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Report /

WORKPLANS

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Environmental Bureau
Oil Conservation Division

Remediation Report

1R-484
Elliott B-9 #2&3 Tank Battery

Unit D, Section 9, T22S, R37E
Lea County, New Mexico

LAI Project No. 6-0104-03

December 18, 2009

Prepared for:
John H Hendrix Corporation
110 N Marienfeld, Suite 400
Midland, TX 79701-4461

Prepared by:
William D. Green, PG No. 136
Texas Registered Professional Geologist

Larson & Associates, Inc.
507 North Marienfeld, Suite 200
Midland, Texas 79701

Larson & Associates, Inc.
Environmental Consultants

December 18, 2009

RECEIVED OCD
2009 DEC 18 P 2:50

Mr. Edward Hansen
State of New Mexico – Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Three OCD Remediation Projects – John H. Hendrix Corporation, Lea County, New Mexico:
No. 1R-483, Elliott B-9 #1,4,&5 Tank Battery, Unit C (NE/4, NW/4), Section 9, T22S, R37E
No. 1R-484, Elliott B-9 #2&3 Tank Battery, Unit D (NW/4, NW/4), Section 9, T22S, R37E
No. 1RP0465, Will Cary #5 Emergency Pit, Unit F (SE/4, NW/4), Section 22, T22S, R37E

Dear Mr. Hansen:

The three enclosed reports are submitted to the State of New Mexico Oil Conservation Division on behalf of John H. Hendrix Corporation by Larson and Associates, Inc., its agent, and present the proposed remedial effort at the referenced sites.

If you have any questions or concerns, please call me at 432.687.0901 to discuss.

Sincerely,

LARSON & ASSOCIATES, INC.

William D. Green, PG No. 136
Texas Licensed Professional Geologist
wgreen@laenvironmental.com

Attachments

CC Ms. Carolyn Haynes – JHHC Midland
Mr. Larry Johnson – OCD District 1

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December 18, 2009

1.0 Executive Summary

This report is submitted to the State of New Mexico Oil Conservation Division (OCD) on behalf of John H. Hendrix Corporation (JHHC) by Larson and Associates, Inc. (LAI), its agent, and presents the proposed remedial efforts at referenced site.

The site is located at Unit D, Section 9, T22S, R37E, Lea County, New Mexico. The site is a former closed production pit, in which surface produced water was disposed. Surface soil has been previously excavated to approximately seven feet below ground surface (bgs), and the soil operable unit remediated by installing a 20-mil thick polyethylene liner to prevent the permeation of meteoric water and the vertical migration of *in situ* chlorides. The surface has been returned to productive capacity with 85% to 90% revegetation of range grass and brush. The remedial options for the groundwater operable unit and a proposed natural attenuation remedy are discussed in this report.

2.0 Responsible Party Contact Information

JHHC's contact for environmental concerns is:

Ms. Carolyn Haynes
John H. Hendrix Corporation
110 N. Marienfeld, Suite 400
Midland, Texas 79701
Office – 432.684.6631, Cell – 575.390.9689
Email – cdoranhaynes@jhhc.org

3.0 Historic Information

The release at this site was identified through the investigation of a closed production pit. The site is located approximately 1.5 miles south of Eunice, New Mexico. Figure 1 presents the site location plotted on a topographic map.

4.0 General Site Characteristics

The Elliot B-9 #2&3 site is at latitude N 32° 24' 44.63", longitude W 103° 10' 31.30" (Figure 1). The surface estate is owned by Mr. Charlie Bettis and is used for oil and gas production and occasional livestock grazing.

The surface elevation is approximately 3,420 feet above mean sea level and slopes gently east-southeast. The nearest surface water is more than two miles from the site. Surface soil is comprised of windblown sand with a vegetation cover of shin oak, sand burr grass, and yucca. No water wells were identified within 1,000 feet of the site using the Office of the State Engineer (OSE) Water Right Lookup database.

Several pipelines are either within the release investigation area, or are adjacent to the points of release. Three pipelines (owned by other interests) were exposed during the soil excavation phase of remediation, and the impervious liner placed below these pipelines.

5.0 Geology

The *Geologic Map of New Mexico* (2003) and the *Geologic Atlas of Texas, Hobbs Sheet* indicate the vicinity's surface geology is comprised of Holocene to mid-Pleistocene age, interlaid eolian and piedmont-slope deposits. This material covers the eastern flank of the Pecos River valley. These surficial deposits are primarily derived from reworking the underlying Tertiary-aged Ogallala Formation of the Southern High Plains, which is also comprised of alluvial and eolian deposits with petrocalcic soils. The Ogallala Formation is comprised of fluviatile sand, silt, clay and localized gravel, with indistinct to massive crossbeds. The Ogallala sand is generally fine- to medium-grained quartz, and is known to contain arsenic, barium and other heavy metals in an easily mobilized Van der Waals bonded surficial coating.

Monitor well boring logs indicate a general lithology of an unconsolidated veneer of eolian sand over an eight- to 20-foot thickness of carbonate-indurated sand (caliche). The caliche layer is most like a zone of illuviation where carbonate dust accumulates from surface transportation by meteoric gravity water transitioning to capillary water. Beneath the caliche layer is a thickness of fine-grained reddish-yellow quartz sand. Red-beds were not encountered at 90' bgs, but using data from other investigations in the area, are less than 100 feet bgs. Depth to groundwater is approximately 80 feet bgs, based on monitor wells data (Table 1).

5.1 Regional Structure

The site is located over the north-central portion of the Central Basin Platform, a large elevated block between the Delaware and Midland Basins of southeastern New Mexico and West Texas. Prior to late Mississippian time this region had only mild structural deformation, producing broad shallow depressions and regional arches. Tectonic events associated with the Marathon-Ouachita orogeny in the late Mississippian uplifted the platform and subsequent Pennsylvanian and early Permian deformation compressed and faulted the area. Deformation ceased in the early Permian, as evidenced by high angle faulting that ended during Wolfcampian-aged sedimentation, and the presence of younger strata draped over the preexisting structures. A period of tectonic quiescence followed, during which erosion and gradual subsidence took place. An expanding sea eventually covered the area, depositing several thousand feet of evaporites, carbonates, and shales.

During Triassic time the region underwent slow uplift and erosion followed by down-warping that created a large landlocked basin that was filled with sediments that accumulated in flood plain, deltaic and lacustrine environments. This was followed by another period of erosion during Jurassic time, and a final marine inundation by Cretaceous seas, resulting in the deposition of a basal clastic unit with overlying marine shales and carbonates.

The Laramide Orogeny (when Rocky Mountains were formed) uplifted the area west of the Permian Basin and the Cretaceous sea retreated to the south and east. There has been no significant faulting since Permian time; only gentle regional tilting with some local folding and small scale faulting. Hills

(1970) postulated that later normal movement may have occurred by reactivation of existing faults, but that the movement was not sufficient to noticeably displace the overlying Permian strata. Hills (1970) further postulated that late movement along the faults may have created a conduit for fresh water for dissolution of Permian evaporite beds. The faults and fractures in the vicinity of the site do not appear to be active. Tension fractures being somewhat more open may be able to hold water longer and thereby account for the enhanced vegetation and development of erosional features such as playas along fractures. On January 2, 1992, a magnitude 5 earthquake beneath the Drinkard Oilfield (approximately seven miles southeast of the facility) demonstrated that the region is not totally without seismic activity.

5.2 Regional Stratigraphy

Regionally, the Precambrian basement is overlain by marine Cambro-Ordovician platform carbonates and Silurian-Devonian carbonates and shales. These sediments are truncated unconformably by Permian deposits consisting of marine shale, limestone, sandstone, marl, and evaporites. Permian age deposits are unconformably overlain by the Triassic Chinle Group. The Triassic Chinle Group is described as a series of fluvial and lacustrine mudstone, siltstone, sandstone, and silty dolomite strata. Cretaceous sediment strata were deposited as a shallow sea transgressed across the region, and unconformably overlie the Chinle Group. As the shallow sea regressed much of the Cretaceous section was eroded away prior to deposition of the overlying Tertiary Ogallala Formation. The depositional facies of the Ogallala Formation is a series of fluvial valley fills with both valley fills and interfluves overlain by eolian sediments. The Quaternary Blackwater Draw Formation, which overlies the Tertiary Ogallala Formation, consists of windblown sands, silts, and clays.

In the Eunice area, the Ogallala formation consists mainly of unconsolidated to poorly consolidated, very fine to medium-grained sand and gravel, with minor amount of silt and clay up to 30 feet thick under the site. Locally the "c" horizon of the modern soil is called the caprock caliche. The caprock is a hard, erosion resistant, pedogenic calcrete that is typically five to ten feet thick but may exceed 20 feet in some areas. In areas, the caliche is actually forming in, and incorporating, Holocene sediments, and often "Caprock" is a misnomer, as the caprock can be found as a deeper stratum in these areas. The upper-most unit, the Blackwater Draw Formation, consists of reddish brown, very fine to fine grained eolian sand with minor amounts of clay and caliche.

6.0 Site Investigation

Site investigation activities were divided into two logical operations units – soil and groundwater. Previous investigations of both media discussed in the following sections.

6.1 Soil Investigation and Remediation

The initial soil investigation was proposed in February 2006. Revisions were made to the work plan in March 2006, with the OCD approving the investigative activities on March 29, 2006. Ten soil borings were installed north of the tank battery in two areas of concern on June 27, 2006, with subsequent soil investigations on July 5, 2006, October 4, 2006, and October 30, 2006. Total Petroleum Hydrocarbons (TPH), benzene, or the light-end BTEX constituents were observed in near-surface samples, but quickly attenuated with depth. Chloride distribution attenuated quickly with depth in all borings except BH-10.

BH-10 appears to have been situated within the former production pit. Chloride values in this boring increased to approximately to 978 milligrams per kilogram (mg/Kg) at 25 feet bgs then decreases erratically with depth.

On December 17, 2007, the OCD approved the pit closure plan (Appendix A). Between May 5, 2008, and May 30, 2008, soil remediation was conducted at the site. The top seven feet of soil was removed from approximately 3,000 square feet of potentially affected land in the north area of concern. Additionally, the south area of concern was excavated to about two feet bgs. A total of 4,548 cubic yards of soil was removed for treatment at the JHHC centralized surface waste management facility (NM-02-0021). The north pit excavations were lined with 20-mil polyethylene geotextile to prevent surface water infiltration prior to backfilling. The surface has been returned to productive capacity with 85% to 90% revegetation of range grass and brush.

6.2 Groundwater Investigation

Prior reported groundwater investigation activities consist of the installation of three monitor wells. MW-01 was installed on October 16, 2007 near the southeast (downgradient) corner of the closed pit. Laboratory analytical results indicated impacted water quality exhibiting chloride and total dissolved solids (TDS) concentrations exceeding New Mexico Water Quality Control Commission Domestic Water Supply (DWS) standards.

Hydrocarbons and targeted volatile organic compounds were not detected. MW-02 was installed upgradient of the site on December 4, 2007. This well exhibited chloride and TDS values within the DWS standards.

On June 29, 2009, LAI installed MW-03 in the downgradient direction, with locations concurred upon by the OCD. The downgradient well exhibited chloride and TDS values below DWS standards.

The three monitor wells associated with this site are aligned with the apparent groundwater gradient (Figure 3). Gauging data on September 10, 2009 indicates a slight groundwater mound exists under MW-01. Groundwater elevation is between 3,347.44 feet (MW-02) and 3,346.32 feet (MW-03). Groundwater gradient direction is towards the east-southeast based upon the plot of the two nearby Elliott B-9 facilities (#2&3 – this site, and #1,4,5), but may be more southerly than the six monitor well configuration suggests. Groundwater gradient slope between the two facilities is approximately 0.00109 ft/ft, consistent with the previous event (June 2009).

