

Use of the
SCREEN POINT 15 GROUNDWATER SAMPLER
and
COMPARISON TO PVC MONITORING WELLS

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I. INTRODUCTION

This study was conducted at two UST sites in central Kansas to investigate the use of Geoprobe System's direct push Screen Point 15 Groundwater Sampler for investigation of groundwater contamination. This study includes a comparison of groundwater samples gathered from existing two-inch PVC monitoring wells and Screen Point 15 groundwater samplers. The information studied includes:

- Static Water Levels
- BTEX compounds
- Gasoline Range Organics (GRO)
- Selected X-VOCs
- Turbidity

Screen Point 15 samplers were installed at two separate sites for purposes of this study. At Site #1 the Screen Point 15 samplers were installed in an alluvial sandy-silty clay formation. Sampling was conducted on a weekly basis for approximately two months. The Screen Point 15 samplers at Site #2 were installed in an alluvial, medium to coarse grained sand formation. Sampling for organic parameters and turbidity measurements were conducted at various purge volumes during the development process.

The Screen Point 15 sampler is a direct push device for sampling groundwater in unconsolidated materials (Figure 1). This sampler is designed primarily for obtaining 'grab' samples of groundwater but it can be left in place for several days or weeks to permit sampling and SWL measurements over a time interval. The heart of this device is a wire-wound, stainless steel screen having a 1.0-inch outside diameter (OD) and 0.004-inch screen slot (PVC screens with 0.01 slot are available). The minimum inside diameter (ID) of the screen is 0.65 inches, and a total of up to 41 inches of screen can be exposed to the formation for sampling. This stainless steel screen is sealed in a steel sheath with 1.5 inches OD to be driven to the desired depth for deployment and sampling. The end of the screen is equipped with a knock out grout plug. This feature enables the operator to grout hole as the Screen Point 15 sampler is removed.

The monitoring wells, which the Screen Point 15 groundwater samplers were installed adjacent to, meet the requirements of a RCRA well as defined in the Technical Enforcement Guidance Document (EPA 1986) and the RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA 1992). Figure 2 provides a cross section and general specifications of the typical monitoring well sampled for comparative purposes in this study.

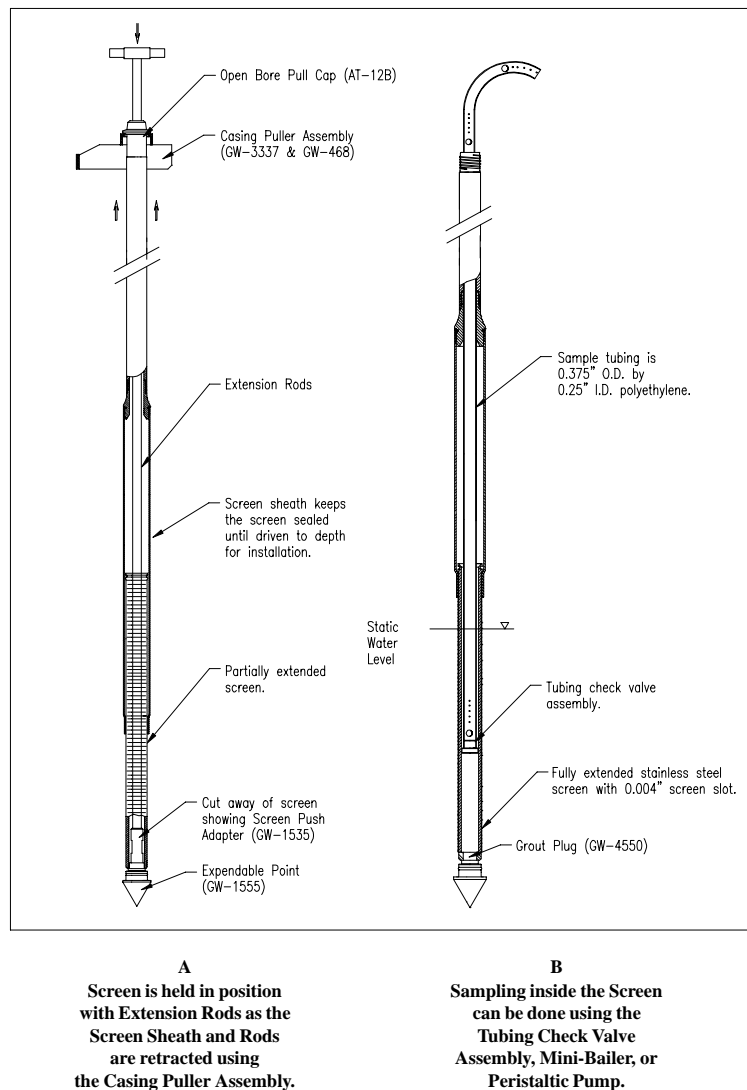


Figure 1
Screen Point 15 Installation and Sampling

II. GENERAL PROCEDURES AND METHODS

The following sections describe the rationale for placement of the Screen Point 15 (SP) samplers at each site and the sampling methods and analytical procedures used during this project.

A. Placement of the Samplers

The placement of the SP groundwater samplers at each location at both study sites was conducted to attempt to minimize the influence of purging and sampling. If the SP15 samplers were placed too close to the existing monitoring wells, then purging the monitoring wells for sampling could have an impact on the analyte concentrations observed in the SP samplers over time. Conversely, placing the SP samplers too far from the existing monitoring wells could lead to measurable differences in the static water levels as well as the contaminant concentrations observed.

Based on these considerations the SP samplers were placed according to the following:

- Set SP sampler ~5 to 10 feet away from well to minimize influence of well purging
- Set SP sampler across groundwater flow gradient from the monitoring wells
 - If set upgradient, purging SP15 will affect well
 - If set downgradient, purging well will affect SP15

The placement of the SP samplers relative to the existing monitoring wells (MWs) and groundwater flow direction at Site #1 are shown on Figure 2. This shows that the SP samplers are placed across the groundwater flow gradient at a distance of approximately ten feet from the existing monitoring wells. This placement configuration along with the relatively low hydraulic conductivity of the fine grained formation being sampled at Site #1 should minimize the cross influence of purging and sampling on the SP sampler and adjacent MW.

