REPORT:
Continuing Site Investigation Including Well Construction, Aquifer Analysis, Pilot Testing and Interim Remedial Action Work Plan

Former Gil's Shell Station
123 West 12th Street, Alturas, CA 96101

Submitted to:
Mr. Eric Rapport
Central Valley Regional Water Quality Control Board
364 Knollcrest Drive, Suite 205
Redding, CA 96002

Prepared by:
Porter Geotechnical
5560 Wildwood Drive
Reno, NV 89511

Prepared on behalf of:
Mr. Roger Reddy
Reddy Enterprises, Inc.
402 N. Main Street
Alturas, CA 96101

October 18, 2013

porter geotechnical

5560 Wildwood Drive
Reno, Nevada 89511
(775) 849-0668
(775) 849-0895 Fax

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Mr. Eric Rapport
Central Valley Regional Water Quality Control Board
364 Knollcrest Drive, Suite 205
Redding, CA 96002

Subject: **Continuing Site Investigation, Including Well Construction, Aquifer Analysis, Pilot Testing and Interim Remedial Action Work Plan Former Gil's Shell, 123 West-12th Street, Alturas, California**

Dear Mr. Rapport,

This report provides a summary of the continuing site investigation of the former leaking underground storage tank site. It includes the results of testing on four additional monitoring wells we drilled in key down-gradient locations from the site. It also includes data from the construction of three extraction wells drilled in petroleum source areas on site. This information is combined with our semiannual groundwater monitoring of all on site monitoring wells. It also includes our aquifer tests and the soil vapor extraction/air sparge pilot tests performed on selected wells. These tests were conducted in response to a request by the Regional Water Quality Control Board for the evaluation of remedial options for treatment of the petroleum contamination.

For the first time our testing has detected low levels of MTBE in the Alturas Community Supply Well (ACSW) No. 5. Based on our findings we are recommending that a combined air sparge/dual phase extraction treatment system be installed at selected locations on the property. Because of the detection in the Supply Well we have also made recommendations to install additional off-site monitoring wells at locations adjacent to the Community Supply Well and in areas to the west and down-gradient of the site.

Should you have any questions, please feel free to give us a call.

Very truly yours,

PORTER GEOTECHNICAL

REGISTERED GEOLOGIST
EDWARD J. PORTER
No. EG 1075
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Edward "Chip" Porter, C.E.G.
Certified Engineering Geologist

REGISTERED PROFESSIONAL ENGINEER
STEVEN C. DEVIN
No. GE2799
Exp. 12/31/13
GEOTECHNICAL
STATE OF CALIFORNIA

Steven C. Devin, P.E., G.E.
Geotechnical Engineer

21 Oct 13

CP:SD:dp

cc: Roger Reddy, Reddy Enterprises, Inc.
Greg Farnam, Modoc County Environmental Health

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CONTINUING SITE INVESTIGATION

Site Location

The subject site was formerly owned by Mr. Roger Reddy of Reddy Enterprises, Inc. and is located at 123 West 12th Street, Alturas California. The station is located a short distance west of the intersection of State Route 299 with US Highway 395 (see Site Location Map, Plate 1). The site is an active service station which includes a mini mart and separate diesel and gasoline service islands and underground fuel storage tanks. The four existing underground gasoline storage tanks were installed in October 1989. The tanks are located south of the fuel canopy on the east side of the property. Diesel underground tanks are located north of the diesel dispensers in the central part of the property. A former underground tank cluster was located immediately south of the station building (see Site Plan, Plate 2 for existing and former tank locations).

The property is located in a primarily commercial neighborhood approximately 300 feet east of the railroad tracks. The topography is moderately flat, sloping gently southward toward the North Fork of the Pit River. The river is located approximately 1 mile south of the site.

Scope of Work

This investigation includes several elements. The first part of our study focused on detailed lithologic logging and testing of the soil in boreholes drilled in offsite down-gradient locations, and in the target onsite source areas. The off site wells were installed in pairs in order to establish accurate measurements of the vertical conductivity through the low permeability silt (subaqueous welded ashfall tuff). In addition, three larger diameter extraction wells were installed in source areas formerly identified on site. The source areas were located in proximity to existing and former underground tank cavities located on site. Core samples obtained from the boreholes were further tested for hydraulic conductivity and soil classification (e.g. gradation and index tests).

We also performed aquifer tests on the wells, including slug tests and constant rate pumping tests. A trailer mounted portable generator and pilot test trailer were also brought onto the site to conduct soil vapor extraction (SVE) and air sparge pilot testing.

Finally we set digital water level data recorders in both onsite and offsite monitoring wells and recorded long term records of water levels. This data was then compared to pumping records

from the Alturas Community Supply Well (ACSW Well No. 5) in order to establish the level of communication between the developed aquifer and the monitored aquifers.

All of this data was then used to develop a Remedial Action Plan.

In Summary the primary tasks performed for this investigation included:

- Drill four, 2-inch diameter monitoring wells, two 15-foot deep wells (designated as MW-18A and MW-19A) and two 30-foot deep wells (designated as MW-18B and MW-19B) in off site down-gradient locations.
- Drill three, 4-inch diameter, 25-foot deep Extraction Wells (designated as EW-1, EW-2, and EW-3) in onsite source areas adjacent to former and existing underground tank backfill cavities. These wells are to be used for in-situ treatment of hot spots on site.
- Collect continuous soil samples through target low permeability zones that separate the identified aquifers. Perform permeability and soil classification tests on selected samples obtained from the borings.
- Survey the elevation of new well heads.
- Perform groundwater monitoring of all wells including both existing and new wells.
- Perform slug tests and stepped drawdown tests on the three new extraction wells.
- Perform constant rate pumping tests and time-drawdown testing of new monitoring wells.
- Prepare a conceptual Groundwater Flow Model that includes both horizontal flow and vertical leakage.
- Conduct Pollution Transport Assessment and Risk Analysis. Comparison of natural attenuation to pollution transport rates.
- Prepare new mass balance calculations based on additional site data.
- Perform Soil Vapor Extraction (SVE) testing of new Extraction Wells.
- Perform Air Sparge testing of both shallow and deep wells.
- Conduct Long Term monitoring of both onsite and offsite well water levels. Establish level of communication between the aquifers pumped by ACSW Well No. 5 on the upper aquifers monitored by our installations.
- Provide conclusions and our recommendations for remedial action work.
- Prepare a plan for Air Sparge and Dual Phase treatment system.
- Recommend additional monitoring well locations, construction and testing.

Geotechnical and Hydrogeological Site Characterization

A total of seven borings were drilled and logged for the current phase of work. Wells were installed in each boring which included the construction of four 2-inch diameter monitoring wells and three 4-inch diameter extraction wells. Monitoring wells were installed in pairs with each pair consisting of: (a) one 15.5-foot total depth shallow well which was screened from 5 to 15 feet below the top of casing (TOC); and (b) one 30.5-foot deep monitoring well which was screened from 20 to 30 feet below the top of casing. Adjacent shallow and deep wells in each pair were laterally separated by approximately 3 to 4 feet. Monitoring wells MW-18A and MW-18B were installed on the west side of Maple Street while MW-19A and MW-19B were installed in 10th Street south of the site and north of the ACSW Well No. 5. Shallow wells have been designated with the suffix "A" while deep wells have been designated with the suffix "B".

Extraction wells, consisting of 4-inch diameter PVC casing screened from 5 to 25 feet, were installed in 12-inch diameter 25.5 foot deep boreholes. Extraction wells were installed on site within the footprint of the contaminated zones identified in previous investigative phases. Extraction well EW-1 was installed in the gasoline contaminated zone southwest of the mini-mart building. Extraction well EW-2 was installed adjacent to existing UST's south of the covered fuel island in a zone impacted by both gasoline and diesel. Extraction well EW-3 was installed adjacent to the existing diesel UST's and diesel fuel islands in the south-central portion of the site.

The location of all monitoring and extraction wells is shown in Plate 2.

Subsurface Exploration

Borings were drilled and logged on June 4th and June 5th 2013 and monitoring wells constructed following the completion of each boring. Borings were advanced with a truck mounted Mobile Drill B-59 rig using 8.25-inch outside diameter (O.D.) hollow stem auger (HSA). The rig was operated by Mr. Ted Ogilvie of Diamond Core Drilling, Inc. We were present to log the borings, obtain samples for testing and observe monitoring well construction.

Monitoring wells installed during earlier phases of the work had generally been installed with air-rotary drill rigs and therefore the reliability of the earlier borehole logs has been suspect due to the difficultly involved in accurately logging borehole cuttings generated by this method of drilling. Therefore hollow stem auger with split-spoon sampling was chosen as the method of drilling for the current phase of the work. A 4-inch inside diameter (I.D.) HSA, which had an

outside diameter (O.D.) of 8.25 inches across the auger flights, was used for the initial exploratory portion of well construction. The 8-inch diameter drill hole left as the auger was withdrawn was sufficient for the construction of the 2-inch diameter PVC monitoring wells. However, larger diameter holes were required for the installation of the 4-inch diameter PVC extraction wells. Therefore, a 12-inch O.D. auger was used to ream and prepare these holes for extraction well installation.

One objective of the current phase of work was to characterize the shallow welded tuff layer previously identified and assess its function as an aquitard. Therefore, one goal of the drilling was to obtain relatively undisturbed samples of this material for laboratory hydraulic conductivity testing. However, obtaining such a sample proved extremely problematic by conventional means. The hardness of the tuff layer precludes undisturbed sampling using thin-walled Shelby tubes and results in fracturing of material recovered by driven split-spoon samplers. While the layer is too hard to sample with conventional soil sampling methods it is also too weak to core with a double or triple tube diamond core barrel. The only type of sampler that may have had a chance of success is a Pitcher sampler or a Denison sampler. Since these are not commonly available we decided to attempt sampling this layer with a Modified California split-spoon sampler which was also used throughout the current phase exploration.

The major benefit of using a Modified California sampler is that material is recovered which is substantially intact when compared with air-rotary cuttings and sampling may be nearly continuous allowing for better definition of subsurface stratigraphy. A 2-inch I.D. sampler driven by a 140-pound hammer falling 30 inches was used for sampling in MW-18 and MW-19 as well as the upper 20 feet of EW-1. A larger 2.5-inch I.D. sampler driven in the same manner was used from 20 feet and deeper in EW-1 as well as all sampling depths in EW-2 and EW-3. Sampling was performed generally in accordance with ASTM D 3550 “Standard Practice for Thick Walled, Ring-Lined, Split Barrel, Drive Sampling of Soils”. The frequency of sampling varied in each borehole with high frequency, nearly continuous, sampling performed in the off-site wells in the depth range of the tuff in both MW-18A and MW-19B and along the screened interval of the well in MW-19B. The maximum sampling interval was 5 feet in all borings.

The upper 15 feet in MW-18B was not logged since MW-18A was located in such close proximity. The shallow well MW-19A was not logged due to its close proximity to the MW-19B which was logged for its entire depth.

The number of 140-pound hammer blows required to drive the sampler over three 6-inch intervals is recorded on the attached logs. The blow count for each 6-inch interval is recorded next to the sample interval shown on the logs. These blow counts can provide a qualitative measure of the relative density of cohesionless soils or the consistency of cohesive soils. Sample driving is terminated either after (a) the sampler has been driven 18 inches or (b) more than 50 blows are required to drive the sampler through a 6-inch interval, in which case the distance driven is recorded per 50 blows of the hammer (*e.g.* 50/4.5" which indicates that 50 blows were required to drive the sampler 4.5 inches). The later condition is defined as "refusal".

Sampling performed in boreholes MW-18A, MW-18B, MW-19A, and MW-19B did not utilize liners inside the split barrel of the Modified California sampler in order to facilitate logging. Samples obtained from each sampling interval were visually classified in the field in accordance with ASTM D 2488 "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)" and then placed in Ziplock bags which were then sealed and placed in an ice chest for transport and storage. Logs of the soil materials encountered and details of monitoring well construction are presented in Appendix 1 - Monitoring Well Borehole Logs, located at the back of this report. Intact intervals of recovered soil were also carefully transferred into sample liners and sealed with wax and plastic end caps. These were then placed in Ziplock bags which were then sealed and placed in an ice chest for transport and storage.

Samples exhibiting signs of petroleum contamination were placed in Ziplock bags and then placed in an ice chest for transport to the analytical laboratory. Wax was not used to seal any of the analytical samples.

Monitoring Well Construction

Monitoring well construction schematics are shown on the Monitoring Well Borehole Logs (Appendix 1) for each well. Well screens consisted of 10-foot lengths of 0.020-inch slotted PVC pipe with flush mount threads. Filter pack materials, which consisted of a poorly graded No. 8 (2.36 mm) medium to coarse sand, were placed in the annulus between the well screen and borehole walls. The filter pack extended 6 inches below the bottom of the screened interval and 18 inches above the screen for the shallow wells and 36 inches above the screen for the deep wells. The remaining annulus was sealed with bentonite chips and granular bentonite. The surface of each well was completed with a flush mounted, bolt down traffic rated box set in concrete.

Geotechnical Testing

Laboratory classification tests were performed on selected samples taken from the borings. These tests included particle size analyses and consistency limits (*i.e.* Atterberg limits) performed in accordance with ASTM D 422 "Standard Test Method for Particle-Size Analysis of Soils" and ASTM D 4318 "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils", respectively. Tested samples were then classified in accordance with ASTM D 2487 "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)". Samples tested in accordance ASTM D 422 were washed over a No. 200 sieve, dried, and then mechanically sieved. Hydrometer tests were not run on the finer fraction of material primarily due to limited sample sizes.

Grain size analyses were performed on a total of nine samples which included: (a) three samples from MW-18B at depths of 20, 25, and 29 feet; (b) four samples from MW-19B at depths of 12.5, 14, 27, and 29 feet; and (c) two samples from EW-2 at depths of 15 and 20 feet. The Atterberg limits of the fraction finer than the No. 40 sieve (0.425 mm) were determined for a total of five samples which included: (a) three samples from MW-18A at depths of 5.5, 6.5, and 9 feet; and (b) two samples from MW-19B at depths of 8 and 20 feet.

Small sample sizes generally precluded performing grains size analyses and consistency limits testing on the same samples. In general, finer grained samples and samples that were tested for permeability as described below were selected for consistency limits testing (*i.e.* ASTM D 4318). Tested samples were washed over a No. 40 sieve with distilled water and the portion passing the sieve was used for limits testing. Tested samples were obtained from locations described in the previous paragraph. Permeability tests were also performed on samples from 6.5 and 20 feet in MW-18A and MW-19B, respectively.

Grain size distribution curves and plasticity charts with the plotted liquid limit and plasticity index of the tested samples are included in Appendix 2. Abbreviated laboratory test results are also summarized on the boring logs.

Selected liner samples were delivered to Sierra Testing Laboratories, Inc. in Placerville, California for permeability testing in accordance with ASTM D 5084 "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter". The dry unit weight and water content of each sample was determined prior to the start, and following the end, of each permeability test. These were also used to calculate

sample bulk porosity. The samples chosen for testing generally had more fines and exhibited some cohesion.

Nine samples were delivered to the lab for permeability testing and tests were successfully run on six of these samples. The other samples did not remain intact during sample preparation and could not be tested. The tested samples included: (a) one sample from a depth of 9 feet in MW-18A; (b) three samples from MW-19B obtained from depths of 6.5, 20 and 25 feet; and (c) two samples from EW-2 obtained from depths of 21.3 and 24 feet.

Laboratory hydraulic conductivity test results are included in Appendix 3. Abbreviated laboratory test results are also summarized on the boring logs.

Geotechnical Properties - Classification

Grain Size: The grain size distribution curves of the tested samples show two groupings of material types. Samples from 20 and 25 feet in MW-18B along with samples from 12.5 and 14 feet in MW-19B consist of both poorly graded fine to medium SAND with Silt and Silty fine to medium SAND. The cleanest sample tested was from 14 feet in MW-19B. This sample had 9.5 percent silt and clay sizes (*i.e.* material finer than the No. 200 sieve (0.075 mm)) and is classified with the USCS Group Symbol SP-SM. The fraction of fines increased to 14.3 percent in the sample taken from 12.5 feet in MW-19B. Since this sample has more than 12 percent fines it is classified as Silty SAND with the USCS Group Symbol SM. Samples obtained from depths of 20 and 25 feet in MW-18B also fall into this grouping having 18.6 and 20.5 percent fines respectively. All of the samples described thus far consist of fine to medium SAND with the silt and clay size fractions varying from about 10 to 20 percent.

A second general material grouping was also encountered. Samples within this grouping generally were classified as Silty SAND or Sandy SILT with USCS Group Symbols SM and ML respectively. These samples had higher fines contents than the first grouping described above with the increased percentage of fines varying from 28.4 to 52.4 percent. Two sub-groups are identified within this grouping. The first includes samples having fines contents in the approximate range of 30 to 40 percent (USCS Group Symbol SM) while the second includes samples having fines contents in the range of 45 to 55 percent (USCS Group Symbol SM for less than 50 percent fines and USCS Group Symbol ML for 50 percent or more fines). Samples obtained from 29 feet in MW-18B, 27 feet in MW-19B, and 20 feet in EW-2 fall into the first

sub-group while samples obtained from 29 feet in MW-19B and 15 feet in EW-2 fall into the second sub-group.

Plasticity: The shallow welded tuff layer along with associated adjacent layers was targeted for testing. Finer grained materials sampled at greater depths in MW-19B were also tested. The liquid limit (LL) of samples tested was in the range of 41 to 50 while the plasticity index (PI) was in the range of 3 to 14. The PI of the samples obtained from the depth interval of 5.5 to 9.0 feet ranged from 5 to 14 with the highest values of 11 and 14 associated with samples having liquid limits of 48 and 50 respectively. The coarser fragments from the portion of these samples retained on the No. 40 sieve were porous and had clay coatings that were noted while manually washing the samples. All samples plot below the "A" line on the plasticity chart which defines the classification boundary between silts (below "A" line) and clays (above "A" line). An additional classification boundary exists at a LL of 50 which, for samples plotting below the "A" line, separates low plasticity Silts (LL<50) from high plasticity "Elastic" Silts (LL≥50) (USCS Group Symbol MH). The sample obtained from the welded tuff layer at 8 feet in MW-19B plots as a low-plasticity Silt (ML) but could also plot as an Elastic Silt with only a slight increase in the LL. The sample obtained from 9 feet in MW-18A plots as an Elastic Silt (MH) on the plasticity chart. This sample could plot as a low-plasticity Silt (ML) with only a slight reduction in LL. Both welded and unconsolidated sub-aqueous ashfall tuffs often are associated with diatomaceous earth and the tubular mineral halloysite and tend to be classified as Elastic Silt (MH). Drying of soil having halloysite as a component prior to determining the Atterberg limits can affect the values obtained. The samples tested were air dried after washing and therefore they may in fact have higher LL and PI and be classified as Elastic Silt (MH). Our past experience with such materials, particularly while performing lab tests, suggests that this is the case with the ashfall tuff.

Natural Water Content, Unit Weight, and Porosity: The natural water content and dry unit weight were determined on each sample tested for permeability. Water contents ranged from a low of 37.0 percent at 6.5 feet in MW-19B to a high of 47.9 percent at 25 feet in EW-2. In general, lower water contents were associated with higher unit weights but this did not always hold true. The average measured water content was 42.2 percent. The natural water was determined for two samples which also had their Atterberg limits determined. These included the sample of the welded tuff from 6.5 feet in MW-18B and the sample of Sandy Silt from 20 feet in MW-19B. For non-indurated fine grained deposits such as the sample from 20 feet, the

value of the natural water content relative to the liquid limit can provide an indication of the stress history of the deposit. Water contents at or above the liquid limit suggest that the deposit is normally consolidated; *i.e.* the past overburden stress has never been greater than the current one. An over-consolidated deposit, which has experienced larger overburden pressures in the past, would exhibit lower porosity than a normally consolidated deposit. The 43.1 percent water content measured on the sample from 20 feet in MW-19B equals the measured liquid limit of 43 which strongly suggests that the deposit is normally consolidated at this location.

The dry unit weight varied from a low of 72.8 pounds per cubic foot (pcf) at 25 feet in EW-2 to 80.8 pcf at depths of 21 and 25 feet in EW2 and MW-19B, respectively. The average dry unit weight of the samples tested was 77.0 pcf.

The bulk porosity of each sample was computed using the reported water contents and dry unit weights. The computed porosities ranged from 0.52 to 0.57. No trend was noted with depth. These compare with an estimate of the effective porosity of 0.20 obtained from a pump test on MW-18B (see below).

The high water content, high porosity, and low dry unit weight reflect the volcanic origin, particle size, and mineralogy of the lacustrine sediments encountered in the borings. The coarser grained fraction of the samples was very porous with surface pores easily identified with the un-aided eye. Finer grained sediments associated with the ashfall layer likely contain an abundance of diatoms which further increase the bulk porosity. Sediments associated with ashfalls are also often associated with the tubular "clay" mineral halloysite which contains bound water as part of its mineral structure. Hence, the porous nature of the sediments dramatically affects their bulk porosity. However, the effective porosity of the deposits is much lower. This is due to the lack of interconnected pores within the clasts, the relative density or consistency of the materials, and bound water associated with finer grained sediments.

Relative Density: Blow counts from driven split-spoon sampling provide a means to estimate the relative density of in-situ material. While the California Modified sampler used for this project did not conform to the size and type of sampler specified for a Standard Penetration Test (SPT) (ASTM D 1586), several correlations are available to estimate the SPT N-value (*i.e.* blows per foot) from non-standard samplers. A correction factor of 0.65 was applied to field blow counts for all California Modified samplers used for this work. The resulting estimates of

field SPT N-values provide a means to describe the relative density or consistency of in-situ materials.

California Modified sampler refusal was encountered at depths of 6.0, 7.5, 9.5, 10.5, and 12 feet in MW-18A and 21.3 feet in MW-18B. An SPT field N-Value of 49 blows per foot was estimated at a depth of 13 to 14 feet in MW-18B. SPT field N-Values of 40 and 38 blows per foot were encountered at depths of 25.5 to 26.5 feet and 29.5 to 30.5 feet in MW-18B. Materials which yielded California Modified refusal are considered to have a very dense relative density (*i.e.* for cohesionless soils, typically clean sands, while cohesive soils with these N-Values are considered hard) while the other materials are all considered to be dense.

California Modified sampler refusal was encountered at depths of 8.0, 10.8, 11.5, 13.8, 14.9, 25.0, 26.5, 27.9, and 29.9 feet in MW-19B. SPT field N-Values of 55, 46, 46, 29 blows per foot were encountered at depths of 5.5 to 6.5, 8.5 to 9.5, 20.5 to 21.5, and 22 to 23 feet, respectively, in MW-19B. Materials which yielded California Modified refusal are considered to have a very dense relative density while the other materials are all considered to be medium dense to dense.

California Modified sampler refusal was encountered at a depth of 21.3 feet in EW-1. SPT field N-Values of 31 and 29 blows per foot were encountered at depths of 10.5 to 11.5 and 15.5 to 16.5, respectively, in EW-1. Materials which yielded California Modified refusal are considered to have a very dense relative density while the other materials are all considered to be medium dense to dense.

California Modified sampler refusal was encountered at depths of 10.5, 16.5, and 21.0 feet in EW-2. Refusal was encountered at depths of 5.8, and 15.9 feet in EW-3. SPT field N-Values were not determined at other depths in these borings due to limited drive intervals in the other samples.

Hydraulic Properties

Vertical Hydraulic Conductivity: The laboratory hydraulic conductivity measured by ASTM D 5084 is considered the conductivity for flow in the vertical direction (K_v) across the sedimentary bedding. Field hydraulic conductivities estimated from the aquifer testing performed for this project are generally considered to be a composite in the horizontal direction

(K_h) or an average with both vertical and horizontal components weighted towards the horizontal direction. Aquifer testing is described in a later section of this report.

The measured vertical hydraulic conductivity varied over approximately one order of magnitude for five of the six samples tested (*i.e.* 3.33 x 10^{-7} cm/sec to 6.09 x 10^{-6} cm/sec (9.44 x 10^{-4} ft/day to 1.73 x 10^{-2} ft/day)). The sixth sample had a hydraulic conductivity about one order of magnitude larger than the highest value of the other samples tested (*i.e.* 5.86 x 10^{-5} cm/sec (0.166 ft/day)). Hence, K_v varied by about two orders of magnitude across the site. Measured Hydraulic Conductivities from both laboratory and field testing are summarized in Table 1.

Table 1 - Summary of Measured and Estimated Hydraulic Conductivity

Summary of Field and Laboratory Hydraulic Conductivity Testing						
Well ID	**Hydro Unit**	**Depth (ft)**	**Field K_h (cm/s)**	**Lab K_v (cm/s)**	**D_{10} K (cm/s)**	**Lab Porosity, n**
MW-19B	Unit 2 - Upper Aquitard	6.5	---	1.13×10^{-6}	---	0.53
MW-18A	Unit 2 - Upper Aquitard	9.0	---	7.81×10^{-7}	---	0.56
MW-19B	Unit 3 - Shallow Confined Aquifer	12.5	---	---	2.60×10^{-3}	---
MW-19B	Unit 3 - Shallow Confined Aquifer	14.0	---	---	4.77×10^{-3}	---
MW-18B	Unit 3 - Shallow Confined Aquifer	20.0	---	---	1.00×10^{-3}	---
MW-19B	Unit 4 - Middle Aquitard	20.0	---	3.33×10^{-7}	---	0.56
EW-2	Unit 4 - Middle Aquitard	21.3	---	6.09×10^{-6}	---	0.52
MW-2	Unit 4 - Middle Aquitard	20 - 30	7.37×10^{-5}	---	---	---
MW-19B	Unit 4 - Middle Aquitard	25.0	---	8.47×10^{-7}	---	0.52
EW-2	Unit 5 - Lower Leaky Aquifer	24.0	---	5.86×10^{-5}	---	0.57
MW-18B	Unit 5 - Lower Leaky Aquifer	25.0	---	---	1.50×10^{-3}	---
MW-18B	Unit 5 - Lower Leaky Aquifer	20 - 30	9.95×10^{-5}	---	---	---
MW-19B	Unit 5 - Lower Leaky Aquifer	20 - 30	8.31×10^{-4}	---	---	---
MW-15B	Unit 5 - Lower Leaky Aquifer	32 - 42	4.21×10^{-4}	---	---	---

Hydraulic Conductivity from Effective Grain Size: The hydraulic conductivity of sands can be roughly estimated using the effective grain size which is the particle size for which 10 percent of the sample is finer (*i.e.* the D_{10} size). Since the lacustrine deposits encountered in the borings consist of fine to medium sand with significant amounts of silt, the D_{10} size was smaller than the No. 200 sieve (0.075 mm) for all samples other than the one obtained from 14 feet in MW-19B. The D_{10} for the other samples was not determined since hydrometer tests were not run which would have defined the portion of the grain size curve the for silt and clay size particles. Correlations for the hydraulic conductivity as a function of D_{10} are generally restricted to use with sand and use.

of such a correlation with D_{10} smaller than the No. 200 sieve (0.075 mm) may be unreliable. The empirical equation developed by Hazen for sands with D_{10} ranging from 0.1 mm to 3.0 mm is:

$$K\ (cm / s) = C \times (D_{10}\ (cm))^2$$

Where C ranges from:
- 40 to 80 for very fine well graded sand with appreciable fines;
- 80 to 100 for medium to coarse, poorly graded sand or well graded clean sand; and
- 120 to 150 for very coarse, very poorly graded sand or gravelly clean sand.

The sample from 14 feet in MW-19B is classified as a "brown, medium to coarse, poorly graded SAND with Silt" with D_{10} = 0.0772 mm. Using a C coefficient of 80 the estimated hydraulic conductivity of this sample is 4.77 x 10^{-3} cm/sec (13.5 ft/day).

The grain size curves having less than 20.5 percent fines were projected to estimate the D_{10} size. These included samples from depths of 12.5 feet in MW-19B and depths of 20 and 25 feet in MW-18B. The estimated D_{10} sizes were 0.066 mm, 0.041 mm, and 0.050 mm, respectively for these samples. Using a C coefficient of 60, the estimated hydraulic conductivity of these samples was 2.6 x 10^{-3}, 1.0 x 10^{-3}, and 1.5 x 10^{-3} cm/sec (7.37, 2.83, and 4.25 ft/day) respectively. The average estimated hydraulic conductivity of the sands with less than 20 percent fines was 2.47 x 10^{-3} cm/sec (7.00 ft/day). These values must be used with caution since the D_{10} sizes are slightly lower than the minimum of 0.1 mm used to develop the correlation. The estimated hydraulic conductivity of these cleaner sands was 3 to 4 order of magnitudes greater than the vertical hydraulic conductivities measured in the lab for the finer-grained samples.

Aquifer Testing

Aquifer testing was performed (a) to make a determination, based on measured aquifer properties, whether a groundwater pump and treat system using existing and recently installed wells is a viable option for remediation at this site; and (b) to determine hydraulic and storage properties of the aquifers encountered for use in contaminant transport calculations. Furthermore, these tests assist in developing design criteria for pump sizing and overall in situ treatment system design.

Aquifer properties sought through field pumping tests and slug tests include the transmissivity, hydraulic conductivity, and the storage coefficient, which is often referred to as the storativity. Basic definitions follow in order to assist the reader.

- The transmissivity (T) of an aquifer is a measure of the volume of water discharged per unit width of an aquifer subjected to a unit hydraulic gradient in the horizontal direction per unit time. The transmissivity describes the water transmission properties of the full thickness of the aquifer which is equal to the product of the horizontal hydraulic conductivity (K_h) and aquifer thickness (b).

- The average hydraulic conductivity (K_{avg}) of an aquifer is a measure of the volume of water discharged per unit area under a unit hydraulic gradient per unit time. The hydraulic conductivity describes the water transmission properties of a unit cross sectional area in a vertical plane.

- The coefficient of storage, or storativity, (S) is a measure of the volume of water released from aquifer storage by expansion of the water and compression of the aquifer. When a confined aquifer is pumped it is not de-watered but rather water is released through storage by a lowering of the potentiometric surface (*i.e.* a reduction in pore water pressure) and compaction of the mineral skeleton (*i.e.* reduction in pore volume). The coefficient of storage of a confined aquifer is defined as the volume of water released from storage per unit area (*i.e.* in a horizontal plane) per unit drop in the potentiometric surface. It is a dimensionless quantity with typical values ranging from 0.00001 to 0.001 in confined aquifers.

- The coefficient of storage (S) of an unconfined aquifer is referred to as its specific yield (S_y). In an unconfined aquifer water is released in a manner similar to a confined aquifer (*i.e.* expansion of water and compression of aquifer) but the aquifer is also de-watered by drainage of the connected voids excepting that retained in the pore volume by surface tension effects. Unconfined aquifers produce significantly greater quantities of water due to this de-watering. Typical values of the storage coefficient (S) for unconfined aquifers range from 0.01 to 0.30.

Aquifer testing for this phase of the work consisted of the three following types of tests.

- Constant discharge pumping tests on 2 inch monitoring wells MW-19B, MW-18B, MW-15B, and MW-2 along with water level recovery monitoring in both the pumped and observation wells following the cessation of pumping.

- Stepped drawdown tests on 4 inch extraction wells EW-1, EW-2 and EW-3 along with water level recovery in the pumped well following the cessation of pumping.

- Falling head slug tests on 4 inch extraction wells EW-1, EW-2 and EW-3.

Water levels were monitored in both the deep pumping well and the adjacent shallow well for the constant discharge pumping tests. Water levels were monitored in the pumping well when the stepped drawdown tests were performed but were not monitored in any adjacent observation wells during the stepped tests. The water level is only monitored in the tested well whenever a slug test is performed.

Water levels and temperature were monitored using Micro Troll Downhole Data-loggers manufactured by In-Situ Inc. A recording interval of 1 minute was used for the constant discharge pumping and stepped drawdown tests while a 1 second recording interval was used for the slug tests. The water level in nearby wells was also periodically measured manually with a sounding tape to evaluate if there was any hydraulic influence from the pumped well on adjacent wells that were not fitted with data-loggers. No influence was noted in any of the tests. All data in the pumped wells and shallow observation wells was collected using these data-loggers.

Periodic timed incremental discharge measurements were made using a stopwatch and a calibrated container. These measurements were repeated frequently during the initial pumping phase to establish a constant pumping rate and then less frequently as each test proceeded in order to maintain constant discharge rates.

A variable speed submersible 1 horsepower (HP) pump was used to pump from the test wells. The pump speed was manually adjusted as rapidly as possible during the very early portion of each test and periodically as necessary thereafter such that a nearly constant discharge could be

maintained and the water level in the pumped well casing not excessively drawn down. Excessive drawdown whereby the water level in the casing falls below the top of the screen causes deviations from the analytical model used when evaluating test data (*e.g.* the assumption of full penetration and constant thickness in a confined aquifer). Extremely high drawdown near the bottom of the casing may also cause damage to the submersible pump. Low permeability formations such as encountered in our testing may exhibit such steep drawdown cones that excessive drawdown can become an issue in data analysis.