Chloride and TDS concentrations exhibited during September 2009 were below DWS standards for MW-02 and MW-03, while MW-01 exhibited 3,750 milligrams/liter (mg/l, parts per million) chlorides and 7,260 mg/l TDS (Figures 4 & 5, Appendix B). These values are consistent with, although slightly lower than, those values reported from the June monitoring event. Chloride concentrations in the upgradient monitor well (MW-02) and downgradient monitor well (MW-03) have remained relatively stable since monitoring was initiated, at 200 mg/l and 84 mg/l, respectively. Chloride concentrations in the source well, MW-01, have fluctuated from a low concentration in September 2008 (3,400 mg/l) to a high concentration in June 2009 (4,500 mg/l). As previously mentioned, geotextile liners were installed in the former pits in May 2008 chloride concentrations in groundwater are expected to gradually decline as gravity water and capillary water draining from beneath the liners decreases.

7.0 Factors Affecting Chlorides in Groundwater Remediation

Chloride migration is controlled by a combination of vadose zone and the aquifer characteristics, as well as Federal, State and local regulations. A complete review of applicable, or relevant and appropriate regulations (ARARs) is not required by the OCD, and is not included in this report. However, a synopsis of pertinent New Mexico regulations are included in support of the decision making process.

7.1 Vadose Zone Characteristics

A few simple principles of soil water and vadose zone morphology must be explained to understand its function in the vertical contaminant transportation.

Soil water is one of three types of water held in the interconnected voids between soil particles: hygroscopic water, capillary water, and gravity water.

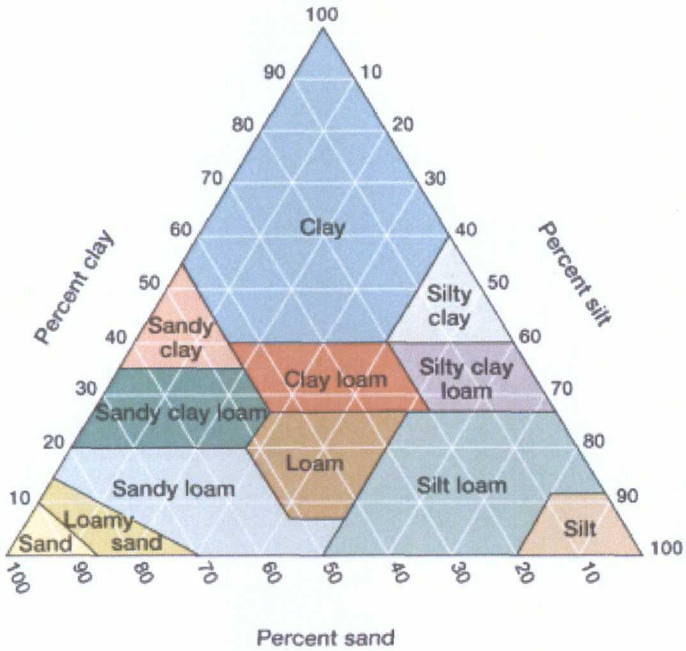
- **Hygroscopic water** is the thin film of water surrounding soil particles and held by Van der Waals attraction. Hygroscopic water is not readily available to plant uptake and may be bound by adhesive forces up to 10,000 bars.
- **Capillary water** is held by cohesive surface tension. This surface tension varies with the chemical composition of the water, and the water can be removed by plant absorption or air drying.
- **Gravity water** is water moving through soil by gravity.

The **vadose zone** is defined as the zone of aeration; that is the unsaturated soils and sediments overlying the saturated zone. The vadose zone can be divided into an upper pendular zone, and lower funicular zone which respond to soil moisture in different ways.

The **pendular** zone is affected by meteoric water percolating into the subsurface. This unit is named for the fluctuating moisture content in response to meteoric events much like a pendulum moves back and forth. In this zone all three types of soil water can be observed in response to recharge events: hygroscopic water between grains, capillary wicking of recharge as a multidirectional wetting front, and gravity water percolating downward.

The **funicular** zone is also called the capillary fringe. In this zone water may move upward under capillary tension some distance from the saturated interface. As gravity water interacts with the capillary water some of the dissolved solids entrained from eluviating material may precipitate into a zone of illuviation. This is one of the processes which creates caliche above the water table. This process is evident in the arid region of southeast New Mexico. Where groundwater potentiometric levels have declined over the millenniums, a caliche horizon may remain as a relic of past conditions.

The proportion of sand, silt, and clay in a soil or sediment – the soil texture – affects the downward migration of water and dissolved constituents. Lithology constrains flow with the size and the interconnection of open pores in the soil or sediment. Clean gravel generally exhibits large, well-connected pore spaces while clay has smaller pores with poorer connectivity but a higher porosity. As a result, the saturated hydraulic conductivity of gravel is higher than the saturated hydraulic conductivity of clay. In the vadose zone the ability of a soil or sediment to transmit chloride depends on how much of the available pore space is filled with water. In a nearly dry soil or sediment, capillary forces hold the water in place, preventing movement. As the moisture content of a soil or sediment increases, more pores become interconnected with water and the soil water pressure increases, also increasing the ability of the unit to transmit water and chloride.



USDA Soil Texture Chart

The site's vadose zone is relatively thick, approximately 80 feet. The primary lithologic soil texture is silty fine sand using the Unified Soil Classification System, which mostly fall into the "sandy loam" category using USDA classification.

Soil moisture content reported from laboratory analyses ranges from 0.3% to 31.9%, with a mean value of 10.1%, a median value of 8.2%, and a mode value of 16.5%. The low value was reported from a sample retrieved from the surface, while the high value was observed in a sample retrieved from about 6 feet bgs.

Geotechnical analyses have not been conducted on the vadose zone strata, but porosity and permeability values can be estimated from published literature values using observed soil textures. Using the values from the *Handbook of Hydrology* (Maidmont, 1993), sandy loam has an effective porosity between 28.3% and 54.1%, with a mean value of 41.2%; the effective porosity is comparable to the specific yield. This same reference lists the residual water content for sandy loam between 2.4% and 10.6%, with a mean value of 4.1% which is similar to laboratory analytical data from the site.

7.2 Aquifer Characteristics

Saturated zone (aquifer) and groundwater movement are generally characterized by the groundwater production features explained by Henry Darcy and other scientists. Values of interest include **Hydraulic Conductivity**, the measure of the ability of fluid to move through the interconnected void spaces of the soil media; **Transmissivity**, the measure of volume at which fluid moves through a unit width of an aquifer under hydraulic gradient; and **Storativity**, the volume of water released from storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer. Hydraulic conductivity is generally estimated from slug test response, while transmissivity and storativity are calculated from aquifer response to stresses from a pumping test. Slug test results are summarized in the following section. Pump testing has not been performed to provide empirical data for modeling, therefore estimates must be used from literature data.

7.2.1 Slug Test Data

Aquifer slug testing was conducted to provide hydraulic conductivity estimates for the design of a remediation pump test. Tests were conducted in monitor well MW-1, southeast and downgradient of the suspected source area. Testing consisted of two hydraulic slug-in falling head tests, followed by three iterations of solid slug falling head and rising head cycles. A synopsis of the procedures and data interpretation follows.

A slug test consists of measuring groundwater head recovery in a well after a near-instantaneous change in head at that well. This is done by rapidly introducing a solid object (the "slug"), or removing the same, into the well causing an abrupt change in water level. The water level in the well returns to static conditions as fluid moves in or out of the well in response to the gradient forced by the sudden change in head. The hydraulic head changes through time, the response data, can be used to estimate the hydraulic conductivity of the formation through comparisons with theoretical models of test response. This data can be used to predict the subsurface movement of a contaminant, and to design a remediation plan. The analysis of response data from slug tests involves fitting straight lines or type curves to plots of field data. To ensure the quality of response data, LAI used an In-Situ® Troll 700 pressure transducer to log the aquifer response in one-second intervals.

AQTESOLV® software provides a variety of slug test response solutions based upon the aquifer conditions encountered. At the Site the bulk of the aquifer is comprised of silty-fine sand primarily deposited by aeolian processes. The High Plains/Ogallala system is considered an unconfined aquifer under water table condition. Based upon the observed aquifer conditions, the Bouwer-Rice slug test solution (1976) was chosen to evaluate the response data.

Bouwer-Rice (1976) developed a method for the analysis of an overdamped slug test in a fully or partially penetrating well in an unconfined aquifer. The Bouwer-Rice method employs a quasi-steady-state model that ignores elastic storage in the aquifer. Assumptions used in the Bouwer-Rice solution include:

- Aquifer has infinite areal extent
- Aquifer is homogeneous and of uniform thickness in the vicinity of the test well
- Test well is fully or partially penetrating
- Flow to well is quasi-steady-state (storage is negligible)
- Volume of the slug is injected into or discharged from the well instantaneously

To perform the slug test analysis, a graph of the slug test data is made by plotting the head difference (y) logarithmically on the Y-axis versus time (t) on the X-axis. The section of the graph which best approximates a straight line slope is used to determine yo , yt , and t. Once the values for yo , yt , t, and natural logarithm of the effective well radius are obtained, they are used to calculate the hydraulic conductivity (K).

The numeric results of the response data indicates a mean falling head hydraulic conductivity of 0.569 ft/day, while the rising head data had a mean hydraulic conductivity of 0.692 ft/day; the average of both rising and falling head tests is 0.631 ft/day. The falling head conductivity extremes were 0.4841 ft/day (Test 3) and 0.8569 ft/day (Test 5); the rising head conductivity extremes were 0.501 (Test 3) and 0.9642 (Test 4). All of the tests appear to indicate the water-bearing zone is composed of silts or fine to coarse sand (Maidmont, 1993), which is consistent with soil boring logs produced during well installation. AQTESOLV printouts are included as Appendix C.

7.2.2 Literature Data

In the Eunice, NM area, groundwater gradient is relatively flat (0.00109 ft/ft, about six feet per mile), and discharge rates are generally very low. Recovering five gallons per hour (gph) in a 4-inch diameter well is often beyond production capacity in this region. Theis estimated the average porosity of the Ogallala aquifer in Lea County at 35% (1934, p.133). This estimate is within other literature value for the previously discussed range of sandy loam soil. Theis also calculated the hydraulic conductivity in and near Lea County, with an estimate of 2 to 17 feet per day and an average of 8 feet per day. Similarly, Theis calculated the specific yield to average 24%.

7.2.3 Long-Term Pump Test Observations from Nearby Sites

In 2008 a pump test was initiated at the Will Cary #5 Emergency Pit (1RP0465) to determined if a well could be continuously pumped at a rate of 80 ml/minute. In 2008 the system recovered a total of 368 gallons of chloride-impacted water.

In 2009 the system was estimated to recover approximately 520 gallons, about 10 gallons per week. The system was not without problems. Initially a solar-battery powered pneumatic pump was installed in MW-1. This pump operated at the maximum recovery capacity, about 80 ml/minute. Oilfield thieves stole the solar panel and battery. The pneumatic system was then changed to use compressed nitrogen tanks; the regulator was stolen and replaced. In June the inlet of the pump started pulling in silt. The pump was reset, but did not remedy the problem. Given the extremely low recovery rate, averaging 3.76 ml/minute, it was decided to remove the pump from the well.

Since the lithology and water-bearing strata are the same geologic units, and the two sites are only located 2.5 miles from each other, and the Elliott B-9 #2&3 site has a relatively short water column (about 3 feet), similar poor recoveries are predicted for the Elliott site.

7.3 Meteoric Infiltration

Precipitation and evaporation affect the water content of the vadose zone and are a control mechanism for contaminant migration. In arid climates, where rainfall occurs in short-duration thunderstorms between extended dry periods, infiltration is not uniform and occurs primarily after large precipitation events. This results in a vadose zone with relatively low water content, as observed in empirical site data. Theis estimated the net infiltration for the area between ¼ and ½ inch per year. There should not be any recharge at the site mobilizing vadose zone contaminants, as the former pits were excavated and the impermeable geotextile liner would preclude vertical migration.

AMIGO Modeling

The American Petroleum Institute (API) has developed AMIGO software as a screening tool to simulate the chloride concentration in a water table (unconfined) aquifer affected by a surface release of chloride. AMIGO uses the output from HYDRUS-1D simulations in a ground water mixing model to graph chloride concentrations over time. The technical basis for AMIGO is presented in the API Publication 4734, *Modeling Study of Produced Water Release Scenarios* (Hendrickx and others, 2005). This program is designed to produce two output graphs; one for chloride concentration to depth in the vadose zone, the second for the flux of chlorides from the vadose zone to groundwater over time. AMIGO was designed with climatic data from the Permian Basin/Hobbs area.