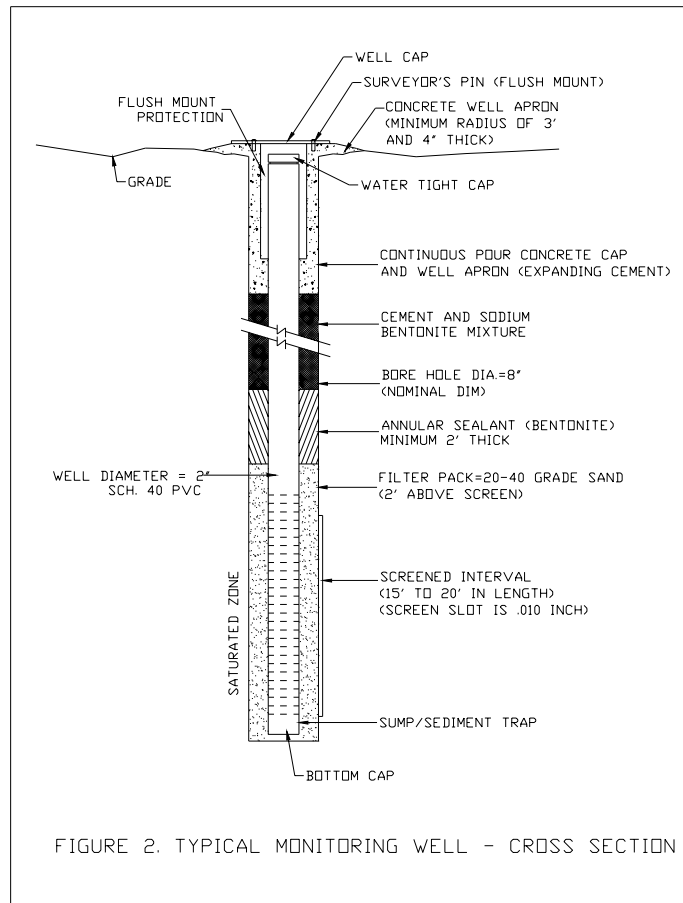


Figure 3 shows the placement of the SP samplers at Site #2 relative to the existing monitoring wells and potentiometric surface. The potentiometric surface contoured on Figure 3 is based on water level measurements from the existing PVC wells at Site #2. This potentiometric surface does not show a simple unidirectional gradient for groundwater flow in the site area as would be expected for an alluvial, unconfined aquifer. The major stream drainage for the area is to the east of Site #2; groundwater flow will be in that general direction. The convoluted potentiometric surface shown on Figure 3 will be discussed in a later section.

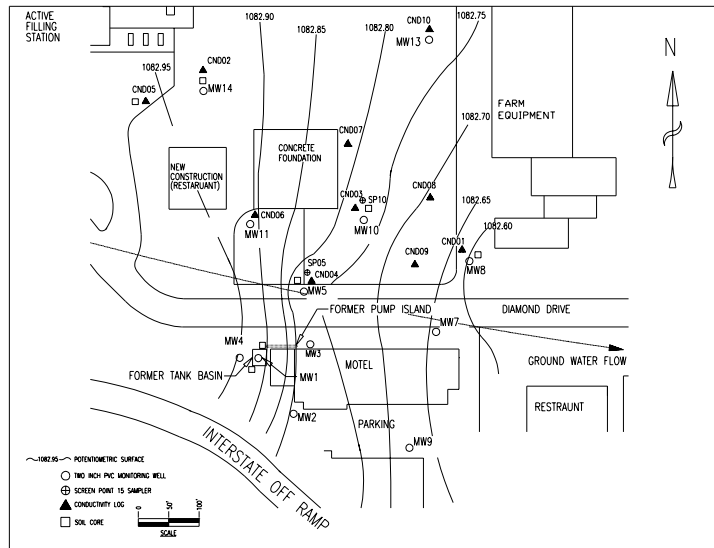


Figure 3
Site #1 Map with Potentiometric Surface

Because Site #2 was in an urban setting, the main controls on placement of the SP samplers relative to the wells had to be cultural influences such as sewer lines, roadways, utilities, and property access. All of these considerations lead to the placement of the SPs as shown on Figure 4. These SP placements are generally across gradient (MW14, MW15) or upgradient (MW9) of the adjacent MW relative to the general eastward groundwater flow pattern in this area.

Three SP groundwater samplers were installed adjacent to MW9 at Site #2 with their screen intervals set at different depths to look for any possible vertical stratification of contaminants. The screen interval depths and designations for these SP samplers and the other samplers at both Site #1 and Site #2 are summarized in Table 1.

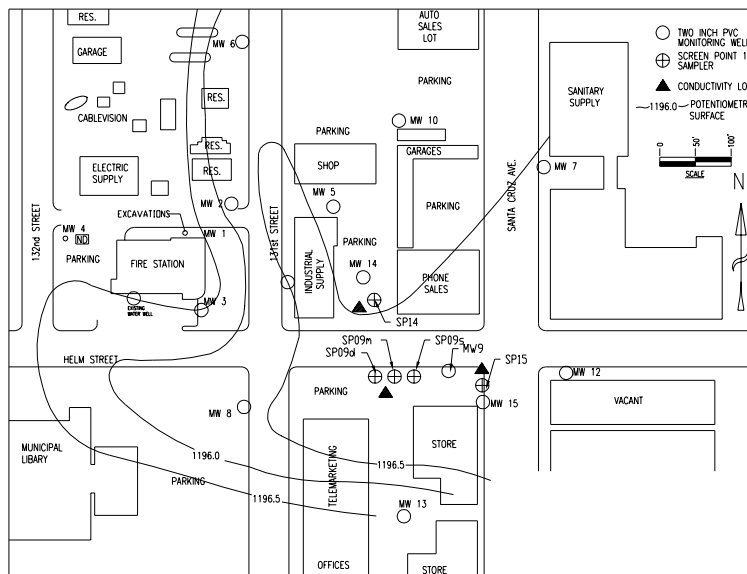


Figure 4
Site #2 Map with Potentiometric Surface

Table 1
Screen Point Designations, Locations, and Screened Intervals

Site #	Monitoring Well Number	MW Screen Interval (feet bgs)	SP Designation	SP Screen Interval (feet bgs)	Distance of SP from Adjacent MW (feet)
1	MW5	13 to 28	SP5	24 to 28	11
1	MW10	13 to 28	SP10	24 to 28	12.5
2	MW9	25 to 40	SP9-s	24 to 28	3.7
2	MW9	25 to 40	SP9-m	30 to 34	6.0
2	MW9	25 to 40	SP9-d	34 to 38	8.2
2	MW14	20 to 40	SP14	31 to 35	12
2	MW15	20 to 40	SP15	31 to 35	5.8

B. Methods and Procedures

Installation Procedure

The SP groundwater samplers were installed using the Geoprobe Model 5400 hydraulically-powered percussion probing machine. The lower end of the sampler screen was driven to the bottom of the desired interval. The stainless steel screen was held in place with extension rods as the screen sheath was retracted exposing the screen to the formation. The detailed procedures for installation of the SP groundwater sampler are provided in the standard operating procedure for this tool (Geoprobe 1995). Figure 1 provides a schematic representation of the deployed SP groundwater sampler.

Equipment Rinsate

Prior to installation, all parts of the SP groundwater sampler and the probe rods were decontaminated by steam cleaning followed by a tap water rinse. After decontamination was completed, an equipment rinsate sample was collected from one of the samplers to be installed at each site. The rinsate was performed by assembling the SP sampler with at least one probe rod attached to the sampler drive head. Then HPLC-grade water was poured directly from the bottle through the rod and partially extended screen, then collected directly into 40 ml VOA vials. The rinsate samples were appropriately labeled and preserved for analysis with the first round of samples collected from each site. The rinsate samples were nondetect for all of the contaminants of concern at each site being studied. The detection limits for each analyte are listed below in the section on analytical method.

SP Groundwater Sampler and Monitoring Well Development

The same procedure for development of the SP sampler was used at both sites. At Site #1, samples were not collected until after development was conducted, while at Site #2 sampling was conducted during the development. Development of the SP samplers was completed using the simple tubing check valve assembly (Geoprobe PN GW-42, Figure 5) to purge the SP samplers. The tubing check valve was threaded into the lower end of 0.375-inch OD by 0.25-inch ID polyethylene (PE) tubing and lowered into the screened interval. The tubing and check valve were oscillated up and down manually to raise water to the surface and purge the SP sampler. As the development purging was conducted, the tubing check valve assembly was raised and lowered through the entire screened interval several times. This was done to achieve an equal amount of development and removal of fines along the entire screened length. Each of the SP samplers at both sites were purged a total of ten gallons (40 liters) during the development process.