Photographs of the Site Testing Work are provided in Appendix 4. Field data records for the tests and water elevation data are included in Appendix 5 through 9.

Constant Discharge Pumping Tests

Pumped wells MW-19B, MW-18B, and MW-2 are 30.5 to 31 feet deep and screened over the interval 20 to 30 feet below top of casing. Pumped well MW-15B is 44 feet deep and screened over the interval 32 to 42 feet below top of casing. Observation wells associated with the pumped wells listed above consisted of the shallow wells MW-19A, MW-18A, MW-7, and MW-15A. Tested wells were constructed with 2-inch PVC casing except observation wells MW-7 and MW-15A which were constructed with 4-inch PVC casing.

The pumped wells generally had too low of a yield using our 1-Hp variable speed aquifer test pump to permit long term constant discharge tests from being conducted (*i.e.* resulting in excessive drawdown due to very steep drawdown cones). Average pumped well discharge varied from 0.39 gallons per minute (gpm) in MW-18B to 0.65 gpm in MW-19B. Initial drawdown in all pumped wells was abrupt reflecting removal of water from storage in the well casing above the pump and losses due to a skin effect. The pumped well discharge was maintained at a nearly constant rate in all tests except on MW-2 and the early portion of MW-15B. Excessive drawdown occurred in MW-2 whereby the water level in the casing fell to essentially the level of the pump intake and the discharge ceased. The pump was then immediately shut down and then re-started after a short recovery period but once again the water level in the casing was drawdown to the pump intake. This happened on three occasions during this test.

The water level in MW-18B was drawdown 5.25 feet below the top of the well screen while pumping the well at a constant rate of 0.39 gpm. Adjusting the pump to lower discharge rates

while still overcoming fixed friction losses and total dynamic head was not possible and therefore the excessive drawdown measured during the test could not be avoided.

Pumping test duration was varied from a minimum of 44 minutes in MW-2 to 126 minutes in MW-19B. Monitoring wells MW-18B and MW-15B were pumped at a constant rate for 93 and 98 minutes respectively. Recovery times, starting from the cessation of pumping, varied from 63 minutes in MW-15B to 131 minutes in MW-19B. Recovery times in MW-2 and MW-18B were 90 and 96 minutes respectively. Pump tests were of such a short duration that barometric effects on water levels could be neglected.

Constant Discharge Pumping Tests - Measured Well Response are summarized in Table 2. Aquifer Constant Discharge Pumping Test Solutions and Analysis Reports for the wells are included in Appendix 5.

Table 2 - Constant Discharge Pumping Tests – Measured Well Response

Pumped Well	Depth to Top of Screen (feet)	Depth to Bottom of Screen (feet)	Pumped Well Static Water Level (feet)	Q (gpm)	Pumped Well Maximum Depth to Water		Observation Well Maximum Drawdown	
					Well	Depth to Water (feet)	Well	Drawdown (feet)
MW-19B	20	30	5.73	0.65	MW-19B	20.62	MW-19A	0.97
MW-18B	20	30	14.68	0.39	MW-18B	25.25	MW-18A	0.022
MW-2	21	31	13.7	0.57 - 0.67	MW-2	28.31	MW-7	0.000
MW-15B	32	42	18.99	0.40	MW-15B	29.51	MW-15A	0.036

Drawdown in Shallow Wells: With the exception of MW-19A, water levels in the shallow observation wells remained relatively stable during the pumping tests. Minor fluctuations in drawdown due to wind gusts or instrument noise were noted in the shallow wells. These up and down fluctuations occurred about either a constant level (MW-18A and MW-7) (*i.e.* a line with a slope of zero representing the moving average between the peaks and valleys of the fluctuations) or about a very gradual linearly increasing trend in drawdown (MW-15A) (*i.e.* a moving average with a small but constant slope). The later condition may reflect leakage from the upper to lower aquifer during pumping but much longer duration pumping would be required to make a definitive conclusion.

Significant drawdown of nearly 1 foot was measured in the shallow well MW-19A during pumping of MW-19B. The measured response in the shallow well to pumping in the adjacent deep well was much smoother and lagged that of the pumped well. This reflects the fact that the observation well is offset 3.5 foot from the pumped well and was unaffected by casing storage while water levels measured initially in a pumped well are dramatically impacted by the rapid emptying of water stored in the well casing.

Stepped Drawdown Tests: As with the constant discharge pumping tests, the purpose of the stepped drawdown tests was to make a determination, based on measured well response, whether a groundwater pump and treat system using the constructed extraction wells is a viable option for remediation at this site. We performed stepped tests on all three of the new 4 inch diameter extraction wells. Each of these wells was 25.5 feet deep and screened from 5 to 25 feet deep. Pump discharge rates were varied in steps from 0.5 to approximately 2.0 gpm. Each well was pumped for approximately 60 minutes. The results of the tests are summarized on Pump Test Analysis Reports included in Appendix 5. Extraction well EW-3 developed the most water. This well reached a near static drawdown level of 10 feet after pumping for a period of 1 hour. The well was able to maintain a flow rate of 0.5 gpm. Extraction well EW-1 developed the least amount of water. Water levels in this well were drawdown 20 feet within 20 minutes after start up of pumping. The well could not sustain a pumping rate of 0.5 gpm. This well was located very close to monitoring well MW-2 in which similar problems were encountered during the constant discharge pumping tests. The estimated long term yield of extraction well EW-1 is in the range of 0.1 to 0.2 gpm or less. This rate will probably be insufficient to establish any significant cone of depression around the pumping well. Plots of the Stepped Drawdown Tests are presented in Appendix 6.

Slug Tests: Slug tests provide estimates of the average formation hydraulic conductivity along the screened interval of the well. They were performed in each of the newly installed 4 inch extraction wells. Each well was fitted with a water level indicator and data-logger set to record levels at 1 second intervals. The tests were run by rapidly pouring water into the well casing and filling it to the top. The water level in the casing then falls at an ever decreasing rate which is recorded by the data-logger. Estimates of average hydraulic conductivity can then be made using graphical plots of the collected data, the type of aquifer, and any one of several analytical models that are available for analyzing such tests and which best fit the data. Plots of the Slug Test Results are presented in Appendix 7.

Aquifer Testing Analyses

Constant Discharge Pumping Tests: Data collected during both the pumping and recovery periods of the tests was reduced and analyzed using Aquifer Test Pro Software v.2013.1 developed by Schlumberger Water Services. This software facilitates the tedious process of curve fitting, type-curve matching, and similar analysis methods.

The following assumptions have been made to facilitate the analysis of test data: (a) aquifers are homogeneous and isotropic; (b) aquifers are of constant thickness and infinite extent; (c) aquifers are pumped at a constant rate; and (d) well screens fully penetrate the pumped aquifer resulting in, with the exception of possible vertical leakage, only horizontal radial flow towards the well. As a result of this last assumption, all aquifers are assumed to be 10 feet thick and coincide with the screened interval of each tested well.

Aquifer Type: Static water level measurements in wells screened over increasing depth intervals (*e.g.* 5 to 15 feet, 20 to 30 feet, and 32 to 42 feet) indicate that there is a downward hydraulic gradient throughout the site. The water bearing units must therefore be confined and may also receive leakage from vertical flow in the confining aquitards.

Analyzing aquifer test data requires knowledge of the hydrogeology of the area influenced by the test (*e.g.* the type and thickness of the pumped aquifer and variation of hydraulic head within surrounding units) so that an appropriate analytical model can be applied. Often such information is not available or obvious prior to the test or before performing an analysis of test data. Diagnostic plots of the logarithm of drawdown (*i.e.* log(s)) versus the logarithm of time (*i.e.* log(t)), together with the derivative (*i.e.* rate of change of drawdown with time) of log(s) with respective to time, when matched against known characteristic plots, provide a means to interpret the test data and apply the most appropriate aquifer type model (*e.g.* confined, unconfined, leaky, double porosity, etc.). These diagnostic plots can also be made using a linear scale for drawdown and log scale for time. Diagnostic Plots for Monitoring Wells MW-19B, MW-19A, MW-15B, and MW-2 are included in Appendix 8. Aquifer Test Validity Checks were run for the constant discharge pumping tests. The results of these checks are presented in Appendix 9.

Data Analysis: The derivative data shown on the diagnostic plots provide insight into aquifer behavior. The derivative data plotted for MW-18B clearly show the characteristic behavior of

a double-porosity or unconfined aquifer. The derivative data for MW-15B clearly show the effect of leakage.

Considerable scatter in the derivative data from MW-19B preclude any interpretation while the pumping time was too short to define later portions of the plotted derivative of the MW-19A data. Interruptions in pumping during the test on MW-2 preclude the use of the derived data from this well.

Derivative data plotting to the left of the measured data during early pumping indicate that well storage and/or losses affect the early data in all wells.

The difficulties encountered with preventing water level drawdown below the top of the well screen as described above, along with the rapid initial drawdown in pumped wells due to the effect of well losses and casing storage, leads us to conclude that the best estimates of aquifer transmissivity are obtained using residual drawdown data collected from the late recovery portion of the tests. Unfortunately these methods do not allow the storage coefficient (*i.e.* storativity) of the aquifer to be determined.

Pumped Well MW-19B: The static water levels in MW-19A and MW-19B were 5.00 and 5.71 feet, respectively, immediately prior to the start of the test. A minor hydraulic gradient of 0.046 ft/ft exists between the mid-points of the well screens directed downward 13° from vertical.

This well was pumped at a rate of 0.65 gpm for 120 minutes after an initial rate of 1.33 gpm during the first 6 minutes. The water level in the well was maintained at the top of the well screen throughout most of the test however it was drawn down 0.38 feet below the top for a short period. The variation in pumping rate during the initial drawdown period precluded the use of the Theis non-equilibrium (1935) or Cooper-Jacob modification (1946) method which would have allowed the transmissivity and storage coefficient to be determined. The Cooper-Jacob modification allows a simplified application of the Theis equation when the drawdown is obtained from late times and/or when the observation well is located very close to the pumped well. Attempts to apply these methods yielded unreasonably low values of the storage coefficient and were therefore discounted.

The Theis recovery method was applied to the recovery data from this well with a computed transmissivity (T) of 18.9 ft^2/day (14.1 gpd/ft). This yields a corresponding hydraulic conductivity (K_{avg}) of 1.89 ft/day (6.67 x 10^{-4} cm/s) when the aquifer is assumed to be 10 feet thick. Application of the Agarwal method (1980) to the recovery data from MW-19B yields a transmissivity 28.2 ft^2/day (211 gpd/ft) along with an average hydraulic conductivity of 2.82 ft/day (9.95 x 10^{-4} cm/s).

While excellent data was collected from the shallow well MW-19A it could not be used in a drawdown or recovery analysis due to the pumping time in MW-19B which was too short to adhere to the assumptions imposed by the method. This well was located 3.5 feet from the pumped well and therefore longer pumping times are required to obtain the necessary data than for the pumped well or closer observation wells.

The minimal head differential in the static water levels along with the significant response of the shallow well to pumping in the deeper well indicates that there is significant hydraulic continuity between the upper and lower aquifers.

Pumped Well MW-18B: The static water levels in MW-18A and MW-18B were 3.79 and 14.70 feet, respectively, immediately prior to the start of the test. The resulting hydraulic gradient between the mid-points of the well screens was 0.712 ft/ft directed downward at an angle 12° from vertical.

This well was pumped at a constant rate of 0.39 gpm for the entire 93 minutes of pumping. The water level in the pumped well was drawn down below the top of the well screen within 3 minutes of the start of the test.

The drawdown and derivative data from this well exhibited a delayed response characteristic of unconfined or double-porosity aquifers. The measured drawdown initially falls on an essentially straight line on a semi-log plot of drawdown versus log time. The drawdown begins to stabilize somewhat between 5 and 9 minutes after the start of pumping and then begins to increase linearly again along a slope parallel to the initial slope. The maximum drawdown in this well exposes the upper 5.25 feet of screen and reduces the submerged screen length to 4.75 feet. Groundwater adjacent to the upper screen then drains slowly by gravity into the well casing reducing the measured drawdown from that which would be expected if only the submerged

screen length were being pumped. Initially some of the groundwater adjacent to the un-submerged well screen is released from storage as with a confined aquifer but most cannot drain rapidly enough to feed the pump and prevent additional dewatering of the well casing. The volume of water released from storage through gravity drainage per foot drop in head per horizontal square foot of aquifer is the specific yield S_y. The specific yield is essentially equivalent to the effective porosity of the aquifer. Once drainage of the zone adjacent to the exposed screen ceases and the casing water level essentially stabilizes with the pumping rate, the drawdown once again begins increasing as noted above.

The data collected from MW-18B appears to be the highest quality of any of the tests conducted. However, while the pump test data characteristics suggest that an unconfined or double-porosity aquifer was tested, the large downward vertical hydraulic gradient between the shallow and deep wells suggests that the lower (*i.e.* pumped) aquifer is confined. If this is the case the shape of the drawdown curve could indicate that a boundary was encountered. However, the presence of a boundary appears to be the least likely explanation for the shape of the curve when the dewatering of the upper portion of the screened length is considered.

Several models were used to analyze the data including: (a) the Cooper-Jacob drawdown versus log time method for late pumping time drawdown data which is applicable to both confined and unconfined aquifers; (b) the Boulton (1963) Type-Curve method for a fully penetrating well in an unconfined aquifer with delayed response; and (c) the Theis Recovery method.

The Cooper-Jacob method was applied to the drawdown data from the second portion of the curve beyond 12.5 minutes which represents a portion of the Theis curve for an unconfined aquifer. The computed transmissivity and storage coefficient were 2.83 ft^2/day (21.2 gpd/ft) and 0.0673 respectively. Typical values of the storage coefficient range from 0.01 to 0.3 in unconfined aquifers and from 0.00001 to 0.001 in confined aquifers. The computed storage coefficient falls within the range for unconfined aquifers. The average hydraulic conductivity along the well screen, K_{avg} was estimated as 0.283 ft/day (9.98×10^{-5} cm/s).

The Boulton Type-Curve method was used to fit type-curves to the delayed response exhibited by the data. This method fits early drawdown data to a Theis type-curve representing a confined aquifer having an associated transmissivity and storage coefficient. A second Theis type-curve is then matched to the data collected after the delayed response and used to calculate the specific

yield (*i.e.* unconfined storage coefficient) of the unconfined aquifer. The two Theis curves are blended over the delayed response period into one curve in Boulton's method. The transmissivity determined using this method was 1.92 ft^2/day (14.4 gpd/ft) which agrees well with other data. The confined storage coefficient (S) and unconfined specific yield (S_y) were estimated to be 0.0204 and 0.204, respectively. The average hydraulic conductivity along the well screen, K_{avg}, estimated using the Boulton method was 0.192 ft/day (6.77 x 10^{-5} cm/s) which is in close agreement with that determined using the Cooper-Jacob method.

The Theis Recovery method was also used to determine the transmissivity from the late recovery residual drawdown data. A transmissivity of 3.37 ft^2/day (25.2 gpd/ft) was determined using this method. The average hydraulic conductivity determined from the recovery data was 0.337 ft/day (1.19 x 10^{-4} cm/s).

The three methods applied to the drawdown data from MW-18B all yielded similar results with computed hydraulic conductivities ranging from 0.192 to 0.337 ft/day (6.77 x 10^{-5} to 1.19 x 10^{-4} cm/s). The computed storage coefficients (0.0204 and 0.0673) fall near the lower end of the range expected from unconfined aquifers. The specific yield of 0.204 is reasonable for an unconfined aquifer in the medium sand (S_y = 0.28), fine sand (S_y = 0.23), and silt (S_y = 0.08) encountered while constructing the monitoring wells.

Pumped Well MW-15B: The static water levels in MW-15A and MW-15B were 4.15 and 18.99 feet, respectively, immediately prior to the start of the test. A hydraulic gradient of 0.544 ft/ft exists between the mid-points of the well screens directed downward 8° from vertical.

The pumping rate of this well varied during the initial 35 minutes of the test after which a constant rate of 0.40 gpm was maintained for an additional 98 minutes. The pump was then shutdown and water level recovery measured for 57 minutes. Pumping rates varied during the first 35 minutes while trying to establish a constant rate without excessive well casing drawdown. A discharge of 0.25 gpm was measured from 12 to 16 minutes into the test and again at 19 to 23 minutes. Additional adjustments were made with the pump controller and the discharge decreased to 0.15 gpm between 28 and 34.5 minutes after which a constant discharge of 0.40 gpm was maintained for the remainder of the pumping period. The water level was maintained a minimum of 1.49 feet above the top of the well screen throughout the pumping portion of the test. The measured drawdown during the early portions of the test was greatly

affected by the difficulty in establishing a constant discharge. Consequently, analytical methods utilizing the initial drawdown data were generally considered not valid.

The Cooper-Jacob method was applied to drawdown data between elapsed pumping times of 60 and 120 minutes. A best fit curve of this data yielded a transmissivity of 12.1 ft^2/day (90.2 gpd/ft) and a storage coefficient of 4.95 x 10^{-8}. This storage coefficient falls below the lower limit of values typical for confined aquifers and therefore raises concerns about the applicability of the Cooper-Jacob method to the available data. The average hydraulic conductivity computed from this method was 1.21 ft/day (4.27 x 10^{-4} cm/s).

The Theis Recovery method and the Agarwal Recovery method were both applied to the recovery data. A manually fitted line to the latest recovery data (*i.e.* smallest values of *t/t'*) yielded a transmissivity of 9.26 ft^2/day (69.3 gpd/ft) and an average hydraulic conductivity of 0.926 ft/day (3.27 x 10^{-4} cm/s). The fitted line intercepts the log-(*t/t'*) axis (*i.e.* zero drawdown) at a value less than one. This suggests insufficient recharge due to either pinching out of the water bearing zone or it may reflect the erratic discharge and drawdown during the early portions of the test. The *t/t'* intercept at zero drawdown should generally fall within the range of 1 to 2.

The Agarwal method yielded similar values for transmissivity (14.4 ft^2/day (108 gpd/ft)) and hydraulic conductivity (1.44 ft/day (5.08 x 10^{-4} cm/s) respectively.

The values of transmissivity computed by the three methods for MW-15B were in close agreement ranging from 9.26 to 14.4 ft^2/day. Consequently the hydraulic conductivity computed from the three methods was also in close agreement ranging from 0.93 to 1.44 ft/day (4.27 x 10^{-4} to 5.08 x 10^{-4} cm/s). The computed storage coefficient was considered unreliable.

Pumped Well MW-2: The static water levels in MW-7 and MW-2 were 4.53 and 14.20 feet, respectively, immediately prior to the start of the test. A hydraulic gradient of 0.426 ft/ft exists between the mid-points of the well screens directed downward 35° from vertical.

As discussed earlier, the discharge rate in this well could not be maintained without drawing down the water level in the well casing to the pump intake. The drawdown data obtained from the pumping portion of this test could not be analyzed to estimate aquifer properties.

The Theis Recovery method was used to analyze the residual drawdown data collected during the 90 minute recovery period which yielded high quality data. The transmissivity computed using this method was 2.09 ft^2/day (15.7 gpd/ft) along with an average hydraulic conductivity of 0.209 ft/day (7.37 x 10^{-5} cm/s). A storage coefficient could not be calculated using this method.

The Agarwal Recovery method was also applied to the data but a curve could not be fitted to the data.

Slug Tests: The methods for analyzing unconfined aquifers pioneered by Hvorslev and further developed by Bouwer and Rice were used to analyze the data obtained from slug tests in EW-1, EW-2, and EW-3. The long screened interval of these wells which penetrate multiple moderate and low permeability zones has an affect on the results obtained from these tests. The slug tests indicate the formations penetrated by the extraction wells have an average conductivity that varies in the range of 8.87 to 14.2 ft/day (3.1 x 10^{-3} to 5.0 x 10^{-3} cm/sec). These values are one to two orders of magnitude greater than the values obtained from the native aquifers tested. Consequently, the location of the extraction wells, all of which are in close proximity to UST backfill, will optimize their effectiveness when used as part of a treatment system. It is our opinion that these values are realistic considering the formations penetrated by the wells and their proximity to UST excavations. These values exceed those estimated from pumping tests on the native aquifers outside of the areas disturbed by the UST installations presumably due to coarse grained materials used to backfill the tank excavations. Plots of the tests are presented in Appendix 7.

Aquifer Properties Summary

The aquifer properties estimated from the constant discharge pumping tests and the recovery tests are summarized on Table 3 - Summary of Aquifer Properties from Pumping Tests. The transmissivity, hydraulic conductivity, and storage coefficient from each analysis are included along with the average values for a given well.

The slug tests are not included because they are not representative of the hydrogeology of the site due to their proximity to tank excavations and the long screen lengths of the extraction wells which create hydraulic communication between strata and results in a composite measure of K which is heavily influenced by the uppermost unconfined aquifer.

A summary of all hydraulic conductivity testing along with estimates made from effective grain size data are shown in Table 1- Summary of Measured and Estimated Hydraulic Conductivity (shown above). The average apparent K_h from pump tests performed on wells having screened intervals from approximately 20 to 30 feet below top of casing was (3.35 x 10^{-4} cm/s). The hydraulic conductivities from MW-2 and MW-18B were in close agreement; *i.e.* 7.37 x 10^{-5} and 9.95 x 10^{-5} cm/s, respectively (0.209 and 0.282 ft/day, respectively) while the K_h value of 8.31 x 10^{-4} cm/s (2.36 ft/day) from MW-19B was almost exactly one order of magnitude greater than the average calculated from MW-2 and MW-18B (*i.e.* 8.66 x 10^{-4} cm/s).

The vertical hydraulic conductivity measured in lab tests varied over a wide range of approximately two orders of magnitude from 3.33 x 10^{-7} to 5.86 x 10^{-5} cm/s (9.44 x 10^{-4} to 1.66 x 10^{-1} ft/day). Excluding the value from a depth of 24 feet in EW-2, K_v varied less than one order of magnitude from 3.33 x 10^{-7} to 6.09 x 10^{-6} cm/s in the depth interval 20 to 25 feet in EW-2 and MW-19B. These values generally fall within the range typical of finer-grained sediments such as silts with some clay.

The laboratory determined value of K_v from the welded ashfall tuff and adjacent cemented zones were in close agreement and ranged from 7.81 x 10^{-7} to 1.13 x 10^{-6} cm/s (2.21 x 10^{-3} to 3.20 x 10^{-3} ft/day) at depths of 9.0 and 6.5 feet in MW-18B and MW-19B, respectively.

An estimate of the apparent ratio of vertical to horizontal hydraulic conductivity (K_v/K_h) was made for the screened interval of MW-19B. This was the only well with sufficient data to make this estimate. Unfortunately, the simplifying assumptions necessary to make the estimate resulted in an unreasonably low value which was discarded.

The water bearing units encountered in the borings and that were in contact with the filter pack of the monitoring wells are generally thin: several inches to perhaps 1 or 2 feet thick. The screened length also penetrated dry to moist layers which were generally finer grained or cemented and are considered to be confining layers. The well response during pumping reflects the hydraulic communication of the water bearing layers with the well screen. The hydraulic conductivity of these zones was estimated using the effective grain size as described above. The estimated K values for these zones ranged from 1.00 x 10^{-3} to 4.77 x 10^{-3} cm/s (2.83 to 13.5 ft/day) which are reasonable values for fine to medium sand.

Table 3 - Summary of Aquifer Properties from Pumping Tests

Pumped Well (screen)	Analysis Method	Transmissivity, T (ft^2/day) {gpd/ft}	Hydraulic Conductivity, K_{avg} (ft/day) {cm/s}	Storage Coefficient, S
MW-19B (20' to 30')	Theis Recovery	18.9 {14.1}	1.89 {6.67 x 10^{-4}}	Not Determined (*i.e.* ND)
	Agarwal Recovery	28.2 {211}	2.82 {9.95 x 10^{-4}}	ND
	Average	23.6 {176}	2.36 {8.31 x 10^{-4}}	ND
MW-18B (20' to 30')	Cooper-Jacob	2.83 {21.2}	0.283 {9.98 x 10^{-5}}	0.0673
	Boulton Type-Curve	1.92 {14.1}	00.192 {6.77 x 10^{-5}}	S = 0.0204 S_y = 0.204
	Theis Recovery	3.37 {25.2}	0.337 {1.19 x 10^{-4}}	ND
	Average	2.71 {20.2}	00.271 {9.95 x 10^{-5}}	S = 0.0439 S_y = 0.204
MW-15B (32' to 42')	Cooper-Jacob	12.1 {90.2}	1.21 {4.27 x 10^{-4}}	Unreliable
	Theis Recovery	9.26 {69.3}	0.926 {3.27 x 10^{-4}}	ND
	Agarwal Recovery	14.4 {108}	1.44 {5.08 x 10^{-4}}	ND
	Average	11.9 {89.2}	1.19 {4.21 x 10^{-4}}	ND
MW-2 (21' to 31')	Theis Recovery	2.09 {15.7}	0.209 {7.37 x 10^{-5}}	ND

While static water level measurements indicate that the lower water bearing units are confined, the storage coefficients determined from pumping tests fall outside of the typical range for confined aquifers. Rather the computed storage coefficients fall within the low end of the range expected for unconfined aquifers. This suggests that there is significant vertical leakage through confining units and into water bearing units. On aggregate, a highly stratified lacustrine deposit such as encountered here could behave as an unconfined aquifer at a macroscopic scale.

Conceptual Site Model

The detailed exploration and testing conducted for the current work phase gives us a high degree of confidence in our findings and the resulting conceptual site model. The boring logs from the current work phase were used to reevaluate the boring logs available from the previous work dating back to 1990. The drilling method and high frequency of sampling used for the current borings, along with laboratory classification testing, allowed us to reinterpret the earlier logs and improve the site characterization. The lithology and hydro-stratigraphy were interpreted from the current and reevaluated boring logs along with recent groundwater level measurements to create a conceptual site model.

Lithology: The project site is underlain by lacustrine sediments along with volcanic ash, possible buried alluvial channels, and deeper older alluvial sediments overlying basalt bedrock at depth. The lacustrine sediments are highly stratified consisting of fine to medium sand with interbedded silt and clayey silt layers. Some cleaner water bearing sand layers were also encountered. The total depth of the lacustrine deposit is unknown but extends down to the maximum depth explored for site investigations related to this LUST site of 44 feet below grade. According to the driller's logs for the ACSW Well No. 5 and ACSW Well No 7, which is located east of A Street between 12th and 13th Streets, the lacustrine sediments extend down to a depth of approximately 50 to 75 feet. According to driller's log the ACSW Well No. 5 well penetrated Gravel at depths below 75 feet with "water gravel" encountered below 295 foot depth. A 10 foot thick layer of "blue" sands was encountered in ACSW Well No. 7 at a depth of 52 feet with loose sands encountered below a depth of 109 feet. These granular deposits are older alluvial sediments which underlie the lacustrine deposits encountered in the bottom of all of the monitoring wells. The older alluvial sediments are in turn underlain by basalt bedrock at a depth of 340 feet in ACSW Well No. 7. See Driller's Logs of the Two Nearest Municipal Wells attached in Appendix 10.

The materials encountered in our borings were correlated with the earlier work and grouped into lithologic units. The lithologic units were described according to predominant soil type and inferred bedding as well as relative depth in the depositional sequence. The relative depth description (*i.e.* upper, middle, and lower) assigned to each lithologic unit also reflects its hydrologic position and function.

Six subsurface cross sections were developed from the reduced log data and geostatistical contouring algorithms. The locations of these sections are shown on the site plan in Plate 2. Cross Sections A-A' through F-F' are shown on Plates 3 through 8, respectively.

The site is generally underlain by layers of sand and gravel (younger alluvial sediments) to a depth of 4.5 to 7 feet below the ground surface. This upper gravel stratum overlies a 1.3 to 3 foot thick weathered, welded ashfall tuff stratum which is continuous across the site except at the current or former UST locations where it has been breached by the excavations. Below the tuff a discontinuous cemented sandy silt layer was noted at some locations in association with the tuff. These two strata overly a 2 to 7 foot thick zone of interbedded silty sand which contains some cleaner, water bearing, sand layers. An additional thin discontinuous layer of silty sand

was also noted below the thicker layer. Each of the aforementioned strata lies within the "Upper" zone which extends from the ground surface to the bottom of the thicker silty sand. The thin discontinuous silty sand layer was grouped with the "Middle" relative depth zone but assigned to the same hydro-stratigraphic unit as the upper silty sand above it.

A sandy silt zone lies beneath the upper lithologic units. This zone consists of sandy silt and silty sand along with a minor clay component which we interpret as the uppermost lacustrine sedimentary unit. As with the upper zone, this zone is interbedded with thin, often discontinuous, layers of silt and fine sand. This zone has a higher proportion of silt and clay sizes than does the upper zone although the absolute differences are slight and could easily vary from location to location. The thickness of this zone varies significantly across the site from 4 feet to nearly 12 feet. This unit thickens from north to the south along Maple Street (Section A-A') while the lower surface dips westerly (Sections E-E' and F-F'). The thickness is more uniform in the north-south section through the middle of the site (Section B-B'). The thickest portion lies in the vicinity of MW-16B at the southwest limit of the area investigated. This unit lies within the "Middle" relative depth zone described above.

A silty sand zone containing water bearing clean sand layers was encountered below the middle sandy silt. Monitoring wells constructed for the current work did not fully penetrate it nor did those installed during the earlier phases. Therefore the total thickness of this layer is unknown.

Hydro-Stratigraphic Units: The lithologic descriptions provided above convey the type of materials encountered along with the geologic environment existing at their time of deposition. The lithologic descriptions also allow inferences to be made about the expected hydrogeologic behavior of the site. However, the observed and inferred behavior can best be condensed into a useful form by assigning the lithologic units into groups with similar hydrogeologic characteristics. Measured groundwater levels from both periodic and continuous long term monitoring allow the hydraulic response of the lithologic units to be correlated and grouped into hydro-stratigraphic units.

The hydro-stratigraphy is shown on the Subsurface Sections. Five hydro-stratigraphic units have been defined and designated with increasing depth as Hydro Unit 1 through Hydro Unit 5. The legend shown for each Subsurface Section shows the grouping of lithologic units into hydro-stratigraphic units. The relative depth and hydrologic function of each Hydro Unit is shown in

parentheses following each lithologic description. Hydro Unit 1 consists of the upper unconfined aquifer that generally overlies the welded tuff which functions as an aquitard except where it has be breached at the UST excavations. Hydro Unit 2 consists of the upper aquitard which includes the welded tuff and associated zones. Hydro Unit 3 consists of a shallow confined aquifer lying below the tuff within the upper silty sand stratum. Water bearing clean sand delivers the highest yield in this zone. Hydro Unit 4 consists of the middle aquitard associated with the low permeability middle sandy silt zone. Hydro Unit 5 consists of the lower leaky aquifer which occurs within the lower silty sand. Water bearing clean sand layers also provides the yield from this aquifer.

It must be noted that the differences in hydraulic behavior between these units is subtle due to the discontinuous nature of the water bearing zones and the expected anisotropy in the hydraulic conductivity between thin beds.

Groundwater Levels

Measured Water Levels (06-19-2013): The depth to static groundwater in the monitoring wells was several feet lower than prior measurements in most wells. Measurements of depths to groundwater were taken from the surveyed top-of-casing (TOC) reference points of the monitor wells. Water level measurements were taken two weeks after the well installation. Groundwater depths and elevations could vary and may not have fully stabilized at the time of measurement. The water level information, including all measurements made to date, is summarized in Table 4 located at the back of this report.

The depth to groundwater in the shallow wells (*i.e.* hydro-stratigraphic units 1, 2, and 3) ranged from 4.80 to 7.50 feet below top of casing. The average depth was calculated at 5.31 feet for monitoring wells MW-4, MW-5, MW-6, MW-7, MW-8, MW-13A, MW-14A, MW-15A, MW-16A, MW-18A, MW-19A, and extraction wells EW-1, EW-2, and EW-3. Wells associated with the shallow unconfined aquifer (*i.e.* Hydro Unit 1) include MW-4, MW-7, MW-8, MW-13A, EW-1, EW-2, and EW-3. Wells associated with the shallow confined aquifer (*i.e.* Hydro Unit 3) include MW-5, MW-14A, MW-15A, MW-18A, and MW-19A. Shallow Groundwater Elevation Contours Hydro Units 1 and 3 are shown on Plate 9, with the shallow unconfined aquifer and the shallow confined aquifer plotted independently. The magnitude and direction of the average hydraulic gradient is also shown on Plate 9 using the color as used for the contours.

