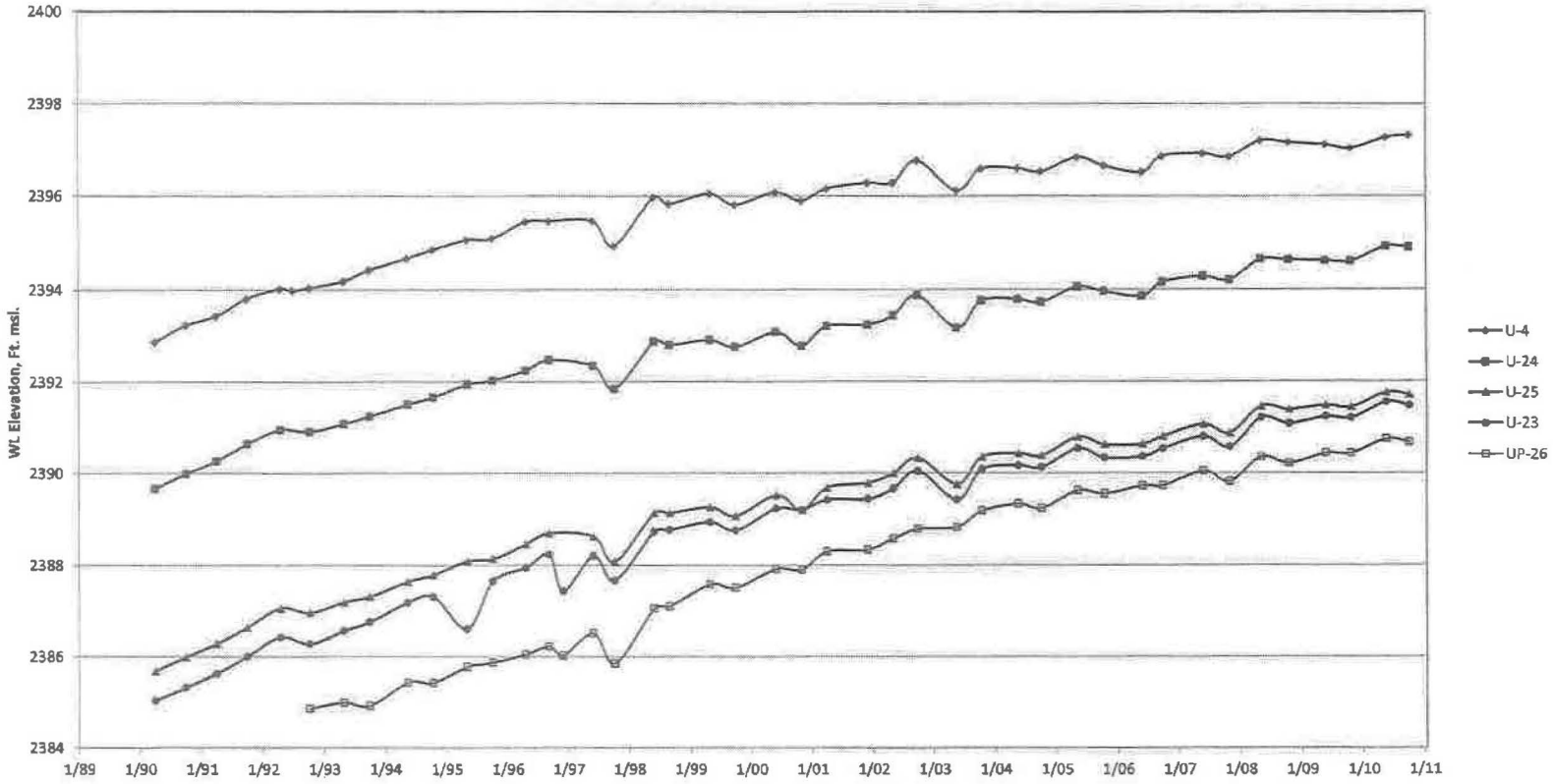


Figure 12
Hydrographs for Upper Aquifer Wells along N-S line on West Side at US Ecology Idaho, Site B

2010 Rising Groundwater Study

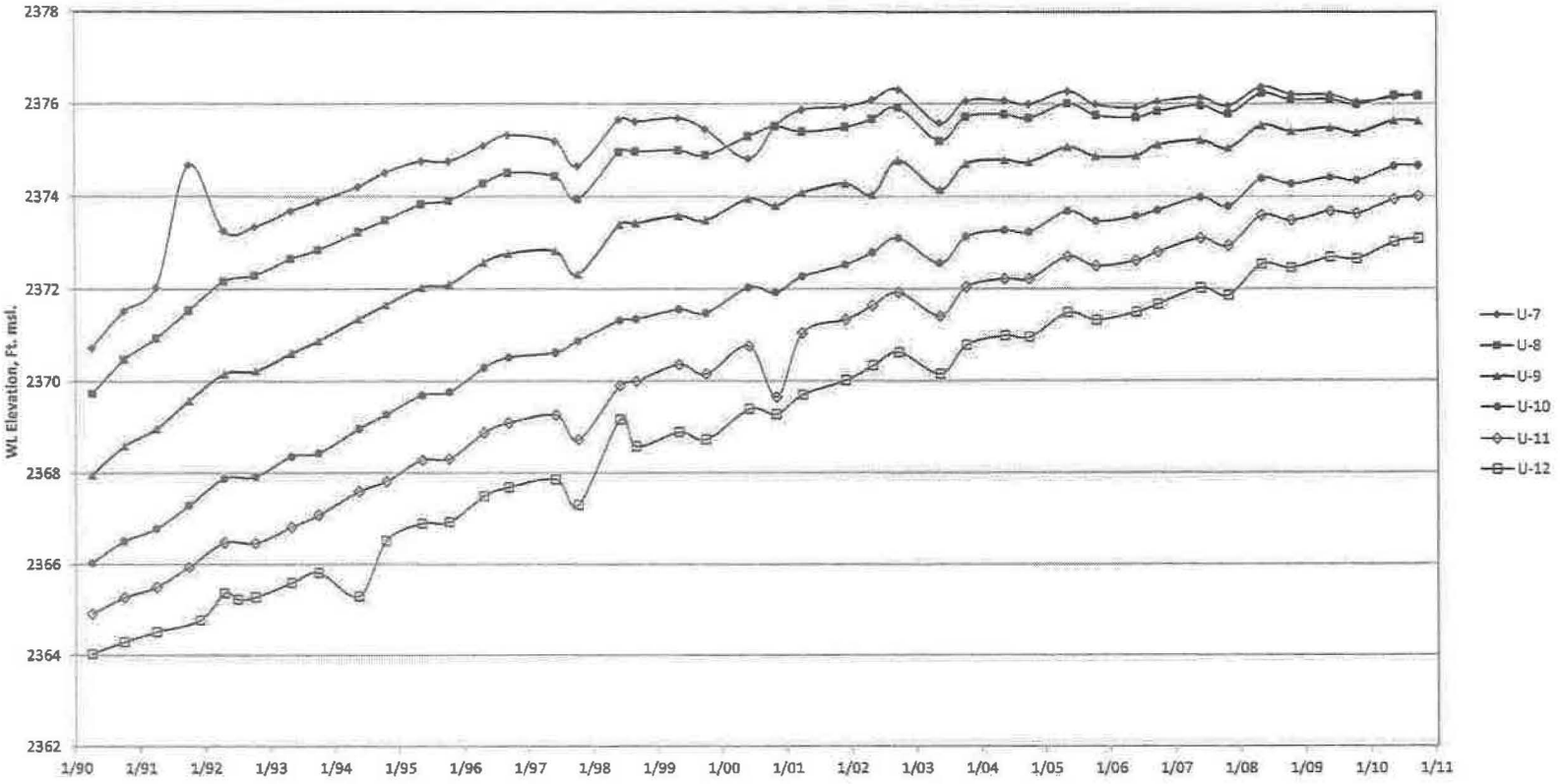


Figure 13
Hydrographs for Upper Aquifer Wells along N-S line on East Side at US Ecology Idaho, Site B
2010 Rising Groundwater Study

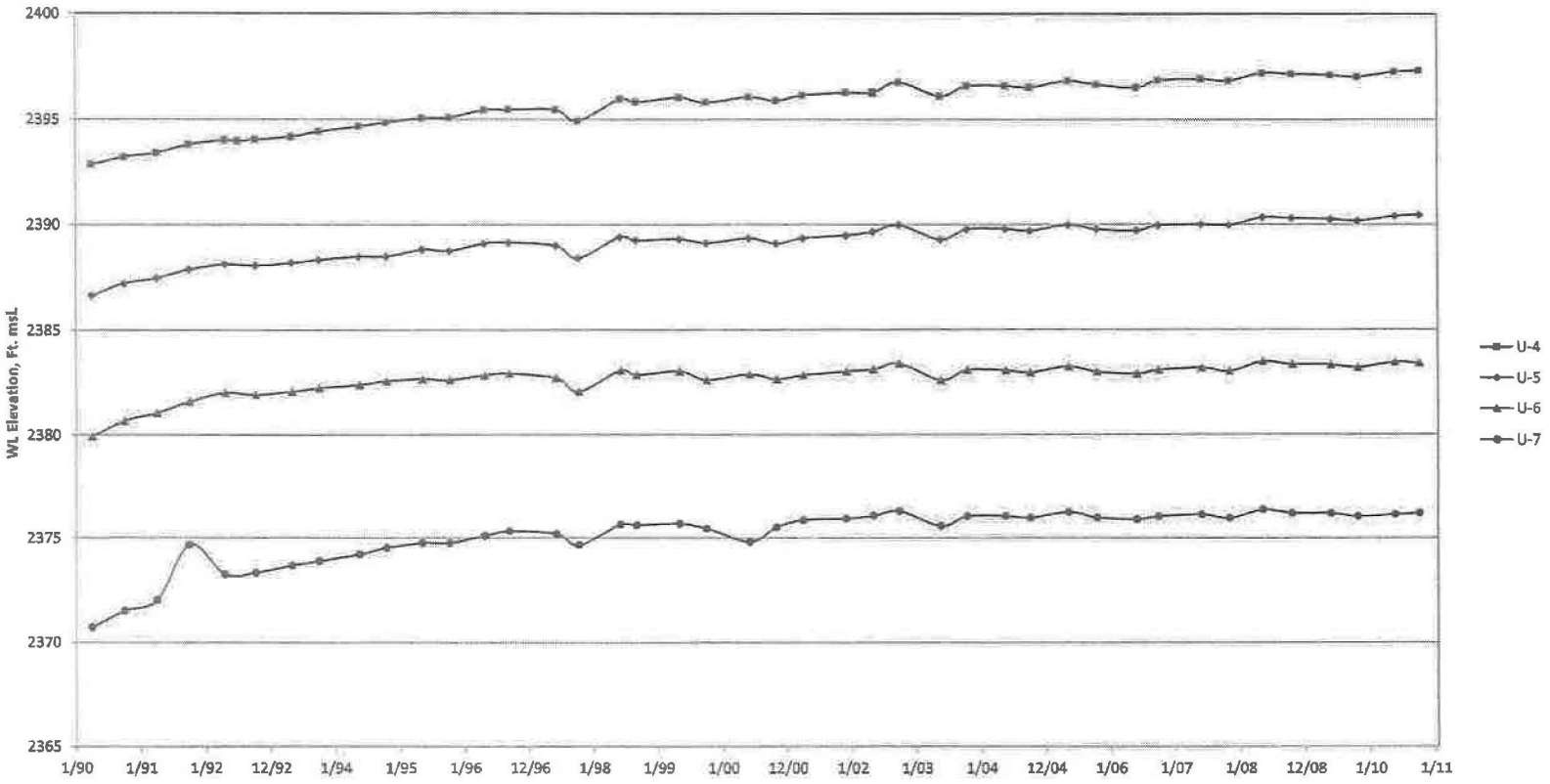


Figure 14
Hydrographs for Upper Aquifer Wells along East-West line across North Side at US Ecology Idaho, Site B
2010 Rising Groundwater Study

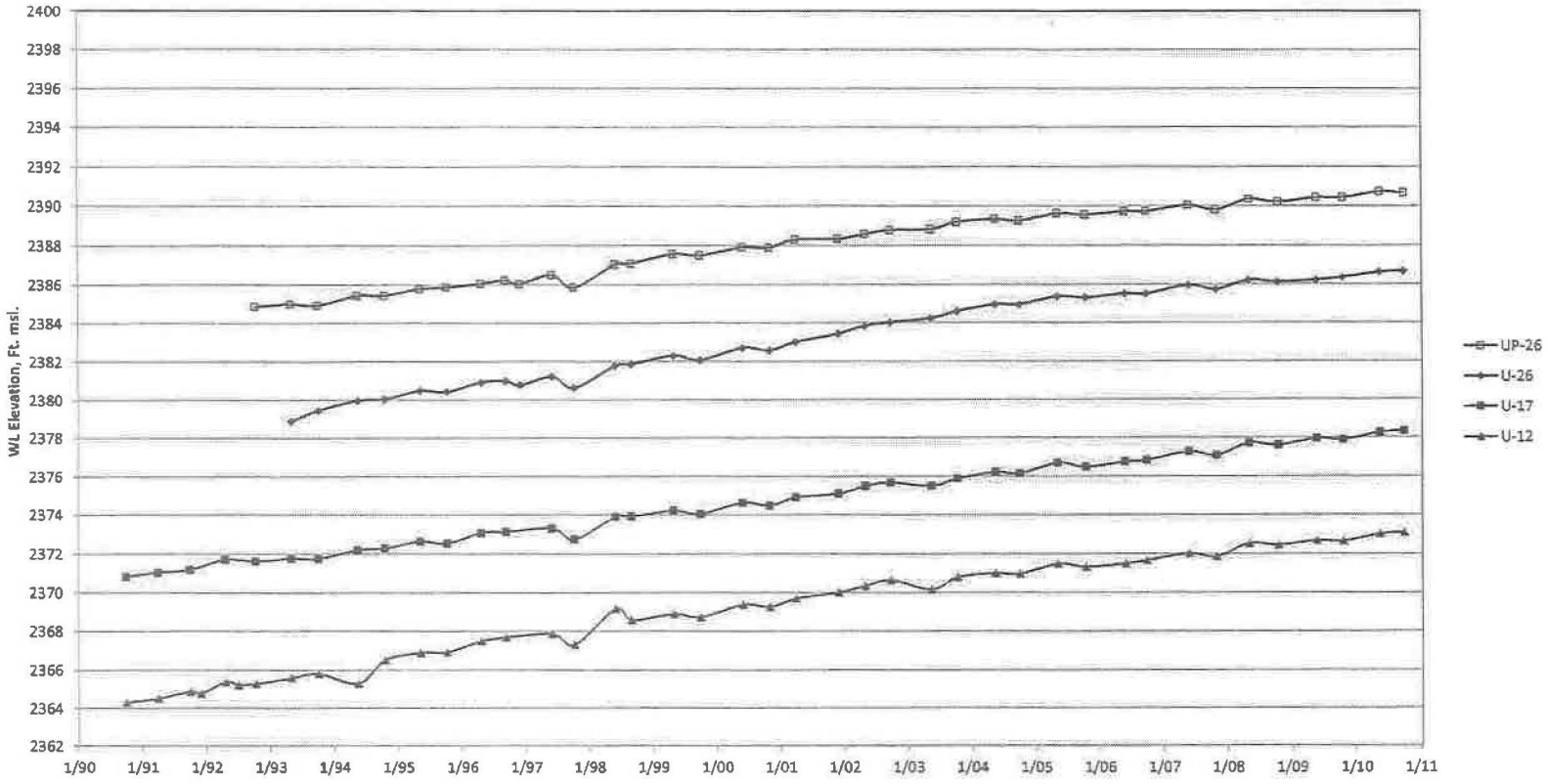


Figure 15
Hydrographs of Upper Aquifer Wells along the Southern Extent of the Upper Aquifer at US Ecology Idaho, Site B
2010 Rising Groundwater Study

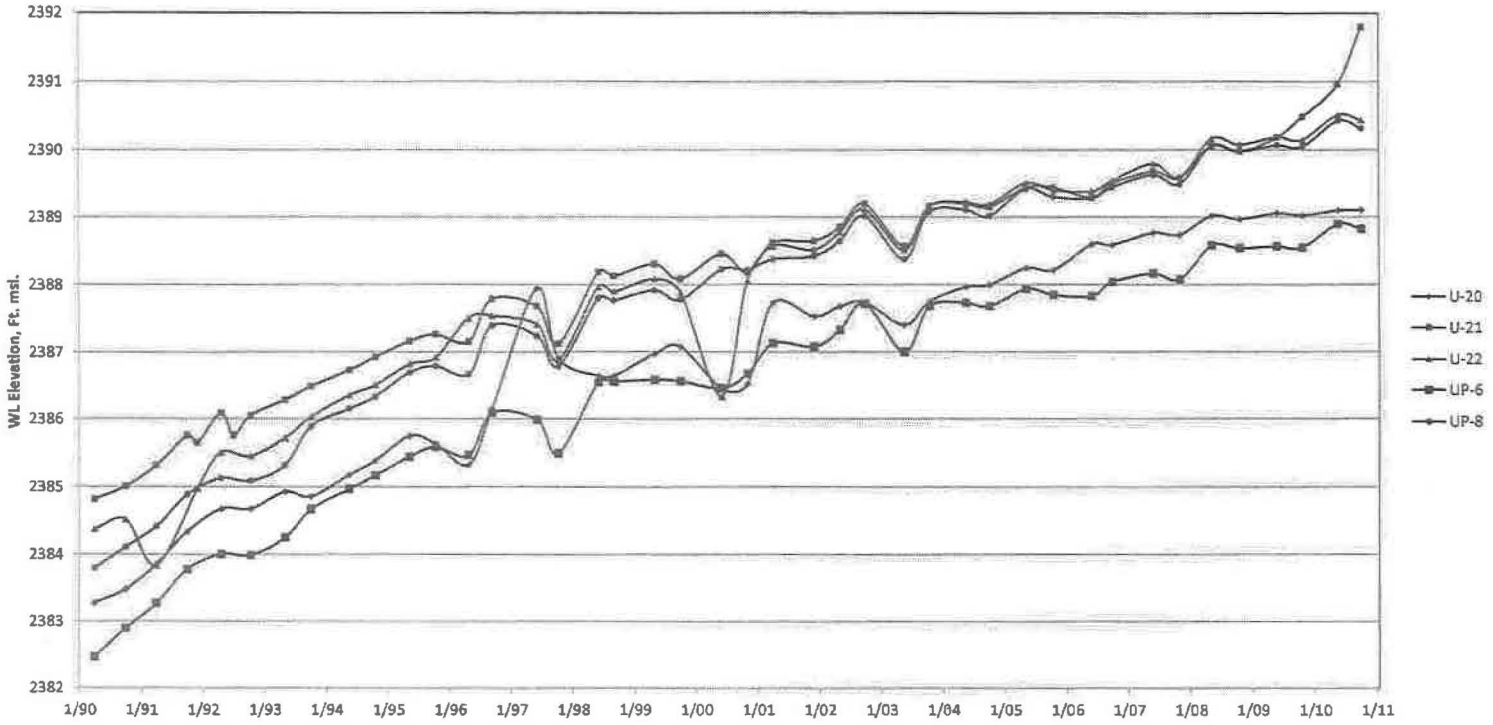


Figure 16
Hydrographs for Silo Wells at US Ecology Idaho, Site B
2010 Rising Groundwater Study

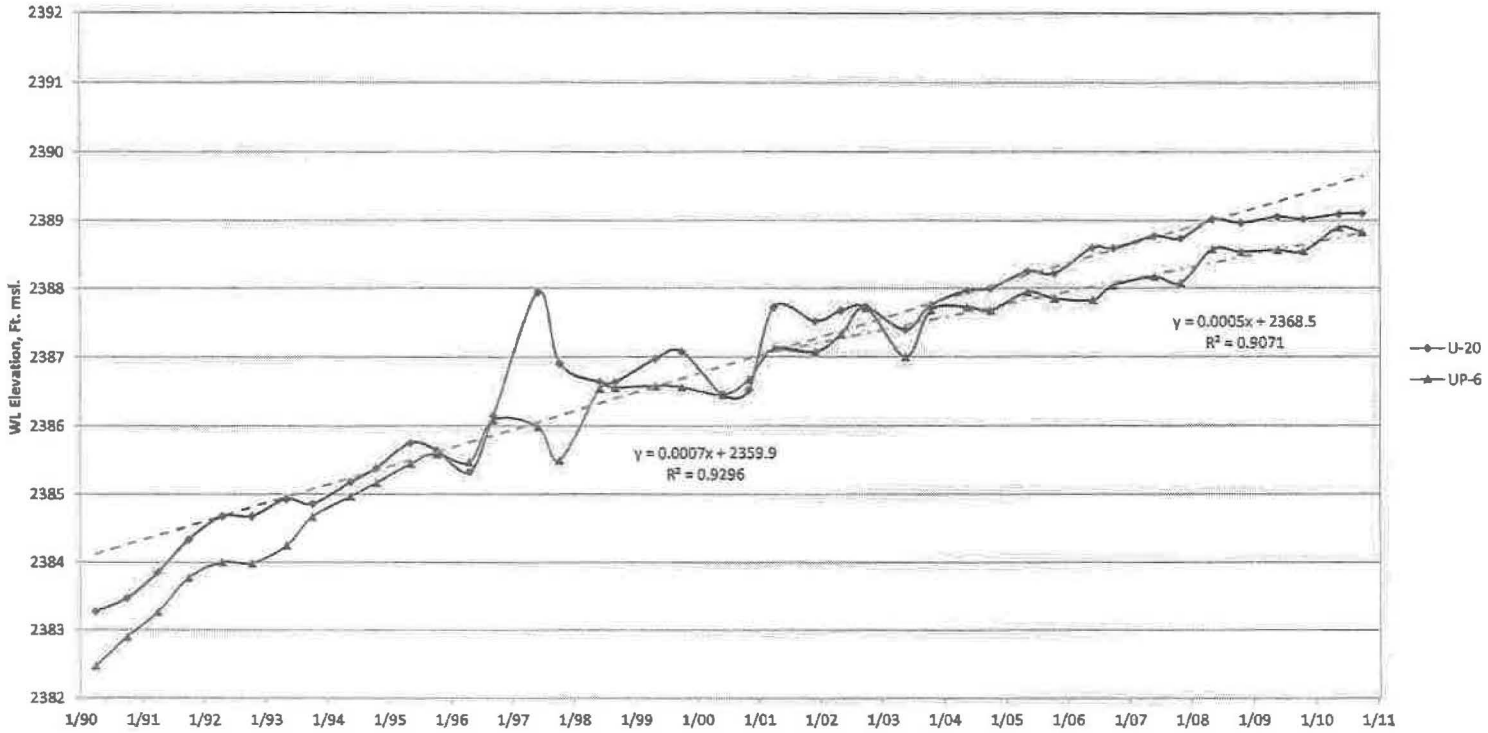


Figure 17
Hydrographs for Silo Wells U-20 and UP-6
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

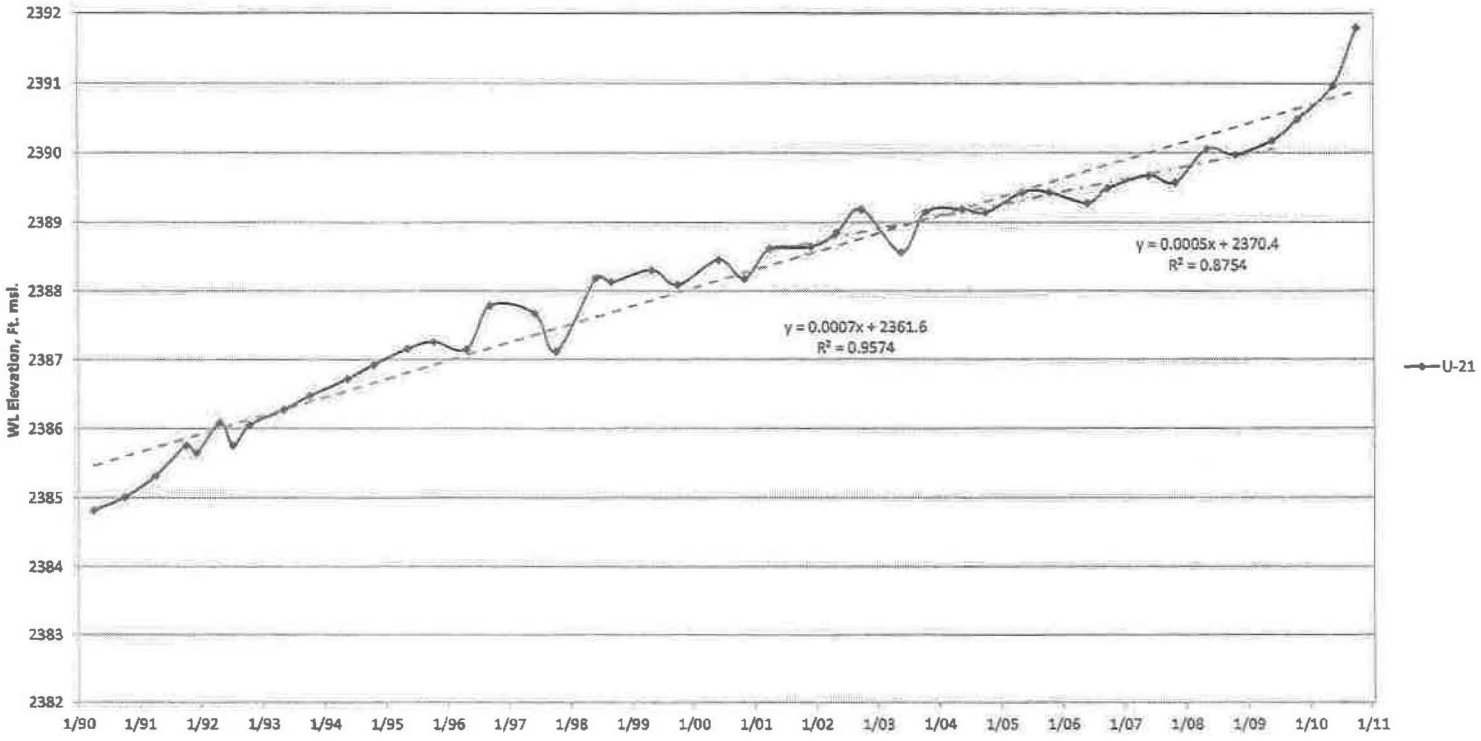


Figure 18
Hydrographs for Silo Well U-21
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

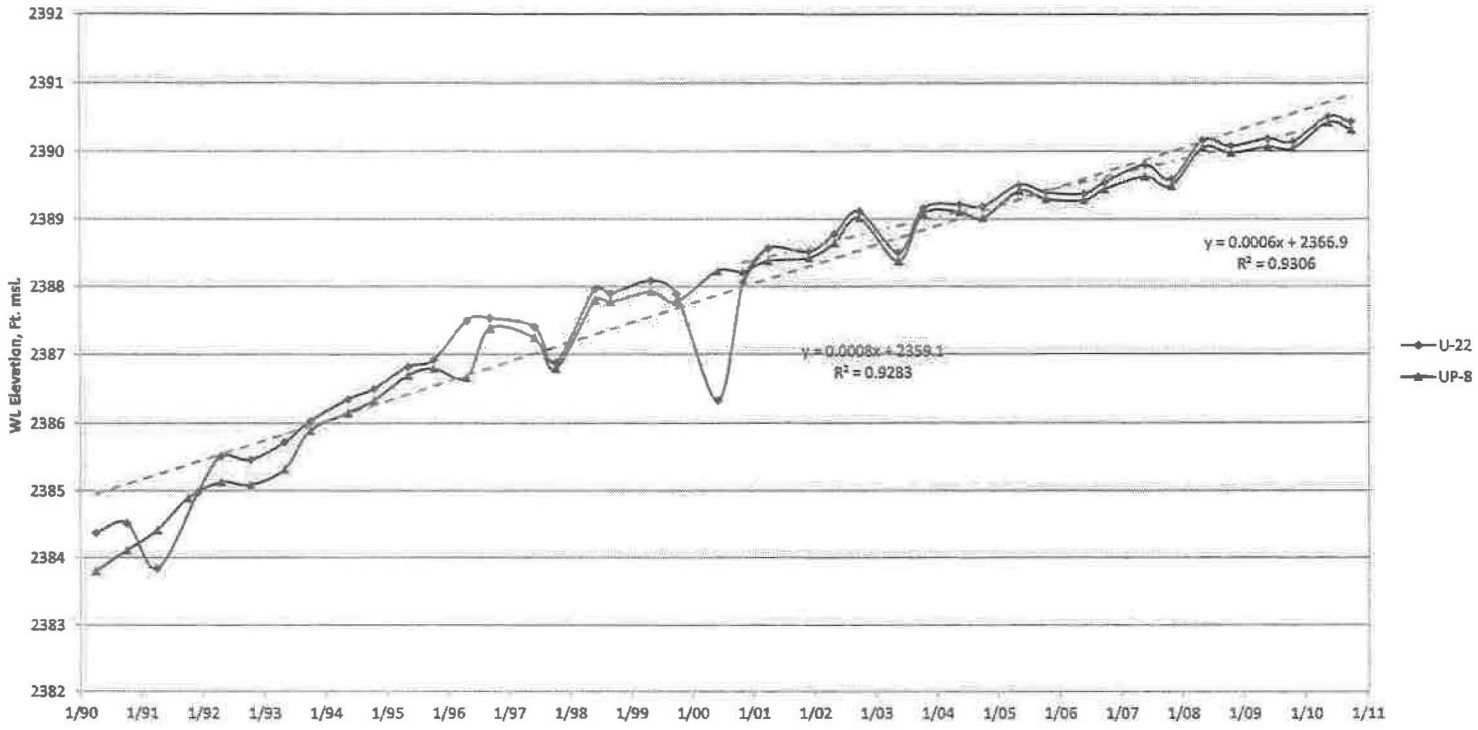


Figure 19
Hydrographs for Silo Wells U-22 and UP-8
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

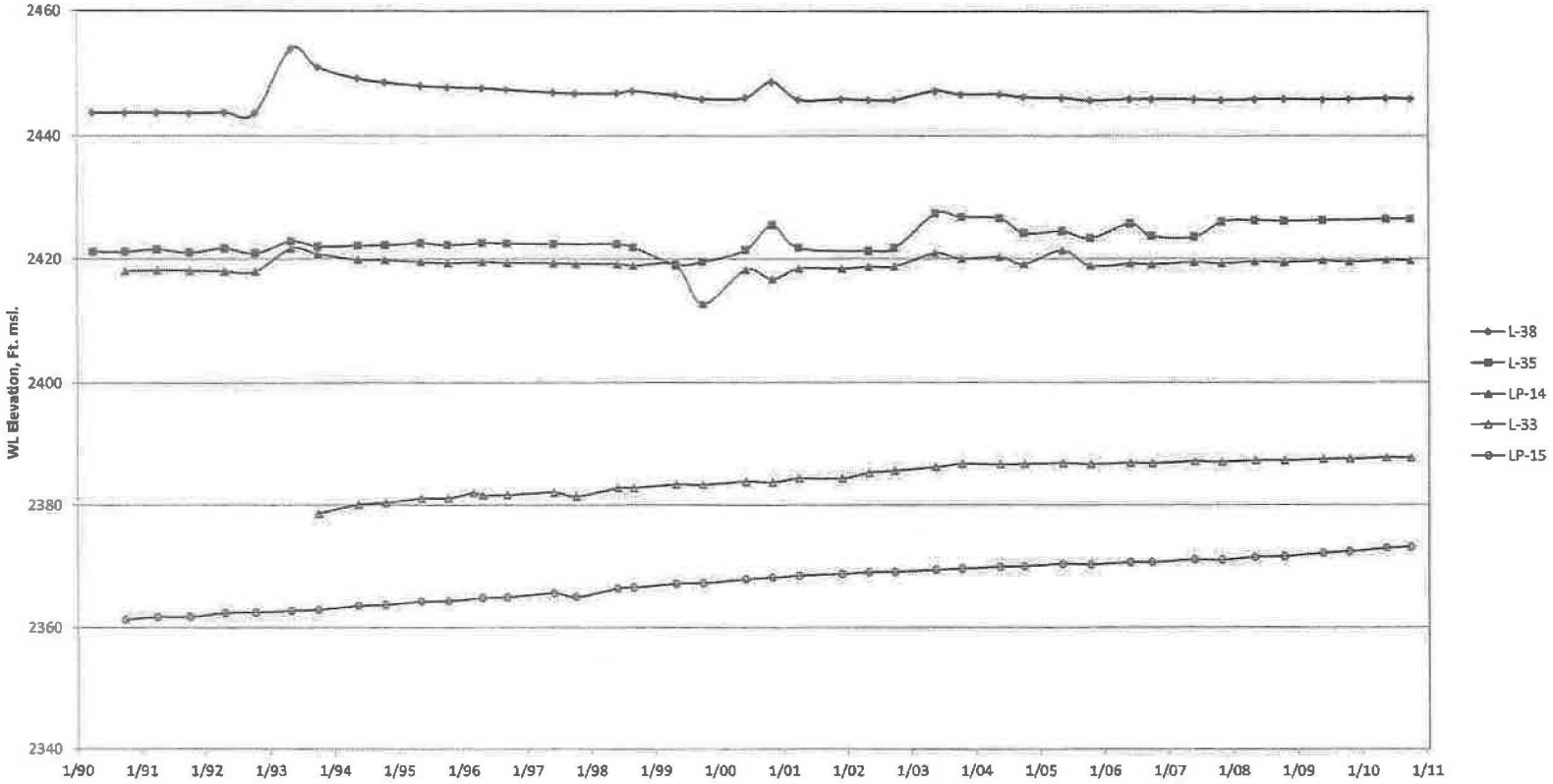


Figure 20
Hydrographs for Lower Aquifer Wells along SW-NE Flowline at US Ecology Idaho, Site B
2010 Rising Groundwater Study

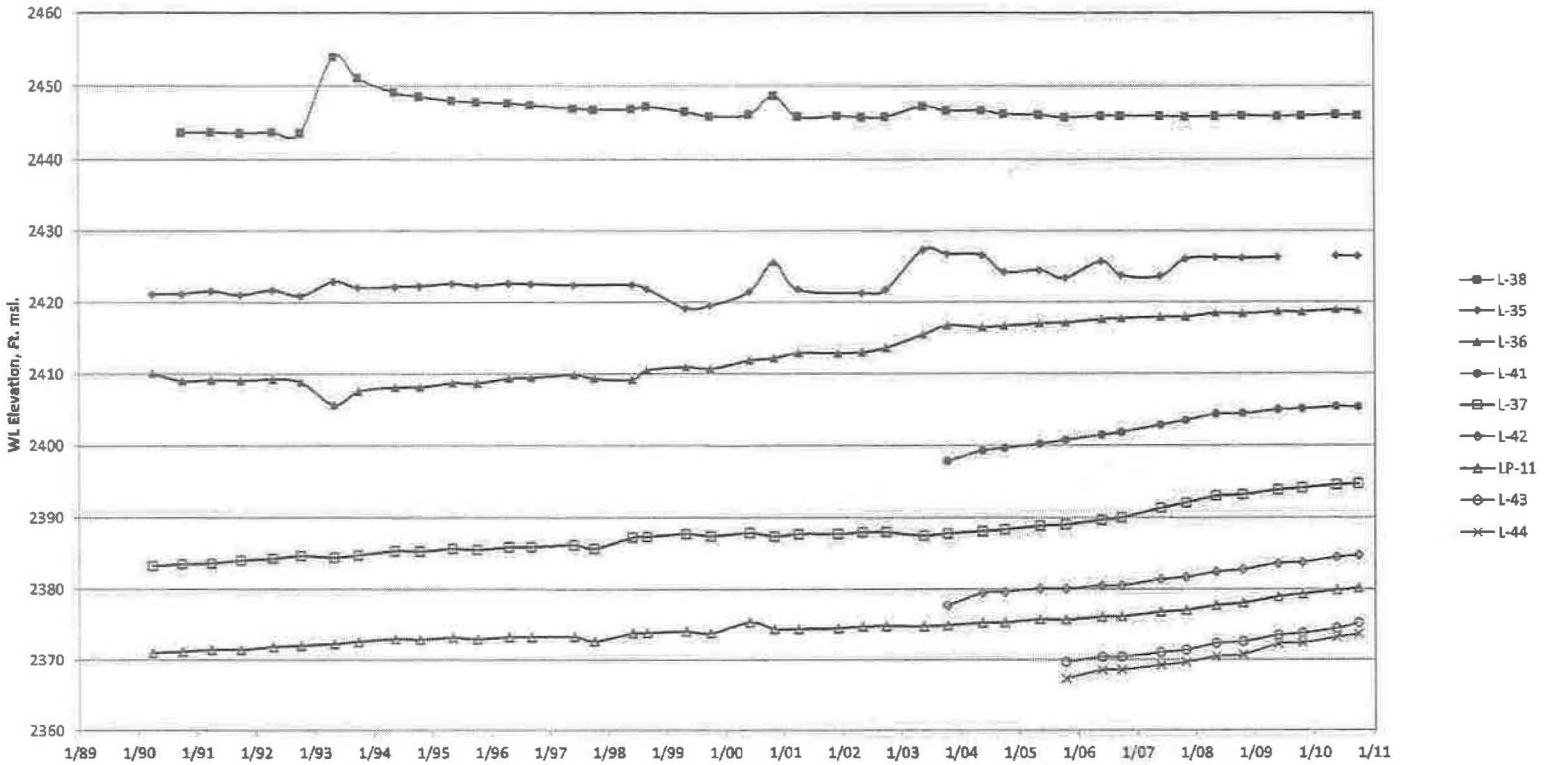


Figure 21
Hydrographs of Lower Aquifer Wells along North Side of Cell 15 at US Ecology Idaho, Site B
2010 Rising Groundwater Study

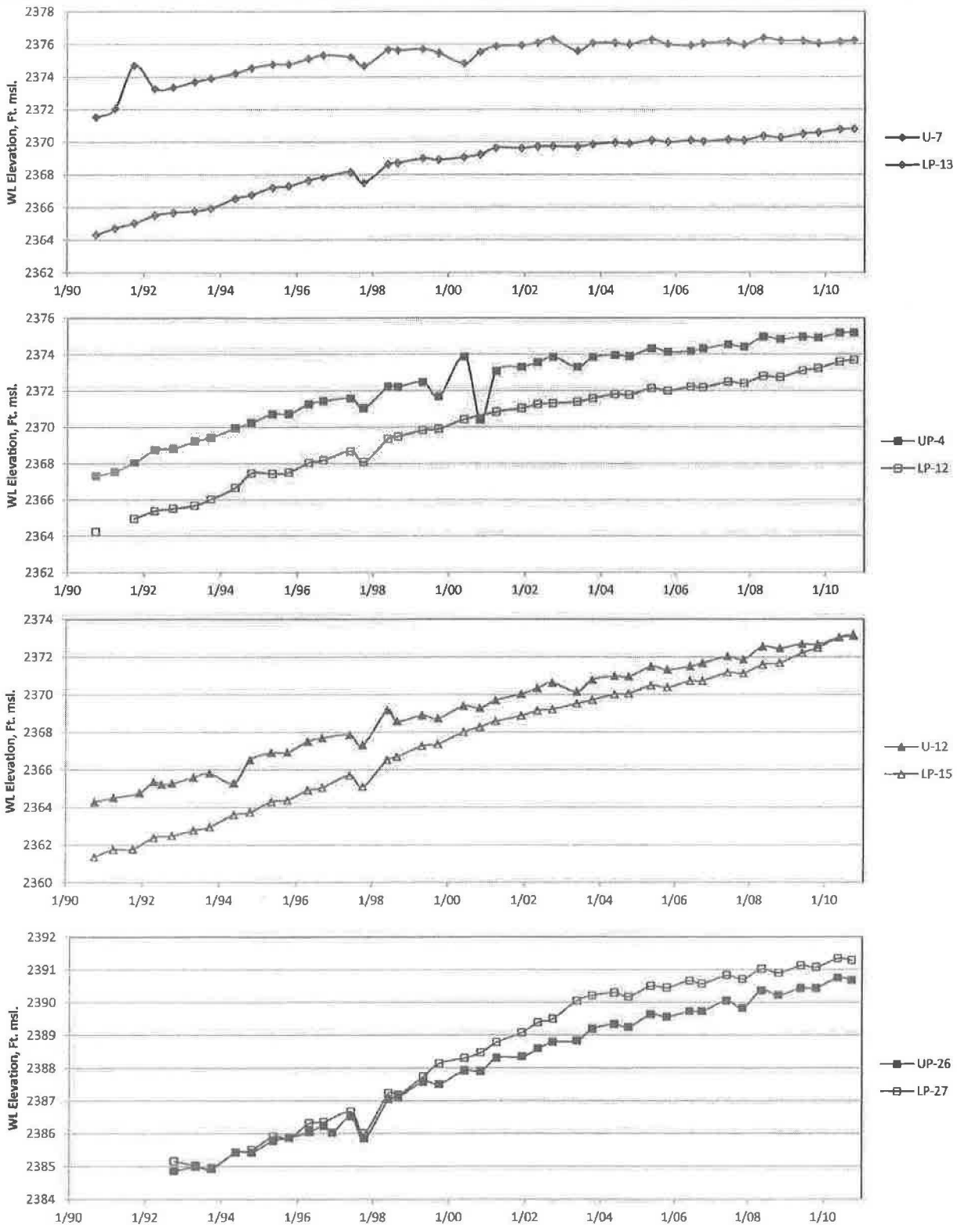


Figure 24
Upper and Lower Aquifer Well Pairs
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

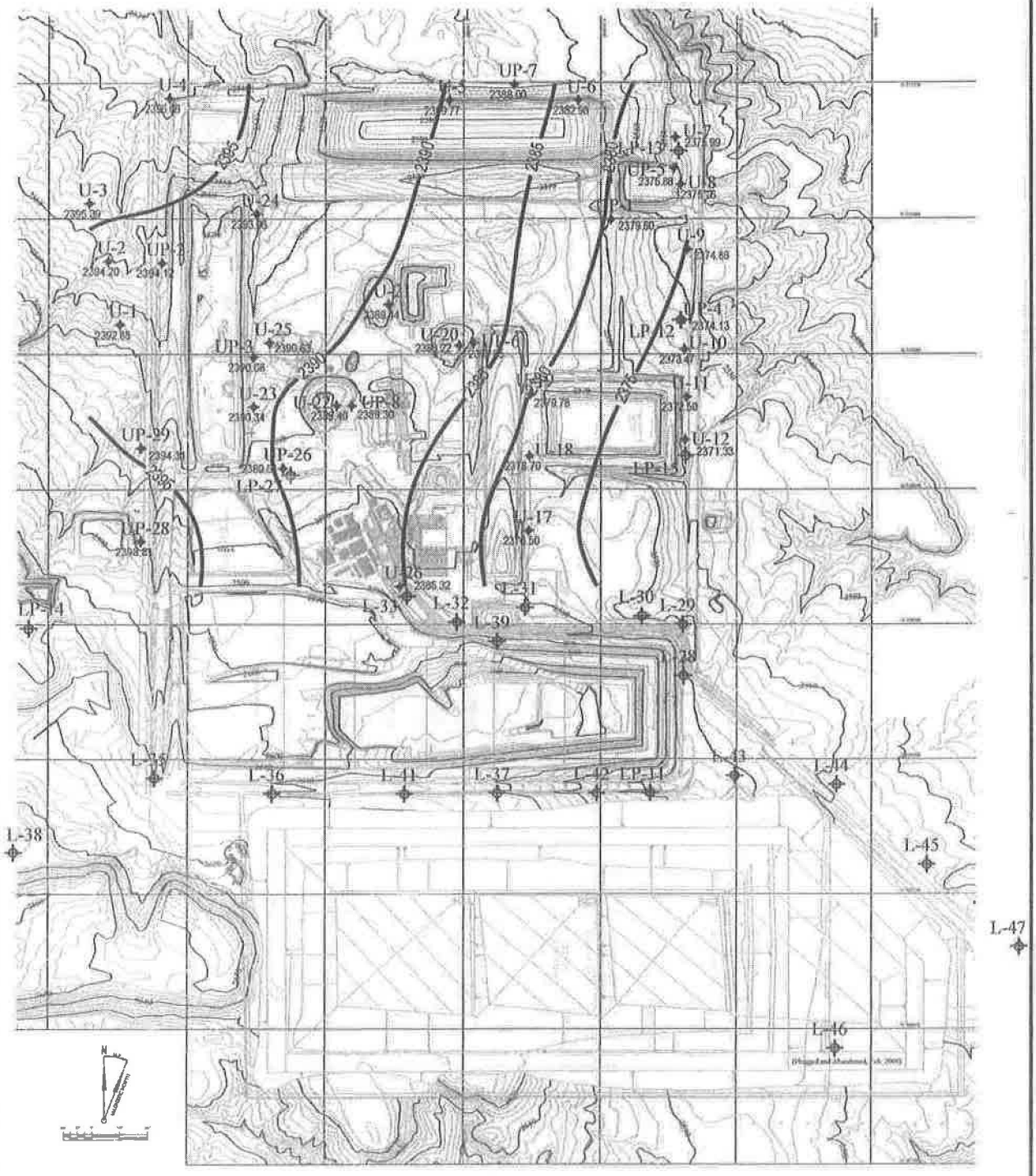


Figure 25
Upper Aquifer Piezometric Surface for October 2005
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

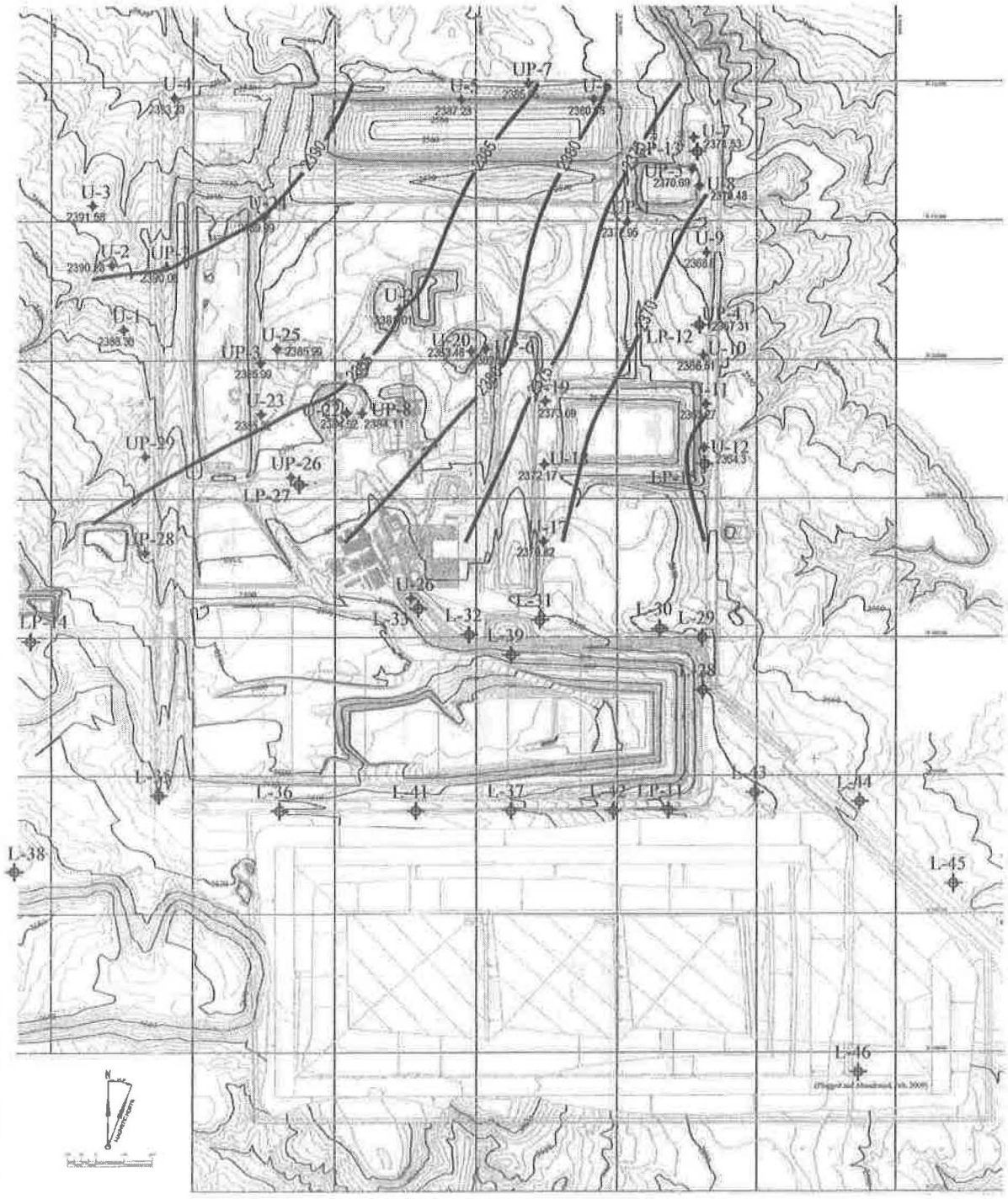


Figure 26
Upper Aquifer Piezometric Surface for October 1990
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

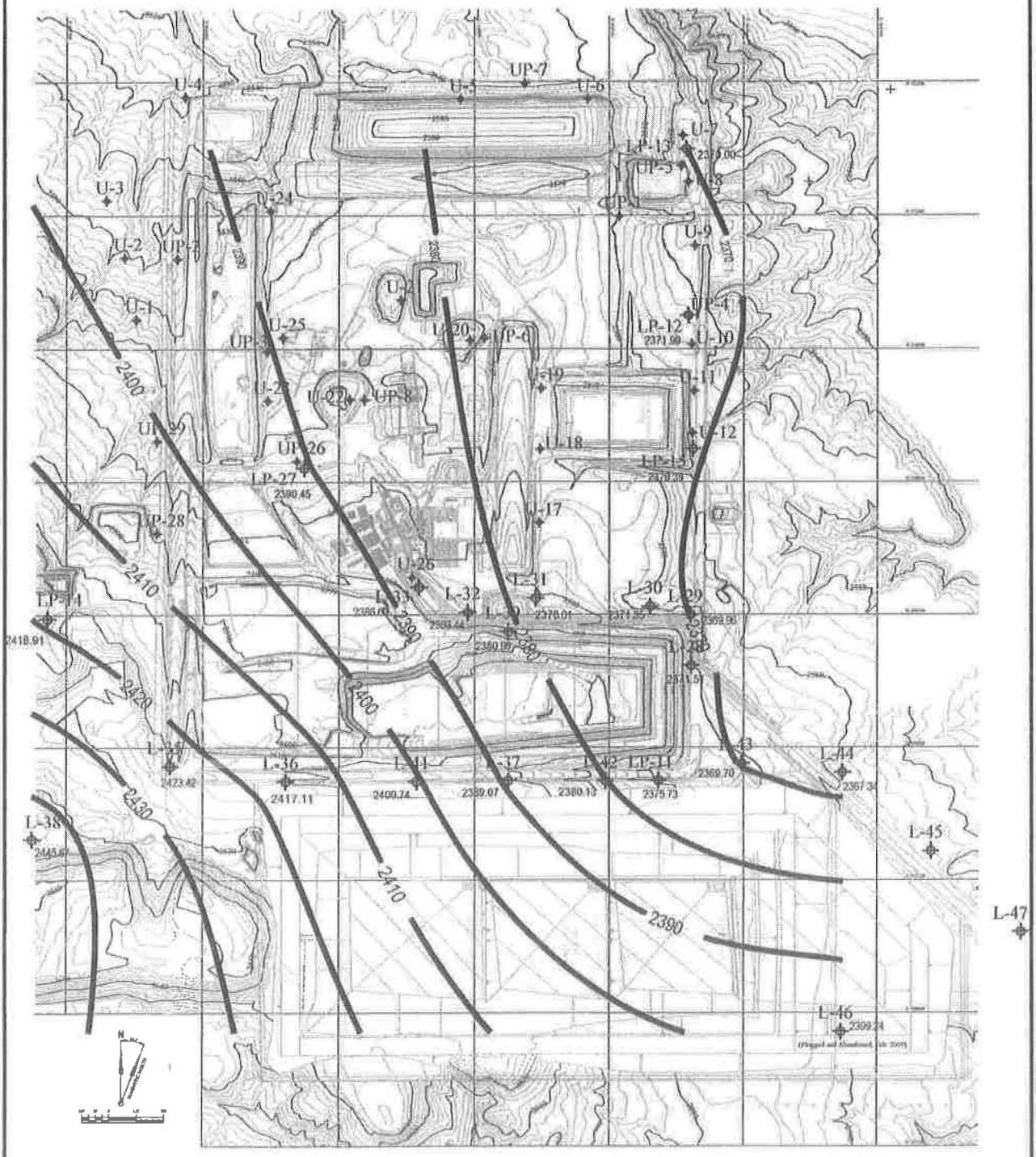


Figure 27
Lower Aquifer Potentiometric Surface for October 2005
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

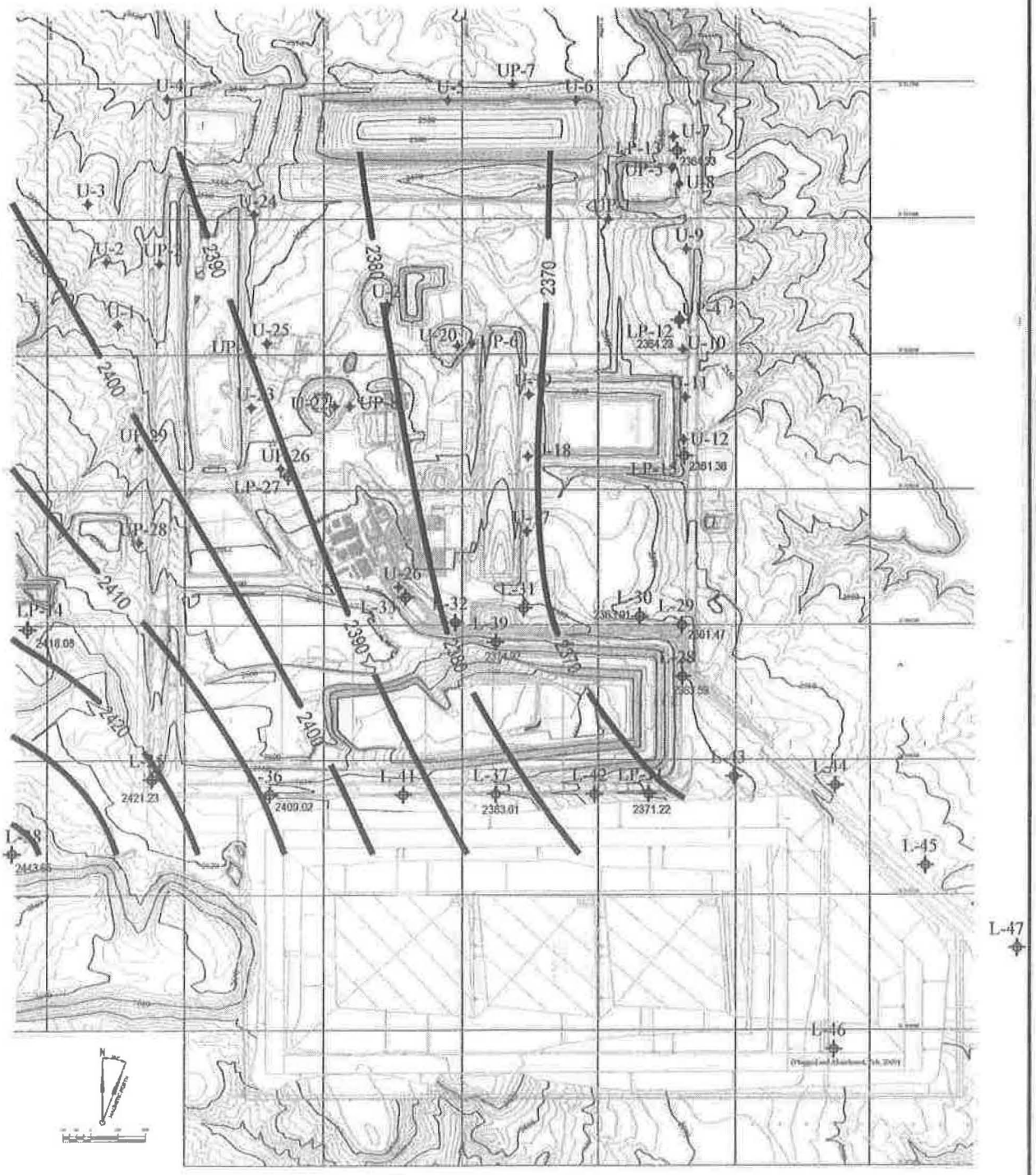


Figure 28
Lower Aquifer Potentiometric Surface for October 1990
at US Ecology Idaho, Site B
2010 Rising Groundwater Study