A model run was conducted with the AMIGO tool (Appendix D). Site specific data from BH-10 was input for the vertical profile, with model defaults for the Lea County area. The model results mimic the limited empirical data, both of which support the removal of the surface source as adequate to abate chlorides leaching to the subsurface and groundwater from meteoric infiltration.

7.4 Regulatory Requirements

In New Mexico, groundwater extraction must be permitted by the New Mexico Office of the State Engineer (OSE), with the extracted groundwater subjected to beneficial use determination. Based upon experience with other remediation efforts, the removal of groundwater for remediation purposes is not considered a beneficial use by the OSE. Furthermore, if groundwater is extracted, reinjection to flush contaminants would require the issuance of a Discharge Permit from the New Mexico Environmental Division (NMED).

8.0 Remedial Options

Unlike hydrocarbons which can be broken into simpler, and less harmful chemicals, terrestrial microorganisms in groundwater do not digest, transform, or affix chloride compounds. Chloride impacted groundwater is typically addressed in one of three ways: pump and treat, pump and dispose, or natural attenuation. The remedial option choice is greatly affected by the site location infrastructure, the physical/chemical conditions at the location and regulatory requirements.

8.1 Pump and Treat

This method extracts chloride impacted groundwater, *ex situ* treats the entrained water, and re-injects the water into the aquifer to flush residual chlorides. Groundwater restoration requires a treatment system, such as reverse osmosis, fractional distillation, or electrodialysis. Each of these technologies creates an effluent of concentrated salts and removed metals requiring waste stream permitting.

8.1 Pump and Dispose

Although similar to a pump and treat system, this method permanently removes water from the aquifer. Extracted groundwater is routed to a disposal system. In the Eunice oilfield, injection wells would entrain and inject water deep into an oil production zone or into another receiving strata, often liquid depleted salt domes.

8.3 Natural Attenuation

The natural attenuation factors for chlorides consist of dilution and dispersion in the aquifer. This technique depends upon aquifer flow and time to reduce concentrations. This technique works best where chloride concentrations in ground water pose little risk to human health or the environment.

9.0 Remedial Selection

The following site observations or estimations have been identified:

- The vadose zone is approximately 80 feet thick
- There should not be any recharge at the site mobilizing vadose zone contaminants due to geotextile liners
- Depth to groundwater is approximately 80 feet bgs
- Red-beds (the bottom of the saturated zone) most are likely less than 100 feet bgs
- Groundwater gradient is relatively flat at 0.00109 ft/ft, about six ft/mile
- The maximum observed chloride content in groundwater during the most recent event is 3,750 mg/L adjacent to the source area
- The maximum observed downgradient chloride content in groundwater is 100 mg/L
- Soil sample moisture content has a median value of 8.2%
- Slug test average hydraulic conductivity is 0.631 ft/day
- Theis calculated the specific yield to average 24%
- Theis estimated the net infiltration for the area between ¼ and ½ inch per year
- The New Mexico OSE requires extracted groundwater meet beneficial use determination

10.0 Conclusions

- Groundwater gradient slope between the two facilities is towards the east-southeast at approximately 0.00109 ft/ft.
- Elliott B-9 #2&3 Tank Battery has chloride and TDS concentrations exceeding DWS values only in the source area MW-01, 3,750 mg/l and 7,260 mg/l, respectfully. MW-02 (upgradient) and MW-03 (downgradient) are within DWS values, and have been within DWS values since the initiation of groundwater investigation.
- Chloride concentrations in groundwater have remained relatively stable, with reductions anticipated as gravity water and capillary water draining from beneath the liners decreases.
- AMIGO computer modeling indicates the removal of the surface source is adequate to abate chlorides leaching to the subsurface.

11.0 Recommendation

Using site data and modeling, LAI recommends monitoring the site to confirm natural attenuation occurs as the vadose zone waters react to the source removal and geotextile capping.

Table 1
Monitor Well Completion and Gauging Summary
John H. Hendrix Corporation
Elliott B-9 Tank Battery #2 and #3 (*1R0484*)
Unit D (NW/4,NW/4), Section 9, Township 22 South, Range 37 East
Lea County, New Mexico

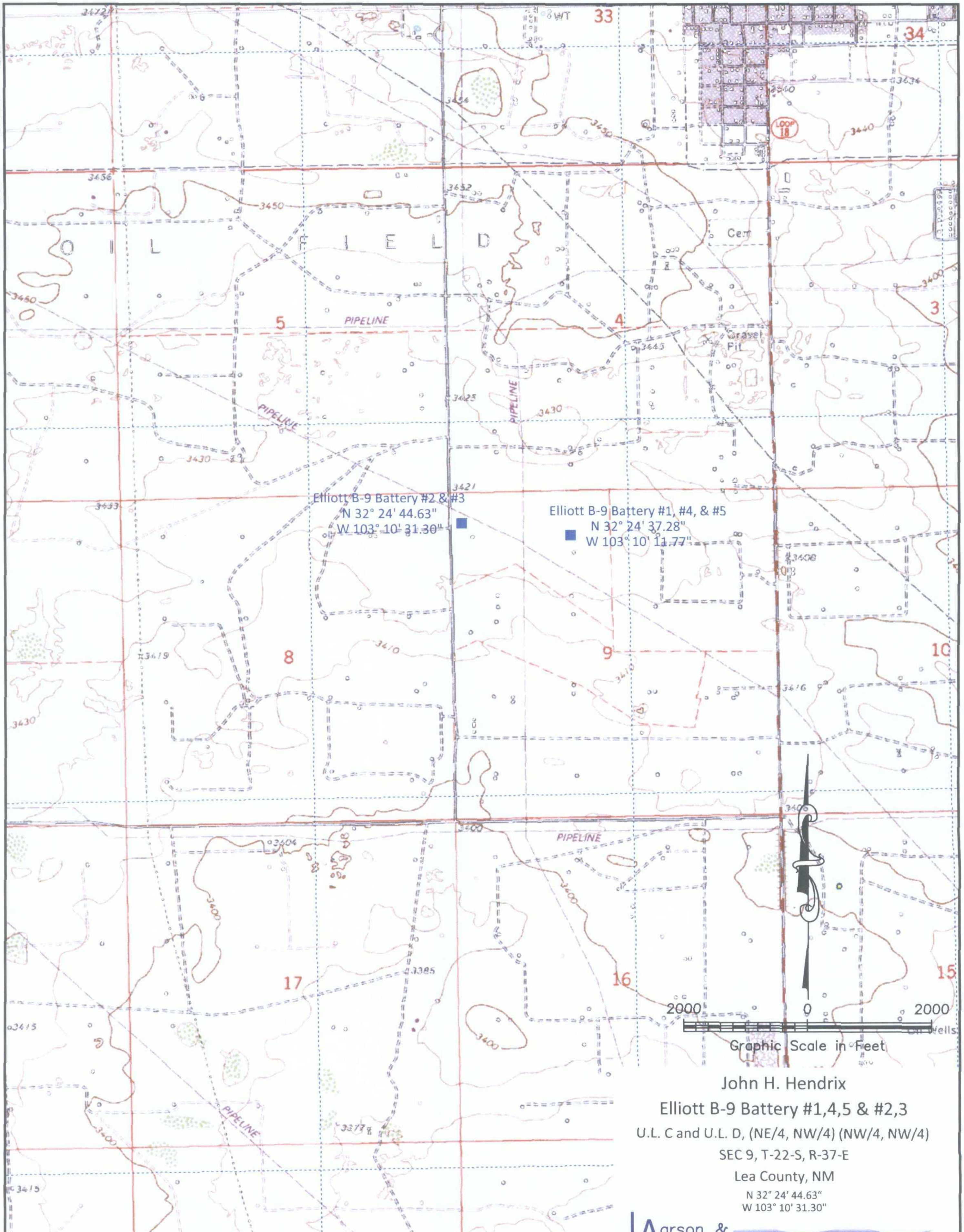
Well Information									Groundwater Data			
Well ID	**Date Drilled**	**Drilled Depth (bgs)**	**Well Diameter (inches)**	**Surface Elevation**	**Screen Interval (bgs)**	**Casing Stickup**	**TOC Elevation**	**Well Depth from TOC**	**Date Gauged**	**Depth to Fluid**	**Depth to Water**	**Corrected Water Elevation**
MW-1	10/16/2007	90	2	3,425.80	66.13 - 85.07	2.61	3,428.41	85.00	10/16/2007	--	79.44	3,348.97
									4/7/2008	--	82.13	3,346.28
									9/4/2008	--	82.11	3,346.30
									6/3/2009	--	81.94	3,346.47
									6/30/2009	--	81.97	3,346.44
									9/10/2009	--	81.94	3,346.47
MW-2	12/3/2007	90	2	3,425.40	66.13 - 85.44	2.59	3,427.99	86.07	12/4/2007	--	79.48	3,348.51
									4/7/2008	--	80.75	3,347.24
									9/4/2008	--	80.73	3,347.26
									6/3/2009	--	80.57	3,347.42
									6/30/2009	--	80.55	3,347.44
									9/10/2009	--	80.55	3,347.44
MW-3	6/29/2009	86	2	3,424.70	66 - 86	2.34	3,427.04	89.93	6/30/2009	--	80.74	3,346.30
									9/10/2009	--	80.72	3,346.32

Notes
bgs - below ground surface
TOC - top of casing
Wells drilled and constructed by Scarborough Drilling, Inc., Lamesa, Texas, Schedule 40 screw-threaded PVC casing and screen.

Table 2
Water Quality Parameters Summary
John H. Hendrix Corporation
Elliott B-9 Tank Battery #2 and #3 (1R0484)
Unit D (NW/4,NW/4), Section 9, Township 22 South, Range 37 East
Lea County, New Mexico

Water Quality	Collection Date	Alkalinity, Total	Chloride	Nitrate	Sulfate	Total Dissolved Solids
NMWQCC Standard (mg/L)		--	**250**	**10**	**600**	**1,000**
MW-01	10/16/2007	271	**3,500**	9.87	243	**6,610**
	4/8/2008	273	**4,410**	--	226	**7,980**
	9/4/2008	340	**3,400**	--	177	**6,440**
	6/3/2009	342	**4,500**	--	202	**7,790**
	9/10/2009	--	**3,750**	--	--	**7,260**
MW-02	10/16/2007	188	222	--	205	973
	4/8/2008	210	229	--	203	920
	9/4/2008	280	194	--	173	856
	6/3/2009	259	204	--	188	892
	9/10/2009	--	200	--	--	879
MW-03	6/30/2009	--	100	--	--	622
	9/10/2009	--	84	--	--	589

Notes
Alkalinity analyzed via EPA Method 310.1.
Anions analyzed via EPA Method 300.
TDS analyzed via EPA Method 160.1.
All values reported in Milligrams per liter (mg/L, parts per million).
< - Indicates the value is less than Method Detection Limit (MDL).