Groundwater elevations from the deep monitoring wells (*i.e.* hydro-stratigraphic units 4 and 5) were also measured. The depth to groundwater in the deeper wells; i.e. MW-1, MW-2, MW-3, MW-13B, MW-14B, MW-15B, MW-16B, MW-18B, and MW-19B, ranged from 6.58 to 19.90 feet. The average depth from these wells was calculated as 12.30 feet, which is about 7 foot deeper than the shallow wells. There is a moderate downward gradient between the shallow confined and lower leaky aquifers (hydro-stratigraphic units 3 and 5, respectively). Based on aquifer testing the deep aquifer is believed to be semi-confined. Deep groundwater elevation contours for Hydro Units 4 and 5 are shown on Plate 10 along with the magnitude and direction of the hydraulic gradient.

Table 5 - Hydro-Stratigraphic Units

Hydro-Stratigraphic Unit	Hydro Unit Description	Lithology	Well Group	Flow Direction	Hydraulic Gradient (ft/ft)
1	Shallow Unconfined Aquifer	Sand and Gravel	EW-1, EW-2, EW-3, MW-4, MW-7, MW-8, MW-13A	Southward and Southeastward	Southward: 0.02166
2	Upper Aquitard	Subaqueous Welded Ashfall Tuff; Sandy Silt with Gravel	N/A	N/A	Vertical – Increases with lateral distance from UST cavities
3	Shallow Confined Aquifer	Interbedded Silty fine Sand and poorly graded Sand	MW-5, MW-14A, MW-15A, MW-16A, MW-18A, MW-19A	Southward along eastern project boundary and Southwestward through "hot" zones	Southward: 0.00476 Southwestward: 0.00533 to 0.00781
4	Middle Aquitard	Interbedded Sandy Silt and Silty fine Sand	MW-1, MW-2, MW-3, MW-13B, MW-18B, MW-19B	Westward along the portion of the site south of MW-1 and MW-4 and Southwestward through the "hot" zone	Westward: 0.05884 Southwestward: 0.10163
5	Lower Leaky Aquifer	Silty Sand and Poorly Graded Sand, some Gravel	MW-14B, MW-15B, MW-16B	Westward	Westward: 0.05195

Considering all the shallow wells in aggregate, the direction of groundwater flow in these wells is toward the south at a moderately flat gradient of approximately 0.00607 ft/ft. This flow direction is consistent with historical measurements of groundwater flow. Based on the current measurements, the direction of groundwater flow for the deep wells is to the west. The gradient is much steeper at 0.0781 ft/ft.

These generalizations of overall flow direction and gradient from the shallow and deep wells can be further refined by considering the depth of the screened interval in each well relative to the

identified hydro-stratigraphic units and the degree to which thin water bearing strata may intersect the screen and contribute to measured water levels in an otherwise low permeability screened zone. Monitoring wells were therefore assigned to Hydro-Stratigraphic Units as shown in Table 5 and measured water levels from each unit were contoured using geostatistical methods and plotted on Plates 9 and 10 as described above.

Based on groundwater elevation data for adjacent shallow and deep monitoring well pairs, a strong downward gradient is present for all but the far northeastern part of the site. The measurements and subsequent leakage calculations provide a key to vertical groundwater movement on this site between the shallow confined and lower leaky aquifers (*i.e.* hydro-stratigraphic units 3 and 5, respectively). It also explains why there have been increases in the concentration of dissolved petroleum constituents, mostly MTBE, in some of the deeper aquifer wells the past 5 to 10 years. The gradient measured between the shallow confined and lower leaky aquifer is generally less on site in the vicinity of the underground tank excavations. In general, gradients are higher between well pairs located along Maple Street, located to the west further from the tank excavations. The tank excavations penetrate the upper aquitard (*i.e.* the subaqueous welded ashfall tuff and sandy silt), and at some locations extend partly into but not through the underlying middle aquitard (*i.e.* hydro-stratigraphic unit 4) which separates the shallow confined and lower leaky aquifers.

Long Term Groundwater Monitoring: Long term groundwater monitoring was conducted in order to measure water level response in monitoring wells to daily pumping cycles of the ACSW Well No. 5. Continuous water level monitoring was conducted in several wells over a period of days. The shortest monitoring duration was 3 days in MW-19A. The longest monitoring duration was 24 days in MW-15B. Monitoring was conducted in (a) the shallow wells MW-7, MW-15A, MW-16A, MW-18A, and MW-19A; and (b) the deep wells MW-1, MW-2, MW-15B, MW-16B, MW-18B, and MW-19B. Three to five wells were monitored simultaneously over any given time period due to a limited number of loggers. Monitoring well pairs MW-7/MW-2, MW-15A/MW-15B, MW-16A/MW-16B, MW-18A/MW-18B, and MW-19A/MW-19B were each monitored contemporaneously to assess the vertical hydraulic characteristics between adjacent well pairs.

Monitoring was performed using the In Situ Micro Troll data-loggers previously described and three RST DT2011 vibrating wire piezometers and data-loggers.

The Variation of Water Levels in Wells With Time is plotted for the shallow and deep wells in figures presented in Plates 11 through 13. The wells are also plotted schematically in each figure such that their well screens and casing are shown at the correct elevation. The relative location along the time axis of each plotted well is arbitrary. The plotted water levels are color-coded with the associated well screens shown for each well. Water levels measured in well pairs for long term monitoring for response from City well pumping are also shown in a similar manner on Plate 11.

Several key observations can be made from the plotted data.

- Water levels fluctuate in a periodic fashion with the same general pattern observed amongst wells for any given time interval. Water levels in deep monitoring wells MW-15B, MW-16B, and MW-18B for the period June 14th to June 19th demonstrate this behavior extremely well.

- Water levels in the deeper wells fluctuate over a wider range than do the shallower wells.

- There is an overall downward trend in the fluctuating water level data with time that is attributed to aquifer pumping.

- All wells exhibit a strong downward hydraulic gradient.

- Water levels in the shallow wells MW-7 and nearby MW-15A experienced a sharp rise on June 25th due to a rain event and possible runoff flowing directly into the top of the uncapped casing (the caps were removed to accommodate the data-loggers).

The difference between the highest and lowest water level measured during long term monitoring for shallow wells and deep wells was computed for each well. The resulting range in drawdown for the shallow wells and deep wells was contoured as shown on Plates 14 and 15, Long Term Groundwater Monitoring Maximum Difference in Water Levels. While it is apparent from Plates 12 and 13 that the deeper wells experience a greater range of drawdown through any given cycle, the plotted maximum drawdown ranges on Plates 14 and 15 are biased towards the deep wells which were monitored for longer durations. This bias is the result of

long term drawdown accumulating from insufficient recharge and recovery occurring between the observed periodic cycles.

The opposite effect occurs for the shallow wells MW-7 and MW-15A due to the rain event. The contoured maximum drawdown range is biased towards these wells due to the spike in the water level and slow drainage from each casing assuming that the shallow unconfined aquifer does not experience a rapid rise of nearly 2 feet from storm water infiltration through the cracked pavement (*i.e.* assuming the spike was caused by storm water flowing into the surface vault, rising to the top edge, and then into the casing).

The top of the ACSW No. 5 well screen lies 36 to 50 feet below the deepest wells installed for this project. The pump cycles automatically with demand and therefore the well is pumped intermittently at a reported rate of 350 to 400 gpm. Pumping records are only available for the total daily volume pumped but not for the pumping time or rate. The average daily pumping rate was computed for the available data from June and early July. A Histogram of Pumping Data is included in Appendix 11 along with plotted water levels from the long term monitoring.

We have concluded that the water level fluctuations observed in the monitoring wells during the long term monitoring are primarily associated with the pumping of the ACSW No. 5 well and possibly other nearby wells. This conclusion is based upon repeated patterns observed in the water levels and the fact that the water level monitoring probes are barometrically compensated. Pumping of the ACSW No. 5 well appears to induce drawdown in the monitoring wells installed for this project. Larger drawdowns were observed in the deeper monitoring wells suggesting that leakage from Hydro Units 4 and 5 is reaching the aquifer pumped by the city well. The westward shift in the hydraulic gradient in Hydro Units 4 and 5 also suggests that the ACSW No. 5 well may be drawing water from coarser materials located to the west of the project site below a depth of 30 to 40 feet.

Analytical Tests

Soil Sampling: A total of six (6) soil samples were collected for laboratory analysis during the drilling of the seven boreholes. A Summary of Soil Analytical Data collected for this investigation along with data collected from the previous tests are presented on Table 6. Copies of the new Laboratory Analytical Reports and chain-of-custody records are also attached in Appendix 12.

Table 6: Soil Sampling Results - Former Gil's Shell, 123 West 12th St., Alturas, California

Sample ID	Sample Depth (ft)	Date	PID	TPH-G	TPH-D	MTBE	Benzene	Toluene	Ethyl benzene	Xylenes
			ppm							
Soil Samples Collected by Others:										
[1]G.S.	6	5/14/1990			**7110**					
[2]MW-1	1-1.5	10/10/1990		<10	**12**		<0.02	<0.02	<0.02	<0.02
[2]MW-2	18	10/10/1990		<10	<10		<0.02	<0.02	<0.02	<0.02
[2]MW-3	16	10/11/1990		<10	<10		<0.02	<0.02	<0.02	<0.02
Soil Samples Collected by Porter Geotechnical:										
TP-1	7	10/5/1993	56	<1	<1		<0.005	**0.012**	<0.005	**0.026**
TP-3	7	10/5/1993	476	**190**	**1000**		<0.33	<0.33	<0.33	**2.5**
TP-4	6	10/5/1993	9,000	**1300**	**4400**		**2.3**	**2.4**	**26**	**150**
TP-5	3	10/5/1993	10,000	**1900**	**110**		<1.3	**2.1**	**9.4**	**110**
TP-6	6	10/5/1993	10,000	**1100**	**160**		<1.3	**15**	**22**	**170**
TP-7	7	10/5/1993	1979	**1.2**	**11**		<0.005	**0.008**	**0.005**	**0.026**
TP-8	9.25	10/5/1993	0	<1.0	<1.0		<0.005	**0.017**	**0.005**	**0.04**
Soil Samples Collected by Growth:										
AS-1	5.5	7/18/1996		**2100**	**1500**	**4.8**	**0.84**	**13**	**21**	**160**
	15	7/18/1996		**21**	**20**	<0.05	**0.052**	**0.061**	**0.11**	**0.43**
Soil Samples Collected For This Investigation:										
MW-18A	6.5	6/5/2013		<1.0	<5.0	<0.005	<0.005	<0.005	<0.005	<0.005
EW-1	10	6/5/2013		**8.8**	<5.0	**0.0058**	<0.005	<0.005	**0.056**	**0.14**
EW-1	15	6/5/2013		<1.0	<5.0	<0.005	<0.005	<0.005	<0.005	**0.0055**
EW-2	5	6/6/2013		<1.0	**47**	**0.11**	<0.005	<0.005	<0.005	**0.011**
EW-2	15	6/6/2013		<1.0	<5.0	**0.67**	<0.005	<0.005	<0.005	<0.005
EW-3	5.5	6/6/2013		<1.0	<5.0	<0.005	<0.005	<0.005	<0.005	<0.005

[1] Sample collected by Sundance Services
[2] Sample collected by Kleinfelder Inc.

BOLD At or exceeds laboratory reporting limits

PID: Photoionization Detector (Total Organic Vapors)

Impacts to the soil were detected at low to moderate levels in four of the boreholes drilled for this phase of the investigation. Analytical results indicate that the primary petroleum contaminant in the soil in EW-2 at 15 feet is the fuel oxygenate MTBE which was detected at a concentration of 670 g/Kg. Gasoline, diesel, volatiles, and fuel oxygenates were detected in the soil samples collected and tested from EW-1 and EW-2. The highest concentration of gasoline was detected in EW-1 at a depth of 10 feet at 8.8 ppm. The highest concentration of diesel was detected in EW-2 at a depth of 5 feet at 47 ppm. None of the offsite boreholes had any detectable levels of soil contamination. The impacted zone in the extraction wells generally extends from depths of about 5 feet to 20 feet. The concentration of benzene and toluene in all samples tested was below detection limits. The absence of benzene and toluene suggests that the petroleum product remaining in the soil is highly weathered and biologically degraded.

Groundwater Sampling: Groundwater samples were collected for laboratory analysis from both existing and new monitoring wells as well as the three new extraction wells. A total of 21 wells were sampled and tested. Two additional water samples were collected and tested from the ACSW Well No. 5.

Water samples from the monitoring wells were collected using new ball-check disposable bailers for each well. ACSW Well No. 5 water samples were collected from a sample port set on the pump discharge at the well head. The samples were labeled, entered onto a chain-of-custody record and placed into a cooler with ice for transport to Alpha Analytical Laboratory in Sparks, Nevada. The groundwater samples were tested for total petroleum hydrocarbons as diesel (TPHd) and gasoline (TPHg) by EPA method SW8015B/DHS LUFT Manual. Benzene, toluene, ethylbenzene and xylenes (BTEX), methyl tertiary butyl ether (MTBE), tertiary butyl alcohol (TBA), di-isopropyl ether (DIPE), ethyl tertiary butyl ether (ETBE) and tertiary amyl methyl ether (TAME) were analyzed by EPA 8260 B. Copies of the laboratory reports are included in Appendix 12. A Summary of Analytical Tests on Groundwater, which includes the results of historic testing, is included in Table 7 which is attached at the back of this report.

Petroleum impacts were detected in 14 of the 21 monitoring wells tested. No levels of contaminants were detected in MW-14A, MW-15A, MW-16A, MW-16B, MW-18A, MW-19A, and MW-19B. Only one of the new offsite monitoring wells had low level impacts (MW-18B). As expected all of the new extraction wells were impacted with moderate to high petroleum levels. Analytical results for this sampling period ranged from below the reporting limits to 0.43

mg/L TPHd in EW-2, 33 mg/L TPHg in EW-1, 38 g/L Benzene in EW-1, 43 g/L Toluene in EW-1, 1100 g/L Ethylbenzene in EW-1 and 5600 g/L Xylene in EW-1. Oxygenates were also present in most wells sampled, with the maximum level measured at 2800 g/L MTBE in EW-3. TBA was reported in several wells with the maximum level detected at 600 g/L in EW-3. DIPE and ETBE were not detected above the reporting limits in any of the wells tested.

Maps showing the Distribution of Various Petroleum Constituents in the Groundwater for both the shallow and the deep groundwater zones are included on Plates 16 through 21. Analytical data indicates three and possibly four source areas. These include the former tank cluster located off the southwest corner of the station building (i.e. mini-mart), the active tank cluster located south of the fuel islands, another source located near the north end of the fuel islands, and possibly a fourth source located in the northwest corner of the property near the former fuel island. Free product remains in the areas of EW-1, EW-2, MW-7, and MW-8 in the shallow unconfined and shallow confined aquifers (i.e. hydro-stratigraphic units 1 and 3, respectively). Contamination in the middle aquitard and lower leaky aquifer is generally at lower concentrations than found in the shallower stratigraphic units. The MTBE plume in the deeper units is more diffused and larger, affecting a greater distance down-gradient from the discharge areas.

Groundwater analytical results from Porter Geotechnical testing are summarized in Table 3. **All hydro-stratigraphic units have been impacted.** The concentrations of petroleum detected this event remains at about the same as the levels reported at the time of the last testing early in 2012. Small decreases were noted in shallow wells MW-4, MW-7 and MW-15A. All of these wells are located near the source area southwest of the mini-mart. As with previous testing, the overall concentration of petroleum is generally much higher in the shallow unconfined and shallow confined aquifers than it is in the deeper middle aquitard and lower leaky aquifer. However some of the deeper wells, such as monitoring well MW-1, have concentrations which approach the levels measured in the unconfined zone. In other words, **the groundwater contaminants, particularly MTBE, which was once trapped above the ashfall tuff has apparently traveled downward through fractures or man-made excavations to impact the deeper groundwater zone in some locations**. The size of the various plumes for the shallow and deep aquifers is presented on Plates 16 through 21.

The gasoline, diesel and benzene plume in the shallow aquifer is generally confined to an area around the northern part of the site and extends to the west across Maple Street. The shallow plume has a surface dimension that is about 320 feet long. Gasoline and benzene in the deep aquifer has also impacted an area which is generally confined to the northern part of the site. The plume of MTBE contamination in the deep aquifer, however, is much larger in surface dimension, measuring more than 500 feet– possibly as great as 750 feet in total length. The down-gradient boundaries of the MTBE plume remain undefined in the areas west of Maple Street.

Groundwater Chemistry Trends

Time series graphs have been prepared for gasoline, diesel, benzene and MTBE for each monitoring well which has sufficient data to permit graphing. The graphs for all of the wells are included in Appendix 13. For some wells we have some 20 years of analytical records. Linear trend lines indicate degradation of gasoline, benzene and sometimes MTBE for most of the shallow wells located near the source area likely due to the combined effects of plume migration and natural attenuation. Because of plume migration in the shallow aquifers there has been an increase in one shallow well, MW-15A, which is located on the west side of Maple Street down-gradient of the pollution sources which underlie the northwest corner of the site and the area southwest of the mini-mart. The trend continues for most all of the other shallow wells that had appreciable detection. The levels continue to decrease in these wells after a sharp spike in concentration that was detected in some wells in the time period 2007 to 2012.

Chemical trends in deep monitoring wells are more complicated, with recent trends showing both increases and decreases, depending on the location of the wells. Overall the contaminant level in several deep wells has increased over the past 4 to 6 years. This is due to the continuing migration and leakage from the shallow aquifers down into the deeper aquifer. The greatest increase has been recorded in deep monitoring wells that are located down-gradient of the central pollution mass. Deep wells with greatest increases include MW-2 and MW-15B. Increases have also been measured in MW-1 and MW-14B. However these wells are located somewhat side-gradient to the pollution mass and deep groundwater flow direction, and the trends are not as clear. The most recent data in these side-gradient wells indicates some decrease. The deep well MW-3, located up-gradient of the discharge (source area), has shown a steady decrease in concentration levels due to plume movement toward the west and southwest.

In summary, the observed changes in the dissolved levels of petroleum contamination in the groundwater indicate that the petroleum levels continue to degrade and thus attenuate with time, particularly in the shallow aquifers. However the data also indicates that migration of the petroleum remains active. It continues to migrate into the deeper groundwater zone, in areas down-gradient of the source area. Increases in MTBE levels in MW-15B which is located west of Maple Street, outside of the zone impacted by free petroleum products, indicate that the MTBE plume is actively migrating westward.

Benzene, which is typically one of the first compounds to biodegrade, has reached non-detectable levels in some of the shallow, mostly up-gradient wells. Gasoline and associated volatile organic compounds in the shallow aquifers are now at levels that in some cases are less than 20 percent of the original level for some of the wells located near the discharge pollution sources areas.

Changes in the diesel concentrations in the shallow groundwater are less linear. Overall the concentrations in all locations measured are lower than 20 years ago, however very little diesel was detected in any of the shallow wells between 1998 and 2004. Levels of diesel once again increased in the shallow aquifer in 2006. The levels in most wells are now higher than they were in 1998 to 2004. The laboratory has noted that some of the diesel detected is from contributions from lighter end hydrocarbons (gasoline) detected in tested samples. Diesel has not migrated to any significant degree into the deep aquifer. It has not increased in shallow down-gradient wells. The diesel plume is clearly less mobile than the plumes of MTBE and gasoline.

Alturas Community Supply Well Monitoring and Testing

For the third time in the past two years the threatened city well was tested for petroleum constituents. Porter Geotechnical obtained authorization from the Alturas Public Works Department for access to sample and test ACSW Well No. 5. The "City Well" is located near the south end of Maple Street a distance of 431 feet from the south property boundary. The total depth of this well is 403 feet with the screened interval extending from 80 to 392 feet below the ground surface. This well is now included in our routine semi-annual testing of on site monitoring wells. We were not able to access the top of the City Well to measure water levels at the time of sampling. No gasoline, BTEX or diesel was detected in this well. **For the first time, however, MTBE was detected in this well at a concentration of 0.69 ppb.** Although this remains far below the Regulatory levels, the detection of MTBE is alarming. We

immediately returned to the site to resample and retest this well to confirm results. No MTBE was detected in the follow up sample.

It is not known if the positive test is an indication that the fringe of the MTBE plume, which extends outside and to the west of our monitoring network, has now reached the City well. It is possible that the one time positive test was in response to the higher pumping rates at the well prior to sample collection. The initial positive detection result was not confirmed with the follow up sample testing.

Dissolved Oxygen

Dissolved oxygen (DO) levels were measured in all wells. The dissolved oxygen level is a good indicator of the level of contamination in the groundwater. The level of dissolved oxygen also controls the rate of biodegradation of the contaminants in the subsurface. As a rule of thumb, areas of low dissolved oxygen correspond with areas of higher groundwater contamination. Areas of higher dissolved oxygen levels will have more rapid biodegradation of pollutants. The level of dissolved oxygen as measured in the past sample event varied from 0.04 ppm, a nearly anaerobic condition in the most impacted area (MW-7 and MW-8), to 4.46 ppm in a shallow well (MW-15A) located well outside of the area impacted by petroleum. Dissolved oxygen levels are presented on Table 4. Many of the measurements were in the range of 0.5 ppm DO or less.

Hydrochemical Facies - Comparison of Inorganic Chemical Analysis of Groundwater

Inorganic tests were performed on groundwater samples collected from deep monitoring well MW-19B. We also obtained the most recent tests performed by the City of Alturas on ACSW Well No. 5. Copies of the Inorganic Chemical Test Results on Groundwater are attached in Appendix 14. These results were used to establish the hydrochemical facies and environment from which the water was obtained. The analysis was used to compare the origins of the groundwater samples from the two wells and determine if in fact the water samples came from similar aquifers. A hydrochemical connection between the two aquifers establishes a potential pathway from the impacted aquifers found under the site to the waters developed in the community supply well.

Most groundwater originates as rain or snow melt that infiltrates into the ground and the underlying aquifers. It starts out as an extremely dilute, slightly acidic oxidizing solution that

causes alterations in the mineralogy of porous subsurface soils and rock through which it infiltrates and flows. It is well known that there is a major ion evolution as groundwater moves along the flow path through various geologic settings with time. Early stage water starts out as bicarbonate dominant. With time it progresses to bicarbonate and sulfate dominant. With more time the chloride levels increase and the bicarbonate and eventually the sulfate levels decrease. The final stage yields chloride dominant water.

The major ion percentages (anions and cations) based on the test results are illustrated in the Trilinear Diagrams of Inorganic Tests on Groundwater shown on Plate 22. Both waters plot in the same calcium magnesium bicarbonate hydrochemical facies which are typical of native water found in an oxidizing environment. This type of water is typical of active groundwater that is flushing through relatively well leached sediments. The only difference is that the deeper City Well water contains a slightly higher percent concentration of calcium and has a somewhat higher, more alkaline pH.

Based on this analysis we can conclude that the groundwater obtained from wells MW-19B and ACSW No. 5 is hydrologically connected. Even though there are aquitards and various lower permeability strata that separate the water sampled in these two wells there is sufficient communication, leakage, and connectivity of flow between the two to cause the inorganic chemistry to be very similar and lie within the same hydrochemical facies environment.

AIR SPARGE AND VAPOR EXTRACTION PILOT TESTING

Introduction

Air Sparge - Vapor Extraction pilot testing was conducted in phases, using two combinations of adjacent well pairs on site for simultaneous injection and extraction. In addition, an extraction test was conducted on the most impacted well (MW-1) without simultaneous sparge injection into an adjacent well. For each well pair the sparge injection wells were located a distance of approximately 30 feet from the extraction well. The two well pairs tested were the deep well pair MW-2 with MW-3 and the shallow well pair MW-4 with MW-7. The injection wells were supplied compressed air at an injection rate of approximately 15 to 20 cubic feet per minute (cfm) @ 5 to 7 psi injection pressure for testing. The vacuum pump pulled vapors from the extraction well at a rate of 40 to 60 cfm at a vacuum pressure of -7 to -9 inches of mercury

(in/Hg). The first part of each test was conducted using air sparge pumping only. For the later part of the test both the air sparge and the vacuum pump were run together. In both tests air flow rates and vapor extraction rates increased when both pumps were run simultaneously.

Air Sparge System Operation

Air sparging is accomplished through aeration of the soil and groundwater with the use of micro-fine well screens. It is an in-situ remedial technology utilized to remove dissolved phase contaminants from the groundwater. Air sparging involves injection of air under low to medium pressure below the dissolved contaminant plume through a series of air sparge points. As air bubbles migrate upward through the soil column, contaminants in the saturated zone are stripped and/or volatilized. The contaminants are transferred to the vadose zone where either a soil vapor extraction system captures, extracts, and treats them, or the vapors are forced to the ground surface without pumping and escape to the atmosphere.

Air sparging also provides oxygen to indigenous hydrocarbon-degrading microbes in the soil and groundwater, thereby enhancing biodegradation of the hydrocarbons. Oxygen serves as a primary electron acceptor, allowing hydrocarbons to be biologically degraded into carbon dioxide and water. Sparging has been most successful in treatment of light non-aqueous phase liquids (LNAPL). Sparging has also been shown to be effective in treating MTBE and other fuel oxygenates. However, the treatment rate is slower for MTBE than it is for LNAPL's since MTBE is more soluble in water, less volatile when dissolved in water, and less hydrophobic than other fuel constituents. Aerobic oxidation of MTBE occurs via co-metabolic degradation with TBA as the first order decay product and the intermediate step in the biodegradation process.

For these tests, we used shallow monitoring well MW-4, deep well MW-1, and Extraction Well EW-3 as the sparge wells. The points were supplied with compressed air through flexible reinforced compressor hoses connected to the top of the well casing. The hoses were temporarily set on top of the pavement. We used a Gast 7½-hp oil-less compressor-blower, powered by a 230-volt, 3-phase electric motor. A trailer mounted diesel powered generator was used to supply the test trailer with the 3 phase power source. The sparge pump used for the testing is rated at 55 cfm at 15 psi flow. The blower was equipped with thermocouple high temperature cutoffs to protect the PVC pipe. The sparge pump is capable of delivering up to 20 psi of compressed air to the sparge points. Photographs of the test setup are included in Appendix 4.

Air Sparge Performance

Air flow rates for the wells tested varied from 10 to 30 cfm after the water table was depressed down near the bottom of the injection well. After the test started the rates were slowly increased until the maximum capacity of the well was established. Air Sparge Test Data is presented on Table 8.

Table 8
Air Sparge Test EW-3, Monitored at MW-1, MW-4 and MW-13A
Former Gil's Gas, Alturas, California

Date	Time	Air Inject Press EW-3 (PSI)	Air Flow Rate EW-3 (ft^3/min)	MW-4 Press (In/WC)	MW-13A Press (In/WC)	Comments
6/19/2013	11:43 AM	3	10			Initial Start-up
6/19/2013	11:45 AM	4	10			Bypass and 30%
6/19/2013	11:52 AM	5	20			Bypass and 80% closed
6/19/2013	11:55 AM	6	25			Bypass at 90% closed
6/19/2013	12:03 PM	6	30	0.06	0.01	Bypass closed 100%
6/19/2013	12:05 PM					Stop test

Abbreviations & Notes

PSI = pounds per square inch
In/WC = inches water column pressure
ft^3/min = cubic feet per minute
1 psi = 27.7 in/wc

Well Detail:	Total Depth	Depth to GW	Dist from Well
EW-3	25 ft.	6.78	0 ft.
MW-4	10.5 ft.	5.8	39 ft.
MW-13A	12 ft.	5.1	59 ft.

Testing on Deep Well MW-1: Monitoring Well MW-1 is 31 feet deep. The 10-foot of well screen is set in moderately dense silty sand and sandy silt. After only 13 minutes of testing we found this formation was generally too dense, fine grained, and impermeable to be suitable for use in sparging. Air flow into the well was less than 10 cfm. During the test, well head pressures continued to rise to above 17 psi. Eventually the sparge pump blower motor overheated, shutting down the test early. We have concluded that due to the density and low permeability of the soil adjacent to the well screen, sparge injection into the middle aquitard or lower leaky aquifer 20 to 30 feet below the ground surface would be problematic.

Shallow Well Testing on MW-4 and EW-3: These wells have well screens that are set primarily in the shallow aquifer. Well screen for MW-4 is very shallow at 5 to 10 feet deep. Well screen

for EW-3 is set from 5 to 25 feet deep. Both wells responded favorable to testing. Air pressure on each shallow well stabilized at 5 to 6 psi. The well head pressure was sufficient to displace the entire height of the initial water column that was found covering the well screen in each injection well. Therefore the injection-treatment zone includes all of the strata adjacent to the well screen sections, with preference to the more permeable strata. The treatment zone with sparging includes strata which lie both above and below the water table.

Early test behavior also indicates that the sparge system air flow into the wells was lower at the start of the test, until the water column was displaced and longer screen sections in the sparge wells were available for air to be forced into formations located below the water table. Once the water column was displaced, well flow increased and injection pressures stabilized. The final air flow rate into the well stabilized at 30 cfm. These rates are sufficient for treatment indicating wells of similar construction and lithology would be suitable for use as Air Sparge Wells.

Measurements of well head pressures in other shallow wells surrounding the sparge well indicate the zone of influence around the sparge well extends out a radius of approximately 40 feet around the injection well. For treatment design purposes we would recommend a maximum distance between injection points of no more than 30 feet to assure treatment in the lower permeability strata found in section.

Soil Vapor Extraction (SVE) Pilot Test

Test Objective: The purpose of the SVE pilot test was to evaluate the effectiveness of the extraction wells installed in treating petroleum contaminated soil at the site. The extraction wells are located in areas we have identified as having the highest petroleum contamination on the site. The vapor extraction test provided quantitative and qualitative measurements of the short term hydrocarbon removal rates through vapor extraction.

Test Elements: Vapor extraction tests were run on all three 4-inch diameter extraction wells, EW-1, 2, and 3. The extraction test on EW-3 was performed while simultaneously sparging the adjacent shallow monitoring well MW-4. The tests on the wells were performed with a 5½-hp, 220-Volt, 3-Phase EG&G Rotron regenerative blower set in a portable trailer. The blower is rated at a maximum flow of 280 scfm at 6.2 in/Hg vacuum pressure. The blower is equipped with a moisture knockout. The knockout traps any free water that might be extracted along with the vapors from the extraction well which could condense and collect in the extraction pipe

between the wellhead and the pump. The pump is also equipped with a particulate filter on the inlet. Controls on the blower consist of two 3-inch gate valves, a vacuum by-pass valve to control pump overheating, thermal cutoffs, and pressure relief regulator. A photograph of the test pump is shown in the photos attached (Appendix 4).

Monitoring points for the SVE test included the following:

- Time as measured SVE hour meter on blower power supply.
- Blower inlet vacuum measured on inlet side of blower.
- Blower exhaust temperature measured downstream of moisture knockout.
- Exhaust flow rate as measured using air velocity measurement, obtained with a Dwyer hot-wire air velocity meter inserted into a sample port on the exhaust pipe.
- Hydrocarbon effluent as measured with a Photovac photoionization detector (PID) inserted into a sample collected from a port on the pump exhaust pipe.
- Hydrocarbon effluent as confirmed by analytical laboratory tests on gas samples collected in Tedlar bags from an exhaust port.
- Moisture accumulation in knockout.
- Vacuum pressure at monitoring wells using Dwyer Digital Manometer fixed to well head cap.

Monitoring records for the Vapor Testing are included in Tables 9 through 11.