Appendix A

Water Level Data and Hydrographs for all Wells at USEI Site B

Data through October 2010

2010 Rising Groundwater Report

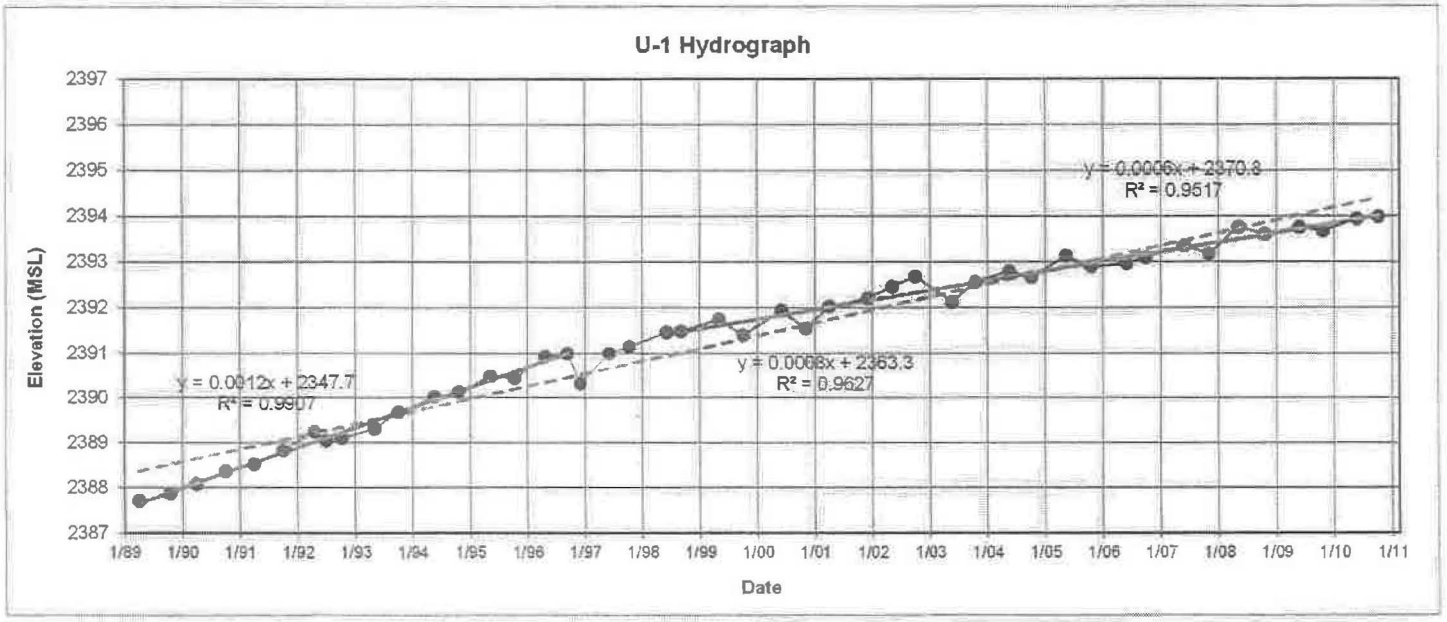
Well: U-1

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	7/92	10/92	5/93	10/93	5/94	10/94	5/95
MP Elevation	2568.46	2568.46	2568.50	2568.50	2568.50	2568.50	2568.50	2568.50	2568.50	2568.50	2568.56	2568.56	2568.56	2568.56
Depth to Water	180.75	180.60	180.42	180.14	179.99	179.68	179.25	179.46	179.40	179.19	178.88	178.54	178.43	178.08
Water Table Elevation	2387.71	2387.86	2388.08	2388.36	2388.51	2388.82	2389.25	2389.04	2389.10	2389.31	2389.68	2390.02	2390.13	2390.48

	10/95	4/96	9/96	12/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01
MP Elevation	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56
Depth to Water	178.13	177.64	177.57	178.24	177.57	177.42	177.10	177.08	176.82	177.17	176.63	177.02	176.54	176.36
Water Table Elevation	2390.43	2390.92	2390.99	2390.32	2390.99	2391.14	2391.46	2391.48	2391.74	2391.39	2391.93	2391.54	2392.02	2392.20

	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08
MP Elevation	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56	2568.56
Depth to Water	176.11	175.89	176.45	176.01	175.77	175.91	175.44	175.68	175.61	175.47	175.21	175.40	174.80	174.96
Water Table Elevation	2392.45	2392.67	2392.11	2392.55	2392.79	2392.65	2393.12	2392.88	2392.95	2393.09	2393.35	2393.16	2393.76	2393.60

	5/09	10/09	5/10	10/10
MP Elevation	2568.56	2568.56	2568.56	2568.56
Depth to Water	174.81	174.89	174.62	174.58
Water Table Elevation	2393.75	2393.67	2393.94	2393.98



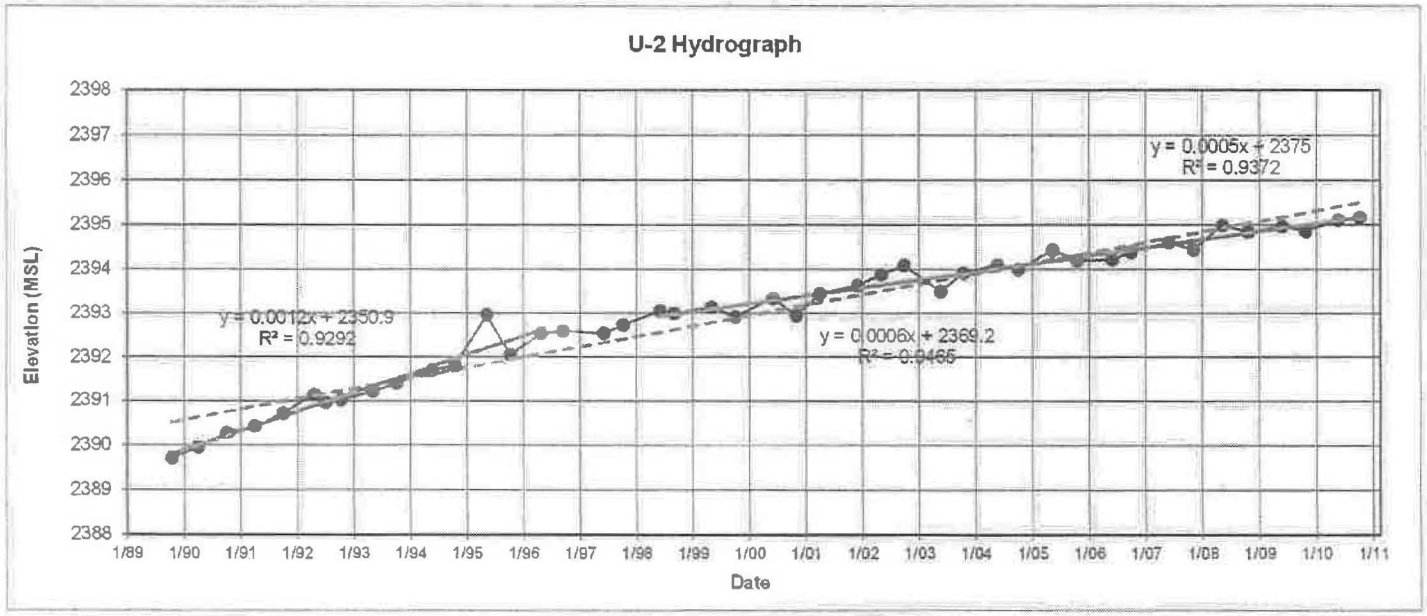
Well: U-2

	10/89	4/90	10/90	4/91	10/91	4/92	7/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2554.16	2554.16	2554.16	2554.16	2554.16	2554.16	2554.16	2554.16	2554.16	2554.05	2554.05	2554.05	2554.05	2554.05
Depth to Water	164.45	164.20	163.88	163.73	163.44	163.02	163.20	163.14	162.94	162.65	162.35	162.24	161.09	162.00
Water Table Elevation	2389.71	2389.96	2390.28	2390.43	2390.72	2391.14	2390.96	2391.02	2391.22	2391.40	2391.70	2391.81	2392.96	2392.05

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05
Depth to Water	161.51	161.45	161.50	161.32	161.00	161.05	160.91	161.13	160.71	161.10	160.61	160.42	160.17	159.96
Water Table Elevation	2392.54	2392.60	2392.55	2392.73	2393.05	2393.00	2393.14	2392.92	2393.34	2392.95	2393.44	2393.63	2393.88	2394.09

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05	2554.05
Depth to Water	160.56	160.13	159.95	160.05	159.61	159.85	159.83	159.66	159.45	159.61	159.06	159.21	159.08	159.19
Water Table Elevation	2393.49	2393.92	2394.10	2394.00	2394.44	2394.20	2394.22	2394.39	2394.60	2394.44	2394.99	2394.84	2394.97	2394.86

	5/10	10/10
MP Elevation	2554.05	2554.05
Depth to Water	158.94	158.88
Water Table Elevation	2395.11	2395.17



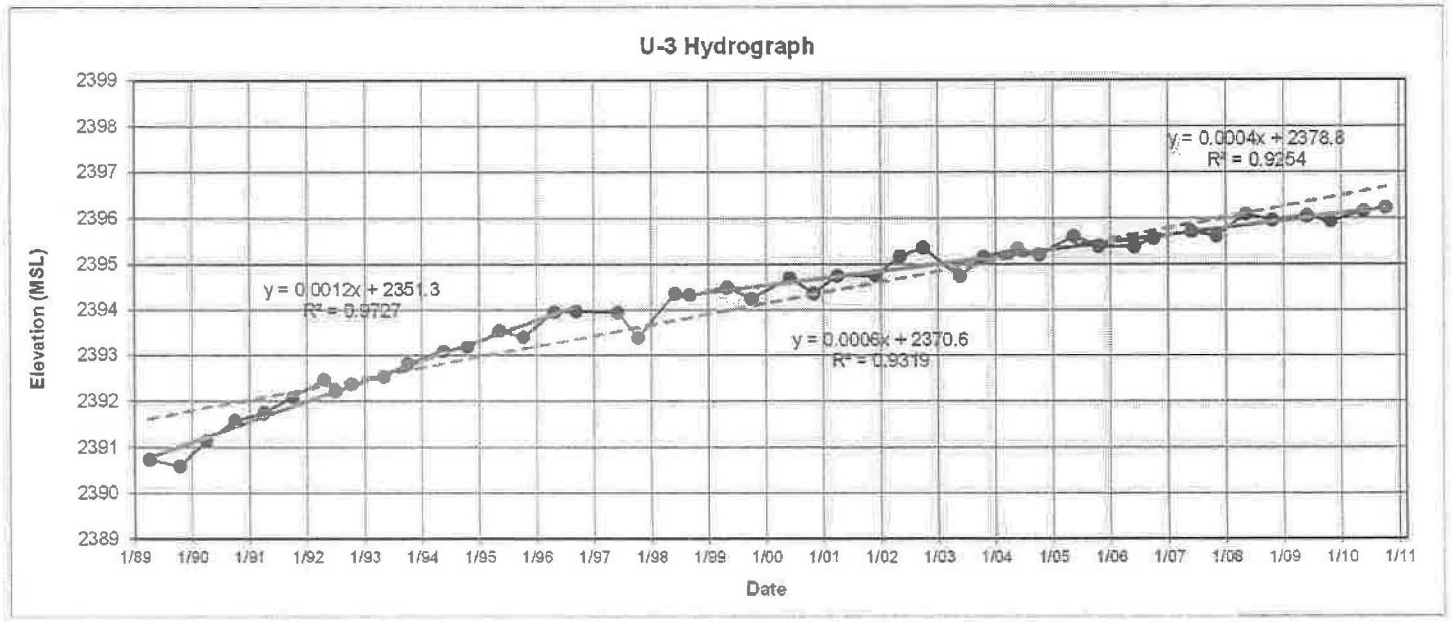
Well: U-3

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	7/92	10/92	5/93	10/93	5/94	10/94	5/95
MP Elevation	2549.54	2549.54	2549.54	2549.54	2549.54	2549.54	2549.54	2549.54	2549.54	2549.54	2549.51	2549.51	2549.51	2549.51
Depth to Water	158.80	158.95	158.40	157.96	157.80	157.45	157.06	157.32	157.17	157.01	156.69	156.42	156.32	155.96
Water Table Elevation	2390.74	2390.59	2391.14	2391.58	2391.74	2392.09	2392.48	2392.22	2392.37	2392.53	2392.82	2393.09	2393.19	2393.55

	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02
MP Elevation	2549.46	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51
Depth to Water	156.05	155.56	155.54	155.57	156.12	155.15	155.18	155.02	155.27	154.81	155.15	154.76	154.76	154.34
Water Table Elevation	2393.41	2393.95	2393.97	2393.94	2393.39	2394.36	2394.33	2394.49	2394.24	2394.70	2394.36	2394.75	2394.75	2395.17

	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09
MP Elevation	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51	2549.51
Depth to Water	154.15	154.77	154.35	154.17	154.30	153.90	154.12	154.13	153.95	153.80	153.90	153.42	153.55	153.46
Water Table Elevation	2395.36	2394.74	2395.16	2395.34	2395.21	2395.61	2395.39	2395.38	2395.56	2395.71	2395.61	2396.09	2395.96	2396.05

	10/09	5/10	10/10
MP Elevation	2549.51	2549.51	2549.51
Depth to Water	153.58	153.35	153.28
Water Table Elevation	2395.93	2396.16	2396.23



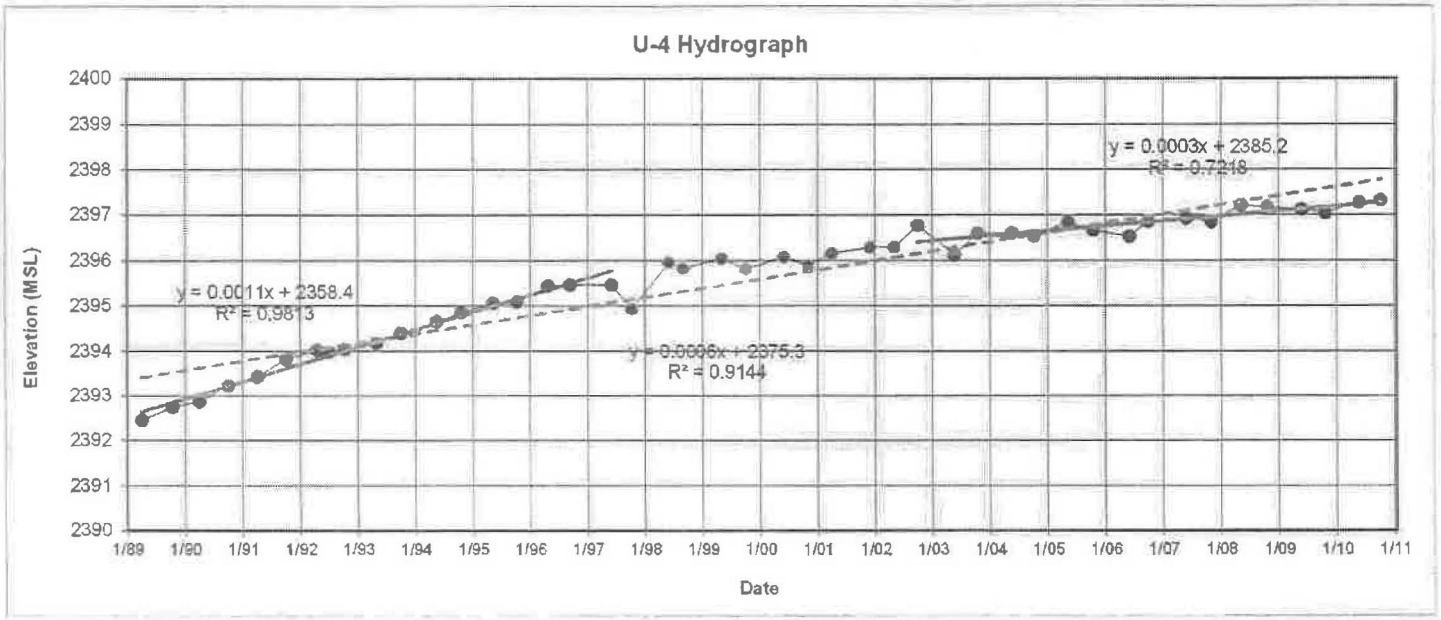
Well: U-4

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	7/92	10/92	5/93	10/93	5/94	10/94	5/95
MP Elevation	2529.75	2529.75	2529.75	2529.75	2529.75	2529.75	2529.75	2529.75	2529.75	2529.75	2529.62	2529.62	2529.62	2529.62
Depth to Water	137.30	137.00	136.88	136.52	136.32	135.94	135.73	135.77	135.71	135.57	135.21	134.96	134.77	134.56
Water Table Elevation	2392.45	2392.75	2392.87	2393.23	2393.43	2393.81	2394.02	2393.98	2394.04	2394.18	2394.41	2394.66	2394.85	2395.06

	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02
MP Elevation	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62
Depth to Water	134.53	134.17	134.15	134.15	134.69	133.65	133.79	133.57	133.80	133.54	133.72	133.46	133.33	133.33
Water Table Elevation	2395.09	2395.45	2395.47	2395.47	2394.93	2395.97	2395.83	2396.05	2395.82	2396.08	2395.90	2396.16	2396.29	2396.29

	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09
MP Elevation	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62	2529.62
Depth to Water	132.85	133.50	133.03	133.02	133.09	132.78	132.96	133.10	132.76	132.70	132.77	132.41	132.45	132.50
Water Table Elevation	2396.77	2396.12	2396.59	2396.60	2396.53	2396.84	2396.66	2396.52	2396.86	2396.92	2396.85	2397.21	2397.17	2397.12

	10/09	5/10	10/10
MP Elevation	2529.62	2529.62	2529.62
Depth to Water	132.58	132.34	132.29
Water Table Elevation	2397.04	2397.28	2397.33



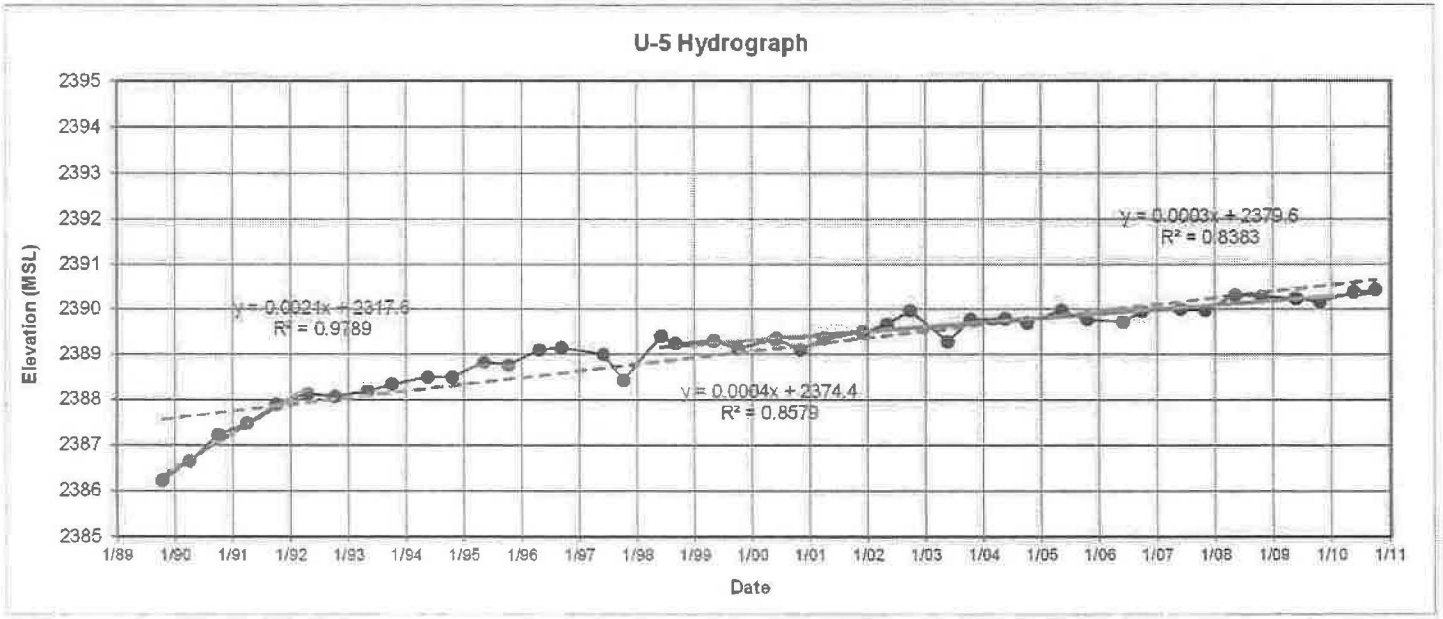
Well: U-5

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2572.13	2572.13	2572.13	2572.13	2572.13	2572.13	2572.13	2572.13	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00
Depth to Water	185.90	185.48	184.90	184.65	184.24	184.00	184.06	183.94	183.66	183.50	183.50	183.18	183.24	182.90
Water Table Elevation	2386.23	2386.65	2387.23	2387.48	2387.89	2388.13	2388.07	2388.19	2388.34	2388.50	2388.50	2388.82	2388.76	2389.10

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00
Depth to Water	182.85	183.00	183.57	182.59	182.75	182.69	182.87	182.65	182.90	182.64	182.51	182.34	182.03	182.72
Water Table Elevation	2389.15	2389.00	2388.43	2389.41	2389.25	2389.31	2389.13	2389.35	2389.10	2389.36	2389.49	2389.66	2389.97	2389.28

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00	2572.00
Depth to Water	182.23	182.21	182.30	182.02	182.23	182.29	182.05	182.00	182.03	181.68	181.71	181.75	181.83	181.61
Water Table Elevation	2389.77	2389.79	2389.70	2389.98	2389.77	2389.71	2389.95	2390.00	2389.97	2390.32	2390.29	2390.25	2390.17	2390.39

	10/10
MP Elevation	2572.00
Depth to Water	181.56
Water Table Elevation	2390.44



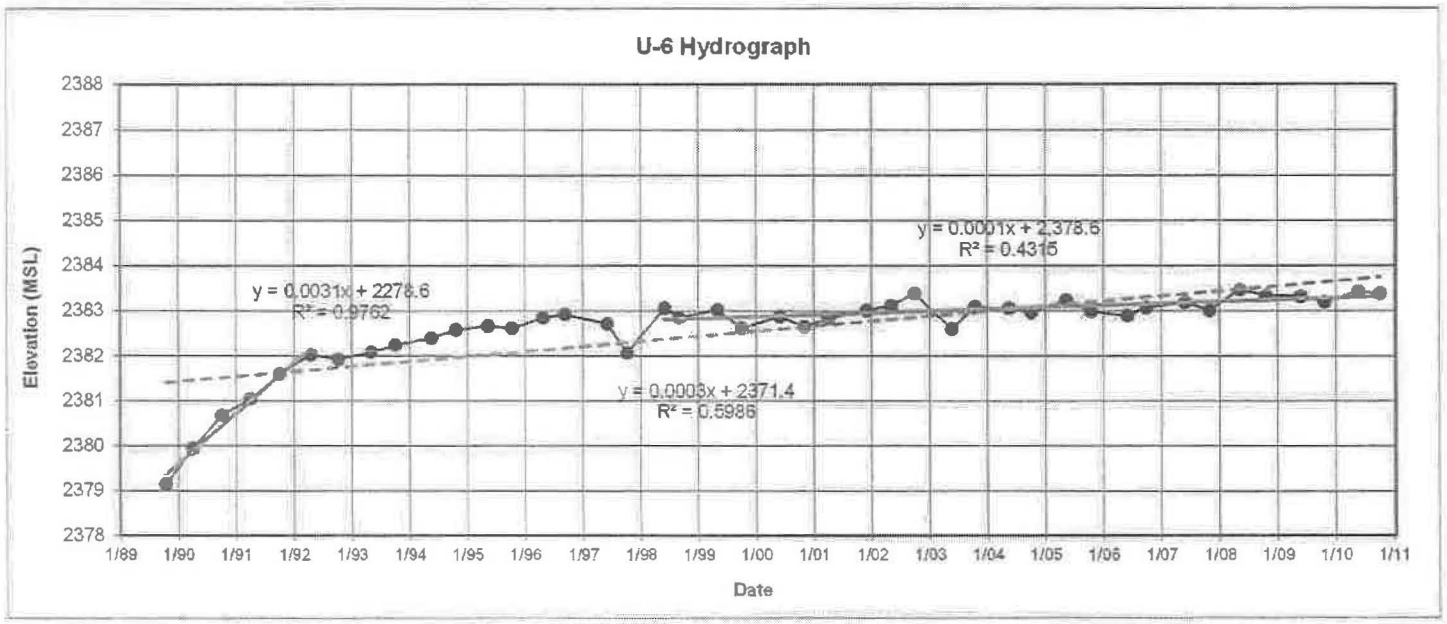
Well: U-6

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2574.50	2574.50	2574.50	2574.50	2574.50	2574.50	2574.50	2574.50	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36
Depth to Water	195.36	194.56	193.82	193.45	192.90	192.48	192.58	192.42	192.12	191.97	191.79	191.70	191.75	191.52
Water Table Elevation	2379.14	2379.94	2380.68	2381.05	2381.60	2382.02	2381.92	2382.08	2382.24	2382.39	2382.57	2382.66	2382.61	2382.84

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36
Depth to Water	191.44	191.65	192.29	191.30	191.51	191.34	191.75	191.49	191.72	191.53	191.35	191.25	190.98	191.77
Water Table Elevation	2382.92	2382.71	2382.07	2383.06	2382.85	2383.02	2382.61	2382.87	2382.64	2382.83	2383.01	2383.11	2383.38	2382.59

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36	2574.36
Depth to Water	191.28	191.30	191.40	191.12	191.38	191.47	191.29	191.18	191.35	190.89	191.02	191.04	191.17	190.92
Water Table Elevation	2383.08	2383.06	2382.96	2383.24	2382.98	2382.89	2383.07	2383.18	2383.01	2383.47	2383.34	2383.32	2383.19	2383.44

	10/10
MP Elevation	2574.36
Depth to Water	191.38
Water Table Elevation	2382.98



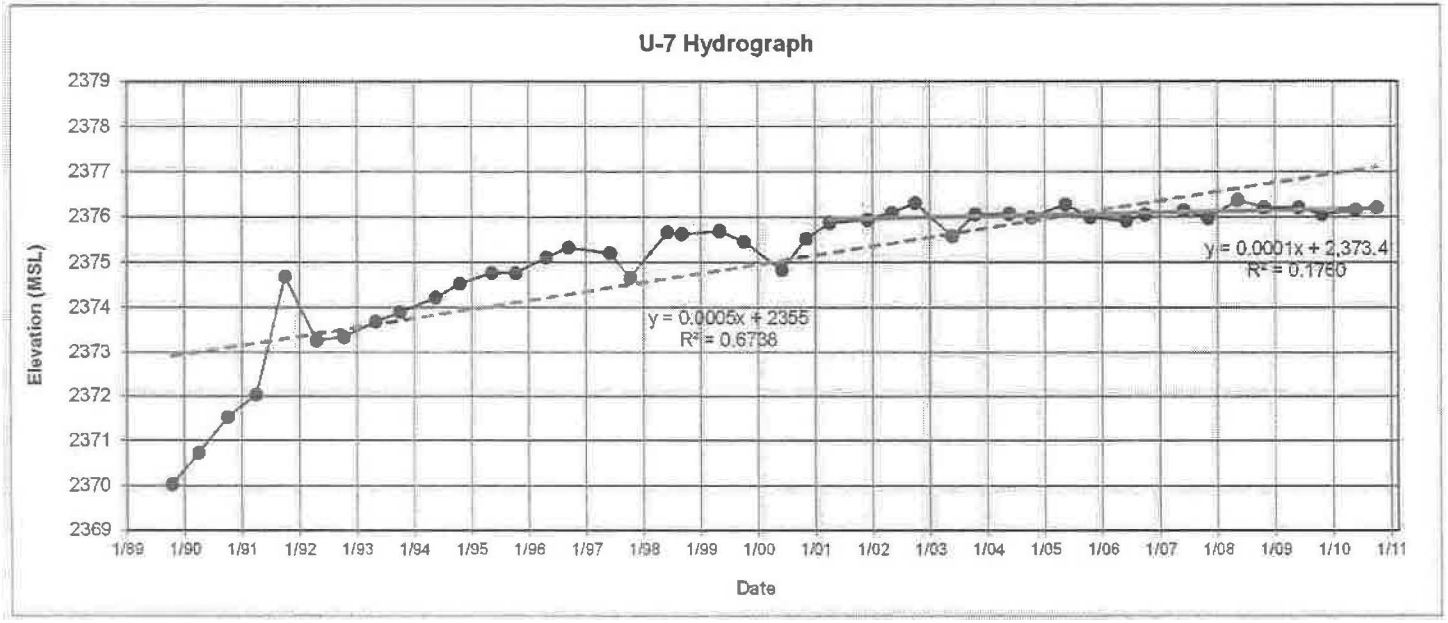
Well: U-7

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2544.89	2544.89	2544.89	2544.89	2544.89	2544.89	2544.89	2544.89	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77
Depth to Water	174.86	174.16	173.36	172.85	170.20	171.62	171.54	171.20	170.87	170.55	170.24	170.00	170.00	169.66
Water Table Elevation	2370.03	2370.73	2371.53	2372.04	2374.69	2373.27	2373.35	2373.69	2373.90	2374.22	2374.53	2374.77	2374.77	2375.11

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77
Depth to Water	169.44	169.57	170.10	169.11	169.15	169.08	169.31	169.94	169.25	168.90	168.83	168.68	168.46	169.19
Water Table Elevation	2375.33	2375.20	2374.67	2375.66	2375.62	2375.69	2375.46	2374.83	2375.52	2375.87	2375.94	2376.09	2376.31	2375.58

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77	2544.77
Depth to Water	168.71	168.70	168.78	168.50	168.78	168.86	168.72	168.63	168.81	168.40	168.56	168.57	168.72	168.62
Water Table Elevation	2376.06	2376.07	2375.99	2376.27	2375.99	2375.91	2376.05	2376.14	2375.96	2376.37	2376.21	2376.20	2376.05	2376.15

	10/10
MP Elevation	2544.77
Depth to Water	168.56
Water Table Elevation	2376.21



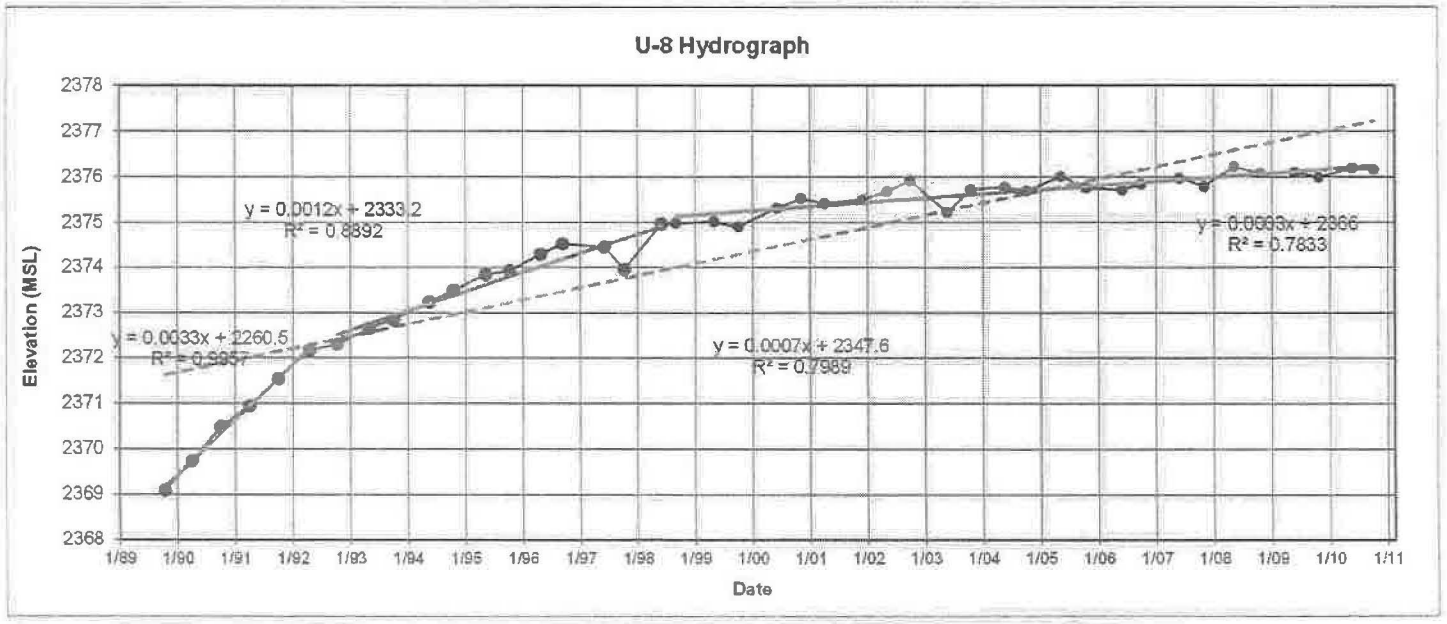
Well: U-8

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2543.09	2543.09	2543.09	2543.09	2543.09	2543.09	2543.09	2543.09	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97
Depth to Water	174.00	173.35	172.61	172.15	171.55	170.92	170.79	170.43	170.12	169.73	169.48	169.13	169.05	168.68
Water Table Elevation	2369.09	2369.74	2370.48	2370.94	2371.54	2372.17	2372.30	2372.66	2372.85	2373.24	2373.49	2373.84	2373.92	2374.29

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97
Depth to Water	168.45	168.52	169.02	168.00	167.99	167.96	168.07	167.66	167.45	167.56	167.47	167.30	167.05	167.76
Water Table Elevation	2374.52	2374.45	2373.95	2374.97	2374.98	2375.01	2374.90	2375.31	2375.52	2375.41	2375.50	2375.67	2375.92	2375.21

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97	2542.97
Depth to Water	167.25	167.20	167.28	166.96	167.21	167.26	167.13	167.00	167.18	166.74	166.88	166.87	166.98	166.78
Water Table Elevation	2375.72	2375.77	2375.69	2376.01	2375.76	2375.71	2375.84	2375.97	2375.79	2376.23	2376.09	2376.10	2375.99	2376.19

	10/10
MP Elevation	2542.97
Depth to Water	166.80
Water Table Elevation	2376.17



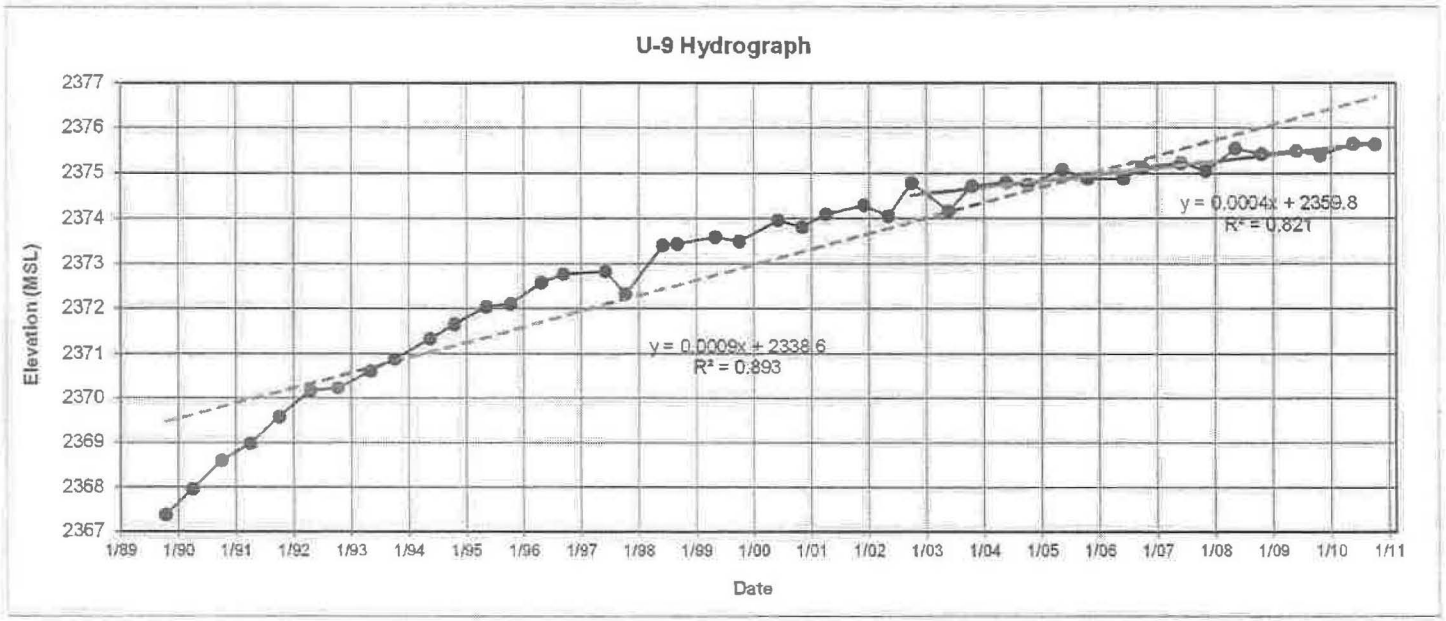
Well: U-9

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2550.48	2550.48	2550.48	2550.48	2550.48	2550.48	2550.48	2550.48	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35
Depth to Water	183.11	182.52	181.88	181.50	180.90	180.31	180.25	179.87	179.47	179.00	178.69	178.31	178.25	177.77
Water Table Elevation	2367.37	2367.96	2368.60	2368.98	2369.58	2370.17	2370.23	2370.61	2370.88	2371.35	2371.66	2372.04	2372.10	2372.58

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35
Depth to Water	177.58	177.52	178.03	176.95	176.92	176.76	176.86	176.39	176.54	176.26	176.06	176.30	175.56	176.19
Water Table Elevation	2372.77	2372.83	2372.32	2373.40	2373.43	2373.59	2373.49	2373.96	2373.81	2374.09	2374.29	2374.05	2374.79	2374.16

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35	2550.35
Depth to Water	175.63	175.55	175.60	175.27	175.47	175.46	175.22	175.12	175.29	174.81	174.93	174.86	174.96	174.71
Water Table Elevation	2374.72	2374.80	2374.75	2375.08	2374.88	2374.89	2375.13	2375.23	2375.06	2375.54	2375.42	2375.49	2375.39	2375.64

	10/10
MP Elevation	2550.35
Depth to Water	174.72
Water Table Elevation	2375.63



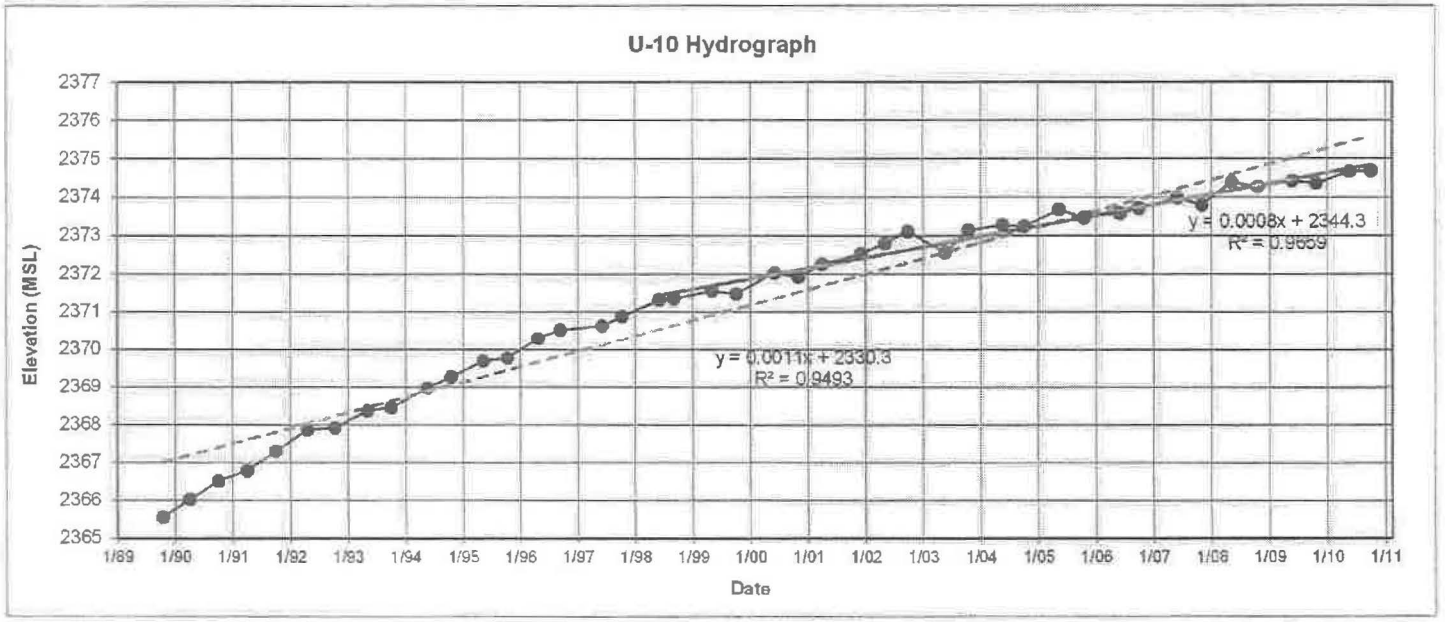
Well: U-10

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2555.15	2555.15	2555.15	2555.15	2555.15	2555.15	2555.15	2555.15	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83
Depth to Water	189.60	189.12	188.64	188.36	187.85	187.27	187.23	186.78	186.38	185.85	185.55	185.13	185.06	184.53
Water Table Elevation	2365.55	2366.03	2366.51	2366.79	2367.30	2367.88	2367.92	2368.37	2368.45	2368.98	2369.28	2369.70	2369.77	2370.30

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83
Depth to Water	184.31	184.20	183.95	183.51	183.48	183.27	183.35	182.79	182.90	182.56	182.30	182.03	181.72	182.27
Water Table Elevation	2370.52	2370.63	2370.88	2371.32	2371.35	2371.56	2371.48	2372.04	2371.93	2372.27	2372.53	2372.80	2373.11	2372.56

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83	2554.83
Depth to Water	181.69	181.55	181.59	181.14	181.36	181.25	181.12	180.84	181.03	180.43	180.55	180.40	180.47	180.16
Water Table Elevation	2373.14	2373.28	2373.24	2373.69	2373.47	2373.58	2373.71	2373.99	2373.80	2374.40	2374.28	2374.43	2374.36	2374.67

	10/10
MP Elevation	2554.83
Depth to Water	180.15
Water Table Elevation	2374.68



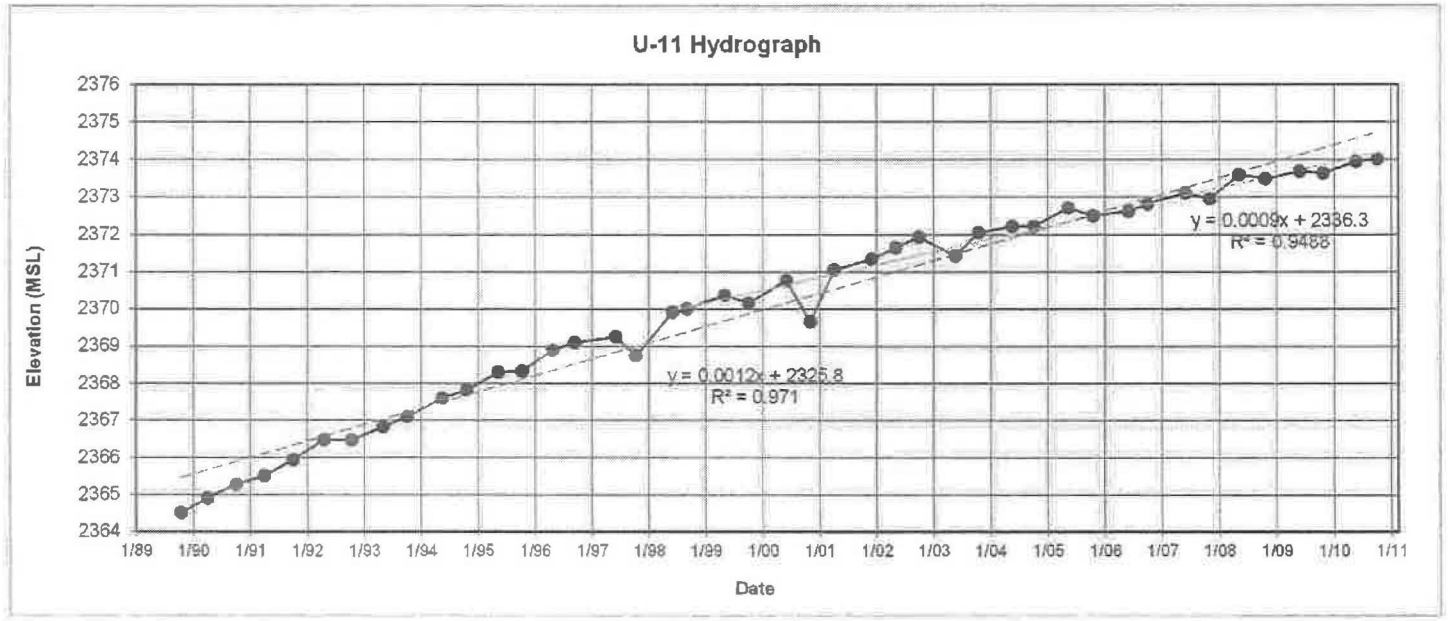
Well: U-11

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2557.64	2557.64	2557.64	2557.64	2557.64	2557.64	2557.64	2557.64	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52
Depth to Water	193.13	192.73	192.37	192.14	191.70	191.16	191.17	190.82	190.43	189.92	189.70	189.23	189.20	188.63
Water Table Elevation	2364.51	2364.91	2365.27	2365.50	2365.94	2366.48	2366.47	2366.82	2367.09	2367.60	2367.82	2368.29	2368.32	2368.89

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52
Depth to Water	188.42	188.26	188.78	187.61	187.52	187.15	187.36	186.75	187.87	186.47	186.18	185.88	185.59	186.10
Water Table Elevation	2369.10	2369.26	2368.74	2369.91	2370.00	2370.37	2370.16	2370.77	2369.65	2371.05	2371.34	2371.64	2371.93	2371.42

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52	2557.52
Depth to Water	185.47	185.30	185.30	184.81	185.02	184.90	184.71	184.41	184.57	183.92	184.03	183.83	183.88	183.57
Water Table Elevation	2372.05	2372.22	2372.22	2372.71	2372.50	2372.62	2372.81	2373.11	2372.95	2373.60	2373.49	2373.69	2373.64	2373.95

	10/10
MP Elevation	2557.52
Depth to Water	183.50
Water Table Elevation	2374.02



Well: U-12

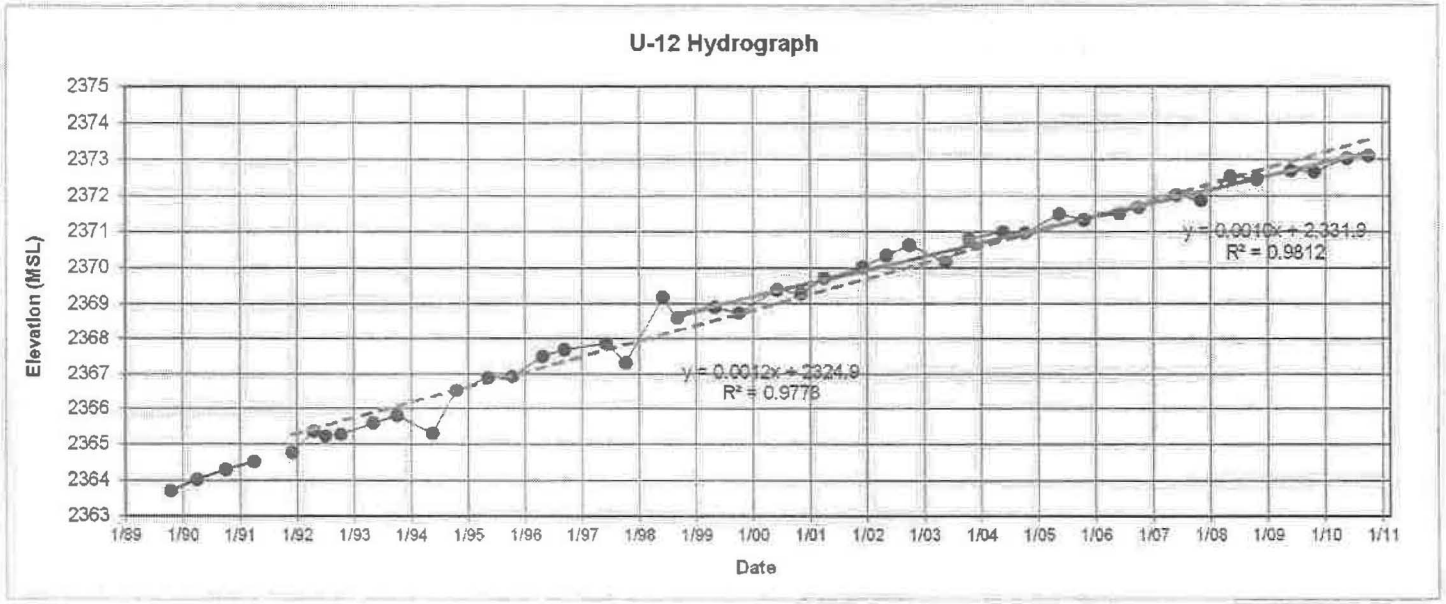
	10/89	4/90	10/90	4/91	10/91	12/91	4/92	7/92	10/92	5/93	10/93	5/94	10/94	5/95
MP Elevation	2559.35	2559.35	2559.35	2559.35	2559.35	2559.35	2559.35	2559.35	2559.35	2559.35	2559.24	2559.24	2559.24	2559.24
Depth to Water	195.65	195.32	195.05	194.83	184.48	194.58	193.98	194.12	194.07	193.76	193.43	193.94	192.72	192.34
Water Table Elevation	2363.70	2364.03	2364.30	2364.52	2374.87[1]	2364.77	2365.37	2365.23	2365.28	2365.59	2365.81	2365.30	2366.52	2366.90

	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02
MP Elevation	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24
Depth to Water	192.31	191.74	191.55	191.38	191.93	190.07	190.65	190.34	190.50	189.85	189.96	189.54	189.22	188.90
Water Table Elevation	2366.93	2367.50	2367.69	2367.86	2367.31	2369.17	2368.59	2368.90	2368.74	2369.39	2369.28	2369.70	2370.02	2370.34

[1] Elevation off-scale; possible measurement error; data point not used in graph

	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09
MP Elevation	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24	2559.24
Depth to Water	188.61	189.08	188.45	188.25	188.28	187.75	187.91	187.74	187.57	187.21	187.37	186.70	186.78	186.55
Water Table Elevation	2370.63	2370.16	2370.79	2370.99	2370.96	2371.49	2371.33	2371.50	2371.67	2372.03	2371.87	2372.54	2372.46	2372.69

	10/09	5/10	10/10
MP Elevation	2559.24	2559.24	2559.24
Depth to Water	186.58	186.21	186.14
Water Table Elevation	2372.66	2373.03	2373.10



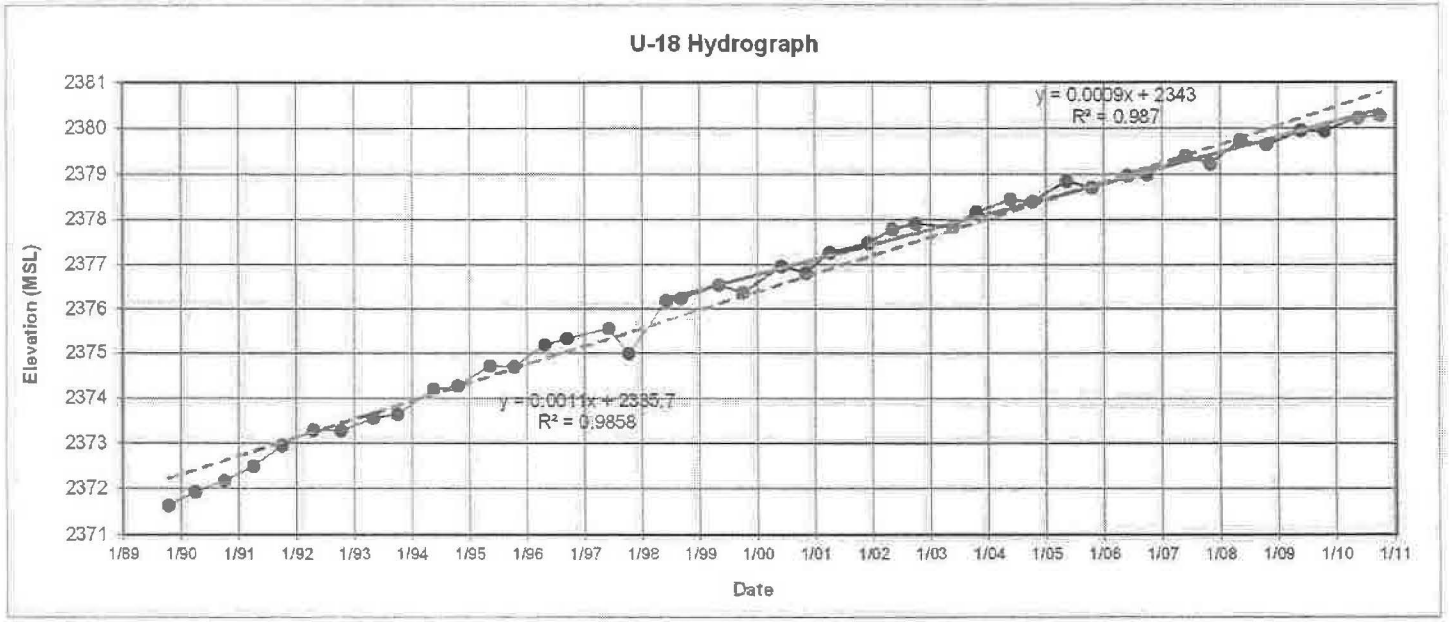
Well: U-18

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2576.53	2576.53	2576.53	2576.53	2576.53	2576.53	2576.53	2576.53	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40
Depth to Water	204.90	204.60	204.36	204.03	203.58	203.24	203.26	202.98	202.76	202.20	202.12	201.68	201.70	201.21
Water Table Elevation	2371.63	2371.93	2372.17	2372.50	2372.95	2373.29	2373.27	2373.55	2373.64	2374.20	2374.28	2374.72	2374.70	2375.19

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40
Depth to Water	201.06	200.83	201.41	200.22	200.17	199.86	200.03	199.44	199.59	199.13	198.92	198.61	198.49	198.57
Water Table Elevation	2375.34	2375.57	2374.99	2376.18	2376.23	2376.54	2376.37	2376.96	2376.81	2377.27	2377.48	2377.79	2377.91	2377.83

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40
Depth to Water	198.24	197.95	198.00	197.55	197.70	197.43	197.41	197.00	197.18	196.66	196.76	196.45	196.46	196.18
Water Table Elevation	2378.16	2378.45	2378.40	2378.85	2378.70	2378.97	2378.99	2379.40	2379.22	2379.74	2379.64	2379.95	2379.94	2380.22

	10/10
MP Elevation	2576.40
Depth to Water	196.13
Water Table Elevation	2380.27



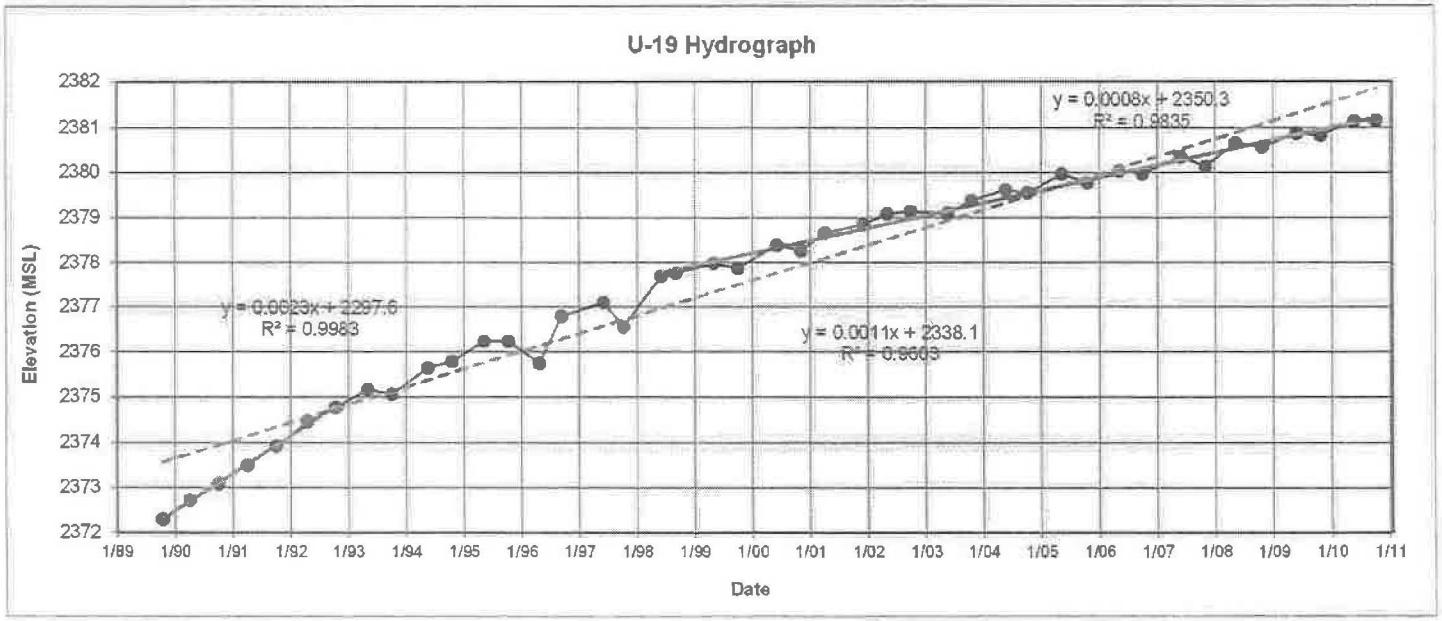
Well: U-19

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2575.54	2575.54	2575.54	2575.54	2575.54	2575.54	2575.54	2575.54	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40
Depth to Water	203.24	202.82	202.45	202.05	201.62	201.08	200.78	200.38	200.34	199.76	199.62	199.16	199.16	199.66
Water Table Elevation	2372.30	2372.72	2373.09	2373.49	2373.92	2374.46	2374.76	2375.16	2375.06	2375.64	2375.78	2376.24	2376.24	2375.74

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40
Depth to Water	198.61	198.30	198.85	197.72	197.64	197.42	197.53	197.01	197.14	196.74	196.55	196.31	196.26	196.30
Water Table Elevation	2376.79	2377.10	2376.55	2377.68	2377.76	2377.98	2377.87	2378.39	2378.26	2378.66	2378.85	2379.09	2379.14	2379.10

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40	2575.40
Depth to Water	196.02	195.78	195.85	195.43	195.62	195.36	195.42	195.05	195.26	194.74	194.83	194.53	194.57	194.27
Water Table Elevation	2379.38	2379.62	2379.55	2379.97	2379.78	2380.04	2379.98	2380.35	2380.14	2380.66	2380.57	2380.87	2380.83	2381.13