John H. Hendrix

Elliott B-9 Battery #1,4,5 & #2,3

U.L. C and U.L. D, (NE/4, NW/4) (NW/4, NW/4)

SEC 9, T-22-S, R-37-E

Lea County, NM

N 32° 24' 44.63"
W 103° 10' 31.30"

Larson & Associates, Inc.
Environmental Consultants

Figure 1- Topographic Map

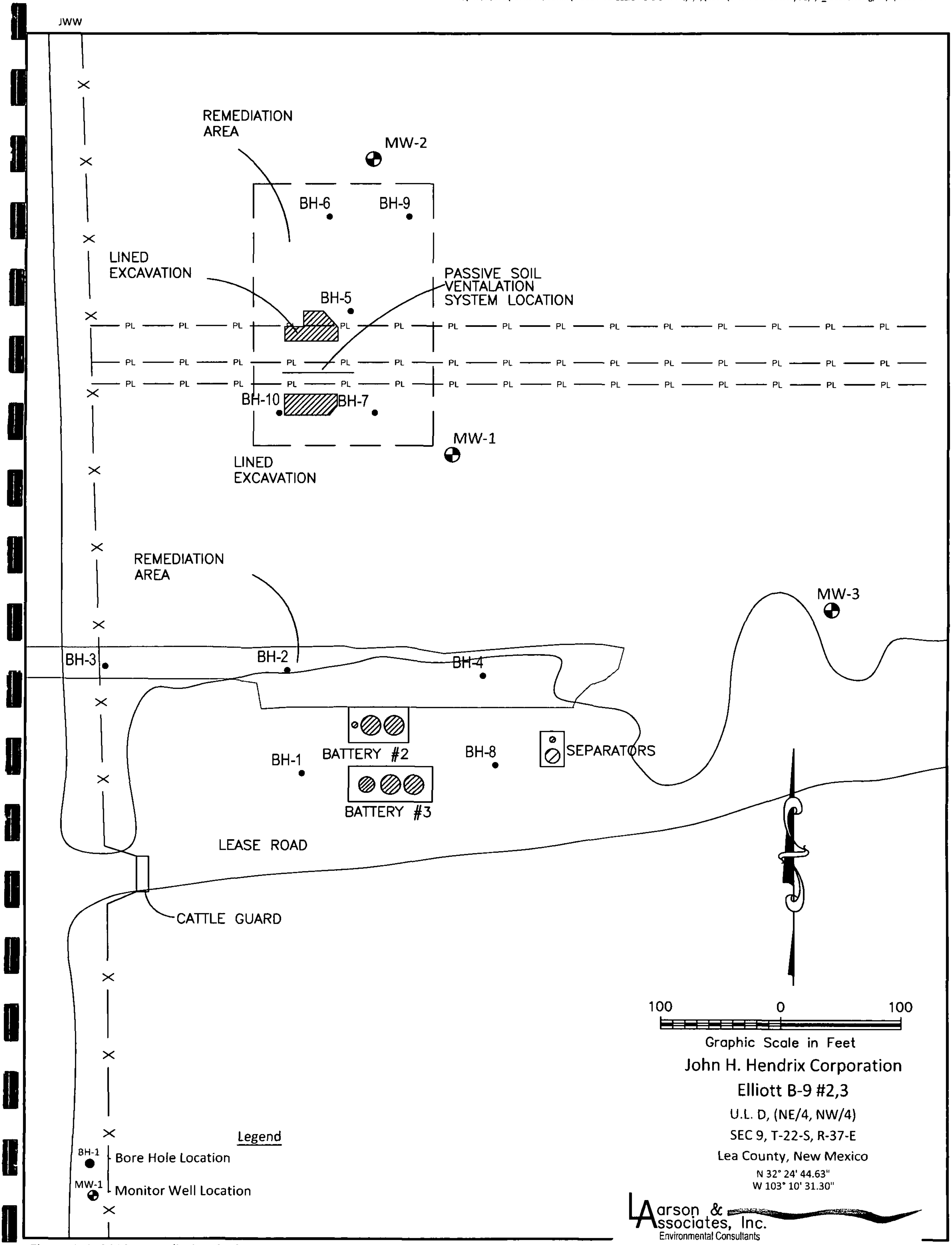


Figure 2- IR0483 Remediation And Excavation Areas

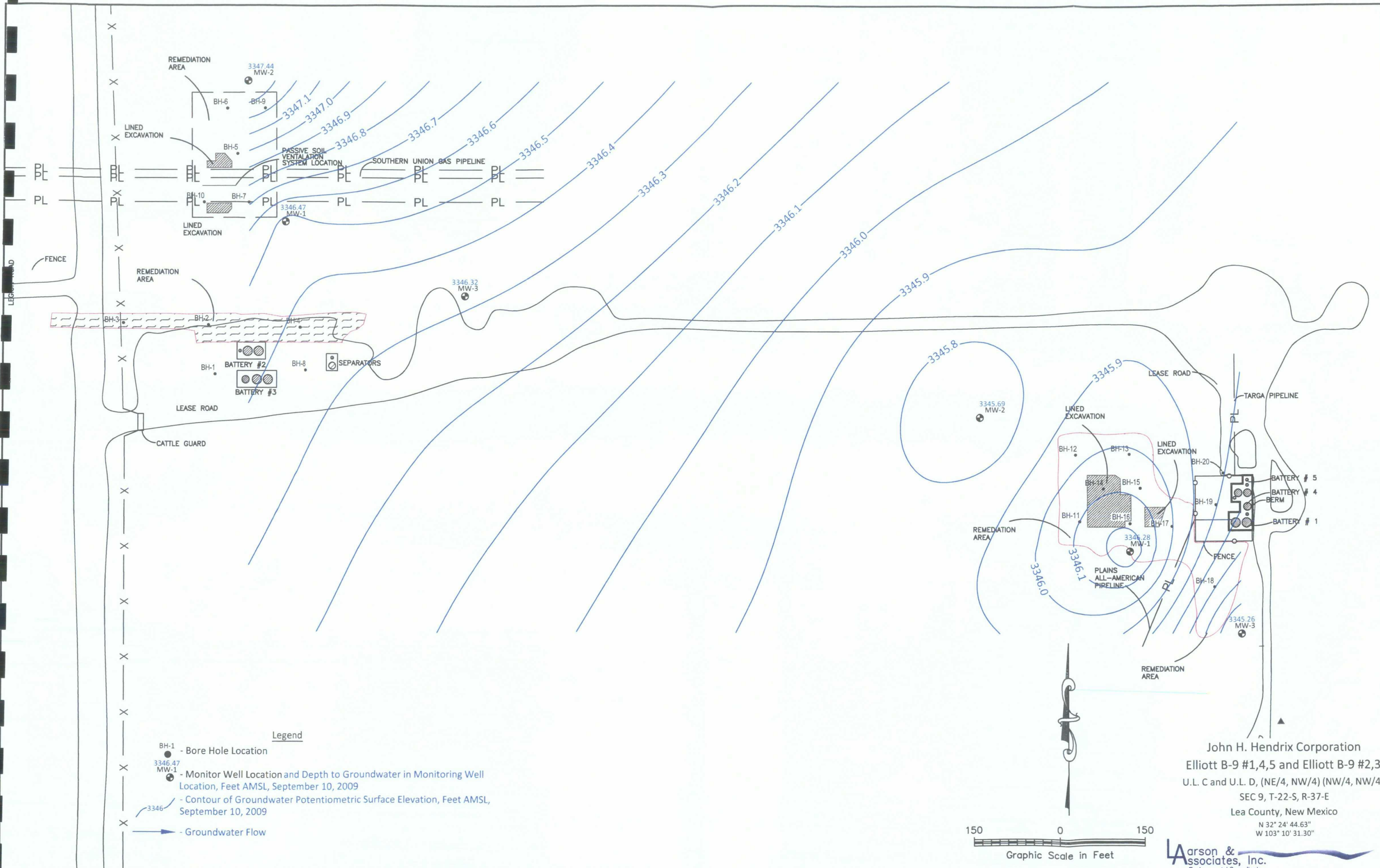
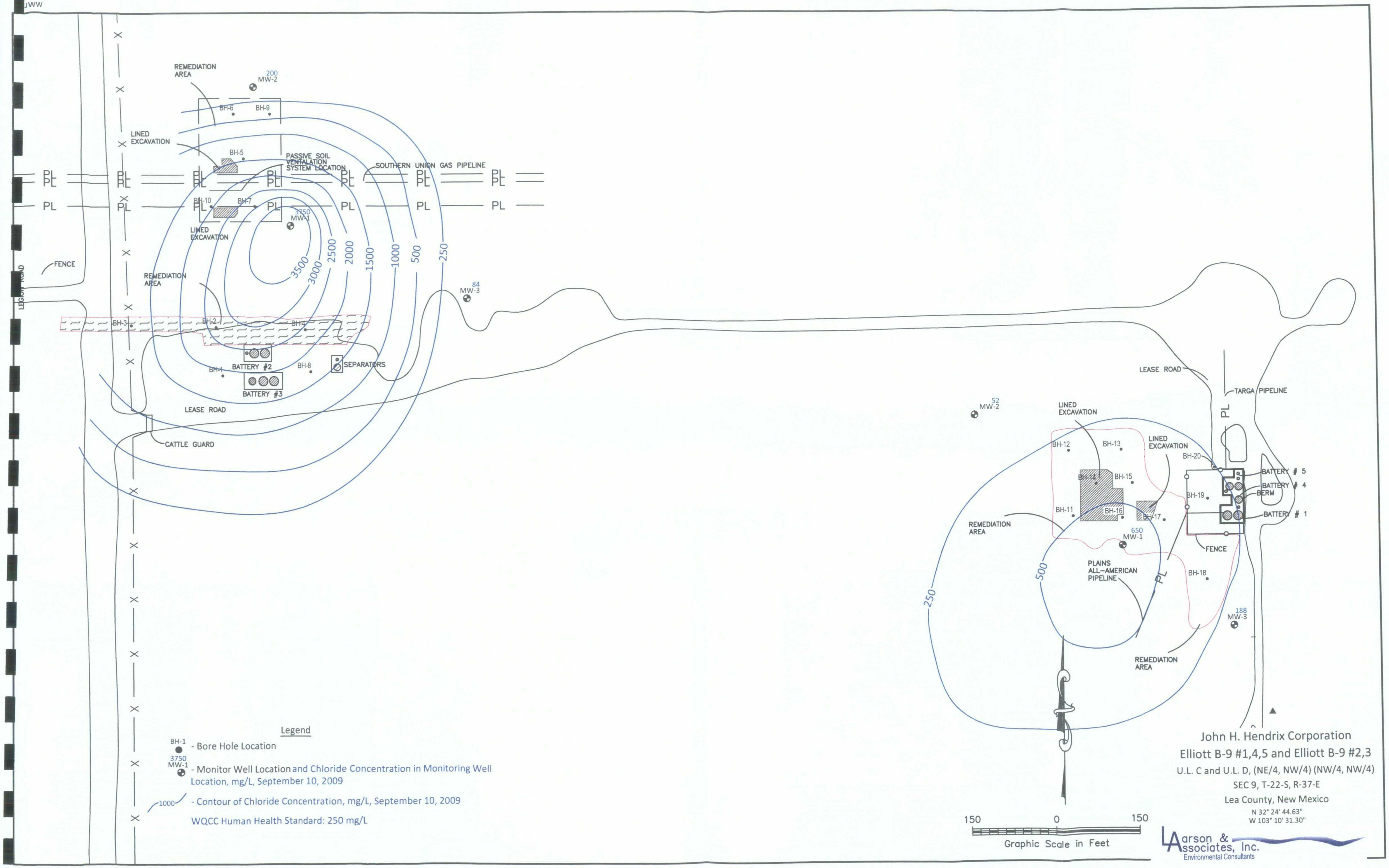