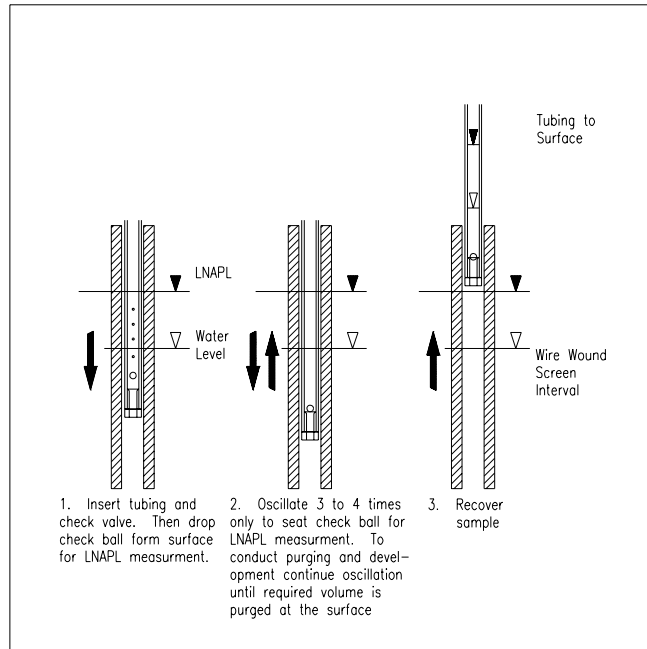


Figure 5
Tubing Check Valve Operation For
Purging, Sampling, and LNAPL Detection

The PVC monitoring wells used for comparison purposes in this study were developed by the drilling contractor following installation. Site investigation reports (GeoCore 1993, 1994, 1995) document that the wells were developed using bailers, and that a minimum of three well volumes were purged from the wells during the development process. Total well depths were monitored during the course of the study at both sites. These measurements indicated the presence of approximately one to four inches of sediment in the sediment traps on the monitoring wells. These development and well conditions were considered to be representative of actual well conditions encountered at the majority of UST facilities during ongoing groundwater investigations. The wells were not redeveloped for this study.

Water Level Measurement

The initial static water level (SWL) measurements at both sites were made shortly after installation of the SP samplers. During all sampling episodes, SWL measurements were taken prior to any disturbance of the water level by purging or sampling. The SWL measurements were made using the Geoprobe Water Level Sounder (PN GW-1200, Figure 6). This water level sounder is specifically designed for use in small diameter, direct push groundwater samplers. The sounder probe changes the water level by less than 0.008 inches (0.0007 ft) to activate the audible and light signals at the surface. The water levels were measured and recorded in the field at 0.005-foot accuracy. The total depth of each SP sampler and well was also measured and recorded to verify that the SP samplers did not silt in between sampling events. After development, the SP samplers did not change more than 0.02 feet (0.25 inches) in total depth through the course of the project.

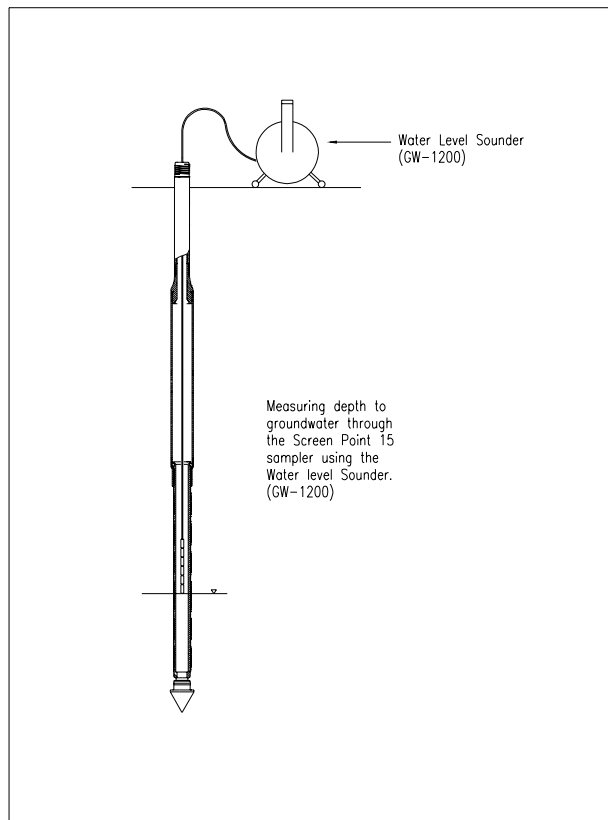


Figure 6
Water Level Measurement

LNAPL Detection and Measurement

Immediately after measuring the static water level, a simple field method was used to detect and measure light nonaqueous phase liquids (LNAPL) inside the SP groundwater samplers and PVC monitoring wells. The tubing/check valve (Geoprobe PN GW-42) and 0.375-inch OD by 0.250-inch ID PE tubing were used (Figure 5). The check valve was threaded into the lower end of the PE tubing and slowly lowered to the bottom of the SP sampler or PVC monitoring well. The tubing check ball was then dropped down the tubing from the surface and allowed sufficient time to settle to the bottom of the PE tubing. The tubing and attached check valve were then oscillated up and down three or four times to seat the check ball onto the check valve. Then the PE tubing was pinched at the surface and quickly, but smoothly, withdrawn from the well. Any LNAPL was visually observed through the translucent PE tubing and measured. After measurement, the LNAPL was drained into a VOA vial.

Site #1: Sample Prepurge and Sampling Method

After measuring the SWLs and LNAPLs each week at Site #1, both the SP samplers and monitoring wells were purged before sampling. The SP samplers were purged using the tubing/check valve described above (Figures 1, 5). The check valve was lowered to the bottom of the screen and then retracted about two feet so that it was centered in the screen interval. Then the tubing and attached check valve were oscillated up and down to raise the formation water to the surface and purge the sampler. At Site #1 four liters were purged from each SP sampler before samples were collected each week.

Before the first samples were collected from the PVC monitoring wells at Site #1, three well volumes (casing volume + saturated filter pack = 50 liters) were purged from the wells. On each subsequent sampling event, only one well volume was purged from each well before samples were collected. This was done to minimize the effects of weekly purging on the SWL and contaminant concentrations, as well as to minimize the amount of purge water generated. The PVC wells were purged with dedicated bailers. The last four liters of the sample prepurge were completed with the tubing/check valve assembly each week. The check valve was lowered to the same depth within the PVC wells that was purged and sampled in the adjacent SP sampler to purge these last four liters.

When the sample prepurge was completed with the tubing/check valve assembly in either the SP sampler or PVC well, the tubing was raised to the surface. The check valve and check ball were removed from the PE tubing and the sample was drained from the bottom of the tube directly into 40 mL vials and capped with zero headspace. The samples were stored in a cooler on ice and transported to the lab for analysis. Use of the tubing check valve to sample from both the SP sampler and PVC well was done so that the same sampling method could be used for both devices. This eliminates potential for differences in sample analyte concentrations between the SP sampler and PVC well because different methods were used to sample the two devices.