	10/10
MP Elevation	2575.40
Depth to Water	194.25
Water Table Elevation	2381.15



Well: U-20

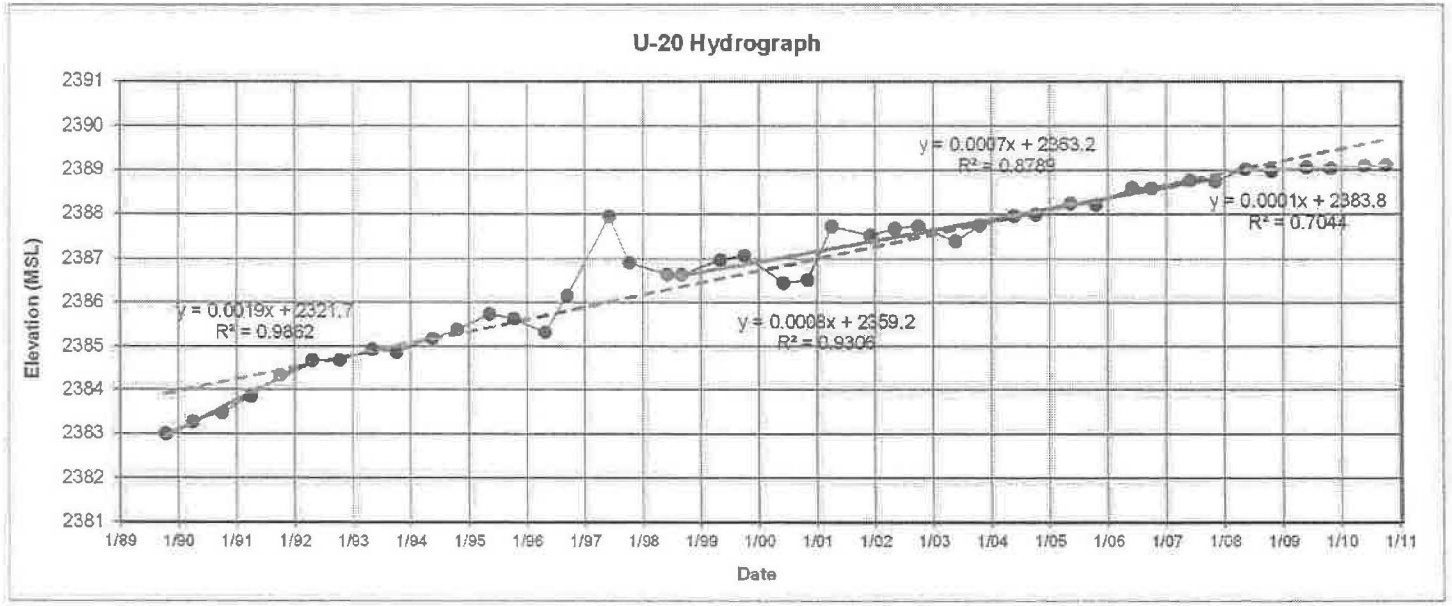
	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2573.60	2573.60	2573.60	2573.60	2573.60	2573.60	2573.60	2573.60	2573.60	2573.25	2573.25	2573.25	2573.25	2573.25
Depth to Water	183.65	190.60	190.32	190.12	189.74	189.26	188.92	188.92	188.67	188.39	188.07	187.86	187.50	187.61
Water Table Elevation	2389.95[1]	2383.00	2383.28	2383.48	2383.86	2384.34	2384.68	2384.68	2384.93	2384.86	2385.18	2385.39	2385.75	2385.64

[1] Elevation off-scale; possible measurement error; data point not used in graph

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25
Depth to Water	187.92	187.10	185.30	186.34	186.61	186.61	186.27	186.17	186.80	186.73	185.52	185.72	185.57	185.51
Water Table Elevation	2385.33	2386.15	2387.95	2386.91	2386.64	2386.64	2386.98	2387.08	2386.45	2386.52	2387.73	2387.53	2387.68	2387.74

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25	2573.25
Depth to Water	185.85	185.50	185.28	185.25	185.00	185.03	184.65	184.66	184.48	184.51	184.23	184.28	184.19	184.22
Water Table Elevation	2387.40	2387.75	2387.97	2388.00	2388.25	2388.22	2388.60	2388.59	2388.77	2388.74	2389.02	2388.97	2389.06	2389.03

	5/10	10/10
MP Elevation	2573.25	2573.25
Depth to Water	184.15	184.14
Water Table Elevation	2389.10	2389.11



Well: U-21

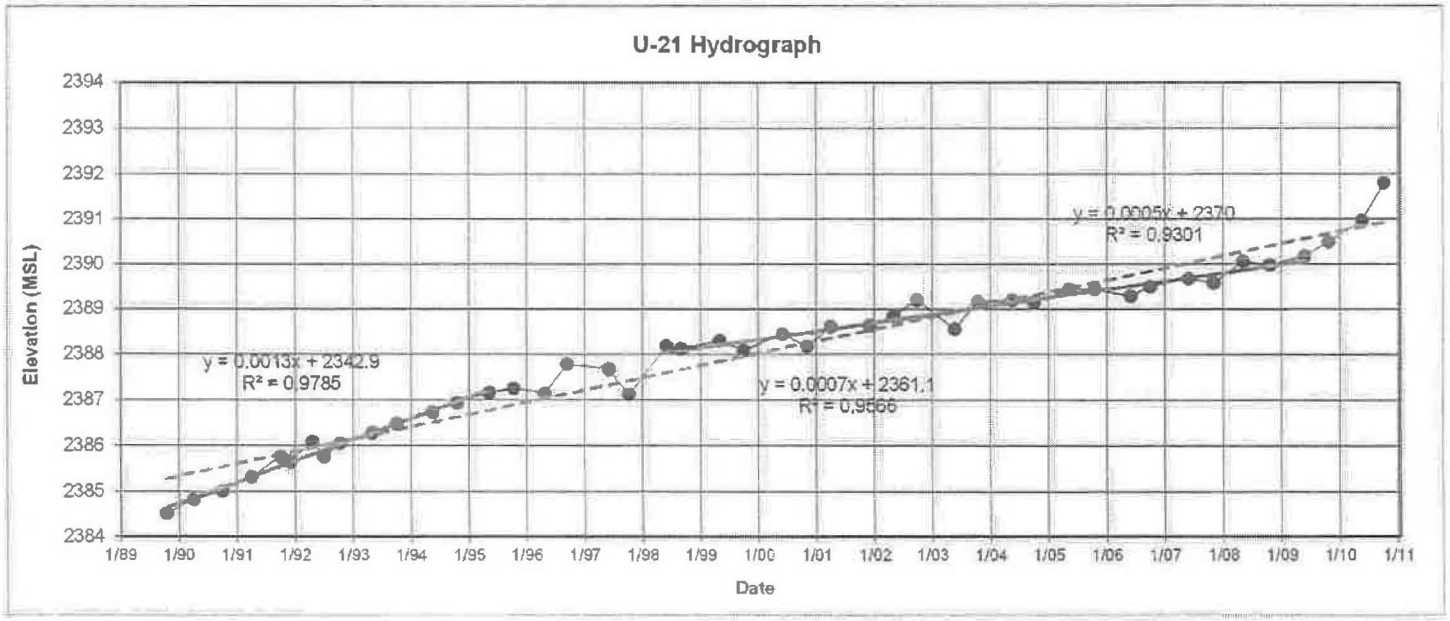
	4/89	10/89	4/90	10/90	4/91	10/91	12/91	4/92	7/92	10/92	5/93	10/93	5/94	10/94
MP Elevation	2573.76	2573.76	2573.76	2573.76	2573.76	2573.76	2573.76	2573.76	2573.76	2573.76	2573.76	2573.68	2573.68	2573.68
Depth to Water	183.11	189.25	188.94	188.75	188.44	188.00	188.11	187.67	188.00	187.71	187.48	187.20	186.95	186.75
Water Table Elevation	2390.65[1]	2384.51	2384.82	2385.01	2385.32	2385.76	2385.65	2386.09	2385.76	2386.05	2386.28	2386.48	2386.73	2386.93

[1] Elevation off-scale; possible measurement error; data point not used in graph

	5/95	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01
MP Elevation	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68
Depth to Water	186.52	186.42	186.53	185.89	186.00	186.56	185.49	185.55	185.37	185.59	185.22	185.50	185.06	185.03
Water Table Elevation	2387.16	2387.26	2387.15	2387.79	2387.68	2387.12	2388.19	2388.13	2388.31	2388.09	2388.46	2388.18	2388.62	2388.65

	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08
MP Elevation	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68	2573.68
Depth to Water	184.83	184.48	185.11	184.52	184.48	184.53	184.24	184.24	184.39	184.18	184.00	184.10	183.62	183.70
Water Table Elevation	2388.85	2389.20	2388.57	2389.16	2389.20	2389.15	2389.44	2389.44	2389.29	2389.50	2389.68	2389.58	2390.06	2389.98

	5/09	10/09	5/10	10/10
MP Elevation	2573.68	2573.68	2573.68	2573.68
Depth to Water	183.50	183.19	182.71	181.88
Water Table Elevation	2390.18	2390.49	2390.97	2391.80



Well: U-22

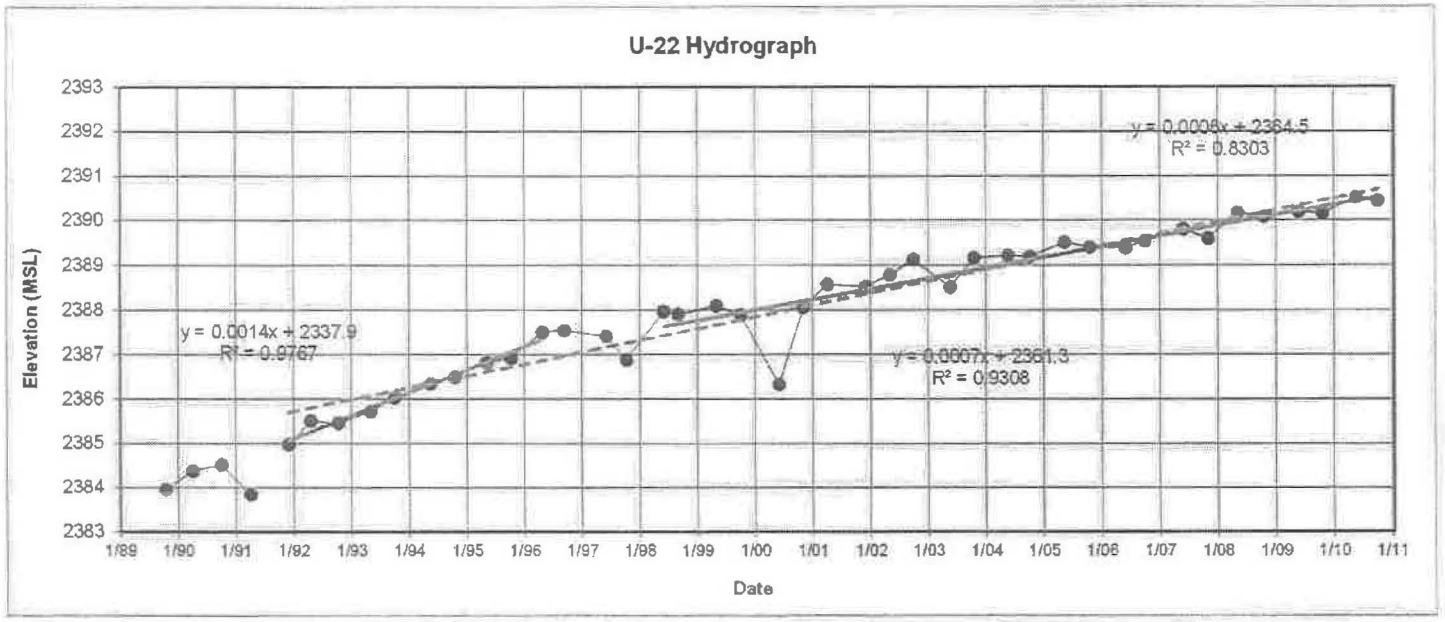
	4/89	10/89	4/90	10/90	4/91	10/91	12/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95
MP Elevation	2579.69	2579.69	2579.69	2579.69	2579.69	2579.69	2579.69	2579.69	2579.69	2579.69	2579.72	2579.72	2579.72	2579.72
Depth to Water	189.34	195.74	195.31	195.17	195.85	184.37	194.71	194.18	194.23	193.97	193.69	193.37	193.22	192.90
Water Table Elevation	2390.35[1]	2383.95	2384.38	2384.52	2383.84	2395.32[1]	2384.98	2385.51	2385.46	2385.72	2386.03	2386.35	2386.50	2386.82

[1] Elevation off-scale; possible measurement error; data point not used in graph

	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02
MP Elevation	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72
Depth to Water	192.80	192.22	192.18	192.31	192.84	191.75	191.82	191.63	191.83	193.39	191.66	191.15	191.20	190.94
Water Table Elevation	2386.92	2387.50	2387.54	2387.41	2386.88	2387.97	2387.90	2388.09	2387.89	2386.33	2388.06	2388.57	2388.52	2388.78

	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09
MP Elevation	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72	2579.72
Depth to Water	190.60	191.21	190.56	190.50	190.53	190.21	190.32	190.34	190.18	189.92	190.13	189.55	189.64	189.53
Water Table Elevation	2389.12	2388.51	2389.16	2389.22	2389.19	2389.51	2389.40	2389.38	2389.54	2389.80	2389.59	2390.17	2390.08	2390.19

	10/09	5/10	10/10
MP Elevation	2579.72	2579.72	2579.72
Depth to Water	189.57	189.20	189.28
Water Table Elevation	2390.15	2390.52	2390.44



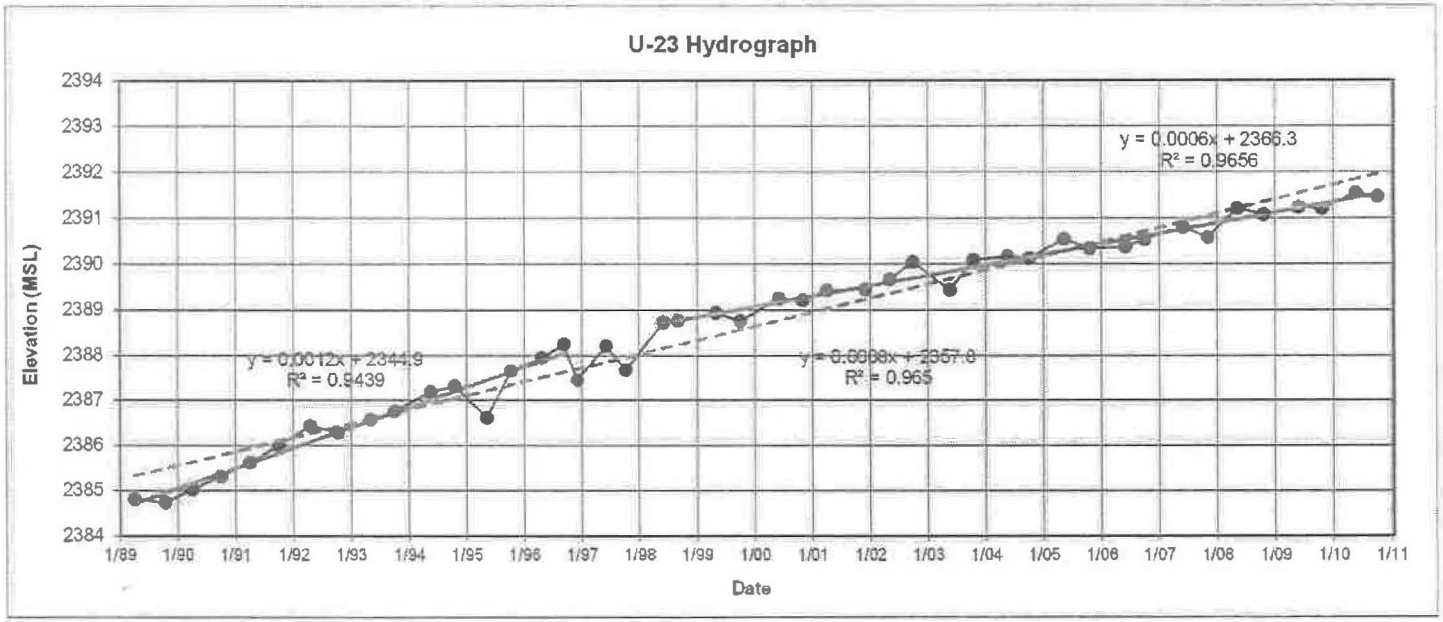
Well: U-23

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2569.88	2569.74	2569.88	2569.88	2569.88	2569.88	2569.88	2569.88	2569.88	2569.85	2569.85	2569.85	2569.85	2569.85
Depth to Water	185.07	185.00	184.85	184.56	184.25	183.88	183.45	183.60	183.31	183.09	182.67	182.54	183.24	182.20
Water Table Elevation	2384.81	2384.74	2385.03	2385.32	2385.63	2386.00	2386.43	2386.28	2386.57	2386.76	2387.18	2387.31	2386.61	2387.65

	4/96	9/96	12/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02
MP Elevation	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85
Depth to Water	181.90	181.61	182.41	181.64	182.18	181.12	181.08	180.91	181.09	180.61	180.64	180.42	180.40	180.18
Water Table Elevation	2387.95	2388.24	2387.44	2388.21	2387.67	2388.73	2388.77	2388.94	2388.76	2389.24	2389.21	2389.43	2389.45	2389.67

	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09
MP Elevation	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85	2569.85
Depth to Water	179.80	180.42	179.76	179.68	179.72	179.30	179.51	179.48	179.31	179.04	179.27	178.64	178.77	178.62
Water Table Elevation	2390.05	2389.43	2390.09	2390.17	2390.13	2390.55	2390.34	2390.37	2390.54	2390.81	2390.58	2391.21	2391.08	2391.23

	10/09	5/10	10/10
MP Elevation	2569.85	2569.85	2569.85
Depth to Water	178.65	178.30	178.38
Water Table Elevation	2391.20	2391.55	2391.47



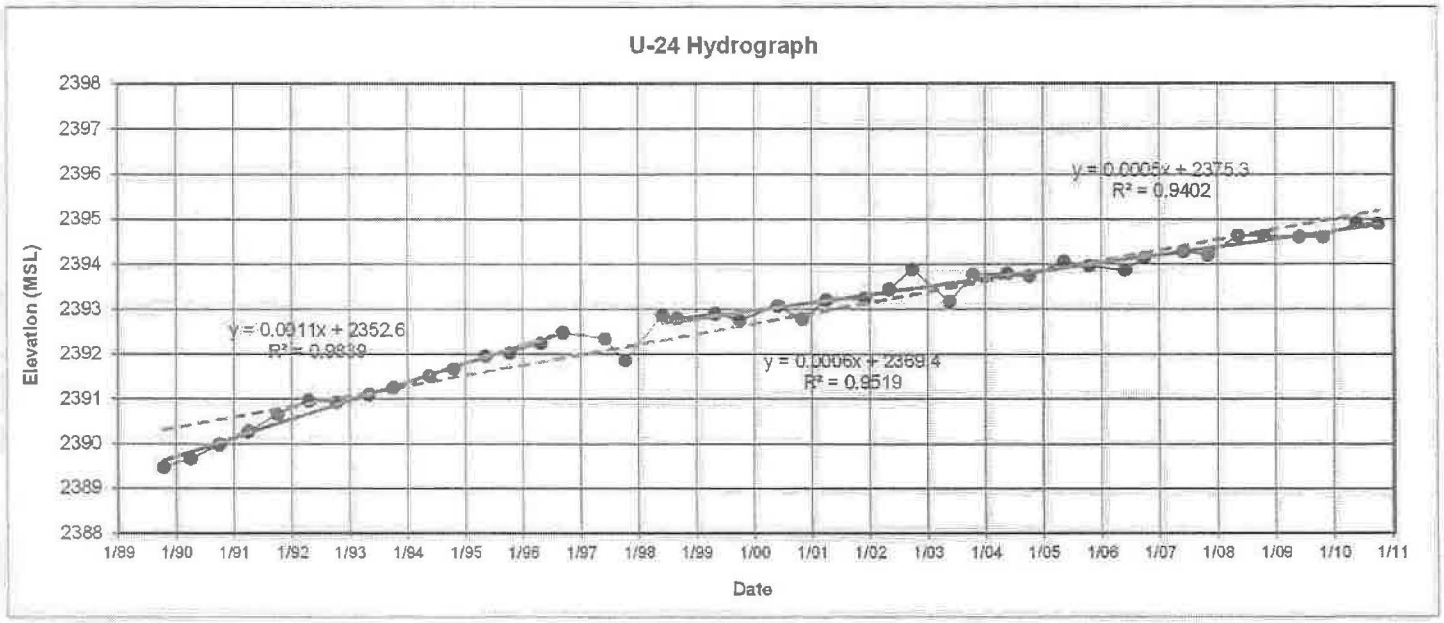
Well: U-24

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2561.59	2561.59	2561.59	2561.59	2561.59	2561.59	2561.59	2561.59	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48
Depth to Water	172.12	171.92	171.60	171.32	170.94	170.63	170.67	170.50	170.23	169.97	169.81	169.53	169.45	169.23
Water Table Elevation	2389.47	2389.67	2389.99	2390.27	2390.65	2390.96	2390.92	2391.09	2391.25	2391.51	2391.67	2391.95	2392.03	2392.25

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48
Depth to Water	169.00	169.13	169.63	168.61	168.68	168.57	168.72	168.40	168.70	168.27	168.24	168.04	167.60	168.31
Water Table Elevation	2392.48	2392.35	2391.85	2392.87	2392.80	2392.91	2392.76	2393.08	2392.78	2393.21	2393.24	2393.44	2393.88	2393.17

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48	2561.48
Depth to Water	167.72	167.69	167.75	167.42	167.52	167.62	167.33	167.20	167.28	166.84	166.85	166.87	166.88	166.56
Water Table Elevation	2393.76	2393.79	2393.73	2394.06	2393.96	2393.86	2394.15	2394.28	2394.20	2394.64	2394.63	2394.61	2394.60	2394.92

	10/10
MP Elevation	2561.48
Depth to Water	166.58
Water Table Elevation	2394.90



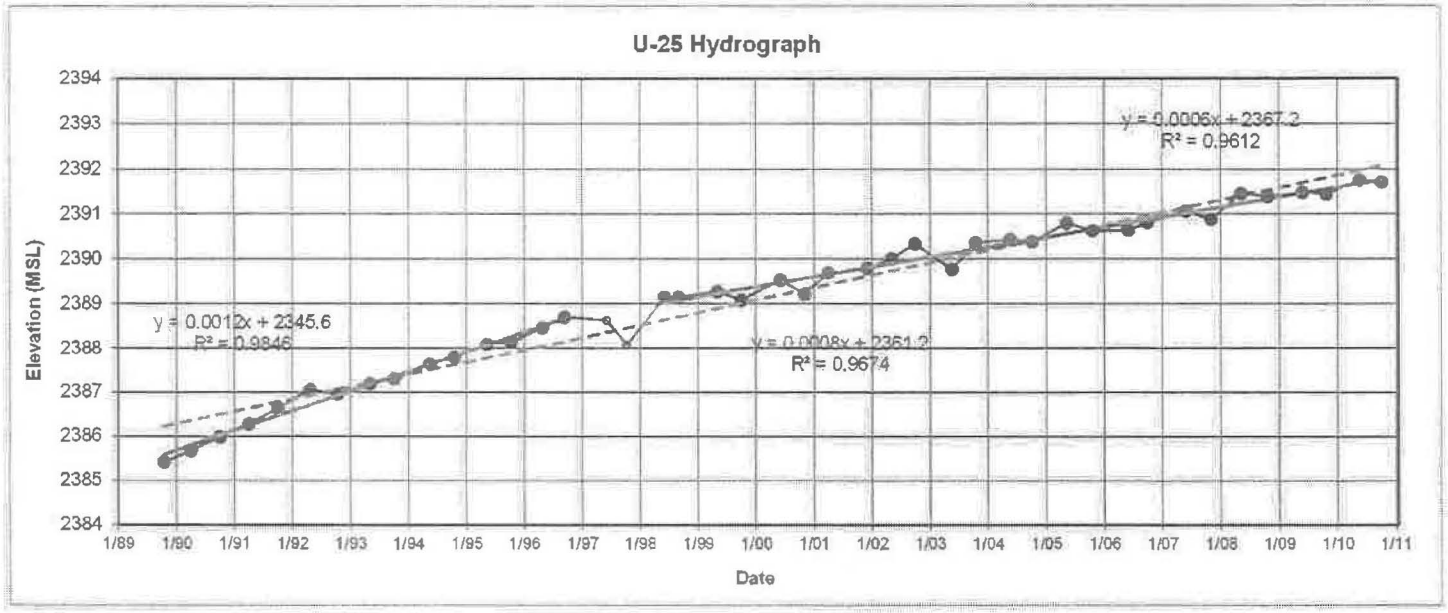
Well: U-25

	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96
MP Elevation	2568.31	2568.31	2568.31	2568.31	2568.31	2568.31	2568.31	2568.31	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19
Depth to Water	182.89	182.63	182.32	182.03	181.67	181.25	181.35	181.12	180.88	180.55	180.40	180.10	180.05	179.73
Water Table Elevation	2385.42	2385.68	2385.99	2386.28	2386.64	2387.06	2386.96	2387.19	2387.31	2387.64	2387.79	2388.09	2388.14	2388.46

	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19
Depth to Water	179.49	179.56	180.11	179.05	179.05	178.92	179.11	178.66	178.98	178.50	178.40	178.19	177.85	178.43
Water Table Elevation	2388.70	2388.63	2388.08	2389.14	2389.14	2389.27	2389.08	2389.53	2389.21	2389.69	2389.79	2390.00	2390.34	2389.76

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19	2568.19
Depth to Water	177.83	177.75	177.80	177.39	177.56	177.55	177.38	177.12	177.31	176.73	176.80	176.71	176.75	176.43
Water Table Elevation	2390.36	2390.44	2390.39	2390.80	2390.63	2390.64	2390.81	2391.07	2390.88	2391.46	2391.39	2391.48	2391.44	2391.76

	10/10
MP Elevation	2568.19
Depth to Water	176.48
Water Table Elevation	2391.71

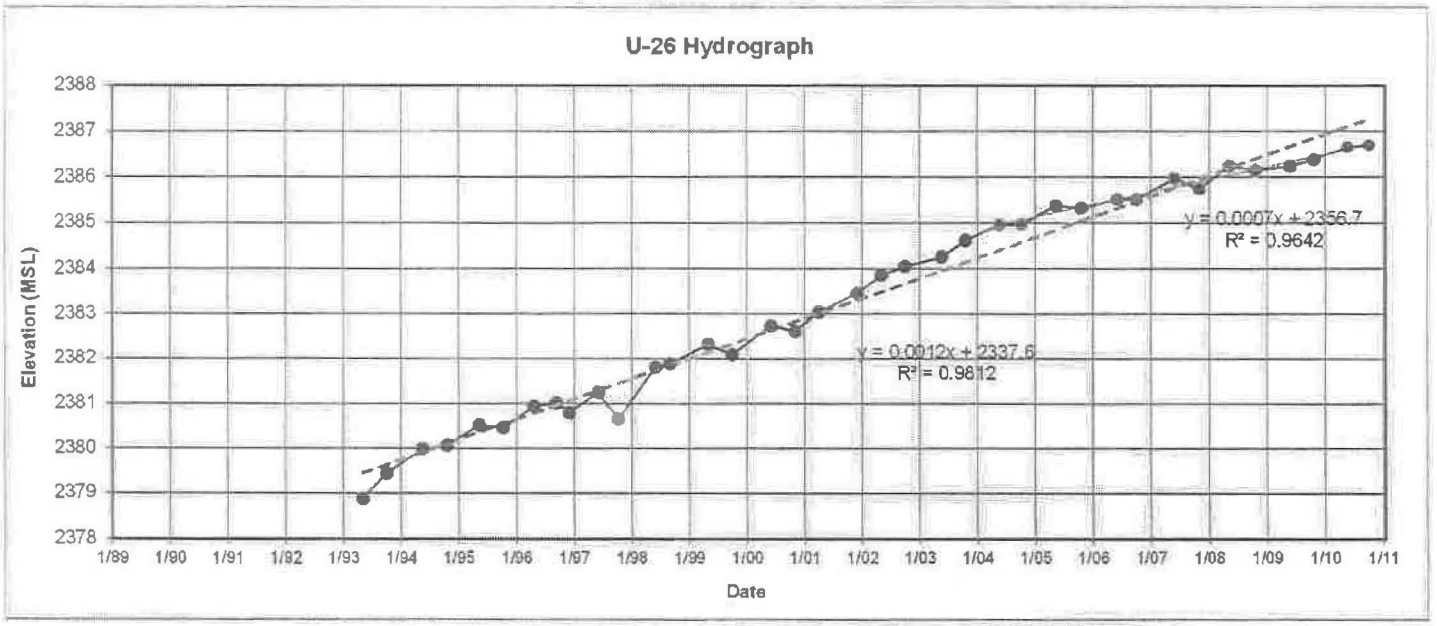


Well: U-26

	5/93	10/93	5/94	10/94	5/95	10/95	4/96	9/96	12/96	6/97	10/97	6/98	9/98	5/99
MP Elevation	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34
Depth to Water	209.46	208.90	208.35	208.28	207.83	207.89	207.40	207.33	207.55	207.10	207.69	206.54	206.46	206.02
Water Table Elevation	2378.88	2379.44	2379.99	2380.06	2380.51	2380.45	2380.94	2381.01	2380.79	2381.24	2380.65	2381.80	2381.88	2382.32

	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06
MP Elevation	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34
Depth to Water	206.25	205.61	205.74	205.31	204.88	204.48	204.29	204.08	203.72	203.38	203.38	202.96	203.02	202.82
Water Table Elevation	2382.09	2382.73	2382.60	2383.03	2383.46	2383.86	2384.05	2384.26	2384.62	2384.96	2384.96	2385.38	2385.32	2385.52

	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34	2588.34
Depth to Water	202.83	202.37	202.59	202.11	202.20	202.11	201.97	201.69	201.65
Water Table Elevation	2385.51	2385.97	2385.75	2386.23	2386.14	2386.23	2386.37	2386.65	2386.69



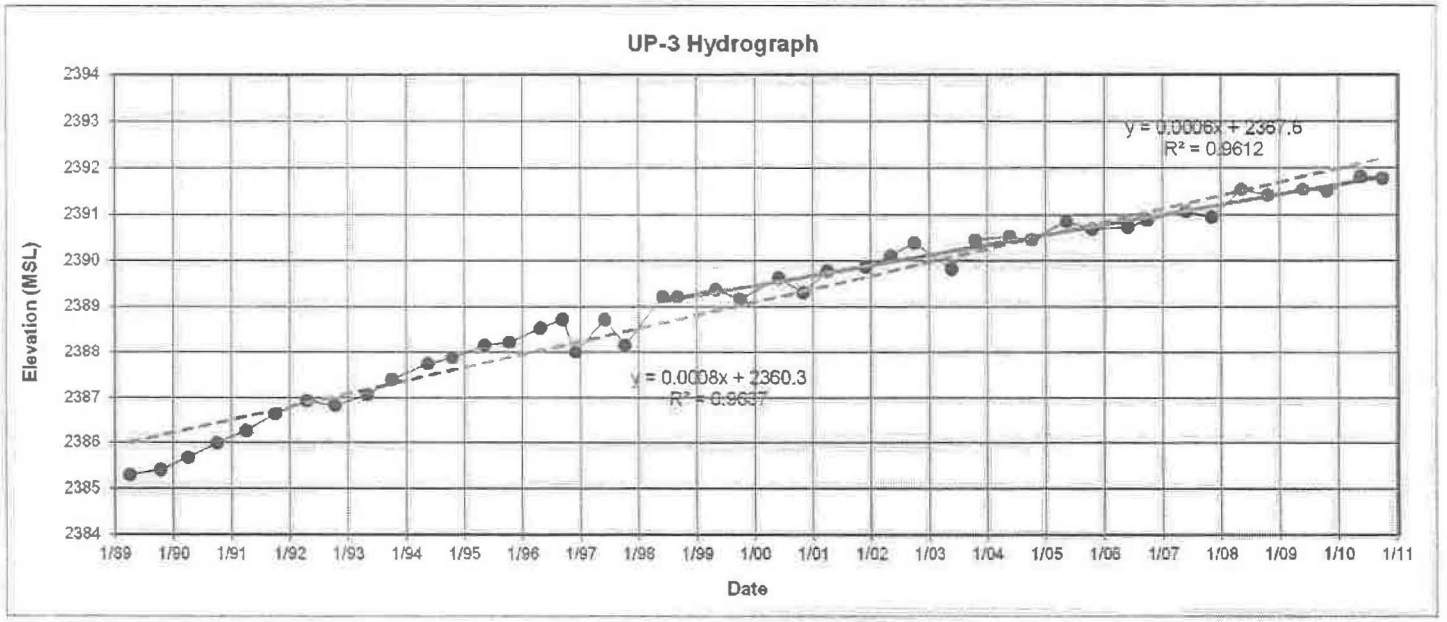
Well: UP-3

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2567.84	2567.84	2567.84	2567.84	2567.84	2567.84	2567.84	2567.84	2567.84	2567.92	2567.92	2567.92	2567.92	2567.92
Depth to Water	182.55	182.44	182.17	181.85	181.58	181.21	180.91	181.02	180.78	180.53	180.18	180.05	179.76	179.70
Water Table Elevation	2385.29	2385.40	2385.67	2385.99	2386.26	2386.63	2386.93	2386.82	2387.06	2387.39	2387.74	2387.87	2388.16	2388.22

	4/96	9/96	12/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02
MP Elevation	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92
Depth to Water	179.39	179.20	179.92	179.20	179.76	178.70	178.70	178.54	178.75	178.29	178.61	178.14	178.05	177.82
Water Table Elevation	2388.53	2388.72	2388.00	2388.72	2388.16	2389.22	2389.22	2389.38	2389.17	2389.63	2389.31	2389.78	2389.87	2390.10

	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09
MP Elevation	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92	2567.92
Depth to Water	177.54	178.10	177.48	177.40	177.47	177.07	177.24	177.20	177.05	176.85	176.98	176.38	176.50	176.38
Water Table Elevation	2390.38	2389.82	2390.44	2390.52	2390.45	2390.85	2390.68	2390.72	2390.87	2391.07	2390.94	2391.54	2391.42	2391.54

	10/09	5/10	10/10
MP Elevation	2567.92	2567.92	2567.92
Depth to Water	176.42	176.10	176.14
Water Table Elevation	2391.50	2391.82	2391.78



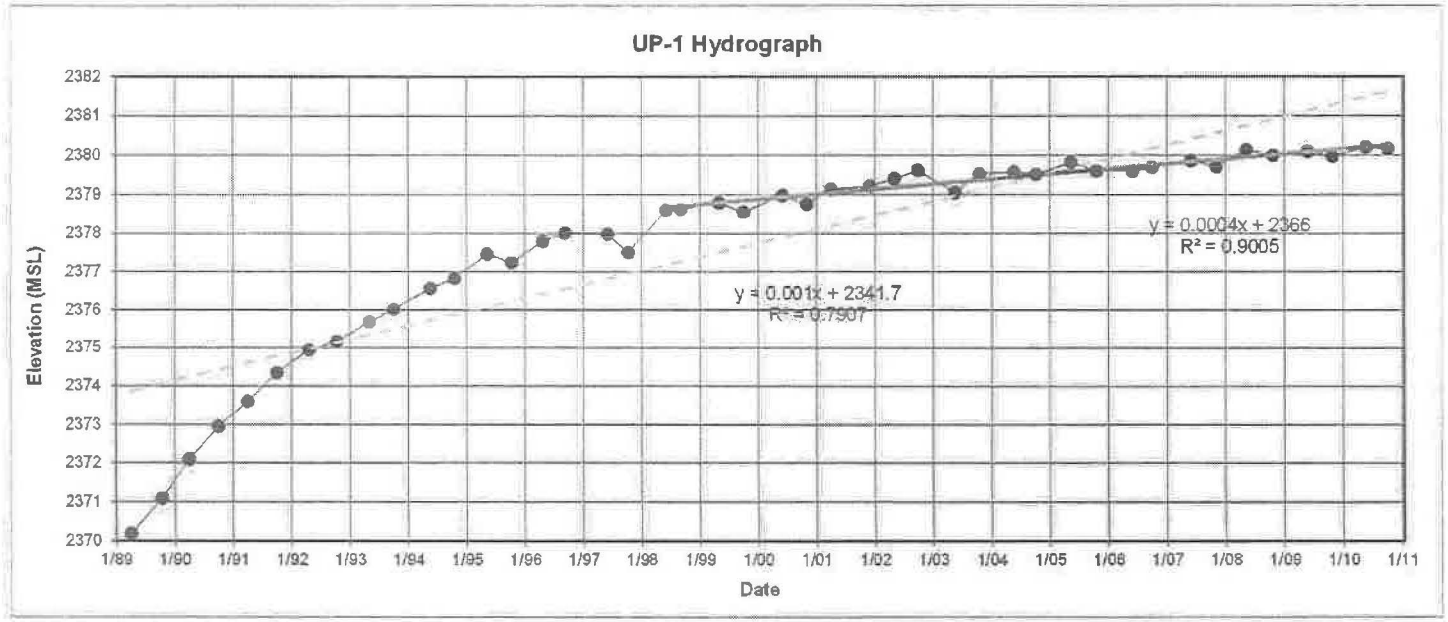
Well: UP-1

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2560.30	2560.30	2560.30	2560.30	2560.30	2560.30	2560.30	2560.30	2560.30	2560.42	2560.42	2560.42	2560.42	2560.19
Depth to Water	190.12	189.20	188.20	187.35	186.70	185.96	185.36	185.13	184.62	184.40	183.86	183.60	182.95	182.95
Water Table Elevation	2370.18	2371.10	2372.10	2372.95	2373.60	2374.34	2374.94	2375.17	2375.68	2376.02	2376.56	2376.82	2377.47	2377.24

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42
Depth to Water	182.62	182.41	182.44	182.91	181.82	181.81	181.63	181.87	181.44	181.66	181.28	181.20	181.02	180.80
Water Table Elevation	2377.80	2378.01	2377.98	2377.51	2378.60	2378.61	2378.79	2378.55	2378.98	2378.76	2379.14	2379.22	2379.40	2379.62

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42	2560.42
Depth to Water	181.37	180.90	180.84	180.91	180.60	180.82	180.82	180.73	180.55	180.71	180.27	180.42	180.32	180.45
Water Table Elevation	2379.05	2379.52	2379.58	2379.51	2379.82	2379.60	2379.60	2379.69	2379.87	2379.71	2380.15	2380.00	2380.10	2379.97

	5/10	10/10
MP Elevation	2560.42	2560.42
Depth to Water	180.21	180.25
Water Table Elevation	2380.21	2380.17



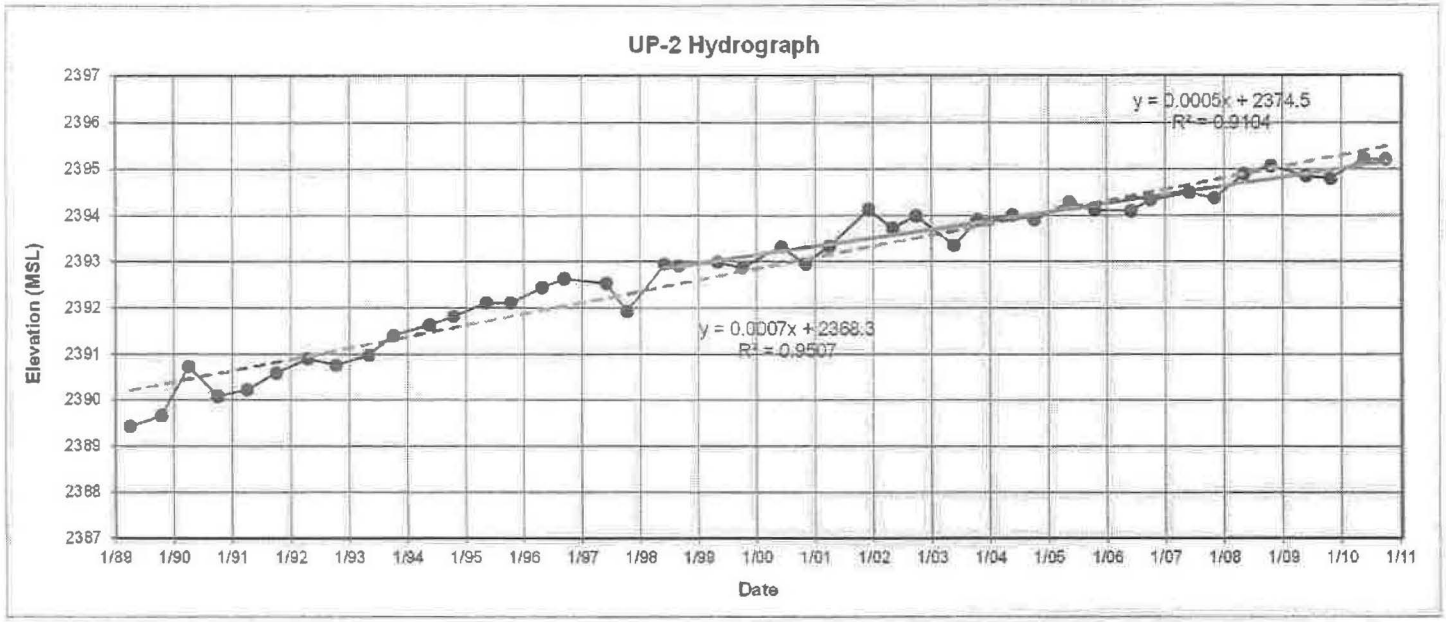
Well: UP-2

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2553.26	2553.26	2553.26	2553.26	2553.26	2553.26	2553.26	2553.26	2553.26	2553.43	2553.43	2553.43	2553.43	2553.43
Depth to Water	163.83	163.60	162.53	163.18	163.03	162.67	162.36	162.50	162.28	162.03	161.80	161.62	161.32	161.32
Water Table Elevation	2389.43	2389.66	2390.73	2390.08	2390.23	2390.59	2390.90	2390.76	2390.98	2391.40	2391.63	2391.81	2392.11	2392.11

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43
Depth to Water	160.99	160.80	160.90	161.51	160.49	160.52	160.44	160.57	160.11	160.48	160.10	159.30	159.70	159.43
Water Table Elevation	2392.44	2392.63	2392.53	2391.92	2392.94	2392.91	2392.99	2392.86	2393.32	2392.95	2393.33	2394.13	2393.73	2394.00

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43	2553.43
Depth to Water	160.08	159.52	159.42	159.52	159.15	159.31	159.33	159.10	158.94	159.06	158.54	158.36	158.58	158.63
Water Table Elevation	2393.35	2393.91	2394.01	2393.91	2394.28	2394.12	2394.10	2394.33	2394.49	2394.37	2394.89	2395.07	2394.85	2394.80

	5/10	10/10
MP Elevation	2553.43	2553.43
Depth to Water	158.22	158.22
Water Table Elevation	2395.21	2395.21



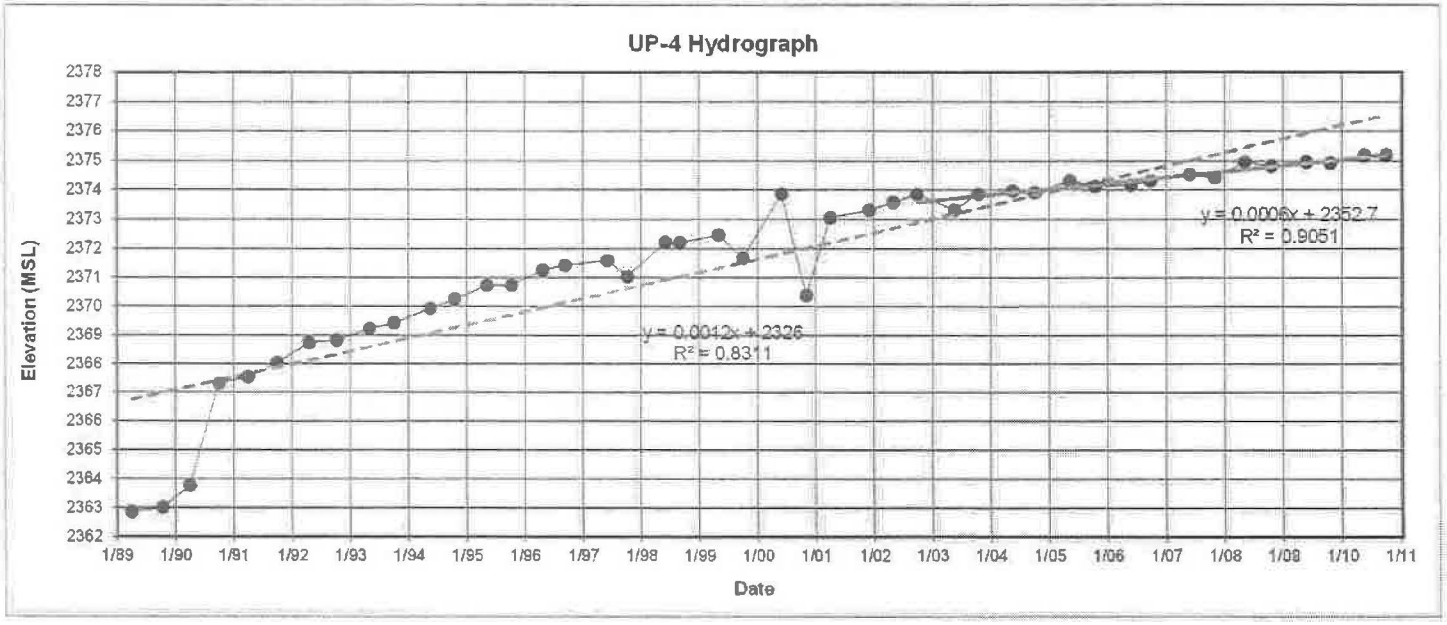
Well: UP-4

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2555.34	2555.34	2555.34	2555.34	2555.34	2555.34	2555.48	2555.48	2555.48	2555.38	2555.38	2555.38	2555.38	2555.38
Depth to Water	192.48	192.33	191.57	188.03	187.80	187.29	186.73	186.65	186.26	185.95	185.44	185.13	184.65	184.64
Water Table Elevation	2362.86	2363.01	2363.77	2367.31	2367.54	2368.05	2368.75	2368.83	2369.22	2369.43	2369.94	2370.25	2370.73	2370.74

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38
Depth to Water	184.12	183.95	183.79	184.34	183.15	183.17	182.91	183.70	181.51	184.99	182.32	182.07	181.81	181.52
Water Table Elevation	2371.26	2371.43	2371.59	2371.04	2372.23	2372.21	2372.47	2371.68	2373.87	2370.39	2373.06	2373.31	2373.57	2373.86

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38	2555.38
Depth to Water	182.07	181.52	181.42	181.48	181.05	181.25	181.20	181.06	180.84	180.96	180.41	180.55	180.41	180.46
Water Table Elevation	2373.31	2373.86	2373.96	2373.90	2374.33	2374.13	2374.18	2374.32	2374.54	2374.42	2374.97	2374.83	2374.97	2374.92

	5/10	10/10
MP Elevation	2555.38	2555.38
Depth to Water	180.20	180.19
Water Table Elevation	2375.18	2375.19



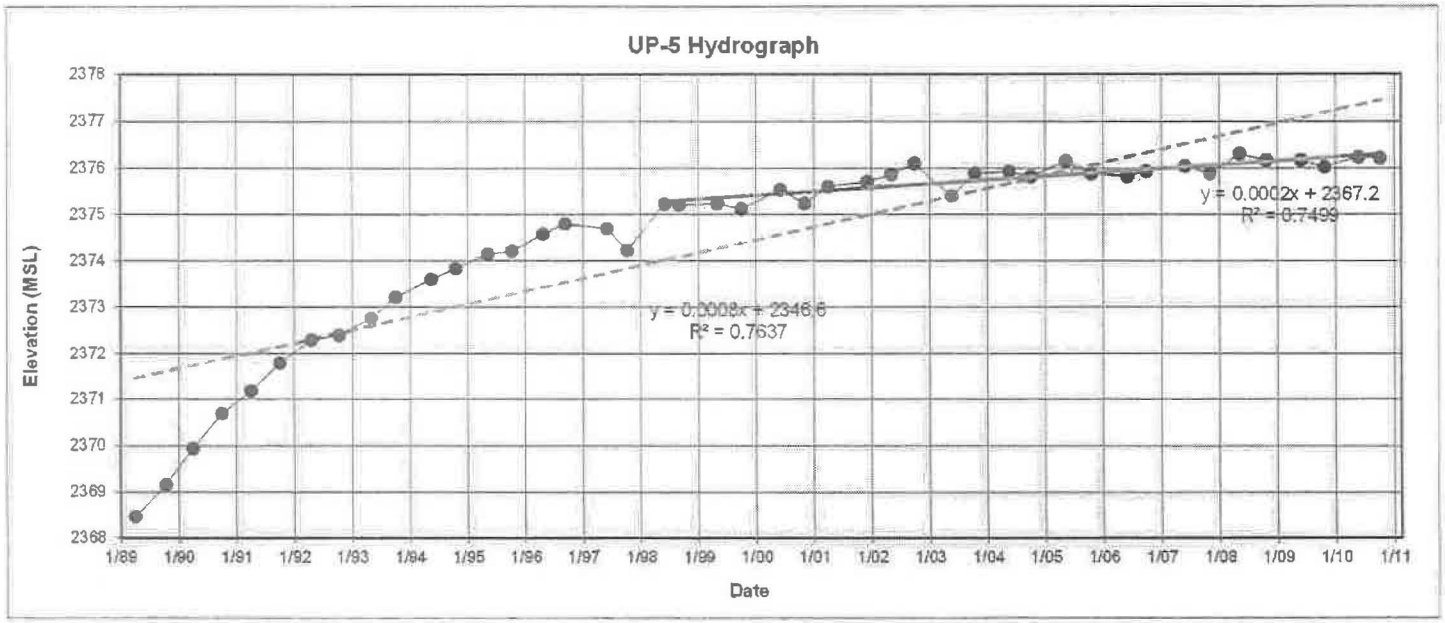
Well: UP-5

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2541.51	2541.51	2541.51	2541.51	2541.51	2541.51	2541.51	2541.51	2541.51	2541.65	2541.65	2541.65	2541.65	2541.65
Depth to Water	173.05	172.35	171.57	170.82	170.33	169.72	169.21	169.11	168.74	168.44	168.05	167.82	167.50	167.44
Water Table Elevation	2368.46	2369.16	2369.94	2370.69	2371.18	2371.79	2372.30	2372.40	2372.77	2373.21	2373.60	2373.83	2374.15	2374.21

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65
Depth to Water	167.07	166.85	166.95	167.43	166.42	166.44	166.41	166.53	166.11	166.41	166.04	165.94	165.78	165.55
Water Table Elevation	2374.58	2374.80	2374.70	2374.22	2375.23	2375.21	2375.24	2375.12	2375.54	2375.24	2375.61	2375.71	2375.87	2376.10

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65	2541.65
Depth to Water	166.25	165.76	165.72	165.82	165.50	165.77	165.83	165.71	165.60	165.76	165.34	165.48	165.48	165.62
Water Table Elevation	2375.40	2375.89	2375.93	2375.83	2376.15	2375.88	2375.82	2375.94	2376.05	2375.89	2376.31	2376.17	2376.17	2376.03

	5/10	10/10
MP Elevation	2541.65	2541.65
Depth to Water	165.41	165.43
Water Table Elevation	2376.24	2376.22



Well: UP-6

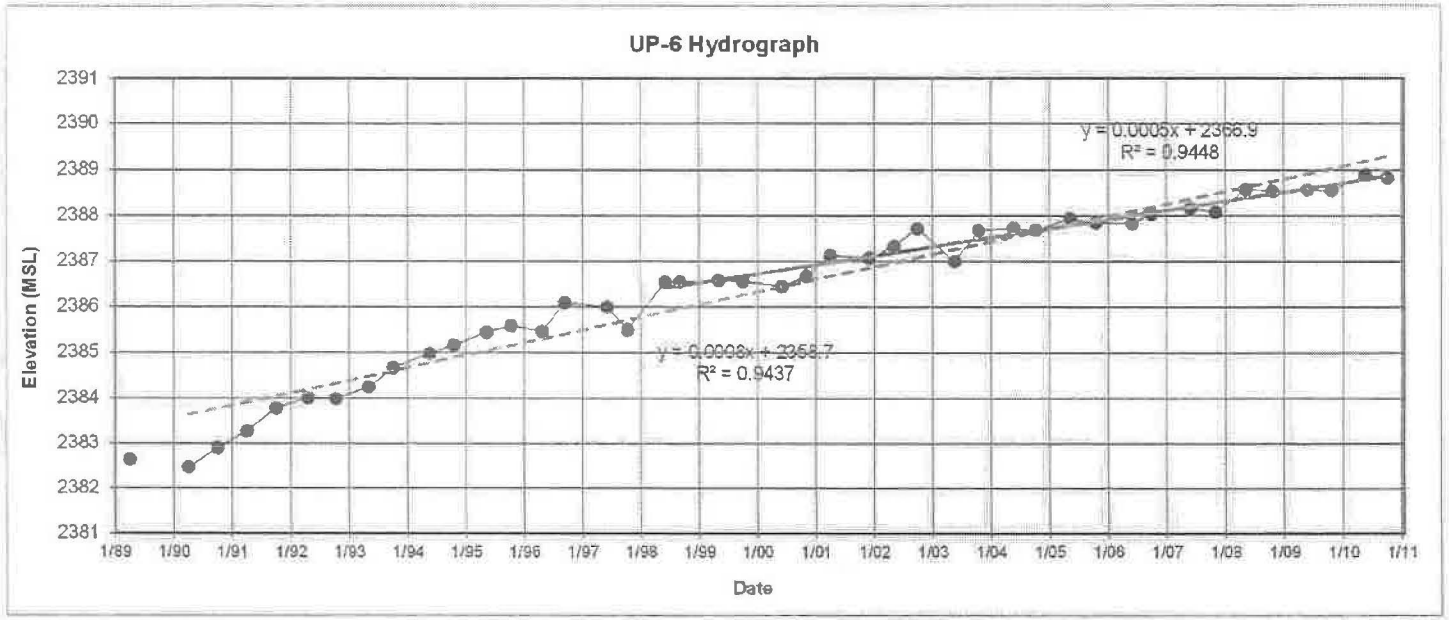
	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2566.34	2565.95	2566.34	2566.34	2566.34	2566.34	2566.34	2566.34	2566.34	2566.45	2566.45	2566.45	2566.45	2566.45
Depth to Water	183.70	188.40	183.87	183.44	183.07	182.56	182.33	182.35	182.09	181.78	181.48	181.28	181.00	180.86
Water Table Elevation	2382.64	2377.75[1]	2382.47	2382.90	2383.27	2383.78	2384.01	2383.99	2384.25	2384.67	2384.97	2385.17	2385.45	2385.59

[1] Elevation off-scale; possible measurement error; data point not used in graph

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45
Depth to Water	180.98	180.36	180.46	180.95	179.91	179.90	179.87	179.89	180.00	179.78	179.32	179.37	179.12	178.73
Water Table Elevation	2385.47	2386.09	2385.99	2385.50	2386.54	2386.55	2386.58	2386.56	2386.45	2386.67	2387.13	2387.08	2387.33	2387.72

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45	2566.45
Depth to Water	179.45	178.77	178.72	178.77	178.51	178.60	178.62	178.41	178.28	178.37	177.87	177.91	177.88	177.90
Water Table Elevation	2387.00	2387.68	2387.73	2387.68	2387.94	2387.85	2387.83	2388.04	2388.17	2388.08	2388.58	2388.54	2388.57	2388.55

	5/10	10/10
MP Elevation	2566.45	2566.45
Depth to Water	177.55	177.62
Water Table Elevation	2388.90	2388.83



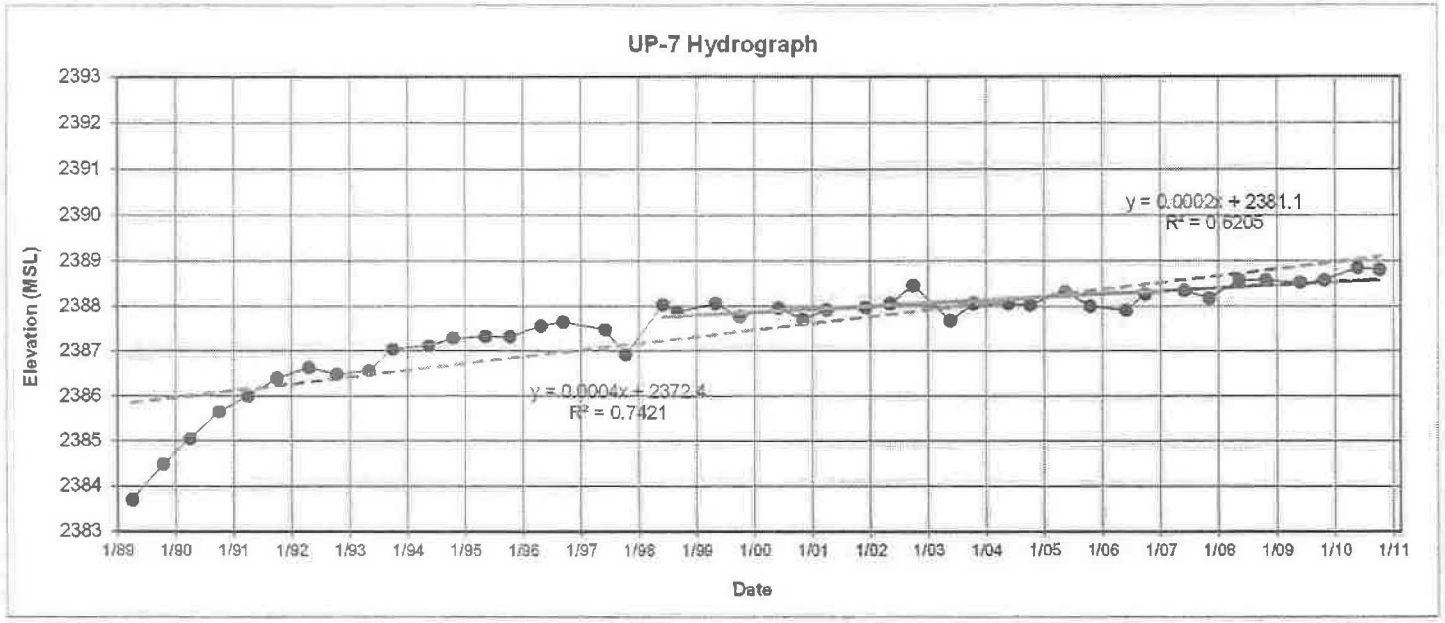
Well: UP-7

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2559.40	2559.40	2559.40	2559.40	2559.40	2559.40	2559.40	2559.40	2559.40	2559.68	2559.68	2559.68	2559.68	2559.68
Depth to Water	175.70	174.92	174.35	173.75	173.41	173.00	172.77	172.92	172.84	172.64	172.56	172.39	172.35	172.36
Water Table Elevation	2383.70	2384.48	2385.05	2385.65	2385.99	2386.40	2386.63	2386.48	2386.56	2387.04	2387.12	2387.29	2387.33	2387.32