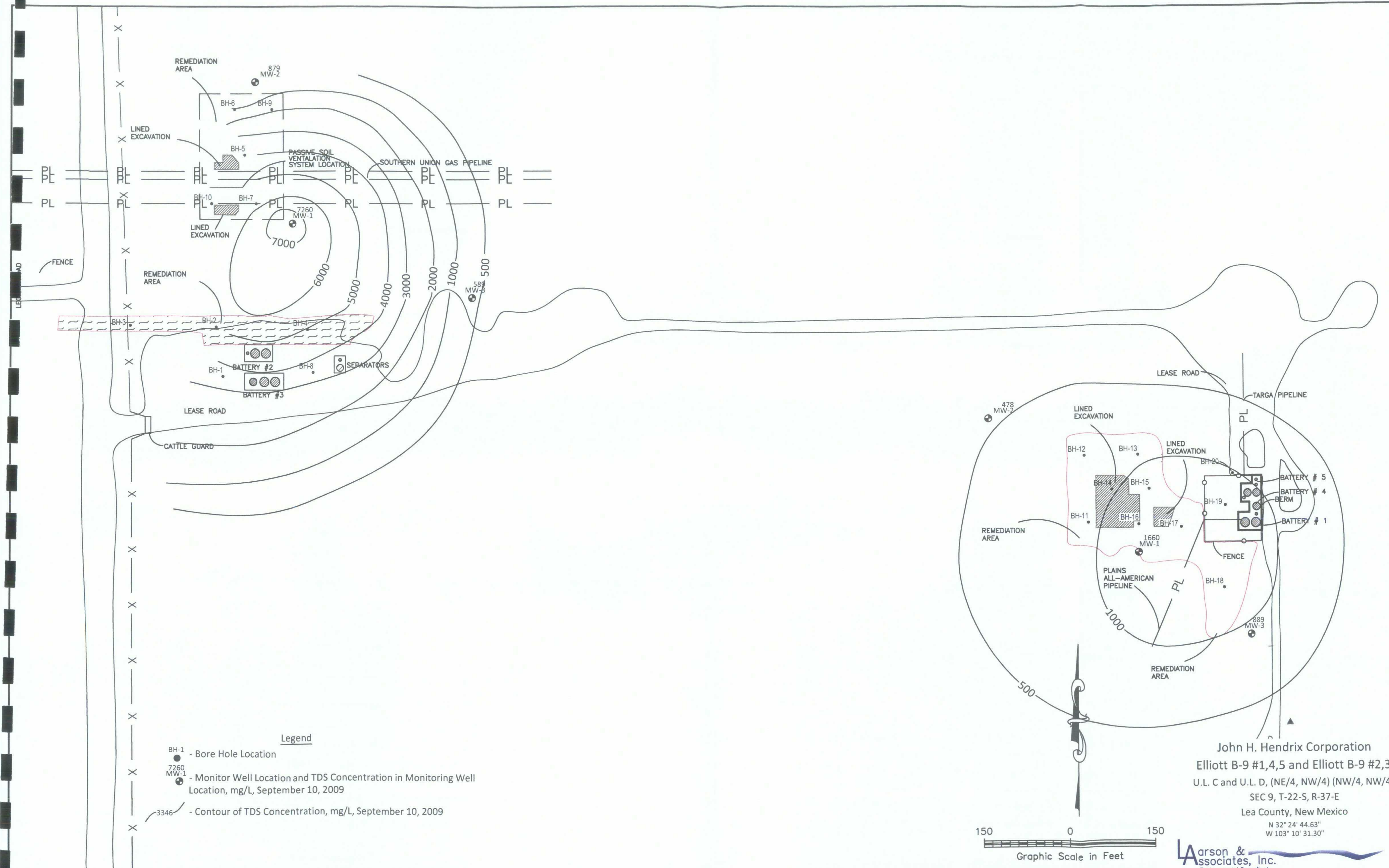
Figure 3- Groundwater Potentiometric Map, September 10, 2009



John H. Hendrix Corporation
Elliott B-9 #1,4,5 and Elliott B-9 #2,3
U.L. C and U.L. D, (NE/4, NW/4) (NW/4, NW/4)
SEC 9, T-22-S, R-37-E
Lea County, New Mexico
N 32° 24' 44.63"
W 103° 10' 31.30"

Larson & Associates, Inc.
Environmental Consultants

Figure 4- Chloride Concentration Map, September 10, 2009



Legend

BH-1 - Bore Hole Location

7260 MW-1 - Monitor Well Location and TDS Concentration in Monitoring Well Location, mg/L, September 10, 2009

3346 - Contour of TDS Concentration, mg/L, September 10, 2009

John H. Hendrix Corporation
Elliott B-9 #1,4,5 and Elliott B-9 #2,3
U.L. C and U.L. D, (NE/4, NW/4) (NW/4, NW/4)
SEC 9, T-22-S, R-37-E
Lea County, New Mexico
N 32° 24' 44.63"
W 103° 10' 31.30"

Larson & Associates, Inc.
Environmental Consultants

Figure 5- TDS Concentration Map, September 10, 2009

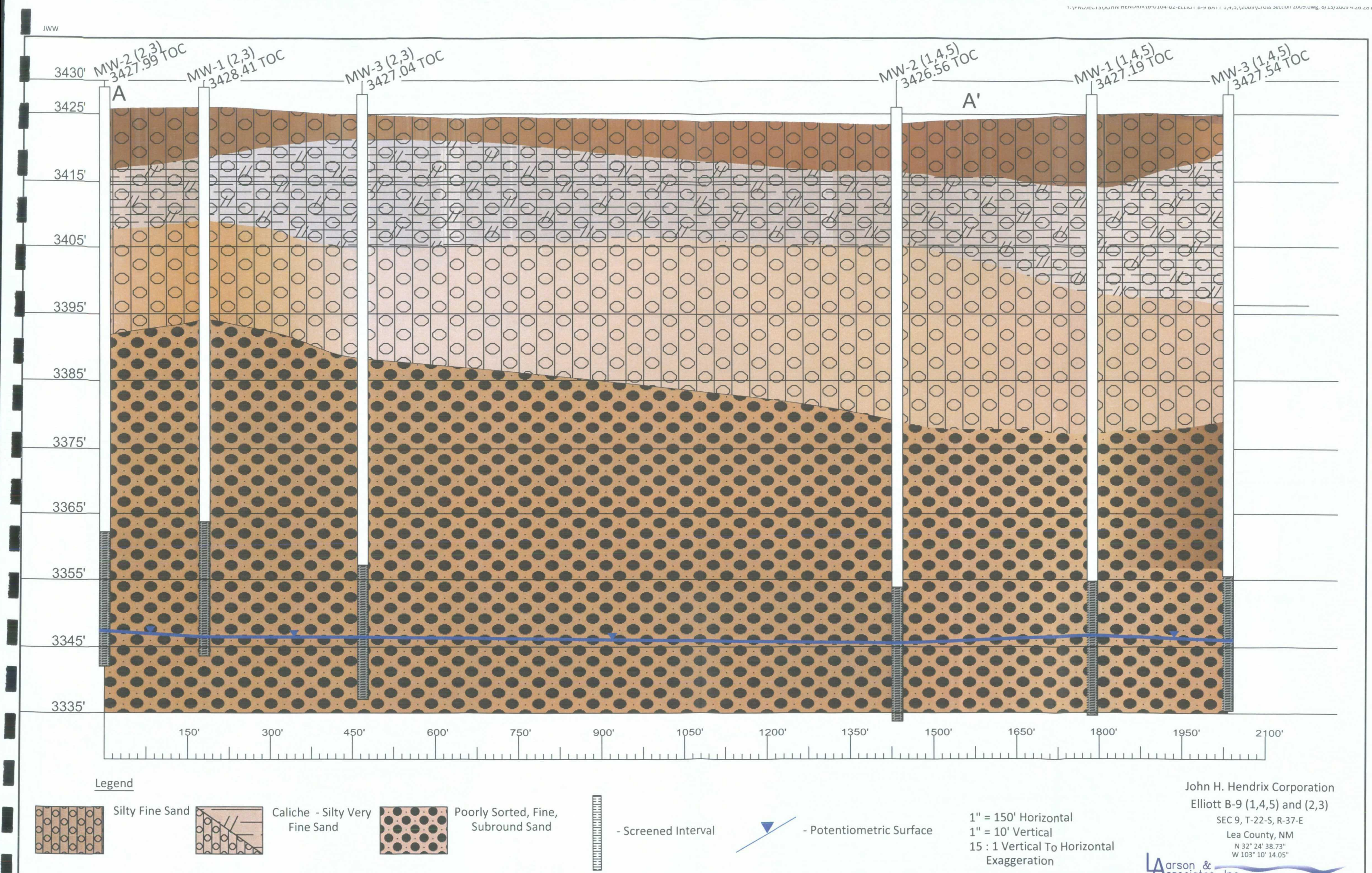


Figure 6 - Cross Section

Mark Larson

From: Price, Wayne, EMNRD [wayne.price@state.nm.us]
Sent: Monday, December 17, 2007 4:13 PM
To: Mark Larson
Subject: John Hindrex 1R0483 and 1R0484 Elliot

Dear Mark,

Sorry for the delay, I was out sick with the flu. Pursuant to our meeting last week OCD hereby approves the pit closure plans as described in the meeting. Groundwater monitoring and possible remediation will continue as discussed.

Please be advised that OCD approval of this plan does not relieve the owner/operator of responsibility should their operations fail to adequately investigate and remediate contamination that pose a threat to ground water, surface water, human health or the environment. In addition, OCD approval does not relieve the owner/operator of responsibility for compliance with any other federal, state, or local laws and/or regulations.

Wayne Price-Environmental Bureau Chief
Oil Conservation Division
1220 S. Saint Francis
Santa Fe, NM 87505
E-mail wayne.price@state.nm.us
Tele: 505-476-3490
Fax: 505-476-3462

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

September 14, 2009

Michelle Green
Larson & Associates, Inc.
507 North Marienfeld, Suite 202
Midland, TX 79701

Re: Elliot B-9 #2 & 3

Enclosed are the results of analyses for sample number H18217, received by the laboratory on 09/10/09 at 1:03 pm.

Cardinal Laboratories is accredited through Texas NELAP for:

Method SW-846 8021	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method SW-846 8260	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method TX 1005	Total Petroleum Hydrocarbons

Certificate number T104704398-08-TX. Accreditation applies to solid and chemical materials and non-potable water matrices.

Cardinal Laboratories is accredited though the State of Colorado Department of Public Health and Environment for:

Method EPA 552.2	Haloacetic Acids (HAA-5)
Method EPA 524.2	Total Trihalomethanes (TTHM)
Method EPA 524.2	Regulated VOCs (V2, V3)

Accreditation applies to public drinking water matrices.

Total Number of Pages of Report: 3 (includes Chain of Custody)

Sincerely,

Celey D. Keene
Laboratory Director

This report conforms with NELAP requirements.

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
LARSON & ASSOCIATES, INC.
ATTN: MICHELLE GREEN
507 N. MARIENFELD, SUITE 202
MIDLAND, TX 79701

Receiving Date: 09/10/09
Reporting Date: 09/13/09
Project Number: 6-0104-03
Project Name: ELLIOTT B-9 #2 & 3
Project Location: NOT GIVEN

Sampling Date: 09/10/09
Sample Type: GROUND WATER
Sample Condition: COOL & INTACT @ 1.5°C
Sample Received By: ML
Analyzed By: HM

LAB NO.	SAMPLE ID	Cl^- (mg/L)	TDS (mg/L)
Analysis Date:		09/11/09	09/11/09
H18217-1	MW-1	3,750	7,260
H18217-2	MW-2	200	879
H18217-3	MW-3	84	589
Quality Control		500	NR
True Value QC		500	NR
% Recovery		100	NR
Relative Percent Difference		< 0.1	0.7

METHOD: Standard Methods, EPA	4500-Cl⁻B	160.1

Chemist

09/14/09
Date

H18217 Larson & Associates

CARDINAL LABORATORIES

2111 Beechwood, Abilene, TX 79603 101 East Marland, Hobbs, NM 88240
(325) 673-7001 Fax (325) 673-7020 (505) 393-2326 Fax (505) 393-2476

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

Page 1 of 1

Company Name: Larsen & Associates, Inc.	**BILL TO**
Project Manager: Michelle Green	P.O. #:
Address: 507 N. Marienfeld, Suite 200	Company: JHHC
City: Midland State: TX Zip: 79701	Attn:
Phone #: 432-687-0901 Fax #:	Address:
Project #: 6-0104-03 Project Owner:	City:
Project Name: Elliot B-9 #2 & 3	State: Zip:
Project Location:	Phone #:
Sampler Name: Roger Brooks	Fax #:

Lab I.D. (FOR LAB USE ONLY)	Sample I.D.	(G)RAB OR (C)OMP.	# CONTAINERS	MATRIX: GROUNDWATER	WASTEWATER	SOIL	OIL	SLUDGE	OTHER :	PRESERV: ACID/BASE:	ICE / COOL	OTHER :	SAMPLING: DATE	TIME	ANALYSIS REQUEST: Chloride (E300)	TDS										
H18217-1	MW-1		2	X							X		9/10/09	12:30	X	X										
-2	MW-2		2	X							X		9/10/09	13:00	X	X										
-3	MW-3		2	X							X		9/10/09	12:00	X	X										

PLEASE NOTE: Liability and Damages. Cardinal's liability and client's exclusive remedy for any claim arising whether based in contract or tort, shall be limited to the amount paid by the client for the analyses. All claims including those for negligence and any other cause whatsoever shall be deemed waived unless made in writing and received by Cardinal within 30 days after completion of the applicable service. In no event shall Cardinal be liable for incidental or consequental damages, including without limitation, business interruptions, loss of use, or loss of profits incurred by client, its subsidiaries, affiliates or successors arising out of or related to the performance of services hereunder by Cardinal, regardless of whether such claim is based upon any of the above stated reasons or otherwise.