Site #2 Sampling Scheme

At Site #2, the PVC wells were purged one well volume (64 liters) and sampled once each week for two weeks prior to installation of the SP samplers. This was done to verify the concentrations of GRO, BTEX, and the various X-VOCs in the groundwater at this site. The purging and sampling scheme conducted at Site #2 was different than that conducted at Site #1. At Site #2, the SP samplers were sampled during the development-purging process at selected purge volume increments, not on a weekly basis after a fixed prepurge volume as done at Site #1. This sampling scheme was used because this is the most common procedure for collecting groundwater grab samples with direct push equipment. The SP samplers and PVC MWs were purged and sampled with the tubing/check valve assembly. The PVC monitoring wells at Site #2 were sampled at the same depths and at similar purge volume increments as the adjacent SP samplers. The purging and sampling scheme followed at Site #2 is given in Table 2 below.

Turbidity Measurements

At Site #2, turbidity measurements were made on the samples. The turbidity meter (Cole Parmer P/N H08391-50) was calibrated following the manufacturer's recommendations and is capable of measuring turbidity in three range settings from a level of 0.0 to 200 nephelometric turbidity units (NTU).

Table 2
Purge Volume Sampling Scheme For Site #2

Purge Volume ¹ (liters)	MW9	SP9-m	SP9-d	MW14	SP14	MW15	SP15
0.2	✓	✓	✓		✓		✓
4	✓	✓	✓	✓	✓	✓	✓
12		✓	✓				
20		✓	✓		✓		✓
40		✓	✓		✓		✓
64 ²	✓			✓		✓	
1 Week Later ³	✓	✓	✓	✓	✓	✓	✓

Notes:

✓ Sample collected at this purge volume.

¹ All samples collected at discrete depth intervals using the tubing check valve system. The PVC wells were sampled at intervals corresponding to the center of the associated SP samplers.

² 64 liters is equivalent to one well volume for the PVC wells. After the first four liters were purged with the tubing check valve system, about 56 liters were purged using the dedicated PVC bailers. The last 4 liters were purged with the tubing check valve system at each discrete depth sampled in the PVC wells. The samples were then collected from the tubing check valve system.

³ All samples collected after 4 liter purge at discrete depth intervals using the tubing check valve system.

The turbidity meter was calibrated in the lab with primary standards and secondary standards of 10 NTU and 40 NTU were used in the field to verify sample measurements. Turbidity measurements were made on samples from the SP and adjacent MW as the purging process was conducted.

C. ANALYTICAL METHOD

The samples for this study were analyzed with a Hewlett Packard 5890 Series II gas chromatograph (GC) using heated headspace methods with manual injection. The GC was factory equipped with a flame ionization detector (FID) and electron capture detector (ECD). The system was retrofitted with an hnuâ Model PI-52 photoionization detector (PID) with a 10.2 eV lamp. A J&W Scientific 30 meter by 0.53mm DBâ -624 megabore capillary column (PN 122-1334) was used for analyte separation on all of the analyses. The PID and FID were run in series to analyze for BTEX, and GRO. The PID was used to quantitate for BTEX and the FID was used for the GRO. A separate analysis was conducted to quantify the concentrations of selected X-VOCs in samples from Site #2. The ECD was used to quantitate the X-VOCs. The temperature ramp for the GC oven and gas flow rates were optimized to obtain analyte separation and accurate identification.

The samples were prepared for GC analysis by a simple heated headspace procedure. A 10 mL aliquot of sample was transferred by disposable pipette to a new pre-cleaned 40 ml VOA vial which was immediately capped. The vial was then heated at 90°C for a minimum of 20 minutes. A gas tight 1000 ml glass syringe was used to pierce the vial septa. Then 500 ml of the headspace gas was manually injected directly into the injection port of the GC.

The GC system was calibrated for each analyte using a three-point calibration curve. A correlation coefficient of 0.99 or greater was required to accept the calibration. Mid-level continuing calibrations were analyzed twice daily. If the relative standard deviation (RSD) for the continuing calibration was greater than 10 percent, the GC system was restandardized. Analytical standards were prepared from commercially available stock standards purchased from ULTRA Scientific or AccuStandard, Inc.

Additional analytical quality control consisted of the preparation and analysis of analytical duplicates, matrix spikes and matrix spike duplicates. One each of these QC samples was analyzed with each group of 20 samples, or at a minimum once a day. A summary of the analyte detection limits is provided in Table 3.

Table 3
Analyte Detection Limits

ANALYTE		DETECTION LIMIT (mg/l)
Benzene	BTEX	5
Toluene		5
Ethylbenzene		5
Total Xylenes		5
GRO (Gasoline Range Organics)		2 (mg/l)
1,1-DCE (1,1-Dichloroethylene)		5
1,1-DCA (1,1-Dichloroethane)		5
1,1,1-TCA (1,1,1-Trichloroethane)		1
1,2-DCA (1,2-Dichloroethane)		5
TCE (Trichloroethylene)		1

III. DISCUSSION AND RESULTS

A. SITE #1: BACKGROUND AND GEOLOGY

Figure 3 is a current map of the Site #1 area. The location of the former UST basin and pump island is shown in Figure 3. Contamination consisting of gasoline range organics and BTEX was detected during an initial environmental investigation (GSI 1994). KDHE utilized an independent drilling contractor to conduct soil borings and install two-inch PVC monitoring wells located as shown on Figure 3. Access was available only to the area north of Diamond Drive for purposes of this study.

Site #1 is located on the alluvial flood plain of the Saline River in central Kansas. The subsurface geology consists of Pleistocene alluvial deposits overlying the bedrock which is the Permian Age Wellington Formation (Latta 1949). The alluvial deposits consist of clays and silty clays that grade into sands with interbedded gravels and silt or clay lenses with depth. The Wellington formation is comprised primarily of gray and greenish shales with some maroon and purple beds (Latta 1949) and serves as a dependable aquitard throughout the area.

Electrical conductivity (EC) logs were obtained adjacent to MW5 and MW10 at Site #1 using Geoprobe Systems' Direct Image[®] Soil Conductivity System. These EC logs are shown in Figures 7a and 7b along with a graphical lithologic log. The lithologic logs are based on continuous soil core samples collected next to each EC log location to a depth of 40 feet. Discrete interval samples were also collected at greater depths at other locations at Site #1 to confirm the results of the EC logs.