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68
Depth to Water	172.12	172.03	172.20	172.77	171.65	171.81	171.62	171.91	171.72	171.97	171.76	171.71	171.62	171.22
Water Table Elevation	2387.56	2387.65	2387.48	2386.91	2388.03	2387.87	2388.06	2387.77	2387.96	2387.71	2387.92	2387.97	2388.06	2388.46

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68	2559.68
Depth to Water	172.00	171.62	171.62	171.65	171.35	171.68	171.77	171.41	171.33	171.50	171.10	171.10	171.15	171.10
Water Table Elevation	2387.68	2388.06	2388.06	2388.03	2388.33	2388.00	2387.91	2388.27	2388.35	2388.18	2388.58	2388.58	2388.53	2388.58

	5/10	10/10
MP Elevation	2559.68	2559.68
Depth to Water	170.83	170.87
Water Table Elevation	2388.85	2388.81



Well: UP-8

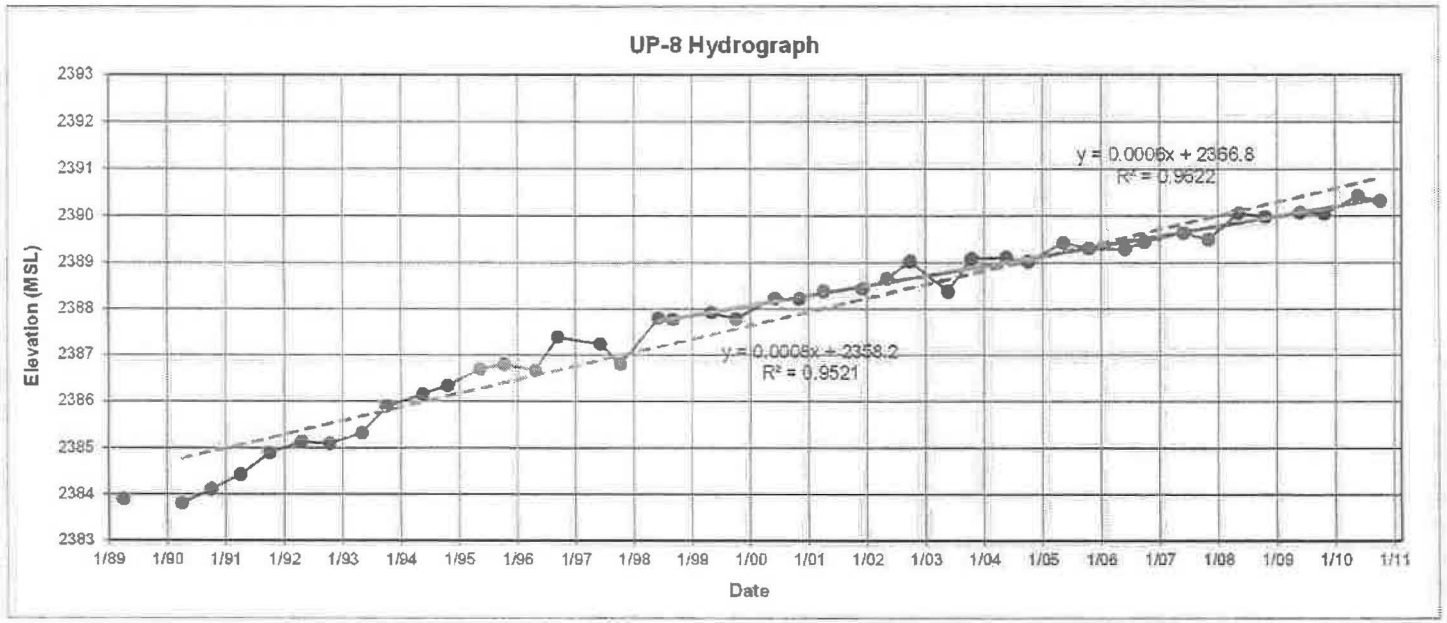
	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2571.41	2571.41	2571.41	2571.41	2571.41	2571.41	2571.41	2571.41	2571.41	2571.69	2571.69	2571.69	2571.69	2571.69
Depth to Water	187.51	193.66	187.61	187.30	186.99	186.52	186.28	186.32	186.09	185.80	185.54	185.36	185.00	184.90
Water Table Elevation	2383.90	2377.75[1]	2383.80	2384.11	2384.42	2384.89	2385.13	2385.09	2385.32	2385.89	2386.15	2386.33	2386.69	2386.79

[1] Elevation off-scale; possible measurement error; data point not used in graph

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69
Depth to Water	185.03	184.30	184.45	184.90	183.89	183.92	183.77	183.91	183.46	183.47	183.31	183.26	183.04	182.67
Water Table Elevation	2386.66	2387.39	2387.24	2386.79	2387.80	2387.77	2387.92	2387.78	2388.23	2388.22	2388.38	2388.43	2388.65	2389.02

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/10	10/10
MP Elevation	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69	2571.69
Depth to Water	183.31	182.61	182.58	182.67	182.27	182.39	182.41	182.25	182.06	182.20	181.63	181.71	181.26	181.37
Water Table Elevation	2388.38	2389.08	2389.11	2389.02	2389.42	2389.30	2389.28	2389.44	2389.63	2389.49	2390.06	2389.98	2390.43	2390.32

	5/10	10/10
MP Elevation	2571.69	2571.69
Depth to Water	181.26	181.37
Water Table Elevation	2390.43	2390.32

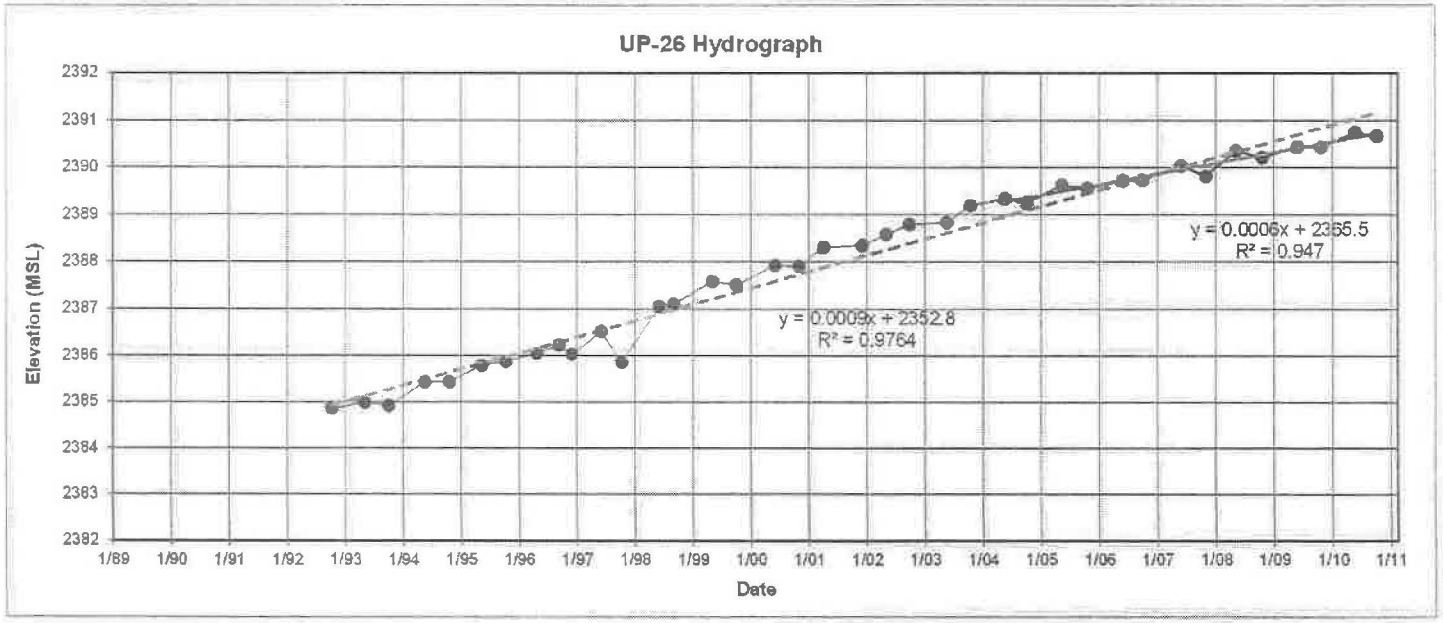


Well: UP-26

	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96	9/96	12/96	6/97	10/97	6/98	9/98
MP Elevation	2576.45	2576.45	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40	2576.40
Depth to Water	191.59	191.46	191.48	190.97	190.97	190.62	190.53	190.35	190.17	190.37	189.88	190.55	189.35	189.30
Water Table Elevation	2384.86	2384.99	2384.92	2385.43	2385.43	2385.78	2385.87	2386.05	2386.23	2386.03	2386.52	2385.85	2387.05	2387.10

	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05
MP Elevation	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4
Depth to Water	188.82	188.89	188.48	188.5	188.1	188.06	187.82	187.61	187.57	187.21	187.06	187.15	186.77	186.84
Water Table Elevation	2387.58	2387.51	2387.92	2387.9	2388.3	2388.34	2388.58	2388.79	2388.83	2389.19	2389.34	2389.25	2389.63	2389.56

	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2576.4	2576.4	2576.4	2576.4	2576.4	2576.4	2576.40	2576.40	2576.40	2576.40
Depth to Water	186.67	186.67	186.35	186.58	186.04	186.18	185.96	185.96	185.65	185.72
Water Table Elevation	2389.73	2389.73	2390.05	2389.82	2390.36	2390.22	2390.44	2390.44	2390.75	2390.68



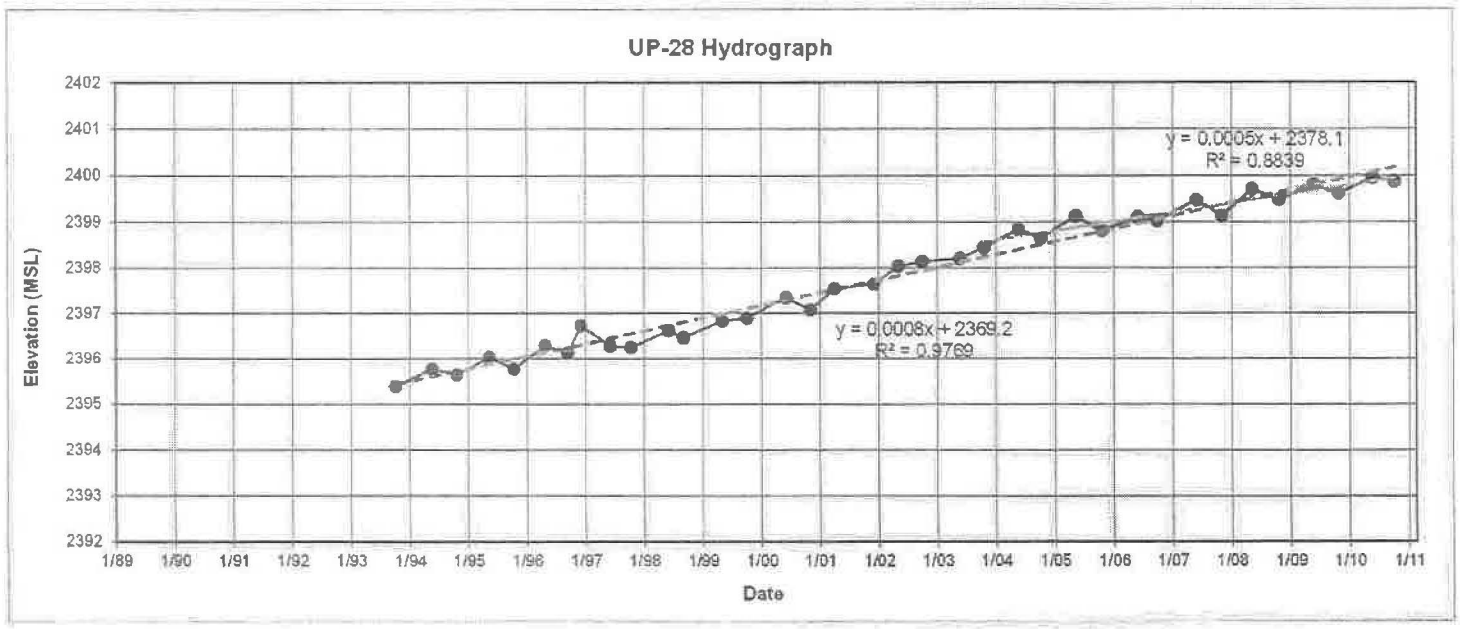
Well: UP-28

	5/93	10/93	5/94	10/94	5/95	10/95	4/96	9/96	12/96	6/97	10/97	6/98	9/98	5/99
MP Elevation	2591.49	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41
Measured Depth to Water	199.31	197.36	196.97	197.10	196.71	196.97	196.44	196.61	196.00	196.45	196.48	196.11	196.27	195.90
Corr Depth to Water[1]	197.95	196.03	195.64	195.77	195.39	195.64	195.12	195.29	194.68	195.13	195.16	194.79	194.95	194.59
Water Table Elevation	2393.53[2]	2395.38	2395.77	2395.64	2396.02	2395.77	2396.29	2396.12	2396.73	2396.28	2396.25	2396.62	2396.46	2396.82

[1] Corrected Elevation = 0.9864(Depth to Water) + 1.36 [2] Water level not used. May not have fully equilibrated.

	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06
MP Elevation	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41
Measured Depth to Water	195.84	195.37	195.65	195.17	195.07	194.67	194.57	194.50	194.26	193.85	194.05	193.57	193.89	193.59
Corr Depth to Water	194.53	194.06	194.34	193.87	193.77	193.37	193.27	193.21	192.97	192.56	192.76	192.29	192.60	192.31
Water Table Elevation	2396.88	2397.35	2397.07	2397.54	2397.64	2398.04	2398.14	2398.20	2398.44	2398.85	2398.65	2399.12	2398.81	2399.10

	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41	2591.41
Measured Depth to Water	193.67	193.22	193.57	192.98	193.21	192.88	193.07	192.73	192.81
Corr Depth to Water	192.39	191.94	192.29	191.71	191.93	191.61	191.79	191.46	191.54
Water Table Elevation	2399.02	2399.47	2399.12	2399.70	2399.48	2399.80	2399.62	2399.95	2399.87



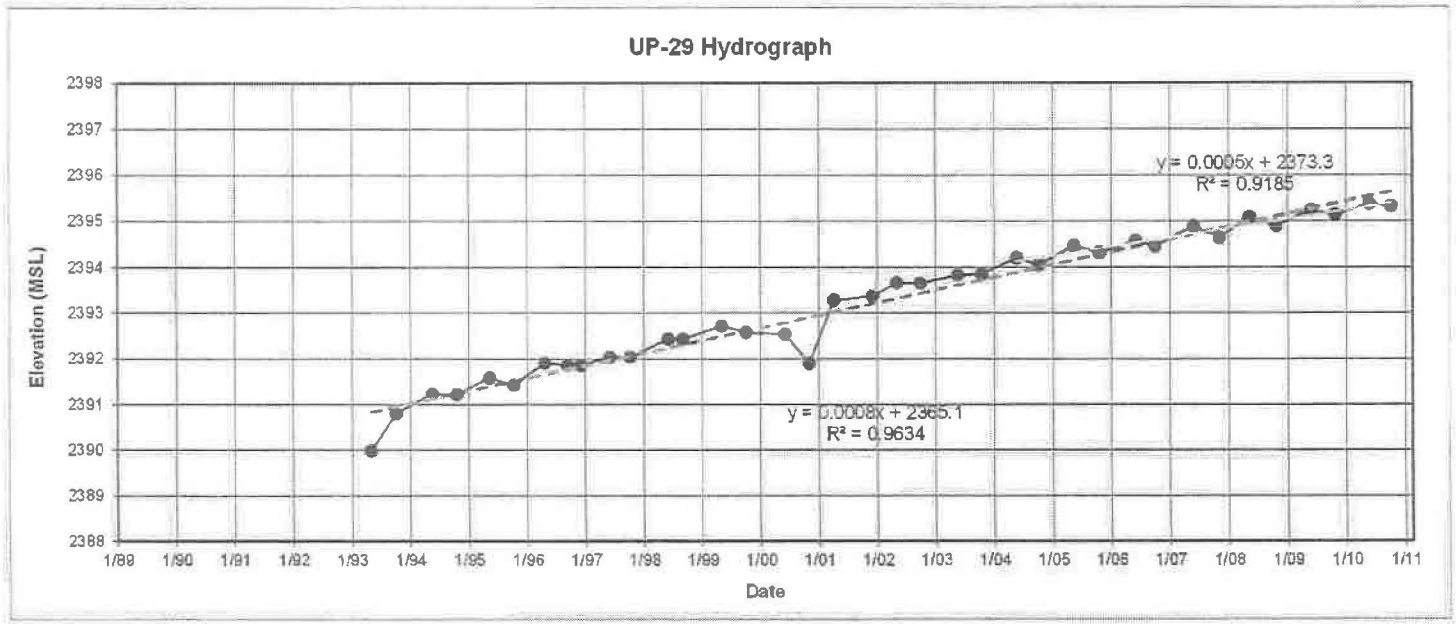
Well: UP-29

	5/93	10/93	5/94	10/94	5/95	10/95	4/96	9/96	12/96	6/97	10/97	6/98	9/98	5/99
MP Elevation	2575.79	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74
Measured Depth to Water	190.33	189.42	188.97	188.98	188.60	188.76	188.26	188.31	188.31	188.11	188.11	187.70	187.71	187.40
Corr Depth to Water[1]	185.80	184.94	184.51	184.52	184.16	184.31	183.84	183.88	183.88	183.69	183.69	183.30	183.31	183.02
Water Table Elevation	2389.99	2390.80	2391.23	2391.22	2391.58	2391.43	2391.90	2391.86	2391.86	2392.05	2392.05	2392.44	2392.43	2392.72

[1] Corrected Elevation = 0.9884(Depth to Water) + 5.29

	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06
MP Elevation	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74
Measured Depth to Water	187.55	187.60	188.26	186.81	186.72	186.41	186.42	186.23	186.21	185.84	186.00	185.56	185.72	185.45
Corr Depth to Water	183.16	183.21	183.84	182.46	182.38	182.08	182.09	181.91	181.89	181.54	181.69	181.28	181.43	181.17
Water Table Elevation	2392.58	2392.53	2391.90	2393.28	2393.36	2393.66	2393.65	2393.83	2393.85	2394.20	2394.05	2394.46	2394.31	2394.57

	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74	2575.74
Measured Depth to Water	185.57	185.11	185.38	184.91	185.1	184.75	184.85	184.6	184.65
Corr Depth to Water	181.2846	180.8483	181.1044	180.6586	180.8388	180.5069	180.6017	180.3646	180.4121
Water Table Elevation	2394.455	2394.892	2394.636	2395.081	2394.901	2395.233	2395.138	2395.375	2395.328



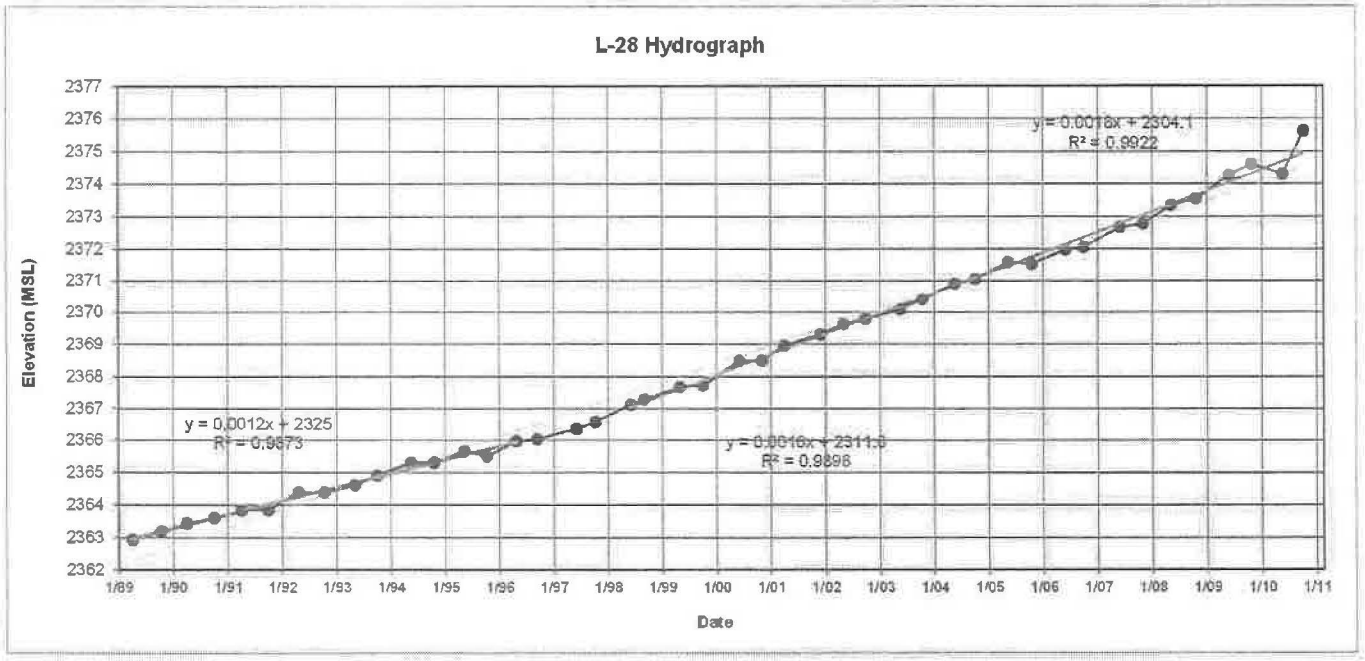
Well: L-28

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2571.88	2571.88	2571.88	2571.88	2571.88	2571.88	2571.69	2571.88	2571.88	2571.83	2571.83	2571.83	2571.83	2571.83
Measured Depth to Water*	212.85	212.58	212.33	212.17	211.93	211.92	211.16	211.35	211.12	210.77	210.35	210.36	209.99	210.16
Corr Depth to Water	208.95	208.69	208.44	208.29	208.05	208.04	207.30	207.49	207.27	206.92	206.52	206.52	206.16	206.33
Water Table Elevation	2362.93	2363.19	2363.44	2363.59	2363.83	2363.84	2364.39	2364.39	2364.61	2364.91	2365.31	2365.31	2365.67	2365.50

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.77	2571.77
Measured Depth to Water*	209.67	209.60	209.27	209.05	208.50	208.33	207.92	207.88	207.11	207.10	206.61	206.25	205.86	205.70
Corr Depth to Water	205.85	205.78	205.46	205.25	204.71	204.55	204.15	204.11	203.36	203.35	202.87	202.52	202.14	201.98
Water Table Elevation	2365.98	2366.05	2366.37	2366.58	2367.12	2367.28	2367.68	2367.72	2368.47	2368.48	2368.96	2369.31	2369.63	2369.79

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/10	10/10
MP Elevation	2571.77	2571.77	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83	2571.83
Measured Depth to Water*	205.39	205.06	204.62	204.47	203.93	203.99	203.51	203.44	202.80	202.69	202.10	201.90	201.13	199.77
Corr Depth to Water	201.68	201.36	200.93	200.79	200.26	200.32	199.85	199.78	199.16	199.05	198.48	198.28	197.53	196.21
Water Table Elevation	2370.09	2370.41	2370.90	2371.04	2371.57	2371.51	2371.98	2372.05	2372.67	2372.78	2373.35	2373.55	2374.30	2375.62

* Corrected depth to water = (0.9744 x measured depth to water) + 1.55



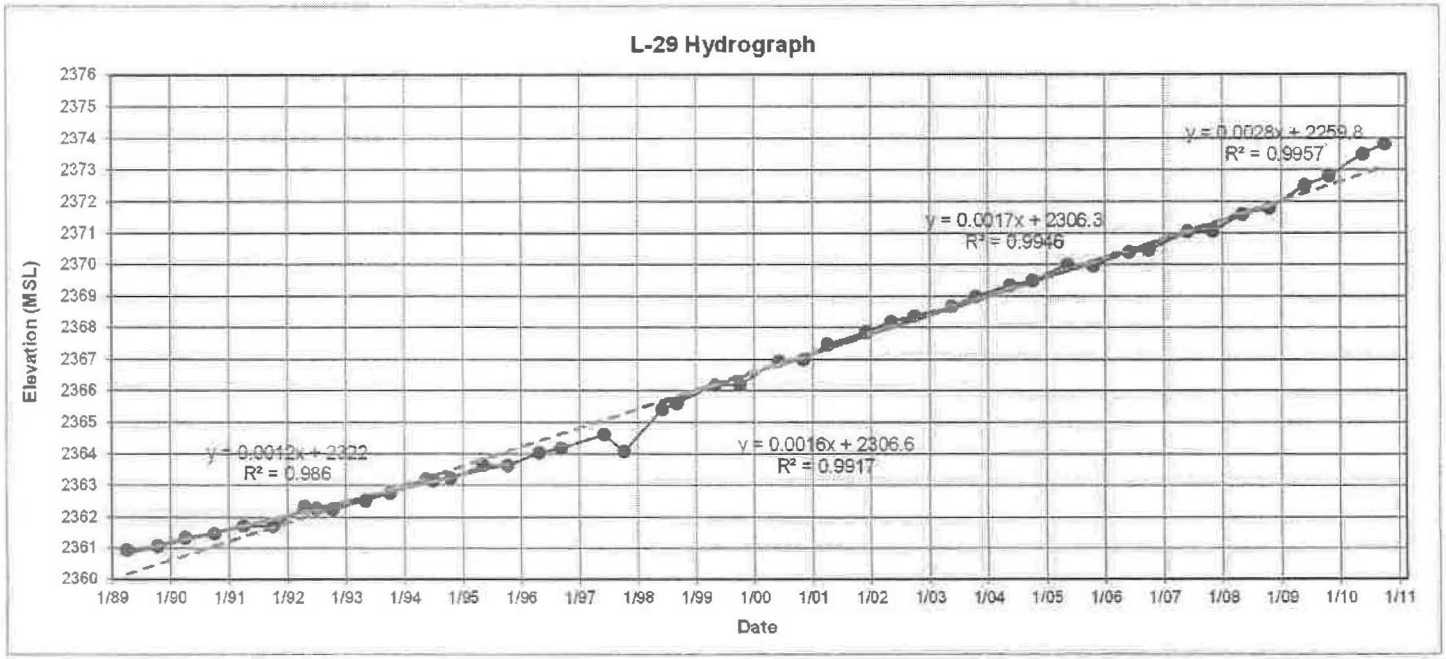
Well: L-29

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	7/92	10/92	5/93	10/93	5/94	7/94	10/94
MP Elevation	2573.17	2573.17	2573.17	2573.17	2573.17	2573.17	2573.17	2573.17	2573.17	2573.17	2573.09	2573.09	2573.09	2573.09
Depth to Water	212.22	212.10	211.83	211.70	211.45	211.46	210.84	210.90	210.92	210.65	210.34	209.88	209.93	209.86
Water Table Elevation	2360.95	2361.07	2361.34	2361.47	2361.72	2361.71	2362.33	2362.27	2362.25	2362.52	2362.75	2363.21	2363.16	2363.23

	5/95	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01
MP Elevation	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09
Depth to Water	209.44	209.46	209.05	208.91	208.48	209.02	207.68	207.49	206.91	206.91	206.15	206.10	205.62	205.24
Water Table Elevation	2363.65	2363.63	2364.04	2364.18	2364.61	2364.07	2365.41	2365.60	2366.18	2366.18	2366.94	2366.99	2367.47	2367.85

	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08
MP Elevation	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09	2573.09
Depth to Water	204.91	204.72	204.42	204.10	203.74	203.60	203.08	203.13	202.68	202.63	202.04	202.02	201.49	201.30
Water Table Elevation	2368.18	2368.37	2368.67	2368.99	2369.35	2369.49	2370.01	2369.96	2370.41	2370.46	2371.05	2371.07	2371.60	2371.79

	5/09	10/09	5/10	10/10
MP Elevation	2573.09	2573.09	2573.09	2573.09
Depth to Water	200.58	200.28	199.60	199.28
Water Table Elevation	2372.51	2372.81	2373.49	2373.81



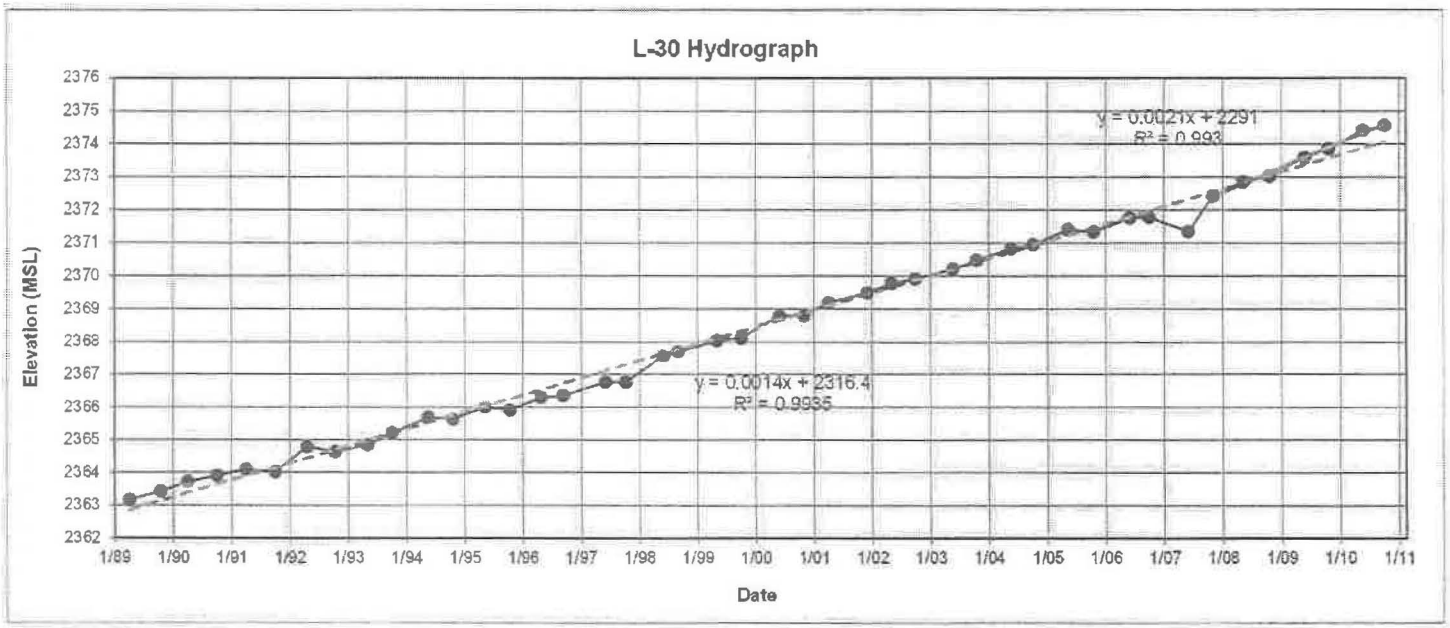
Well: L-30

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2569.22	2569.22	2569.22	2569.22	2569.22	2569.22	2569.22	2569.22	2569.22	2569.12	2569.12	2569.12	2569.12	2569.12
Depth to Water	206.05	205.79	205.50	205.31	205.12	205.20	204.42	204.48	204.27	203.90	203.44	203.50	203.12	203.21
Water Table Elevation	2363.17	2363.43	2363.72	2363.91	2364.10	2364.02	2364.80	2364.64	2364.85	2365.22	2365.68	2365.62	2366.00	2365.91

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12
Depth to Water	202.82	202.76	202.35	202.35	201.56	201.42	201.07	200.99	200.32	200.32	199.92	199.62	199.33	199.20
Water Table Elevation	2366.30	2366.36	2366.77	2366.77	2367.56	2367.70	2368.05	2368.13	2368.80	2368.80	2369.20	2369.50	2369.79	2369.92

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12	2569.12
Depth to Water	198.90	198.64	198.28	198.16	197.70	197.77	197.35	197.33	197.76	196.70	196.27	196.10	195.54	195.26
Water Table Elevation	2370.22	2370.48	2370.84	2370.96	2371.42	2371.35	2371.77	2371.79	2371.36	2372.42	2372.85	2373.02	2373.58	2373.86

	5/10	10/10
MP Elevation	2569.12	2569.12
Depth to Water	194.70	194.55
Water Table Elevation	2374.42	2374.57

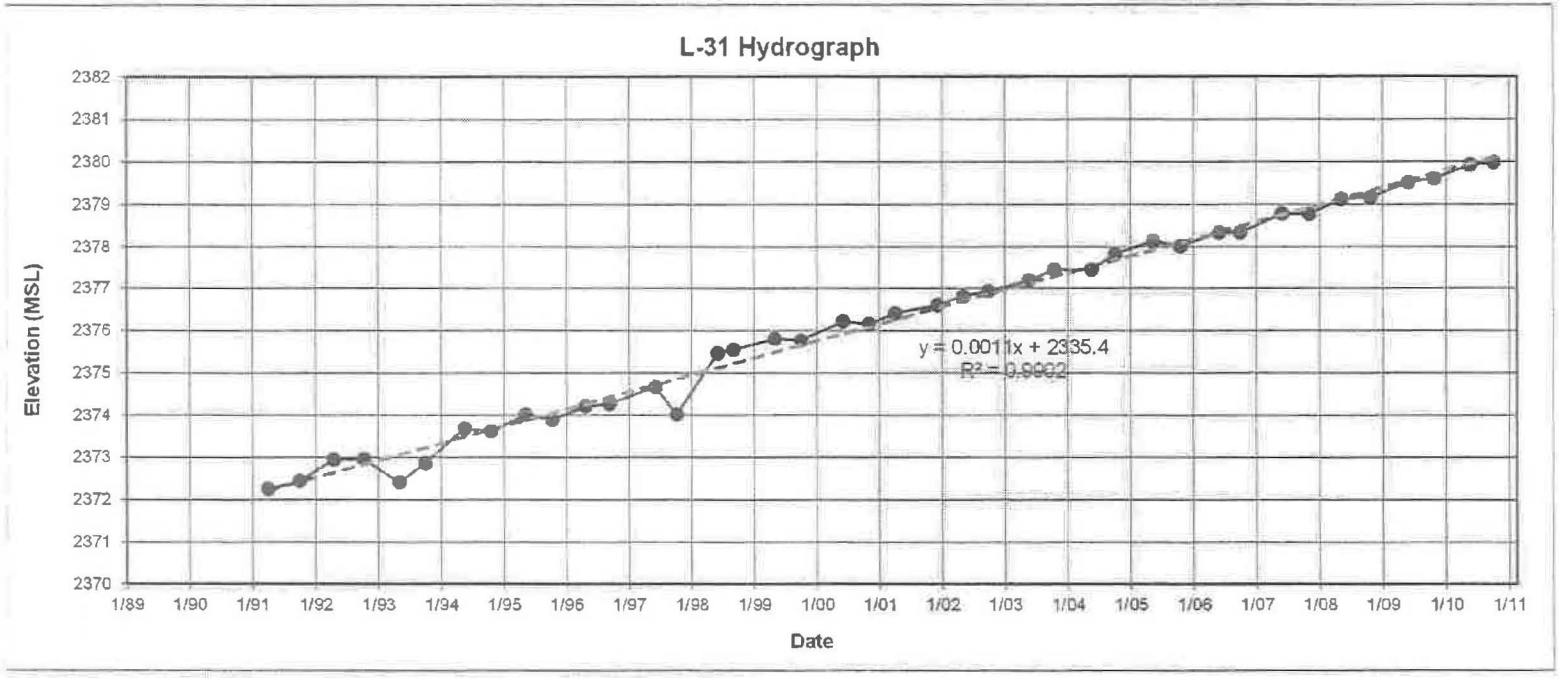


Well: L-31

	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96	9/96	6/97	10/97
MP Elevation	2583.57	2583.57	2583.38	2583.38	2583.38	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48
Depth to Water	211.32	211.13	210.43	210.42	210.97	210.61	209.80	209.87	209.47	209.60	209.27	209.21	208.82	209.46
Water Table Elevation	2372.25	2372.44	2372.95	2372.96	2372.41	2372.87	2373.68	2373.61	2374.01	2373.88	2374.21	2374.27	2374.66	2374.02

	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04
MP Elevation	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48
Depth to Water	208.02	207.94	207.68	207.72	207.26	207.32	207.07	206.88	206.67	206.55	206.29	206.03	206.03	205.65
Water Table Elevation	2375.46	2375.54	2375.8	2375.76	2376.22	2376.16	2376.41	2376.6	2376.81	2376.93	2377.19	2377.45	2377.45	2377.83

	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48	2583.48
Depth to Water	205.35	205.47	205.15	205.15	204.7	204.71	204.36	204.32	203.97	203.88	203.56	203.5
Water Table Elevation	2378.13	2378.01	2378.33	2378.33	2378.78	2378.77	2379.12	2379.16	2379.51	2379.6	2379.92	2379.98

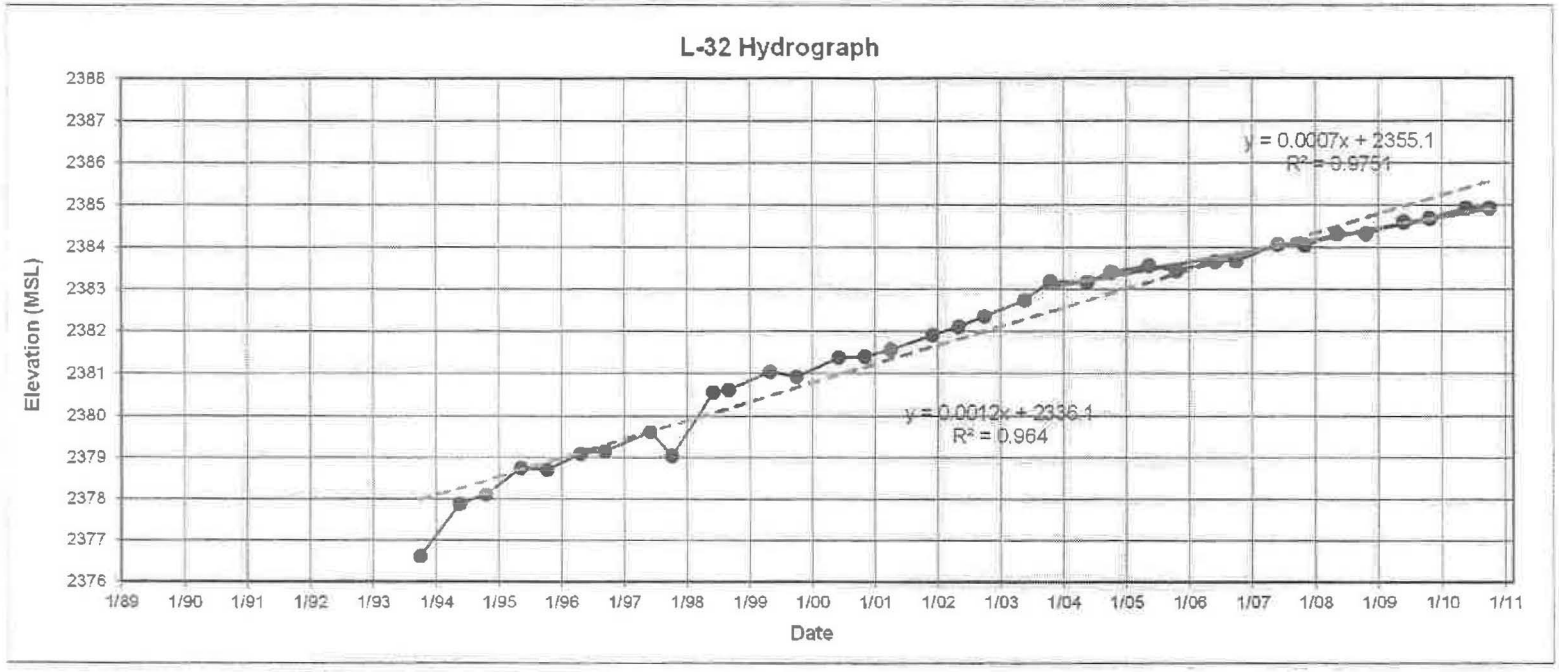


Well: L-32

	10/93	5/94	10/94	5/95	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00
MP Elevation	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96
Depth to Water	212.34	211.08	210.85	210.21	210.25	209.87	209.81	209.35	209.92	208.41	208.35	207.92	208.04	207.59
Water Table Elevation	2376.62	2377.88	2378.11	2378.75	2378.71	2379.09	2379.15	2379.61	2379.04	2380.55	2380.61	2381.04	2380.92	2381.37

	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07
MP Elevation	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96
Depth to Water	207.56	207.40	207.05	206.85	206.61	206.22	205.78	205.79	205.55	205.40	205.52	205.30	205.29	204.88
Water Table Elevation	2381.40	2381.56	2381.91	2382.11	2382.35	2382.74	2383.18	2383.17	2383.41	2383.56	2383.44	2383.66	2383.67	2384.08

	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96	2588.96
Depth to Water	204.91	204.63	204.63	204.36	204.28	204.03	204.03
Water Table Elevation	2384.05	2384.33	2384.33	2384.60	2384.68	2384.93	2384.93

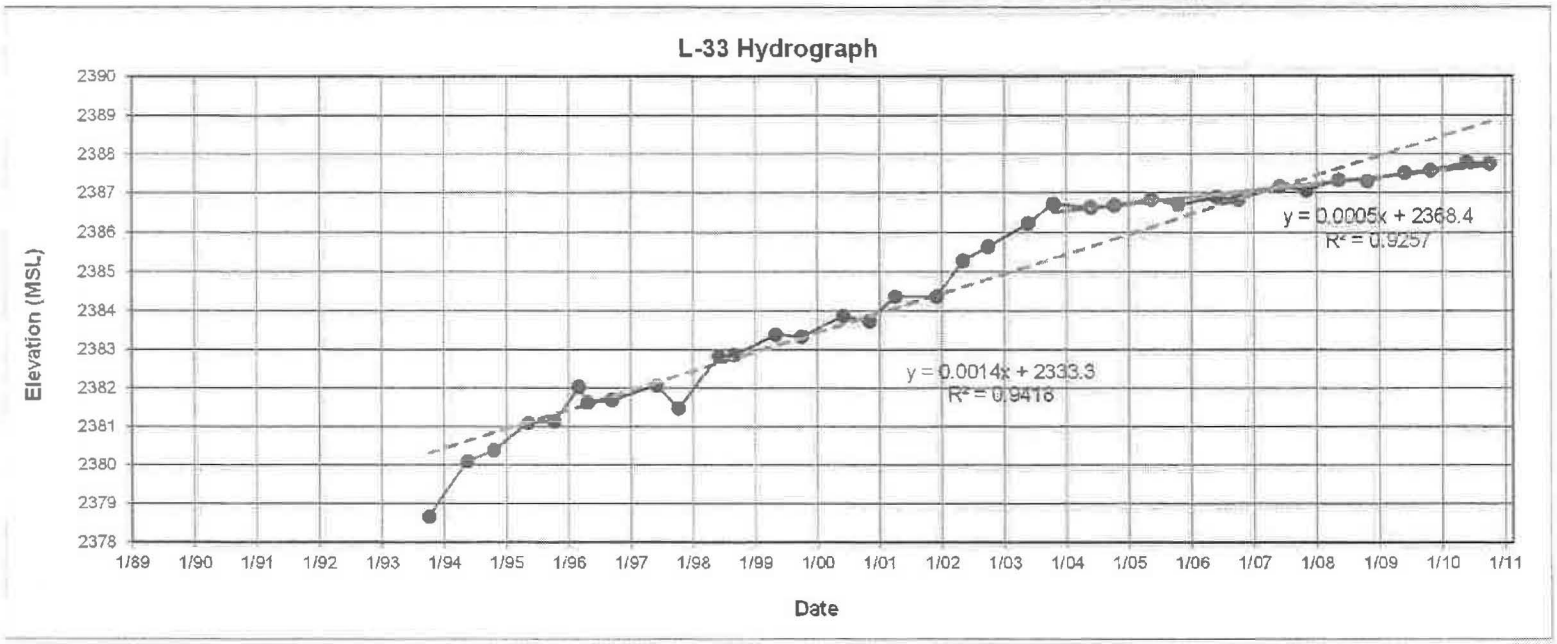


Well: L-33

	10/93	5/94	10/94	5/95	10/95	3/96	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99
MP Elevation	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23
Depth to Water	210.57	209.13	208.86	208.14	208.10	207.20	207.60	207.54	207.16	207.76	206.40	206.37	205.84	205.89
Water Table Elevation	2378.66	2380.10	2380.37	2381.09	2381.13	2382.03	2381.63	2381.69	2382.07	2381.47	2382.83	2382.86	2383.39	2383.34

	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06
MP Elevation	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23
Depth to Water	205.36	205.50	204.86	204.86	203.95	203.59	203.01	202.51	202.61	202.55	202.40	202.54	202.35	202.41
Water Table Elevation	2383.87	2383.73	2384.37	2384.37	2385.28	2385.64	2386.22	2386.72	2386.62	2386.68	2386.83	2386.69	2386.88	2386.82

	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23	2589.23
Depth to Water	202.07	202.17	201.90	201.93	201.71	201.66	201.45	201.48
Water Table Elevation	2387.16	2387.06	2387.33	2387.30	2387.52	2387.57	2387.78	2387.75

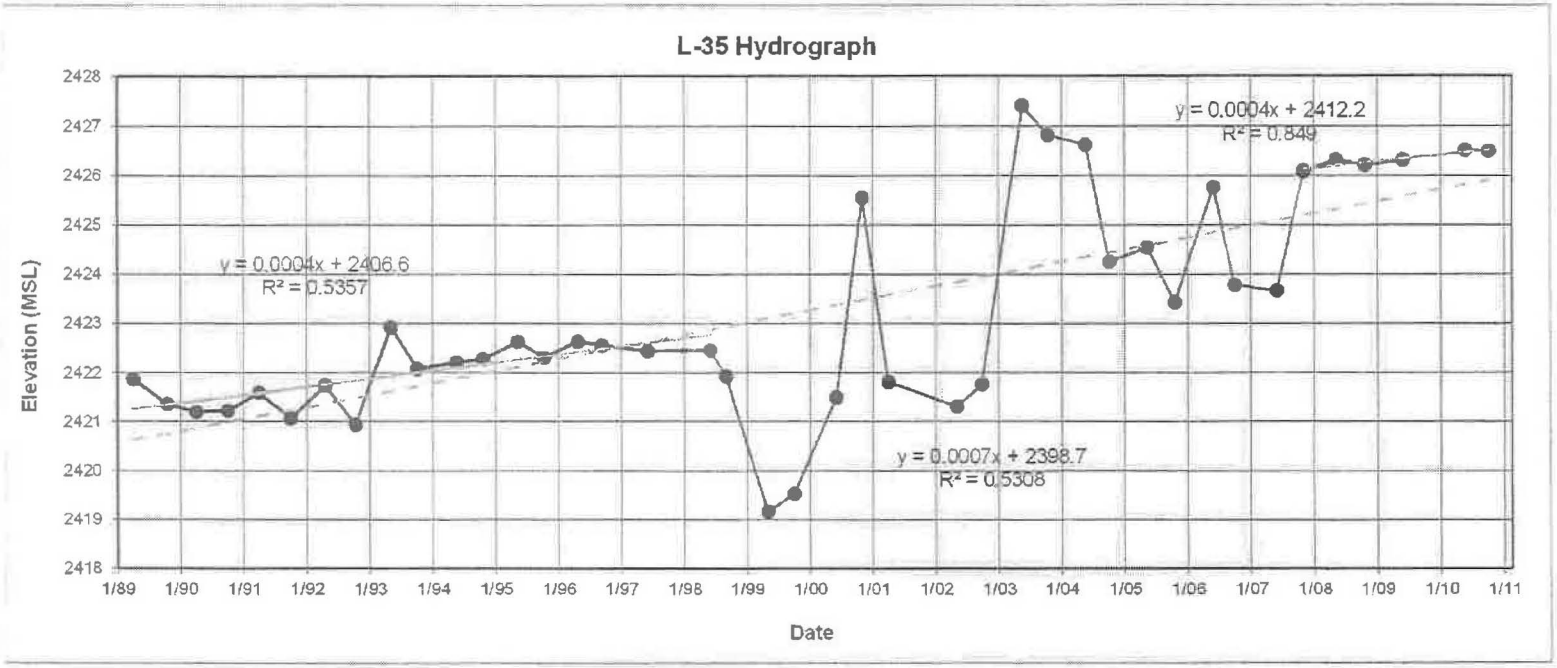


Well: L-35

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2615.40	2615.16	2615.40	2615.40	2615.40	2615.40	2615.40	2615.40	2615.40	2615.16	2615.16	2615.16	2615.16	2615.16
Depth to Water	193.53	193.80	194.20	194.17	193.80	194.33	193.65	194.46	192.47	193.08	192.95	192.88	192.53	192.85
Water Table Elevation	2421.87	2421.36	2421.20	2421.23	2421.60	2421.07	2421.75	2420.94	2422.93	2422.08	2422.21	2422.28	2422.63	2422.31

	4/96	9/96	6/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	5/02	9/02	5/03	10/03
MP Elevation	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16
Depth to Water	192.52	192.60	192.72	192.70	193.23	196.00	195.63	193.66	189.61	193.34	193.85	193.39	187.76	188.34
Water Table Elevation	2422.64	2422.56	2422.44	2422.46	2421.93	2419.16	2419.53	2421.50	2425.55	2421.82	2421.31	2421.77	2427.40	2426.82

	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16	2615.16
Depth to Water	188.54	190.91	190.62	191.74	189.4	191.38	191.5	189.07	188.85	188.95	188.85	nm	188.65	188.67
Water Table Elevation	2426.62	2424.25	2424.54	2423.42	2425.76	2423.78	2423.66	2426.09	2426.31	2426.21	2426.31		2426.51	2426.49



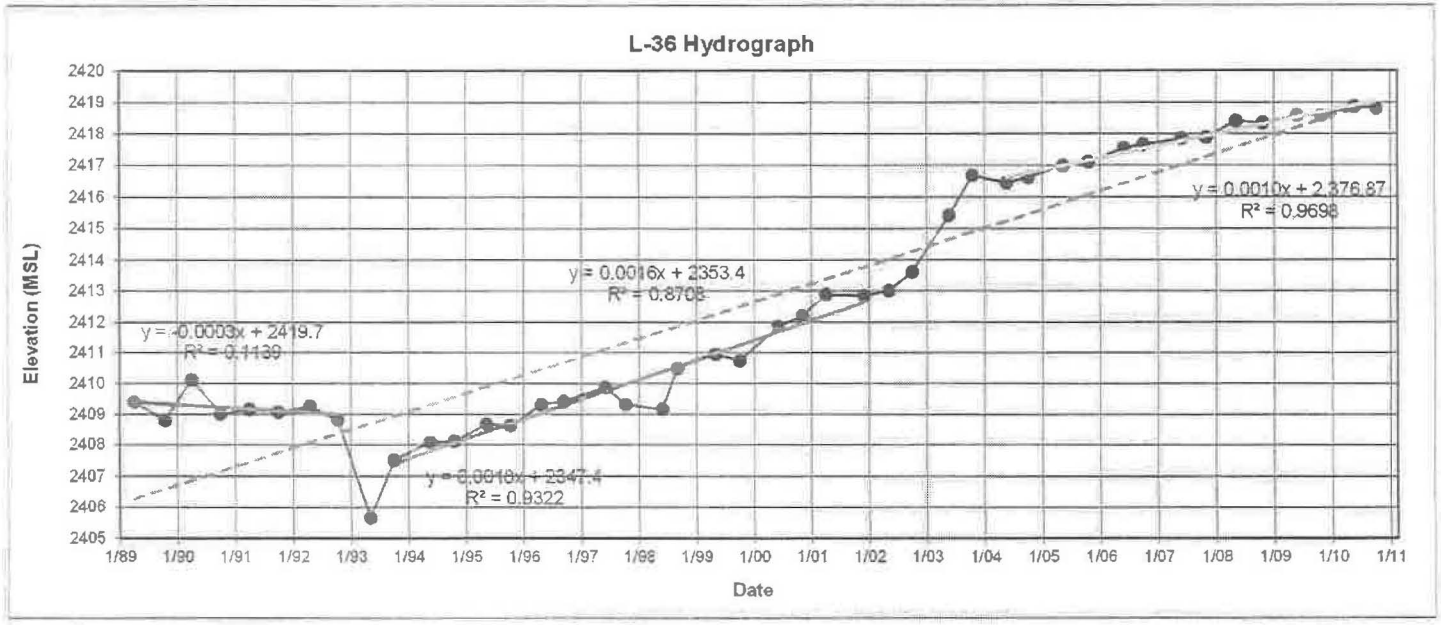
Well: L-36

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2614.64	2614.35	2614.64	2614.64	2614.64	2614.64	2614.64	2614.64	2614.64	2614.65	2614.65	2614.65	2614.65	2614.65
Depth to Water	205.24	205.55	204.52	205.62	205.48	205.57	205.39	205.82	208.98	207.13	206.57	206.53	205.97	206.02
Water Table Elevation	2409.40	2408.80	2410.12	2409.02	2409.16	2409.07	2409.25	2408.82	2405.66	2407.52	2408.08	2408.12	2408.68	2408.63

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65
Depth to Water	205.33	205.23	204.78	205.33	205.49	204.15	203.70	203.91	202.79	202.46	201.77	201.81	201.65	201.04
Water Table Elevation	2409.32	2409.42	2409.87	2409.32	2409.16	2410.50	2410.95	2410.74	2411.86	2412.19	2412.88	2412.84	2413.00	2413.61

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65	2614.65
Depth to Water	199.24	197.97	198.20	198.03	197.66	197.54	197.11	196.99	196.79	196.76	196.24	196.30	196.06	196.07
Water Table Elevation	2415.41	2416.68	2416.45	2416.62	2416.99	2417.11	2417.54	2417.66	2417.86	2417.89	2418.41	2418.35	2418.59	2418.58

	5/10	10/10
MP Elevation	2614.65	2614.65
Depth to Water	195.78	195.84
Water Table Elevation	2418.87	2418.81



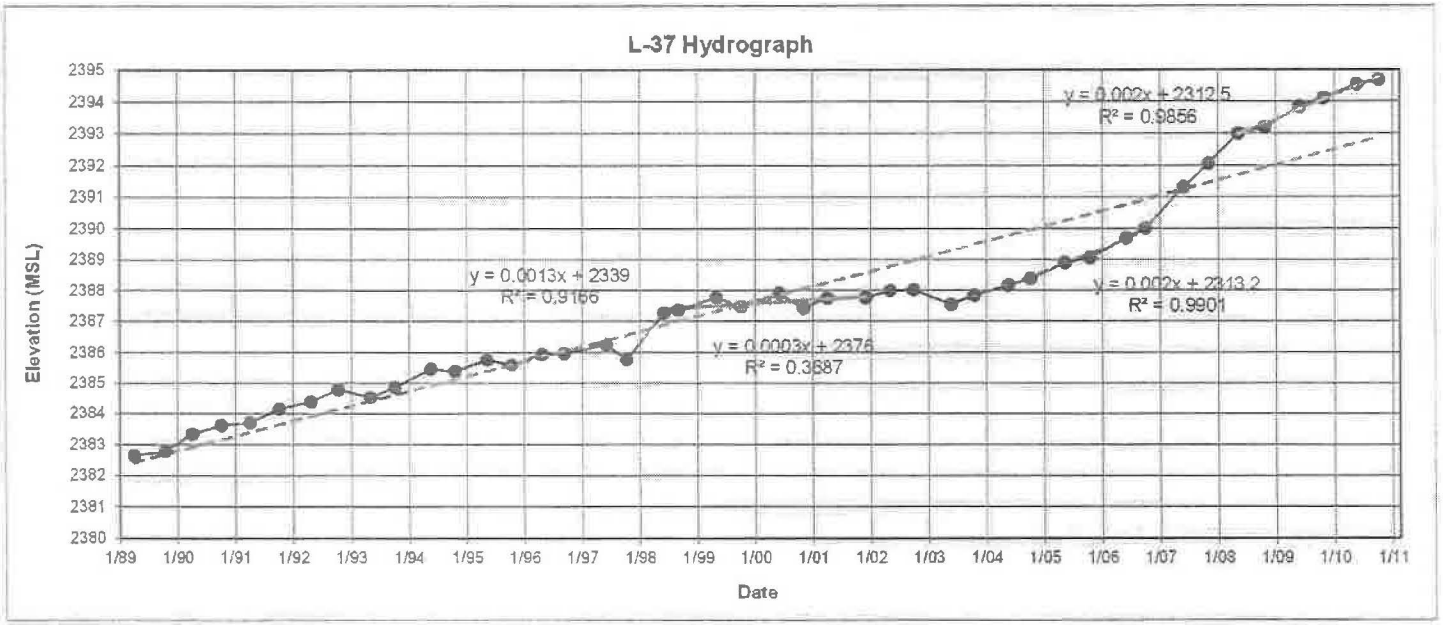
Well: L-37

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2605.10	2605.10	2605.10	2605.10	2605.10	2605.10	2605.10	2605.10	2605.10	2605.11	2605.11	2605.11	2605.11	2605.11
Depth to Water	222.46	222.32	221.77	221.49	221.40	220.96	220.72	220.32	220.57	220.25	219.66	219.73	219.36	219.52
Water Table Elevation	2382.64	2382.78	2383.33	2383.61	2383.70	2384.14	2384.38	2384.78	2384.53	2384.86	2385.45	2385.38	2385.75	2385.59

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11
Depth to Water	219.17	219.15	218.86	219.35	217.85	217.75	217.54	217.65	217.20	217.69	217.36	217.35	217.12	217.09
Water Table Elevation	2385.94	2385.96	2386.25	2385.76	2387.26	2387.36	2387.77	2387.46	2387.91	2387.42	2387.75	2387.76	2387.99	2388.02

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11	2605.11
Depth to Water	217.57	217.27	216.95	216.73	216.21	216.04	215.42	215.10	213.80	213.05	212.11	211.92	211.27	211.01
Water Table Elevation	2387.54	2387.84	2388.16	2388.38	2388.90	2389.07	2389.69	2390.01	2391.31	2392.06	2393.00	2393.19	2393.84	2394.10

	5/10	10/10
MP Elevation	2605.11	2605.11
Depth to Water	210.57	210.43
Water Table Elevation	2394.54	2394.68