Table 9
Vapor Extraction Test On EW-1, Monitored at MW-13A
Former Gil's Gas, Alturas, CA

Date	Time	Blower Vac Press	Inlet Temp	Exhaust Speed	Air flow	PID	HC Removal Rate	MW-13-A	TPHg	Benzene	Toluene	Ethyl benzene	Xylenes	MTBE	Comments
		in/Hg	F°	fpm	cfm	ppm	lbs/day	in/WC	mg/m³						
6/20/2013	7:52	3.5		642	31.50	319									
6/20/2013	8:02				0.00	312									
6/20/2013	8:04	4	60	1064	52.20	475									
6/20/2013	8:08						8.4		1800	<1.3	<1.3	11	19	<1.3	Air sample
6/20/2013	8:10			791	38.81	375									
6/20/2013	8:16	5													
6/20/2013	8:19					449									
6/20/2013	8:20	5		730	35.82	20		1.25							
6/20/2013	8:23	5.7	62.9	1240	60.84										
6/20/2013	8:27					414		1.07							
6/20/2013	8:35					277									
6/20/2013	8:38							0.78							
6/20/2013	8:47	6	68	1037	50.88										
6/20/2013	8:49	6				446									Starts to slurp water
6/20/2013	8:50	7.4			0.00	404									

Well Detail:

EW-1	DTW = 5.46	Screen = 5-25 ft	20 ft.
MW-13A	DTW = 5.67 ft	Screen = 2-12 ft	

lbs/day calc: (TPHg) x scfm x (1/1000) x (1/453.59) x (1/35.31) x 1440

Table 10
Vapor Extraction Test on EW-2 without Air Sparge Injection
Former Gil's Gas, Alturas, CA

Date	Time	Blower Vac Press	Inlet Temp	Exhaust Speed	Air flow	PID	HC Removal Rate	TPHg	Benzene	Toluene	Ethyl benzene	Xylenes	MTBE	Comments
		in/Hg	F°	fpm	cfm	ppm	lbs/day	mg/m³						
6/20/2013	9:16	5												Start Vapor Extraction MW-1, by pass at 50%
6/20/2013	9:17					23.6								Bypass @ 70% closed
6/20/2013	9:20		72.6	1448										
6/20/2013	9:23	5				15.8								
6/20/2013	9:25	5.7				15.5								
6/20/2013	9:32		78.7	1368	67.1175	17.2								
6/20/2013	9:40													Leakage from nearby tank well cover
6/20/2013	9:45	6				10.2								
6/20/2013	9:46													
6/20/2013	9:50		76.6	1200		13.8		84	<0.25	<0.25	2.2	4.3	0.77	Lab sample
6/20/2013	9:58					46.8	0.52							
6/20/2013	10:17		77.3	1410	69.17813									
6/20/2013	10:23													No influence in MW-13A, pumps slurps water
6/20/2013	10:25													Stop test

Well Detail:

EW-2 DTW = 5.89 Screen = 5-25 ft Distances Between Wells: 75 ft.

lbs/day calc: (TPHg) x scfm x (1/1000) x (1/453.59) x (1/35.31) x 1440

Table 11
Vapor Extraction Test On EW-3 with Air Sparge Injection into MW-4
Former Gil's Gas, Alturas, CA

Date	Time	Blower Vac Press	Inlet Temp	Exhaust Speed	Air flow	PID	HC Removal Rate	MW-1	MW-13A	Sparge Injection Pressure	Sparge Air Flow Rate	TPHg	Benzene	Toluene	Ethyl benzene	Xylenes	MTBE	Comments
		in/Hg	F°	fpm	cfm	ppm	lbs/day	in/WC	in/WC	psi	cfm	mg/m³						
6/19/2013	2:05 PM	**2.0**				**9.7**												Start Sparging MW-2
6/19/2013	2:23 PM	5.0	64.2	950	46.60938	8.1												
6/19/2013	2:29 PM	6.0	60	1150	56.42188	63												
6/19/2013	2:35 PM	6.0	60	1207	59.21844	13.2												
6/19/2013	2:37 PM	7.0		482	23.64813	85.3												
6/19/2013	2:40PM					8.3												Start slurping water, partly open
6/19/2013	2:53 PM	8.5																Pass
6/19/2013	3:00 PM	8.5	70					-0.52	0.02									
6/19/2013	3:01 PM			630	30.90938					5	30							Start sparging
6/19/2013	3:19 PM					36.5		-0.08										
6/19/2013	3:20 PM																	
6/19/2013	3:45 PM						0.45		0			160	<0.20	<0.20	<0.20	<0.20	2.9	Air sample

Well Detail:

MW-1	DTW = 8.50 ft	Screen = 21-31 ft	Distances Between Wells:	MW-1 to EW-3 40 ft
MW-13A	DTW = 5.10 ft	Screen = 2-12 ft		MW-13A to EW-3 45 ft
EW-3	DTW = 6.78 ft	Screen = 5-25 ft		

lbs/day calc: (TPHg) x scfm x (1/1000) x (1/453.59) x (1/35.31) x 1440

***Data Reduction**:* The rate at which petroleum constituents are extracted from the SVE system was calculated by obtaining measurements of hydrocarbon concentration and the air flow rate through the system. The concentration of hydrocarbons was derived from both laboratory test results and field PID measurements. Data records for measured vapor values are presented on the tables. The volumetric flow rate of extracted air was determined using a Dwyer Thermal Anemometer and measurement of the exhaust pipe's discharge area.

Measurements obtained from the vacuum gauges on the SVE pipe and from the digital manometer at the monitor well heads were used quantitatively and qualitatively to determine the flow and pressure at the extraction point.

Soil Vapor Extraction Test Results and Analysis

Vacuum Pressure and Air Flow: Vacuum pressure on the extracted wells (as measured at pump) varied from -2 to -8.5 in/Hg. These values tended to increase (i.e. increasing vacuum) with time of pumping, but appeared to stabilize near the end of each test. Vacuum pressure was lower in EW-2 due to short-circuit air flow through the formation and back up to the ground surface through extensive cracks in the pavement in the area surrounding the well. The moderately high water table in each well also affected the test. If vacuum pressure exceeded about -6 in/Hg the vacuum pump started to draw groundwater through the vapor extraction piping.

Air flow rates varied during each test, ranging from 60 to 70 cfm from each well. The final air flow rates increased in response to start up of air sparging in the adjacent well. We measured the radius of influence around the extracted well by monitoring vacuum pressure at surrounding well heads. The effective radius of influence was approximately 60 feet. The relatively large radius of influence was due in part because of the high water table elevation and consequent thin vadose zone along with the relatively open formation in the upper most soil units.

Temperature: Inlet air to the pump (i.e. air extracted from the formation) was measured in the range of 60 to 80 degrees F. These values are likely elevated somewhat by the temperature of the flexible extraction pipe which was located on the top of the warm asphalt at the time of testing.

Vapor Analysis: Petroleum content in the extracted vapor was measured using both a PhotoVac photoionization detector (PID) in the field and laboratory tests on vapor samples collected from the vapor extraction pump discharge. The PID is calibrated with isobutylene gas and is more sensitive to the volatile components in gasoline. It is less sensitive to the heavier, larger chain hydrocarbons such as diesel. The PID values measured for these tests varied from a low of 10 ppm measured shortly after the pump was started to stabilized levels of 40 to 475 ppm depending upon the well. The highest levels were measured from EW-1 at 475 ppm, the lowest was measured from EW-2 at approximately 10 ppm. EW-1 is located in a gasoline source zone while EW-2 is in a zone impacted by diesel. The volatile concentrations measured by the PID reflect these differences.

Analytical results from vapor tests confirmed field measurements. The tests indicate moderate to high concentrations of petroleum were extracted from the wells tested. The highest levels were detected in vapor extracted from EW-1. Elevated levels were also detected in vapors extracted from EW-2 and EW-3. Tests for extracted gasoline were in the range of 84 mg/m^3 to 1800 mg/m^3. Other vapors extracted in lower concentrations include, benzene, toluene, ethyl benzene, xylenes and MTBE. Copies of the laboratory reports on vapor samples are included in Appendix 12.

Hydrocarbon Recovery Rate: The hydrocarbon recovery rate was calculated based on the results of the three laboratory tests. The volatile recovery rate was calculated using the following extraction formula:

<u>Vapor Extraction Calculations</u>

Removal Rate ($Vr_{(TPH)}$) for Vapor:

$\mathbf{Vr}_{(TPH)} = \mathbf{C_f} \times \mathbf{Q}$

where: $\mathbf{C_f}$ = avg. vapor concentration (mg/m^3), and $\mathbf{Q}$ = avg. flow rate (ft^3/min)

$\mathbf{Vr}_{(TPH)}$ = (260 mg / m^3) × (1 m^3 / 35.31 ft^3) × (1g / 1000 mg) × (1 lb / 454 g) × (170 ft^3 / min) × (1440 min / day)

Conc. mg/m^3 × System Flow × [(1g ÷ 1000 mg) × (1 lb ÷ 453.59 g) × (1 m^3 ÷ 35.31 ft^3) × 1440 min/day]

<u>EW-1 @ 8:08</u>

$\mathbf{Vr}_{(TPH)}$ = 1800 mg/m^3 × 52 cfm × [1/1000 × 1/453.59 × 1/35.31 × 1440] = **8.4 lb/day**

1800 mg/m^3 × 52 cfm × (0.00008990) = **8.4 lb/day**

<u>EW-2 @ 9:50</u>

$\mathbf{Vr}_{(TPH)}$ = 84 mg/m^3 × 77 cfm × 8.99 × 10^{-5} = **0.58 lb/day**

EW-3 @ 3:45

$\mathbf{Vr}_{(TPH)} = 160\ mg/m^3 \times 31\ cfm \times 8.99 \times 10^{-5} =$ **0.45 lb/day**

Based on the above calculations we have determined that the early time extraction rates for the individual wells tested range from 0.45 lb/day as measured from EW-3 to a high of 8.4 lb/day as measured from EW-1. The combined early time recovery rate from the three wells is a total of 9.37 lbs/day. We anticipate that extraction rates will decrease from measured rates with time and as the formation is treated.

FURTHER INVESTIGATION AND PILOT TESTING CONCLUSIONS

Additional Soil and Groundwater Testing

Soil and groundwater tests performed on samples obtained from the additional monitoring wells installed for this investigation indicate that the soil contamination zone or (source plume) is mostly confined to the northern half of the site and in the area west of the site but east of the line of wells located along the west side of Maple Street. No impacted soil was detected in the wells drilled to the south along 10th Street.

Groundwater testing on samples obtained from wells installed for this phase of the investigation reveals that the dissolved plume of MTBE in the deeper groundwater zone encompassing the middle aquitard and the lower leaky aquifer (*i.e.* hydro-stratigraphic units 4 and 5) extends an unknown distance further west beyond the limits of the current monitoring well network. It has migrated west of the wells located along the western edge of Maple Street. The highest concentrations of gasoline, BTEX and diesel in the groundwater remain centered over the northern and central parts of the site which remain as essentially "continuous" contributing source zones. However, these source zones are subject to advective transport, hydrodynamic dispersion, and natural attenuation yielding decaying contaminant concentrations at a given fixed observation point. The MTBE plume is much larger than the source zones and includes areas to the west an unknown distance under Maple Street. The concentrations of contaminants remain high in most wells with levels highest in the shallow wells. The concentrations in the deeper wells average about 50 percent less than that of the shallow aquifer. The largest plume of groundwater contamination is now in the deep aquifer with a longitudinal (i.e. major axis) surface dimension of more than 500 feet and possibly as long as 750 feet or more.

There is clear evidence since 2003, when the deep monitoring well MW-15B was installed, the MTBE plume has shifted with time toward the west. In 2003 there were two water samples collected from this deep well with no detectable levels of MTBE. As confirmed with this latest testing, MTBE in this well is now at approximately 60 ppb. The well is located directly down-gradient of the central part of the source area on the site in what we consider the major axis of migration for the deep groundwater plume. We do not know how far west the plume has migrated without the installation of additional deep monitoring wells in locations further west of Maple Street. We also do not know if the westward flow of groundwater is intercepted at some point down-gradient by the zone of influence (drawdown cone) which has developed around the ACSW Well No. 5. Due to the close proximity of the city well, it is possible that at some point west of Maple Street the westward flow has been captured in the drawdown cone that develops around the Community Supply Well. Pumping of the City Well, typically at 350 to 400 gpm, may also induce downward vertical leakage from the impacted zones into the aquifer materials adjacent to the well screen. The one time detection of MTBE in the City well may in fact be an indication that the plume has already reached the ACSW Well No. 5.

Recent testing indicates the concentration levels in many wells have stabilized or are continuing to decrease at a slow rate. The only exceptions are the increases in MTBE concentration noted in the deep down-gradient wells which are continuing to rise which indicates that the MTBE plume is still migrating westward.

For the first time, we have detected a low level of MTBE in the ACSW Well No. 5. The positive test result was not duplicated in follow up testing. It is possible that the leading edge of the MTBE plume has already reached the well. It is also possible that the one time detection has no statistical significance. Confirmation will require additional testing. However, groundwater elevation data suggests that a cone of depression is present around the supply well. Long term monitoring data confirms how production has an influence in many monitoring wells installed for this investigation. Impacts to this community water supply will remain a concern.

Mass Balance Estimates

Hydrocarbon Mass in Soil: Soil analytical test data collected from boreholes drilled on this site is limited, as most wells were drilled with an air rotary drill which did not provide samples suitable for testing. Some of the most reliable sample test results were collected from test pits excavated in 1993. Combining this early test data with the testing performed for this

investigation and assuming an 80 percent decrease in petroleum levels over the past 20 years through natural biodegradation, we have estimated the mass of petroleum remaining in the soil.

For this estimate we assume the impacted soil zone lies predominantly between depths of 3 feet to 23 feet below existing grade. The impacted soil zone has surface dimensions of approximately 140 feet long by 140 feet wide. This estimate is based on a 200 ppm average concentration of TPH (TPHg and TPHd combined) remaining in the soil within the impacted soil plume. This concentration is approximately 80 percent lower than many of the original lab tests conducted in 1993. We estimate the remaining mass of hydrocarbons in the impacted soil zone to be approximately 6500 lbs.

Sparge Test Results

At this site we have shown that air sparging the shallow aquifer would be beneficial for providing environmental conditions which will improve biodegradation rates of contaminants. It is a preferred method of treatment when used in conjunction with vapor extraction. Dissolved oxygen levels remain low in areas where dissolved petroleum contaminants are detected in the groundwater. Thus, without any remediation in the area explored, bioactivity is slower than desired and in some areas is nearly anaerobic which further slows biodegradation rates. Many of the soils encountered on site are relatively dense and have a moderate to moderately-low permeability. These zones will be less likely to respond to air sparge or vacuum extraction treatment, however because of their permeability they will not be the stratigraphic units that are responsible for significant plume migration.

Air sparging will increase oxygen levels in the injection zones. It will also increase subsurface temperatures through the injection of 150 degree F air into the subsurface which should also increase volatilization and biodegradation of the remaining contaminants. Based on the field tests, we measured a 40 to 50 foot radius of influence around each sparge point. The system design should be capable of maintaining a 15 psi injection pressure with an air flow rate of approximately 10 cfm per sparge well.

The deeper wells which were screened within the middle aquitard and lower leaky aquifer were found not suitable for use in air sparge treatment. The higher density and lower permeability of the middle aquitard, generally found at depths of approximately 20 to 30 feet below the ground surface, restricted air flow and caused excess pressures and overheating in the sparge

pump. It is possible that new wells constructed with well screen set in the deeper more sandy strata found at depths below 30 feet could be used for sparging, provided the pump was capable of maintaining injection pressures in the range of 20 to 25 psi.

Vapor Extraction Test Results

Vapor extraction tests were performed both with and without air sparge injection. Moderate to high levels of petroleum were extracted from each well tested. Levels of gasoline were detected in the extracted vapor in the range of 84 to 1800 mg/m^3. Lower levels of BTEX compounds and oxygenates were also detected in the extracted vapor samples. Early treatment process time extraction rates for individual wells tested ranged from 0.45 to 8.4 lb/day hydrocarbons. A combined total rate for the three wells tested was moderately high at 9.37 lbs/day. Extraction rates are expected to decrease with time as the formation is treated. Often rates can be reduced to 10 percent of the original levels after the first 6 months of treatment. The radius of influence around the extraction well was moderately high at 60 feet. The open formation in the uppermost strata lends well to insitu treatment using vapor extraction.

The shallow depth to groundwater, which at times can be as little as 5 feet below the ground surface, is a major factor which will tend to reduce the effectiveness of this form of insitu treatment at this site. The extensive network of cracks and broken asphalt on the pavement surface above the contaminated zone is also a major impediment to successful SVE. The deteriorated pavement allows for short-circuiting of extracted vapors between the extraction well screen and the ground surface. These limiting factors can be at least partially addressed by combining the installation of a VES system with groundwater pumping from the same extraction collection points. It may also be necessary to turn off the vapor extraction system at times of the year when the water table is highest. The depth to groundwater can vary seasonally by as much as 5 feet in elevation. To address the concerns with cracks in the pavement a heavy oil slurry seal will need to be applied to the pavement in all treatment areas.

Provided that the above mitigating measures are included as part of the overall design, we believe the results of the vapor extraction test show that the system will effectively capture contaminated soil vapor from the petroleum impacted zone that remains under the site.

Pollution Migration and Sensitive Receptor Risk

The potential time frame for the MTBE plume to reach ACSW Well No. 5 was assessed using an analytical model assuming a worst case scenario whereby the hydraulic gradient is directed southward. A retarded advective-dispersive analytical model (Domenico, 1987) was used for the analysis to estimate the time to reach the city well at the MTBE detection limit (0.5 ppb) and at the taste and odor threshold (5 ppb). Analyses were performed assuming both a constant source concentration and a decaying source concentration. The Pollution Migration Analyses are included in Appendix 15 attached to this report.

The source area for these analyses was the UST excavation near MW-6 and EW-2. A review of past analytical testing on groundwater samples obtained from MW-6 indicated a maximum MTBE concentration of 20,000 ppb on January 22, 2007. Subsequently, MTBE concentrations in MW-6 have been fluctuating about a decreasing trend. The decrease in MTBE concentration is due to advective-dispersive mass transport and biodegradation. These mechanisms can be grouped to calculate a lumped exponential decay constant. The MTBE concentration versus time was plotted using the data from 2007 to the present. The data was also manually smoothed (weeded) to obtain a nearly perfect fit to an exponential decay curve. The decay constants determined from curve fitting of the plotted data were -0.0011966/day and -0.0018226/day for the complete data set and smoothed data, respectively. The correlation coefficients were 0.796 and 0.998 for the complete data set and smoothed data, respectively.

The MTBE concentration in MW-1 fluctuated between 28 and 130 ppb from 1996 to 2002. The concentration then began to climb from 2003 to 2010 and now appears to be decreasing. The maximum MTBE concentration in MW-1 was measured in 2010 at a level of 1700 ppb. The relative concentration in MW-1 versus time was plotted for the period 2003 to 2010 in order to estimate a longitudinal dispersion coefficient (D_x). The advective velocity (5.28×10^{-2} ft/day) for flow between MW-6 and MW-1 was also estimated in order to compute D_x and the longitudinal dispersivity ($_x$). A longitudinal dispersion coefficient of 0.25 ft^2/day and a longitudinal dispersivity of 4.80 feet were estimated from this analysis which compares well with published values and values computed from the Xu and Eckstein (1995) regression equation.

The mass transport analyses were performed assuming the following parameters and boundary conditions.

- The source area was assumed to be the UST excavation near MW-6 and EW-2. The source dimensions are 45 feet wide by 20 feet deep in a vertical plane. The MTBE concentration did not vary spatially within the cross section.

- Two analyses were performed with one considering decay of the MTBE concentration in the source area with time and the second assuming a constant concentration with time.

- Adsorption onto the soil matrix is governed by the linear Freundlich isotherm with a partition coefficient (K_d) of 0.01242 mL/g.

- The mass transport velocity, or retarded velocity, can be thought of as the advective groundwater velocity divided by the retardance factor. Adsorption of contaminants onto the soil matrix has the macroscopic effect of slowing down the contaminant plume. A retardance factor (R_f) of 1.06 was estimated for the interaction of MTBE with the silty soils present at the site.

- The longitudinal dispersivity $_x$ (*i.e.* or $_L$) was estimated using a regression equation from Xu and Eckstein (1995) as 22.0 feet with a plume length of 779 feet as described below.

$$_L = 0.83 \times (\log(L_s))^{2.414} \text{ with } L_s \text{ and } _L \text{ in meters}$$

- The horizontal transverse dispersivity and the vertical transverse dispersivity were assumed to be 0.10 and 0.05 times the longitudinal dispersivity respectively.

- The total plume length L_s had to be estimated in order to estimate the longitudinal dispersivity from the regression equation. It was assumed that the leading edge of the plume was located where the MTBE concentration was at the detection limit of 0.5 ppb. The Domenico (1987) equation was solved iteratively for combinations of L_s and time that would yield the detection limit concentration at the distance L_s and a taste and odor threshold at the city well (*i.e.* 730 feet from source). This value of L_s (*i.e.* 779 feet) was then used in the Xu and Eckstein equation to estimate longitudinal dispersivity (*i.e.* 22.0 feet).

- The estimated time of the MTBE plume to reach the ACSW No. 5 well at a concentration of 5 ppb was 33.2 years when degradation of MTBE in the source area is considered. Detectable concentrations of MTBE are anticipated at 30.5 years with this scenario.

- The MTBE taste and odor limit time estimate decreases to 20.1 years when degradation of MTBE in the source area is neglected.

Low-Threat Underground Storage Tank Case Closure Checklist Review

The RWQCB has reviewed this site (see regulatory letter prepared April 23, 2013) and found that it does not meet criteria established by the State Water Resources Control Board for Low Threat Case Closure. Reasons cited include the following:

- Full development of conceptual site model.
- Presence of free product as sheen floating on groundwater in some wells.
- Location of water supply well less than 1000 feet from the site.
- MTBE concentrations greater than 1000 g/L in the groundwater.
- Threat to health and safety due to the extended time frame to meet water quality objectives.
- Potential human health risk from residual levels of petroleum contamination in the soil.

The RWQCB has requested that the above issues be addressed in our plan. Porter Geotechnical generally agrees with the RWQCB low-threat case closure assessment. With this report we have satisfied the requirement for development of a full conceptual site model. The recommendations provided in the work plan, which follows, provide interim remedial measures which we believe will redirect remedial efforts to address the concerns listed in order to achieve timely site closure.

Final Summary and Conclusions - Continuing Site Investigation

This Combined Investigation provides, for the first time since the discovery of the release in 1989, a Conceptual Site Model based on detailed borehole logging, soil laboratory testing, aquifer response testing and monitoring, and onsite treatment equipment Pilot Testing. These results were used to perform a Pollution Migration Analyses and Assessment of Sensitive Receptor Risk. Elevated Risk to the nearby Community Supply well resulted in the preparation

of a Remedial Action Work Plan. The following summary highlights our conclusions developed from these combined phases of work:

Conceptual Site Model:

- Soil classification tests on recovered cores from the boreholes indicate subsurface soils generally belong to one of two groups. The aquifers are primarily poorly graded, low plasticity, fine to medium sand with silt and silty fine to medium sand, USCS group symbol SM. Silt and clay size fraction varies from 10 to 20 percent. The aquitards are classified as silty sand or sandy silt of low to medium plasticity with USCS group symbol SM and ML. The aquitards have a higher percentage of fines varying from 28.4 to 52.4 percent, higher density and lower porosity. Based on water content and liquid limit, both of these sediment groups are essentially normally consolidated. Except for a thin veneer of surficial alluvium, both groups are lacustrine deposits.

- The presence of a nearly continuous layer of 1 to 3 foot thick subaqueous ashfall tuff was confirmed with this investigation. The tuff lies 4.5 to 7 feet below the ground surface. The tuff is classified as a dense to very dense, low permeability, elastic silt (MH). Because the tuff has been penetrated by excavations for current and former underground tanks on the site, it has not prevented cross contamination of deeper aquifers.

- Well drillers reports indicate that the lacustrine deposits extend down to a depth of approximately 50 to 75 feet in this area. The finer grain lacustrine sediments are in turn underlain by more coarse grain, clean sand and gravel deposits. These older alluvial deposits are typical of alluvial stream sedimentary sequences. This "water gravel" is in turn underlain by basalt bedrock at an approximate depth of 340 feet in ACSW Well No. 7, located less than ¼ mile from the property.

Hydro Stratigraphy and Groundwater Movement:

- Laboratory measured permeability tests, (K_v) performed on core samples obtained from the aquitard sediments varied over approximately one order of magnitude in the range of 3.33×10^{-7} cm/sec to 6.09×10^{-6} cm/sec (9.44×10^{-4} ft/day to 1.73×10^{-2} ft/day). The aquifer sample test was in the range of 10^{-5} cm/sec. The laboratory tests measure the hydraulic conductivity in the vertical direction across the bedding.

- We have identified five Hydro-stratigraphic Units within the depth explored of 42 feet. These units consist of alternating layers of higher and lower permeability strata, as described above. We designate these layers, starting from the surface and increasing depth: Shallow Unconfined Aquifer, Upper Aquitard (Tuff), Shallow Confined Aquifer, Middle Aquitard, and Lower Leaky Aquifer.

- Groundwater flow in the Shallow Unconfined, the most contaminated aquifer, flows toward the south, toward the Community Supply Well at a gradient of 0.02166. Groundwater flow in the Shallow Confined Aquifer, which also contains high levels of MTBE, flows southward and toward the southwest at gradients that vary from 0.00476 to 0.00781. The Lower Leaky Aquifer, which contains less MTBE, flows toward the west at a much steeper gradient of 0.05195.

- Long term groundwater monitoring of selected wells indicates pumping of the ACSW No. 5 well induces drawdown in the monitoring wells installed for this project. Larger drawdowns were observed in the deeper monitoring wells, suggesting that leakage from Hydro Units 4 and 5 is reaching the aquifer pumped by the city well. The westward shift in the hydraulic gradient in Hydro Units 4 and 5 also suggests that the ACSW No. 5 well may be drawing water from coarser materials located to the west of the project site below a depth of 30 to 40 feet.

- Constant Discharge Pumping Tests found that the average apparent K_h on wells generally varied from 3.27×10^{-4} to 9.95×10^{-5} cm/s. (0.926 to 2.82 ft/day). Transmissivity (T) was in the range of 14.1 to 211 gpd/day. The conductivity values are faster than rates computed by laboratory permeability tests. The results indicate that groundwater flow through the aquifer toward the tested wells is influenced to a large degree by the presence of thin open high conductivity sand layers. It also indicates that the lower water bearing units are confined, the storage coefficients determined from pumping tests fall outside of the typical range for confined aquifers. Rather, the computed storage coefficients fall within the low end of the range expected for unconfined aquifers. This suggests that there is significant vertical leakage through confining units and into water bearing units. On aggregate, a highly stratified lacustrine deposit, such as encountered here, could behave as an unconfined aquifer at a macroscopic scale.

- A strong downward gradient is present between aquifers for all but the far northeastern part of the site. The measurements and subsequent leakage calculations indicate groundwater movement on this site between the shallow confined and lower leaky aquifers (*i.e.* hydro-stratigraphic units 3 and 5, respectively). It also explains why there have been increases in the concentration of dissolved petroleum constituents, mostly MTBE, in some of the deeper aquifer wells the past 5 to 10 years.

Soil and Groundwater Analytical Test and Trend Analysis:

- No petroleum impacted soil was detected in offsite wells installed for this phase of investigation. Gasoline, diesel, and volatile organic compounds were detected in soils drilled for installation of on-site extraction wells. The highest levels were detected in EW-1 at a depth of 10 feet. Mass balance calculations indicate an estimated 6500 lbs of hydrocarbons remain in the impacted soil under the site.

- Petroleum impacts from gasoline and diesel were detected in the groundwater in 14 of the 21 monitoring wells tested. The highest levels were detected in the installed extraction wells and monitoring wells MW-1, MW-2, and MW-4. All of these wells are located in what we have identified as former discharge areas located around former and existing underground tanks and piping. Oily, free product sheens were observed in all of these wells.

- Groundwater analysis indicates all hydro-stratigraphic units have been impacted by hydrocarbons. Free product remains in the shallow unconfined and shallow confined aquifers. The groundwater contaminants, particularly MTBE which was once trapped above the ashfall tuff, has apparently traveled downward through fractures or man-made excavations to impact the deeper groundwater zone in some locations.

- For the first time MTBE was detected in the Alturas Community Supply Well "ACSW No. 5" at a concentration of 0.69 ppb. Although this remains far below the Regulatory levels, the detection of MTBE is alarming. No MTBE was detected in the follow up sample. The implication is significant and warrants prompt follow up action.

- Linear trend lines indicate degradation of gasoline, benzene and sometimes MTBE for most of the shallow wells located near the source area likely due to the combined effects

of plume migration advective-dispersive transport, and natural attenuation. Because of plume migration in the shallow aquifers there has been an increase in one shallow well. Apparent first-order decay for MTBE, the primary contaminant of concern in the deeper aquifers, was calculated at -0.0011966/day and -0.0018226/day for the complete data set and smoothed data respectively. The correlation coefficients were 0.796 and 0.998 for the complete data set and smoothed data respectively.

- Chemical trends in deep monitoring wells are more complicated, with recent trends showing both increases and decreases, depending on the location of the wells. Overall the contaminant level in several deep wells has increased over the past 4 to 6 years. This is due to the continuing migration and leakage from the shallow aquifers down into the deeper aquifers.

- Hydrochemical facies comparison of inorganic analysis of groundwater samples obtained from the shallow (middle) confined aquifer (MW-19B) and the ACSW Well No. 5 reveals a hydrochemical connection between the two aquifers. Both wells contain Calcium Magnesium Bicarbonate facies type water typical of native water found in an oxidizing environment.

Pilot Testing-Remedial Option Selection:

- Pilot testing indicates the three new extraction wells can be used to capture to the degree possible impacted water which collects in the gravel backfilled UST excavations before it enters the deeper hydro-stratigraphic units. Pumping rates from these wells is too low to have any significant effect in hydraulic control of the plume movement however.

- Air Sparge testing found that the middle aquitard and lower leaky aquifer wells (wells 20 to 30 feet deep) unsuitable for use in sparging due to the lower permeability of this stratigraphic zone.

- Shallow wells with base depth of 20 feet or less responded favorable to sparge testing. These wells can accept up to 30 cfm air stream maintained at 5 psi. The radius of influence around each sparge well is approximately 40 feet diameter.

- Vapor Extraction tests on new 4-inch diameter 25-foot deep extraction wells indicate moderate to high concentrations of petroleum were extracted from wells tested. Recovery rates of HC varied from 0.45 to 8.4 lbs/day. We therefore conclude that vapor extraction in combination with air sparging is a viable method of treating the residual levels of contamination on this site.

- The shallow depth to groundwater at certain times of the year may affect recovery rates or vapor extraction pump operation. Much of the proposed recovery system will utilize shallow trenches, shared by other piping as part of the collection system. Because of the cracked nature of the overlying asphalt, a heavy crack filler and seal coat will need to be applied to the pavement surface to prevent short-circuiting with the surface.

Pollution Migration Analyses:

- The movement of MTBE plume front between MW-6 and MW-1 was used to assess parameters needed to predict the time required for MTBE to reach ACSW No. 5 well. The advective velocity was calculated to be 5.28×10^{-2} ft/day for flow between MW-6 and MW-1. The longitudinal dispersivity $_x$ was estimated as 22.0 feet using a regression equation from Xu and Eckstein (1995) and a plume length of 779 feet. These values compare well with published values.

- The estimated time of the MTBE plume to reach the ACSW No. 5 well at a concentration of 5 ppb was 33.2 years when degradation of MTBE in the source area is considered. Detectable concentrations of MTBE are anticipated at 30.5 years with this scenario. These values compare favorable with our earlier predicted time intercept.

- The MTBE taste and odor limit time estimate decreases to 20.1 years when degradation of MTBE in the source area is neglected.

- The one time detection of MTBE in ACSW Well No. 5 could mean that the discharge has already reached the supply well.

Recommendations

The following provides our recommendations for future course of action related to the cleanup and monitoring work on this site:

Additional Monitoring and Investigation:

- Installation of two additional monitoring wells in areas west of Maple Street to track middle aquitard and lower leaky aquifer plume movement and extent. Each of these wells would be screened over a 10 -foot interval from 35 to 45 feet. One of these wells would be located 100 feet west of the west shoulder of Maple Street and 50 feet north of MW-18. The second well would be located 100 feet to the west of Maple Street and 150 feet south of MW-18. These proposed locations are shown as green circles on Plate 2.

- Installation of a group of three signal wells located approximately 25 feet north-northwest of ACSW Well No. 5. These wells will have discrete 10 -oot long well screen sections set at 5 to 15 feet, 25 to 35 feet, and 50 to 60 feet deep, respectively. The proposed locations of these wells are shown on Plate 2.

- All wells would be constructed of 2-inch PVC casing using the same design as was used for the recently installed monitoring wells MW-18 and MW-19.

- Conduct long term continuous monitoring of the newly installed wells in a manner similar to that used in the current report to assess the water level response to pumping of the city well.

- Verify presence of MTBE in ACSW Well No. 5 with monthly sampling and testing for MTBE.

Remedial Action:

- Obtain approval of the attached Work Plan from the RWQCB.

- Proceed with budgeting and obtain preapproval of cost associated with implementation of Corrective Action Plan from USTCF..

- Schedule and Startup of Corrective Action implementation.

- Details concerning the proposed Corrective Action are included in the Interim Remediation Work Plan which follows this investigation and is attached as a part of this report.

- To stay within USTCF fiscal year budget limits it may be necessary to perform work tasks in phases.

Limitations

The data, information, and interpretations contained in this report are presented solely as a preliminary basis and guide to the existing environmental conditions of this property. The conclusions and professional opinions presented herein were developed by Porter Geotechnical in accordance with generally accepted engineering and environmental practices. As with all environmental investigations, the opinions expressed herein are subject to revisions in light of new information, new governmental regulations or new interpretations of existing regulations which may be developed in the future. No warranties are either expressed or implied. This report was not prepared for use by any parties other than Mr. Reddy and the regulatory agencies overseeing this project. It may not contain sufficient information for the purposes of other parties or other uses. The information contained is valid as of the date of this report and should not be construed as a warranty for future conditions on the site.