Terms and Conditions: Interest will be charged on all accounts more than 30 days past due at the rate of 24% per annum from the original date of invoice, and all costs of collections, including attorney's fees.

Sampler Relinquished: Roger Brooks	Date: 9-10-09 Time: 13:03	Received By: [signature]	Phone Result: ☐ Yes ☐ No Add'l Phone #:
Relinquished By:	Date: Time:	Received By:	Fax Result: ☐ Yes ☐ No Add'l Fax #:
Delivered By: (Circle One) Sampler - UPS - Bus - Other:	Temp. 1.5°C	Sample Condition: Cool ☑ Yes ☐ No; Intact ☑ Yes ☐ No	CHECKED BY: (Initials) [initials]

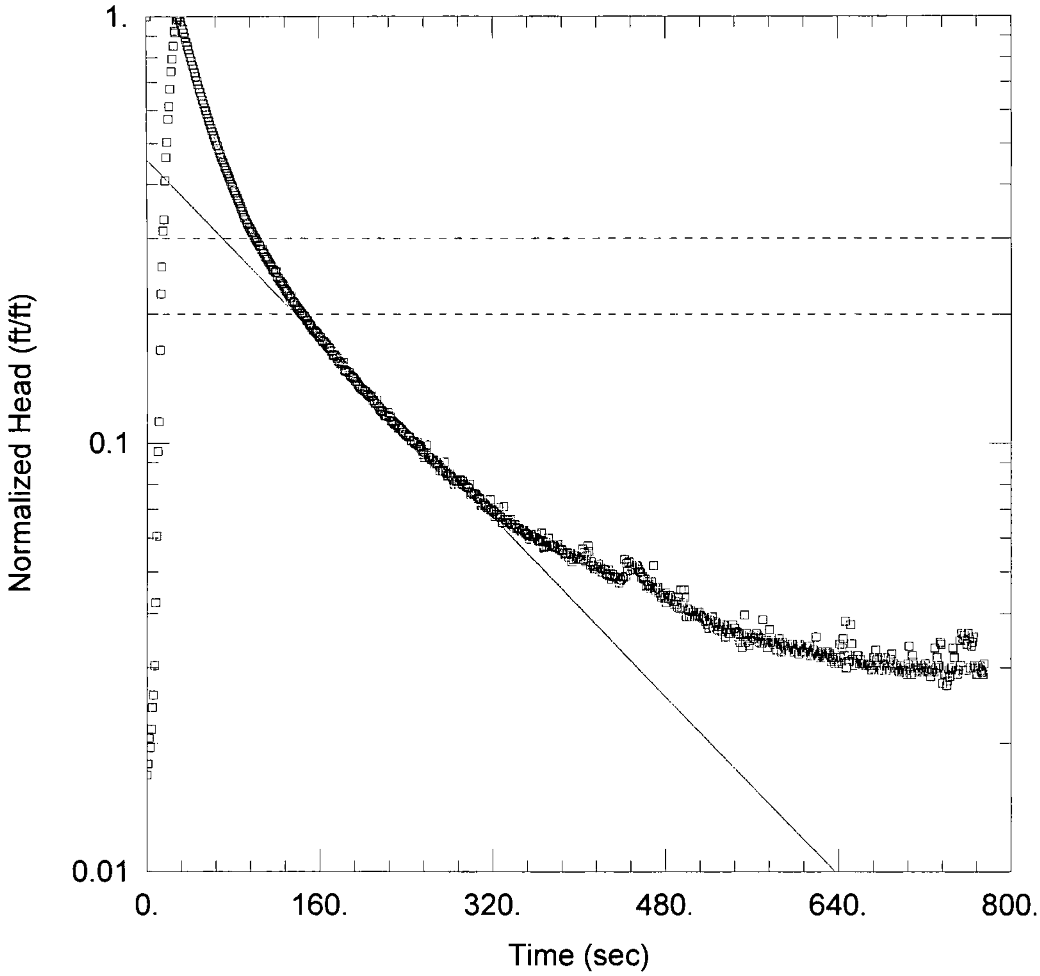
REMARKS: LARSON CONTACT: MICHELLE GREEN 432-687-0901

† Cardinal cannot accept verbal changes. Please fax written changes to 325-673-7020.

#26

Slug Test Summary
John H. Hendrix Corporation
Elliott B-9 Tank Battery #2 and #3 (1R0484)
Unit D (NW/4, NW/4), Section 9, Township 22 South, Range 37 East
Lea County, New Mexico

MW-ID & Test	Falling Head K	Rising Head K	Well Average
MW-01 Test 1	0.5032		
MW-01 Test 2	0.5083		
MW-01 Test 3	0.4841	0.501	
MW-01 Test 4	0.4923	0.9642	
MW-01 Test 5	0.8569	0.6121	
MW-01 Averages	0.569	0.692	0.631



MW-01 TEST 1 FALLING HEAD

Data Set:
Date: 11/13/09 Time: 15:54:50

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 1 Falling Head
Test Date: 11/13/09

AQUIFER DATA

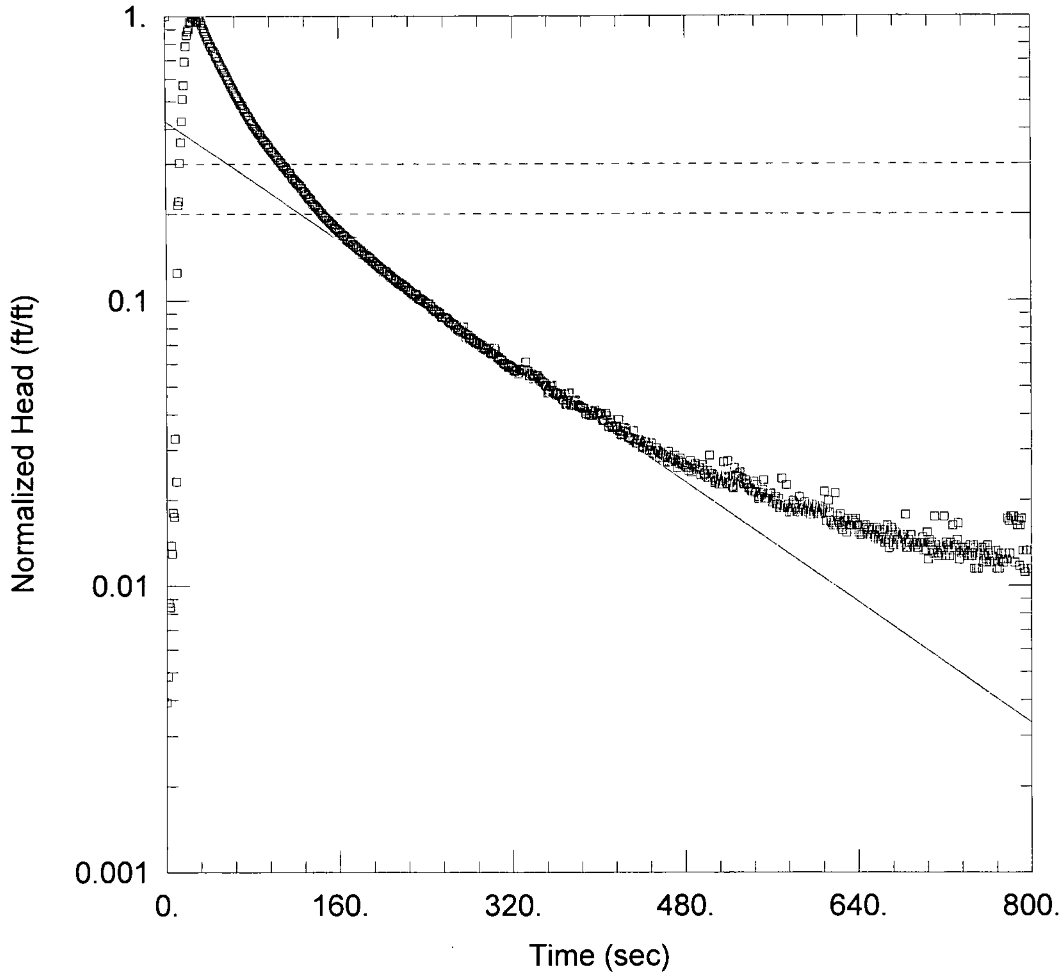
Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-01 Test 1 Falling Head)

Initial Displacement: 2.97 ft Static Water Column Height: 3.08 ft
Total Well Penetration Depth: 20. ft Screen Length: 20. ft
Casing Radius: 0.083 ft Well Radius: 0.083 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice
K = 0.5032 ft/day y0 = 1.358 ft



MW-01 TEST 2 FALLING HEAD

Data Set:
Date: 11/13/09 Time: 16:13:22

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 2 Falling Head
Test Date: 11/13/09

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

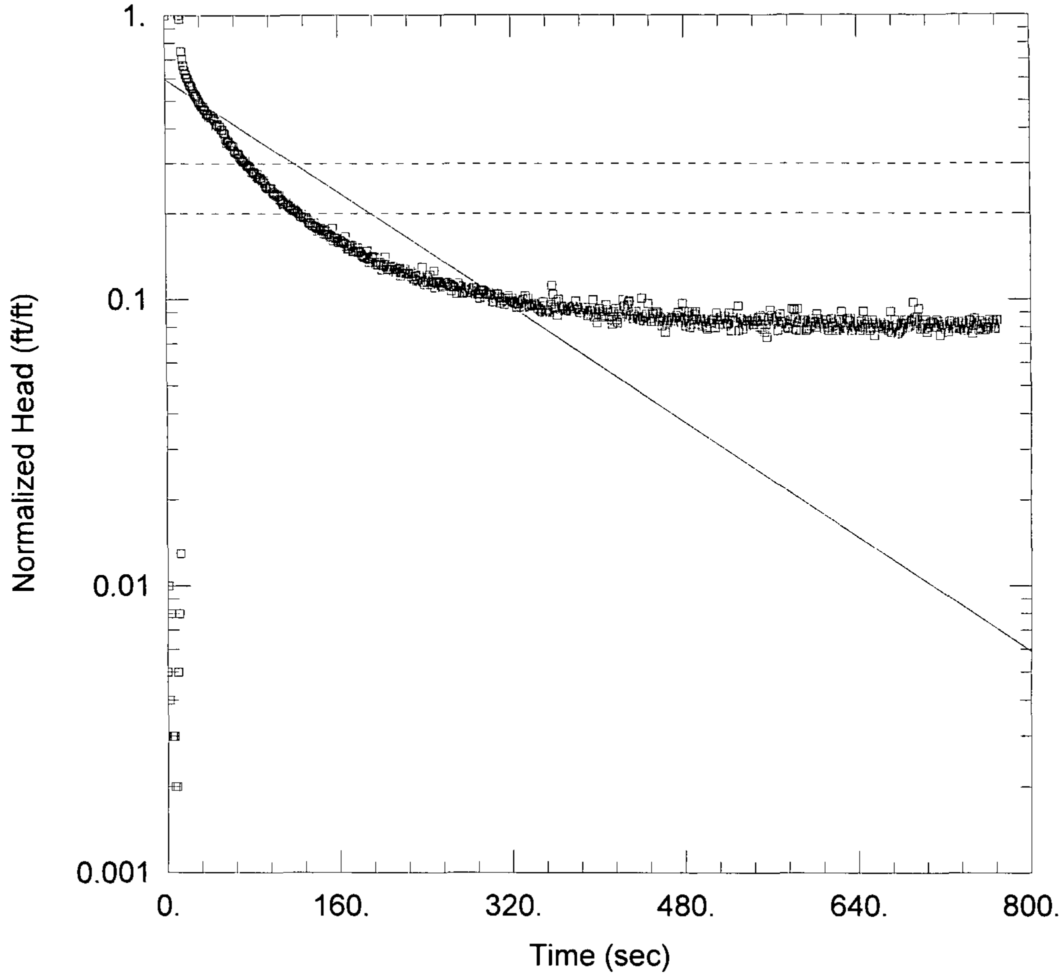
WELL DATA (MW-01)