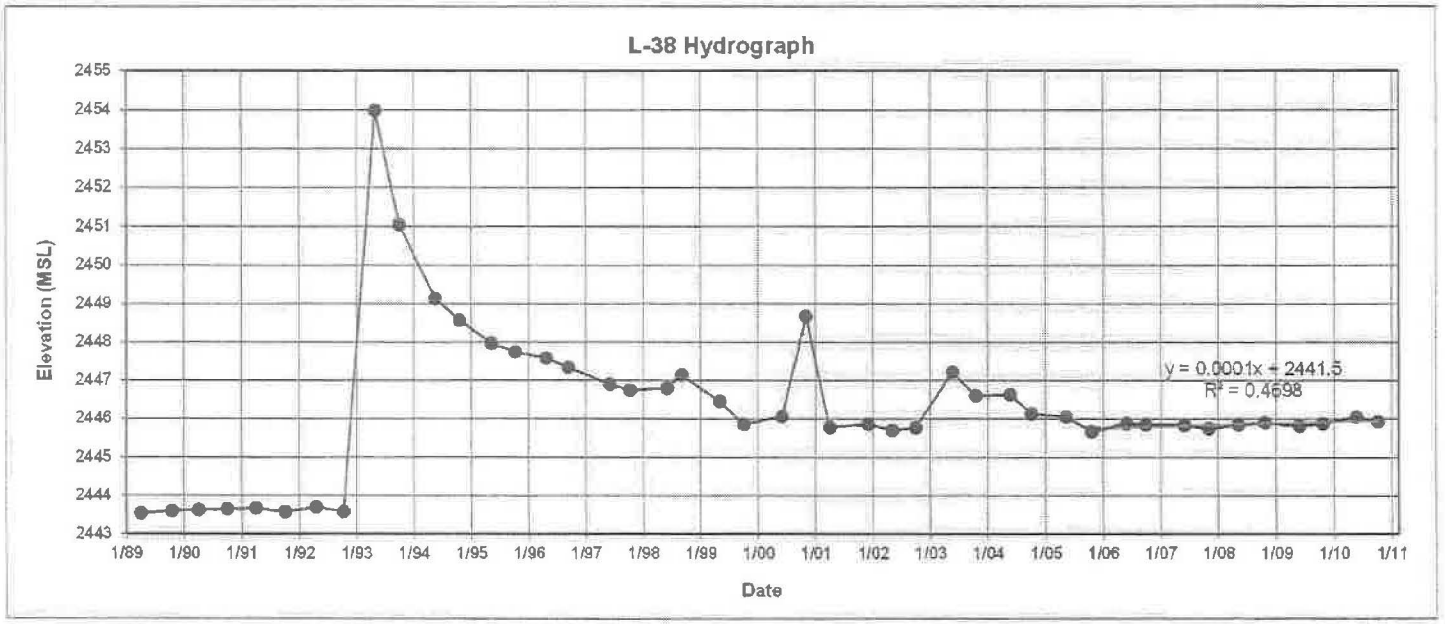
Well: L-38

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2634.08	2634.08	2634.08	2634.08	2634.08	2634.08	2634.08	2634.08	2634.08	2634.90	2634.90	2634.90	2634.90	2634.90
Depth to Water	190.54	190.48	190.45	190.43	190.41	190.51	190.38	190.50	180.10	183.85	185.77	186.34	186.93	187.15
Water Table Elevation	2443.54	2443.60	2443.63	2443.65	2443.67	2443.57	2443.70	2443.58	2453.98	2451.05	2449.13	2448.56	2447.97	2447.75

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90
Depth to Water	187.31	187.56	188.00	188.15	188.10	187.76	188.44	189.05	188.84	186.24	189.12	189.04	189.20	189.14
Water Table Elevation	2447.59	2447.34	2446.90	2446.75	2446.80	2447.14	2446.46	2445.85	2446.06	2448.66	2445.78	2445.86	2445.70	2445.76

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90	2634.90
Depth to Water	187.68	188.29	188.26	188.77	188.85	189.23	189.02	189.05	189.06	189.15	189.05	189.00	189.08	189.02
Water Table Elevation	2447.22	2446.61	2446.64	2446.13	2446.05	2445.67	2445.88	2445.85	2445.84	2445.75	2445.85	2445.90	2445.82	2445.88

	5/10	10/10
MP Elevation	2634.90	2634.90
Depth to Water	188.85	188.97
Water Table Elevation	2446.05	2445.93



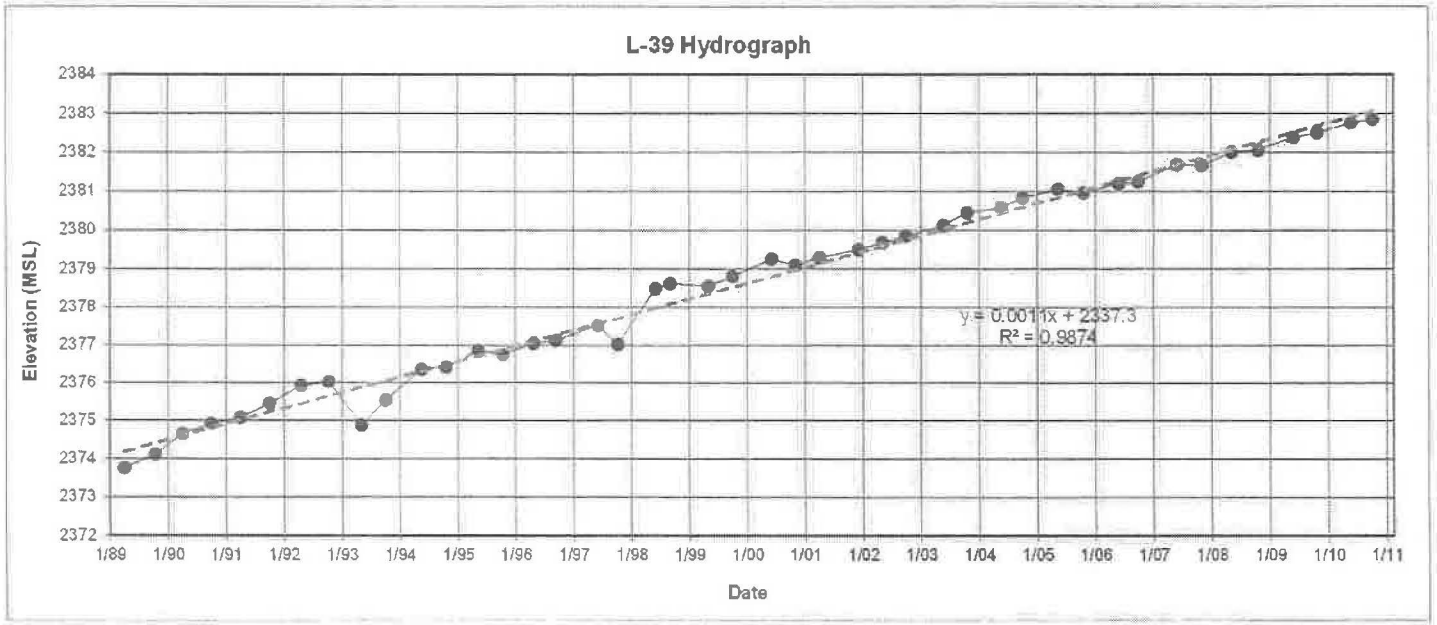
Well: L-39

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2593.56	2593.56	2593.56	2593.56	2593.56	2593.56	2593.56	2593.56	2593.56	2593.47	2593.47	2593.47	2593.47	2593.47
Depth to Water	219.80	219.44	218.91	218.64	218.48	218.12	217.64	217.54	218.68	217.93	217.12	217.06	216.61	216.72
Water Table Elevation	2373.76	2374.12	2374.65	2374.92	2375.08	2375.44	2375.92	2376.02	2374.88	2375.54	2376.35	2376.41	2376.86	2376.75

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47
Depth to Water	216.42	216.35	215.96	216.45	214.98	214.85	214.92	214.66	214.22	214.37	214.17	213.97	213.79	213.62
Water Table Elevation	2377.05	2377.12	2377.51	2377.02	2378.49	2378.62	2378.55	2378.81	2379.25	2379.10	2379.30	2379.50	2379.68	2379.85

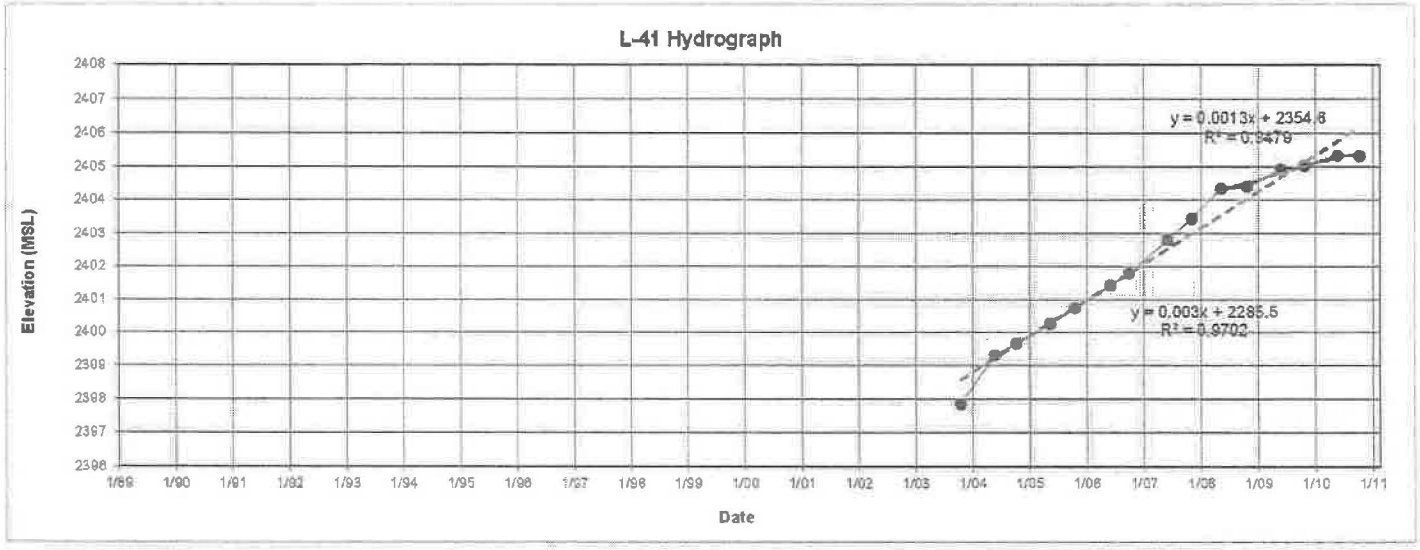
	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47	2593.47
Depth to Water	213.35	213.02	212.90	212.64	212.42	212.51	212.27	212.22	211.78	211.80	211.46	211.41	211.10	210.98
Water Table Elevation	2380.12	2380.45	2380.57	2380.83	2381.05	2380.96	2381.20	2381.25	2381.69	2381.67	2382.01	2382.06	2382.37	2382.49

	5/10	10/10
MP Elevation	2593.47	2593.47
Depth to Water	210.71	210.62
Water Table Elevation	2382.76	2382.85



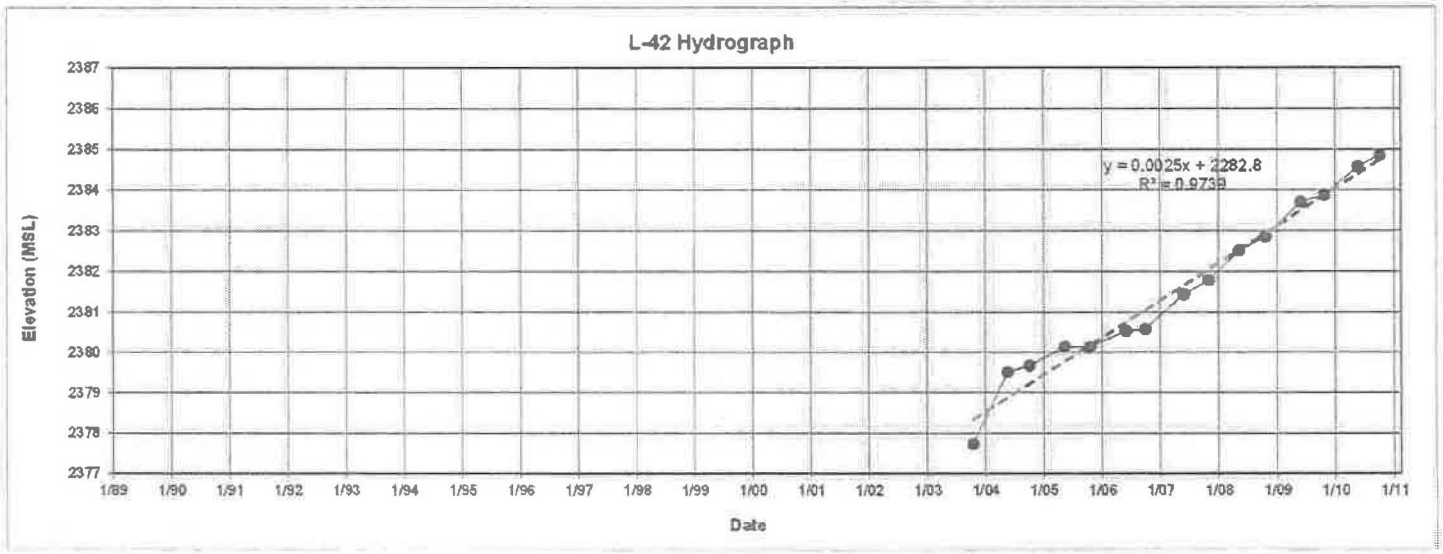
Well: L-41

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94	2608.94
Depth to Water	211.10	209.64	209.28	208.70	208.20	207.51	207.16	206.15	205.5	204.6	204.54	204.02	203.91	203.61	203.62
Water Table Elevation	2397.84	2399.30	2399.66	2400.24	2400.74	2401.43	2401.78	2402.79	2403.44	2404.34	2404.40	2404.92	2405.03	2405.33	2405.32



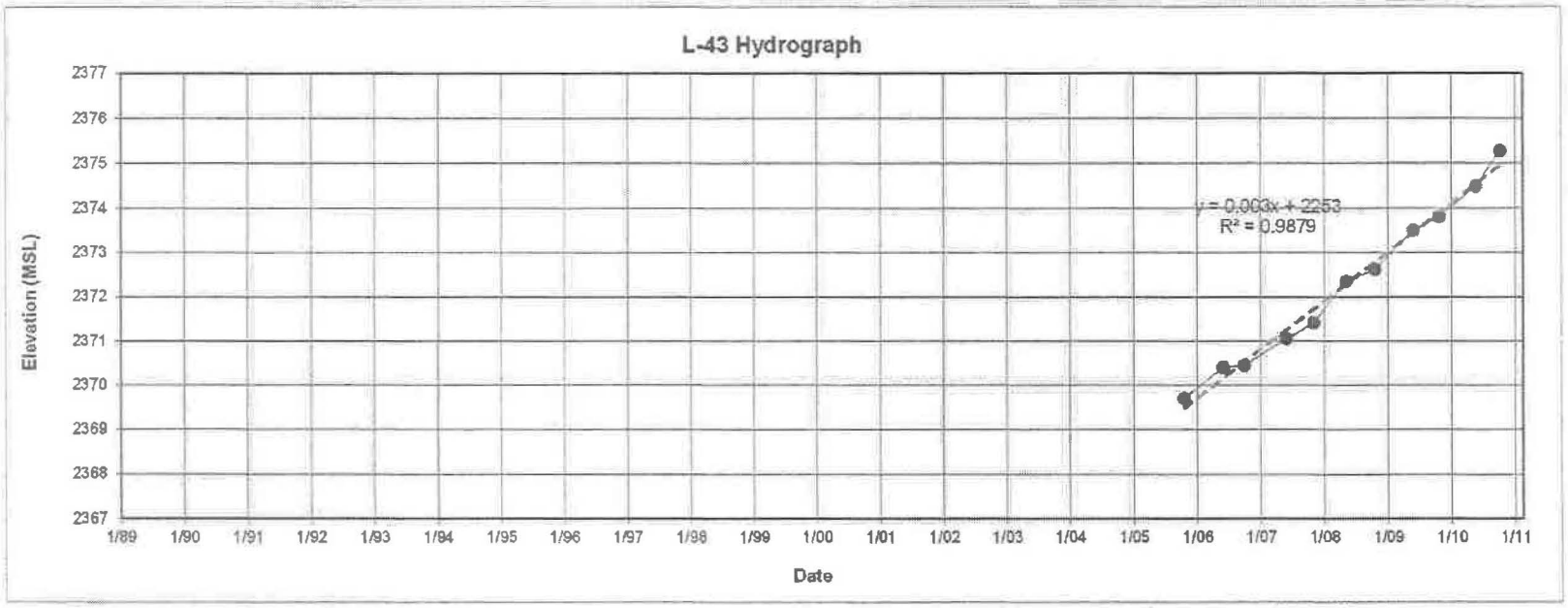
Well: L-42

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08	2588.08
Depth to Water	210.35	208.57	208.41	207.94	207.95	207.55	207.51	206.64	206.30	205.57	205.22	204.38	204.21	203.50	203.22
Water Table Elevation	2377.73	2379.51	2379.67	2380.14	2380.13	2380.53	2380.57	2381.44	2381.78	2382.51	2382.86	2383.70	2383.87	2384.58	2384.86



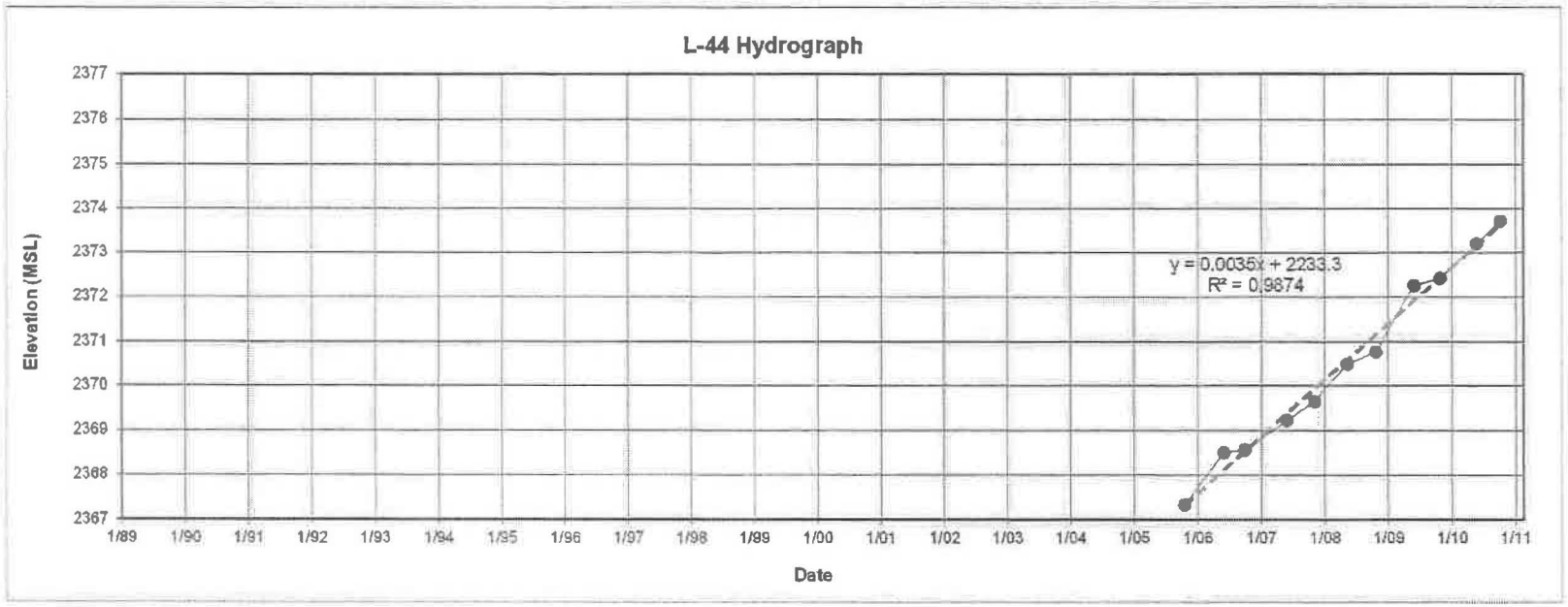
Well: L-43

	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2572.72	2572.72	2572.72	2572.72	2572.72	2572.72	2572.72	2572.72	2572.72	2572.72	2572.72
Depth to Water	203.02	202.32	202.28	201.67	201.30	200.36	200.10	199.21	198.91	198.23	197.45
Water Table Elevation	2369.70	2370.40	2370.44	2371.05	2371.42	2372.36	2372.62	2373.51	2373.81	2374.49	2375.27



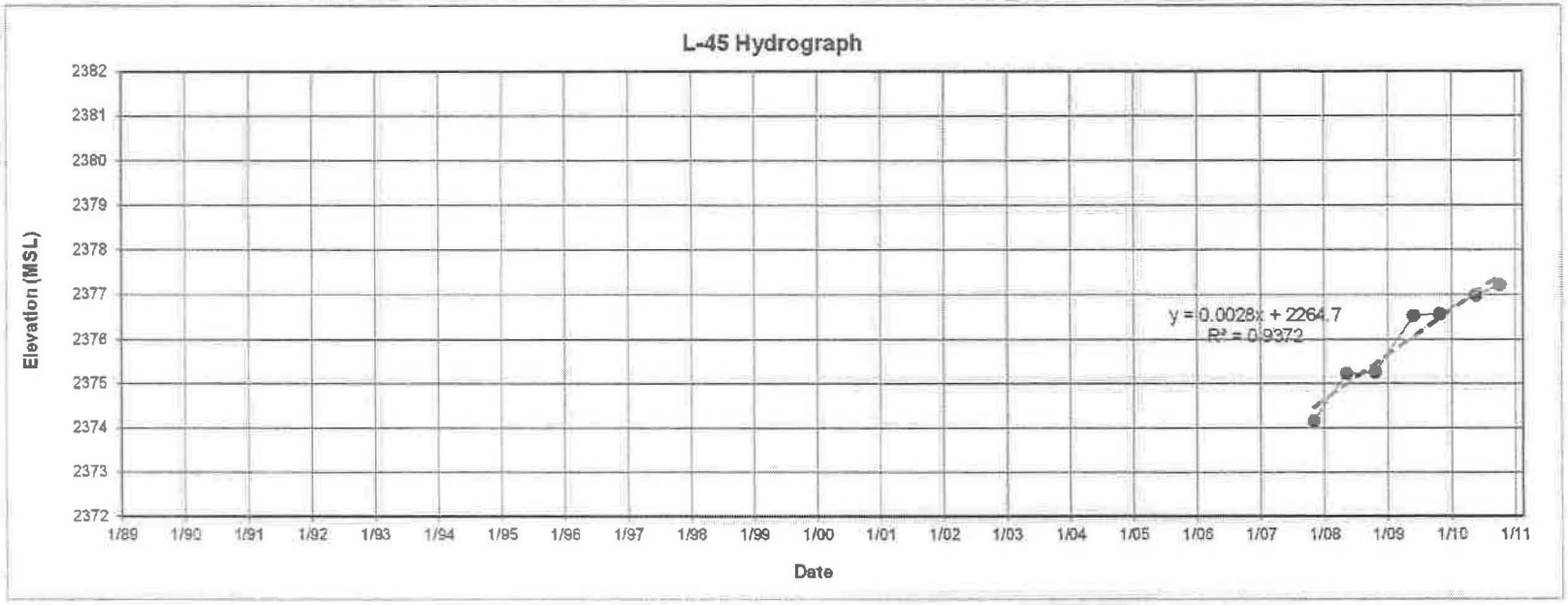
Well: L-44

	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2559.71	2559.71	2559.71	2559.71	2559.71	2559.71	2559.71	2559.71	2559.71	2559.71	2559.71
Depth to Water	192.37	191.20	191.14	190.49	190.07	189.23	188.95	187.45	187.29	186.50	185.99
Water Table Elevation	2367.34	2368.51	2368.57	2369.22	2369.64	2370.48	2370.76	2372.26	2372.42	2373.21	2373.72



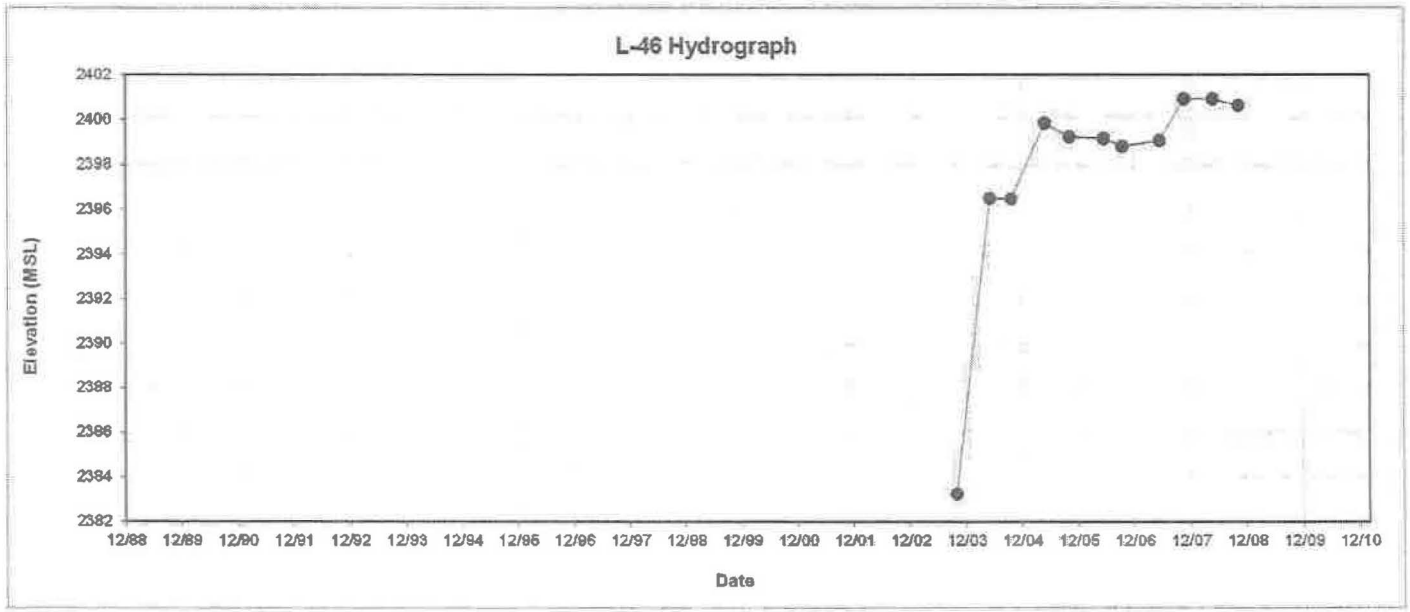
Well: L-45

	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2555.88	2555.88	2555.88	2555.88	2555.88	2555.88	2555.88
Depth to Water	181.72	180.65	180.62	179.35	179.31	178.90	178.66
Water Table Elevation	2374.16	2375.23	2375.26	2376.53	2376.57	2376.98	2377.22



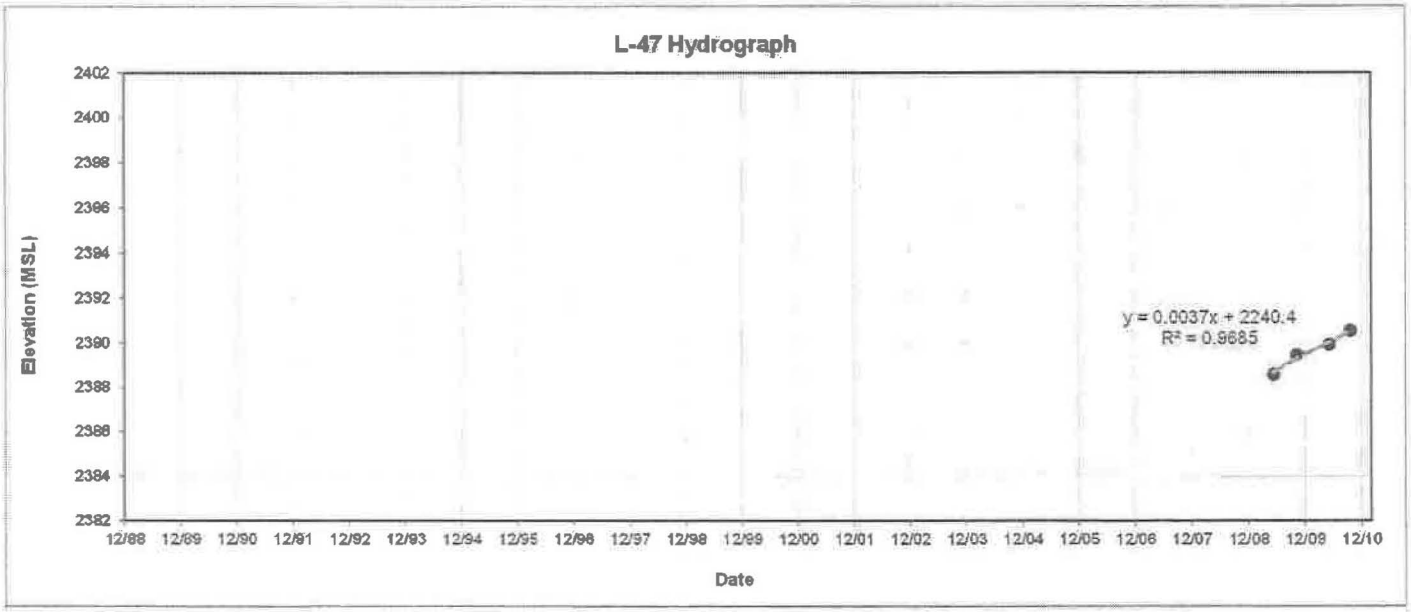
Well: L-46

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08
MP Elevation	2583.42	2583.42	2583.42	2583.42	2583.42	2583.42	2583.42	2583.42	2583.42	2583.42	2583.42
Depth to Water	200.16	186.90	186.93	183.58	184.18	184.26	184.60	184.35	182.51	182.51	182.80
Water Table Elevation	2383.26	2396.52	2396.49	2399.84	2399.24	2399.16	2398.82	2399.07	2400.91	2400.91	2400.62



Well: L-47

	5/09	10/09	5/10	10/10
MP Elevation	2555.93	2555.93	2555.93	2555.93
Depth to Water	167.33	166.46	165.99	165.36
Water Table Elevation	2388.60	2389.47	2389.94	2390.57



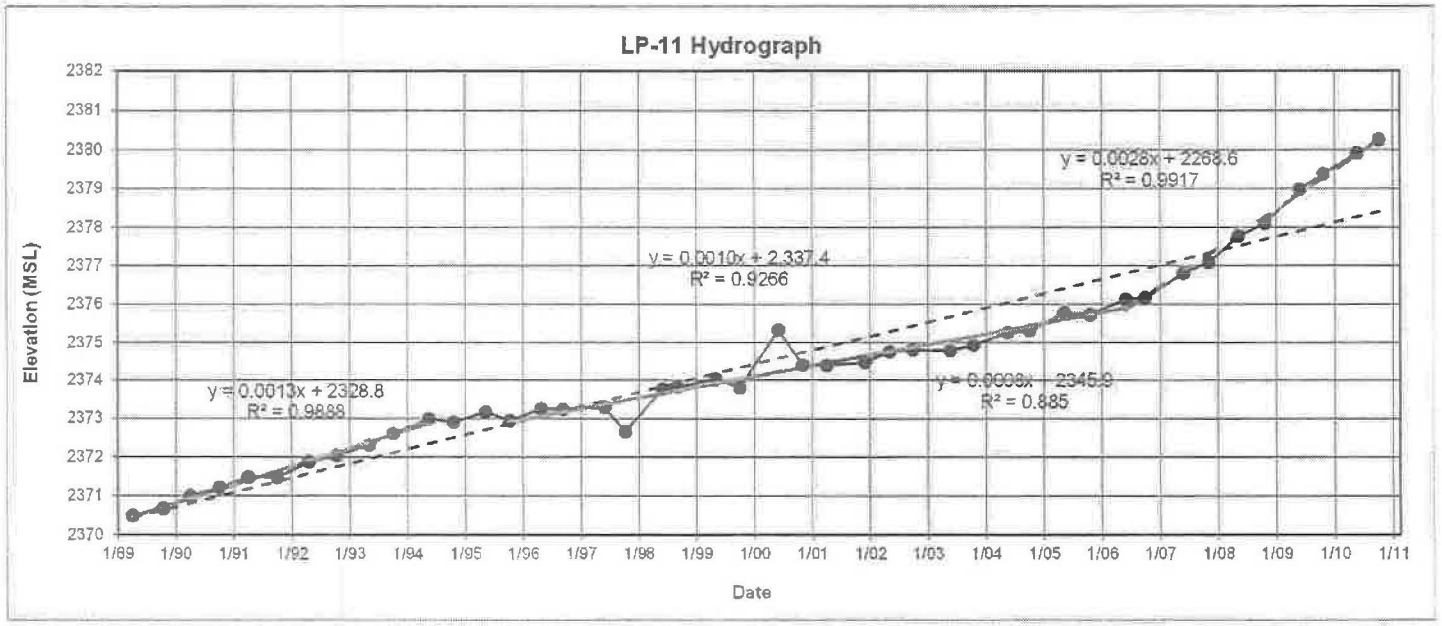
Well: LP-11

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2580.63	2580.63	2580.63	2580.63	2580.63	2580.63	2580.63	2580.63	2580.63	2580.77	2580.77	2580.77	2580.77	2580.77
Depth to Water	210.13	209.95	209.62	209.41	209.15	209.15	208.76	208.59	208.33	208.17	207.78	207.87	207.60	207.83
Water Table Elevation	2370.50	2370.68	2371.01	2371.22	2371.48	2371.48	2371.87	2372.04	2372.30	2372.60	2372.99	2372.90	2373.17	2372.94

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77
Depth to Water	207.52	207.53	207.48	208.12	207.00	206.95	206.74	206.97	205.44	206.37	206.38	206.30	206.02	205.97
Water Table Elevation	2373.25	2373.24	2373.29	2372.65	2373.77	2373.82	2374.03	2373.80	2375.33	2374.40	2374.39	2374.47	2374.75	2374.80

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77	2580.77
Depth to Water	205.99	205.84	205.50	205.45	204.99	205.04	204.65	204.61	203.97	203.69	203.00	202.67	201.79	201.39
Water Table Elevation	2374.78	2374.93	2375.27	2375.32	2375.78	2375.73	2376.12	2376.16	2376.80	2377.08	2377.77	2378.10	2378.98	2379.38

	5/10	10/10
MP Elevation	2580.77	2580.77
Depth to Water	200.86	200.52
Water Table Elevation	2379.91	2380.25



Well: LP-12

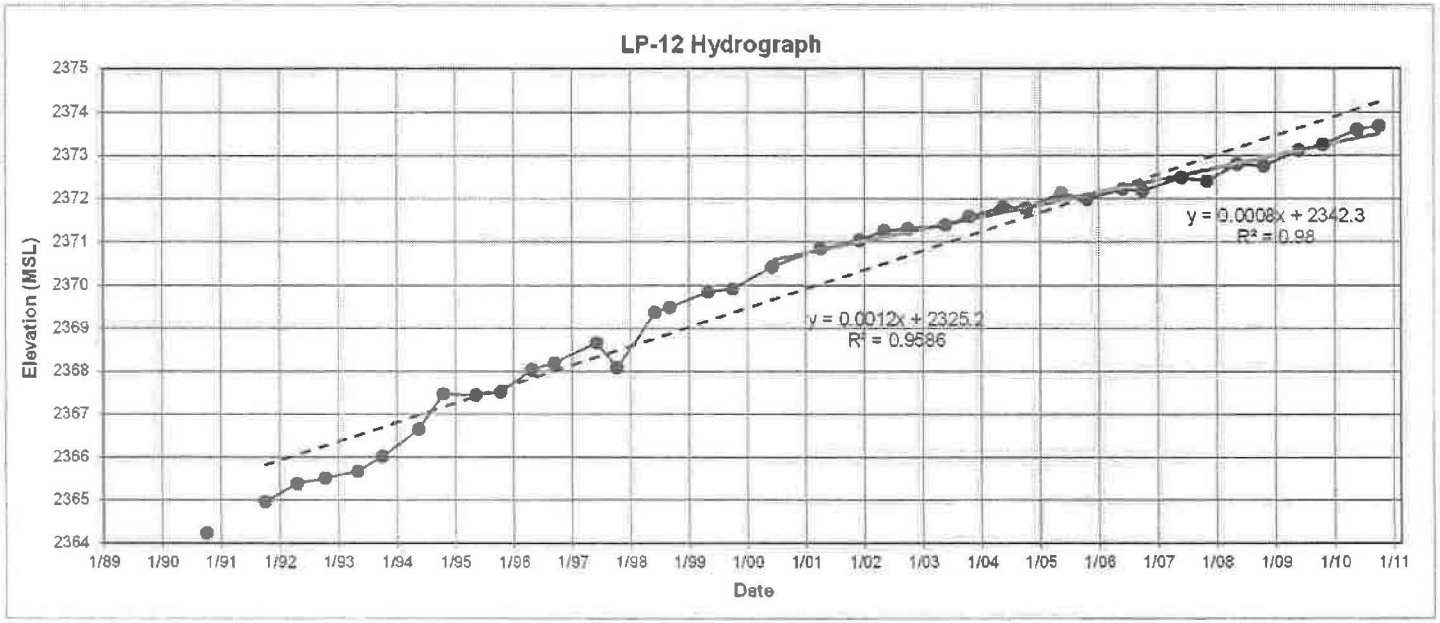
	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation			2555.48	2555.48	2555.48	2555.48	2555.34	2555.34	2555.34	2555.51	2555.51	2555.51	2555.51	2555.51
Depth to Water			188.66	191.25	199.85	190.53	189.96	189.83	189.67	189.49	188.85	188.04	188.07	188.00
Water Table Elevation			2366.82	2364.23	2355.63 [1]	2364.95	2365.38	2365.51	2365.67	2366.02	2366.66	2367.47	2367.44	2367.51

[1] Elevation off-scale and/or probable measurement error; data point not used in graph

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	4/01	12/01	5/02	9/02	5/03
MP Elevation	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51
Depth to Water	187.47	187.32	186.84	187.43	186.15	186.03	185.67	185.60	185.08	184.67	184.47	184.25	184.20	184.11
Water Table Elevation	2368.04	2368.19	2368.67	2368.08	2369.36	2369.48	2369.84	2369.91	2370.43	2370.84	2371.04	2371.26	2371.31	2371.40

	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10
MP Elevation	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51	2555.51
Depth to Water	183.91	183.70	183.73	183.38	183.52	183.29	183.33	183.02	183.10	182.71	182.75	182.40	182.27	181.92
Water Table Elevation	2371.60	2371.81	2371.78	2372.13	2371.99	2372.22	2372.18	2372.49	2372.41	2372.80	2372.76	2373.11	2373.24	2373.59

	10/10
MP Elevation	2555.51
Depth to Water	181.83
Water Table Elevation	2373.68



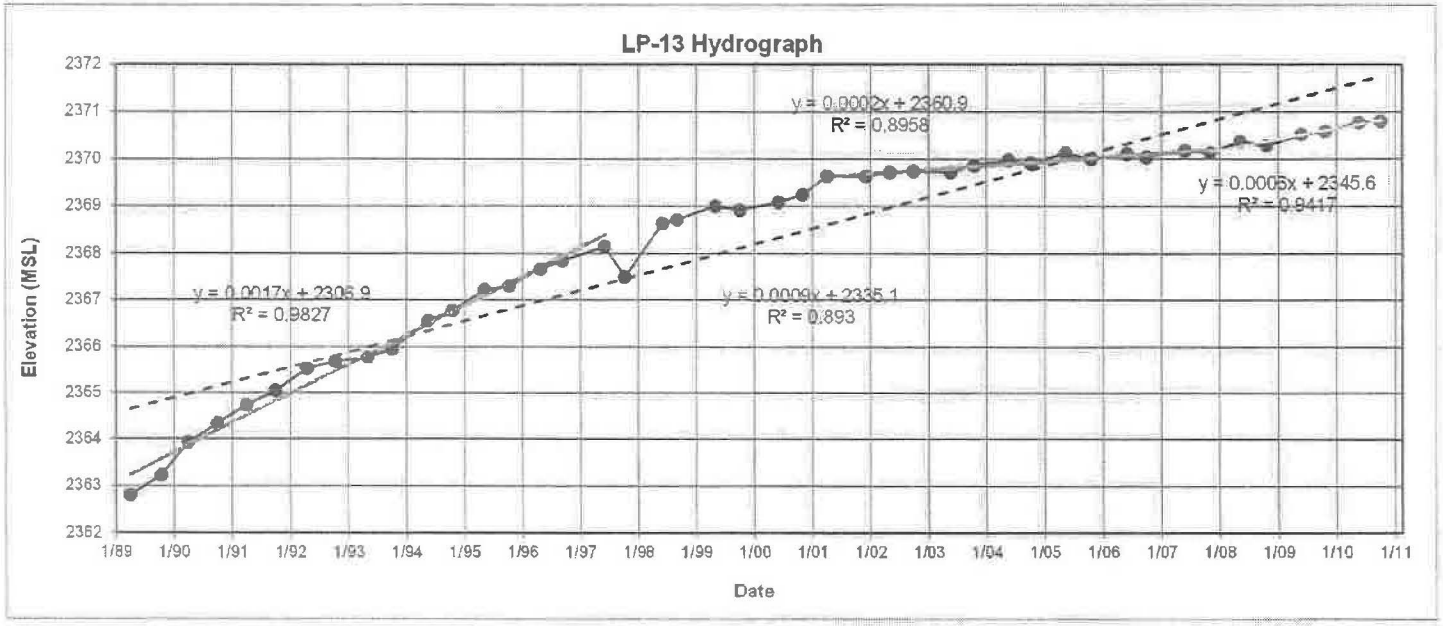
Well: LP-13

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80
Depth to Water	181.00	180.57	179.87	179.47	179.07	178.76	178.28	178.12	178.03	177.85	177.25	177.03	176.58	176.50
Water Table Elevation	2362.80	2363.23	2363.93	2364.33	2364.73	2365.04	2365.52	2365.68	2365.77	2365.95	2366.55	2366.77	2367.22	2367.30

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80
Depth to Water	176.13	175.95	175.65	176.30	175.16	175.08	174.80	174.88	174.72	174.55	174.16	174.17	174.08	174.06
Water Table Elevation	2367.67	2367.85	2368.15	2367.50	2368.64	2368.72	2369.00	2368.92	2369.08	2369.25	2369.64	2369.63	2369.72	2369.74

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80	2543.80
Depth to Water	174.08	173.93	173.82	173.89	173.68	173.80	173.69	173.76	173.63	173.68	173.43	173.52	173.28	173.22
Water Table Elevation	2369.72	2369.87	2369.98	2369.91	2370.12	2370.00	2370.11	2370.04	2370.17	2370.12	2370.37	2370.28	2370.52	2370.58

	5/10	10/10
MP Elevation	2543.80	2543.80
Depth to Water	173.03	173.00
Water Table Elevation	2370.77	2370.80



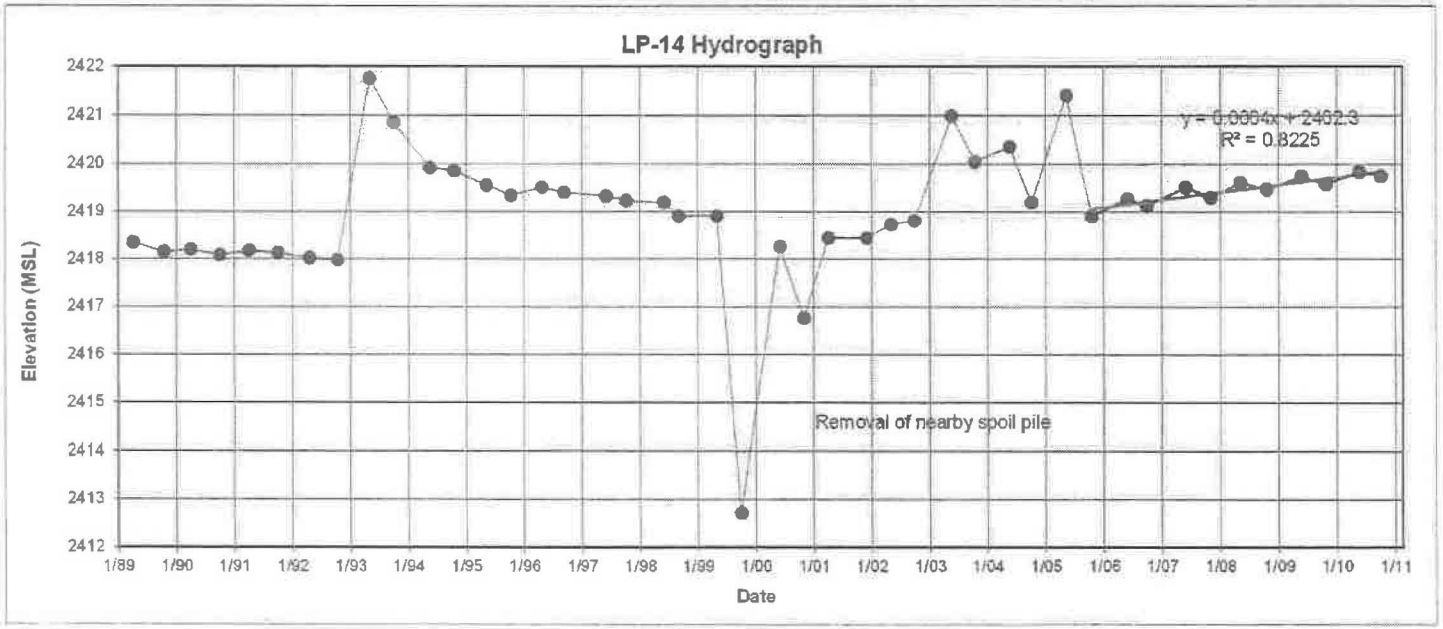
Well: LP-14

	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2607.99	2607.99	2607.99	2607.99	2607.99	2607.99	2607.99	2607.99	2607.99	2608.26	2608.26	2608.26	2608.26	2608.26
Depth to Water	189.65	189.85	189.80	189.91	189.82	189.87	189.97	190.01	186.24	187.40	188.34	188.40	188.71	188.92
Water Table Elevation	2418.34	2418.14	2418.19	2418.08	2418.17	2418.12	2418.02	2417.98	2421.75	2420.86	2419.92	2419.86	2419.55	2419.34

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26
Depth to Water	188.75	188.86	188.93	189.03	189.07	189.35	189.35	195.55	190.00	191.50	189.82	189.82	189.53	189.45
Water Table Elevation	2419.51	2419.40	2419.33	2419.23	2419.19	2418.91	2418.91	2412.71	2418.26	2416.76	2418.44	2418.44	2418.73	2418.81

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26	2608.26
Depth to Water	187.28	188.21	187.91	189.07	186.85	189.35	189.00	189.14	188.75	188.97	188.65	188.79	188.52	188.68
Water Table Elevation	2420.98	2420.05	2420.35	2419.19	2421.41	2418.91	2419.26	2419.12	2419.51	2419.29	2419.61	2419.47	2419.74	2419.58

	5/10	10/10
MP Elevation	2608.26	2608.26
Depth to Water	188.42	188.50
Water Table Elevation	2419.84	2419.76



Well: LP-15

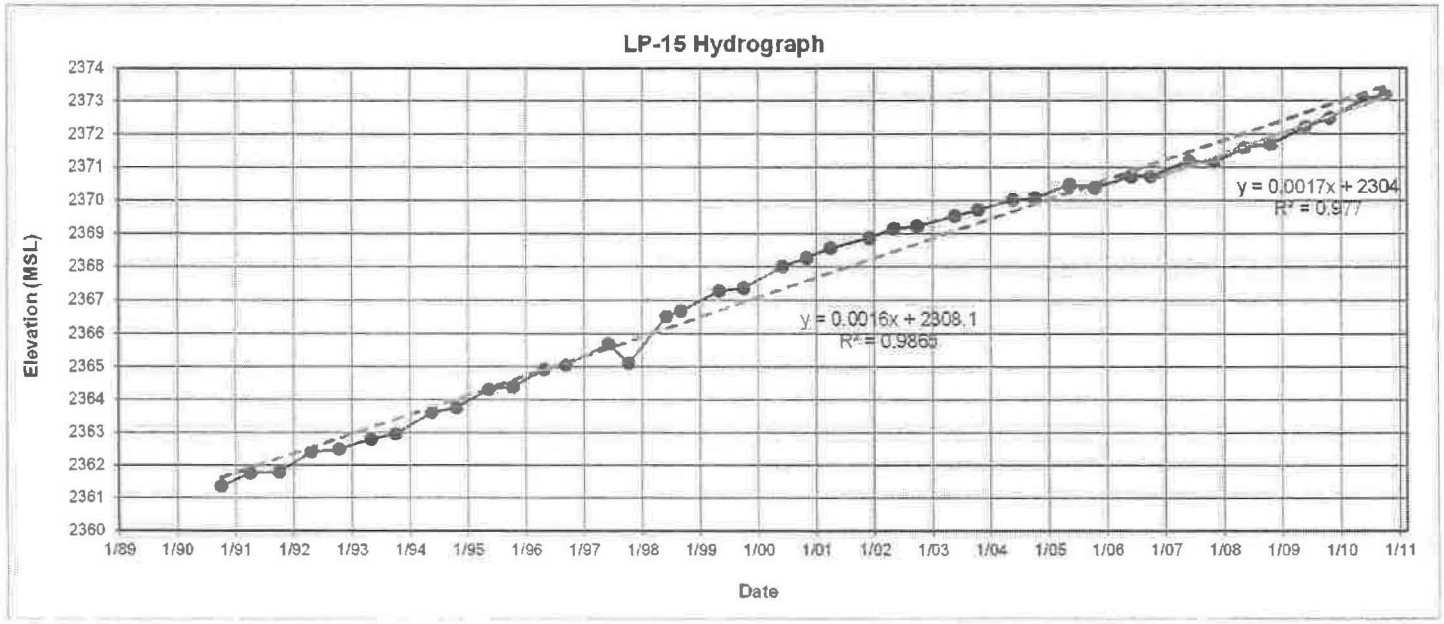
	4/89	10/89	4/90	10/90	4/91	10/91	4/92	10/92	5/93	10/93	5/94	10/94	5/95	10/95
MP Elevation	2559.76	2559.76	2559.76	2559.76	2559.76	2559.76	2559.76	2559.76	2559.76	2559.81	2559.81	2559.81	2559.81	2559.81
Depth to Water	212.10	199.05	198.53	198.40	198.00	197.97	197.36	197.27	196.97	196.85	196.20	196.06	195.50	195.42
Water Table Elevation	2347.66[1]	2360.71	2361.23	2361.36	2361.76	2361.79	2362.40	2362.49	2362.79	2362.96	2363.61	2363.75	2364.31	2364.39

[1] Elevation off-scale; possible measurement error; data point not used in graph

	4/96	9/96	6/97	10/97	6/98	9/98	5/99	10/99	6/00	11/00	4/01	12/01	5/02	9/02
MP Elevation	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81
Depth to Water	194.90	194.76	194.11	194.71	193.29	193.13	192.54	192.45	191.80	191.54	191.23	190.93	190.66	190.59
Water Table Elevation	2364.91	2365.05	2365.70	2365.10	2366.52	2366.68	2367.27	2367.36	2368.01	2368.27	2368.58	2368.88	2369.15	2369.22

	5/03	10/03	5/04	10/04	5/05	10/05	5/06	9/06	5/07	11/07	5/08	10/08	5/09	10/09
MP Elevation	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81	2559.81
Depth to Water	190.28	190.09	189.80	189.75	189.32	189.42	189.08	189.08	188.63	188.67	188.22	188.12	187.59	187.33
Water Table Elevation	2369.53	2369.72	2370.01	2370.06	2370.49	2370.39	2370.73	2370.73	2371.18	2371.14	2371.59	2371.69	2372.22	2372.48

	5/10	10/10
MP Elevation	2559.81	2559.81
Depth to Water	186.77	186.63
Water Table Elevation	2373.04	2373.18

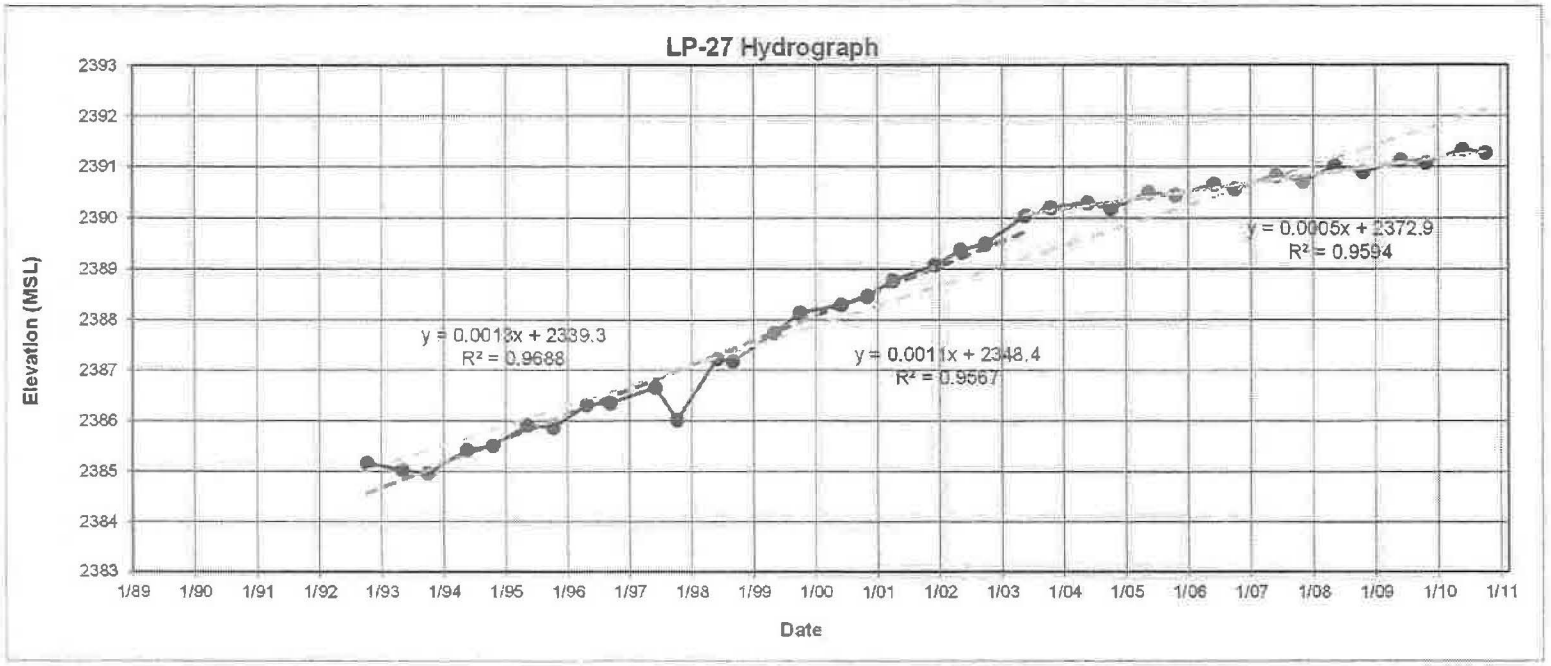


Well: LP-27

	10/92	5/93	10/93	5/94	10/94	5/95	10/95	4/96	9/96	6/97	10/97	6/98	9/98	5/99
MP Elevation	2576.78	2576.78	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63
Depth to Water	191.62	191.75	191.67	191.21	191.13	190.72	190.77	190.32	190.28	189.97	190.62	189.40	189.45	188.89
Water Table Elevation	2385.16	2385.03	2384.96	2385.42	2385.50	2385.91	2385.86	2386.31	2386.35	2386.66	2386.01	2387.23	2387.18	2387.74

	10/99	6/00	11/00	4/01	12/01	5/02	9/02	5/03	10/03	5/04	10/04	5/05	10/05	5/06
MP Elevation	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63
Depth to Water	188.49	188.33	188.16	187.85	187.55	187.25	187.13	186.58	186.42	186.33	186.45	186.13	186.18	185.97
Water Table Elevation	2388.14	2388.3	2388.47	2388.78	2389.08	2389.38	2389.5	2390.05	2390.21	2390.3	2390.18	2390.5	2390.45	2390.66

	9/06	5/07	11/07	5/08	10/08	5/09	10/09	5/10	10/10
MP Elevation	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63	2576.63
Depth to Water	186.06	185.8	185.92	185.61	185.73	185.5	185.55	185.29	185.35
Water Table Elevation	2390.57	2390.83	2390.71	2391.02	2390.9	2391.13	2391.08	2391.34	2391.28



Appendix E.14
Alternative Concentration Limit Demonstration Report

Alternate Concentration Limit Demonstration for ESII Site B

Prepared for

Envirosafe Services of Idaho, Inc.



Prepared by

CH2MHILL

April 1999

Revision 2

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Acronyms

ACL—Alternate Concentration Limit Program

bgs—below ground surface

CR—cancer risk

CTC—carbon tetrachloride

gpm—gallons per minute

HQ—hazard quotient

MCL—maximum concentration limit

MGRT—migration of organic and inorganic chemicals in groundwater

NAPL—non-aqueous phase liquids

RCRA—risk-based corrective action

SWMU—solid waste management units

TOC—total organic carbon

TOX—total organic halides

TSCA—Toxic Substances Control Act

VOC—volatile organic compounds

Executive Summary

In response to the detection of Volatile Organic Compounds (VOCs) in several monitoring wells at Site B, Envirosafe Services of Idaho, Inc. (ESII), has conducted an evaluation of the pertinent data and is proposing the establishment of a site-wide Alternate Concentration Limit (ACL) program. This ACL program is founded on four basic premises:

1. The source of the VOCs is fugitive soil vapors from non-specific solid waste management units and non-regulated past practice units.
2. There is no exposure scenario and, therefore, no risk to onsite workers associated with impacted groundwater beneath the facility.
3. There is a slight exposure risk associated with impacted groundwater leaving the facility.
4. The slow-moving groundwater system, the fine-grained and organic-rich geologic matrix, and the degradation properties of the VOCs produce highly protective degradation and attenuation factors that will effectively prevent significant migration of organic compounds in the groundwater away from their source.