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INTERIM REMEDIAL ACTION WORK PLAN

INTERIM REMEDIAL ACTION WORK PLAN

Introduction

Pilot test results presented in this report, earlier investigations on this site, and remedial systems which have operated successfully on the Chevron station cleanup in Alturas, which has similar soil and groundwater conditions, indicate the proposed remedial options considered (dual phase extraction, soil vapor extraction (SVE), and air sparge treatment) should provide significant reduction of petroleum hydrocarbon concentrations in the impacted soil and groundwater. The proposed system should help control the continuing increases in dissolved contaminant levels in the middle and lower aquifers, accelerate degradation, and bring this site to a more rapid site closure. Similar recommendations for treatment were made by Growth Resources, an earlier consultant working on this site in November 1996. At that time, the RWQCB approved Growth's Work Plan but the system was never installed due to changes in property ownership and changes in consultants working on this site. The one-time impact of MTBE we have detected in the ACSW #5 underscores the importance of implementation of this plan without further delay.

Dual Phase Extraction-Extraction Wells

We have determined that petroleum contamination, which is concentrated in the shallow unconfined aquifer, continues to seep down through both man-made excavations which penetrate the upper aquitard, and as seepage through the aquitard into the shallow confined and lower leaky aquifers. Once in these deeper hydro-stratigraphic units it migrates down-gradient toward the potential sensitive receptors. The 4-inch diameter extraction wells are located in petroleum source zone targets, within the man-made excavations. The plan is to capture, to the degree possible, impacted water which collects in these excavations using the three extraction wells before it enters the deeper hydro-stratigraphic units. Pumping groundwater from these backfilled excavations will permit more efficient extraction of petroleum vapors from the source areas by extending the depth of the treatment zone to include depths below the water table with the SVE system. Pilot tests on extraction wells indicate hydrocarbon recovery rates using SVE as high as 8.4 lb/day from one of the extraction wells.

Because of the relatively low groundwater yield from the extraction wells, we propose the use of low-flow bladder pumps. The pumps will discharge into a central separator tank which will separate any free product. Contaminated water will then be treated through an air stripper before

it is discharged into the sanitary sewer. Soil vapors shall be extracted through a separate pipe connected to the well head back to the SVE Pump. Depending on Air Quality Discharge limits, vapors may need to be treated through granular activated carbon before discharged to the air. Plans and Details concerning the Proposed Dual Phase Extraction System and Dual Phase/Air Sparge Treatment Plant Schematic are shown on Plates 23 and 24, respectively.

Trench Based Soil Vapor Extraction

Much of the petroleum contamination lies at very shallow depths. The highest levels of gasoline and diesel in the soil have been detected in the depth range of 3 to 7 feet below the ground surface. Pilot testing by Growth Resources has shown that significant concentrations of hydrocarbons can be recovered from shallow 3-foot deep recovery trenches using SVE.

Factors that must be included in the design and operation of the SVE system is the high water table, which averages 5.31 feet in the shallow unconfined aquifer. There may be certain times of the year when the water table is too high or when infiltration of rainfall limits extraction through the shallow trench based SVE system. Another consideration is the cracked pavement that overlies the surface in some of the contaminated zones. Cracks in the pavement will tend to short-circuit extracted vapors. Our plan calls for the pavement surface to be sealed in areas of trench-based SVE installation.

We propose that the Trench Based SVE system will share, to the extent feasible, the trenches which will need to be installed for the construction of the proposed Air Sparge Treatment System. Perforated Vapor Extraction piping will be set near the bottom of 1-foot wide, 3-foot deep trenches which will extend through impacted zones as shown on the Remediation Site Plan, Plate 23. Details of the proposed trench construction are also shown on this Plan. The plan also shows the areas where the cracks of the asphalt will need to be sealed. We are recommending a slurry seal be applied to the pavement surface. We are recommending that the trenches be divided into treatment zones through the SVE manifold. The maximum length of individual treatment sections should not exceed 100 feet in total length. For this site we are recommending the use of a 7½ Hp Zephyr VLR 300 Rotary Claw Vacuum blower equipped with moisture knockout and central controls. The blower pull is rated at 300 cfm and 24 in/Hg. The SVE treatment system will be enclosed in a weather-proof treatment shed.

Air Sparge Treatment-Sparge Wells

Pilot testing indicates the shallow unconfined aquifer responded favorably to sparge treatment into shallow wells. We are proposing the installation of ten, 2-inch diameter, 15-foot deep sparge wells at locations shown on the attached remediation plan. The grid established should assure sufficient overlap of the effective radius of 50 feet. Screen should be set at the bottom 5 feet for each well. Details of proposed sparge well construction are shown on Plate24.

We are recommending the pumps used for the sparging be capable of maintaining a minimum air flow to each well of 10 cfm at 15 psi. We anticipate this will require installation of at least 2 or possibly 3 sparge pumps. Pumps operation will be cycled daily with timers to maintain efficiency. The level of dissolved oxygen will be measured in monitoring wells located adjacent to sparge wells. These measurements will be used to optimize sparge pump cycle and duration.

Estimate of Costs and Schedule

We estimate the cost for installation of the system outlined above would be approximately $180,000 to $200,000 including cost for operation and maintenance for 1 year. We recently installed a similar system for $150,000 on another project. We anticipate the system installation could be completed in 60 to 90 days, with full implementation start up by the end of four months after authorization to proceed and approval of USTCF budget change order request.

TABLES

Table 4: Groundwater Depths & Elevations - Former Gil's Shell, 123 West 12th St., Alturas, California									
Well	**Date**	**TOC Elev (ft)**	**Well Depth (ft)**	**Screens (ft)**	**Diam (in)**	**DTW (ft)**	**GW Elev (ft)**	**DO (mg/L)**	**Comments**
MW-1	1/22/2007	100.00	31.30	21-31	2	8.57	91.43	1.56	
	3/12/2007					7.04	92.96	3.86	
	5/31/2007	4375.03				8.01	4367.02		Surveyed Elev Datum
	8/28/2007					11.17	4363.86		
	4/2/2008					7.13	4367.90		
	7/8/2008					8.90	4366.13		
	10/4/2008					10.55	4364.48	3.21	
	2/11/2010					8.00	4367.03		
	7/20/2010					6.77	4368.26	1.10	
	5/7/2011					5.81	4369.22	1.28	
	2/25/2012					7.92	4367.11	2.70	
	4/12/2012								
	5/1/2012					6.55	4368.48		
	6/18/2013					8.50	4366.53	0.08	
MW-2	1/22/2007	98.83	31.00	21-31	2				
	3/12/2007								Dry
	5/31/2007	4373.94							Surveyed Elev Datum; Dry
	8/28/2007								Dry
	4/2/2008								Filled with mud
	7/8/2008								Cap Stuck
	10/4/2008								Cap Stuck
	2/11/2010								Cap Stuck
	7/20/2010								Not Found
	5/7/2011								Cap Stuck
	2/15/2012								Cap Stuck
	4/12/2012					9.27	4364.67	1.03	
	5/1/2012	4373.87				9.35	4364.52		
	6/18/2013					13.13	4360.74	0.12	
MW-3	1/22/2007	100.07	28.50	18-28	2	6.10	93.97	1.21	
	3/12/2007					6.47	93.60	0.81	
	5/31/2007	4375.05				6.15	4368.90		Surveyed Elev Datum; Odor
	8/28/2007					8.57	4366.48		
	4/2/2008					5.21	4369.84		
	7/8/2008					6.71	4368.34		
	10/4/2008					8.11	4366.94	2.85	
	2/11/2010					6.00	4369.05	3.00	
	7/20/2010					7.28	4367.77	1.00	
	5/7/2011					4.26	4370.79	0.63	
	2/15/2012					6.55	4368.50	0.27	
	4/12/2012								
	5/1/2012					5.52	4369.53		
	6/18/2013					6.58	4368.47	0.10	
MW-4	1/22/2007	99.94	10.50	5-10	4	7.21	92.73	0.78	
	3/12/2007					5.16	94.78	0.91	
	5/31/2007	4374.93				5.80	4369.13		Surveyed Elev Datum
	8/28/2007					7.43	4367.50		
	4/2/2008								Could Not Locate
	7/8/2008					5.62	4369.31		
	10/4/2008					7.69	4367.24	0.94	
	2/11/2010					6.24	4368.69	2.80	
	7/20/2010					5.94	4368.99	1.50	
	5/7/2011					4.48	4370.45	0.72	
	2/15/2012					6.52	4368.41	0.43	
	4/12/2012								

Table 4: Groundwater Depths & Elevations - Former Gil's Shell, 123 West 12th St., Alturas, California									
Well	Date	TOC Elev (ft)	Well Depth (ft)	Screens (ft)	Diam (in)	DTW (ft)	GW Elev (ft)	DO (mg/L)	Comments
	5/1/2012					5.32	4369.61		
	6/18/2013					5.80	4369.13	0.13	
MW-5	1/22/2007	100.30	15.50	5-15	4	6.64	93.66	1.66	
	3/12/2007					5.37	94.93	0.59	
	5/31/2007	4375.31				5.60	4369.71		Surveyed Elev Datum
	8/28/2007					7.32	4367.99		
	4/2/2008					4.86	4370.45		odor
	7/8/2008					5.66	4369.65		
	10/4/2008					7.41	4367.90	3.72	
	2/11/2010					5.86	4369.45	3.60	
	7/20/2010					5.70	4369.61	1.10	
	5/7/2011					4.04	4371.27	0.44	
	2/15/2012					6.25	4369.06	0.36	
	4/12/2012								
	5/1/2012					5.05	4370.26		
	5/1/2012					5.05	4370.26		
	6/18/2013					5.41	4369.90	0.14	
MW-6	1/22/2007	100.60	12.50	4.5-12	4	6.69	93.91	1.74	
	3/12/2007					5.49	95.11	0.62	
	5/31/2007	4375.12				5.67	4369.45		Surveyed Elev Datum
	8/28/2007					7.32	4367.80		
	4/2/2008					4.76	4370.36		Sheen
	7/8/2008					5.89	4369.23		
	10/4/2008					7.21	4367.91	2.15	
	2/11/2010					5.75	4369.37	1.50	
	7/20/2010								Not Found
	5/7/2011					4.16	4370.96	0.34	
	2/15/2012					6.10	4369.02	0.35	
	4/12/2012								
	5/1/2012					5.03	4370.09		
	6/18/2013								Not Tested
MW-7	1/22/2007	99.20	10.50	5-10	4	5.60	93.60	1.61	
	3/12/2007								Dry
	5/31/2007	4374.26							Surveyed Elev Datum; Dry
	8/28/2007					4.95	4369.31		Bailed Dry
	4/2/2008						4374.26		Very Muddy
	7/8/2008					0.86	4373.40		
	10/4/2008						4374.26	1.90	
	2/11/2010						4374.26	11.00	
	7/20/2010								Not Found
	5/7/2011					0.50	4373.76	0.17	
	2/15/2012					0.50	4373.76	1.87	
	4/12/2012								
	5/1/2012	4374.27				3.00	4371.27		
	6/18/2013					4.50	4369.77	0.04	
MW-8	1/22/2007	99.40	10.50	5-10	4				
	3/12/2007								Dry
	5/31/2007	4374.97					4374.97		Dry
	4/2/2008					3.67	4371.30		Very Murky
	7/8/2008					4.24	4370.73		
	10/4/2008					7.83	4367.14	2.30	
	2/11/2010					4.80	4370.17	3.90	
	7/20/2010					4.65	4370.32	1.70	
	5/7/2011					3.23	4371.74	0.88	

Table 4: Groundwater Depths & Elevations - Former Gil's Shell, 123 West 12th St., Alturas, California									
Well	Date	TOC Elev (ft)	Well Depth (ft)	Screens (ft)	Diam (in)	DTW (ft)	GW Elev (ft)	DO (mg/L)	Comments
	2/15/2012					5.20	4369.77	0.45	
	4/12/2012								
	5/1/2012					4.10	4370.87	0.04	
	6/18/2013					4.25	4370.72	0.04	
MW-9B	1/22/2007	100.44	30.00	24.7-29-7	2				
	3/12/2007								Dry
	5/31/2007	4375.47							not found
	4/2/2008								not found
	7/8/2008								not found
	10/4/2008								not found
MW-10A	1/22/2007	100.53	10.50	5-10.5	2				
	3/12/2007								Dry
	5/31/2007	4375.56							Destroyed
	4/2/2008								Destroyed
	7/8/2008								Destroyed
	10/4/2008								Destroyed
MW-10B	1/22/2007	100.55	26.00	21.7-25.7	2				
	3/12/2007								Dry
	5/31/2007	4375.58							Destroyed
	4/2/2008								Destroyed
	7/8/2008								Destroyed
	10/4/2008								Destroyed
MW-11A	1/22/2007	99.30	10.50	5-10.5	2	5.56	93.74	2.73	
	3/12/2007					3.99	95.31	4.24	
	5/31/2007	4373.68							Surveyed Elev Datum; Dry
	4/2/2008					2.76	4370.92		
	7/8/2008					3.88	4369.80		
	10/4/2008					5.94	4367.74		
	2/11/2010					4.64	4369.04		
	7/20/2010					4.55	4369.13	11.00	
	5/7/2011					2.46	4371.22	3.20	
	2/15/2012					4.95	4368.73	5.89	
	4/12/2012								
	5/1/2012	4377.35				3.30	4374.05		
MW-13A	1/22/2007	99.85	12.00	2-12	2				
	3/12/2007								Dry
	5/31/2007	4375.00							Destroyed
	4/2/2008								Dry
	7/8/2008								
	10/4/2008								
	2/11/2010								
	7/20/2010								Not Found
	5/7/2011								Bent
	2/15/2012								
	4/12/2012					5.50	4369.50	0.57	
	5/1/2012	4375.21				5.22	4369.99		
	6/18/2013					5.10	4370.11	0.07	
MW-13B	1/22/2007	99.85	31.00	21-31	2				
	3/12/2007								Dry
	5/31/2007	4375.18							
	4/2/2008					1.98	4373.20		Bent
	7/8/2008								Bent
	10/4/2008								Bent
	2/11/2010								Bent

Table 4: Groundwater Depths & Elevations - Former Gil's Shell, 123 West 12th St., Alturas, California									
Well	Date	TOC Elev (ft)	Well Depth (ft)	Screens (ft)	Diam (in)	DTW (ft)	GW Elev (ft)	DO (mg/L)	Comments
	7/20/2010					2.99	4372.19	1.10	
	5/7/2011					1.02	4374.16	0.22	
	2/15/2012								
	4/12/2012								
	5/1/2012	4375.21				9.43	4365.78		
	6/18/2013					1.88	4373.33	0.08	
MW-14A	7/20/2010		15.00	5-15	4	13.64		31.40	No TOC
	5/7/2011								
	2/15/2012								
	4/12/2012					6.70		1.21	
	5/1/2012	4376.40				6.95	4369.45		
	6/18/2013					7.50	4368.90	0.10	
MW-14B	8/28/2007		30.00	20-30	2	15.00			
	4/2/2008					10.86			
	7/8/2008								
	10/4/2008								
	2/11/2010					11.33			
	5/7/2011					9.38		0.65	No TOC
	2/15/2012					7.50		1.17	
	4/12/2012					10.48		3.62	
	5/1/2012	4376.39				9.40	4366.99		
	6/18/2013					12.90	4363.49	0.96	
MW-15A	5/1/2012	4373.03	15.00	5-15	4	4.12	4368.91		
	6/19/2013					4.34	4368.69	4.46	
MW-15B	5/1/2012	4373.33	42.00	32-42	2	12.97	4360.36		
	6/19/2013					19.90	4353.43	0.44	
MW-16A	5/31/2007	4371.86	15	5-15	4	4.68	4367.18		Surveyed Elev Datum
	8/28/2007					6.88	4364.98		
	4/2/2008					4.35	4367.51		
	7/8/2008					5.08	4366.78		
	10/4/2008					7.93	4363.93	5.49	
	2/11/2010					5.00	4366.86	7.20	
	7/20/2010								Not Tested
	5/7/2011					3.49	4368.37	0.87	
	2/15/2012					5.41	4366.45	0.44	
	4/12/2012								
	5/1/2012	4372.10				3.96	4368.14		
	6/19/2013					4.50	4367.60	1.87	
MW-16B	5/31/2007	4372.16	40	30-40	2	13.16	4359.00		Surveyed Elev Datum
	8/28/2007					17.75	4354.41		
	4/2/2008					10.43	4361.73		
	7/8/2008					16.03	4356.13		
	10/4/2008					15.77	4356.39	6.33	
	2/11/2010					11.90	4360.26		
	7/20/2010								Not Tested
	5/7/2011								Under Dirt Pile
	2/15/2012								
	4/12/2012					10.62	4361.54		
	5/1/2012	4371.90				10.03	4361.87		
	6/19/2013					15.92	4355.98	0.94	
MW-18A	6/19/2013	4372.77	15	5-15	2	4.92	4367.85	1.06	
MW-18B	6/19/2013	4372.95	30	20-30	2	15.83	4357.12	0.19	

Table 4: Groundwater Depths & Elevations - Former Gil's Shell, 123 West 12th St., Alturas, California									
Well	**Date**	**TOC Elev (ft)**	**Well Depth (ft)**	**Screens (ft)**	**Diam (in)**	**DTW (ft)**	**GW Elev (ft)**	**DO (mg/L)**	**Comments**
MW-19A	6/19/2013	4372.30	15	5-15	2	4.8	4367.50	0.13	
MW-19B	6/19/2013	4372.08	30	20-30	2	5.65	4366.43	1.76	
EW-1	6/19/2013	4374.54	25	5-25	4	5.32	4369.22	0.08	
EW-2	6/19/2013	4375.54	25	5-25	4	5.89	4369.65	0.08	
EW-3	6/19/2013	4375.33	25	5-25	4	6.78	4368.55	0.53	

Table 7: Groundwater Analytical Results - Former Gil's Shell, 123 West 12th St., Alturas, California										
Well ID	Date Sampled	TPHd	TPHg	B	T	E	X	MTBE	TBA	TAME
		mg/L		µg/L						
MW-1	1/22/2007	**0.16**	**0.20**	<0.50	<0.50	<0.50	<0.50	**360**	<10	<1.0
(Deep)	3/12/2007	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**1.2**	<10	<1.0
	5/31/2007	<0.050	**0.35**	<0.50	<0.50	<0.50	<0.50	**570**	**19**	**1.7**
	8/28/2007	**0.064**	**0.25**	<0.50	<0.50	<0.50	<0.50	**350**	**23**	<1.0
	4/2/2008	<0.050	**0.64**	<0.50	<0.50	<0.50	<0.50	**1200**	**39**	<3.0
	7/8/2008	**0.18**	**0.44**	<0.50	<0.50	<0.50	<0.50	**1200**	**48**	**3.8**
	10/4/2008	<0.050	**0.55**	<1.0	<1.0	<1.0	<1.0	**1100**	**63**	<2.0
	2/11/2010	<0.050	**1.4**	<2.0	<2.0	<2.0	<2.0	**1600**	**48**	**4.4**
	7/20/2010	<0.10	**1.4**	<2.5	<2.5	<2.5	<2.5	**1700**	**120**	<5.0
	5/7/2011	<0.10	**0.8**	<2.5	<2.5	<2.5	<2.5	**1400**	<50	<5.0
	2/25/2012	<0.050	**0.62**	<1.5	<1.5	<1.5	<1.5	**1400**	**55**	**3.9**
	6/18/2013	<0.050	**0.82**	<2.0	<2.0	<2.0	<2.0	**1300**	**200**	<4.0
MW-2	1/22/2007									
(Deep)	3/12/2007									
	5/31/2007									
	4/2/2008									
	7/8/2008									
	10/4/2008									
	4/12/2012	**0.15**	**0.67**	<1.5	<1.5	<1.5	<1.5	**1100**	**80**	**3.3**
	6/18/2013	**0.12**	**0.77**	<1.5	<1.5	<1.5	<1.5	**1200**	**260**	**4.2**
MW-3	1/22/2007	**0.18**	**0.15**	**2.7**	<0.50	**1.0**	<0.50	**22**	<10	<1.0
(Deep)	3/12/2007	**0.077**	**2.2**	<0.50	<0.50	**1.2**	**5.5**	**23**	<10	<1.0
	5/31/2007	<0.050	**1.5**	<0.50	<0.50	**0.77**	**19**	**24**	<10	<1.0
	8/28/2007	**0.30**	**0.57**	**5.1**	**2.0**	**16**	**32**	**21**	<10	<1.0
	4/2/2008	<0.050	**0.95**	**12**	**1.9**	**18**	**17**	**25**	<10	<1.0
	7/8/2008	**0.14**	**1.4**	**16**	**4.1**	**52**	**72**	**26**	<20	<2.0
	10/4/2008	**2.9**	**1.6**	**19**	**4.0**	**34**	**57**	**28**	<10	<1.0
	2/11/2010	**1.5**	**0.8**	<0.50	<0.50	<0.50	**0.93**	**32**	<10	<1.0
	7/20/2010	<0.10	**0.41**	**3.3**	<0.50	**5.6**	**17**	**20**	<10	<1.0
	5/7/2011	**1.5**	**0.13**	<0.50	<0.50	**0.7**	**1.6**	**0.64**	<10	<1.0
	2/25/2012	**0.26**	**0.8**	**3.2**	<0.50	**1.8**	**0.5**	**11**	<10	<1.0
	6/18/2013	**0.14**	**0.7**	**2.4**	<0.50	**1.2**	**0.62**	**18**	<10	<1.0
MW-4	1/22/2007	**3.3**	**1.4**	**47**	<2.5	<2.5	**7.7**	**4600**	**770**	**15**
(Shallow)	3/12/2007	**0.19**	**5.0**	**34**	<10.0	<10.0	<10.0	**5700**	**480**	**20**
	5/31/2007	**1.7**	**4.1**	**46**	<5.0	**6.8**	**13**	**4000**	**570**	**14**
	8/28/2007	**1.5**	**5.0**	**31**	<5.0	<5.0	**19**	**4800**	**130**	**15**
	4/2/2008									
	7/8/2008	**1.1**	**1.9**	**14**	<5.0	<5.0	<5.0	**3900**	**480**	**14**
	10/4/2008	**0.66**	**3.0**	**64**	<10	**12**	**21**	**4600**	**480**	<20
	2/11/2010	**0.47**	**2.3**	**31**	<2.0	<2.0	<2.0	**2100**	**230**	**7.6**
	7/20/2010	**0.45**	**2.6**	<5.0	<5.0	<5.0	**6.3**	**3200**	**560**	<10
	5/7/2011	**0.34**	**1.1**	<2.5	<2.5	<2.5	<2.5	**2400**	**210**	**8.5**
	2/25/2012	**0.32**	**1.5**	11	<2.5	<2.5	<2.5	**2500**	**290**	**9.1**
	6/18/2013	**0.41**	**0.91**	**8.9**	<1.5	**1.60**	<1.5	**1100**	<30	**5.5**
MW-5	1/22/2007	**0.35**	**2.0**	**5.1**	**6.2**	**22**	**160**	**2.5**	**22**	<1.0
(Shallow)	3/12/2007	**1.4**	<0.050	<0.50	<0.50	<0.50	<0.50	**3.8**	<10	<1.0
	5/31/2007	**0.12**	**1.6**	**3.7**	**1.7**	**42**	**71**	**1.8**	<10	<1.0
	8/28/2007	**0.23**	**3.8**	**18**	**12**	**200**	**160**	**2.4**	<10	<1.0
	4/2/2008	**0.29**	**3.1**	**3.7**	**6.3**	**110**	**290**	**3.0**	<40	<4.0
	7/8/2008	**0.29**	**2.4**	**3.2**	**3.1**	**75**	**220**	<1.0	<20	<2.0
	10/4/2008	**0.66**	**5.1**	**11**	**14**	**200**	**390**	**2.5**	<40	<4.0
	2/11/2010	**0.28**	**1.3**	**3**	**2**	**28**	**36**	<0.50	<10	<1.0
	7/20/2010	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	5/7/2011	**0.66**	**2.3**	**6.9**	**3.5**	**14**	**52**	**1.1**	<10	<1.0
	2/25/2012	**1.2**	**0.93**	<1.0	**1.6**	**12**	**51**	<1.0	<20	<2.0
	6/18/2013	**0.071**	**1.2**	**3.3**	**3.0**	**29**	**66**	<0.50	<10	<1.0
MW-6	1/22/2007	**34**	**22**	**590**	<15	**790**	**790**	**20000**	**11000**	**60**

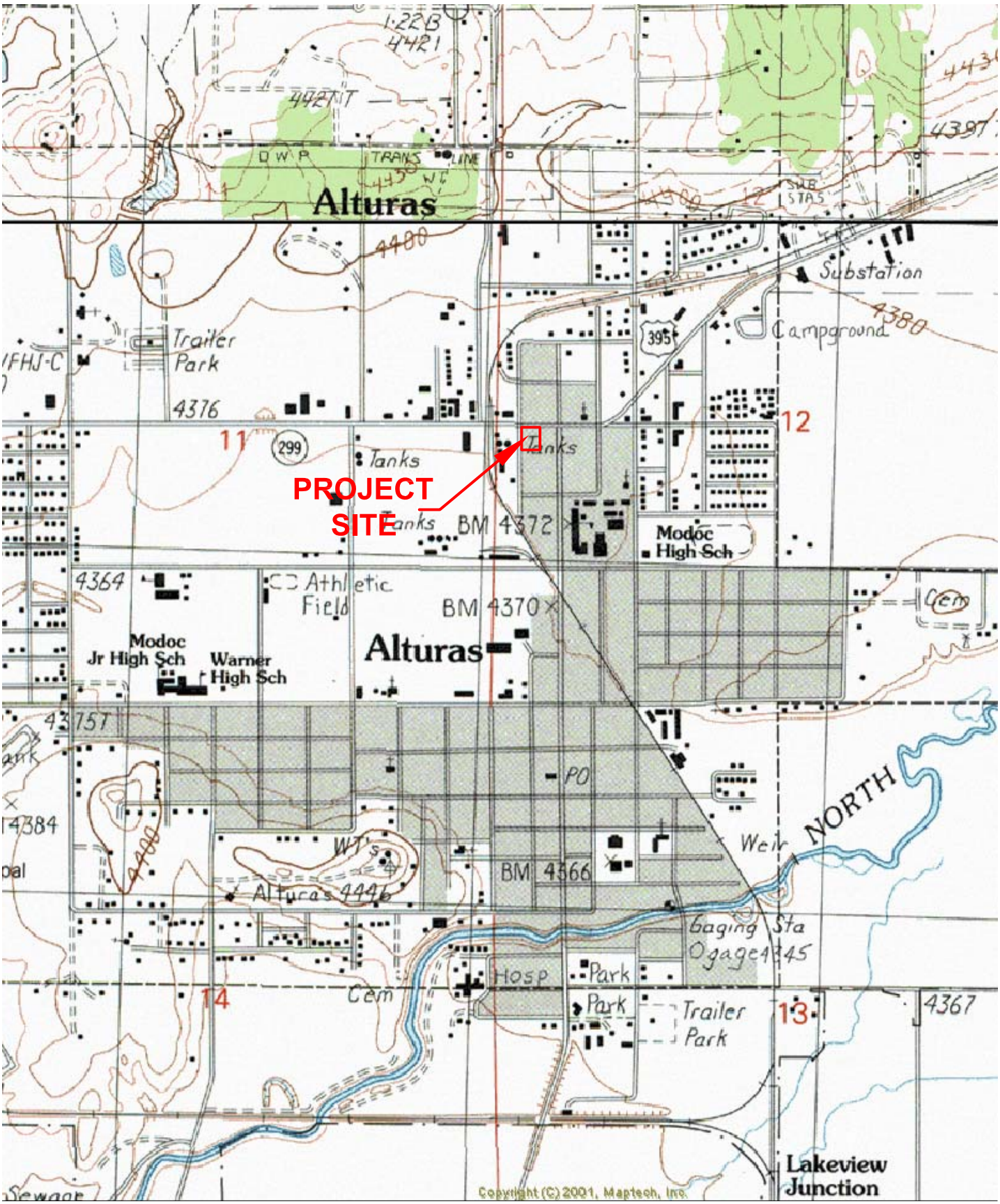
Table 7: Groundwater Analytical Results - Former Gil's Shell, 123 West 12th St., Alturas, California										
Well ID	Date Sampled	TPHd	TPHg	B	T	E	X	MTBE	TBA	TAME
		mg/L		µg/L						
(Shallow)	3/12/2007	**8.4**	**16**	**390**	<15	<15	**250**	**12000**	**7700**	**43**
	5/31/2007	**8.3**	**13**	**440**	<10	**520**	**190**	**8200**	**5900**	**29**
	8/28/2007	**32**	**13**	**300**	<20	**27**	**25**	**13000**	**5100**	**42**
	4/2/2008	**11**	**5.7**	**140**	<10	**46**	**13**	**5900**	**2900**	<20
	7/8/2008	**14**	**4.1**	**130**	<5.0	**30**	**7.7**	**3800**	**1200**	**16**
	10/4/2008	**91**	**6.9**	**210**	**5.0**	**71**	**55**	**6700**	**2000**	**19**
	2/11/2010	**3.1**	**4.9**	**120**	<2.5	<2.5	<2.5	**2800**	**1600**	**12**
	5/7/2011	**4.3**	**1.6**	**67**	<1.0	<1.0	<1.0	**1300**	**1000**	**6.3**
	2/25/2012	**17**	**1.3**	**65**	<1.0	<1.0	<1.0	**650**	**210**	**3.6**
	6/18/2013	NS	NS	NS	NS	NS	NS	NS	NS	NS
MW-7	1/22/2007	**0.57**	**0.099**	<0.50	<0.50	<0.50	**0.74**	<0.50	<10	<1.0
(Shallow)	3/12/2007									
	5/31/2007									
	8/28/2007	**0.82**	<0.20	<1.0	**2.8**	**1.7**	**11**	<1.0	<20	<2.0
	4/2/2008	**0.21**	<0.10	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	7/8/2008	**0.9**	<0.20	<1.0	<1.0	<1.0	<1.0	<1.0	<20	<2.0
	10/4/2008	**0.82**	<0.30	<1.5	<1.5	<1.5	<1.5	**7.0**	<30	<3.0
	2/11/2010	**1.8**	<0.20	<1.0	<1.0	<1.0	<1.0	<1.0	<20	<2.0
	5/7/2011	**1.5**	<0.20	<1.0	<1.0	<1.0	<1.0	<1.0	<20	<2.0
	2/25/2012	**0.37**	<0.20	<1.0	<1.0	<1.0	<1.0	<1.0	<20	<2.0
	4/12/2012	**1.0**	**11**	**330**	**26**	**180**	**410**	**24**	<100	<10
	6/18/2013	**0.2**	**0.71**	**5.6**	**4.1**	**2.1**	**15**	<0.50	<10	<1.0
MW-8	1/22/2007									
(Shallow)	3/12/2007									
	5/31/2007									
	4/2/2008	**1.5**	**1.8**	**38**	**2.5**	**61**	**89**	<1.0	<20	<2.0
	7/8/2008	**0.35**	**1.5**	**93**	**19.0**	**71**	**230**	<1.0	<20	<2.0
	10/4/2008	**0.86**	**5.5**	**310**	**39**	**320**	**430**	<2.0	<40	<4.0
	2/11/2010	**1.4**	**1.2**	**27**	**1.7**	**20**	**23**	<0.50	<10	<1.0
	7/20/2010	<0.10	**0.16**	**6.6**	**0.57**	**2.5**	**2.9**	<0.50	<10	<1.0
	5/7/2011	**0.43**	**2.3**	**89**	**72**	**130**	**540**	<2.5	<50	<5.0
	2/25/2012	**0.87**	**1.5**	<1.0	**1.2**	**4.8**	**300**	<1.0	<20	<2.0
	6/18/2013	**0.38**	**1.2**	**13**	**1.4**	**4.9**	**24**	<0.50	<10	<1.0
MW-11A	1/22/2007	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
(Shallow)	3/12/2007	**0.25**	<0.050	<0.50	<0.50	<0.50	<0.50	**0.91**	<10	<1.0
	5/31/2007									
	4/2/2008									
	7/8/2008	**0.096**	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	10/4/2008									
	2/11/2010	**0.630**	<0.050	<0.50	<0.50	<0.50	<0.50	**32**	<10	<1.0
	7/20/2010	**0.21**	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	5/7/2011	<0.10	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-13A	1/22/2007									
(Shallow)	3/12/2007									
	5/31/2007									
	4/2/2008									
	7/8/2008									
	10/4/2008									
	2/11/2010									
	4/12/2012	**0.19**	**0.72**	**1.8**	**1.1**	**2.8**	**10**	**15**	<10	<1.0
MW-13B	1/22/2007									
(Deep)	3/12/2007									
	5/31/2007									
	4/2/2008									
	7/8/2008									
	10/4/2008									
	2/11/2010									