Initial Displacement: 3.32 ft Static Water Column Height: 3.08 ft
Total Well Penetration Depth: 20. ft Screen Length: 20. ft
Casing Radius: 0.083 ft Well Radius: 0.083 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.5083 ft/day y0 = 1.41 ft



MW-01 TEST 3 FALLING HEAD

Data Set: Z:\...\MW-01 Test 3 Falling Head.aqt
Date: 11/24/09 Time: 16:59:23

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 3 Falling Head
Test Date: 11/13/09

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

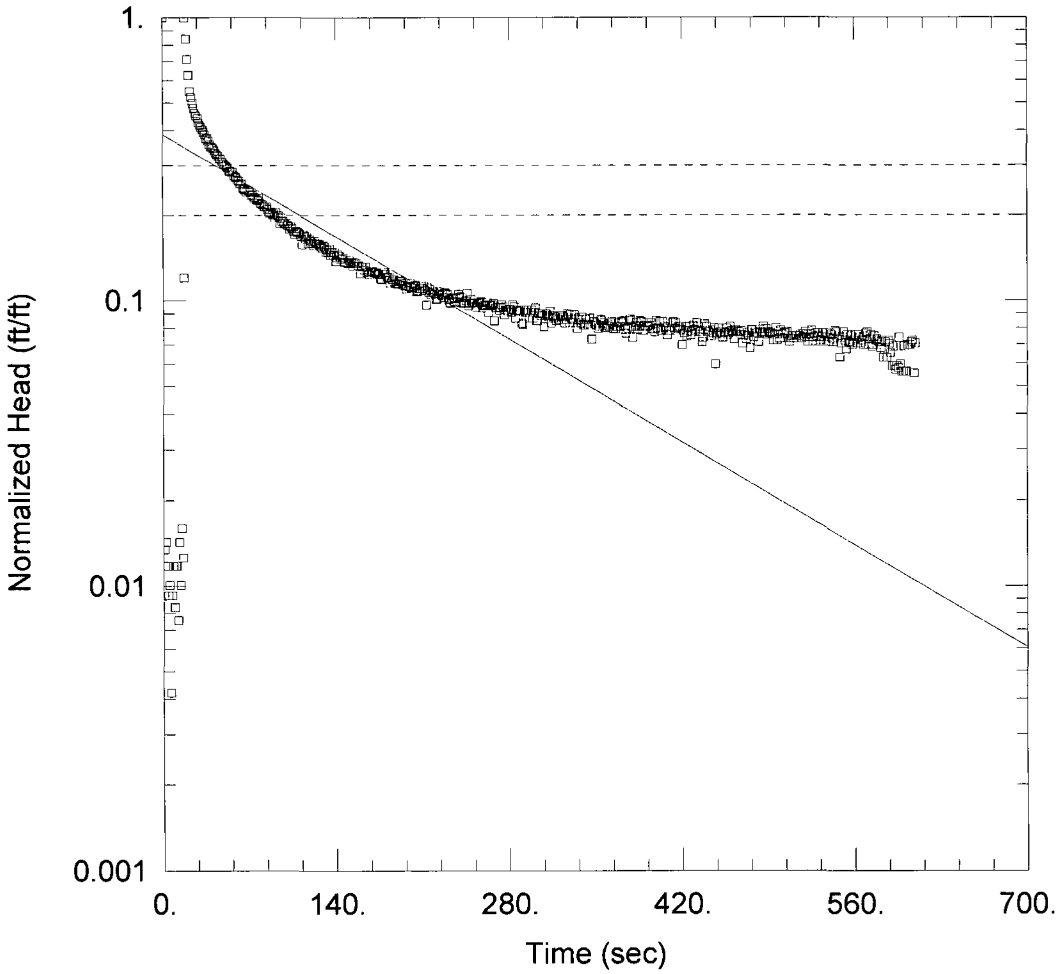
WELL DATA (MW-01 Test 3 Falling Head)

Initial Displacement: 1.003 ft
Static Water Column Height: 3.08 ft
Total Well Penetration Depth: 20. ft
Screen Length: 20. ft
Casing Radius: 0.083 ft
Well Radius: 0.083 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.4841 ft/day
y0 = 0.598 ft



MW-01 TEST 3 RISING HEAD

Data Set: Z:\...\MW-01 Test 3 Rising Head.aqt
Date: 11/25/09 Time: 08:40:24

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 3 Rising Head
Test Date: 11/13/09

AQUIFER DATA

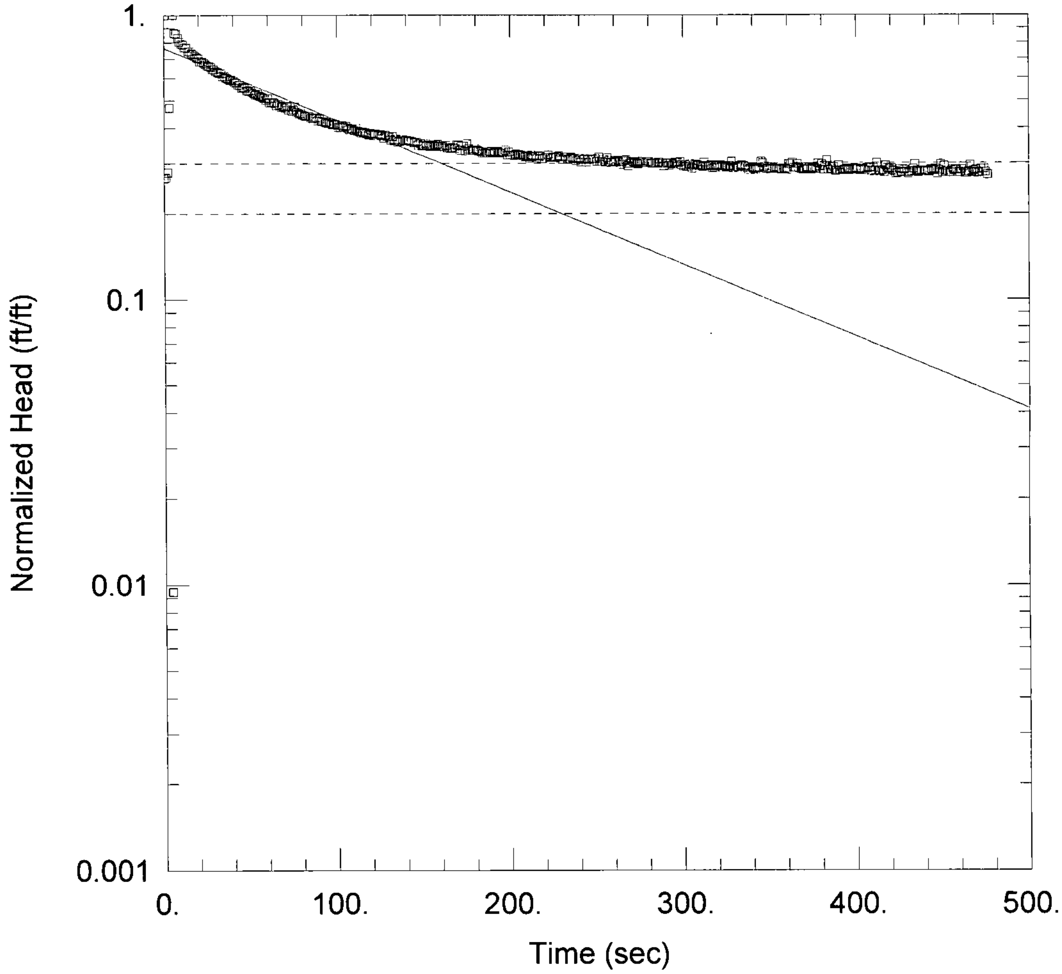
Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-01 Test 3 Rising Head)

Initial Displacement: 1.19 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 3.08 ft
Screen Length: 20. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.501 ft/day
y0 = 0.4596 ft



MW-01 TEST 4 FALLING HEAD

Data Set: Z:\...\MW-01 Test 4 Falling Head.aqt
Date: 11/25/09 Time: 09:17:42

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 4 Falling Head
Test Date: 11/13/09

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

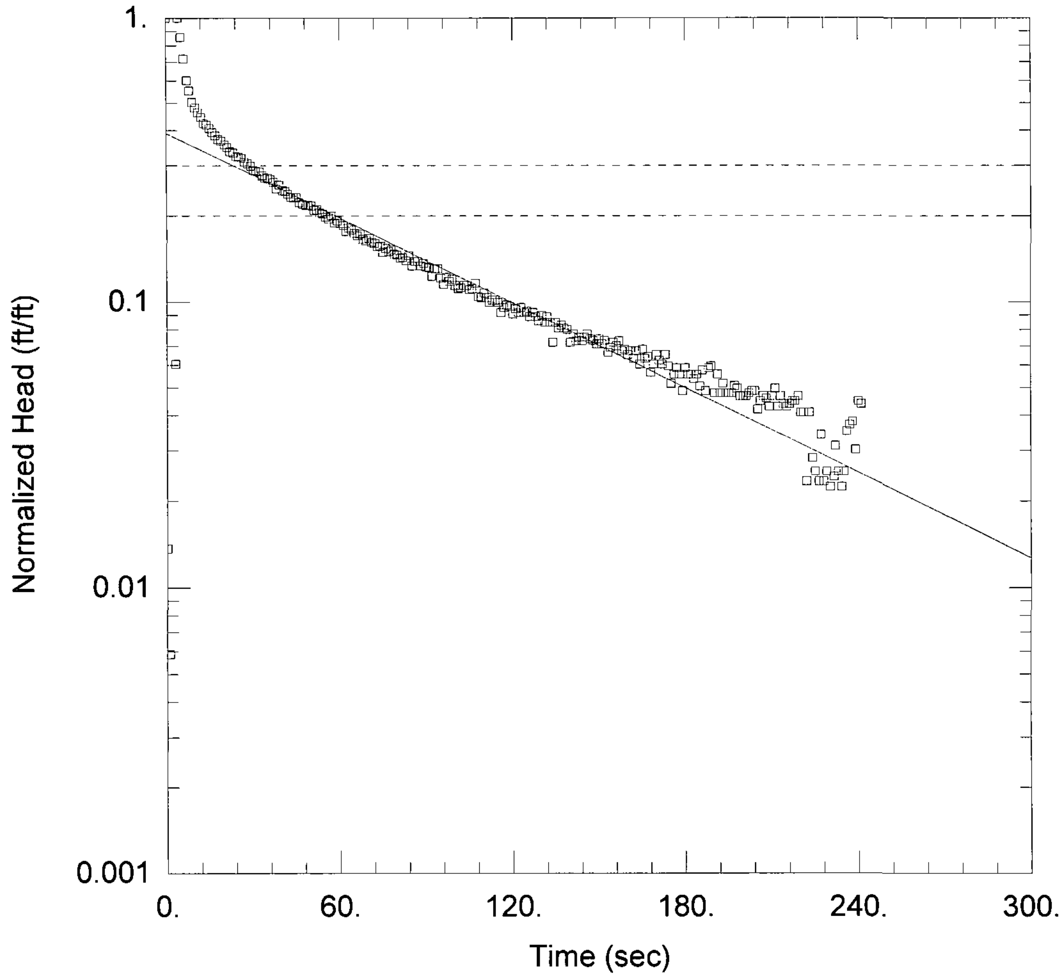
WELL DATA (MW-01 Test 4 Falling Head)

Initial Displacement: 0.846 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 3.08 ft
Screen Length: 20. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.4923 ft/day
y0 = 0.6451 ft



MW-01 TEST 4 RISING HEAD

Data Set: Z:\...\MW-01 Test 4 Rising Head.aqt
Date: 11/25/09 Time: 09:37:16

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 4 Rising Head
Test Date: 11/13/09