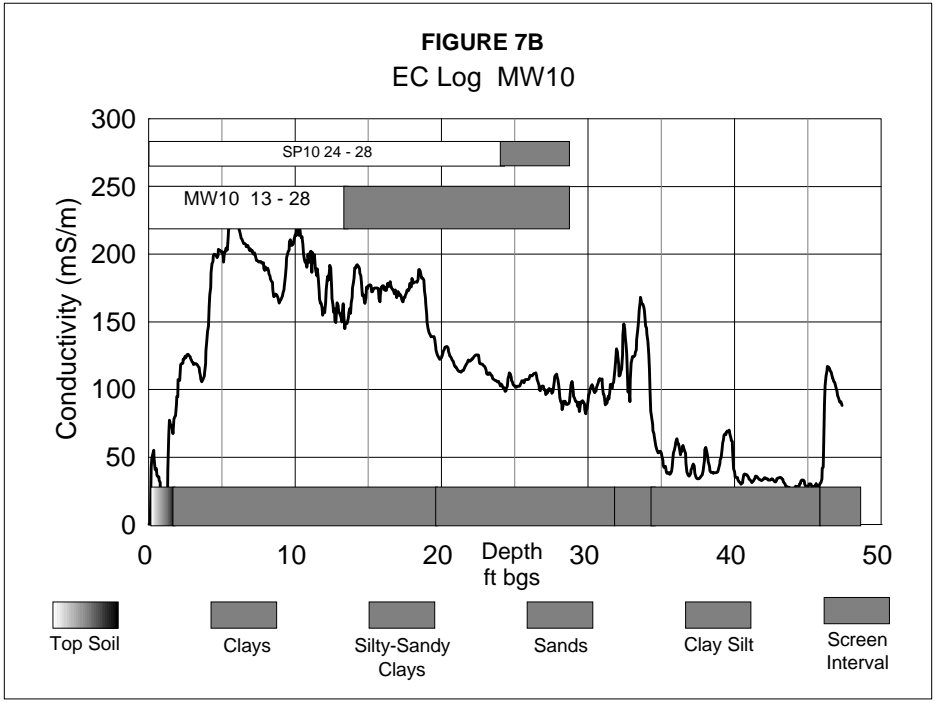
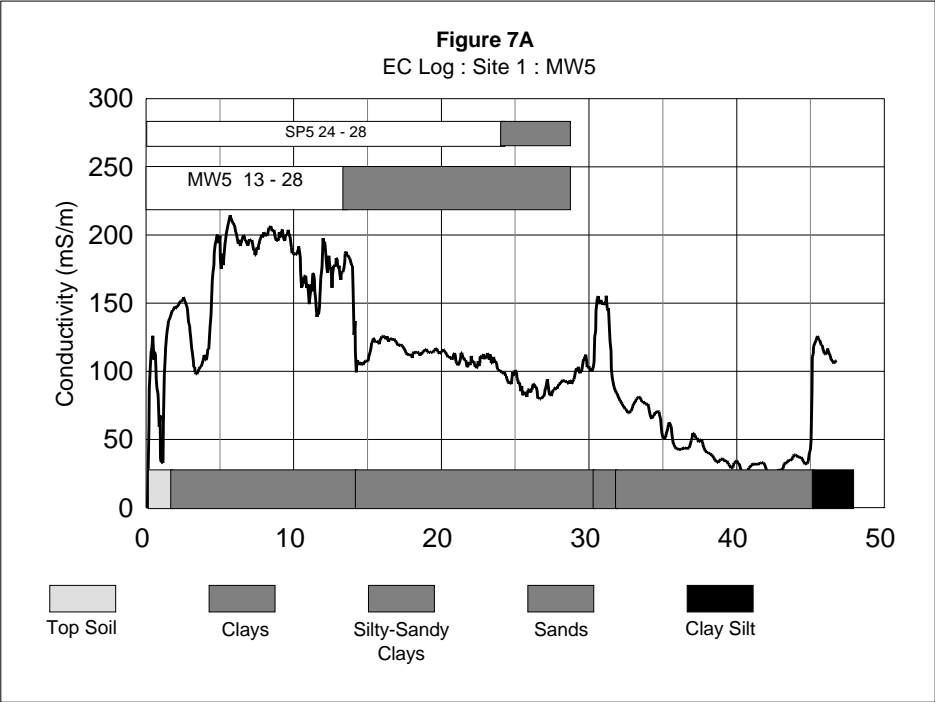
As indicated by the EC logs (Figures 7a, 7b) and confirmed by the lithologic samples, the top soil at Site #1 is underlain by 15 to 20 feet of clays. The clays are underlain by 12 to 15 feet of silty to sandy clays. A one- to two-foot thick clay lens is present beneath these deposits. Below the clay lens is a coarse sand layer 12- to 15-foot thick which exhibits a distinctly lower electrical conductivity. Below the sand layer, the EC log reveals the presence of a unit of higher electrical conductivity. Discrete interval sampling and EC logs at other locations showed that this is a clay layer about five-feet thick which forms an aquitard beneath the entire site (Geoprobe 1996). Figures 7a and 7b also show the well depths and screen intervals for MW5 and SP5, and MW10 and SP10, respectively.

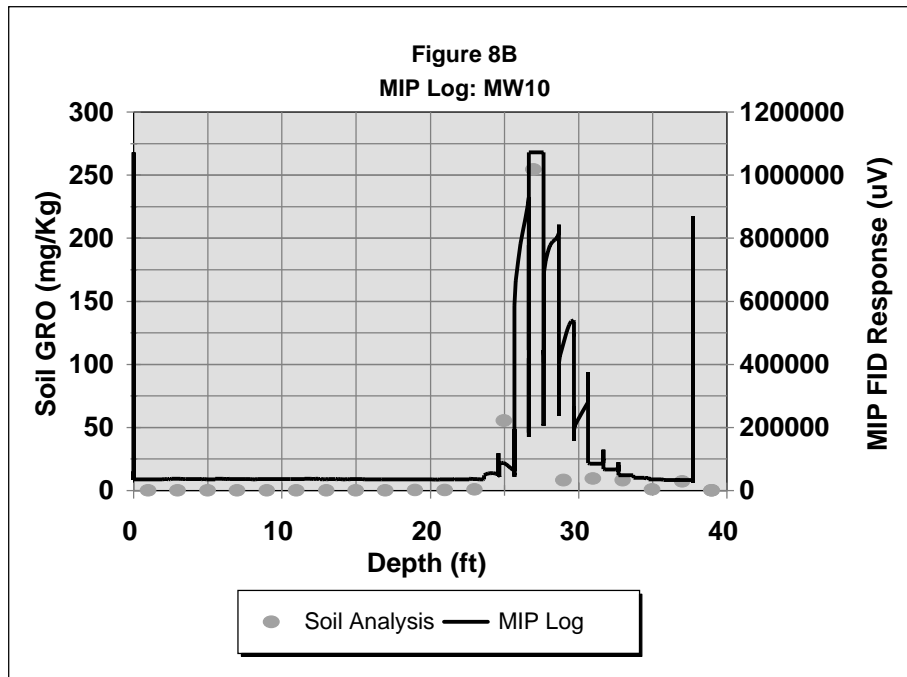
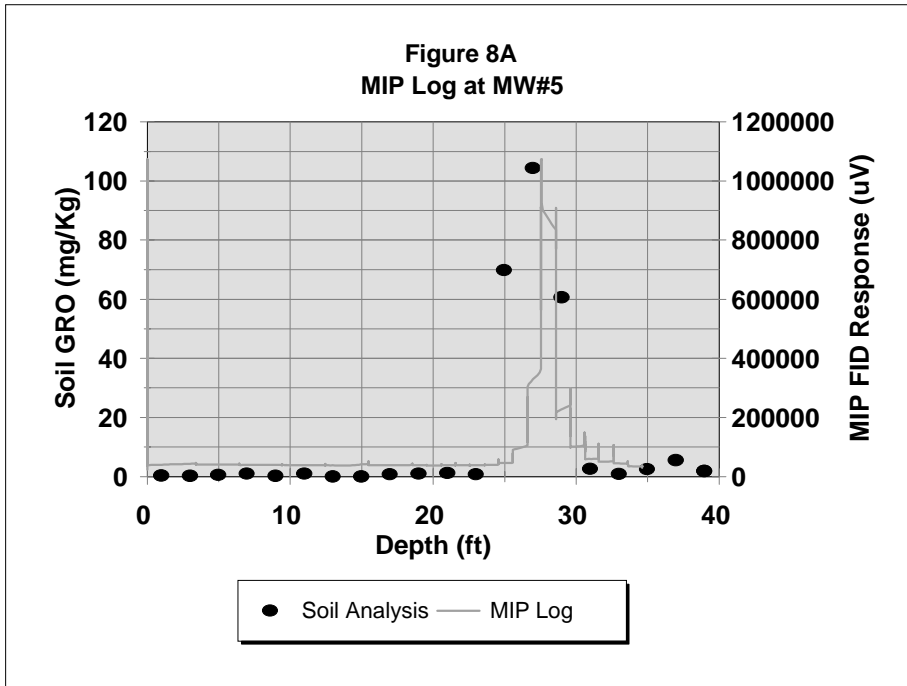
SELECTING APPROPRIATE SCREEN INTERVALS FOR THE SCREEN POINT 15 GROUNDWATER SAMPLERS AT SITE #1