Table 7: Groundwater Analytical Results - Former Gil's Shell, 123 West 12th St., Alturas, California										
Well ID	**Date Sampled**	**TPHd**	**TPHg**	**B**	**T**	**E**	**X**	**MTBE**	**TBA**	**TAME**
		mg/L		**µg/L**						
	7/20/2010	**0.18**	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	5/7/2011	**0.39**	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-14A	7/20/2010	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
(Shallow)	4/12/2012	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**1.2**	<10	<1.0
	6/18/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-14B	8/28/2007	**0.18**	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
(Deep)	4/2/2008	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	7/8/2008									
	10/4/2008									
	2/11/2010	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	5/7/2011	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	2/25/2012	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	4/12/2012	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**1.2**	<10	<1.0
	6/18/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**0.72**	<10	<1.0
MW-15A	5/3/2012	**0.077**	<0.050	<0.50	<0.50	<0.50	<0.50	**1.2**	<10	<1.0
(Shallow)	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-15B	5/3/2012	**0.066**	<0.050	<0.50	<0.50	<0.50	<0.50	**64**	<10	<1.0
(Deep)	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**56**	<10	<1.0
MW-16A	5/31/2007	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
(Shallow)	8/28/2007	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	4/2/2008	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	7/8/2008	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	10/4/2008	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	2/11/2010	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	7/20/2010									
	5/7/2011	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	2/25/2012	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-16B	5/31/2007	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
(Deep)	8/28/2007	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	4/2/2008	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	7/8/2008	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	10/4/2008	**0.057**	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	2/11/2010	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-18A	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-18B	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**1.9**	<10	<1.0
MW-19A	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
MW-19B	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
EW-1	6/19/2013	**0.14**	**33**	**38**	**43**	**1100**	**5600**	**35**	**500**	<50.0
EW-2	6/19/2013	**0.43**	**2.0**	**21**	<2.0	**8.1**	**35**	**1900**	<40	**11**
EW-3	6/19/2013	**0.13**	**2.3**	**5.9**	<2.5	**5.5**	<2.5	**2800**	**600**	**14**
Alturas Com Supply Well #5	4/12/2012	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	11/29/2012	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<10	<1.0
	6/19/2013	<0.050	<0.050	<0.50	<0.50	<0.50	<0.50	**0.69**	<10	<1.0
	7/8/2013							<0.50	<10	<1.0
Regulatory Levels - Water										
***ESL**			0.10	1.0	40	30	20	5		
****MCL**			NA	1.0	150	300	1750	13		

Table 7: Groundwater Analytical Results - Former Gil's Shell, 123 West 12th St., Alturas, California										
Well ID	Date Sampled	TPHd	TPHg	B	T	E	X	MTBE	TBA	TAME
		mg/L		µg/L						
T&O Threshold			0.005	0.35	42	29	17			

*** Bold = Exceeds Laboratory Reporting Limits**

PLATES



Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 1 - Location Map.dwg, 10/16/2013 2:10:04 PM

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Proj. 2145.1

Location Map

Former Gil's Shell Station
123 West 12th Street
Alturas, California

Plate

1

US Hwy 395

Hwy 299

10th STREET

MAPLE STREET

Approx. Location of UST Excavations (Typical)

Proposed Future Monitoring Well Locations (Typical)

MW-10B
MW-5
MW-3
EW-2
MW-6
MW-1
EW-3
MW-13A
MW-13B
EW-1
MW-7
MW-2
MW-4
MW-8
MW-9B
MW-11B
MW-15A
MW-15B
MW-14B
MW-18A
MW-18B
MW-19A
MW-19B
MW-16A
MW-16B

A
A'
B
B'
C
C'
D
D'
E
E'
F
F'

4375.8
4375.6
4375.4
4375.2
4375
4374.8
4374.6
4374.4
4374.2
4374
4373.6
4373.8
4373.2
4373.4
4373

Legend

- Monitoring Wells
- Municipal Wells
- Subsurface Sections
- Ground Surface Contours
- UST Excavations (Approx)

N

0 60 120 Feet

1 inch = 60 feet

Site Plan and Monitoring Well Locations
Former Gil's Gas
Alturas, California

PLATE 2

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Section A-A' - Lithology and Hydro-Stratigraphy along Maple Street

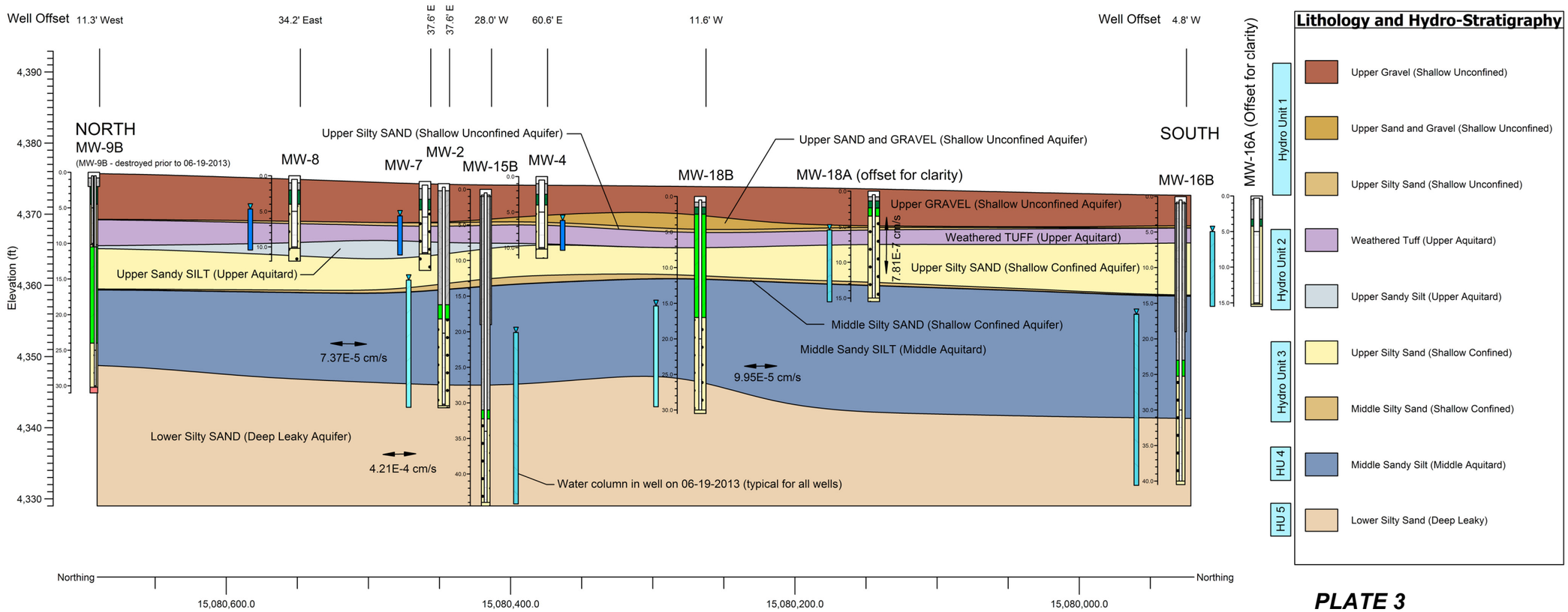


PLATE 3

Section B-B' - Lithology and Hydro-Stratigraphy 125 feet East of Maple Street (Some Wells Omitted for Clarity)

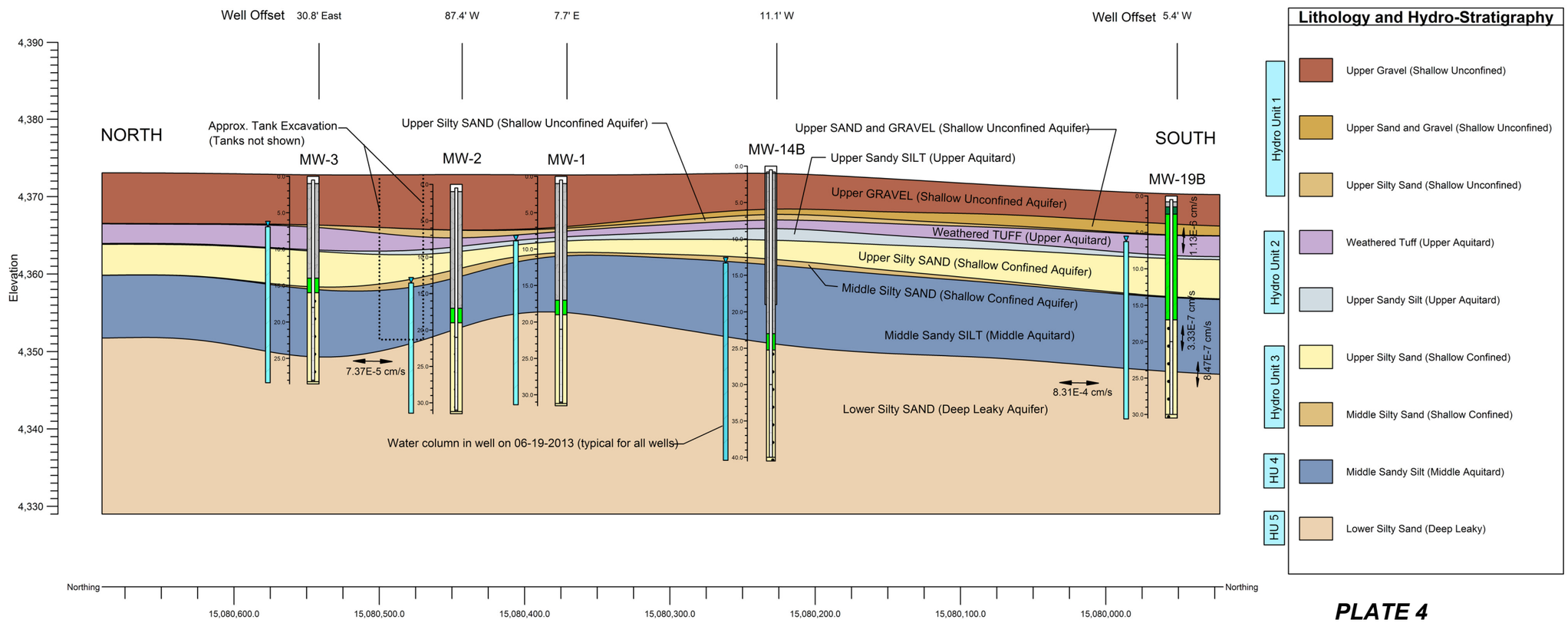


PLATE 4

Section C-C' - NE-SW through Contaminated Zone

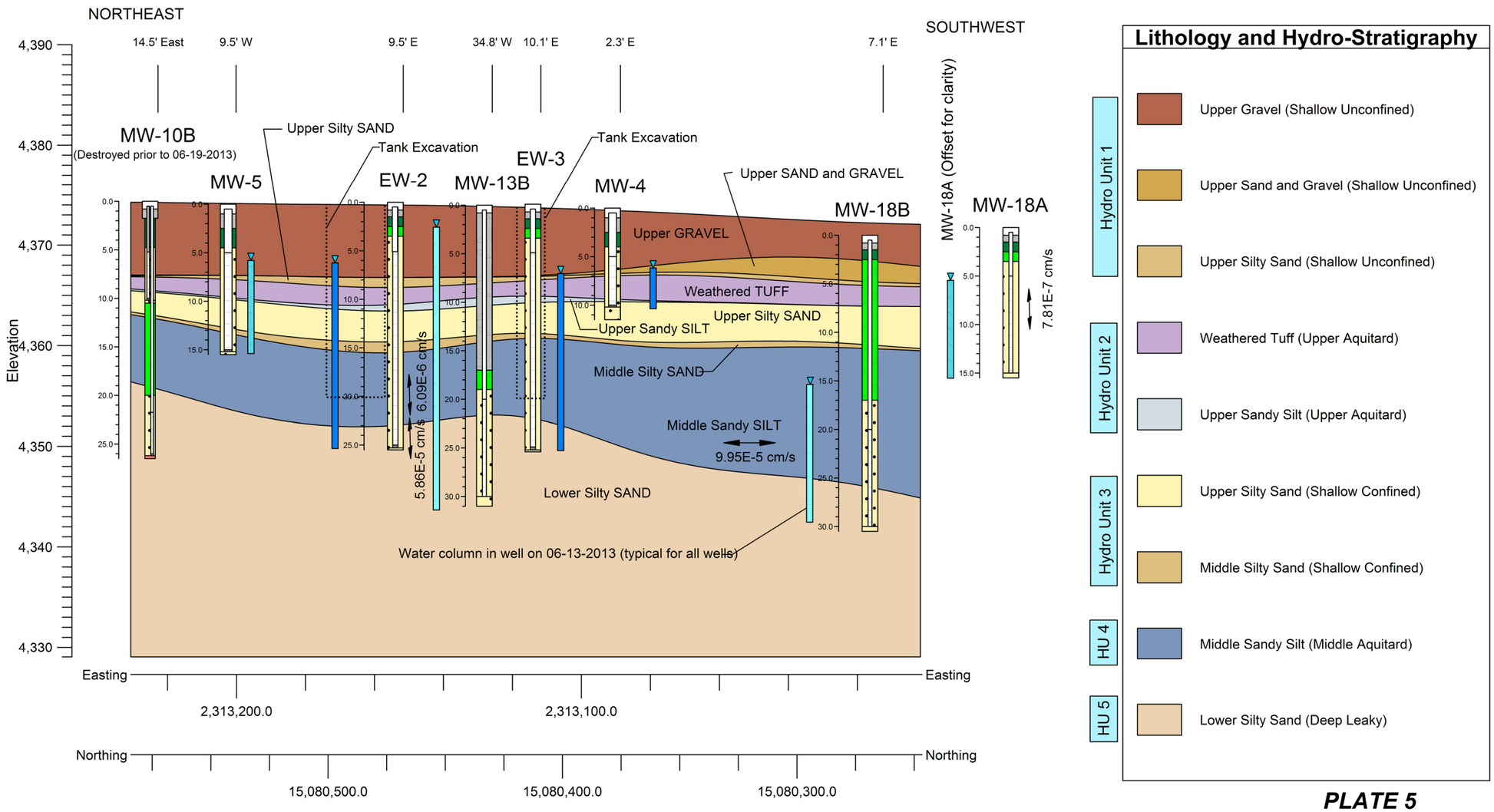


PLATE 5

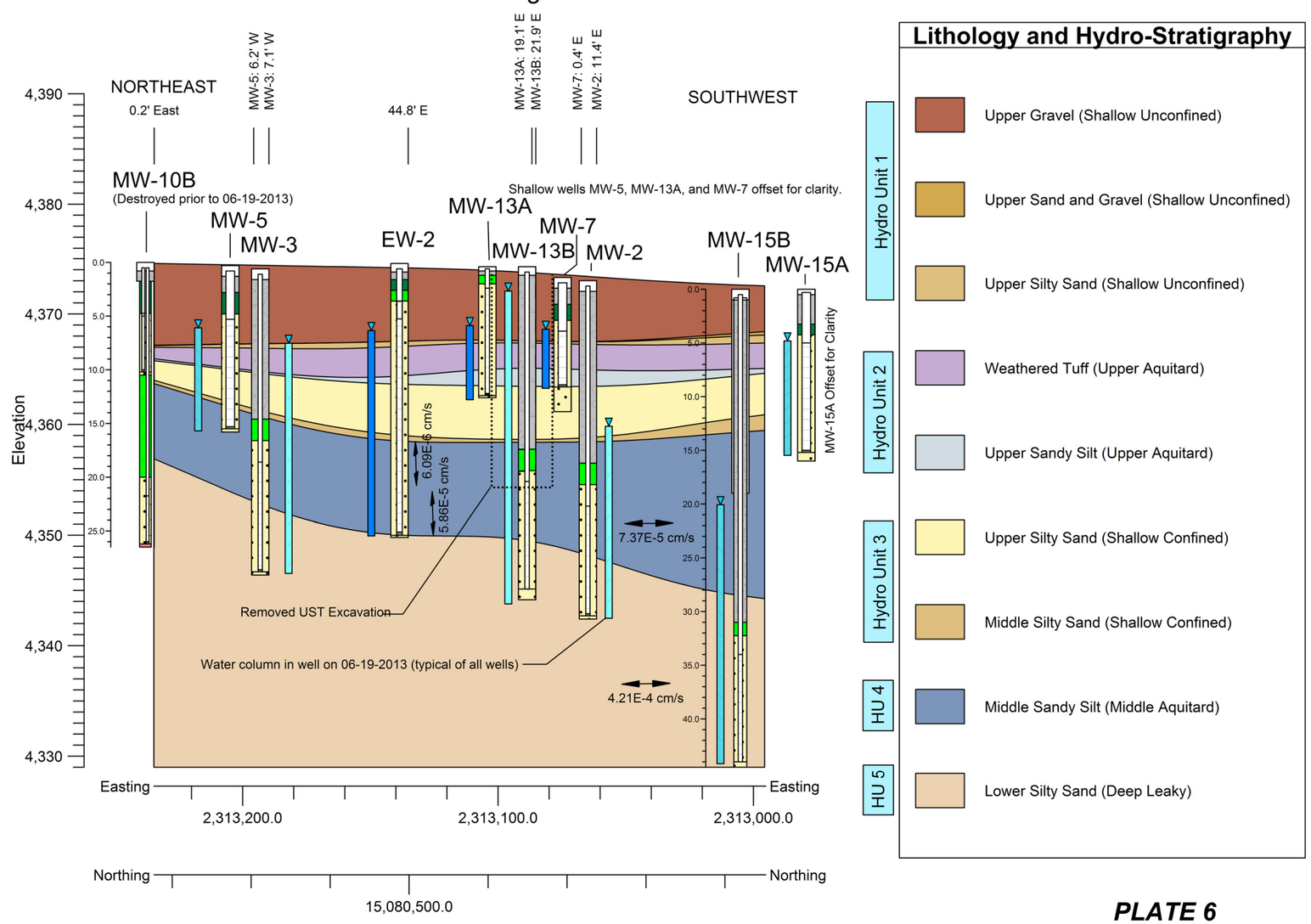

Section D-D' NE-SW Section through Contaminated Zone
NORTHEAST
0.2' East
MW-5: 6.2' W
MW-3: 7.1' W
44.8' E
MW-13A: 19.1' E
MW-13B: 21.9' E
MW-7: 0.4' E
MW-2: 11.4' E
SOUTHWEST
MW-10B
(Destroyed prior to 06-19-2013)
MW-5
MW-3
EW-2
MW-13A
MW-13B
MW-7
MW-2
MW-15B
MW-15A
Shallow wells MW-5, MW-13A, and MW-7 offset for clarity.
MW-15A Offset for Clarity
Elevation
4,390
4,380
4,370
4,360
4,350
4,340
4,330
6.09E-6 cm/s
5.86E-5 cm/s
7.37E-5 cm/s
4.21E-4 cm/s
Removed UST Excavation
Water column in well on 06-19-2013 (typical of all wells)
Easting
2,313,200.0
2,313,100.0
2,313,000.0
Northing
15,080,500.0
Hydro Unit 1
Hydro Unit 2
Hydro Unit 3
HU 4
HU 5
Lithology and Hydro-Stratigraphy
Upper Gravel (Shallow Unconfined)
Upper Sand and Gravel (Shallow Unconfined)
Upper Silty Sand (Shallow Unconfined)
Weathered Tuff (Upper Aquitard)
Upper Sandy Silt (Upper Aquitard)
Upper Silty Sand (Shallow Confined)
Middle Silty Sand (Shallow Confined)
Middle Sandy Silt (Middle Aquitard)
Lower Silty Sand (Deep Leaky)

PLATE 6

Section E-E' - MW-18B to MW-14B

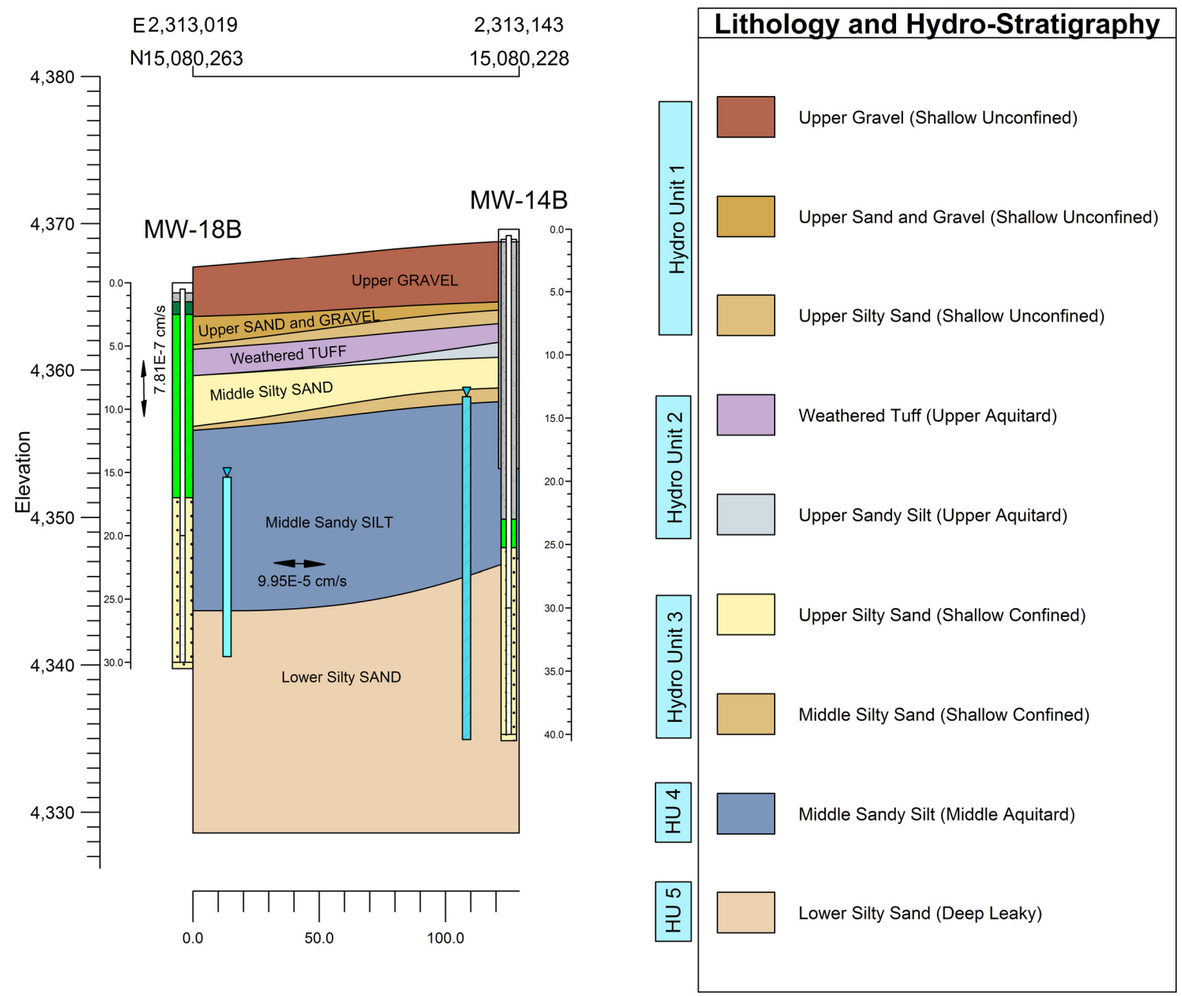


PLATE 7

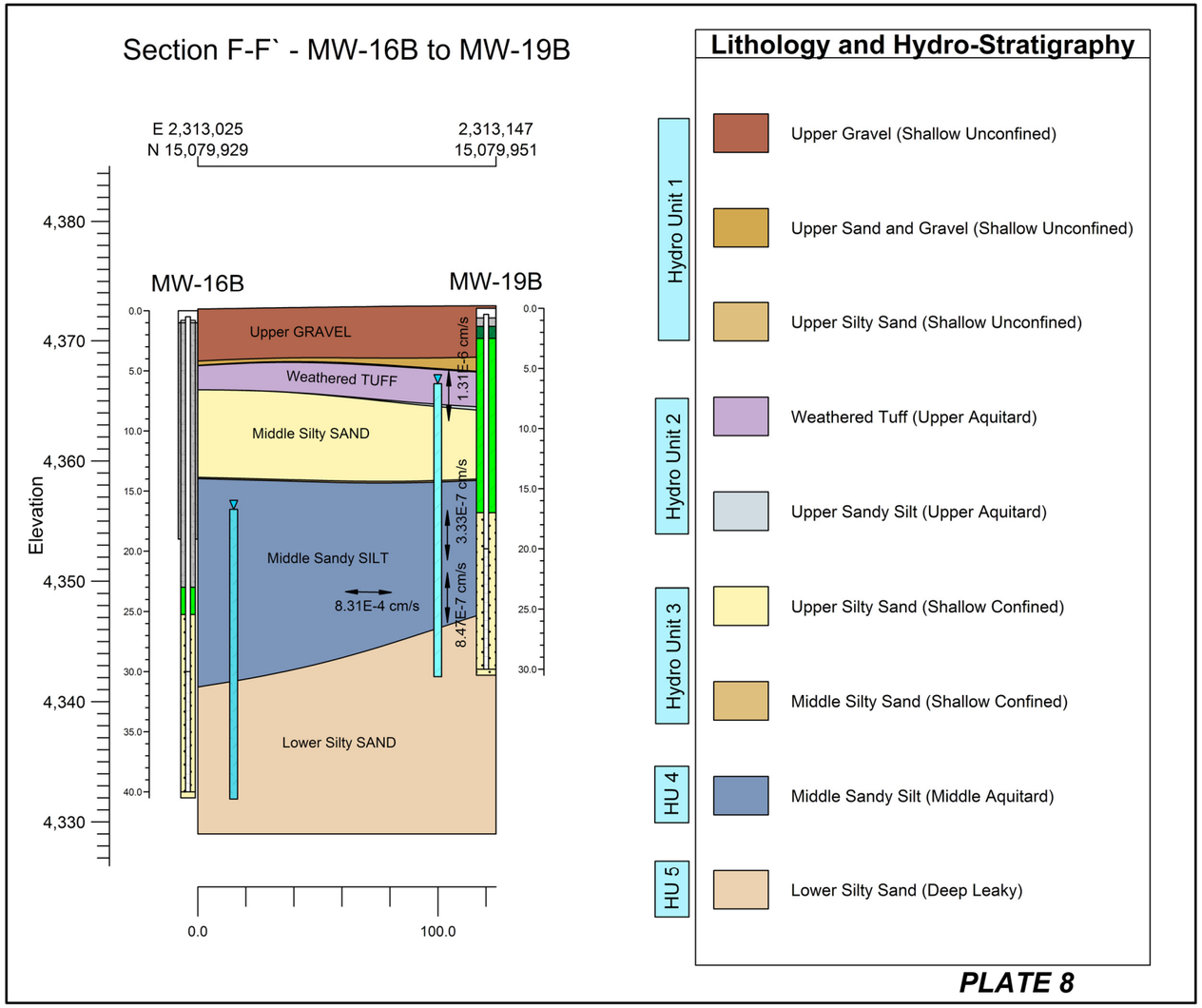
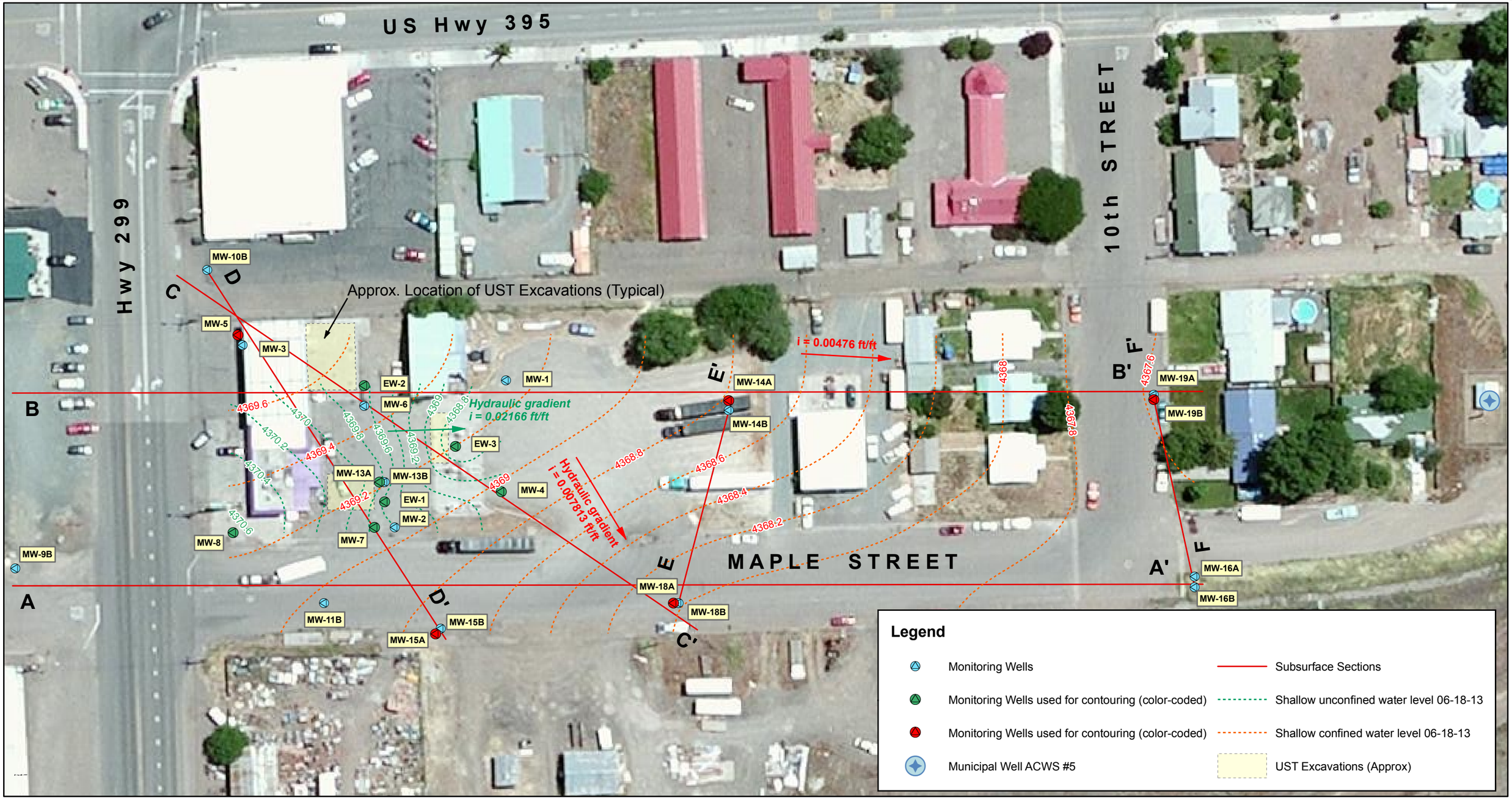

Section F-F` - MW-16B to MW-19B
E 2,313,025
N 15,079,929
2,313,147
15,079,951
MW-16B
MW-19B
Elevation
4,380
4,370
4,360
4,350
4,340
4,330
Upper GRAVEL
Weathered TUFF
Middle Silty SAND
Middle Sandy SILT
Lower Silty SAND
8.31E-4 cm/s
1.31E-6 cm/s
3.33E-7 cm/s
8.47E-7 cm/s
0.0
100.0
Lithology and Hydro-Stratigraphy
Hydro Unit 1
Hydro Unit 2
Hydro Unit 3
HU 4
HU 5
Upper Gravel (Shallow Unconfined)
Upper Sand and Gravel (Shallow Unconfined)
Upper Silty Sand (Shallow Unconfined)
Weathered Tuff (Upper Aquitard)
Upper Sandy Silt (Upper Aquitard)
Upper Silty Sand (Shallow Confined)
Middle Silty Sand (Shallow Confined)
Middle Sandy Silt (Middle Aquitard)
Lower Silty Sand (Deep Leaky)

PLATE 8



N

0 30 60 120 Feet

1 inch = 60 feet

Hydro-Units 1 and 3
(Shallow Unconfined Aquifer and Shallow Confined Aquifer)
Water Levels (06-18-2013)
Former Gil's Gas
Alturas, California