The proposed ACL divides the current monitoring wells into four categories with different allowable concentration limits based on the position of the well, regulatory status, and potential exposure risk. The four well categories and proposed ACLs are the following:

- **Unimpacted Background Wells.** If a VOC is confirmed to be present in any of the unimpacted background wells at a level that is above the applicable detection monitoring criteria, ESII will conduct an evaluation and investigation into the source of the cause of the contamination. Specific ACLs for background wells are not proposed at this time.
- **Level 1 Compliance Wells.** These wells are located interior to the site. The risk-based corrective action (RCRA) and Toxic Substances Control Act (TSCA) Permit restricts the use of these wells for periodic groundwater sampling and testing. There is no realistic or quantifiable risk of exposure associated with these wells. In addition, the position of the wells relative to the groundwater flow direction and velocity provides for significant travel time and, consequently, significant degradation and attenuation of the VOCs before the impacted groundwater reaches the facility boundary. The ACL for Level 1 Compliance Wells is 0.5 percent of the solubility of any one VOC in water, or a cumulative 0.5 percent of solubility in water for multiple VOCs.
- **Level 2 Compliance Wells.** Level 2 Compliance Wells are those wells located on the facility boundary and, therefore, represent the quality of water leaving the site. For individual compounds, the ACL for Level 2 Compliance Wells is established at the $1x10^{-5}$ (industrial exposure scenario) cancer risk, or a Hazard Quotient of 1 (modified industrial exposure scenario) for non-carcinogens. If a regulatory established maximum concentration limit (MCL) exists, it takes precedence over either ACL. The risk

associated with multiple compounds will be determined by summing the cancer risk or hazard quotient of the individual compounds present.

- **Special Status Wells.** VOC soil vapors originating from within the facility boundary have impacted Monitoring Well U-1. Monitoring Well U-1 is on ESII property and hydraulically upgradient of the site, but it is outside the permitted facility boundary. Consequently, Monitoring Well U-1 is placed in the special status category until ESII and DEQ can resolve the regulatory status and the required response to this situation. Groundwater in Monitoring Well U-1 flows into the site and the well is locked and secured. Thus, there is no exposure risk for this well.

The site conditions and results of the evaluation of VOCs in groundwater at Site B that support and justify the proposed ACLs are the following:

- Historical, regulatory-sanctioned, waste disposal practices resulted in a large reservoir of VOCs absorbed into the upper 10s of feet of the soil column across the northern half of the site.
- The pattern of low-level (part per billion) detections of the same VOCs, an impacted upgradient well, and the variable concentrations observed between repeat sampling events, indicate that the source of the VOCs is the result of widespread soil vapors interacting with the variable geology of the site.
- Analysis of the detection of VOCs in Monitoring Well U-21 adjacent to one of the missile silos concluded that it was the result of vapor transfer and not a liquid release.
- A thick, dry, sand strata extending from approximately 30 to 110 feet below ground surface (bgs) provides a large potential reservoir for allowing the accumulation, mixing, and lateral spreading of soil gas vapors from individual solid waste management units (SWMUs). Because of mixing and lateral transport within the sand, it is not feasible to positively identify any single SWMU as a vapor source supplying the VOCs detected in the monitoring wells.
- The geologic stratum between the bottom of the sand (110 feet bgs) and the water table (140 to 180 feet bgs) consists of interbedded silts and fine sands. This material is highly protective against vertical liquid migration because of low in-situ moisture contents, a high degree of stratification, and large hydraulic conductivity contrasts between layers.
- The stratified materials from 110 feet bgs to the water table are less protective against vapor transport because they are more permeable to vapor than to water, and the myriad of interbedded sand seams provide a preferred flow path for vapor migration.
- Thicker sand layers underlie the northwest quarter of the site, and the sand extends deeper (closer) to the water table than beneath the remaining areas of the site. All currently impacted wells are located in the northwest corner where more rapid vertical migration of VOC soil vapors is expected.
- The Upper and Lower Aquifers are not viable aquifers according to a water resources definition of an aquifer. Except for the Upper Aquifer in the extreme northwest corner of the site, neither aquifer yields enough water to be used for purposes other than possibly low-yielding stock wells. In addition, the water quality for both aquifers is

marginal for domestic consumption because it is naturally high in sodium and total dissolved solids.

- Access to the wells, and, therefore, potential exposure to the "uppermost" aquifer within the facility boundary and on the west, south, and east perimeter, is restricted by ESII ownership of the property. There are no springs or natural groundwater discharge points in the vicinity of the site. The monitoring wells are locked, and access is restricted by RCRA Permit to trained sampling crews who wear personal protective equipment during sampling events.

- There are no offsite, private wells near the facility. ESII owns property to the east, south, and west. The nearest potential receptor is a future domestic well installed on the adjoining property across the north facility boundary. Under the current hydraulic gradient pattern, groundwater in the Upper Aquifer flows diagonally into the site across the northern facility boundary. Assuming typical Upper Aquifer well yields are achieved, it will not be feasible to pump the new (hypothetical) well at a rate high enough to significantly change the flow patterns. Consequently, even if a future well is installed to the north and adjacent to the site, it will still be upgradient of the facility.

- In addition to the low permeability and resultant slow groundwater movement, the high carbon content in saturated sediments of the Upper and Lower Aquifers facilitates natural degradation and attenuation of the VOCs as demonstrated by the Migration of Organic and Inorganic Chemicals in Groundwater (MYGRT) fate and transport model. Estimated dilution and attenuation factors indicate that concentrations exceeding the solubility of the VOCs in groundwater are required for significant transport of the compounds from the interior of the facility to the facility boundary.

- Research on solvent fate and transport in the subsurface environments indicates that if a VOC is detected at a concentration above 10 percent of its solubility, it is likely that a free-phase liquid release has occurred. To provide an additional conservative safety factor, constituent ACLs for Level 1 Compliance Wells are proposed at concentrations substantially below those indicative of a liquid release.

- Establishing the ACL for Level 1 Compliance wells at the 0.5-percent water solubility concentration ensures that an investigation will be conducted to evaluate specific conditions, potential risks, and potential corrective actions, if necessary, if this threshold is exceeded.

- Fate and transport modeling using the MYGRT model indicates VOCs at the part-per-billion level will not migrate significantly away from the point of entry of the VOCs into the groundwater. Thus, if the proposed ACLs for a Level 2 Compliance Well are exceeded, the extent of the contamination will still be within the immediate proximity of Site B, where corrective actions can be applied.

SECTION 1

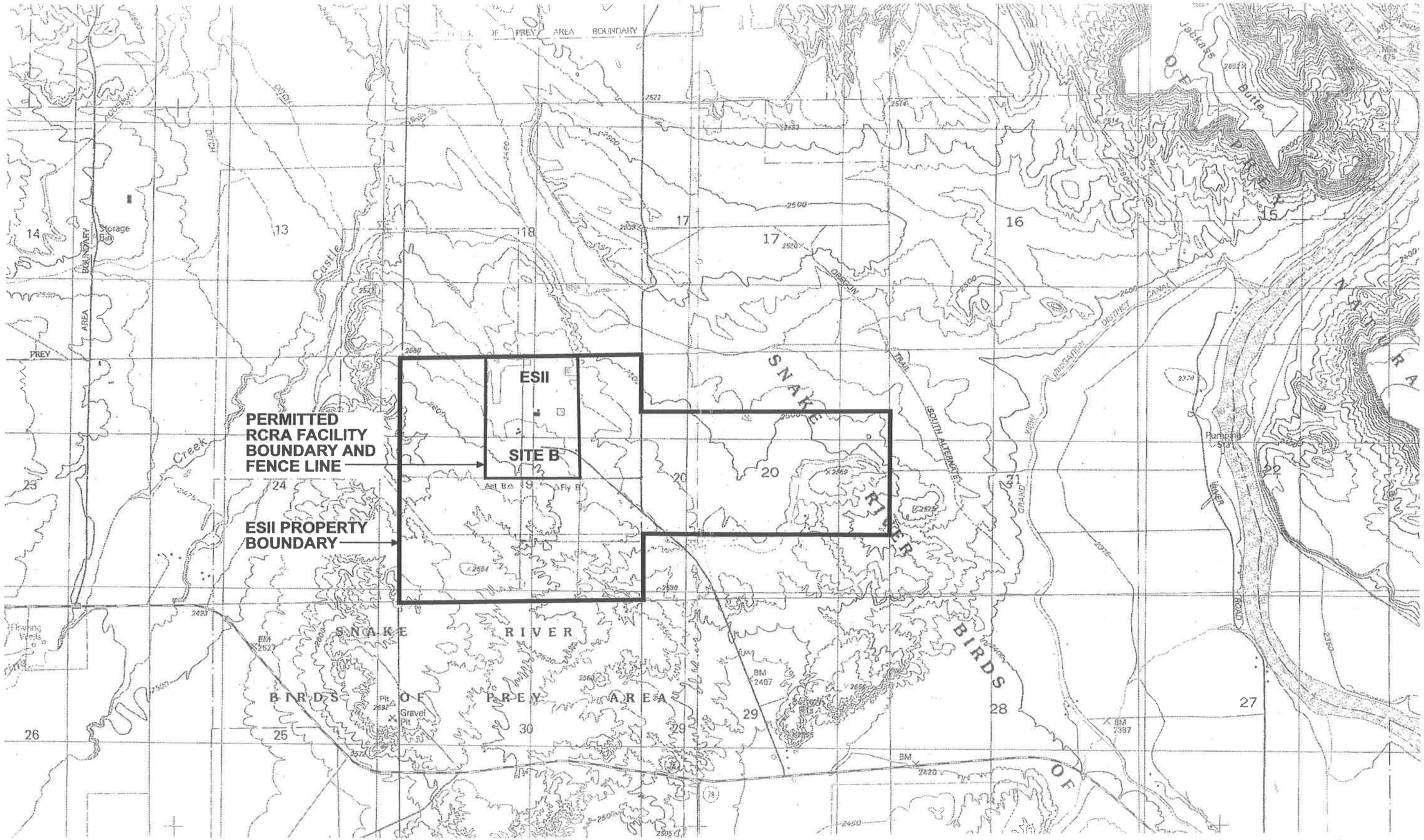
Introduction

Envirosafe Services of Idaho, Inc. (ESII) owns and operates a permitted commercial hazardous waste treatment, storage, and disposal facility, (EPA I.D. No.: IDD073114654) known as Site B (Figure 1). In the September 1996 semiannual groundwater monitoring event, performed in accordance with Part IX—Groundwater and Vadose Monitoring Program of ESII's Site B RCRA Permit, carbon tetrachloride was detected in Monitoring Well U-23 at a concentration of 71 µg/L. Carbon tetrachloride is one of the 26 volatile organic compounds (VOCs) listed as monitoring criteria constituents in Permit Condition *IX.E.2.* of ESII's RCRA Permit. This value exceeded the detection monitoring criteria of 20 µg/L established in Permit Condition *IX.F.1.a.* Subsequent verification samples from Monitoring Well U-23, collected in October 1996, confirmed that carbon tetrachloride was present above the statistical monitoring criteria.

Other VOCs were detected in several other Upper Aquifer monitoring wells at Site B both prior to and subsequent to the detection of carbon tetrachloride in Monitoring Well U-23. Only low levels of VOCs are being detected at sporadic and variable concentrations in multiple wells, one of which (Monitoring Well U-1) is hydraulically upgradient of the site. Using available data, evaluated the potential cause of the detection of these constituents in the groundwater at Site B, and has concluded that fugitive soil vapors associated with subsurface waste disposal is the likely source.

This ACL demonstration document has been prepared pursuant to Permit Condition *IX.F.3.a.* and *40 CFR 264.94(b)*, in response to the September 1996 detection of VOCs in Monitoring Well U-23. Evaluation of available data suggests that diffuse soil vapors are the likely source for the detected VOCs. Because the soil vapors do not appear to be originating from a specific solid waste management unit (SWMU), ESII is proposing a site-wide ACL. Consequently, the data and evaluation presented in this document support a site-wide ACL and compliance groundwater monitoring program in accordance with *40 CFR 264.99*. ACLs are proposed in accordance with *40 CFR 264.94(b)*, to establish an alternate groundwater protection standard under *40 CFR 264.92* for the compliance monitoring program. The *40 CFR Part 264* regulations referenced in this document are incorporated by reference in *IDAPA 16.01.05.008*.

The proposed ACL allows higher concentrations in interior wells based on the chemical and physical properties of the VOCs, and on the degradation and attenuation attributes of the slow-moving groundwater system. Lower ACLs based on health-risk-based criteria are proposed for wells on the facility boundary. In addition to submitting this ACL demonstration document, ESII will conduct a field investigation of the soil vapors underlying Site B.



APPROXIMATE SCALE IN FEET

0 2000 4000

N

Base Map from USGS 7.5 Minute Topographic Quadrangles
(Castle Butte, Idaho [1992] and Jackass Butte, Idaho [1992])

FIGURE 1
LOCATION MAP OF ESII SITE B
ESII SITE B
ACL DEMONSTRATION

CH2MHILL

142505.D1.01

P:\142505\DRAWINGS\FH-FIGS\ACL\ACL-FIGS.FH4 22-MAY-1998

Following this Introduction, the remainder of this document is organized into the sections described below:

Section 2—Site Description and Background

This section presents an overview of ESII Site B, and describes the site history and hydrogeology. Water quality data pertinent to this ACL demonstration document is also provided in this section.

Section 3—Fate and Transport Evaluation of VOCs

This section presents an evaluation of the fate and transport of VOCs in the subsurface at Site B. Chemical and physical characteristics of potential VOC releases into the unsaturated sediments (vadose zone) are examined, as are the expected effect of the vadose zone hydrogeology of Site B on the migration of soil gas vapors and the detection of VOCs in groundwater. Fate and transport analysis of VOCs in the vadose zone serves as the basis for evaluating the data presented in Section 4.

Section 4—Data Summary and Evaluation

This section provides an evaluation of potential sources and mechanisms causing the VOC detections. This section also includes analysis of the groundwater sampling data; an evaluation of Cell 5 and other SWMUs; and a review of monitoring well construction as it pertains to potential vertical migration pathways for VOC soil vapors.

Section 5—ACL Development

This section presents the methodology and development of the proposed site-wide ACL for ESII Site B. The section discusses the basis for both the risk-based ACLs, and the ACLs supported by fate and transport modeling.

Section 6—Propose Alternate Concentration Limits for ESII Site B

This section provides the specific ACLs being proposed for Site B based on the results of the data evaluations, and as supported by fate and transport modeling.

Section 7—References

This section contains references cited in this document.

SECTION 2

Site Description and Background

Site History

ESII Site B, formerly a U.S. Air Force Titan missile base, is located approximately 10 miles northwest of the town of Grand View, Owyhee County, in southwestern Idaho. The Air Force constructed the defense site in the late 1950s and early 1960s. In 1972, the site was purchased from the Air Force and converted to a hazardous waste disposal site by Western Containment Corporation (Wescon). Wescon used the three missile silos—which are 160 feet deep and 40 feet in diameter—other ancillary underground missile base structures, and numerous shallow, unlined trenches for waste disposal In 1981, ESII purchased the site and continued to operate the facility for hazardous waste disposal. In December 1988, ESII received a RCRA Subtitle C Part B Permit, and, in 1989, received a TSCA Permit for the Facility.

Site Setting and Hydrogeology

Site Setting

ESII is located on a gentle, northeast sloping terrace at an elevation of 2,500 to 2,600 feet, about 3 miles south of the Snake River in southwestern Idaho. The climate is arid and the area receives less than 8 inches of precipitation annually.

ESII Site B overlies what once was a very large freshwater lake as a result of a much wetter climate and lava dams that had formed across the ancestral Snake River along the Oregon/Idaho state line. This lake was deep and relatively stable for thousands of years, allowing a thick accumulation of fine-grained silt and clay. These sediments, referred to as the lacustrine (lake deposits) facies of the Glenns Ferry Formation, extend from at least 1,700 feet to about 260 feet below ESII Site B.

Beginning 1 to 2 million years ago, the lake environment became unstable and the resultant water level fluctuations allowed fine sand deposits from tributary streams (fluvial deposits) to be deposited over the lacustrine clays in what previously was the deep, offshore parts of the lake. However, during this unstable period, lake levels would periodically rise for lengthy periods and new deposits of lacustrine clays would cover the fluvial sands. The Lower Aquifer at ESII Site B is representative of this depositional environment where, for a geologically brief period, lake levels were low enough for thin beds of very fine sand to reach this location only to be covered again, perhaps seasonally, with clays. The result is a 20- to 40-foot-thick section consisting of thin, discontinuous, fine sands interbedded with clays and silts. The Lower Aquifer section at ESII Site B typically extends from about 260 to 230 feet bgs.

After the Lower Aquifer sands were deposited, an extended period of stable, higher lake levels returned and resulted in a 20- to 30-foot-thick deposit of lacustrine clayey silt and clay that overlies the Lower Aquifer sands. This interval, referred to as the inner confining

clay in the ESII Site B geologic characterization reports, extends from about 230 to 210 feet bgs. It forms a continuous layer that underlies the entire facility.

After the inner confining layer had accumulated, lake levels began fluctuating again. During this period, the fine-grained, thinly bedded, fluvial sands, interbedded with lacustrine clays representing the basal portion of the Upper Aquifer at ESII Site B, were deposited. Because they represent similar environments of deposition, the basal portion of the Upper Aquifer sequence is very similar to the Lower Aquifer. However, in contrast to the previous period of fluctuation and return to stability, which produced the Lower Aquifer and inner confining clay, lake levels continued to fluctuate and began a period of recession. This period of fluctuating but receding lake levels produced the middle and upper portions of the Upper Aquifer, which is typified by an upward coarsening pattern of thicker and coarser sand beds interbedded with fewer and thinner clay and silt beds. The basal portion of the Upper Aquifer extends from about 210 feet to 190 feet bgs. From 190 feet to about 120 feet bgs, Upper Aquifer sediments undergo the transition from dominantly lacustrine (silts and clays) to dominantly fluvial deposits (sands).

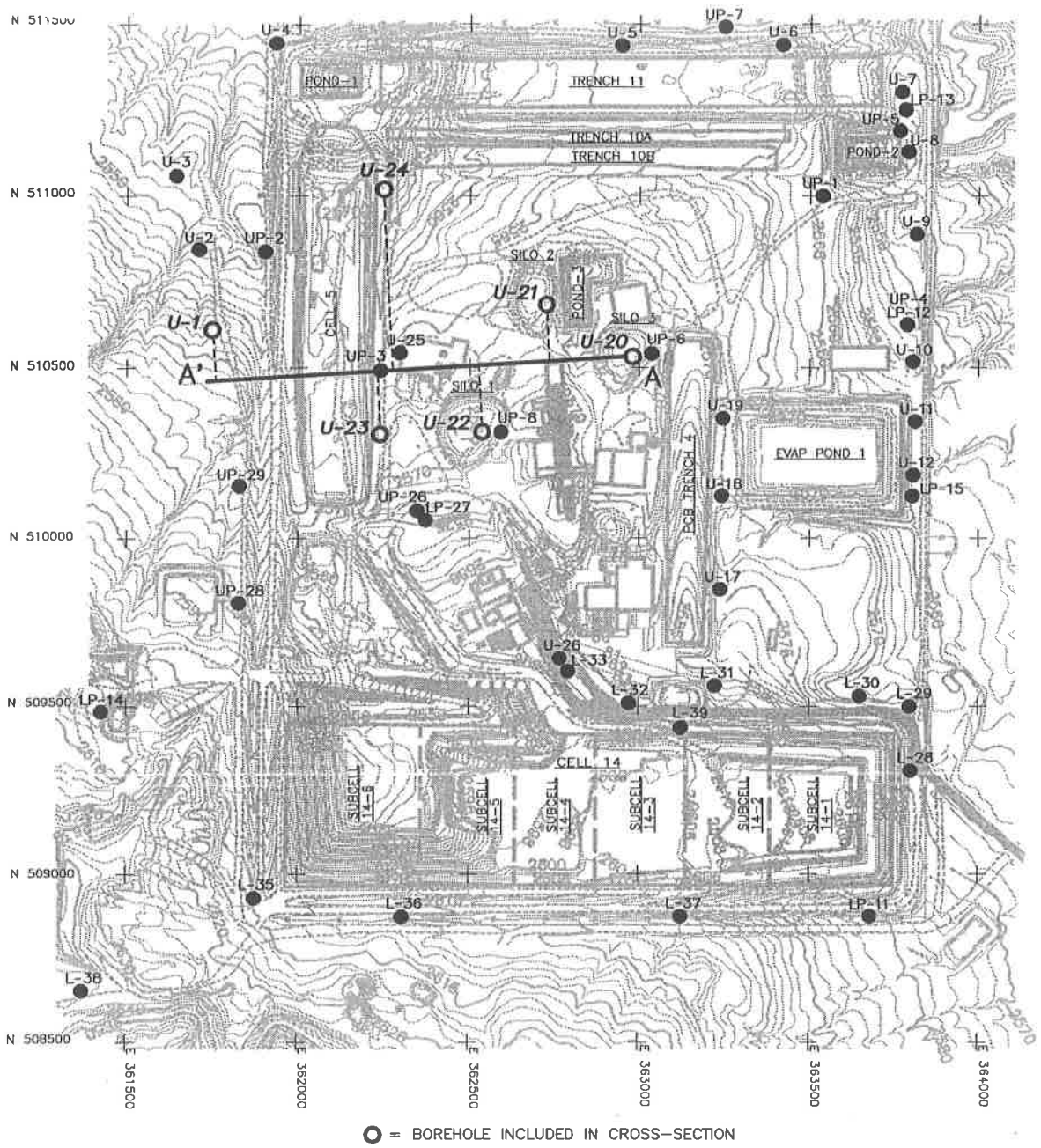
From about 120 feet to 30 feet bgs, the geologic section consists of thick, dry, fine to coarse-grained fluvial and windblown sands. The overall characteristic of this section is the sand deposits, although sporadic and thin, discontinuous clay and silt beds are also present. Overlying these fluvial sands, and extending to the surface at ESII Site B are the coarse sand and gravel deposits of the Bruneau Gravels. The Bruneau Gravels overlie the entire site with the exception of where they have been removed by site construction activities or where they are thinly covered by recent soil or ash layers. These deposits reflect the high-energy environment of the paleo-Snake River as it began to develop and cut down into the underlying formations. The principal stratigraphic features are illustrated on cross section A-A', which is located in Figure 2 and shown in Figure 3.

Following deposition of the sediments at ESII Site B, tectonic forces tipped the formations and contacts between the various geologic units described above to the north-northeast. The angle that previously horizontal geologic formations make with a horizontal plane is referred to as dip and is reported in degrees from horizontal. The orientation of a line formed by the intersection of a dipping bed and a horizontal plane is referred to as the strike. By definition, strike direction is perpendicular to the direction of dip. The formations at ESII Site B dip about 3 degrees to the north-northeast and strike northwest-southeast. As will be discussed, this minor structural dip and the resultant orientation and attitude of the various geologic units described above have a significant effect on groundwater monitoring and the potential for migration of VOC soil gas vapors at ESII Site B.

Hydrogeology

As described above, there are two water-bearing portions of the sedimentary sequence underlying ESII Site B. These geologic strata have been referred to as the Upper Aquifer and Lower Aquifer, although neither are productive enough to be considered aquifers in any context or ability to produce a sufficiently usable quantity of groundwater.

The Lower Aquifer sediments are present and saturated beneath all of ESII Site B. The aquifer matrix and hydraulic properties are consistent, and groundwater in this aquifer moves slowly from southwest to northeast. Figure 4 provides a recent potentiometric map



O = BOREHOLE INCLUDED IN CROSS-SECTION

N

0 250 500 750 1000

SCALE: IN FEET

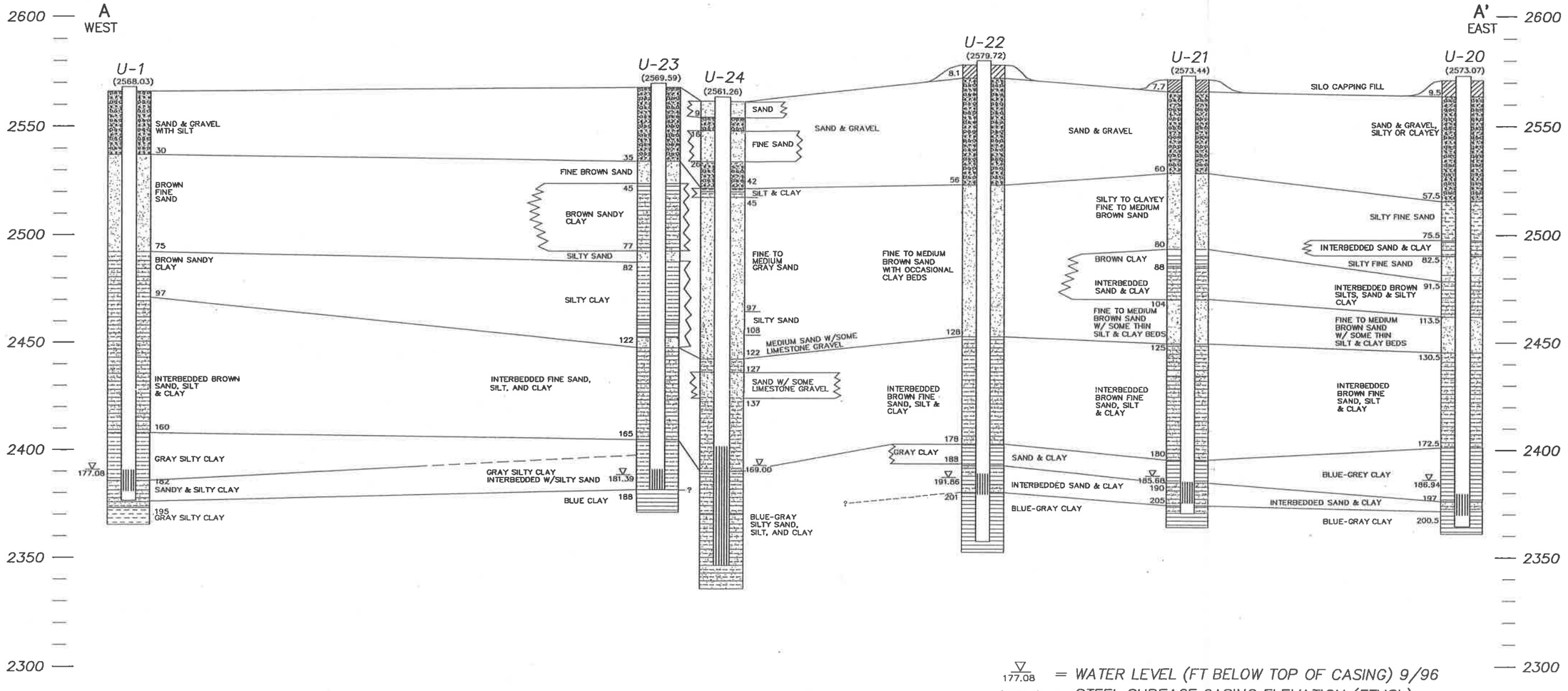
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FIGURE 2
LOCATION OF GEOLOGIC CROSS-SECTION A-A'
ESII SITE B
ACL DEMONSTRATION

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SCALE:
1" = 100' HORIZONTAL
1" = 50' VERTICAL



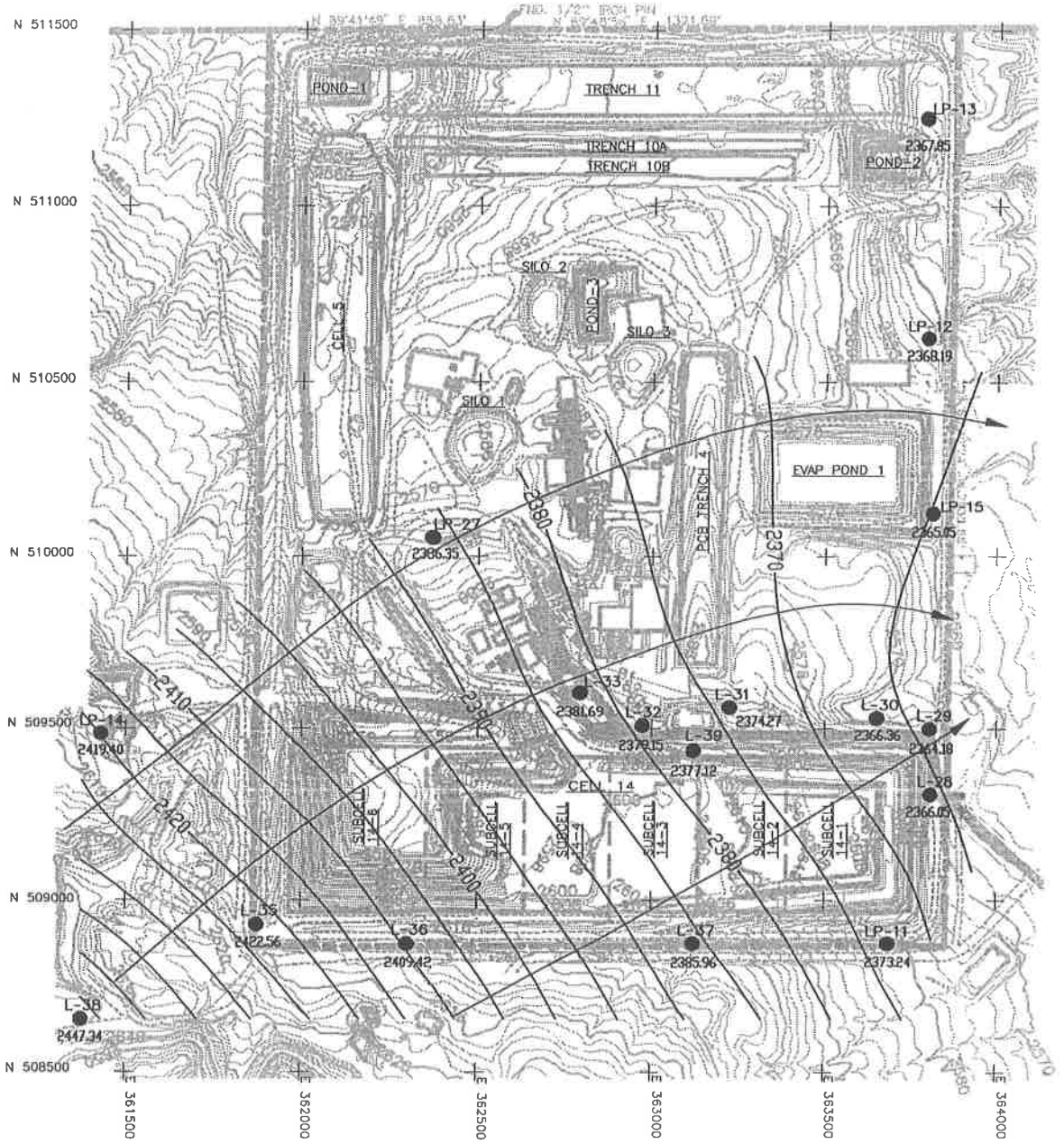
$\frac{\nabla}{177.08}$ = WATER LEVEL (FT BELOW TOP OF CASING) 9/96
(2580.3) = STEEL SURFACE CASING ELEVATION (FTMSL)

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FIGURE 3
GEOLOGIC CROSS SECTION A–A'
ESII SITE B
ACL DEMONSTRATION

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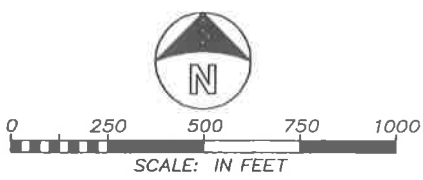


FIGURE 4
LOWER AQUIFER POTENTIOMETRIC SURFACE (FT MSL), FALL 1996
ESII SITE B
ACL DEMONSTRATION

142505.D1.01

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22-May-19 LA9_96.DWG

for the Lower Aquifer. The Lower Aquifer is under confined conditions beneath ESII Site B. Lower Aquifer wells yield less than 0.5 gallons per minute (gpm).

The Upper Aquifer at ESII Site B is much more complicated than the Lower Aquifer. While the bottom of the Upper Aquifer is defined as the top of the inner confining clay, there is no identifiable geologic top to the Upper Aquifer. The Upper Aquifer is considered an unconfined aquifer, which means that the top of the aquifer is defined as the water table. Water in the Upper Aquifer enters the site from the northwest and flows generally to the east-southeast across the site as shown in Figure 5. The water table and groundwater flow direction in the Upper Aquifer is essentially parallel to the strike of the formations. The north-northeast structural dip and the northwest-southeast sloping water table combine to produce a situation where the Upper Aquifer sedimentary sequence gradually emerges above the water table from north to south across the site.

This emergence phenomenon has two profound effects on the physical and hydrogeologic characteristics of the Upper Aquifer at ESII Site B. As a result of the dipping beds and emergence of the aquifer, as defined by the water table to the top of the inner confining clay or bottom of the Upper Aquifer sediments, is wedge-shaped. The saturated thickness of the aquifer is thickest across the northern edge of the site and thins from north to south until all of the Upper Aquifer sediments are above the water table. The southern edge of saturation in the Upper Aquifer crosses ESII Site B near the northern edge of Cell 14 on the southern side of the facility. The southern limit of saturation moves back and forth as the water table fluctuates. Over the past 10+ years, water levels have risen 5 to 10 feet in the Upper Aquifer. As a result of the gentle northward dip of the aquifer, for every 1 foot in water table rise, the southern limit of saturation moves southward approximately 20 feet. In addition, as the water tables rises, previously unsaturated sand seams become saturated.

The second significant characteristic of the Upper Aquifer, controlled by the combination of dipping strata and geologic deposition, is that the aquifer yield decreases from north to south across the site. This decrease is the result of the combined effect of reduced saturated thickness as explained above, as well as the influence of the coarsening upward sedimentary sequence described previously. Thus, as one moves from north to south in the Upper Aquifer, the saturated thickness decreases while the remaining saturated sands are thinner, finer, and less abundant.

The upper part of the Upper Aquifer beneath the northwest side of the site is sandier than the Upper Aquifer sediments beneath the central and eastern sides of the site. Combining these sandier sediments with the structural dip and resultant saturated thickness variations, the northwest side of the site is the most productive portion of the Upper Aquifer. The Upper Aquifer yields vary from approximately 5 gpm in the northwest corner to less than 0.5 gpm on the eastern side of the facility and across the southern extent of the aquifer. In addition, because there are more and thicker sand beds in the Upper Aquifer section in the northwestern portion of the site, the transition from the Upper Aquifer sequence to the overlying sands occurs at a greater depth than elsewhere on the site.

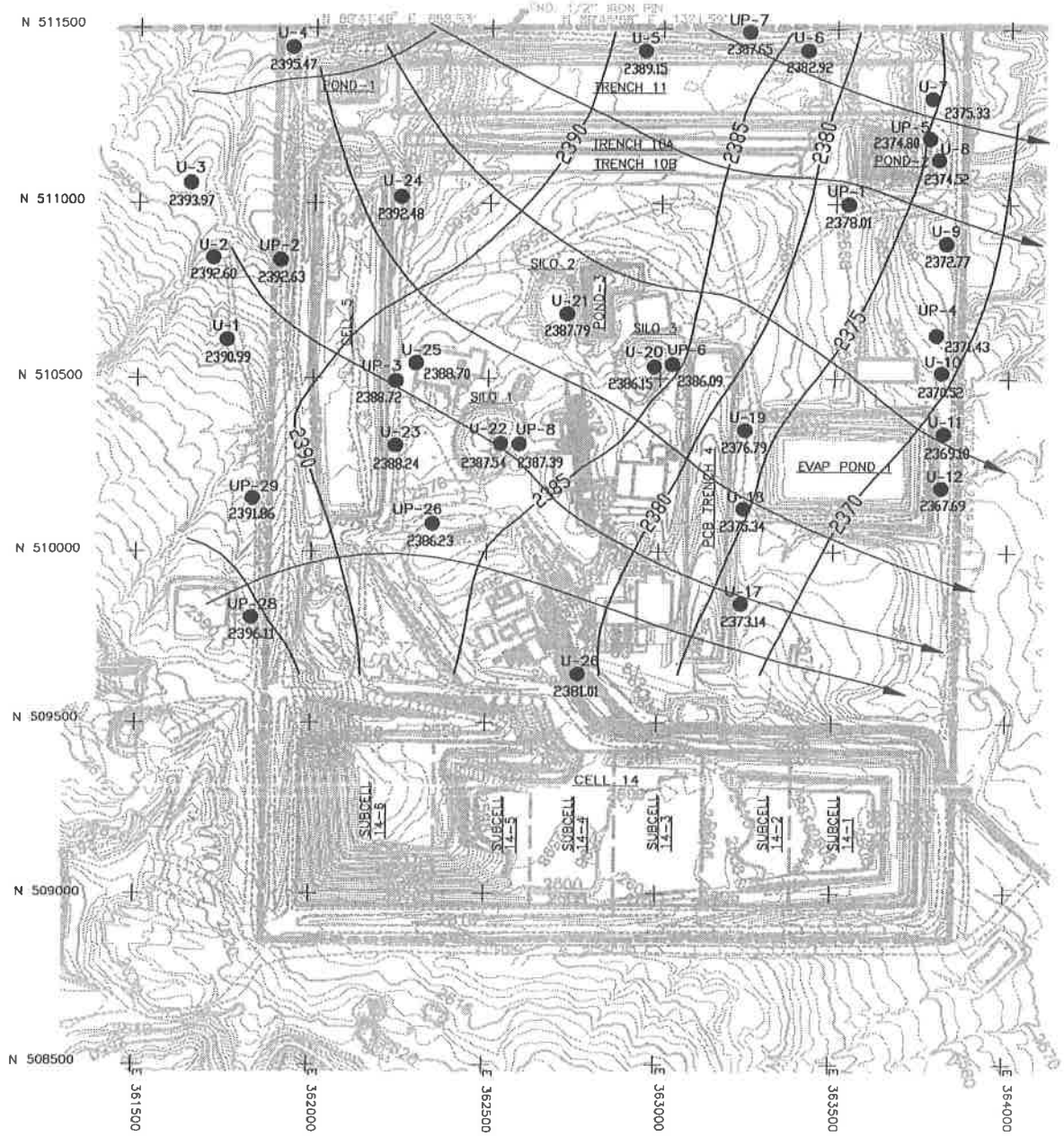




FIGURE 5
UPPER AQUIFER WATER TABLE
(FT MSL), FALL 1996
ESII SITE B
ACL DEMONSTRATION

CH2MHILL

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Water Quality

ESII's RCRA groundwater detection monitoring system, as required by Permit Condition *IX.D*, includes 32 monitoring wells and 18 piezometers (Figure 6). Twenty-six monitoring wells are sampled semiannually and six are sampled annually. The sampling parameters consist of the 26 specific VOCs listed in Table 1, total organic carbon (TOC), total organic halides (TOX), specific conductivity, temperature, and pH. The RCRA Permit establishes the groundwater monitoring criteria and responses required if the criteria are exceeded. The monitoring criteria (Permit Condition *IX.F*) for wells in the Detection Monitoring Program are exceeded if any one VOC is detected at over 20 µg/L or any four VOCs are present above their respective practical quantitation limits (PQLs). If the detection monitoring criteria are exceeded in any well, and the exceedance is confirmed by additional sampling, ESII is required to evaluate the cause of the exceedance, enter into compliance monitoring, and either submit a petition to establish an ACL or begin corrective action. As shown in Table 2, detection monitoring criteria VOCs have been detected in several wells at ESII Site B since April 1989.

In October 1991, carbon tetrachloride, chloroform, and chloromethane were detected in Monitoring Well U-21, the dedicated downgradient well for past practice unit Silo 2 (Figure 6). The presence of these compounds was subsequently confirmed by the December 1991 re-sample. In November 1993, ACLs were established, and a Compliance Monitoring Program was developed for Monitoring Well U-21. The ACL groundwater protection standards for U-21 were based on an onsite exposure and Insert Figure 6 risk scenario. Compliance monitoring for Monitoring Well U-21 is continuing because the concentrations of VOCs are below the established ACL groundwater protection standards that would trigger corrective action. In addition, a corrective measure study was completed for Monitoring Well U-21 (CH2M HILL, 1993). This study concluded that soil vapors, not a direct liquid release, had caused the groundwater contamination at Monitoring Well U-21.

In October 1995, carbon tetrachloride was detected in Monitoring Well U-1 at a concentration of 5 µg/L, and 1,1,2,2 tetrachloroethane, a detection monitoring VOC constituent, was detected in Monitoring Well U-22 at 6.7 µg/L. In April 1996, carbon tetrachloride was detected in Monitoring Well U-1 at a concentration of 12 µg/L. Because these concentrations were below the monitoring criteria established by ESII's operating permit, no additional sampling was performed and no additional regulatory response was required.

In September 1996, groundwater analytical results indicated the presence of carbon tetrachloride in Monitoring Well U-1 at a concentration of 14 µg/L and in Monitoring Well U-23 at a concentration of 71 µg/L. The concentration in Monitoring Well U-23 exceeded the VOC monitoring criteria of Permit Condition *IX.F.1.a.* (20 µg/L), and, in accordance with the permit, ESII notified the Idaho Division of Environmental Quality (IDEQ) of the results in a letter dated October 25, 1996. As required by the permit, ESII collected two verification samples from Monitoring Well U-23 on October 29, 1996. Carbon tetrachloride was detected in both verification samples at concentrations of 88 µg/L and 130 µg/L, which provided the confirmation required by Permit Condition *IX.F.3.* that a detection monitoring criteria constituent was detected above the statistical monitoring

TABLE 1
List of Organic and Inorganic Parameters in Detection Monitoring Program

Constituent	CAS No.
Benzene	71-43-2
Bromodichloromethane	75-27-4
Bromoform (tribromomethane)	75-25-2
Bromomethane	74-83-9
Carbon Tetrachloride	56-23-5
Chlorobenzene (monochlorobenzene)	108-90-7
Chloroethane (ethyl chloride)	75-00-3
2-chloroethylvinyl ether	110-75-8
Chloroform	67-66-3
Chloromethane (methyl chloride)	74-87-3
cis-1,3-Dichloropropene	10061-01-5
Dibromochloromethane	124-48-1
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethene	75-35-4
1,2-Dichloropropane	78-87-5
Ethylbenzene	100-41-4
Methylene Chloride*	75-09-2
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethene	127-18-4
Toluene	108-88-3
Trans-1,2-Dichloroethene	156-60-5
Trans-1,3-Dichloropropene	10061-02-6
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethene	79-01-6
Vinyl chloride	75-01-4
Total Organic Halogens (TOX)	-----
Total Organic Carbon (TOC)	-----
pH	-----
Specific Conductance	-----
Temperature	-----

* Added to Compliance Monitoring Program for U-21 and U-4 adopted November 24, 1993.

criteria. In accordance with Permit Condition *IX.F.3.*, Monitoring Wells U-1 and U-23 were sampled on December 20, 1996, and analyzed for Appendix IX constituents.

No organic constituents other than carbon tetrachloride at 5.4 µg/L (U-1) and 11.0 µg/L (U-23) were detected in this sample. To provide additional groundwater data, the piezometer wells nearest Monitoring Well U-23 (UP-3, UP-26, UP-28, and UP-29) were sampled on January 13, 1997, and analyzed for Appendix IX constituents (excluding dioxins/furans and metals). The only VOC constituents detected were in piezometer UP-3, where carbon tetrachloride and chloroform were detected at concentrations of 7 µg/L and 9.7 µg/L, respectively. No VOCs were detected in the samples collected from piezometers UP-26, UP-28, and UP-29. In response to the confirmed presence of carbon tetrachloride above the detection monitoring criteria, a Class 2 Permit modification request, dated March 7, 1997, was submitted to IDEQ to establish a Compliance Monitoring Program for Monitoring Well U-23.

In the July 1997 semi-annual detection monitoring sample event, carbon tetrachloride was detected in Monitoring Well U-1 at 29 µg/L, which exceeded the detection monitoring criteria. The sample from Monitoring Well U-23 for this sample event contained no detectable VOCs. In October 1997, carbon tetrachloride was detected in Monitoring Well U-1 at 14 µg/L and in Monitoring Well U-23 at 16 µg/L. In the October 1997 sample, carbon tetrachloride was also detected in Monitoring Well U-24 at 8.3 µg/L, and chloroform was detected at 26 µg/L in Monitoring Well U-20 and at 5.1 µg/L in Monitoring Well U-22. The confirmation sample for Monitoring Well U-20, however, did not contain detectable concentrations of chloroform or any other VOC.

Three other VOCs have each been detected once in three different monitoring wells: carbon disulfide, 4.0 µg/L in Monitoring Well U-1; tetrachloroethylene, 5.1 µg/L in Monitoring Well U-21; and 1,1,2,2-tetrachloroethane, 6.7 µg/L in Monitoring Well U-22. These spurious detections have all been below the detection monitoring criteria for VOCs and consequently were not subject to confirmation sampling. The erratic appearance of these volatile organic compounds is consistent with the soil vapor transport mechanism described in the following section of this document.

Methylene chloride was detected in Monitoring Well U-21 beginning in December 1991, when it was added to the list of analytes. Methylene chloride is a common laboratory contaminant and, while it may be present in Monitoring Well U-21, the actual in-situ concentration may be lower than the laboratory results indicate.

The data in Table 2 suggests that the frequency of detection of these VOCs may be increasing, although the impacted wells are still limited to those in the northwest corner of the site. With the exception of the occasional presence of carbon disulfide; tetrachloroethylene; 1,1,2,2-tetrachloroethane; and methylene chloride, the VOCs detected consist of carbon tetrachloride, chloroform, and chloromethane. Because chloroform and chloromethane are degradation products of carbon tetrachloride, this ACL analysis will focus primarily on carbon tetrachloride.

TABLE 2
Summary of VOC Detections

	Apr 89	Oct 90	Apr 91	Oct 91	Dec 91	Feb 92	Mar 92	Apr 92	Jul 92	Oct 92	Mar 93	May 93	Oct 93
U-1													
CTET	ND[a]	ND	ND	ND	-----[b]	-----	ND	ND	ND	ND	ND	ND	ND
CDS	ND	-----	-----	-----	-----	-----	4.0	ND	ND	-----	-----	-----	-----
UP-3													
CTET	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
CF	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
U-20													
CF	ND	6.0	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND
U-21													
CM	ND	ND	-----	21.0	120.0	12.0	-----	ND	52.0	20.0	ND	55.0	56.0
MC	ND	-----	-----	-----	39.0	ND	-----	ND	24.0[c]	15.0	12.0	19.0	22.0
CF	7.0	7.0	-----	30.0	200.0	8.0	-----	20.0	130.0	80.0	48.0	110.0	130.0
CTET	ND	ND	-----	4.0	35.0	7.0	-----	ND	14.0	8.0	ND	14.0	14.0
PCE	ND	ND	-----	ND	ND	ND	-----	ND	ND	ND	ND	ND	ND
U-22													
CF	ND	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND
1,1,2,2-PCA	ND	ND	-----	ND	-----	-----	-----	-----	-----	ND	-----	-----	ND
U-23													
CTET	ND	ND	15.0	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND
CF	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
U-24													
CTET	ND	ND	ND	ND	-----	-----	-----	ND	-----	ND	-----	ND	ND

[a]ND = not detected.

[b]----- = not sampled.

[c]Compound detected in blank at the same concentration.

CTET = Carbon Tetrachloride
CDS = Carbon Disulfide
CF = Chloroform
CM = Chloromethane
MC = Methylene Chloride
1,1,2,2-PCA = 1,1,2,2-Tetrachloroethane
PCE = Tetrachloroethene

TABLE 2
Summary of VOC Detections (Continued)

	May 94	Oct 94	May 95	Oct 95	Apr 96	Sep 96	Oct 96	Dec 96	Jan 97	Jul 97	Oct 97
U-1											
CTET	ND	ND	ND	5.0	12.0	14.0	-----	5.4	-----	29.0	14.0
CDS	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
UP-3											
CTET	-----	-----	-----	-----	-----	-----	-----	-----	7.0	-----	8.3
CF	-----	-----	-----	-----	-----	-----	-----	-----	9.7	-----	5.1
U-20											
CF	-----	ND	-----	ND	-----	ND	-----	-----	-----	-----	26.0
U-21											
CM	48.0	18.0	31.0	24.0	38.0	13.0	-----	-----	-----	48.0	11.0
MC	7.5	7.2	13.0	12.0	13.0	ND	-----	-----	-----	12.0	6.3
CF	84.0	54.0	140.0	120.0	140.0	73.0	-----	-----	-----	130.0	79.0
CTET	10.0	ND	8.2	8.2	12.0	7.3	-----	-----	-----	12.0	12.0
PCE	ND	ND	ND	ND	ND	ND	-----	-----	-----	ND	5.1
U-22											
CF	-----	ND	-----	ND	-----	ND	-----	-----	-----	-----	5.1
1,1,2,2-PCA	-----	ND	-----	6.7	-----	ND	-----	-----	-----	-----	ND
U-23											
CTET	ND	ND	ND	ND	ND	71.0	130.0	11.0	-----	ND	16.0
CF	-----	-----	-----	-----	-----	-----	6.4	-----	-----	-----	5.1
U-24											
CTET	ND	ND	ND	ND	ND	ND	-----	-----	-----	-----	8.3

[a]ND = not detected.

[b]----- = not sampled.

[c]Compound detected in blank at the same concentration.

CTET = Carbon Tetrachloride
CDS = Carbon Disulfide
CF = Chloroform
CM = Chloromethane
MC = Methylene Chloride
1,1,2,2-PCA = 1,1,2,2-Tetrachloroethane
PCE = Tetrachloroethene

SECTION 3

Fate and Transport Evaluation of VOCs

Introduction

Two possible source scenarios for the detection of VOCs in groundwater in monitoring wells at ESII Site B have been developed and are outlined as follows:

- A liquid release has reached groundwater and VOCs have dissolved into groundwater, creating a groundwater plume. Given sufficient time, the dissolved VOCs within this plume at the initial point of contact migrate with the groundwater in the direction of groundwater flow and create a downgradient VOC plume.
- The release of VOCs occurred within the unsaturated soil media above the groundwater. VOC soil gas vapors have migrated and made surficial contact with groundwater at multiple points, dissolving into the groundwater and resulting in the detection of VOC constituents. If a sufficient mass of vapors migrates to the groundwater, VOCs may be detected in the monitoring wells downgradient from the initial area(s) of vapor contact.

The distribution of VOCs in the unsaturated zone and saturated zone will differ significantly for each of these source scenarios. This evaluation is organized in two parts. First, general fate and transport models and partitioning models that describe the distribution of VOCs between liquid, vapor, soil, and water are used to analyze the potential/probable source scenarios that could have caused the observed detection of VOCs in monitoring wells at Site B. The second part of the evaluation presents the results of previous analyses using the MYGRT model to assess the fate and transport of VOCs, regardless of source, in the groundwater at Site B. In Section 4, the model results and site data are compared to arrive at conclusions regarding the cause of VOCs detected in the monitoring wells.

Fate and Transport of VOCs in the Vadose Zone

This section describes the fate and transport of carbon tetrachloride through the vadose zone at ESII Site B. Carbon tetrachloride was selected for fate and transport modeling because this compound and its primary degradation products, chloroform, methylene chloride, and chloromethane, are the principle VOCs detected in groundwater beneath Site B. The other three VOCs, carbon disulfide, tetrachloroethene, and 1,1,2,2-tetrachloroethane, have only been detected once at trace concentrations (less than 7 µg/L); whereas, carbon tetrachloride and its degradation products have repeatedly been detected at concentrations exceeding the Site B detection monitoring criteria.

Carbon tetrachloride belongs to a general category of liquid organic compounds called "solvents." The term solvent(s) is commonly used to describe these chemicals when discussing fate and transport because of their similar properties and will be used in the discussions that follow. A summary of the chemical and environmental properties for

carbon tetrachloride is presented in Table 3. The fate and transport modeling evaluates release of solvents to soils, migration of solvents through soils, migration of solvents to and in groundwater, and the fate of solvents in these mediums. In Section 4, results of the modeling are compared to groundwater sample results, the hydrogeology of Site B, Cell 5 data, and monitoring well construction to support the conclusion that the most likely scenario causing the detection of VOCs in the groundwater at Site B is soil vapor transport.

TABLE 3
Chemical and Environmental Properties of Carbon Tetrachloride

Vapor Pressure (mm Hg)	109
Solubility (mg/L)	825
Henry's Constant (unitless)	10.0°C 0.567 17.5°C 0.883 24.8°C 1.244 34.6°C 1.823
Relative Vapor Density (unitless)	1.62
Koc (mL/g)	439
Density (g/cm3)	1.59
Absolute Viscosity (cP)	0.97
Half-Lives (Mackay et al., 1993) Air Water Soil Sediment	 ~ 2 years ~ 2 months ~ 8 months ~ 2 years

Source: Pankow and Cherry, 1996.

Transport Mechanics through Unsaturated Soil and Groundwater

The major transport mechanisms that control the migration of solvents in the subsurface are vaporization, volatilization, diffusion, and advection. These mechanisms are a function of the partitioning of the solvent source between vapor and liquid and the gas, water, and soil composition of the subsurface matrix.

1. **Vaporization** occurs when the solvent evaporates directly into the atmosphere from a liquid or solid phase.
2. **Volatilization** occurs when the dissolved-in water or sorbed phase of the solvent volatilizes into a gas.
3. **Diffusion** occurs when higher concentrations migrate to areas of lower concentrations because of chemical gradients; the migration occurs in gas, water, and solid phases.
4. **Advection** is the movement of a substance in response to pressure or density gradients, and applies to vapor movement through the soil pore space, liquid movement through the soil pore space, and liquid movement with groundwater.

Partitioning factors are unique to each solvent and include vaporization, gas to aqueous partitioning, aqueous to solid partitioning, and gas to solid partitioning. Each is described as follows:

- **Vaporization** is determined by the vapor pressure of a solvent or Raoult's Law, if the solvent is a compound.

- **Gas-to-Aqueous Partitioning** is described by Henry's Law.

- **Aqueous to-Solid Partitioning** is described by the distribution coefficient k_d, which is estimated by $k_d = k_{oc} \times f_{oc}$, where k_{oc} is the organic carbon/water partitioning coefficient and where f_{oc} is the fraction of organic carbon in the soil. This factor describes the sorption (absorption and adsorption) of the solvent to soil particles.

- **Gas-to-Solid Partitioning** is a factor only when the soils are very dry (less than 1 percent moisture). When soils contain moisture, the gas to liquid partition and liquid to solid partition are the controlling factors.

- **Degradation** is the process that transforms a compound to other compounds, called transformation products. The process of degradation can occur biologically or chemically. The degradation process limits migration of constituents by destroying constituent mass with time. The term "half-life" is used to describe the degradation rate. The half-life is the time required for the mass of constituents to be reduced by one-half.

Introduction to Modeling the Behavior of Solvents in the Subsurface

Fate and transport modeling, presented in this section, is based on research into the behavior of a class of solvents, commonly referred to as Non-Aqueous Phase Liquids (NAPLs), which is being conducted by the University Consortium Solvents-in-Groundwater Research Program. Carbon tetrachloride is included in this class of compounds. This consortium includes some of the most respected groundwater, vadose zone, and soil researchers in the world: John Cherry, Stan Feenstra, James Pankow, and Bernard Kueper, to name a few. Through their combined research into solvent subsurface behavior, they have developed models to describe transport, assessment, fate, migration, and soil/air/groundwater partitioning. Ongoing field experiments for this research are conducted at a Canadian Forces Base in Ottawa, at a site known as the Borden Research Site.

Recognition of the importance of solvent vapor and liquid solvent transport from soil to groundwater has evolved in the last several years through a combination of advanced models, laboratory experiments, and actual field-scale experiments. The most authoritative text addressing the fate and transport of these solvents is a result of the work conducted by the University Consortium Solvents-in-Groundwater Research Program and is included in *Dense Chlorinated Solvents and other DNAPLs in Groundwater* (Pankow et al., 1996). This research is pertinent because soil conditions at the Borden Research Site, with silty sand and alluvial soils, are similar to the conditions at ESII Site B.

In addition to the core studies described above, the following published research includes information on solvent fate and transport applicable to ESII Site B. From each citation,

findings pertinent to fate and transport modeling at ESII Site B are briefly summarized as follows:

- For release to unsaturated soils where solvents are sorbed to soil particles, transport is controlled by vapor diffusion (Mendoza et al., 1996).

- Measurable reductions in the VOC concentrations at the release zone occur over time periods measured in decades (Johnson and Pankow, 1992).

- For release to unsaturated soils where the mass released is sufficient, a vapor plume that is denser than air will form and migrate vertically down, displacing the soil pore air. As the vapor plume migrates vertically and spreads horizontally, the VOC adsorption equilibrium in soils must be satisfied before the vapor front can advance (Mendoza et al., 1996).

- Movement of a dissolved groundwater plume will be controlled by advection and partitioning between the solvents dissolved in groundwater and those sorbed to the saturated soil matrix (Anderson et al., 1992).

- For a groundwater plume caused by vapor transport, the concentration gradients within the plume will be comparatively flat and at the plume boundaries the concentration gradient will be sharp (Anderson et al., 1992).

- For a groundwater plume caused by free solvents in the groundwater, the groundwater plume concentration gradient will be characterized by an exponential fall-off in concentrations near the source area to a point where only the dissolved phase is present. The gradient will then remain comparatively flat (Feenstra and Guiguer, 1996).

- The rate of solvent transport out of residual pools in the groundwater soil matrix is controlled by vertical diffusion only. Residual solvent pools in groundwater remain for decades to centuries (Johnson and Pankow, 1992).

- Pressure, gravity, and geologic structure control the transport of free liquid solvents in the groundwater soil matrix, not the flow of groundwater. Residual pools of solvents are found at the release area and are distributed based on soil matrix factors (Feenstra and Guiguer, 1996).

- Solvent mass, porosity, vertical dispersion, effective aqueous diffusion, groundwater velocity, and pool length control the rate of natural dissolution of free liquid solvent pools in groundwater. The time required for complete dissolution of a pool is measured in centuries (Johnson and Pankow, 1992).

- Research shows that before free liquid solvents can enter the water table, they will pool until the mass of solvent can overcome the resistance pressure of the water. Large pools of solvents above the water table are required for free liquid solvents to penetrate the liquid solvent and water interface (Schwille, 1988; Kueper and McWhorter, 1991).

- The rate of degradation (half-life) of carbon tetrachloride in vadose soils and groundwater ranges from 2 months to 2 years (Mackay et al., 1993).