After the EC logs were completed, the membrane interface probe (MIP), under development by Geoprobe Systems, was used to obtain the VOC sensor logs shown in Figures 8a and 8b. These logs were run at a distance of eight to ten feet from the respective monitoring wells. Plotted along with the VOC logs are results of the GRO analysis of soil samples taken at two-foot intervals from the soil cores collected at each location. Both the MIP logs and soil core analyses show that contamination at these two locations is not present above 25 feet bgs. This is seven feet below the static water level measured in monitoring wells MW5 and MW10.

As noted above, the fine-grained soils and sediments grade downward into coarser-grained alluvial deposits of sands and fine gravels at Site #1. Familiarity with the local geology has shown that the fine-grained sediments generally will not yield water when the electrical conductivity is above 100 mS/m. Inspection of the EC logs (Figures 7a, 7b) shows that the electrical conductivity drops below 100 mS/m at about 25 feet bgs at both locations. Test installations of SP groundwater samplers at both locations above 25-foot depth did not yield water. But when SP sampler screens were set to a depth of 24- to 28-feet bgs, the static water level rose to about 18-feet bgs, the same as in the adjacent monitoring wells. Also, several inches of free product were observed in SP5 adjacent to MW5 and a product sheen was observed on water purged from SP10 set adjacent to MW10.

At the MW10 location, a test installation of an SP sampler was done with the screen set at 34- to 38-feet bgs. This correlates with the top of the sand layer as defined by the EC logs and lithologic samples (Figure 7b). Analysis of this groundwater sample for BTEX and GRO was nondetect for all of the analytes. This test installation shows that the seal on the screen sheath of the SP sampler maintains its integrity when driven through a contaminated zone. This also shows that the Screen sheath forms an effective annular seal above the extended screen preventing the downward migration of contaminants and preventing cross contamination of samples.





In summary, the information used to select the SP sampler screen intervals is:

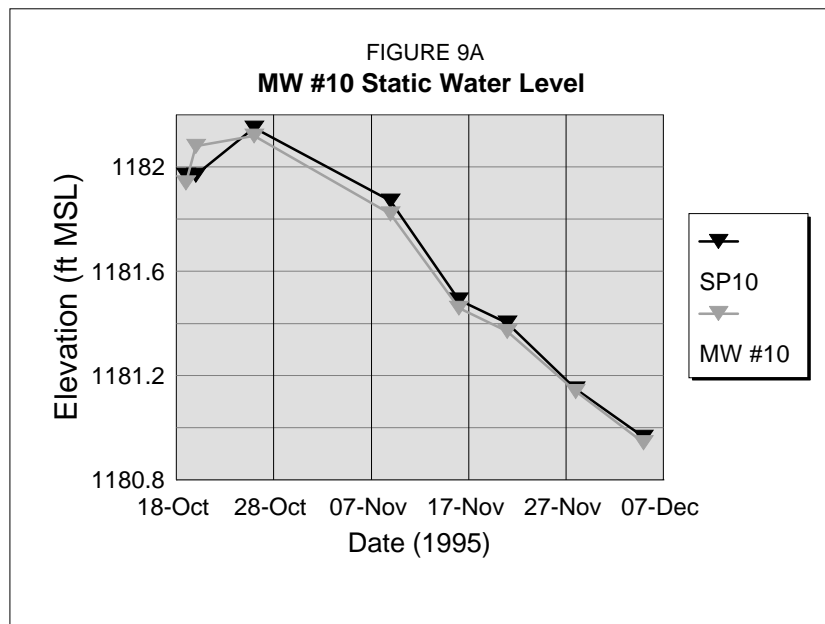
- EC logs and geologic logs from these two locations indicate the 24- to 28-foot interval is most likely to yield water of the interval screened by the PVC wells.
- MIP logs for VOCs and soil core analysis show the formation is contaminated below 25 feet, and this zone is the source of hydrocarbons in MW5 and MW10.
- Test installation of SP sampler at 24- to 28-feet bgs yields water and contaminants.
- Test installation of SP sampler above 24 feet yields no water.
- Test installation of SP sampler at 34- to 38-feet below clay lens yields copious water but not contaminated.
- 24- to 28-foot interval corresponds to lower portion of the 15-foot PVC well screen.

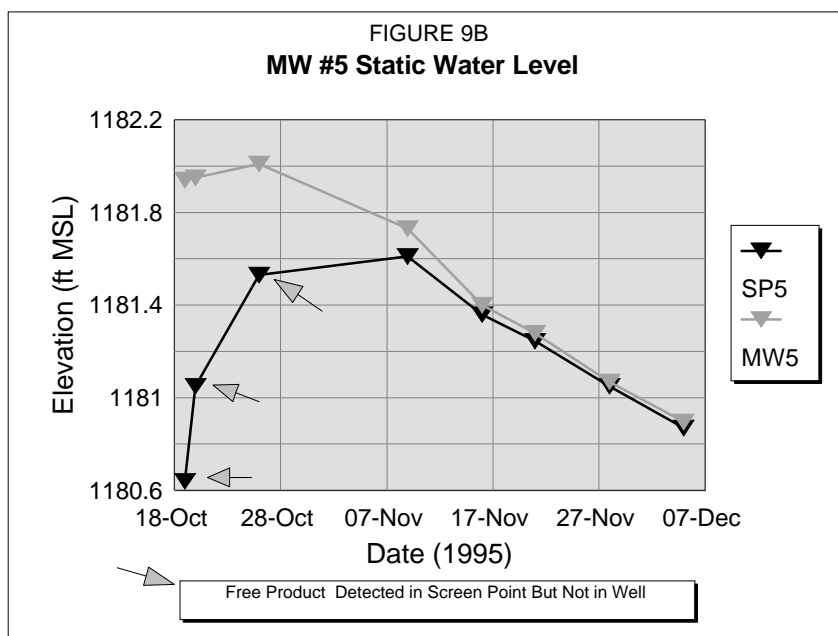
At Site #1, the SP sampler screens were set from 24 to 28 feet bgs corresponding with the lower portion of the PVC well screens.