PLATE 9

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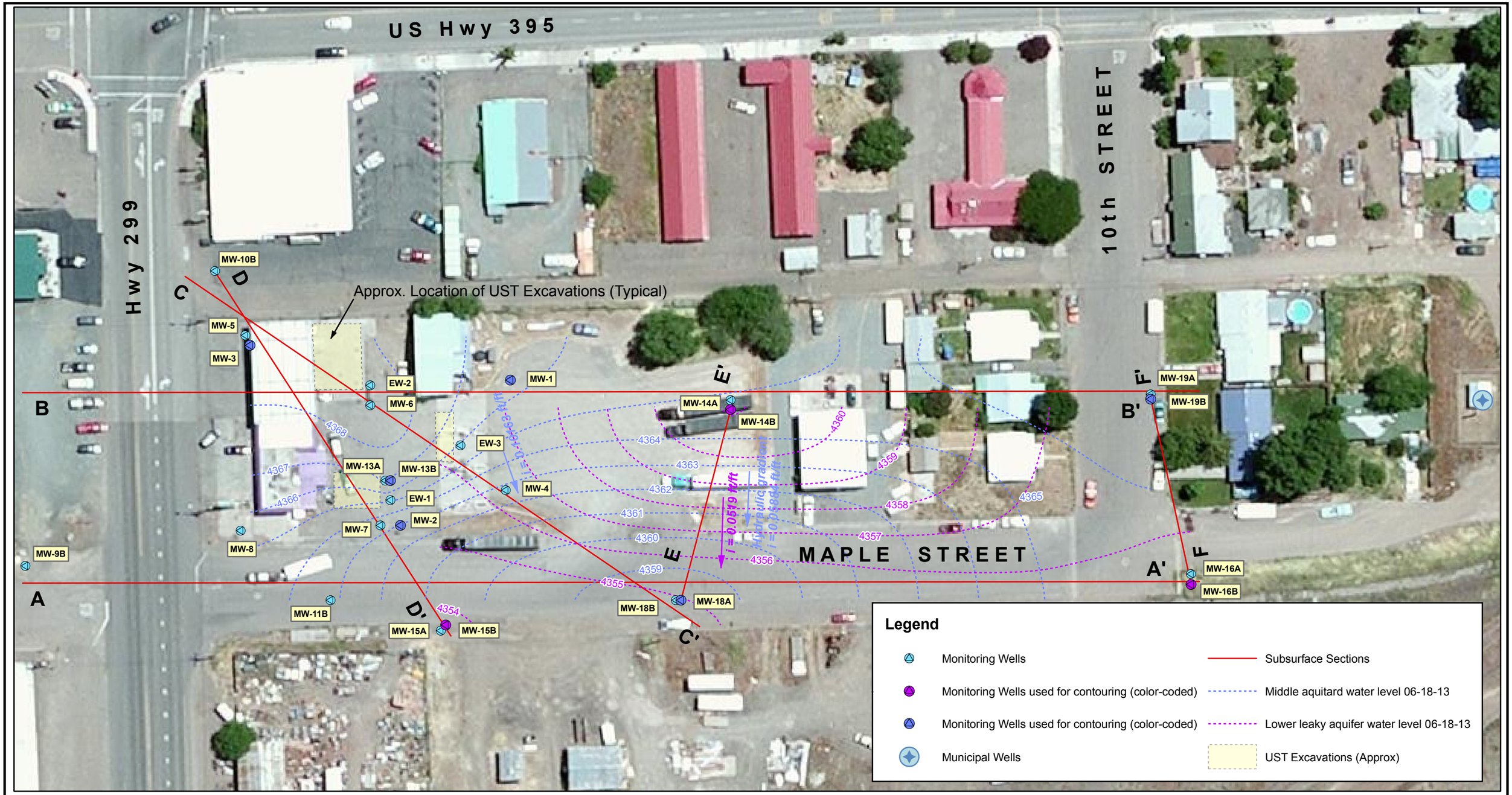

N

0 60 120 Feet

1 inch = 60 feet

Hydro-Units 4 and 5
(Middle Aquitard and Lower Leaky Aquifer)
Water Levels (06-18-2013)
Former Gil's Gas
Alturas, California

PLATE 10

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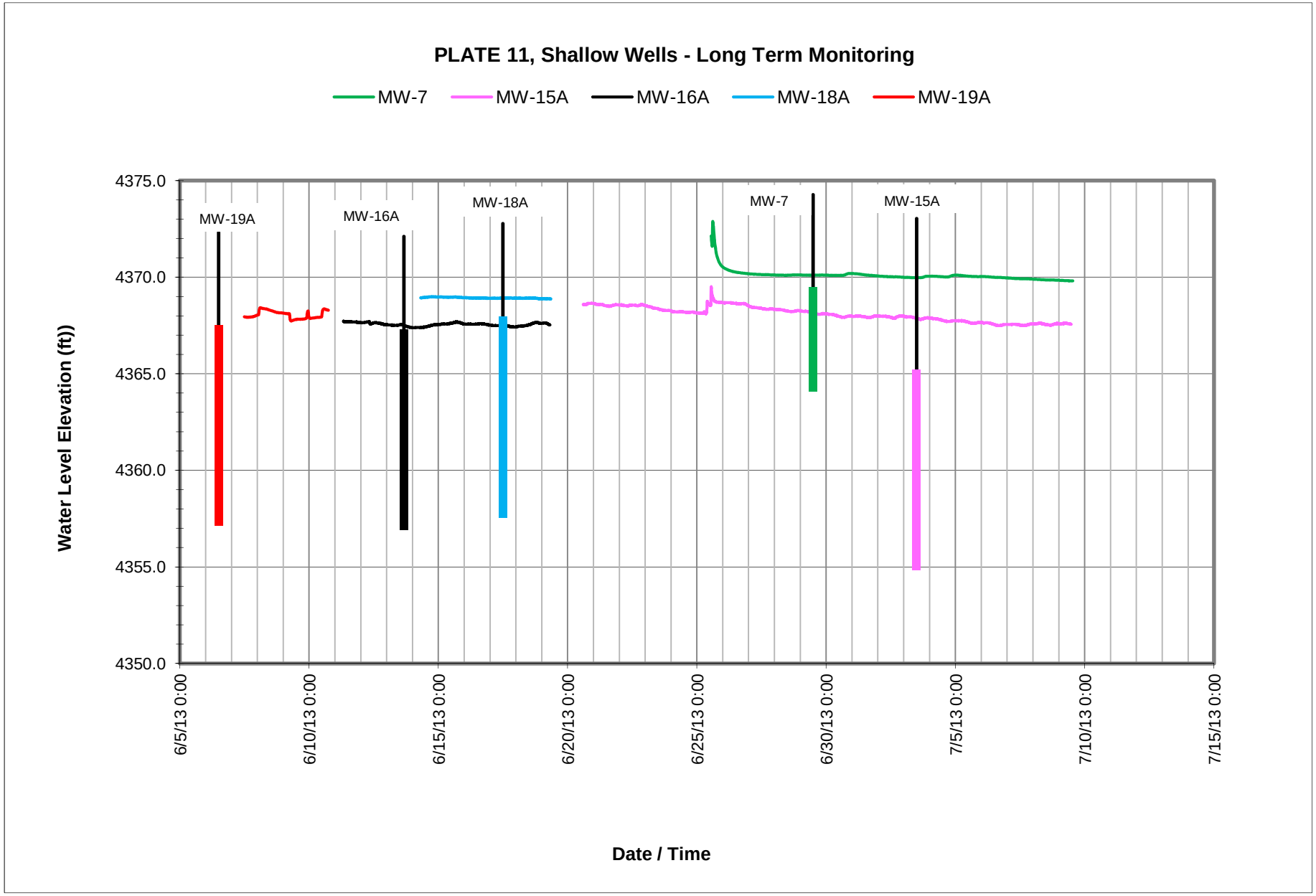


PLATE 11, Shallow Wells - Long Term Monitoring
MW-7
MW-15A
MW-16A
MW-18A
MW-19A
Water Level Elevation (ft))
4375.0
4370.0
4365.0
4360.0
4355.0
4350.0
MW-19A
MW-16A
MW-18A
MW-7
MW-15A
6/5/13 0:00
6/10/13 0:00
6/15/13 0:00
6/20/13 0:00
6/25/13 0:00
6/30/13 0:00
7/5/13 0:00
7/10/13 0:00
7/15/13 0:00
Date / Time

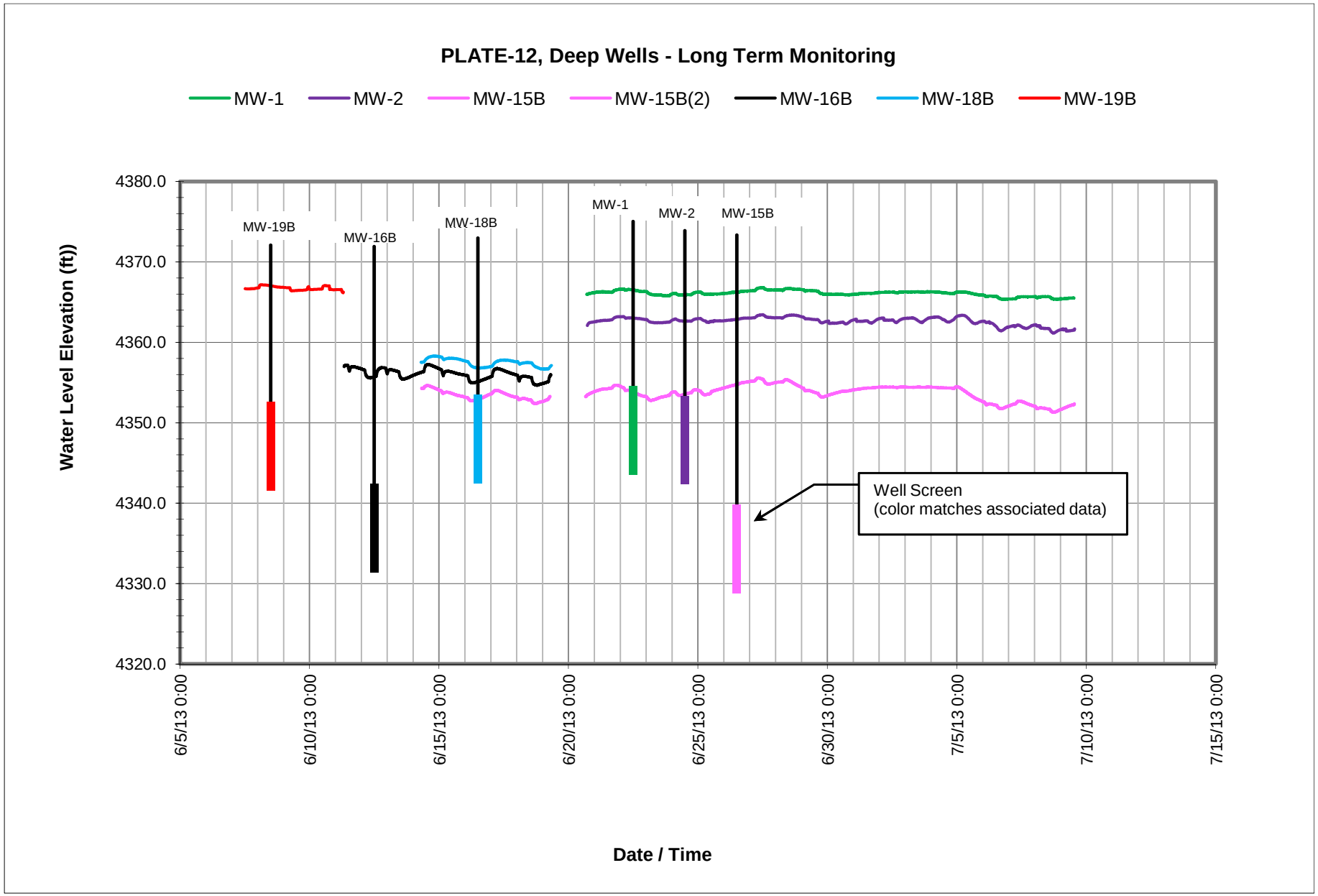


PLATE-12, Deep Wells - Long Term Monitoring
MW-1
MW-2
MW-15B
MW-15B(2)
MW-16B
MW-18B
MW-19B
Water Level Elevation (ft))
4380.0
4370.0
4360.0
4350.0
4340.0
4330.0
4320.0
MW-19B
MW-16B
MW-18B
MW-1
MW-2
MW-15B
Well Screen
(color matches associated data)
6/5/13 0:00
6/10/13 0:00
6/15/13 0:00
6/20/13 0:00
6/25/13 0:00
6/30/13 0:00
7/5/13 0:00
7/10/13 0:00
7/15/13 0:00
Date / Time

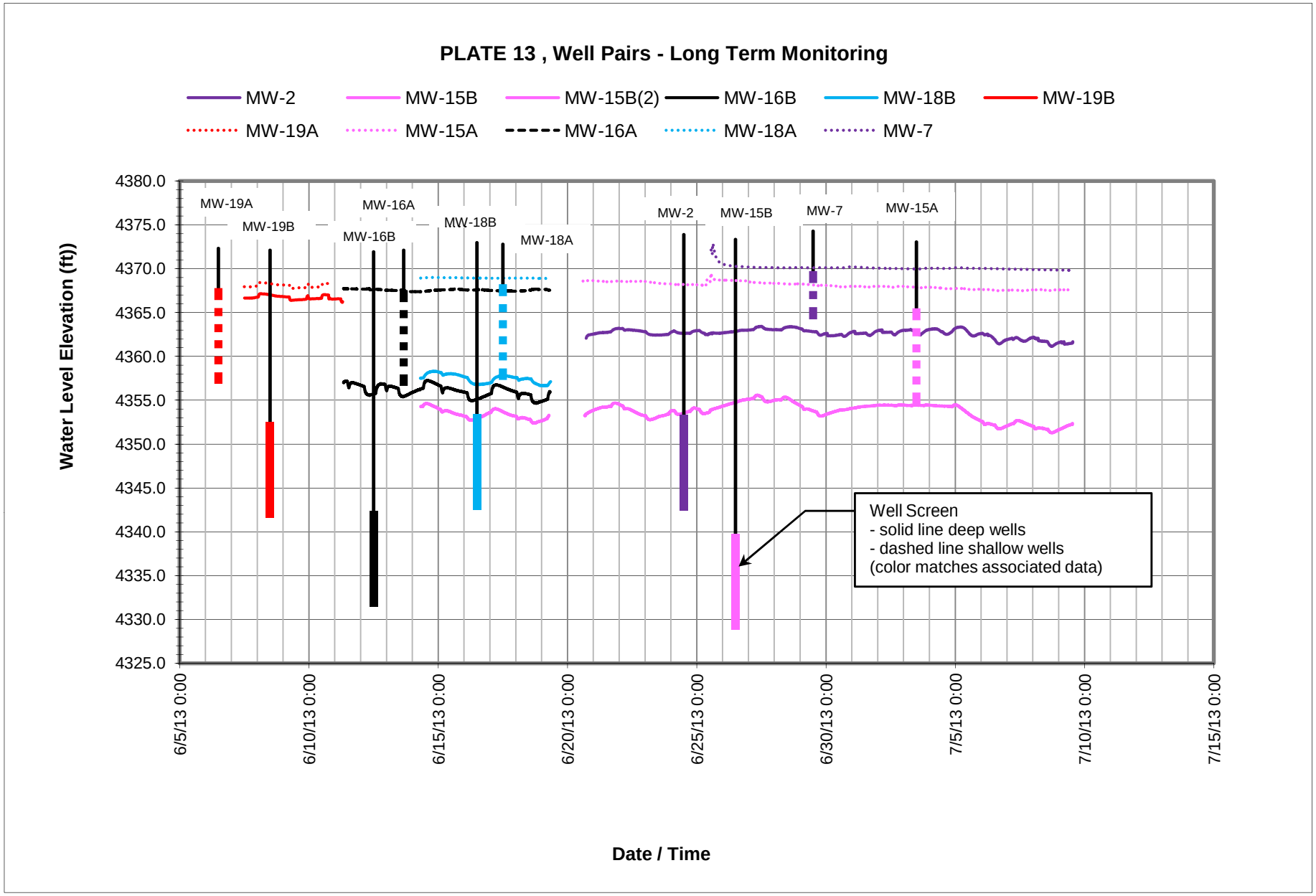
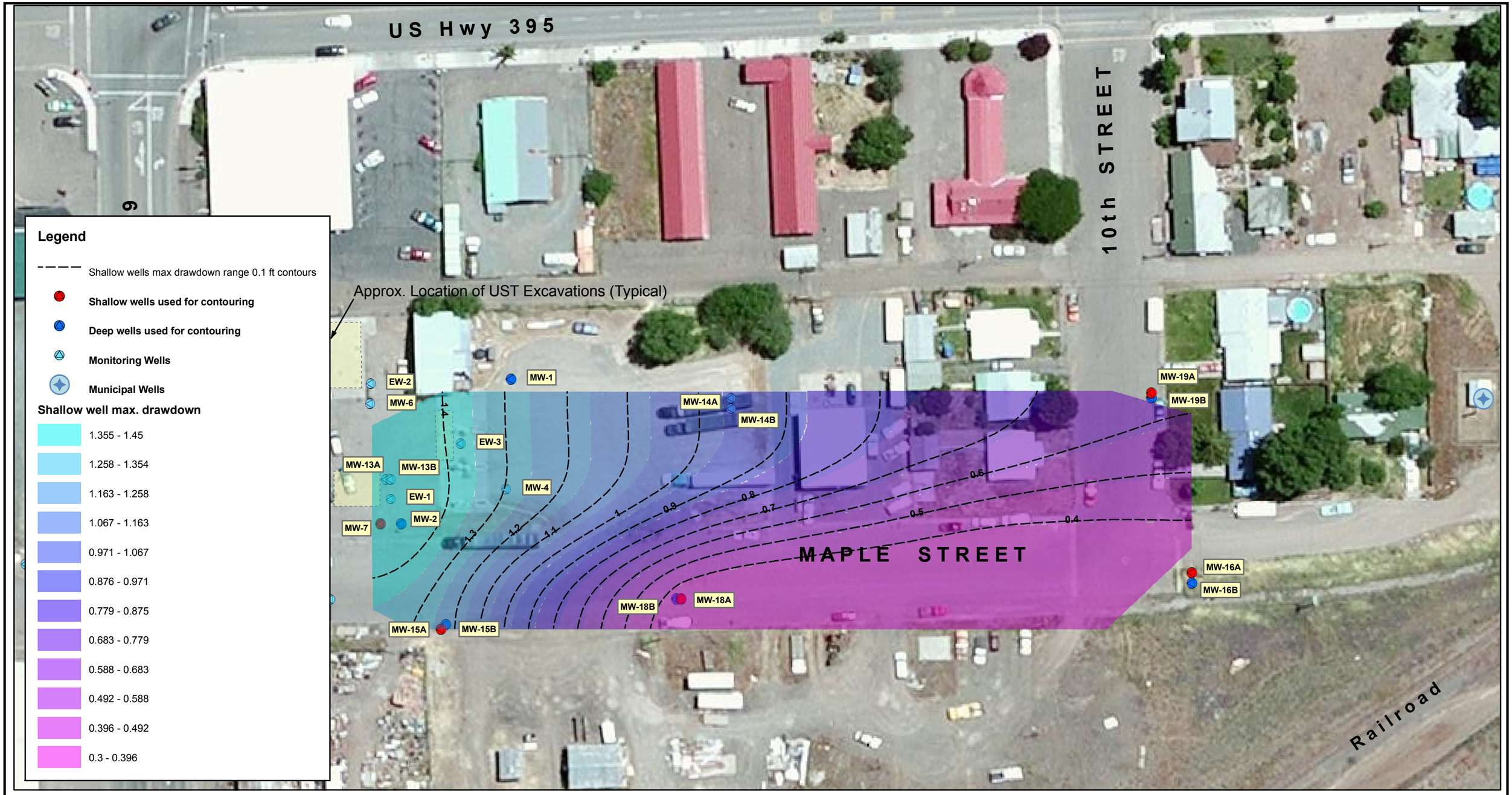


PLATE 13 , Well Pairs - Long Term Monitoring
MW-2
MW-15B
MW-15B(2)
MW-16B
MW-18B
MW-19B
MW-19A
MW-15A
MW-16A
MW-18A
MW-7
Water Level Elevation (ft))
4380.0
4375.0
4370.0
4365.0
4360.0
4355.0
4350.0
4345.0
4340.0
4335.0
4330.0
4325.0
MW-19A
MW-19B
MW-16A
MW-16B
MW-18B
MW-18A
MW-2
MW-15B
MW-7
MW-15A
Well Screen
- solid line deep wells
- dashed line shallow wells
(color matches associated data)
6/5/13 0:00
6/10/13 0:00
6/15/13 0:00
6/20/13 0:00
6/25/13 0:00
6/30/13 0:00
7/5/13 0:00
7/10/13 0:00
7/15/13 0:00
Date / Time



N

0 60 120 Feet

1 inch = 60 feet

Long Term Groundwater Level Monitoring
Maximum Difference in Shallow Well Water Levels
Former Gil's Gas
Alturas, California

PLATE 14

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N

0 60 120 Feet

1 inch = 60 feet

Long Term Groundwater Level Monitoring
Maximum Difference in Deep Well Water Levels
Former Gil's Gas
Alturas, California

PLATE 15

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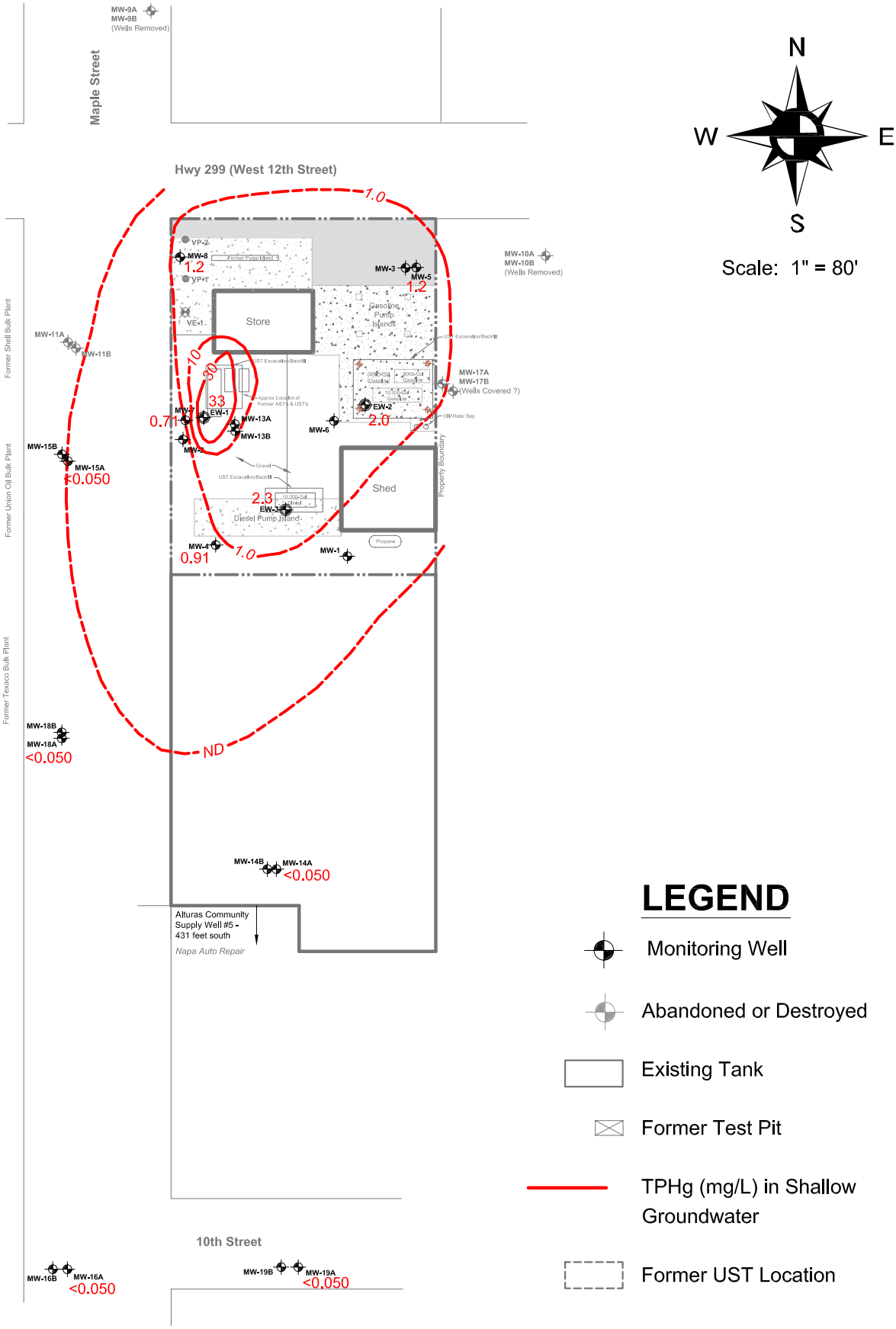


Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 16 - TPHg-Shallow.dwg, 10/25/2013 9:55:03 AM

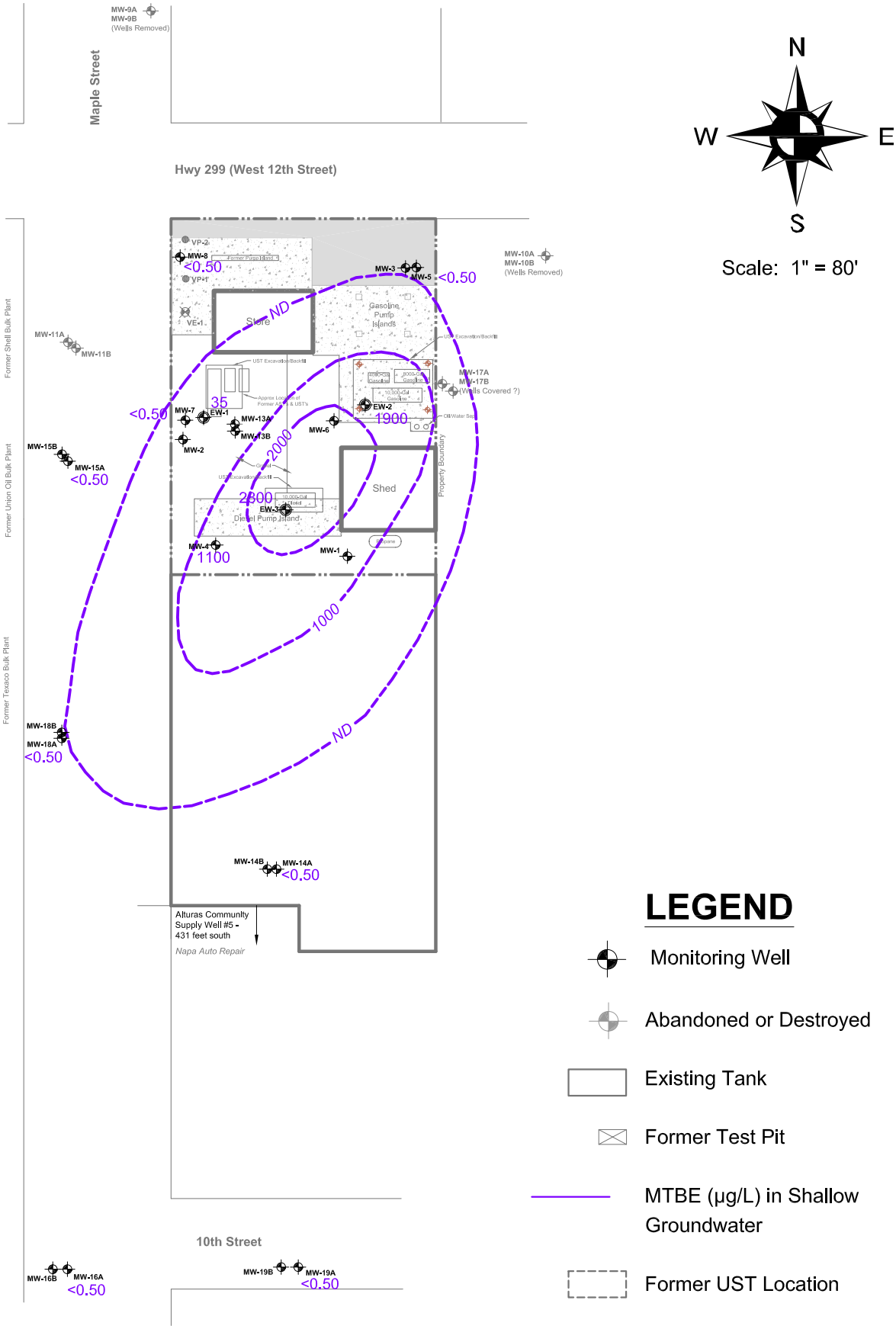
porter geotechnical

Proj. 2145.1 Drawing by: DIP

TPHg in Shallow Groundwater 6/18/13

Former Gil's Shell Station
123 West 12th Street, Alturas, CA

Plate **16**



Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 17 - MTBE-Shallow.dwg, 10/25/2013 9:50:46 AM