In summary, the general fate and transport model for alluvial sandy/silty soil shows that for liquid solvent migration, both pore-scale heterogeneities and solvent characteristics control the horizontal and vertical depth of migration. In alluvium, where pore-scale heterogeneities are generally oriented in the horizontal direction because of the nature of alluvial deposition, liquid solvents will spread much greater in the horizontal direction compared to the downward vertical gradient. For vertical movement of liquid solvent through soil, the mass of solvent available must be greater than the mass of solvent that will partition and sorb to soils and be trapped in the pore space. Liquid solvents that reach the groundwater table will pool on top of the water table until the pool depth overcomes the capillary pore water forces. Liquid solvent will then migrate horizontally and vertically through groundwater along soil heterogeneities. Solvent will dissolve into groundwater and generate a plume in the downgradient direction. The plume concentrations will be characterized by an exponential decrease from the area of liquid solvent/groundwater contact to a comparatively flat concentration gradient present in the downgradient plume direction away from source area.

Vapor transport can occur either solely, or along with liquid solvent migration. Vapor transport occurs by two distinct mechanisms: advective flow and diffusion. Vapor advection transport occurs when a sufficient mass of solvent in soils generates soil gas vapors in sufficient concentrations to develop a soil gas plume denser than air. This type of vapor transport is fast, moves vertically, spreads horizontally, and the migration path (vertical versus horizontal) can be enhanced or restricted by major changes in the soils strata. Advection-type vapor plumes will cause an impact on groundwater quality over a significantly wider area than the release area.

Soil gas vapor diffusion transport is the controlling transport mechanism when there is insufficient vapor mass to cause advection transport. Soil gas vapor diffusion is slow, moves in all directions, and will move at different rates, depending on the soils strata. Soil gas vapor diffusion could cause comparatively low concentration of constituents detected in the groundwater over a wide area compared to the size of the release area. The travel distance of soil gas vapor diffusion through soils, because of its slow rate, is highly dependent on soils characteristics.

Conceptual Analytical Models of Solvent Migration in the Subsurface

Several analytical field screening models have been developed by the Solvents-in-Groundwater Research Program Consortium to model site-specific solvent migration. These models have been constructed for ESII Site B and are discussed below. The models include a soil partitioning model, a soil/groundwater partitioning model, and a field screening groundwater model. All of the models constructed and the equations for the models can be found in *Dense Chlorinated Solvents and other DNAPLs in Groundwater* (Pankow and Cherry, 1996).

Partitioning Model for Solvents by Feenstra and Cherry

For assessment of solvent partitioning in the vadose zone, Feenstra and Cherry developed a semi-quantitative model based on the equilibrium partitioning calculations of the solvent and soil characteristics (Feenstra and Cherry, 1996). Their model describes how a solvent is partitioned among being dissolved in pore water, sorbed onto soil solids, present in soil pores as a gas, and a free liquid solvent. To indicate these partitions, an equilibrium pore

water concentration called the "dissolved partition" is calculated. The sorbed partition is equal to the dissolved partition times the partitioning coefficient between pore water and soil solids (organic carbon-water partition) (Feenstra et al., 1991). The soil gas partition is equal to the dissolved partition times the dimensionless Henry's Law Constant (Feenstra et al., 1991; Gossett, 1987).

The equilibrium partitioning equations assume no free liquid or solvent exists until the hypothetical pore water concentration equals or exceeds the solubility of the solvent. A boundary condition for equilibrium partitioning occurs when the bulk volume percent of the solvent approaches the porosity value and resultant comparative percentages of solvent in sorbed, dissolved, and gas phases approaches zero.

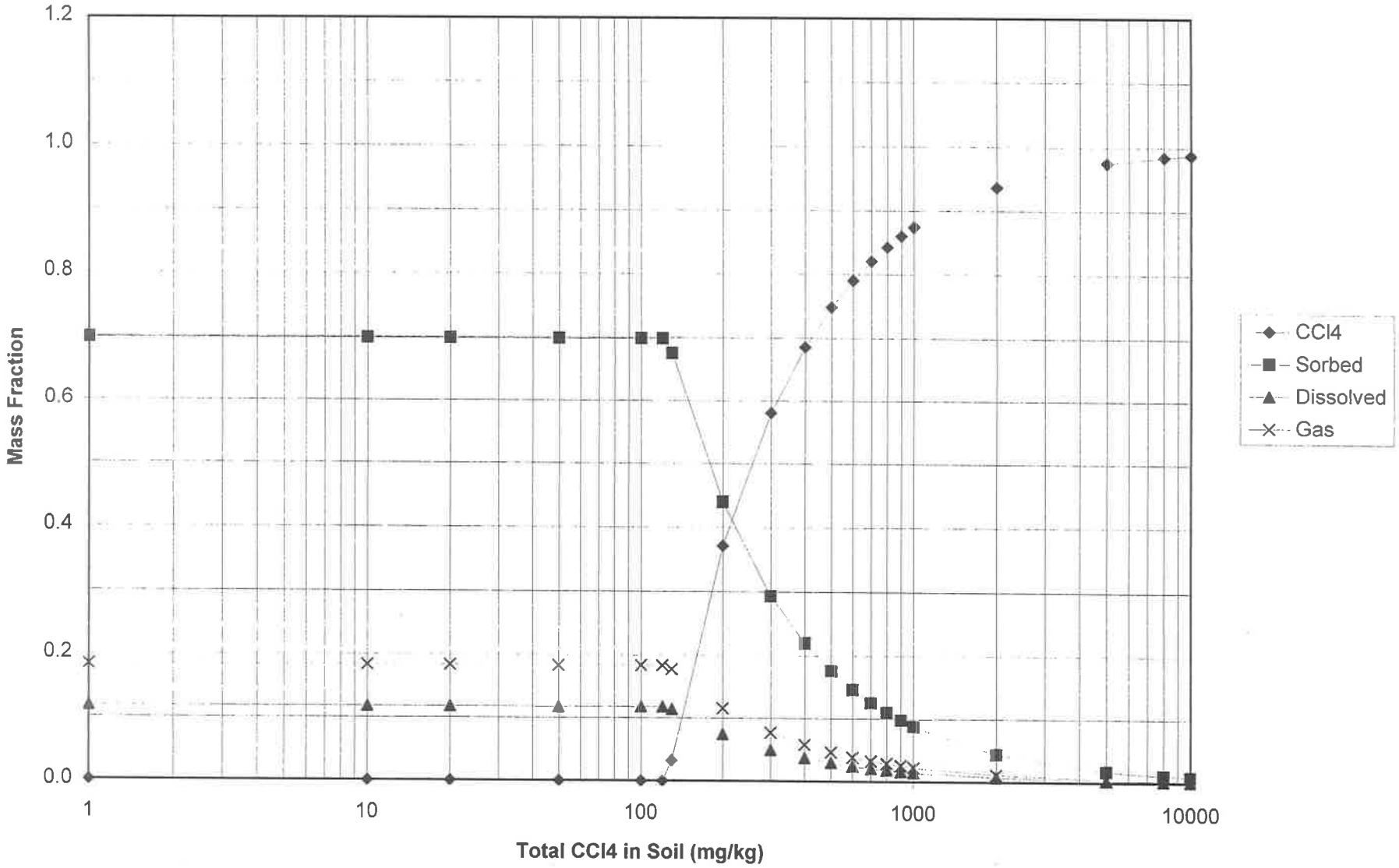
A partitioning model for carbon tetrachloride was constructed using the technique of Feenstra and Cherry and is presented in Figure 7. Input parameters used in the calculations are shown in Table 4. Equations of the model are shown in Table 5. The input parameters were selected to simulate the soil conditions in the vadose zone sands at ESII Site B.

TABLE 4
Feenstra and Cherry Model Input Parameters for Carbon Tetrachloride

Parameter	
ρb (bulk density of soil, g/cc) (Hunt, 1984)	1.76
φw (volume fraction of water-filled porosity) (CH2M HILL, 1986b)	0.12
φa (volume fraction of air-filled porosity) (Hunt, 1984)	0.373
Hc (dimensionless Henry's Constant at 10°C) (Gossett, 1987)	0.567
Koc (organic carbon-water partition coefficient) (Schwille, 1988)	439
foc (fraction of organic materials in soil) (CH2M HILL 1986b)	0.001

As shown in Table 4, the input parameters are a combination of established constants and site-specific values. Bulk density of the soil was taken from Hunt (1984) and adjusted for the site's average volume of water-filled porosity, assumed to be 12 percent for the upper sands. The soil moisture (12 percent) represents the average of soil moisture in the upper sandy soil at the site (Vadose Zone Characteristics at ESII Site B, CH2M HILL, 1986b). The dimensionless form of Henry's Law Constant, (H_c), was obtained from a study by Gossett (1987). The φ_a and K_{oc} constants were obtained from Feenstra and Cherry (1996).

Figure 7
Relative Proportion of CCl4 in Soil Gas, Dissolved Partition (12 % saturation), and Soil Solid Phases
adapted from Feenstra and Cherry, 1996



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As shown in Table 5, the equations are straightforward arithmetic. The method of solution can be found in Feenstra and Cherry (1996).

TABLE 5
Feenstra and Cherry Model Equations and Relationships

Total Mass	$Mt = Ms + Mw + Ma$
Mass Sorbed	$Ms = Cs\ \rho b$
Mass Dissolved Partition	$Mw = Cw\ \varphi w$
Mass Soil Gas	$Ma = Ca\ \varphi a$
Total Soil Concentration	$Ct = Mt/\rho b$
Concentration Sorbed	$Cs = Kd\ Cw$
Concentration Soil Gas	$Ca = Cw\ Hc$
Dissolved Partition	$Cw = Ct\rho b\ /(Kd\rho b + \varphi w + Hc\varphi a)$
Distribution Coefficient	$Kd = Kocfoc$
Solvent Porosity	$\theta DNAPL = (Ct\rho b - C(Kd\rho b + \varphi w + Hc\varphi a))/Cw$
Where:	
Mt = total mass in soil	Ms = Mass of sorbed solids
Mw = Mass in dissolved partition	Ma = Mass in soil gas
Ct = Concentration in soil	Cs = Concentration sorbed
Cw = Concentration in pore water	Ca = Concentration in soil gas
φw = water-filled porosity	φa = Air-filled porosity
ρb = bulk density of soil	Kd = Partition coefficient between pore water and soil
Hc = Henry's Law Constant	foc = Fraction of organic material
C = Solubility of Solvent	Koc = Organic carbon-water partitioning

The model indicates soils will adsorb carbon tetrachloride up to a concentration of 120 mg/kg (Figure 7). Until this concentration is reached, all carbon tetrachloride mass is partitioned between soil gas (19 percent), dissolved in soil moisture (11 percent), and sorbed to soil particles (70 percent); no free liquid is present.

Unsaturated Soil and Groundwater Partitioning Model by Feenstra, Mackay, and Cherry

This model describes partitioning between solvents in unsaturated soil and groundwater. The model is based on the partitioning calculations of solvent and soil characteristics developed by Feenstra, Mackay, and Cherry (Feenstra et al., 1991). Application of this model is used to assess the solvent concentration at equilibrium conditions between the soil and groundwater. Equilibrium conditions occur when the rate of vapor and diffusion transport between unsaturated soils and groundwater approaches zero. If the soil

concentration is known, the equilibrium concentration in the groundwater can be calculated; or if the concentration in the groundwater is known, the equilibrium concentration in the soils can be calculated. Sandy soil conditions were assumed in the model to represent minimum soil sorbtion conditions that result in maximum groundwater concentrations.

A model for carbon tetrachloride using the techniques of Feenstra, Mackay, and Cherry, was constructed (Figure 8). Input parameters used in the calculations are shown in Table 6. Equations of the model are shown in Table 7.

TABLE 6
Feenstra, Mackay, and Cherry Model Input Parameters

Parameter	
ρ_b (bulk density of soil g/cc) (Hunt, 1984)	1.76
φ_w (volume fraction of water-filled porosity), (CH2M HILL, 1986b)	0.12
φ_a (volume fraction of air-filled porosity) (Hunt, 1984)	0.373
H_c (dimensionless Henry's Constant at 17.5°C), (Gossett, 1987)	0.883
K_{oc} (organic carbon-water partition coefficient) (Schwille, 1988)	439
f_{oc} (fraction of organic materials in soil) (CH2M HILL, 1986b)	0.01, 0.001

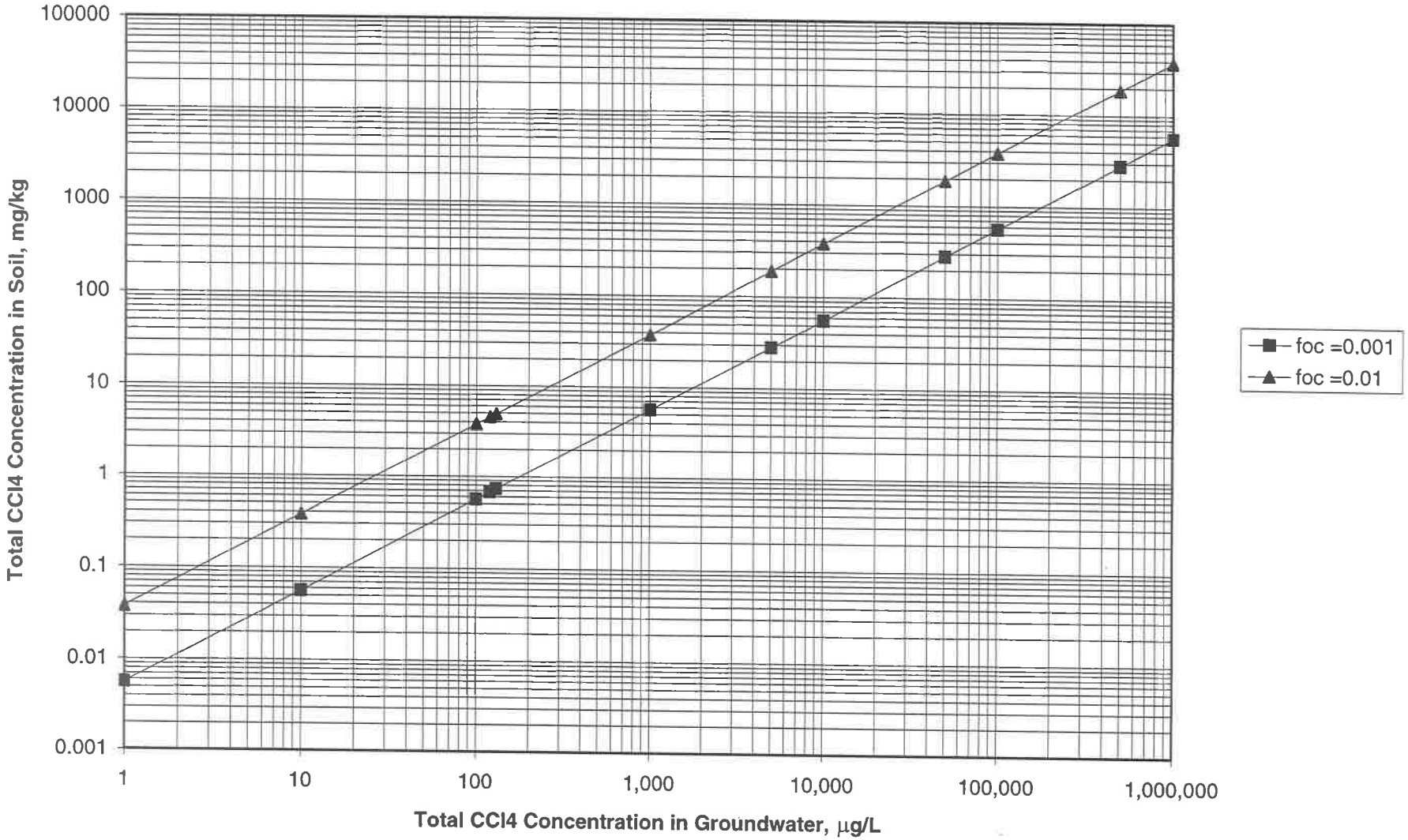
TABLE 7
Feenstra, Mackay, and Cherry Model Equations and Relationships

Concentration in Soil	$Ct = (KdCw\rho b + Cw\varphi w)/\rho b$
Dissolved Partition	$Cw = Ct\rho b /(Kd\rho b + \varphi w)$
Distribution Coefficient	$Kd = Kocfoc$
Where:	
Ct = soil concentration	Cw = dissolved concentration
φw = water-filled porosity	φa = air-filled porosity
ρb = bulk density of soil	Kd = partition coefficient between pore water and soil
Hc = Henry's Law Constant	foc = fraction of organic material

As shown in Table 6, the input parameters are a combination of established constants and site-specific values. The parameters presented in Table 6 are also used in Table 4, except for the fraction of organic material (f_{oc}) in soils, which in Table 6 includes a range of values that covers the range of f_{oc} typically found in sandy and silty soils.

Figure 8
Equilibrium Relation between CCl4 in Soil (Sorbed and Dissolved, 12% Saturation) and CCl4 in Groundwater

adapted from Feenstra et al., 1991



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The method of solution is to calculate the distribution coefficient (k_d), then solve for the dissolved partition given a known soil concentration, or solve for the concentration in the soil given a known dissolved partition, accounting for dissolved and sorbed phases, and plot the result.

The equilibrium soil/groundwater relationship for solvents was solved for two f_{oc} values (0.001 and 0.01) that are representative of sandy soils at ESII Site B. Because of the heterogeneity in the unsaturated alluvial soils at the site, f_{oc} values will vary. An f_{oc} of 0.001 represents soils with a trace of organic material (representative of sands). An f_{oc} of 0.01 represents a typical sand and silt alluvium soil. Modeling a range of f_{oc} illustrates the range of solvent soil concentrations in equilibrium with a given groundwater concentration.

For example, the model indicates that for a concentration in soils of 1 mg/kg carbon tetrachloride, the equilibrium groundwater concentration ranges between 27 µg/L (f_{oc} = 0.01) and 200 µg/L (f_{oc} = 0.001). For a concentration in soil of 100 mg/kg, the equilibrium groundwater concentration ranges between 2,700 µg/L (f_{oc}=0 .01) and 20,000 µg/L (f_{oc}=0 .001). Note that a 100 mg/kg carbon tetrachloride soil concentration is just below the maximum soil absorption capacity of 120 mg/kg developed in the previous model. A concentration of 100 mg/kg carbon tetrachloride represents the approximate threshold concentration when free liquid carbon tetrachloride may be present in soils, and thereby may cause free liquid migration.

In summary, this model estimates the equilibrium concentration of solvents between unsaturated soils and groundwater. With known groundwater solvent concentrations, the approximate range of solvent concentrations that may be found in soils is estimated. If an active source of solvents is present in soils, the soils solvent concentrations will exceed the concentration in equilibrium with the groundwater concentrations. If no soil source is present, concentrations in soils will be less than or equal to the corresponding groundwater equilibrium condition. These relationships are key criteria used to evaluate the significance of site data relating to the potential impact of solvents to groundwater.

Field Screening Model to Assess the Phases of Solvent and Corresponding Groundwater Concentration Observed in Groundwater Monitoring Well Samples

To assess the phases of solvent and corresponding groundwater concentrations, field screening models have been developed through observations and research at actual solvent release sites. The following models are presented by Feenstra and Cherry (1996), are based on solvent concentrations in groundwater, and are represented by samples from groundwater monitoring wells, which indicate when free liquid solvent is present in the groundwater:

- For groundwater that is in direct contact with a free liquid solvent, the groundwater concentration will approach the solvent's solubility in water (Feenstra and Cherry, 1996). For the solvent carbon tetrachloride, the 100-percent solubility is 825 mg/L (825,000 µg/L).

- The threshold concentration of dissolved solvents in groundwater that indicates that a free liquid solvent is probably contacting groundwater is 10 percent of the solvent's solubility in water. Groundwater concentrations above 10-percent solubility are usually

due to free liquid solvents contacting groundwater. For carbon tetrachloride, the 10 percent solubility concentration is 82.5 mg/L (82,500 µg/L).

- The minimum threshold concentration of dissolved solvents in groundwater that indicates a free liquid solvent may be contacting groundwater is 1 percent of the solvent's solubility in water (1-percent solubility). For carbon tetrachloride, the 1-percent solubility concentration is 8.25 mg/L (8,250 µg/L). Groundwater concentrations below the 1-percent solvent solubility concentration indicate free liquid solvents are not in direct contact with groundwater, and the transport of solvent to groundwater is most likely by the vapor phase.

Another factor controlling the fate and transport of free liquid solvent migration through soils is the mass of free liquid solvent that will be retained in soil pore space. Research at the Borden Research Site indicated that after free liquids have passed through sandy/silty soils, 20 percent of the soil pore space will be occupied by residual free liquid trapped in the soil pores. The mass fraction of carbon tetrachloride in soils with 30-percent soil pore volume occupied by carbon tetrachloride will be 5 percent, or 50,000 mg/kg, (assuming a soil porosity of 30 percent, a soil density of 1.76 g/cc, and carbon tetrachloride with a liquid density of 1.59 g/cc).

Fate and Transport of VOCs in Groundwater

This section summarizes the results of fate and transport modeling conducted in response to the detection of monitoring criteria VOCs in groundwater at Monitoring Well U-21 (CH2M HILL, 1993) and Monitoring Well U-23 (CH2M HILL, 1997). The objectives of the studies were to evaluate the attenuation of groundwater constituent(s) between the monitoring wells and the downgradient facility boundary.

MYGRT Model

The model used for analyzing fate and transport in groundwater at ESII Site B was MYGRT, Version 2.0. (Tetra Tech, Inc., 1989). The model was applied without any code modifications. MYGRT is capable of simulating the subsurface behavior of nonreactive and reactive compounds. With the MYGRT model, chemical fate and transport can be evaluated in either one or two dimensions. The model includes the processes of advection, dispersion, retardation, and degradation. It is applicable to both inorganic and organic compounds.

The MYGRT model incorporates the following assumptions:

- Solute transport occurs in two dimensions, along and transverse to the primary direction of groundwater flow.
- The aquifer is homogeneous and isotropic with respect to hydraulic conductivity.
- Groundwater flow is steady and uniform.
- Advection occurs at the same rate as the seepage velocity.
- Dispersion can be represented by Fick's Law.

- Sorption can be described by linear, equilibrium partitioning between aqueous and sorbed phases.

- Degradation can be described by a first-order process; the rate of degradation is assumed to be the same for the aqueous and sorbed phases.

Rationale for Model Selection

MYGRT was selected because it is based on a recognized analytical solution to the two-dimensional transport equation. MYGRT was also selected because it has received widespread use. A detailed discussion of the rationale for selecting MYGRT, including a detailed comparison of MYGRT to eight other analytical groundwater models, is provided in the report entitled *Fate and Transport of Carbon Tetrachloride, Chloroform, and Chloromethane at ESII Site B* (CH2M HILL, 1993).

Model Results

The MYGRT models were run using input parameters obtained from site characterization data, chemical handbooks, and current research information on the fate and transport of VOCs in hydrogeologic systems. The model was used to calculate the concentration of a compound at the site boundary that would result from a starting concentration of 1,000,000 µg/L in groundwater at the impacted monitoring well, that is, Monitoring Well U-21 or Monitoring Well U-23. The predicted concentrations at the site boundary were low, ranging from 0.0 µg/L for trans-1,3-dichloropropene (which did not reach the facility boundary after 100,000 years of simulated migration), to 0.29 µg/L for vinyl chloride.

The ratio of the source concentration at the impacted monitoring well to the concentration at some distance is the dilution attenuation factor (DAF). For the Monitoring Well U-23 simulations (CH2M HILL 1997), the calculated DAF values varied from 3,400,000 for vinyl chloride to 6.3×10^{70} for 1,1,2,2-tetrachloroethane. For the Monitoring Well U-21 analysis, the DAFs ranged from 33,000 for chloroform to 1×10^{10} for chloromethane. These high DAFs indicate that very high concentrations of VOCs in interior wells are necessary to produce detectable concentrations in downgradient wells. In most cases, the VOC would have to be present at concentrations at or above the solubility level of that VOC in groundwater.

The specific model input parameters and results obtained for the MYGRT simulations conducted specifically for Monitoring Wells U-21 and U-23 are provided in CH2M HILL 1993a and CH2M HILL 1997, respectively. The conclusions reached from the fate and transport analyses indicate that the slow-moving groundwater, fine-grained carbon-rich sediments, and the chemical-physical properties of VOCs all combine to significantly slow down and degrade the compounds. The degradation attenuation factors are so large that it is necessary to begin with free product and concentrations exceeding the solubility limit in interior wells in order to get detectable concentrations at the downgradient facility boundary. Low concentrations of VOCs transported to the groundwater via soil vapor mechanisms will degrade quickly as the impacted groundwater moves away from the point of contact with the vapors.

Degradation

Degradation of carbon tetrachloride is a significant factor in fate and transport. The approximate 1-year degradation half-life for carbon tetrachloride in soil and water indicates that for every year of time passage, one-half the mass of carbon tetrachloride can be expected to be transformed to degradation products. The reduction in constituent mass produces a corresponding decrease in concentration gradients that result in reducing the driving force of migration and the concentration gradient component migration distance. Degradation is an important factor controlling the limits of migration and the removal of constituents.

Carbon tetrachloride degrades along a pathway of transformation products. In successive order they are: carbon tetrachloride to chloroform, chloroform to dichloromethane, dichloromethane to chloromethane, and chloromethane to methane. Representative degradation half-lives of these constituents, as reported in the literature, are presented in Table 8.

TABLE 8
Degradation Half-Lives of Constituents

	Half-Life in Days	
Constituent	**Soil**	**Groundwater**
Carbon Tetrachloride[a]	180-360	60
Chloroform[b]	28-180	56-1,800
Dichloromethane[a]	—	7-28
Chloromethane[a]	7-28	14-56
Methane	—	—

Sources:
[a]Mackay et al., 1993. (Aerobic degradation half-life shown).
[b]U.S. Environmental Protection Agency, 1993.

The process of degradation combined with fate and transport through the soil/groundwater, the passage of time, and point of measurement within the system all impact the constituents measured at any given location and at any given time. At locations where these combined factors favor the persistence of carbon tetrachloride, carbon tetrachloride will predominate, and chloroform, the first transformation product, may be detected at comparatively low concentrations or not at all. In contrast, at locations where carbon tetrachloride is degraded and fate and transport favor transformation products, chloroform and/or dichloromethane and chloromethane will predominate, and carbon tetrachloride may be detected at comparatively low concentrations or not at all. Relative constituent concentrations ranging between these two ends of the spectrum may be expected at any specific sampling location within the impacted media.

SECTION 4

Data Summary and Evaluation

This section presents the data and evaluation basis to support ACL development, and is divided into the following topics:

- Evaluation of groundwater sampling data
- Effect of hydrogeology on migration of soil gas VOC vapors
- Evaluation of Cell 5 data
- Evaluation of Monitoring Wells U-1 and U-23 construction

Evaluation of Groundwater Sampling Data

This section provides a summary and evaluation of the VOC groundwater sampling data collected from monitoring wells and piezometers at Site B. The data pertinent to this evaluation are summarized in Table 2. All monitoring wells shown on Figure 6 have been sampled for VOCs annually to semiannually since 1989 (or when the well was incorporated into the detection monitoring program). Table 2 only shows those wells in which VOCs have been detected.

As presented in Section 3, the dehalodegradation products of carbon tetrachloride proceed from carbon tetrachloride to chloroform, to dichloromethane, to chloromethane, and to methane. Chloroform, being the initial degradation product of carbon tetrachloride, would likely be the degradation product first detected. Degradation products can be found very irregularly distributed in sampling data because they are intermediate products that may or may not be present at any specific point in time, and because of a combination of the factors that control their detectability, including the rate of formation from the parent compound, rate of degradation to the next component, and fate and transport to the point of sampling. Although the chloroform detected could be from a past chloroform source, the variability of the data and the low percentage of detects indicate that the detection of chloroform is due to carbon tetrachloride degradation.

The groundwater data indicate that the source of detected VOCs is a result of the migration of constituent vapors in the soil gas. The following analysis supports this conclusion:

- Only Upper Aquifer wells in the northwest corner of the site have been affected by VOCs.

- The groundwater sampling data do not indicate the presence of additional organic compounds, including other Method 8240 VOCs; Method 8270 semivolatiles; Method 8080 chlorinated pesticides and PCBs; Method 8140 organic phosphate pesticides; Method 8150 herbicides; and, dioxins or furans.

- Except for possibly methylene chloride in Monitoring Well U-21, only carbon tetrachloride or its related degredation products, chloroform and chloromethane, have been detected.

- The corrective measures study completed in response to the October 1991 detection of chloroform and chloromethane in Monitoring Well U-21 (Silo 2) (CH2M HILL 1993b) concluded that, based on the limited number of VOCs detected, the low and variable concentrations, and the reduction in concentrations during a time series sampling event, soil vapor, and not a liquid release, provide the best plausible explanation.

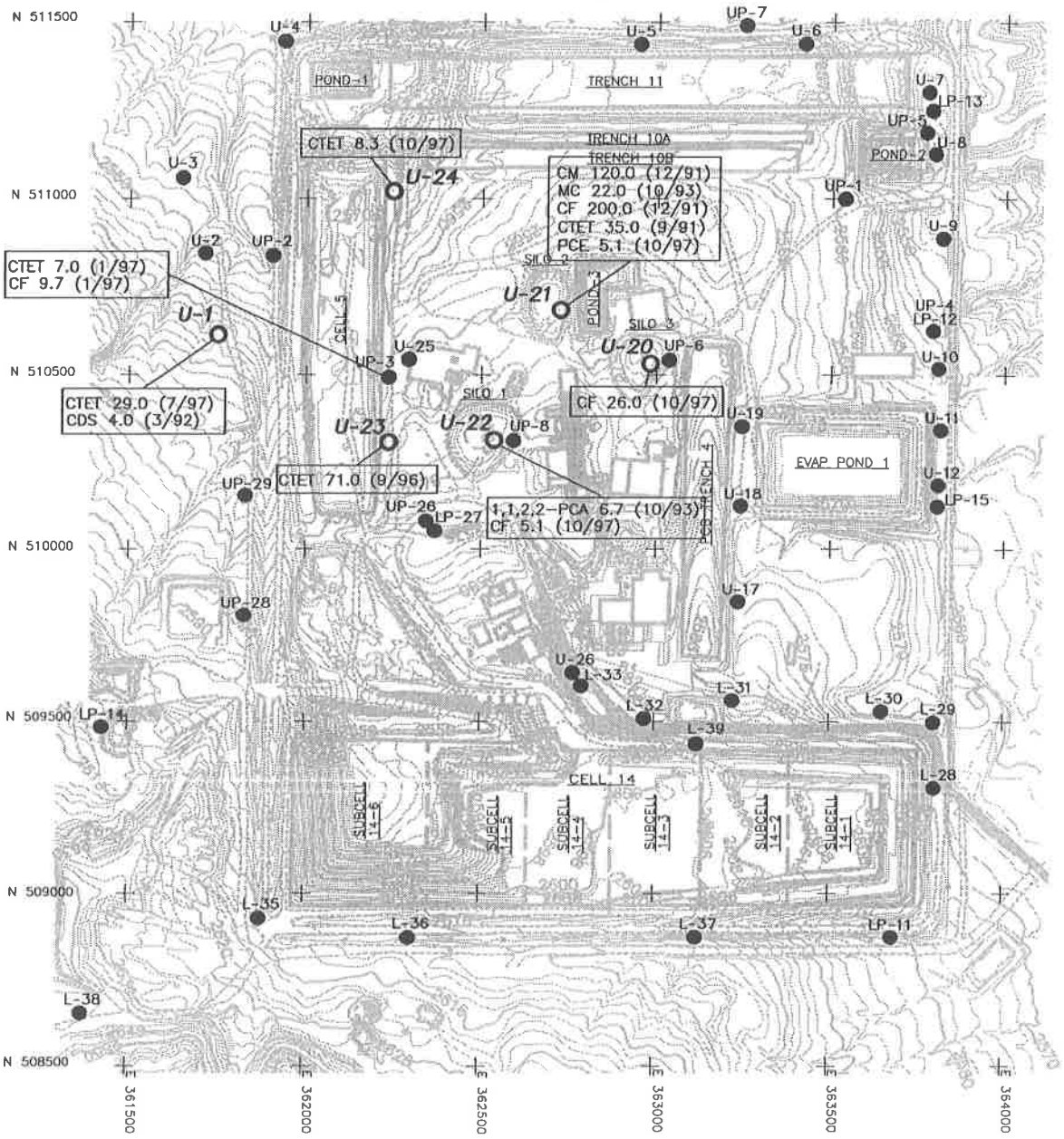
- Groundwater detections caused by VOC vapor transport can be highly variable and will be impacted by heterogeneities in vadose soils. This model is consistent with low-level VOC concentrations detected in some monitoring wells (U-1, U-20, U-21, U-22, U-23, U-24, and UP-3) and not in other monitoring wells (that is, U-2, U-3, U-4, U-17, U-18, U-19, U-25, UP-26, UP-28, and UP-29) as shown in Figure 9. The data do not indicate a liquid release model scenario because a liquid release to groundwater would be expected to result in significantly higher and more persistent and consistent detections of organic constituents in groundwater.

- Only the more volatile organic compounds (for example, carbon tetrachloride and chloroform) were detected, which further indicates vapor migration is the probable cause. A liquid release would be expected to contain other organic constituents that would be detected in groundwater. This is especially true for Monitoring Wells U-20, U-21, and U-22, which are next to the missile silos.

- Repeated sampling of Monitoring Wells U-21 (CH2M HILL 1993b) and U-23 resulted in a significant decrease in detectable VOCs, indicating soil vapor gas migration. The vapor diffusion mass transfer rate is slow enough that repeated sampling events can remove the VOC mass that is available to partition from the soil gas to the groundwater interface, resulting in lower or non-detectable VOC groundwater concentrations in successive samples. For Monitoring Well U-23, the carbon tetrachloride detections decreased from 130 µg/L (October 29, 1996) to 88 µg/L in the successive duplicate, and to 11 µg/L (December 23, 1996).

- This time-series sampling conducted over a 3-day test at Monitoring Well U-21 resulted in a reduction of chloroform from 69 µg/L to non-detect.

- Comparison of well constituent concentration data to liquid and vapor release models indicates the detections of VOCs in groundwater from the monitoring wells at Site B are not representative of a liquid release to groundwater, but are consistent with soil gas vapors. Liquid release models indicate that VOC detections in groundwater need to exceed 1 percent of the solvent's water solubility before a liquid to groundwater release scenario may be considered. The water solubility and corresponding 1-percent solubility for carbon tetrachloride are 825 mg/L and 8.25 mg/L. The highest detection for carbon tetrachloride is 0.130 mg/L (Monitoring Well U-23, October 29, 1996). The water solubility and corresponding 1-percent solubility for chloroform are 8,000 mg/L and 80 mg/L, respectively. The highest detection for chloroform was 0.140 mg/L (U-21, May 1995 and April 1996). The detected VOCs are far below groundwater concentrations indicative of a liquid release scenario to groundwater.



KEY
CM = CHLOROMETHANE
CDS = CARBON DISULFIDE
MC = METHYLENE CHLORIDE
CF = CHLOROFORM
CTET = CARBON TETRACHLORIDE
1,1,2,2–PCA = 1,1,2,2–TETRACHLOROETHANE
PCE = TETRACHLOROETHENE

N

0 250 500 750 1000
SCALE: IN FEET

FIGURE 9
MAP OF VOC MAXIMUM DETECTIONS (PPB)
ESII SITE B
ACL DEMONSTRATION

CH2MHILL

22-May-1998 VOC_LOC.DWG

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- Comparison of the well constituent concentration data to liquid and vapor release models indicates that the spatial pattern of VOC detections in the monitoring wells is not representative of a liquid release, but is consistent with soil gas vapors. Solvent liquid releases spread horizontally as liquid migrates vertically. The horizontal spread to vertical migration ratio has been shown to be as high as 10:1. The liquid release scenario would impact a large area of groundwater, and all monitoring wells within the impacted area would be affected. The current pattern of well VOC detection is inconsistent with this release scenario. VOCs were detected in Monitoring Wells U-1, U-20, U-21, U-22, U-23, U-24, and piezometer UP-3, but were not detected in adjacent Monitoring Wells U-2, U-17, U-18, U-19, U-25, and piezometers UP-26 and UP-29. This data is consistent with the soil gas vapor diffusion pathway through soils, which is highly influenced by soil heterogeneities resulting in localized impacts on groundwater that are not uniform. The fact that carbon tetrachloride was detected in Monitoring Well U-1, an upgradient background well, can only be explained by the soil gas vapor pathway scenario.

Effect of Hydrogeology on Migration of Soil Gas VOC Vapors

Influence of ESII Site B Hydrogeology on the Detection of VOCs

This section relates the detection of VOCs in Monitoring Wells U-23 and U-1 to the geology of ESII Site B as described in the previous sections. As discussed in previous sections, the VOCs detected in Upper Aquifer monitoring wells at Site B are believed to be derived from soil gas vapors as opposed to a direct release of liquid solvents to groundwater. The stratigraphy of ESII Site B has a strong influence on the potential extent, potential migration, and detection of VOC soil gas vapors. Consequently, the following discussion addresses the effect that the geology at ESII Site B has on the potential migration and subsequent detection of soil gas vapors.

Prior to ESII's ownership, wastes disposed of in the past practice units (PPU) at ESII Site B, with the exception of the three missile silo complexes, were placed in unlined trenches directly into the upper 20 to 30 feet of sediments at the site. The lined and unlined trenches comprising the regulated units constructed by Wescon, Inc., were excavated into the upper 50 feet of sediments. As described previously, the upper 100 to 120 feet of sediment at ESII Site B consists of the Bruneau Gravels and the dry, loose sands of the Glenns Ferry Formation.

Volatilization of the VOCs in the waste produces soil gas vapors around the unlined disposal area. VOC soil gas vapors could then migrate by diffusion between the waste disposal area(s) and the surrounding sediments, spreading VOCs from areas with higher concentrations to areas with lower concentrations. Because the concentration gradients near the source(s) are elevated, and the dry porous sands in the upper 100 feet of the subsurface are highly permeable and do not readily retard VOC vapors, VOC soil gas vapors can readily migrate vertically and laterally away from the contributing sources, and will potentially commingle with the vapors coming from other sources.

Once VOC soil gas vapors have reached the bottom of these surficial sands, they will encounter the finer-grained and moister materials, which represent the transition from predominantly fluvial to predominantly lacustrine type deposits. Lateral migration within

the surficial sands will continue based on concentration diffusion properties. Vertical migration into the finer-grained (silt and clay) materials will be slower, primarily because of the increased moisture content and increased organic material content of the fine-grained strata. Preferential migration pathways within the myriad of thin sand beds and sand seams within this portion of the geologic section will control the extent and rate of vertical and lateral migration of the vapors. Lateral changes in the sediment matrix above groundwater, such as the higher sand content in the unsaturated portion of the Upper Aquifer section on the northwest side of the site, will also tend to accumulate vapors and allow them to spread laterally and vertically along preferential flow paths.

Migration of organic compounds also occurs by diffusion from areas of higher to lower concentrations, based on the relative concentrations within a given strata, and between adjoining strata and based on the properties of the geologic matrix. Once vapors have entered a sand bed, the preferential migration pathways will be along strike (northwest-southeast) and up and down dip (northeast-southwest). Diffusive movement up dip to the south will allow the vapors to enter the fluvial sands south of the initial vapor entry into the sand bed. Diffusive movement to the north will put the vapors in contact with the top of the Upper Aquifer south of the initial vapor entry point into the sand bed. Because groundwater levels in the Upper Aquifer are rising, the net flow direction in the southern saturated extent of individual sand beds is to the south (up dip) and to the east (along strike). Consequently, VOCs that are diffused at the interface into the groundwater from the vapor will tend to stay near the water table at the point of entry, and will move laterally, preferentially within the individual sand bed.

The detection of VOCs in the groundwater at Site B is the combined effect of all of these controlling factors, including the following:

- Potential source location(s)
- Concentration gradients
- Vertical and horizontal movement in the thick fluvial sand interval to a depth of about 120 feet
- Preferential migration up and down dip (north and south) and along strike within individual sand beds that are within the interbedded sediments that comprise the unsaturated portion of the Upper Aquifer geologic sequence

The net result of soil gas vapor migration at ESII Site B is that the VOCs detected in monitoring wells may not have originated from the PPU or regulated unit nearest to the wells.

The detection of carbon tetrachloride in Monitoring Well U-1, at a lower concentration and 1 year prior to the detection of carbon tetrachloride in Monitoring Well U-23, is not inconsistent given the known geology and the characteristics of VOC soil gas vapor migration. Both Monitoring Wells U-1 and U-23 are hydrogeologically and spatially related in a manner that is also consistent with the expected result of vapor transport and migration. These wells are located along strike of each other, and both wells sample water from the lower part of the Upper Aquifer near its southern limit of saturation. The higher sand content above the water table on the west and northwest sides of the site could have

allowed the vapors to reach the water table in the vicinity of Monitoring Well U-1 first. The lower VOC concentrations detected at Monitoring Well U-1 could be attributed to the location of Monitoring Well U-1 being further away from the initial source. Therefore, soil gas concentrations will be lower and result in lower groundwater concentrations.

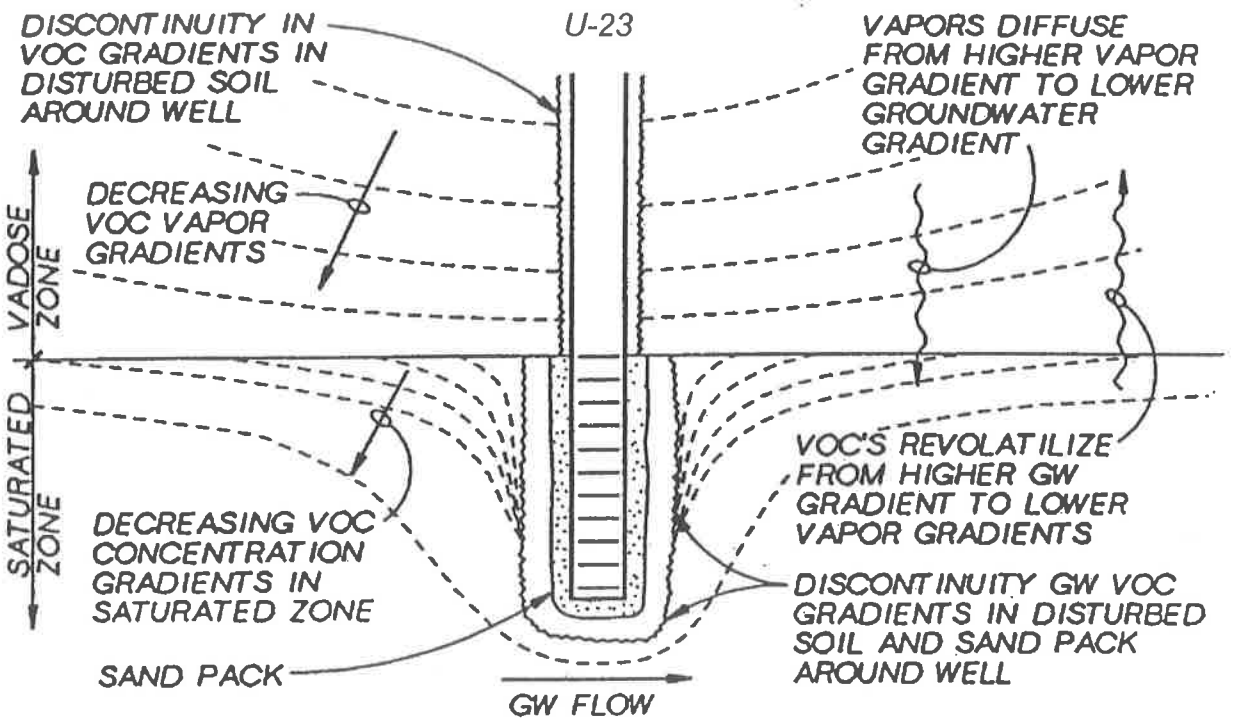
Probable migration of the vapors into the strata above the water table eventually reached the water table near Monitoring Well U-23. Apparently the vapor concentrations are higher near Monitoring Well U-23, suggesting that it may be nearer to the initial source where concentration gradients will be comparatively higher. The soil gas vapors were slower to reach the groundwater at Monitoring Well U-23 because of increased travel distance and/or slower migration rates through the clayey strata. In addition, as vapors are dissolved into the groundwater west of Monitoring Well U-23, advective groundwater movement would carry the impacted water into Monitoring Well U-23 and the contribution from vapors near the well would be cumulative.

The low concentration of carbon tetrachloride in Monitoring Well U-24 (8.3 µg/L) suggests that the soil vapors may be just beginning to contact groundwater near that well. Based on groundwater flow directions, it is possible that the soil vapors have reached groundwater northwest of Monitoring Well U-24. This portion of the site contains very sandy strata and the penetration of soil vapors to groundwater may cover large portions of the northwest portion of the site. However, the absence of VOCs in Monitoring Well U-4 indicates that the vapor plume does not extend to the northwest corner of the site.

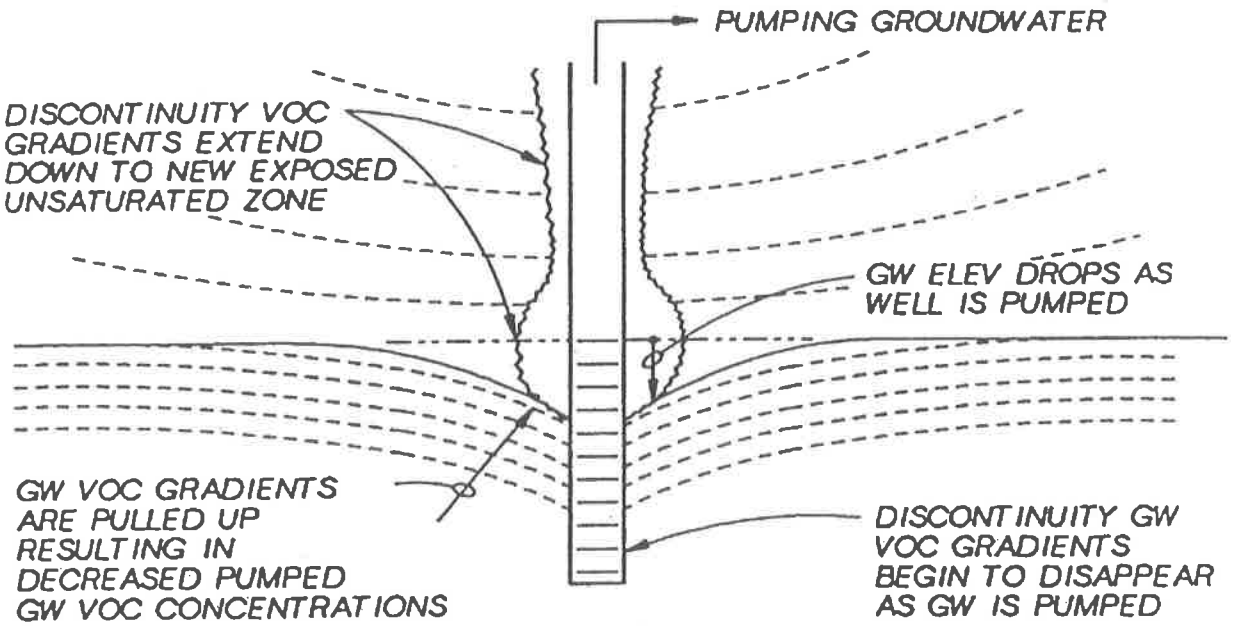
The hydrogeologic conditions of dipping sand seams and the VOC soil gas vapor transfer mechanism at ESII Site B make correlating monitoring well results with past practice units difficult, if not impossible. Detection of VOCs in groundwater stemming from soil gas vapors is expected to be erratically distributed, based on the complex soil gas vapor transport flow path rather than a more typical concentration gradient distribution that would result from a direct liquid release.

Once VOC soil gas vapor contacts the groundwater, VOCs begin to diffuse from the vapor phase into the water. The transfer rate from vapor to groundwater is compound- and concentration-specific. Because the groundwater levels are always in a state of flux, and concentration gradients, barometric pressure, and earth tides influence the concentration of the soil gas vapors in contact with the groundwater, equilibrium concentrations between the groundwater and vapors are not achieved. Equilibrium conditions are affected by this chemically and physically dynamic situation as well as by the impact of groundwater withdrawals during a groundwater sampling event as illustrated in the idealized vapor halo model in Figure 10. Consequently, as observed by the frequent sampling of Monitoring Well U-23, concentrations of carbon tetrachloride detected in groundwater samples are often erratic. In contrast to sample results at Monitoring Well U-23, the Monitoring Well U-1 sample results are relatively consistent, illustrating the variability in soil gas vapor transport and transfer mechanisms within the overall system.

There are several possible explanations for the erratic sample results at Monitoring Well U-23 versus the consistent results at Monitoring Well U-1. It is possible that the impacted area and consequently the volume of impacted groundwater is smaller at Monitoring Well U-23 than at Monitoring Well U-1. It is also possible that the transfer rate of detected constituents from the vapor phase to groundwater is slower. The highly variable sample results at Monitoring Well U-23 also indicate there is only a very limited volume of



TRANSITION EQUILIBRIUM



PUMPING WELL EQUILIBRIUM

FIGURE 10
VAPOR HALO IDEALIZED MODEL
ESII SITE B
ACL DEMONSTRATION

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water being impacted by the vapor transfer processes near the well. At Monitoring Well U-1, the comparatively higher percentage of coarser sediments may allow more stable equilibrium conditions, and or the soil gas vapor-groundwater contact area and/or volume is larger and, therefore, resulted in more consistent concentration of carbon tetrachloride in the samples.

In general, the immediate transfer of soil gas vapors to groundwater will be restricted to impacting the uppermost saturated portions of the individual sand seams comprising the Upper Aquifer at ESII Site B. In locations where the dominate water-bearing sand seam for a given well is also in direct contact with soil gas vapors, detection of VOCs may occur; assuming adequate time has elapsed since the last sampling event for a sufficient mass transfer of soil gas VOCs from the vapor phase into the groundwater near the well.

Evaluation of Cell 5 Data

Because most of the impacted wells are near Cell 5, this section evaluates Cell 5 construction and Cell 5 leachate analytical data to determine if Cell 5 may be a source of the carbon tetrachloride detected at Monitoring Wells U-1, U-23, and U-24. This section is organized as follows:

- Cell 5 Construction
- Cell 5 Leachate Analytical Data
- Evaluation

Cell 5 Construction

Cell 5 is a double-lined RCRA and TSCA landfill cell that is currently active for landfilling of wastes, including PCB waste. The cell is approximately 1,100 feet long and 200 feet wide. The cell is divided into three sub-cells, each having a primary and secondary leachate collection sump. Monitoring wells U-1, U-2, and U-3 are located upgradient of Cell 5 and Monitoring Wells U-23, U-24, and U-25 are designated downgradient monitoring wells for the south, central, and northern sumps, respectively. Figure 11 presents an east-west composite cross section from Monitoring Well U-23 through Cell 5 to Monitoring Well U-1. Figure 12 provides an annotated schematic of the construction of Cell 5 and of the collection sumps.

As shown, Cell 5 consists of a bottom secondary leachate collection system, a previously constructed and no longer used intermediate collection system, and a primary leachate collection system. The bottom secondary leachate collection system is constructed with a bottom 40-mil high density polyethylene (HDPE) liner followed by a sand layer and associated secondary leachate collection piping. An intermediate leachate system is located between the secondary leachate system and the 60-mil primary leachate system bottom liner. This intermediate system includes a 60-mil HDPE liner and leachate collection system. This was the original primary liner and leachate collection system. However, when small defects in the HDPE were discovered during construction, it was overlaid with an approved primary liner and leachate collection system. The primary leachate collection system consists of a 60-mil HDPE bottom liner, geotextile fabric, a sand drainage layer, and geotextile filter fabric. The sand layer drains to the primary leachate collection sumps. Above the filter fabric is a layer of protective soil upon which waste material is placed. The

bottom of the Cell 5 secondary sump is approximately 150 feet above groundwater. All three leachate collection systems are monitored for liquids that are removed in accordance with ESII's current operating permits.

Cell 5 Leachate Analytical Data

The water that collects in the sumps is from condensation and free moisture that develops as the cell is loaded and moisture is driven from the compacting soils. The primary sump collects rainfall and condensation from the working cell. The secondary sump collects condensation that develops within the fill between the liners. Collected leachate is measured and discharged to onsite evaporation ponds. The 1995 total leachate volumes were 15,205 gallons collected in the primary collection sumps and 222 gallons collected in the secondary collection sumps. These volumes are typical of historic collection volume data.

As required by ESII's RCRA and TSCA Permits, ESII monitors the primary, old primary, and secondary sumps at Cell 5 for liquids. In May 1990, ESII obtained a composite sample from all three primary collection sumps and a composite sample from all three secondary collection leachate sumps in Cell 5. The 1990 samples were collected after the cell became operational, and were submitted for analysis of Appendix IX parameters. The analytical results from these samples for carbon tetrachloride and chloroform are provided in Table 9. As shown in Table 9, carbon tetrachloride and chloroform were present in both the primary and secondary sumps.

TABLE 9
Sump Leachate Analytical Results

	May-90		Dec-96	Dec-96
Analytes (µg/L)	Cell 5 Composite Primary	Cell 5 Composite Secondary	Cell 5 Sump 1 Primary	Cell 5 Sump 2 Primary
Carbon Tetrachloride	2180	63	nd	nd
Chloroform	25	32	52	75

In December 1996, ESII collected individual samples from two of the primary sumps in Cell 5 Sub-Cell 1 (southerly) and Sub-Cell 2 (central) of Cell 5. Sub-Cell 3 was dry; therefore, no sample was obtained. The three secondary sumps were dry; therefore, no samples were obtained. Both Sub-Cell 1 and Sub-Cell 2 primary sump samples were submitted for Appendix IX analysis. Results from this analysis indicate no detection of carbon tetrachloride in either primary sump.

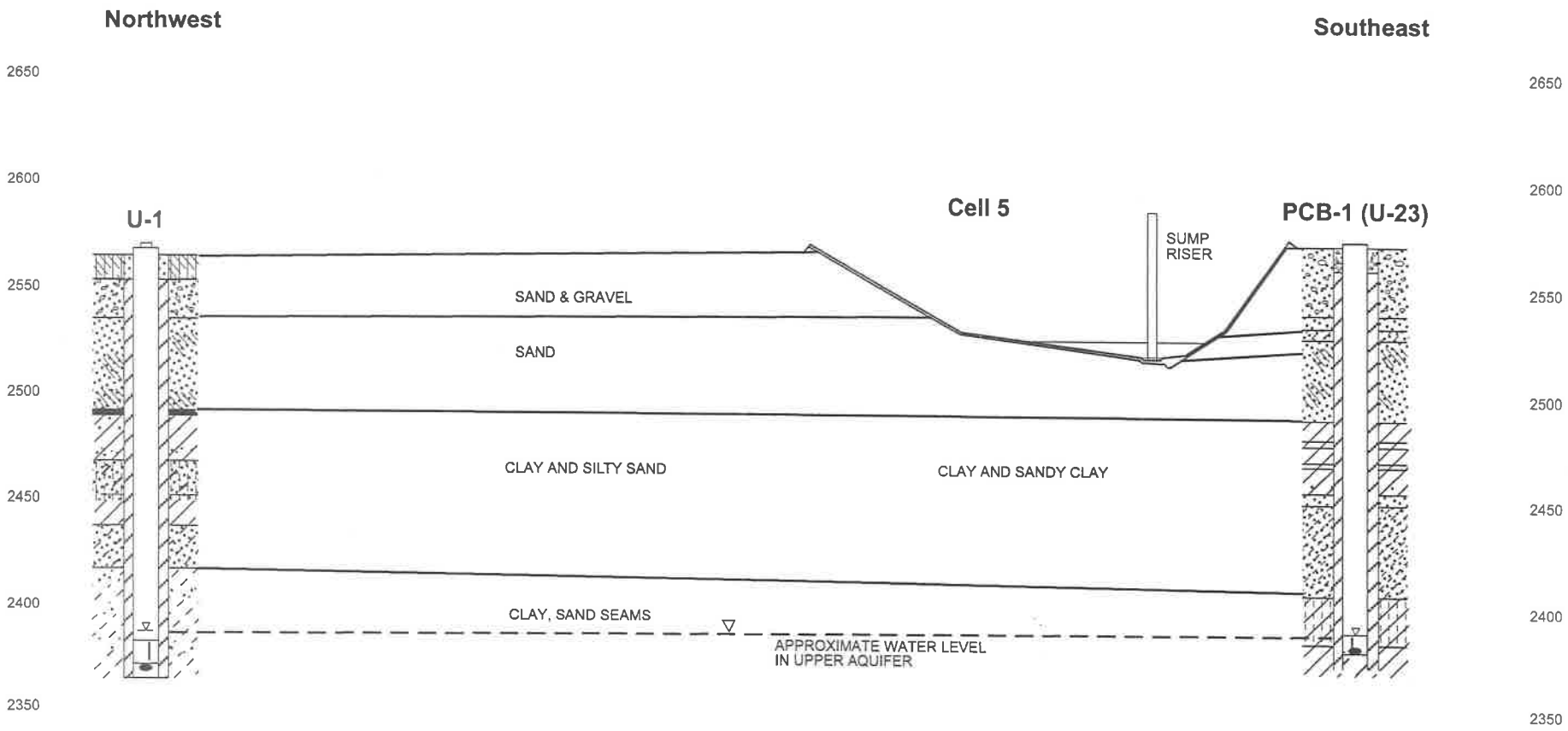


FIGURE 11
CROSS SECTION
THROUGH CELL 5
ESII SITE B
ACL DEMONSTRATION

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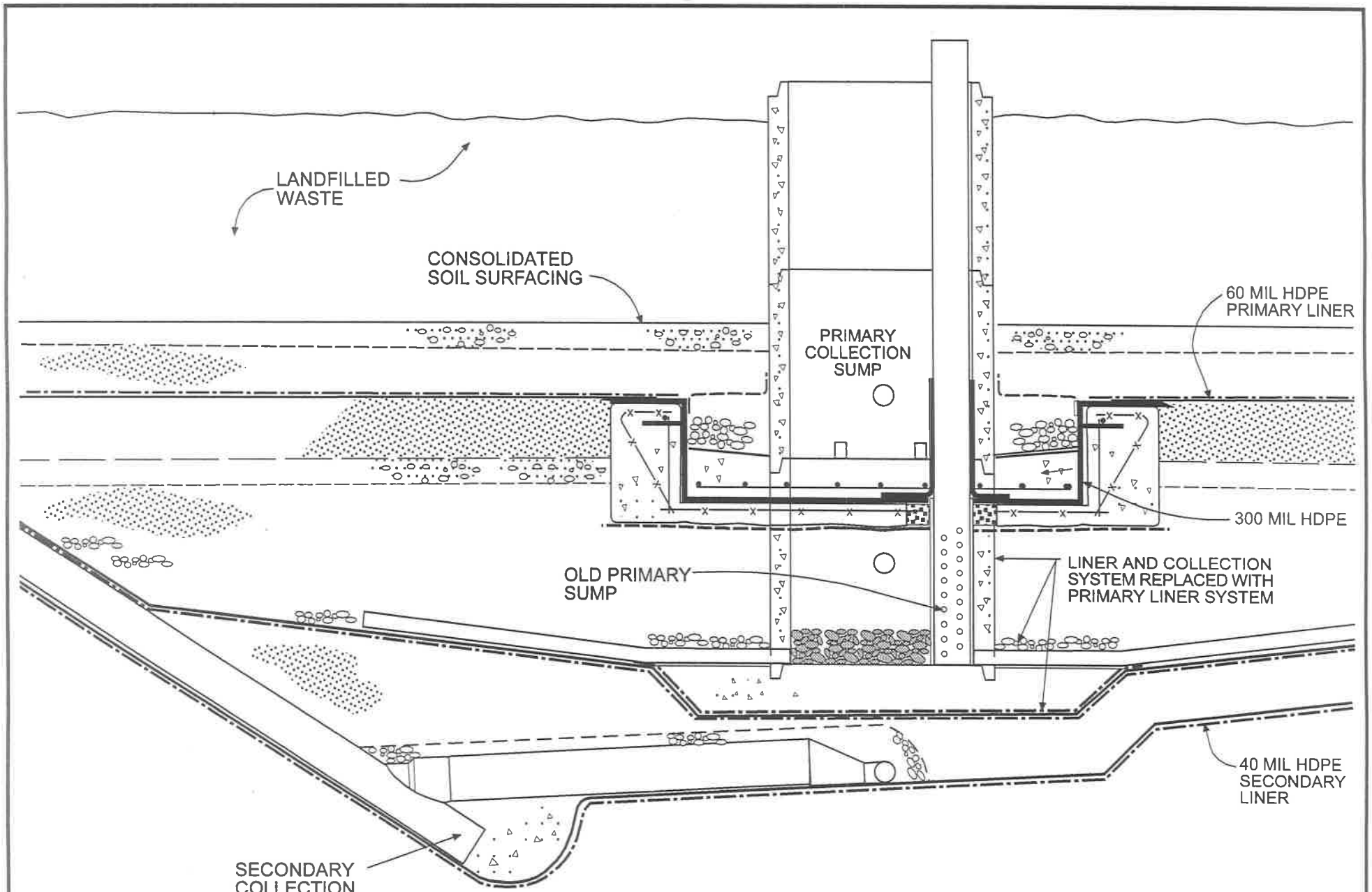


FIGURE 12
SCHEMATIC OF CELL 5
ESII SITE B
ACL DEMONSTRATION

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CH2MHILL

Evaluation

The two release scenarios from Cell 5 that would have the potential for the VOCs to impact groundwater are as follows:

- A VOC dissolved in water release of sufficient magnitude that would migrate vertically downward for a distance of approximately 150 feet to groundwater

- A sufficient release of liquid solvent that would cause a vapor plume to reach groundwater

The volume of water released from a cell necessary to migrate through soils to groundwater was evaluated in a report by CH2M HILL (1987). The report analyzed the diffusion/dispersion processes for a hypothetical liquid water release from an average disposal unit at ESII Site B and estimated water volumes necessary to reach groundwater. The report concluded that a volume of water equaling the volume of an average disposal unit at ESII Site B would not infiltrate down to groundwater. This diffusion/dispersion analysis demonstrated that a release equivalent to many times a disposal unit's volume is needed to cause liquid water to infiltrate through the vadose soils to groundwater.