SITE #1 RESULTS

Static Water Level and LNAPLs

The static water levels (SWL) measured from MW10 and the adjacent SP sampler (SP10) are shown in Figure 9a. LNAPL was reported in MW10 after its initial installation (GSI 1995). The product was bailed out at that time and did not return. Measurable free product was not observed in MW10 or SP10 during the course of this project. A spotty product sheen was observed on the purge water from both of these wells during each sampling event. After measuring the SWL in SP10, it was developed by purging ten gallons using the tubing check valve system. As Figure 9a shows, the SWL the following day was slightly lower in SP10 than in MW10. This is probably an effect of the slow recharge rate in the fine-grained formation at Site #1 following the development purging. After the October 19th measurement, the difference in the SWL for SP10 and MW10 averages less than 0.03 foot.





No LNAPLs had been reported after the initial installation of MW5 (GSI 1995) and only a spotty sheen was observed on the purge water from this well during this project. The SWL at SP5 at Site #1 showed a large difference in the measured SWL elevations on the first three days of measurement when compared to MW5 (Figure 9b). On the first day that SP5 was installed (October 19), measurements for LNAPLs were not conducted. On the following days, LNAPLs were measured using the tubing check valve method as described above. On October 20th, 11.25 inches of LNAPL were measured in SP5 with the tubing check valve but only a sheen was observed on the water in MW5. Again on October 26th, 2.25 inches of LNAPL were measured in SP5, but only a sheen was observed on the water in MW5. Use of the tubing check valve system exaggerates the thickness of any LNAPL measured in the probe rods due to displacement by the tubing. Though this method cannot be used to determine exact thickness measurements of LNAPL to allow for correction of the water level, it clearly demonstrates why the difference in SWL was observed in SP5 and MW5 on the dates in question. The SWL measurements for SP5 and MW5 for the remaining measurements are all very close (Figure 9b).

BTEX and GRO at Site #1

The results for the GRO, BTEX, and benzene analyses from the two monitoring wells and SP samplers at Site #1 are plotted relative to each other in Figures 10A, 10B, and 10C respectively. The one-to-one line is also shown on these figures. Points above this one-to-one line indicates that the SP sampler produced samples with higher concentrations than the paired monitoring well. Conversely, points below the one-to-one line indicates that the SP sampler produced samples with lower concentrations than observed in the paired monitoring well. In general, for each of the parameters plotted in Figures 10A, 10B, and 10C, the SP5 generally produced samples with higher concentrations than the paired monitoring well, MW5. Conversely, SP10 generally produced samples with lower concentrations than the paired MW10 monitoring well.

FIGURE 10A
GRO: Site 1

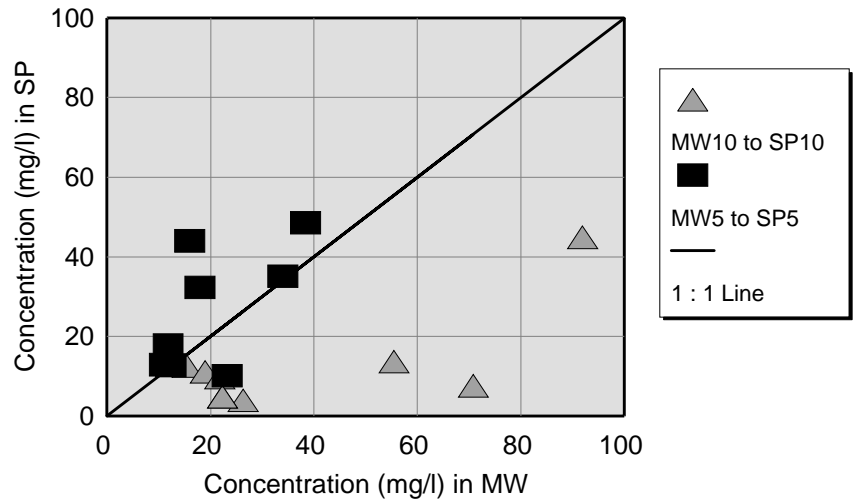
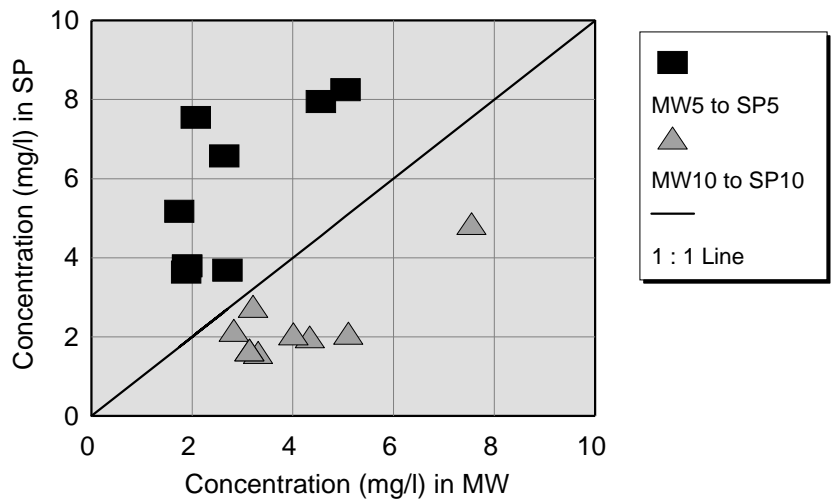
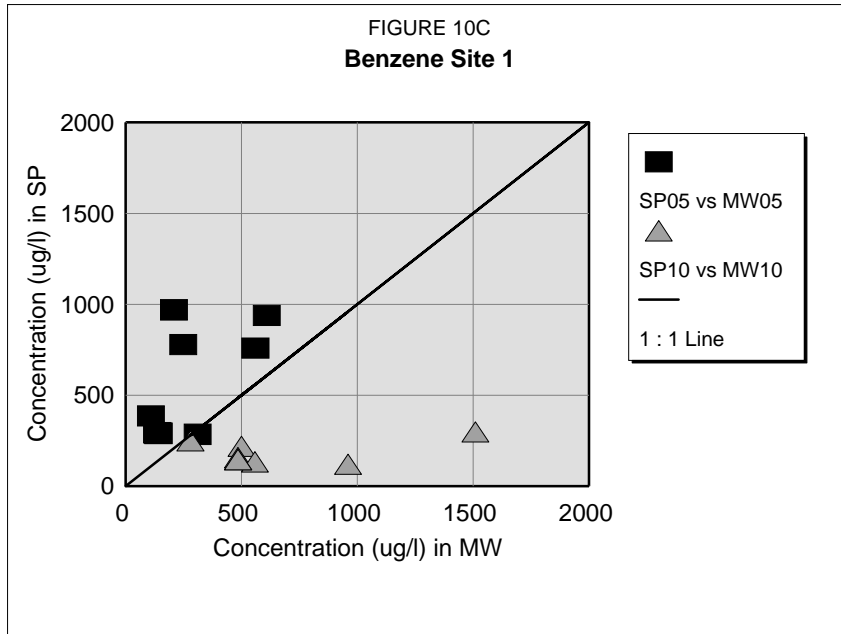
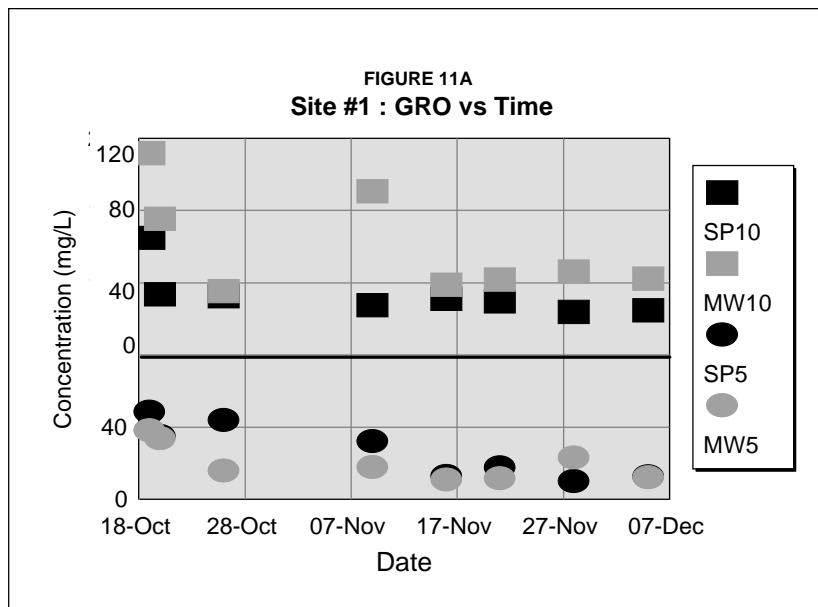