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

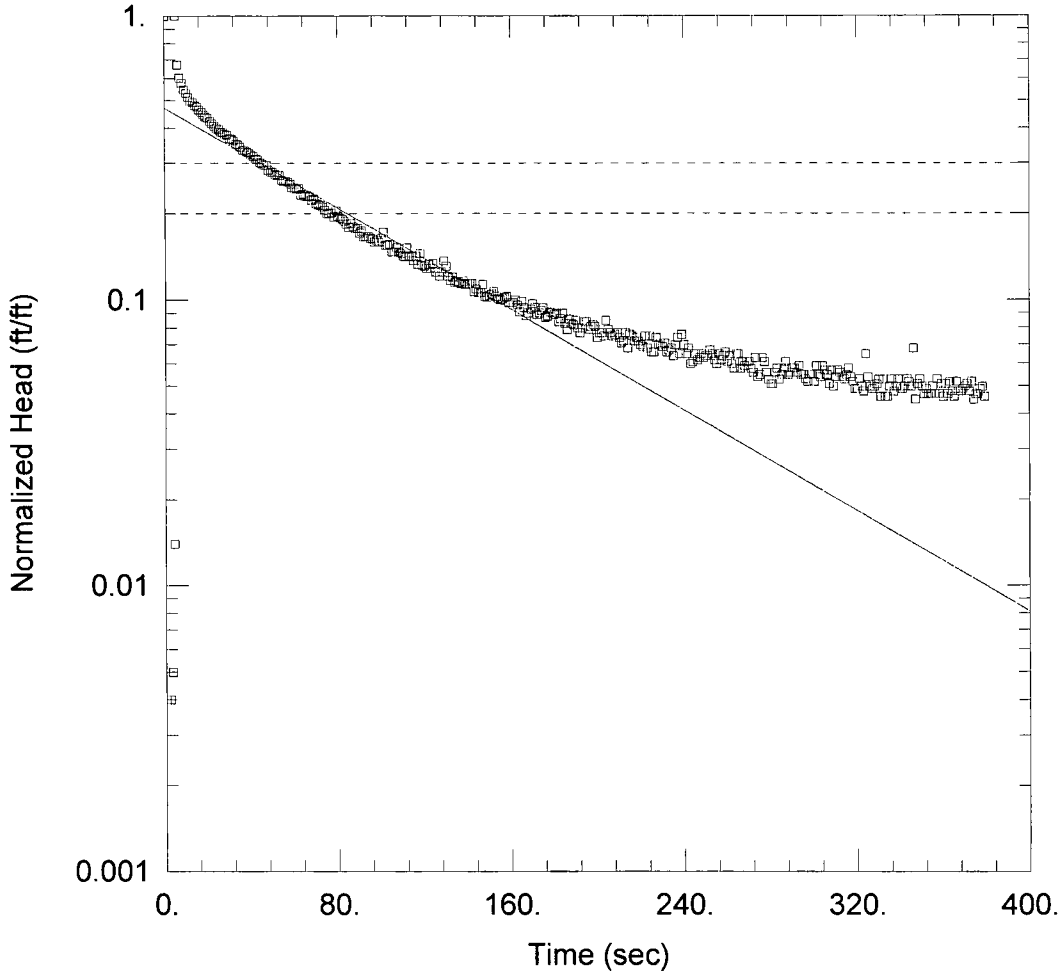
WELL DATA (MW-01 Test 4 Rising Head)

Initial Displacement: 1.025 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 3.08 ft
Screen Length: 20. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.9642 ft/day y0 = 0.3999 ft



MW-01 TEST 5 FALLING HEAD

Data Set: Z:\...\MW-01 Test 5 Falling Head.aqt
Date: 11/25/09 Time: 10:33:30

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 5 Falling Head
Test Date: 11/13/09

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

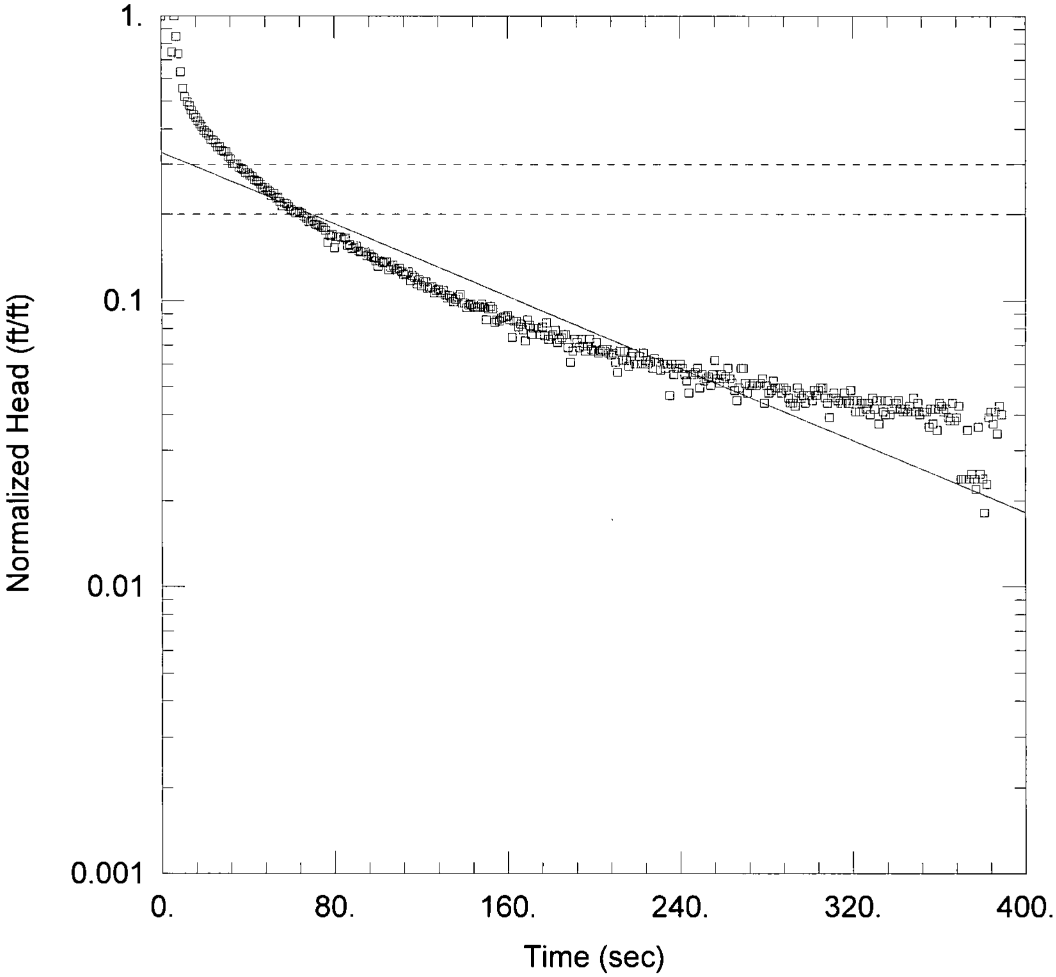
WELL DATA (MW-01 Test 5 Falling Head)

Initial Displacement: 1.003 ft
Total Well Penetration Depth: 20. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 3.08 ft
Screen Length: 20. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.8569 ft/day y0 = 0.4719 ft



MW-01 TEST 5 RISING HEAD

Data Set: Z:\...\MW-01 Test 5 Rising Head.aqt
Date: 11/25/09 Time: 10:40:35

PROJECT INFORMATION

Company: Larson & Associates, Inc.
Client: JHHC
Project: 6-0104-03
Location: Elliot B-9 2&3
Test Well: MW-01 Test 5 Rising Head
Test Date: 11/13/09

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-01 Test 5 Rising Head)

Initial Displacement: 1.048 ft Static Water Column Height: 3.08 ft
Total Well Penetration Depth: 20. ft Screen Length: 20. ft
Casing Radius: 0.0833 ft Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.6121 ft/day y0 = 0.3466 ft

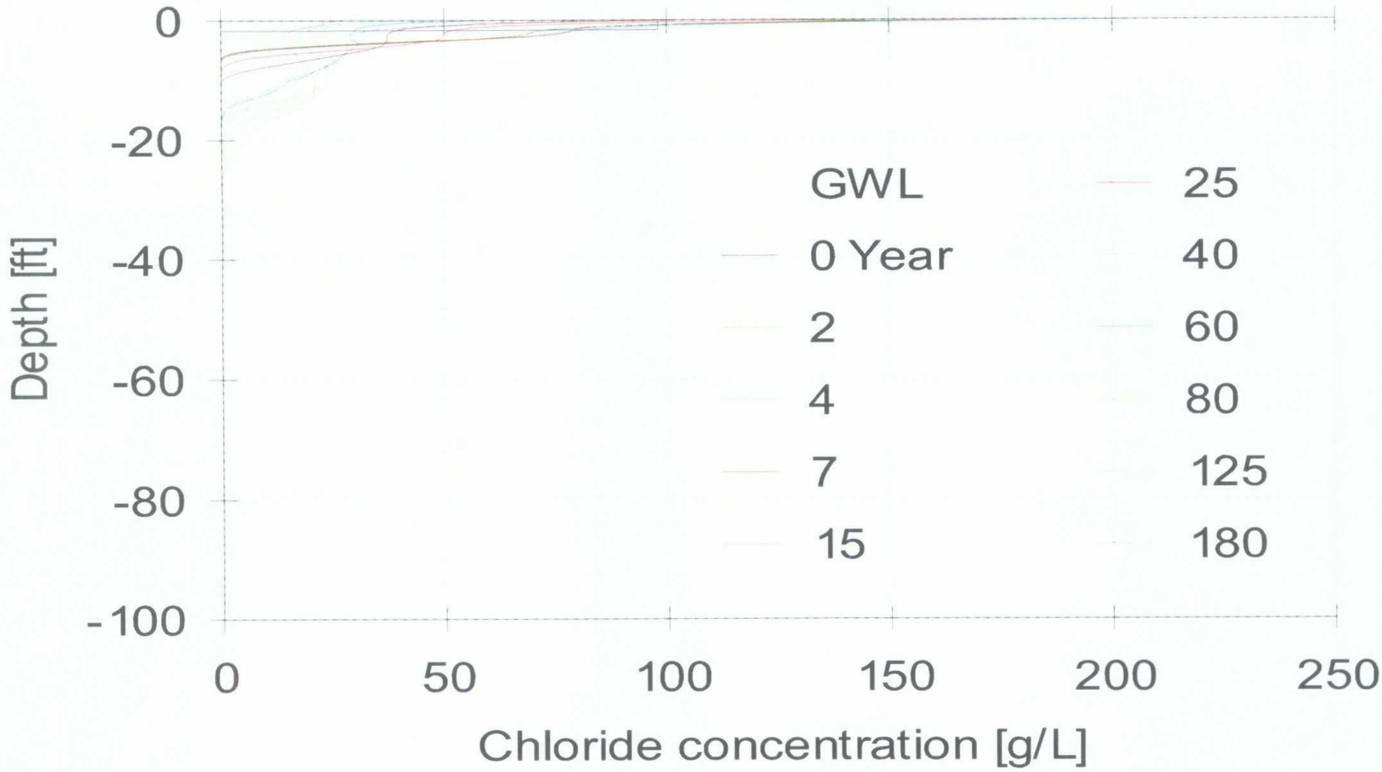
Project: Elliot B-9 23.ami
Path: C:\Program Files\API\AMIGO\Projects\Elliot B-9 23.ami
Date: 11/30/2009
Units: English (inches)
Climate: Arid Hot (NM/W.Texas, Hobbs)
Plant Uptake Trigger: 1% Input Concentration

Groundwater Characteristics
Background Cl Concentration in Aquifer: 100 [mg/L]
Aquifer porosity: 0.4 [-]
Groundwater Table Depth: 80 [ft]
Aquifer Thickness: 15 [ft]
Slope of Water Table: 0.0011 [-]
Hydraulic Conductivity: 0.6 [ft/d]
Groundwater Flux: 0.0099 [ft2/d]

Source Characteristics
Chloride Load:: 18.8756 [kg/m2]
Max. length of the spill in direction of GW flow:: 50 [ft]

Soil Profiles
Surface Layer: Loam
Soil Profile: P7 - Sandy Clay (1) + Caliche (1) + Medium Sand (1)

Distant Well Parameters
Distance to Well:150[ft]
Source Width:50[ft]
Longitudinal Dispersivity:10[-]
Transverse Dispersivity:1[-]



Max Concentration 100.003 [mg/L] at time 51.608 Year