The VOC dissolved in water release from Cell 5 can be ruled out because the leachate data indicate the following:

- Very little leachate volume is collected in the primary liners and almost no leachate ever collects in the secondary liners. RCRA and TSCA restrict the placement of liquids in Cell 5. Therefore, the leachate generated in the arid climate at ESII Site B is primarily a small amount of rainfall in the primary system and an even smaller amount of condensation in the secondary system. Therefore, there is no potential for a liquid water source to produce the required water volume necessary to migrate to groundwater.

- The leachate data indicate that the liquid water collected in the secondary leachate collection sumps is condensation as evidenced by the small annual volume collected and the periodic absence of any liquids in the collection sumps. Therefore, the primary liner is containing liquids as designed and will prevent the potential release of liquids from the cell.

The liquid solvent release can also be ruled out. At the point of liquid solvent release, soils are saturated with solvents and the dispersion and degradation of solvents in these saturated soils takes place over time periods measured in decades. If the solvent release source was the contents of Cell 5, which are contained in a dual-lined RCRA trench, the time required for the dispersion and degradation of the residual solvent would be many decades. Therefore, if the contents of Cell 5 were the source of solvent release, then free liquid solvents should be present in leachate, and solvent concentrations in the leachate water would be very high and representative of free liquid solvents. A solvent concentration in water representative of the presence of free liquid solvent is the 10-percent solubility concentration. For carbon tetrachloride, this concentration is 82.5 mg/L and for chloroform this concentration is 80 mg/L. No carbon tetrachloride was detected in the 1996 primary sump samples, conclusively demonstrating Cell 5 contents, past or present, contained no appreciable carbon tetrachloride. Only a trace of chloroform (0.052 mg/L and

0.075 mg/L) was detected. That is far below the concentration indicating the presence of liquid solvents.

In summary, the Cell 5 data indicate that the integrity of the Cell 5 liner system is intact and that there is no realistic release scenario from Cell 5 that would result in the observed concentration of VOC constituents in the groundwater.

Evaluation of Monitoring Wells U-1 and U-23 Construction

The construction of Monitoring Wells U-1 and U-23 was evaluated to confirm that well construction is appropriate and will prevent a preferential pathway for vapor migration along the installed well.

The construction of Monitoring Wells U-1 and U-23 is presented in Figure 13. As shown in Figure 13, Monitoring Well U-1 is constructed with 118 feet of 8-inch steel outer casing and a 4-inch PVC inner casing. The outer casing was fitted with an oversized drive shoe and, as the outer casing was installed, granulated bentonite was worked down the outside. The outer casing was seated in the bedded clayey strata, which begins at 109 feet at this location. The open hole was drilled from 118 feet to 199 feet in the clayey strata and the 4-inch PVC well screen and casing was installed. The well screen silica sand filter pack extends from the bottom of the boring to 178 feet. The bentonite seal extends from the bottom of the surface grout plug down to the top of the filter sandpack.

Monitoring Well U-23 is constructed with 140 feet of 8-inch steel outer casing and a 4-inch PVC inner casing. The outer casing was fitted with an oversized drive shoe and, as the outer casing was installed, granulated bentonite was worked down the outside. The outer casing was seated in the bedded clayey strata, which begins at 120 feet at this location. The open hole was drilled from 140 to 196 feet in the clayey strata and the 4-inch PVC well screen and casing was installed. The well screen silica sand filter pack extends from the bottom of the boring to 179 feet. The bentonite seal extends from the bottom of the surface grout plug to the top of the sand filter pack.

At Monitoring Well U-1, the steel casing extends from the surface to 118 feet and the uncased hole filled with bentonite chips extends to 178 feet, or the top of the sandpack.

At Monitoring Well U-23, the steel casing extends from the surface to 140 feet and the uncased hole filled with bentonite chips extends to 179 feet, or the top of the sandpack. The boring logs for each well location (previously submitted in the Site Characterization and Groundwater Monitoring Report [CH2M HILL, February 1986a]) show a predominately clayey sand-sandy clay strata that begins at 109 feet at Monitoring Well U-1 and 120 feet at Monitoring Well U-23. Steel casing at both wells extends into the clayey sand-sandy clay strata classified as Glenns Ferry Lacustrine clayey silt soils. The in situ moisture content (percent volume) of this strata is relatively high, averaging approximately 43 percent (Table 7, Vadose Zone Characteristics at ESII Site B [CH2M HILL, 1986b]). Visual observations during the investigation of this strata (CH2M HILL, 1986b) were consistent with these results, and soils were observed to be slightly moist to moist. The bentonite chips in the open bore holes at Monitoring Well U-1 and Monitoring Well U-23 are within this strata, which has a comparatively high moisture content. The high moisture content in the soils where the open holes are located at both wells (Monitoring Wells U-1 and U-23) is

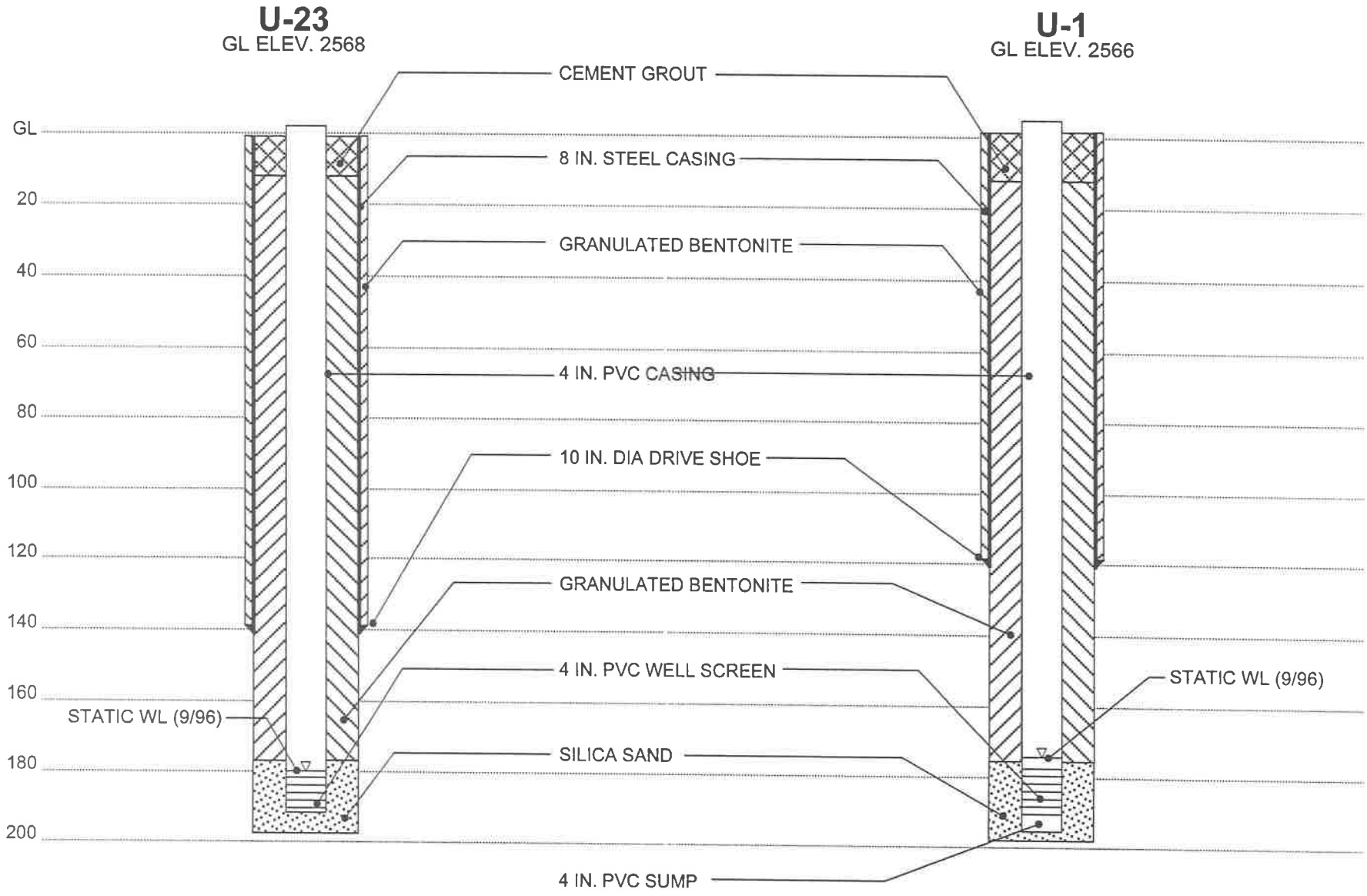


FIGURE 13
WELL CONSTRUCTION DETAILS
ESII SITE B
ACL DEMONSTRATION

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more than sufficient to adequately hydrate the bentonite and seal the hole. Evaluations of bentonite hydration have shown that in a comparatively moderate humid environment, bentonite will hydrate in a relatively short time period. Research regarding the hydration of bentonite shows that bentonite exhibits a matric suction of over 75 bars at air dry conditions (Jahangir, 1994). Sands exhibit a matric suction of less than 1 bar at near dry conditions. Because water moisture flows from a point of high energy (low bar) to a point of low energy (high bar), bentonite placed in even moderately dry sand will hydrate. This research showed that bentonite will hydrate to a gravimetric water content of 100 percent in about 3 weeks time when placed on sand with a gravimetric water content of 5 percent. Similar results (Amble, 1994) showed bentonite hydrated to 80 to 140 percent of saturation within 90 days of placement in soil. The high moisture content of the soils in the strata penetrated by the wells at ESII Site B assures that the bentonite hydrated in a relatively short time period after construction and would not provide a preferred vapor migration pathway.

The well construction evaluation indicates no potential migration pathway exist along the installed wells, including Monitoring Wells U-1 and U-23.

Summary of the Evaluation of Release Scenarios

Evaluation of Groundwater Sampling Data

In summary, comparatively low levels (120 to 200 µg/L) of carbon tetrachloride, chloroform, and chloromethane have been detected in several monitoring wells at the northwest corner of Site B. Beginning with the first detection of chloroform in U-21 in 1989, seven additional wells have been impacted.

A liquid to groundwater release can be ruled out based on the compilation of monitoring data and fate and transport modeling. A liquid release within the upper 30 feet of soils would need to migrate vertically an additional 150 feet to groundwater. The horizontal spread of the liquid and the associated vapor advection plume would encompass an area hundreds of feet laterally from the source before groundwater would be reached. Groundwater concentrations would immediately begin to rise rapidly as the mass transport to groundwater continued at ever-increasing rates. As the vapor preceding advection plume contacted groundwater, concentrations could quickly rise up to the 1-percent solubility concentration (8,250 µg/L for carbon tetrachloride) range. When free liquid begins to contact groundwater, concentrations of 80,000 µg/L or greater could be observed. The significantly lower concentrations of carbon tetrachloride observed in the monitoring wells, from nondetect (nd) to 130 µg/L, are not consistent with a solvent vapor advection and/or free liquid source.

The small subset of VOCs being detected is primarily associated with carbon tetrachloride and its degradation products. Waste streams at Site B contain many more VOCs and other organic compounds. If a liquid release(s) were responsible for the impacted groundwater, other compounds would be seen. The limited set of VOCs is not consistent with a liquid release.

The concentration ranges observed are consistent with vapor diffusion transport to groundwater. Vapor diffusion is a slow process compared to vapor advection and free liquid advection. Vapor diffusion gradients and mass transport can be very low, resulting in

comparatively long-term changes in groundwater concentrations. Because the diffusion mass transfer rate from soil vapor to groundwater is low, groundwater concentration gradient profiles can be very thin (surficial) near the groundwater surface. As a result, sample results may be highly variable and time-dependent. These fate and transport factors are consistent with the observed data.

Evaluation of Hydrogeology on Migration of Soil Gas VOC Vapors

Subsurface geologic conditions at the site significantly impact the potential migration and distribution of VOC vapors in the vadose soils and, ultimately, the potential detection of constituents in groundwater samples. The upper 120 feet of coarser sands and gravels are comparatively permeable and allow soil gas vapors to disperse. Conversely, the clayey sand seamed strata below inhibits VOC mass migration generally, but provides interbedded permeable zones for potential preferred migration. Therefore, groundwater monitoring results are expected to be variable. The groundwater monitoring results from the monitoring wells and piezometers in the northwest portion of Site B are consistent with this evaluation.

Evaluation of Cell 5 Data

This evaluation focused on the possibility of Cell 5 as a potential source of carbon tetrachloride detected in Monitoring Wells U-1 and U-23. The evaluation summarized Cell 5 data and analyzed the data using the fate and transport models.

The data evaluation concluded that Cell 5 is not the source of the carbon tetrachloride detected in groundwater. Fate and transport models indicate that the highest solvent concentrations will be found at the source and the high source area concentrations will remain for many decades until liquid advection, solvent vapor advection, and vapor diffusion eventually transport the solvent away from the source area. The analytical results of Cell 5 leachate demonstrate that it now contains non-detectable amounts of carbon tetrachloride, and therefore was never a source containing significant carbon tetrachloride. A release of solvents dissolved in water (waterborne release) is also ruled out. The data show that the cell's primary liner is containing the small volume of precipitation and condensation that collects in the leachate sump system. Therefore, there is no potential for a release from Cell 5.

Evaluation of Monitoring Well U-1 and U-23 Construction

The wells were constructed appropriately for the site conditions. The construction would be expected to prevent the potential for a preferential pathway of soil gas migration along the well. Therefore, groundwater samples are representative of in-situ conditions.

Summary and Conclusions

The evaluation regarding the detection assessment of VOCs in the Upper Aquifer groundwater at Site B provided the following conclusions:

- Cell 5 is neither a past nor present release source of carbon tetrachloride in the groundwater.

- Monitoring well construction methods are appropriate and do not provide preferential migration pathways.
- Vapor migration dispersed soil gas vapors in vadose soils, from past practice units, appears to be the probable source of the VOCs detected.
- No free liquid solvent release to groundwater appears to have occurred.
- Preferential soil gas migration pathways, slow diffusion and solubility rates, and changes in equilibrium conditions, combined with the limited water production in the clayey strata of the Upper Aquifer, are responsible for the variable groundwater sample results.
- The geology of the northwest corner is more conducive to vapor transport because of increased sand content; however, soil vapors may penetrate to the "uppermost" aquifer over other portions of the site in the future.
- Groundwater conditions beneath and adjoining the facility do not support industrial, commercial, agricultural, or domestic uses.

The data and evaluations provided in this document do not indicate that a potential release scenario would be considered a potential human health or environmental threat. Therefore, a site-wide Alternate Concentration Limit (ACL) is appropriate based on the slow flow properties of the aquifer, the widespread nature of the soil vapor source, the limited exposure potential provided by the isolation of the site, the poor water resource potential of the uppermost aquifer, and the lack of nearby receptors.

SECTION 5

ACL Development

Introduction

The proposed ACLs are based on risk of exposure and fate and transport characteristics of VOCs in the subsurface at Site B. This approach is founded on two basic premises:

1. There are no realistic exposure pathways, and, therefore, no exposure risks associated with interior site wells because they are permitted monitoring wells and access is strictly controlled. The presence of VOCs in the groundwater beneath the facility boundary represents minimal exposure risk because of the isolated rural site setting, the poor water resource potential of the Upper and Lower Aquifers, and because the adjoining property hydraulically downgradient from the current facility boundary is also owned by ESII.
2. Fate and transport modeling indicates that the geologic media, slow-moving groundwater, and the physical and chemical nature of the mobile synthetic volatile organic compounds combine to produce very large degradation and attenuation factors. These results indicate that free-phase solvents would have to reach the uppermost aquifer at interior wells before downgradient wells would be significantly affected.

The following sections describe the exposure and fate and transport issues pertinent to establishing an ACL for ESII Site B.

Potential Exposure and Risk

Onsite Exposure to Groundwater

Operations within the facility boundary are strictly controlled by the TSCA and RCRA Part B Permit conditions. Potential future use within the facility boundary, other than as a hazardous waste facility, is protected and controlled by deed restrictions.

Groundwater monitoring wells within the facility boundary are permitted for monitoring use only. Other uses of groundwater within the facility boundary are not permitted, including any use as a non-potable or consumptive supply.

Water levels range from 140 to about 200 feet bgs, which prevents incidental or easy access to the groundwater. In addition, the uppermost water bearing zones beneath the facility do not yield a sufficient water volume to be considered a viable source of water for any other use other than monitoring.

Monitoring wells are sampled twice each year by health and safety-trained ESII staff and contractors. No one other than authorized, trained personnel has access to the locked wells. The established sampling procedures require the use of gloves and protective garments, and samples are collected in a manner that avoids contact with groundwater. Vapor

monitoring equipment is used during sampling to detect the presence of VOCs and to determine if a respirator is required during sampling.

The dedicated sampling pumps installed in the wells are inoperative except with a removable surface-mounted pneumatic motor. The motor and associated air compressor used to actuate the pumps is removed between sampling events. Therefore, incidental, unauthorized contact with the well water is prevented.

In summary, permit conditions restrict exposure to onsite groundwater, other than for limited monitoring purposes. During monitoring, appropriate health and safety measures are used to limit incidental contact with the water removed from the wells. Therefore, onsite groundwater poses no realistic or quantifiable exposure risk.

Offsite Exposure to Groundwater

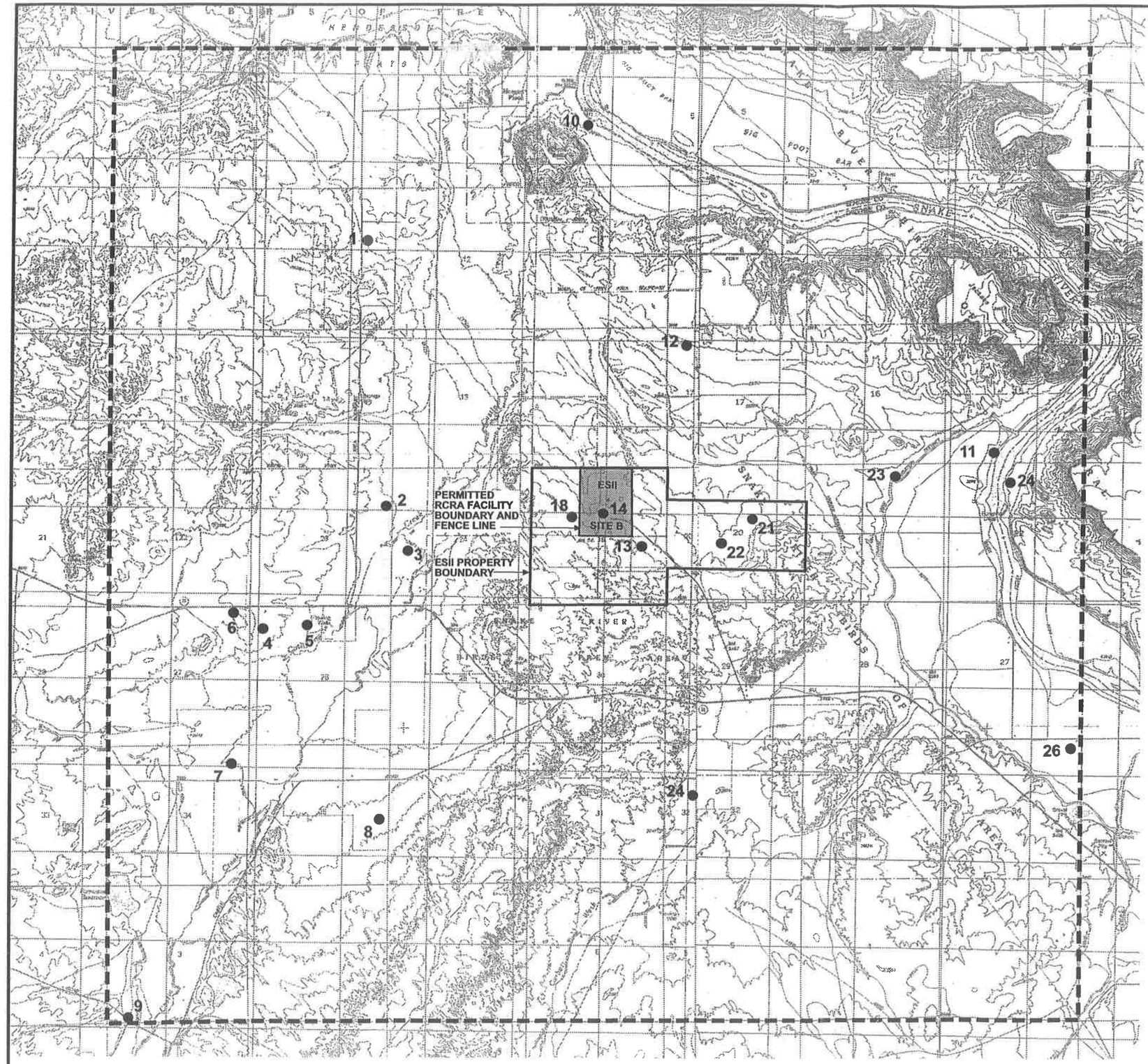
The low well yields and poor water quality of the upper water-bearing zones limit groundwater use at the facility boundary. In addition, the site is located in an isolated rural area in an arid environment. Therefore, commercial or residential development is unlikely to be established in this area. Development at the facility boundary on the east (downgradient) side is not currently possible because the adjacent property is also owned by ESII.

The well inventory presented in Figure 14 indicates the closest downgradient shallow well to Site B is a stock well located approximately 2 miles northeast. This well is completed in shallow sand and gravel along the Snake River and yields over 50 gpm. The high yield and high dilution potential of the river gravels will preclude any possible adverse effects from synthetic organic compounds in the Upper Aquifer at Site B. The other wells within 2 miles of the site are all deep and penetrate far enough into the regional artesian system that they either flow at the surface or have static water levels less than 20 feet bgs. The hydraulic heads in these wells are higher that the hydraulic head in the uppermost aquifers at Site B which will prevent any possible impact from contaminants in the aquifers at Site B.

As discussed in Section 3, fate and transport studies completed by ESII indicate that the attenuation and degradation of VOCs in the hydrogeologic systems underlying Site B is very protective against significant offsite transport and is sufficient to degrade the compounds to below detectable levels.

Although the potential for exposure to contaminated groundwater at the facility boundary is very low, it cannot be totally dismissed because land uses and property ownership may change. It is important, however, to note that the aquifer properties and basic water chemistry will not change and, therefore, if any exposure to groundwater occurs, it is likely to be through incidental contact of stock water or domestic culinary and bathing uses.

The low source concentration characteristics of a diffuse soil vapor transport mechanism and the high degradation and attenuation attributes of the site support the proposed approach of establishing ACLs based on exposure potentials and on indicators of significant VOC releases. The proposed ACL approach is provided in the next section.



Base Map from USGS 7.5 Minute Topographic Quadrangles
(Castle Butte, Idaho [1992] and Jackass Butte, Idaho [1992])

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P:\142505\DRAWING\FH-FIGS\ACL\ACL-FIGS.FH4 04-JUNE-1998

Index of Well Logs Within a 3-Mile Radius of Section 19, R2E, T4S (ESII Site B)[a]

Well Log Number	Township and Range	Section	Quarter - Quarter Section	Total Depth (feet)	Use	Date Drilled
1	R1E, T4S	11	SE of NE	1,115	D, S	11/4/88
2	R1E, T4S	23	NE of NE	600	D	10/21/69
3	R1E, T4S	24	NW of SW	200	S	9/28/92
4	R1E, T4S	26	NW of NW	656	D	NI
5	R1E, T4S	26	NE of NW	840	S	1/30/93
6	R1E, T4S	27	NE of NE	500	D	9/10/97
7	R1E, T4S	34	NE of NE	2,980	I	7/8/92
8	R1E, T4S	35	NE of SE	35	I	9/12/66
9	R1E, T5S	3	SW of SW	130	I	9/5/66
10	R2E, T4S	6	NE of SW	320	D	8/3/67
11	R2E, T4S	15	SE of SW	100	D	12/22/88
12	R2E, T4S	17	NW of NW	2,350	D	2/10/79
13	R2E, T4S	19	NE of SE	1,608	D	6/1/78
14	R2E, T4S	19	SW of NE	3,080	A	11/12/58
15 *	R2E, T4S	19	SW of NE	280	M	8/28/93
16 *	R2E, T4S	19	SW of NE	275	M	9/16/93
17 *	R2E, T4S	19	SW of NE	235	M	3/12/93
18	R2E, T4S	19	SE of NW	800	D	10/26/84
19 *	R2E, T4S	19	SE of NW	280	M	2/5/93
20 *	R2E, T4S	19	SE of NW	230	M	2/6/93
21	R2E, T4S	20	SW of NE	1,270	D	11/21/75
22	R2E, T4S	20	NW of SW	620	D	4/18/74
23	R2E, T4S	21	NW of NE	73	S	11/20/96
24	R2E, T4S	22	NE of NW	220	D	10/11/88
25	R2E, T4S	32	SW of NW	420	D	4/1/87
26	R2E, T4S	34	NE of NE	235	D	3/28/78

[a] From Idaho Department of Water Resources

NOTES:

D = Domestic
I = Irrigation
M = Monitor
A = Abandoned Artesian Supply Well
S = Stock Water
NI = Not Indicated
* = ESII monitoring wells not shown on map

APPROXIMATE SCALE IN FEET
0 4000 8000

N

FIGURE 14
LOCATION MAP OF
KNOWN WATER WELLS
ESII SITE B
ACL DEMONSTRATION

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SECTION 6

Proposed Alternate Concentration Limits for ESII Site B

The aquifers at Site B consist of thinly bedded, very fine-grained sand to silty sand, in a predominantly silty clay organic and mineral-rich matrix. Well yields are generally less than 0.5 gpm and groundwater velocities are slow. Fate and transport modeling conducted during the ACL analysis for Monitoring Well U-21 (CH2M HILL, 1993a) and the analysis completed for Monitoring Well U-23 (CH2M HILL, 1997) indicate that natural attenuation and degradation rates for synthetic organic compounds in this environment are very high; therefore, the potential for significant migration of organic contaminants is low.

Evidence for the presence of widespread soil vapors at Site B was presented in Section 4 of this document and in the U-21 Corrective Measures Study (CH2M HILL 1993b) and the U-23/U-1 ACL analysis, (CH2M HILL 1997). Soil vapor transport will, and has, resulted in widespread but low levels of organic compounds reaching the groundwater in wells interior to the site and in nearby upgradient Monitoring Well U-1. Consequently, the ACL Compliance Monitoring Program recognizes the natural protective properties of the groundwater system beneath the site and the fact that the probable source of the soil vapors is pre-RCRA and pre-ESII disposal of volatile organic compounds.

The proposed ACLs allow higher concentrations in interior wells where there is significant attenuation and degradation potential and no risk of exposure. The program establishes lower concentrations for wells along the facility boundary, where shorter travel times reduce the potential for attenuation and degradation and increase the risk of exposure if contaminated groundwater leaves the facility.

Monitoring Well Classification

The proposed ACL program divides the monitoring wells at Site B into four categories: Upgradient Background Wells, Level 1 Compliance Wells, Level 2 Compliance Wells, and Other Wells. These well classifications are described as follows:

- **Upgradient Background Wells**. Upgradient Background Wells (UGB) are all hydraulically upgradient, unimpacted wells. Carbon tetrachloride, a VOC, has been detected in upgradient Monitoring Well U-1 since October 1995. Since Monitoring Well U-1 has been impacted by the site, it is proposed for reclassification as discussed below under Special Status Wells.

- **Level 1 Compliance Wells**. Level 1 Compliance Wells (L1C) include all interior wells downgradient of designated solid waste management units.

- **Level 2 Compliance Wells**. Level 2 Compliance Wells (L2C) include all wells on the east and northern site boundaries where groundwater flow paths will potentially carry impacted groundwater off the facility. Groundwater flow paths at Monitoring Wells U-5

and U-6 along the northwest facility are actually into the northwest corner of the site. However, since ESII does not own the adjoining property to the north, these two wells will be designated L2C wells.

- **Special Status Wells.** This category was added to accommodate Monitoring Well U-1, which has become impacted by soil vapors migrating from the facility. Monitoring Well U-1 is approximately 200 feet outside the western side of the current permitted facility boundary. ESII owns the property on which Monitoring Well U-1 is located and the impacted groundwater at this location flows back into the upgradient side of the site. ESII will continue to sample Monitoring Well U-1 for detection monitoring parameters on a semiannual basis and will report the results to IDEQ. However, until the regulatory status of Monitoring Well U-1 is resolved, it is not subject to the trigger levels established for the Site B ACL program.

Figure 15 shows the existing wells at Site B and their classification under the proposed ACL program. As shown on Figure 15 there are two proposed wells, U-13 and U-14, along the southeast facility boundary. These wells are proposed to be installed and maintained as piezometers. If detection monitoring constituents are detected in wells U-17, U-18, or U-19, wells U-13 and U-14 will be equipped with pumps, and incorporated into the monitoring program as Level 2 Compliance wells, as described above.

Concentration Limits

- The proposed ACL program establishes concentrations based on the classification of the individual well in which VOCs have been detected above the detection monitoring criteria of the Part B Permit. The concentration limits for the monitoring wells are as follows:

- **Detection Monitoring Criteria, Downgradient Wells.** Detection levels for detection monitoring will be the estimated quantitation limit (EQL) of 1 µg/L as recommended by SW 846 for the 26 specific VOCs analyzed by Method 8260B. A well will trigger from detection monitoring to compliance monitoring if the presence of any VOC above the EQL is confirmed in two independent samples collected after the initial detection. If both of the confirmation samples are above the EQL, the impacted well will be included in the Compliance Monitoring Program. If VOCs are detected in only one of the two confirmation samples, the well will be resampled. Evaluation of the sample results and resampling will continue until either both samples are non-detect for VOCs, or until VOCs are confirmed in both samples.

- **Upgradient Unimpacted Background Wells.** Detection monitoring criteria will apply. The stipulated background concentration for the 26 detection monitoring VOCs is zero. If any of the Upper Aquifer upgradient background wells, U-2, U-3, and U-4, or Lower Aquifer upgradient background well L-38, (Figure 15) become impacted by VOCs above the detection monitoring criteria, they will also fall into the "Special Status Well" classification because they are upgradient of the site, but outside of the current facility boundary.

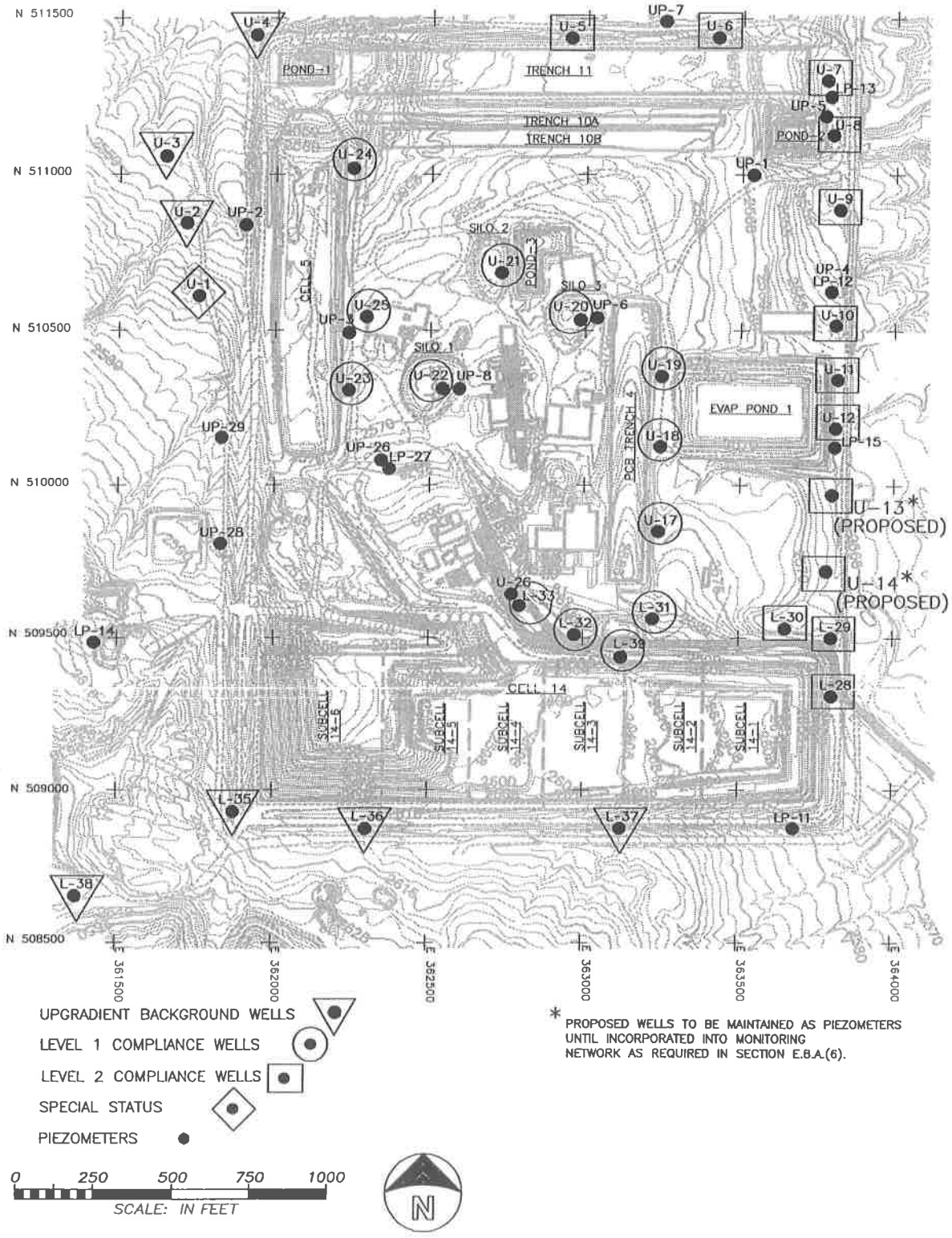


FIGURE 15
COMPLIANCE MONITORING WELL DESIGNATIONS
ESII SITE B
ACL DEMONSTRATION

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- **Level 1 Compliance Wells (L1C)**. Corrective action requirements of *IDAPA 16.01.05.008* will apply if the following ACLs are exceeded in an L1C Compliance Well:
  - Any single synthetic organic compound equal to 0.5 percent of its solubility in water.
  - If multiple constituents are present, a cumulative total of 0.5 percent solubility based on the summation of solubility percentages represented by the concentration of each constituent detected.
- **Level 2 Compliance Wells (L2C).** Corrective Action Requirements will apply if the following ACLs are exceeded in an L2C Compliance Well:
  - If a maximum concentration limit (MCL) has been established by the EPA for drinking water, the MCL will apply.
  - If an MCL has not been established, a concentration equal to $1x10^{-5}$ industrial cancer risk for carcinogenic constituent will apply.
  - If multiple carcinogenic compounds are present, but none exceed their respective MCLs (if available), a cumulative $1x10^{-5}$ industrial cancer risk will apply.
  - For individual non-carcinogenic hazardous constituents, the limit shall be a hazard quotient of 1 based on a modified industrial scenario.
  - If multiple non-carcinogenic hazardous constituents are present, but none exceed their respective MCLs (if available), a cumulative hazard quotient of 1 based on a modified industrial scenario will apply.

Figure 15 shows the existing monitoring wells at ESII Site B and their proposed classification. Table 10 provides a list of the 26 VOCs on the current Detection Monitoring Program, and the other 25 VOCs on the Appendix IX list of analytes and their respective slope factors and reference doses used to calculate the carcinogenic and hazardous quotients for each compound. Table 10 also provides the one-half percent solubility levels, which apply to Level 1 Compliance wells, and the respective MCLs, CRs, or HQs that apply to Level 2 Compliance wells based on a 10^{-5} residential cancer risk or hazard quotient equal to 1 under a modified industrial exposure scenario. Table 11 provides the formulae used to calculate the cancer risk and hazard quotient concentration.

The modified industrial exposure scenario of non-carcinogenic hazardous compounds uses the residential exposure scenario defined in EPA Region IX Preliminary Remediation Goal, except that industrial exposure factors and durations are used. This modification incorporates the inhalation pathway that is not typically included under an industrial exposure scenario. This modification was incorporated to reduce the allowable concentration of non-carcinogens in Level 2 Compliance wells to be similar to the 10^{-5} industrial cancer risk concentrations.

The distinction between L1C and L2C Wells, and therefore the difference in allowable concentrations, is based on the fact that there is no exposure risk at an L1C Well. Because the L1C Wells are locked, dedicated monitoring wells, there is no potential exposure except to trained samplers who are wearing personal protective equipment during the periodic,

infrequent sampling events. Furthermore, the L1C Wells are all located interior to the site. Groundwater flow paths from L1C Wells to the downgradient facility boundary involve long distances and slow times, allowing natural attenuation and degradation processes to reduce the concentrations, while allowing adequate time for implementing a Corrective Action Program.

L2C Wells are also locked and dedicated monitoring wells offering no exposure at the wellhead or to groundwater in the well. However, given the proximal location of these wells either to private property (U-5 and U-6) or to the downgradient facility boundary, a slight potential for offsite exposure risks is assumed and low concentration criteria are applied.

Other Compounds

If a well exceeds the Detection Monitoring Criteria and is placed in the Compliance Monitoring or Corrective Action Program, complete Appendix IX (less dioxin) analyses will be conducted. Table 12 provides the metals, selected inorganic non-metals, and pesticides and herbicides included in the Appendix IX analyses that are also listed in *40 CFR 264.94*, Table 1, as adopted by *IDAPA 16.01.05.008*, and for which EPA has codified groundwater protection standards (GPS). These constituents are not highly mobile, nor are they likely to spread via vapor transport, and their presence above the groundwater protection standards listed in Table 12 is not likely. Therefore, the establishment of statistical background concentrations will not occur until any of these compounds are detected in concentrations exceeding the groundwater protection standards. Notification of the exceedance will be provided to the Agency within 7 days of receipt of the analytical results that indicate constituent exceedance. Then beginning with the next regularly scheduled sampling event, ESII will collect one set of four independent samples for the well in which the GPS was exceeded, and one set of four independent samples from the upgradient background monitoring well associated with the impacted well. A second set of four independent samples from the impacted well and associated upgradient well will be collected during the next regularly scheduled semi-annual sampling event.

Within 30 days of receipt of the second set of independent samples, ESII will establish control limits for the background well and compare those results to the downgradient well. ESII will then follow the evaluation procedures discussed in the next section.

Table 10
Monitoring Co[illegible]ents, Toxicity Information, Solubilities and ACL Concentrations
ESII Site B ACL Demonstration

Monitoring Constituents	CAS	Carcinogenic Slope Factors SFo (1/(mg/kg-d))	Source	SFi (1/(mg/kg-d))	Source	Non-Carcinogenic Reference Doses RfDo (mg/kg-d)	Source	RfDi (mg/kg-d)	Source	.5% Solubility (µg/L)	Industrial HQ =1 with Industrial Exposure Durations in Residential Equation (µg/L)	Industrial 10^{-5} CR using Equation in Permit (µg/L)	MCL [a] (µg/L)	Notes	ACL Concentration [b] (µg/L)	Basis [b]
Acetone	67641	n/a		n/a		1.00E-01	i	1.00E-01	r	5.00E+06	8.52E+02	n/a	n/a		8.52E+02	HQ
Acrolein	107028	n/a		n/a		2.00E-02	h	5.70E-06	i	1.04E+06	5.83E-02	n/a	n/a		5.83E-02	HQ
Acrylonitrile	107131	5.40E-01	i	2.40E-01	i	1.00E-03	h	5.70E-04	i	3.68E+05	5.23E+00	5.30E+00	n/a		5.30E+00	CR
Allyl chloride	107051	n/a		n/a		5.00E-02	h	2.90E-04	i	1.80E+04	2.96E+00	n/a	n/a		2.96E+00	HQ
Benzene	71432	2.90E-02	i	2.90E-02	i	n/a	n	n/a	n	8.90E+03	n/a	9.87E+01	5.00E+00		5.00E+00	MCL
Bromodichloromethane	75274	6.20E-02	i	6.20E-02	r	2.00E-02	i	2.00E-02	r	2.25E+04	1.70E+02	4.62E+01	1.00E+02	c	1.00E+02	MCL
Bromoform (tribromomethane)	75252	7.90E-03	i	3.90E-03	i	2.00E-02	i	2.00E-02	r	1.60E+04	1.70E+02	3.62E+02	1.00E+02	c	1.00E+02	MCL
Bromomethane	74839	n/a		n/a		1.40E-03	i	1.40E-03	i	6.50E+04	1.19E+01	n/a	n/a		1.19E+01	HQ
2-Butanone (Methyl ethyl ketone)	78933	n/a		n/a		6.00E-01	i	2.90E-01	i	1.38E+06	2.70E+03	n/a	n/a		2.70E+03	HQ
Carbon disulfide	75150	n/a		n/a		1.00E-01	i	2.00E-01	i	1.45E+04	1.46E+03	n/a	n/a		1.46E+03	HQ
Carbon tetrachloride	56235	1.30E-01	i	5.30E-02	i	7.00E-04	i	n/a	x	4.00E+03	n/a	2.20E+01	5.00E+00		5.00E+00	MCL
Chlorobenzene	108907	n/a		n/a		2.00E-02	i	5.70E-03	h	2.44E+03	5.51E+01	n/a	1.00E+02		1.00E+02	MCL
Chlorodibromomethane	124481	8.40E-02	i	8.40E-02	r	2.00E-02	i	2.00E-02	r	2.00E+04	1.70E+02	3.41E+01	1.00E+02	c	1.00E+02	MCL
Chloroethane (Ethyl Chloride)	75003	n/a		n/a		n/a	n	2.90E+00	i	2.87E+04	n/a	n/a	n/a		no value	no value
2-Chloroethyl vinyl ether	110758	n/a		n/a		n/a		n/a		7.50E+04	n/a	n/a	n/a		no value	no value
Chloroform	67663	6.10E-03	i	8.10E-02	i	1.00E-02	i	1.00E-02	r	4.65E+04	8.52E+01	4.69E+02	1.00E+02	c	1.00E+02	MCL
Chloromethane	74873	1.30E-02	h	6.30E-03	h	n/a		n/a		3.18E+04	n/a	2.20E+02	n/a		2.20E+02	CR
1,2-Dibromo-3-chloropropane	96128	1.40E+00	h	2.40E-03	h	5.70E-05	r	5.70E-05	i	5.00E+03	4.85E-01	2.04E+00	n/a		2.04E+00	CR
1,2-Dibromoethane (EDB)	106934	8.50E+01	i	7.70E-01	i	5.70E-05	r	5.70E-05	h	5.85E+04	4.85E-01	3.37E-02	n/a		3.37E-02	CR
1,1-Dichloroethane	75343	n/a		n/a		1.00E-01	h	1.40E-01	h	2.75E+04	1.12E+03	n/a	n/a		1.12E+03	HQ
1,2-Dichloroethane (EDC)	107062	9.10E-02	i	9.10E-02	r	2.90E-03	i	n/a	x	4.35E+04	n/a	3.14E+01	5.00E+00		5.00E+00	MCL
1,1-Dichloroethylene	75354	6.00E-01	i	1.80E-01	i	9.00E-03	i	9.00E-03	r	2.00E+03	7.67E+01	4.77E+00	7.00E+00		7.00E+00	MCL
1,2-Dichloroethylene (trans)	156605	n/a		n/a		2.00E-02	i	2.00E-02	r	3.00E+03	1.70E+02	n/a	1.00E+02		1.00E+02	MCL
trans 1,4-Dichloro-2-butene**	110576	9.30E+00	r	9.30E+00	h	n/a		n/a			n/a	3.08E-01	n/a		3.08E-01	CR
Dichlorodifluoromethane	75718	n/a		n/a		2.00E-01	i	5.70E-02	h	1.40E+03	5.51E+02	n/a	n/a		5.51E+02	HQ
1,2-Dichloropropane	78875	6.80E-02	h	6.80E-02	r	1.10E-03	r	1.10E-03	i	1.35E+04	9.37E+00	4.21E+01	5.00E+00		5.00E+00	MCL
cis 1,3-Dichloropropene*	10061015	1.80E-01	h	1.30E-01	h	3.00E-04	i	5.70E-03	i	1.35E+04	1.21E+01	1.59E+01	n/a		1.59E+01	CR
trans 1,3-Dichloropropene*	10061026	1.80E-01	h	1.30E-01	h	3.00E-04	i	5.70E-03	i	1.40E+04	1.21E+01	1.59E+01	n/a		1.59E+01	CR
Ethylbenzene	100414	n/a		n/a		1.00E-01	i	2.90E-01	i	7.60E+02	1.88E+03	n/a	7.00E+02		7.00E+02	MCL
Ethyl methacrylate	97632	n/a		n/a		9.00E-02	h	9.00E-02	i	1.00E+02	7.67E+02	n/a	n/a		7.67E+02	HQ
2-Hexanone	591786	n/a		n/a		n/a		n/a		1.75E+05	n/a	n/a	n/a		no value	no value

Table 10
Monitoring Co. ..nts, Toxicity Information, Solubilities and ACL Concentrations
ESII Site B ACL Demonstration

Monitoring Constituents	CAS	Carcinogenic Slope Factors SFo (1/(mg/kg-d))	Source	SFi (1/(mg/kg-d))	Source	Non-Carcinogenic Reference Doses RfDo (mg/kg-d)	Source	RfDi (mg/kg-d)	Source	.5% Solubility (µg/L)	Industrial HQ =1 with Industrial Exposure Durations in Residential Equation (µg/L)	Industrial 10^{-5} CR using Equation in Permit (µg/L)	MCL [a] (µg/L)	Notes	ACL Concentration [b] (µg/L)	Basis [b]
Iodomethane (Methyl Iodide)	74884	n/a		n/a		n/a		n/a		7.00E+04	n/a	n/a	n/a		no value	no value
Methacrylonitrile	126987	n/a		n/a		1.00E-04	i	2.00E-04	h	1.25E+05	1.46E+00	n/a	n/a		1.46E+00	HQ
Methylene bromide	74953	n/a		n/a		1.00E-02	h	1.00E-02	r	2.15E+04	8.52E+01	n/a	n/a		8.52E+01	HQ
Methylene chloride	75092	7.50E-03	i	1.60E-03	i	6.00E-02	i	8.60E-01	h	8.35E+04	2.27E+03	3.82E+02	5.00E+00		5.00E+00	MCL
Methyl methacrylate	80626	n/a		n/a		1.40E+00	i	2.00E-01	i	8.00E+04	1.99E+03	n/a	n/a		1.99E+03	HQ
Methyl Isobutyl Ketone	108101	n/a		n/a		8.00E-02	h	2.30E-02	h	9.55E+04	2.22E+02	n/a	n/a		2.22E+02	HQ
Propiononitrile (Propanenitrile)	107120	n/a		n/a		n/a		n/a		5.15E+05	n/a	n/a	n/a		no value	no value
Styrene	100425	n/a		n/a		2.00E-01	i	2.90E-01	i	1.50E+03	2.30E+03	n/a	1.00E+02		1.00E+02	MCL
1,1,1,2-Tetrachloroethane	630206	2.60E-02	i	2.60E-02	i	3.00E-02	i	3.00E-02	r	1.00E+03	2.56E+02	1.10E+02	n/a		1.10E+02	CR
1,1,2,2-Tetrachloroethane	79345	2.00E-01	i	2.00E-01	i	n/a		n/a		1.45E+04	n/a	1.43E+01	n/a		1.43E+01	CR
Tetrachloroethylene (PCE)	127184	n/a	n	n/a	n	1.00E-02	i	n/a	n	7.50E+02	n/a	n/a	5.00E+00		5.00E+00	MCL
Toluene	108883	n/a		n/a		2.00E-01	i	1.10E-01	h	2.58E+03	1.01E+03	n/a	1.00E+03		1.00E+03	MCL
1,1,1-Trichloroethane	71556	n/a		n/a		n/a	n	n/a	n	2.20E+04	n/a	n/a	2.00E+02		2.00E+02	MCL
1,1,2-Trichloroethane	79005	5.70E-02	i	5.60E-02	i	4.00E-03	i	4.00E-03	r	2.25E+04	3.41E+01	5.02E+01	5.00E+00		5.00E+00	MCL
Trichlorofluoromethane	75694	n/a		n/a		3.00E-01	i	2.00E-01	h	5.50E+03	1.80E+03	n/a	n/a		1.80E+03	HQ
1,2,3-Trichloropropane	96184	7.00E+00	h	7.00E+00	r	6.00E-03	i	5.00E-03	r	9.50E+03	4.38E+01	4.09E-01	n/a		4.09E-01	CR
Trichloroethylene (TCE)	79016	n/a	n	n/a	n	n/a	x	6.00E-03	r	5.50E+03	n/a	n/a	5.00E+00		5.00E+00	MCL
Vinyl acetate	108054	n/a		n/a		1.00E+00	h	5.70E-02	i	1.00E+05	5.76E+02	n/a	n/a		5.76E+02	HQ
Vinyl chloride	75014	1.90E+00	h	3.00E-01	h	n/a		n/a		5.50E+03	n/a	1.51E+00	2.00E+00		2.00E+00	MCL
Xylene (mixed)	1330207	n/a		n/a		2.00E+00	i	n/a	x	9.95E+02	n/a	n/a	1.00E+04		1.00E+04	MCL

** Values for 1,4-Dichloro-2-butene, CAS 764410

* Values for 1,3-Dichloropropene, CAS 542756

a. MCLs from 40 CFR 141.61 (effective date 12/31/98)

b. Compares MCL, Industrial 10^{-5} CR and HQ=1 (HQ uses DEQ's combined Industrial/Residential exposure scenario).

c. Total trihalomethanes, MCL=100 ug/L as sum of Chloroform, Bromoform, Bromodichloromethane and Chlorodibromomethane, EPA 822-B-96-002 indicates 80 ug/L as proposed rule.

Sources: i = Iris, h = Heast, n = NCEA, r = route to route extrapolations from established slope factors or reference doses, x = Withdrawn from Iris or Heast.

Table 11
Procedures for Evaluating the Cancer Risk and Hazard Quotient for Level 2 Compliance Wells

Industrial Carcinogenic Risk Determination using ESII Permit Condition IX.I.7.a.2

$$CR=[(C \times 1000\ ug/mg \times I \times F \times D)/(W \times 70\ yr \times 365\ d/yr)]xSFo$$

or for a given CR (i.e. 10^{-5})

$$C\ (ug/l) = \frac{(CR \times W \times 70 \times 365 \times 1000\ ug/mg)}{I \times F \times D \times Sfo}$$

Where:

Exposure Factors (Industrial)	
C = chemical concentration (ug/L)	
I = Ingestion rate (1 liter/day)	1
F = exposure frequency (days/yr)	250
D = exposure duration (yrs)	25
W = body weght (kg)	70
CR = cancer risk	
Sfo = Oral Slope Factor	

Calculating the Total Cancer Risk:

For each constituent detected at or above the EQL in a Level 2 Compliance Well, calculate the cancer risk (CR) as shown above, and sum as follows:

$$\text{Total Cancer Risk} = CR_1 + CR_2 + CR_3 + \ldots.$$

Industrial, Non-Carcinogenic Hazard Risk Determination using EPA Reg. IX PRG. Tap Water (as modified by DEQ)

$$HQ = \frac{C \times Efr \times Edr \times [(IRWa/RfDo) + ((VFw \times IRAa)/ RfDi)]}{Bwa \times Atn \times 1000\ ug/mg)}$$

or for a given HQ (i.e. 1)

$$C\ (ug/l) = \frac{(HQ \times Bwa \times Atn \times 1000\ ug/mg)}{Efr \times Edr \times [(IRWa/RfDo) + ((VFw \times IRAa)/ RfDi)]}$$

Where:

Exposure Factors (Industrial)	
C = Chemical concentration (ug/L)	
IRWa = Ingestion rate, water, adult (liter/day)	2
IRAa = Inhalation rate, adult (m^3/day)	20
EFr = Exposure frequency (days/year)	250
EDr = Exposure duration (years)	25
BWa = Body weight, adult (kg)	70
InhFadj = Inhalation factor ([m^3-yr]/[kg-d])	11
IFWadj = Ingestion factor, water ([l-yr]/[kg-d])	1.1
HQ = Hazard quotient	1
RfDo = Oral reference dose	
RfDi = Inhalation reference dose	
Atn = Averaging time (Edr X 365), (days)	9125
VFw = Volatilization factor for water (L/m^3)	0.5

Calculating the Total Non-Cancer Hazard Risk:

For each constituent detected at or above the EQL in a Level 2 Compliance Well, calculate the non-cancer hazard quotient (HQ) as shown above, and sum as follows:

$$\text{Total Hazard Index} = HQ_1 + HQ_2 + HQ_3 + \ldots.$$

TABLE 12
Compounds with Groundwater Protection Standards (40 CFR 264.94, TABLE 1)

Constituent	Maximum Concentration (mg/L)
Arsenic	50
Barium	1000
Cadmium	10
Chromium	50
Lead	50
Mercury	2
Selenium	10
Silver	50
Endrin (1,2,3,4,10,10-hexachlor-1,7-epoxy-1,4,4a,5,6,7,8,9a-octahydro-1, 4-endo, endo-5,8-dimethano naphthalene)	0.2
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	4
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenylethane)	100
Toxaphene ($C_{10}H_{10}Cl_6$) Technical chlorinated camphene, 67-69 percent chlorine)	5
2,4-D (2,4-Dichlorophenoxyacetic acid)	100
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	10

Data Reporting and Evaluation

ESII will evaluate the data from each compliance monitoring sample as described previously and as summarized below:

- For the occurrence of single constituents listed in Table 10, the one-half percent solubility for Level 1 Compliance Wells or the respective MCL, 10^{-5} industrial cancer risk, or HQ=1 for the modified industrial exposure for Level 2 Compliance Wells will apply.
- The composite impacts of multiple constituents will be determined by adding either the cumulative solubilities for Level 1 Compliance Wells or summing the cancer risks or hazard quotients for the Level 2 Compliance Wells.

Table 11 contains the procedure to use to calculate the Hazard Quotient and the cancer risk for any synthetic organic compound detected in a Level 2 Compliance Well. The resultant values will be compared to the allowable concentration limits described in this section.

If the evaluation of the compliance monitoring data indicates that one or more of the constituents listed in Table 12 has exceeded the groundwater protection standards, ESII will notify IDEQ of the exceedance within 7 days of making such a determination. Beginning with the next scheduled semiannual sampling event, ESII will collect the first four independent samples of the impacted well and associated background well. The second set of four independent samples will be collected during the next semiannual sampling event.

As described in the previous section, within 30 days of receiving the sample results on the second set of four independent samples, ESII will establish control limits for the background wells, compare the results to the downgradient wells, and report the results to IDEQ. If the downgradient wells are not out of control compared to the upgradient background wells, no action is necessary and compliance monitoring will continue as may be required based on the detection of organic constituents. Because of natural occurrences and spatial variations resulting from geochemical processes and aquifer matrices unrelated to site activities, exceeding groundwater protection standards for inorganic parameters will not automatically require ESII to begin corrective action. If the downgradient wells are out of control for inorganic constituents, ESII will submit a plan to DEQ to evaluate the cause of the exceedance within 60 days.

SECTION 7

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