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Proj. 2145.1

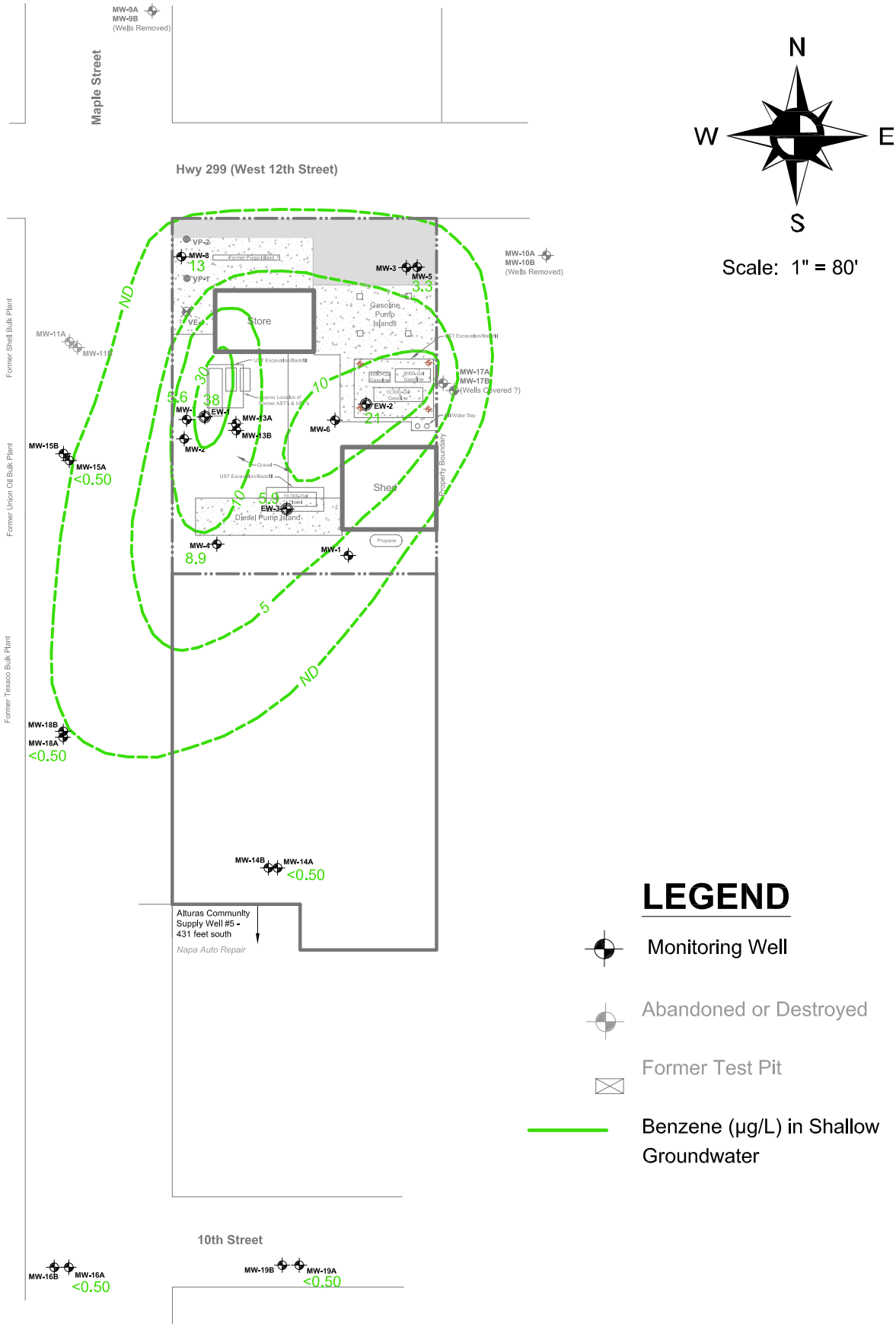
Drawing by: DIP

MTBE in Shallow Groundwater 6/18/13

Former Gil's Shell Station
123 West 12th Street, Alturas, CA

Plate

17



Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 18 - Benz-Shallow.dwg, 10/25/2013 12:29:55 PM

porter geotechnical

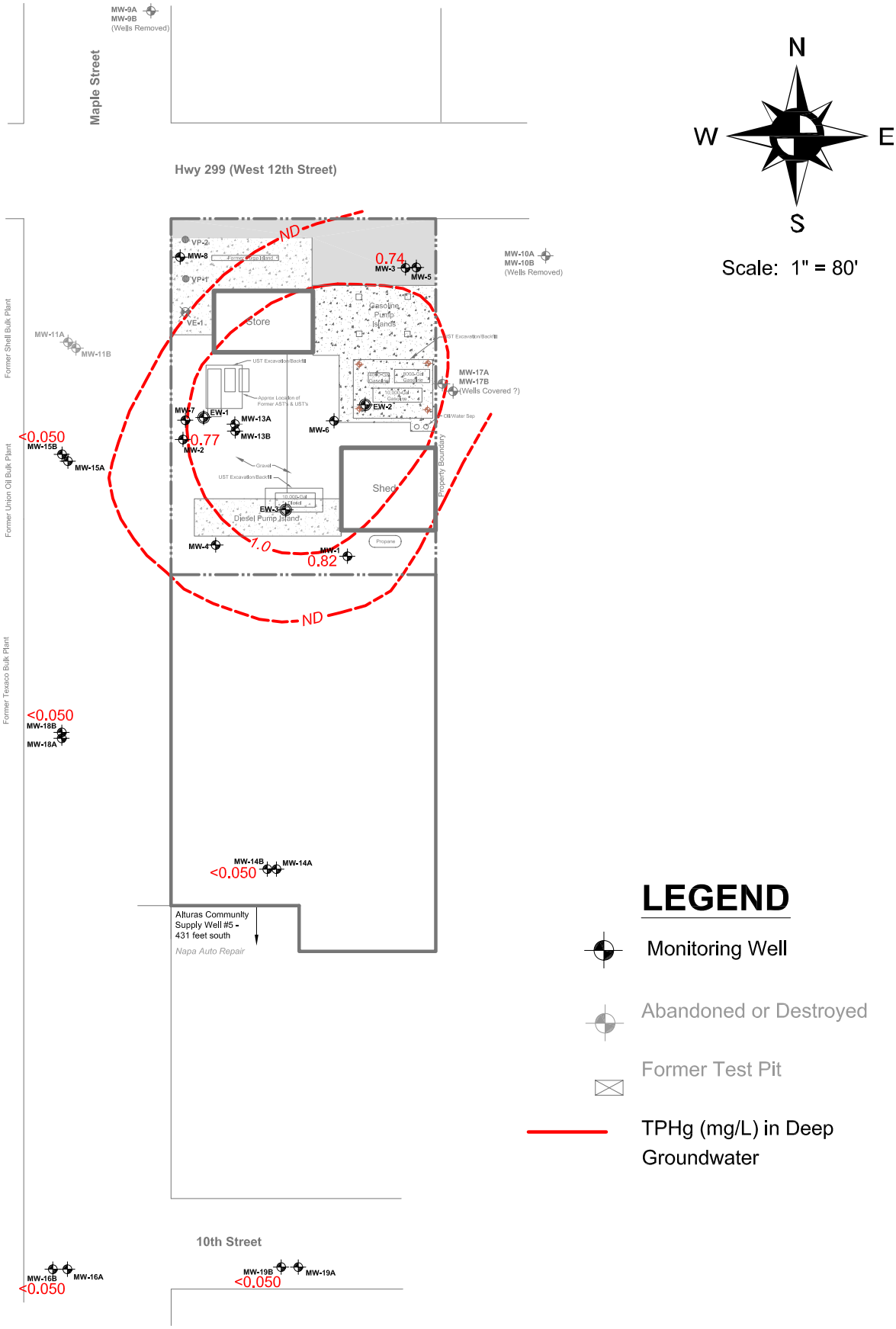
Proj. 2145.1

Drawing by: DIP

Benzene in Shallow Groundwater 6/18/13

Former Gil's Shell Station
123 West 12th Street, Alturas, CA

Plate
18



Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 19 - TPHg-Deep.dwg, 10/25/2013 12:11:28 PM

porter geotechnical

Proj. 2145.1

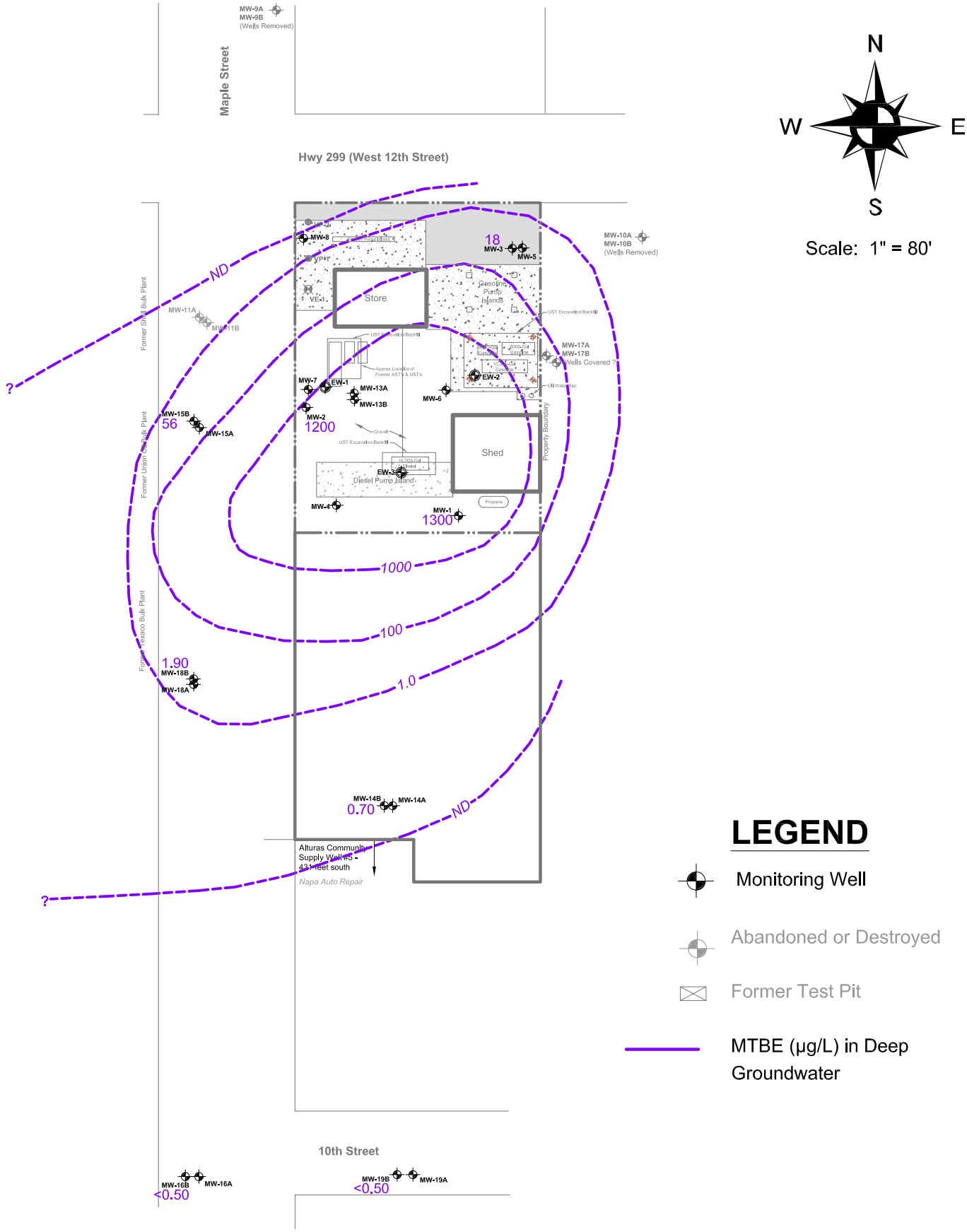
Drawing by: DIP

TPHg in Deep Groundwater 6/18/13

Former Gil's Shell Station
123 West 12th Street, Alturas, CA

Plate

19



LEGEND

- Monitoring Well
- Abandoned or Destroyed
- Former Test Pit
- MTBE (µg/L) in Deep Groundwater

Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 20 - MTBE-Deep.dwg, 10/25/2013 12:07:17 PM

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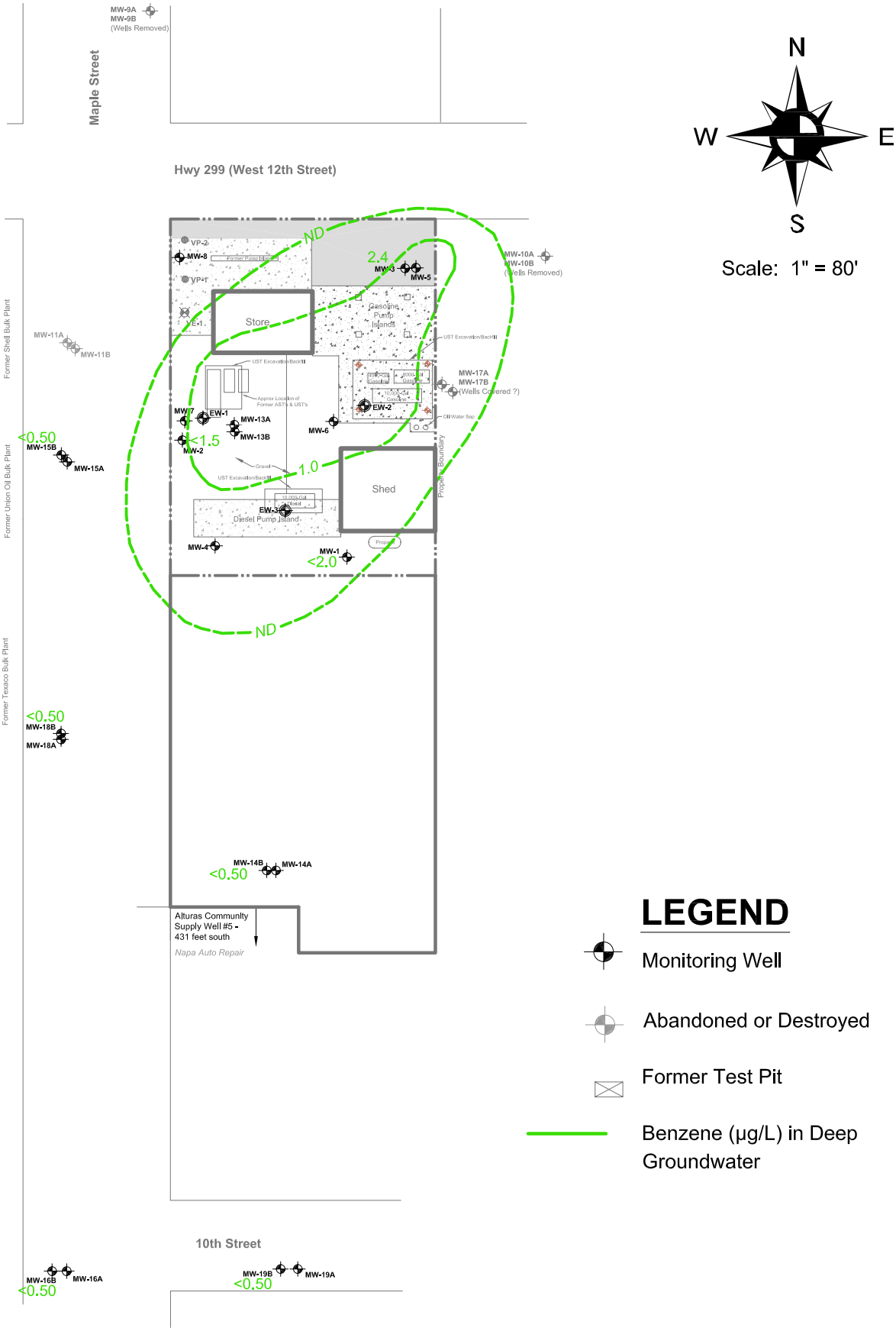
Proj. 2145.1

Drawing by: DIP

MTBE in Deep Groundwater 6/18/13

Former Gil's Shell Station
123 West 12th Street, Alturas, CA

Plate
20



Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 21 - Benz-Deep.dwg, 10/25/2013 11:13:32 AM

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Proj. 2145.1

Drawing by: DIP

Benzene in Deep Groundwater 6/18/13

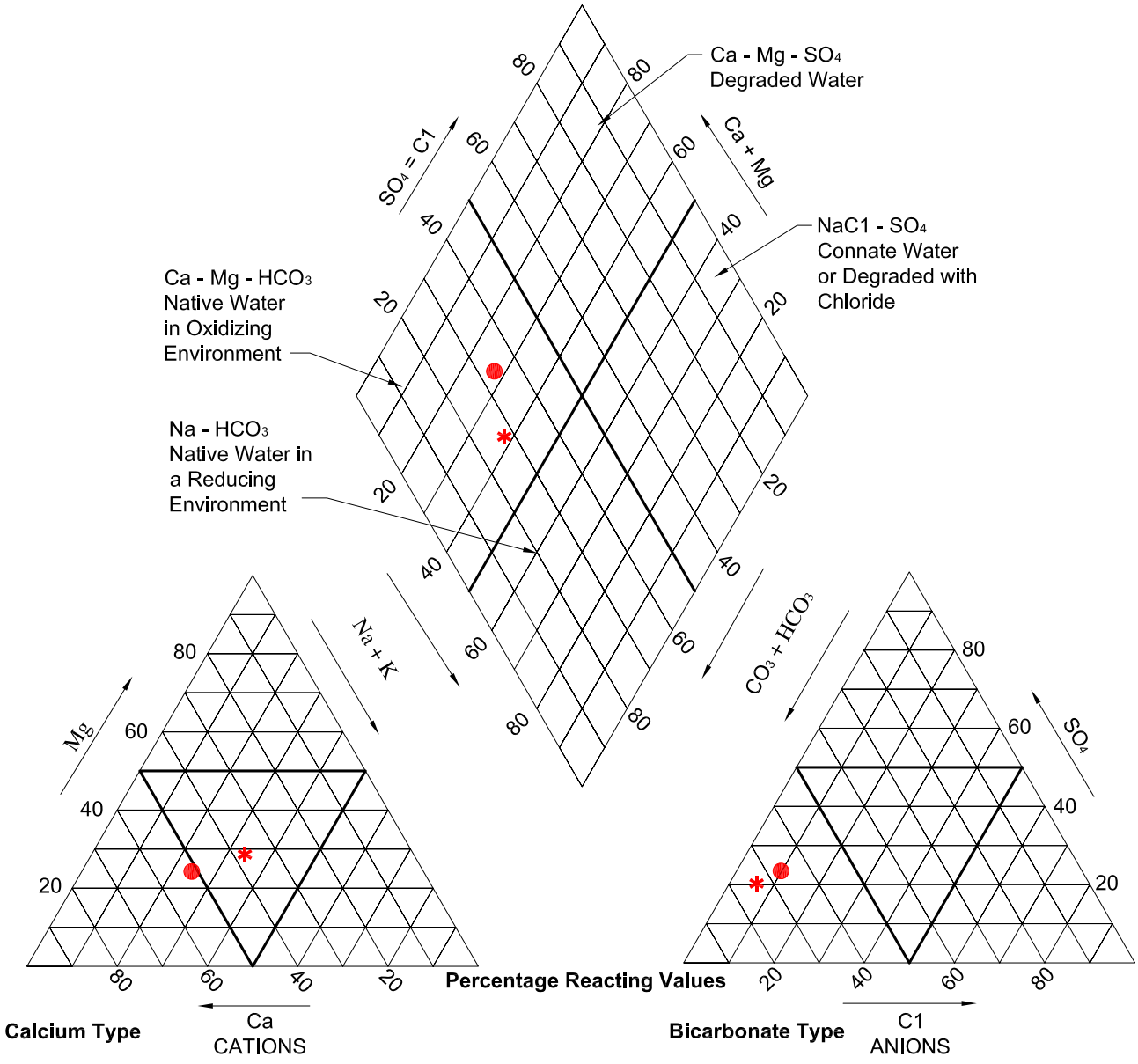
Former Gil's Shell Station
123 West 12th Street, Alturas, CA

Plate

21

Name	Symbol	TDS	pH
MW-19B	*	490	7.3
ACSW #5	●	341	8.01

Conclusion: Both well waters plot in same environment. ACSW Well has higher Calcium %. Both wells classify as "Native Water in Oxidizing Environment" Ca - Mg - HCO_3 type water.



Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 22 - Trilinear Diagram.dwg, 10/25/2013 10:49:39 AM

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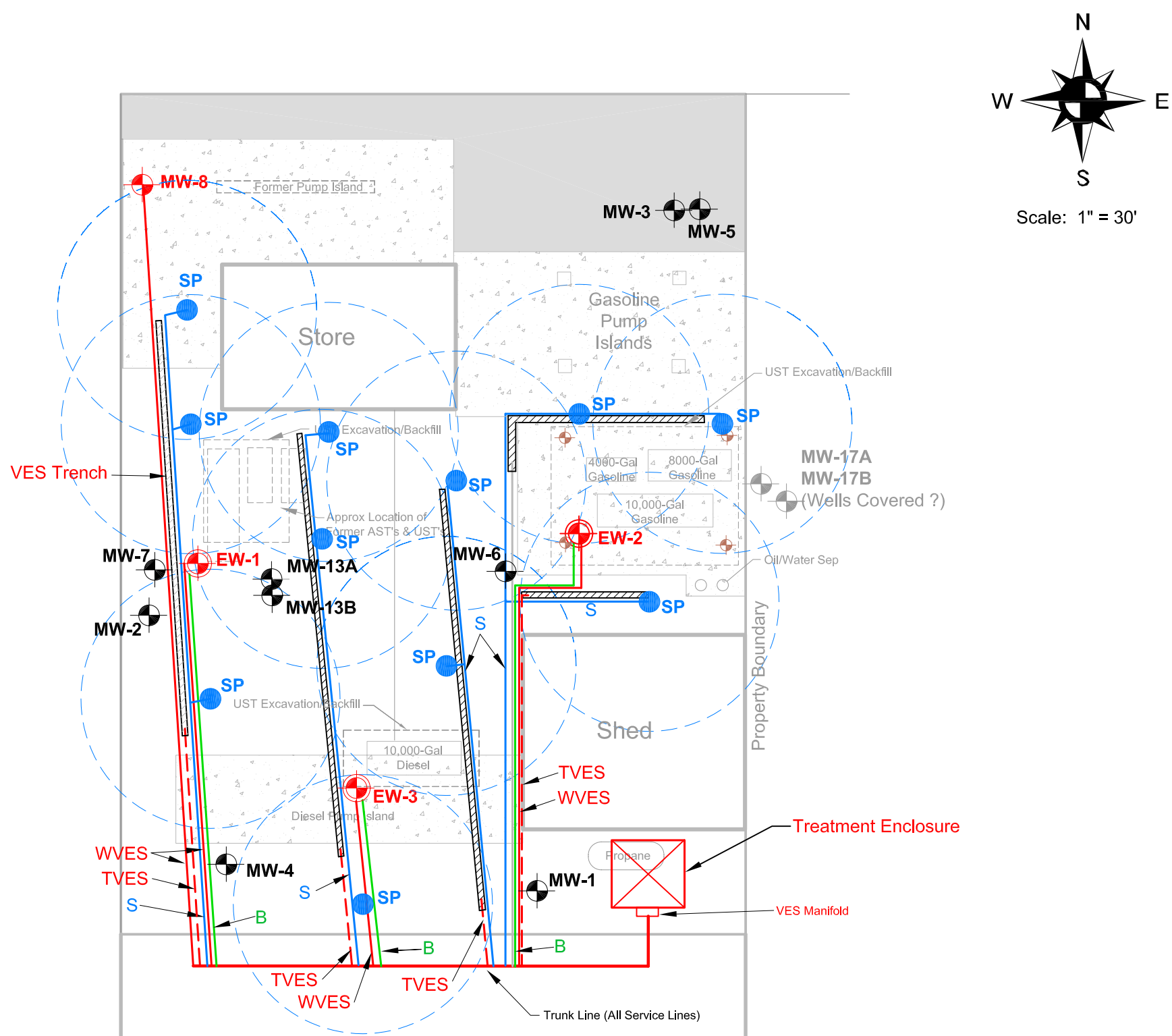
Proj. 2145.1 Dwg: DIP

Trilinear Diagram

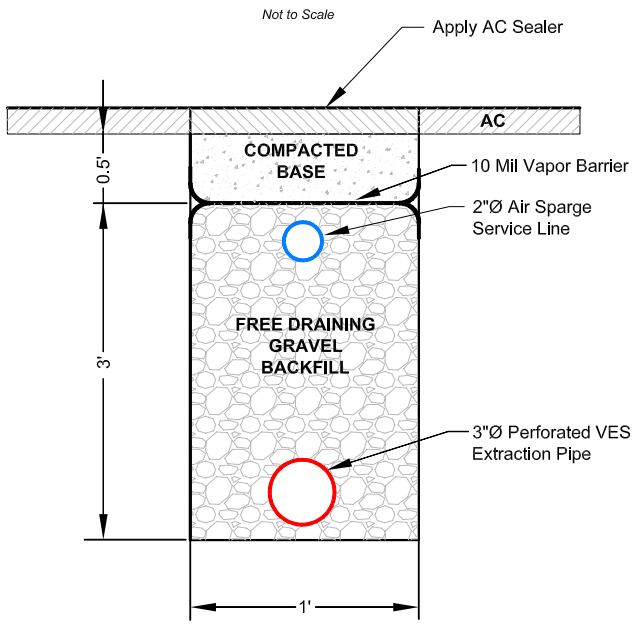
Former Gil's Shell Station
123 West 12th Street, Alturas, CA

PLATE
22



Soil Vapor Extraction (VES) Trench Detail

Not to Scale



LEGEND

MW	Monitoring Well
SP	Proposed Shallow Sparge Points 15' TD with 60'Ø Radius of Influence
EW	Dual Phase Extraction Well (GWPT & VES)
MW-8	VES Well (No GWPT)
	VES Recovery Trench
WVES	Well VES Service Line
TVES	Trench VES Service Line
S	Sparge Service Line
B	Bladder Pump Compressed Air and GW Discharge Service Line

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Proj. 2145.1 Drawn by: DIP

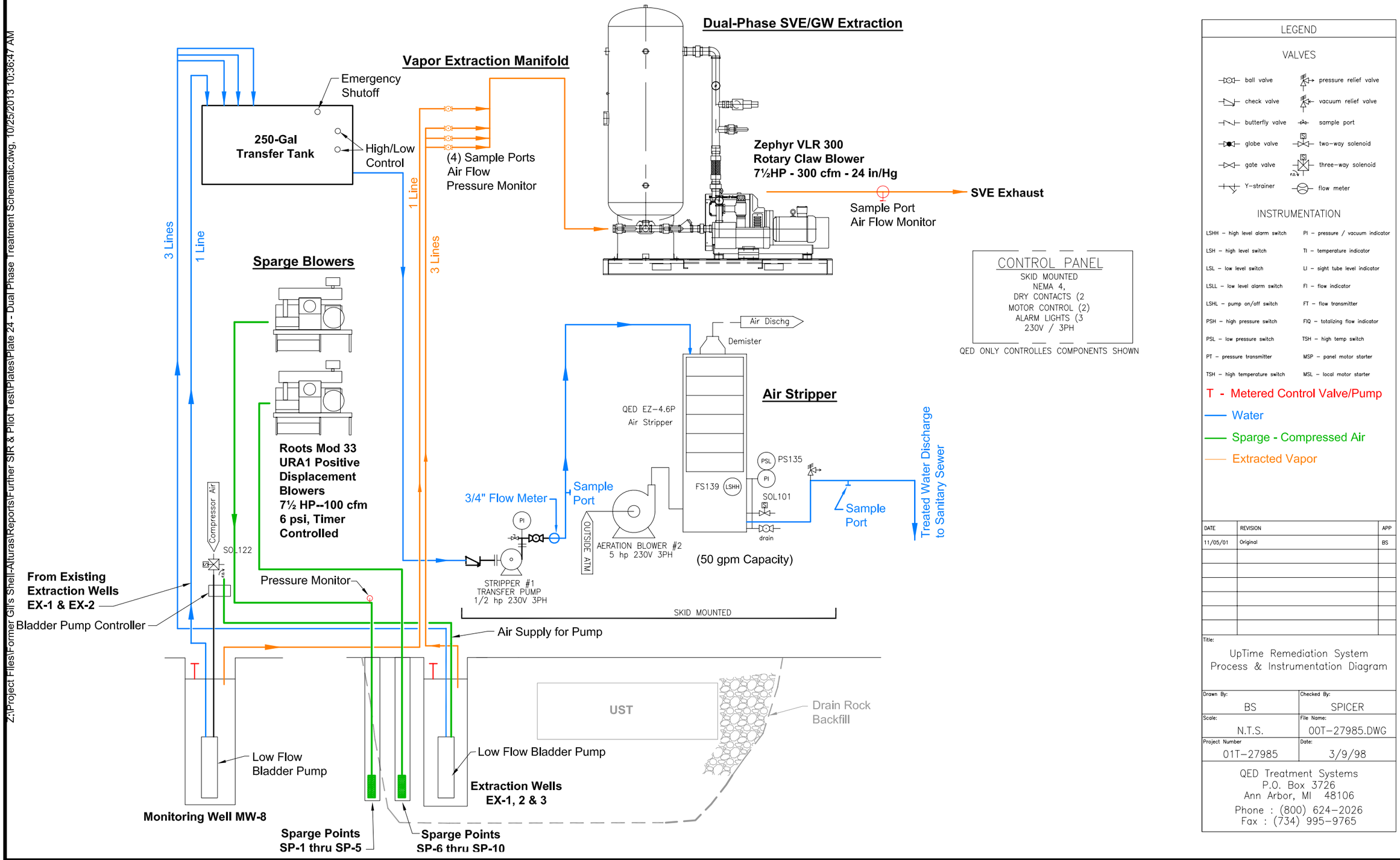
Proposed Air Sparge Wells, Extraction Wells and VES Recovery Trenches

Former Gil's Shell Station
123 West 12th Street, Alturas, CA

PLATE **23**

Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 23 - Proposed AS & EW & Trench.dwg, 10/25/2013 10:38:05 AM

Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 24 - Dual Phase Treatment Schematic.dwg, 10/25/2013 10:36:47 AM



LEGEND

VALVES

- ball valve
- check valve
- butterfly valve
- globe valve
- gate valve
- Y-strainer
- pressure relief valve
- vacuum relief valve
- sample port
- two-way solenoid
- three-way solenoid
- flow meter

INSTRUMENTATION

LSHH – high level alarm switch	PI – pressure / vacuum indicator
LSH – high level switch	TI – temperature indicator
LSL – low level switch	LI – sight tube level indicator
LSLL – low level alarm switch	FI – flow indicator
LSHL – pump on/off switch	FT – flow transmitter
PSH – high pressure switch	FIQ – totalizing flow indicator
PSL – low pressure switch	TSH – high temp switch
PT – pressure transmitter	MSP – panel motor starter
TSH – high temperature switch	MSL – local motor starter

T - Metered Control Valve/Pump

Water

Sparge - Compressed Air

Extracted Vapor

DATE	REVISION	APP
11/05/01	Original	BS

Title: UpTime Remediation System Process & Instrumentation Diagram

Drawn By: BS	Checked By: SPICER
Scale: N.T.S.	File Name: 00T-27985.DWG
Project Number 01T-27985	Date: 3/9/98

QED Treatment Systems
P.O. Box 3726
Ann Arbor, MI 48106
Phone : (800) 624-2026
Fax : (734) 995-9765

PLATE 24

Dual-Phase & Air Sparge Treatment Schematic Process Diagram

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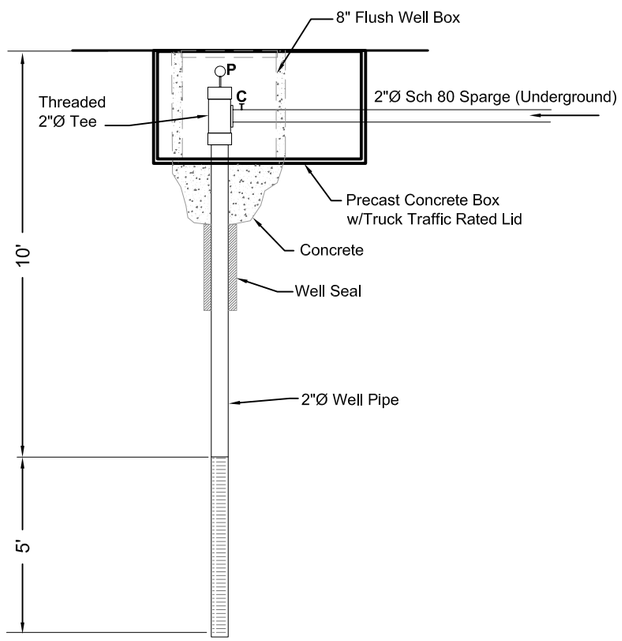
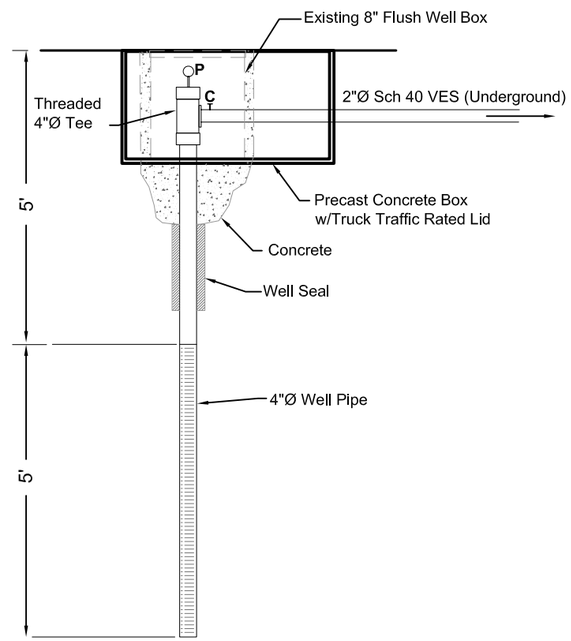
Drawn by: QED/DIP

Proj. 2145.1

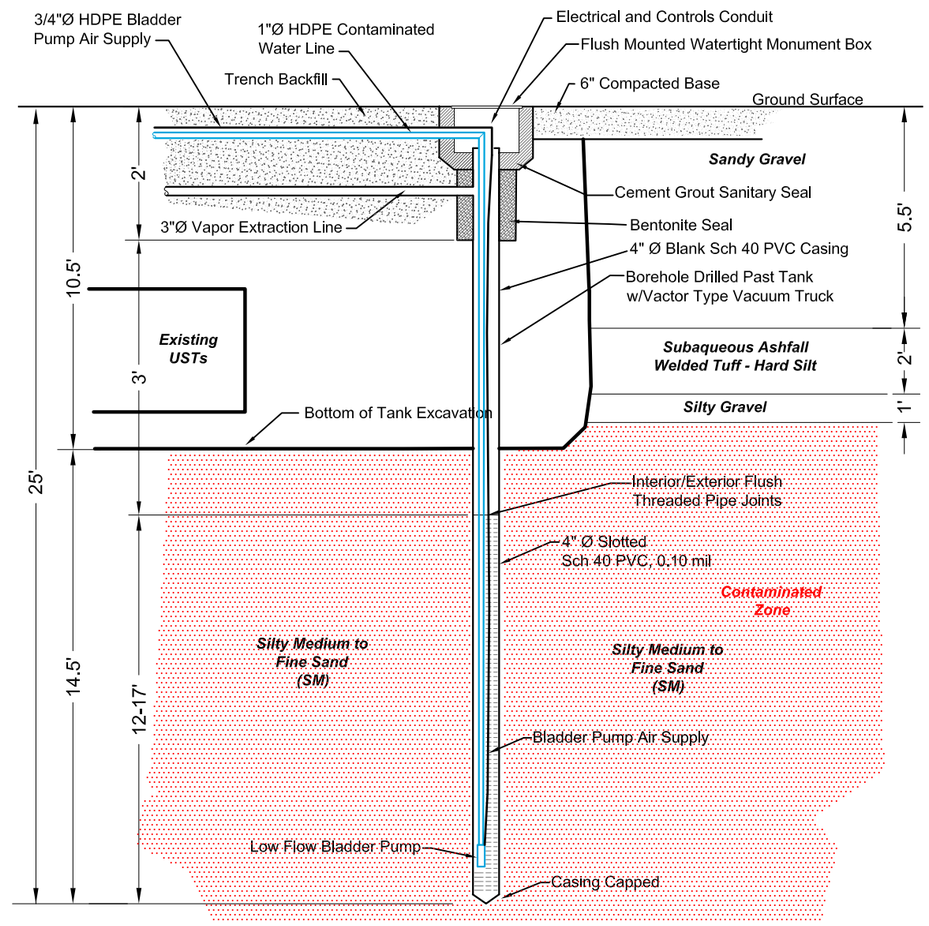
Proposed Sparge Wells



Vapor Extraction Well (Existing) MW-8



Extraction Well Heads for EX-1, EX-2 and EX-3



Not to Scale

PLATE
25

Proposed UST Recovery Well Heads
UST Recovery System

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Drawn by: DIP

Proj. 2145.1

Z:\Project Files\Former Gil's Shell-Alturas\Reports\Further SIR & Pilot Test\Plates\Plate 25 - Proposed UST Recovery Well Heads.dwg, 10/28/2013 10:26:13 AM