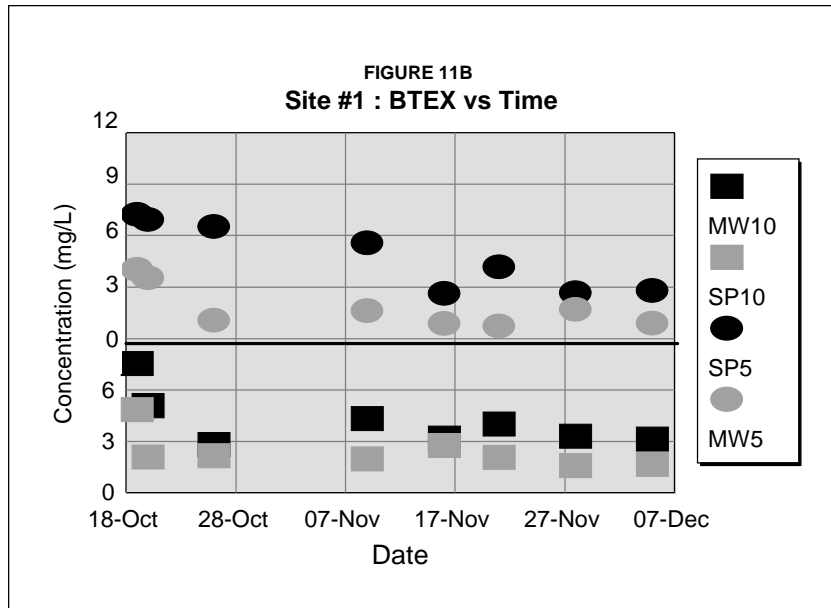
FIGURE 10B
BTEX: Site 1





The GRO results and BTEX results for the paired samplers are plotted against time on Figures 11A and 11B, respectively. Both data sets for the paired SP5 and MW5 and paired SP10 and MW10 show a decreasing trend over time in these figures. The results for the paired samplers also converge toward similar concentrations over time. At the MW10 location, the PVC well is higher in concentration for both BTEX and GRO than the paired SP sampler. While at the MW5 location, the SP sampler is higher for BTEX and GRO than the paired PVC monitoring well.





As noted above, LNAPLs were detected in MW10 after it was initially installed, but no LNAPLs were detected in SP10 emplaced adjacent to MW10. Similarly, LNAPLs were measured in SP5 after it was initially emplaced but LNAPLs were never detected in MW5. As the graphs show (Figure 10, 11), in each case the sampling device, SP5 and MW10, which yielded LNAPLs after installation, was the device that gave higher results each time the paired devices were sampled for analysis. This is consistent with what would intuitively be expected from this situation and suggests that the differences observed between the paired SP sampler and PVC well are due primarily to heterogeneity of the distribution of contaminants in the fine grained formation.

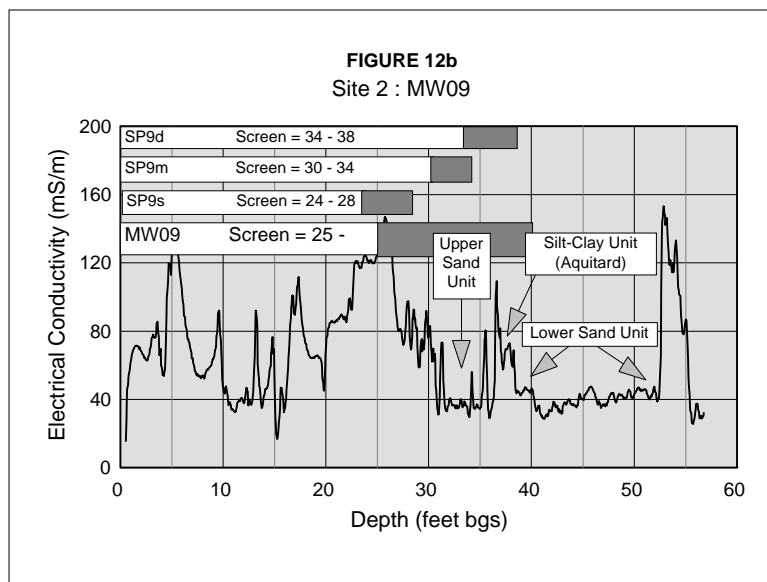
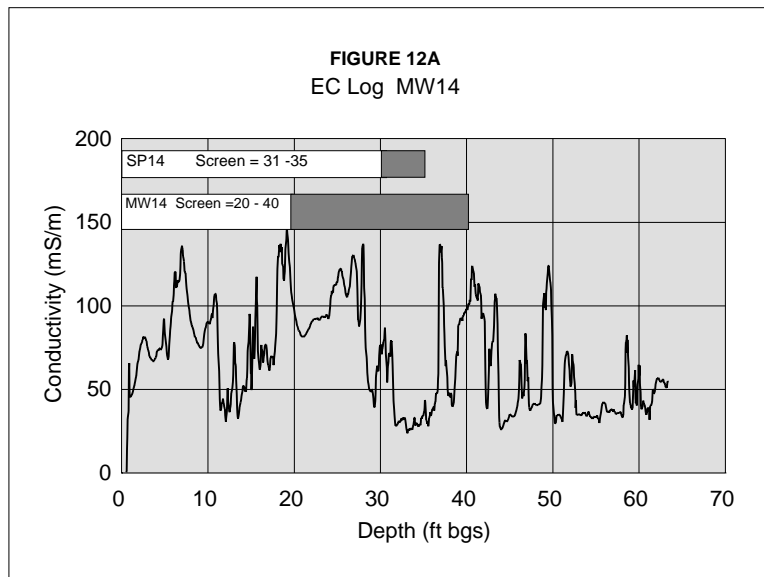
B. SITE #2

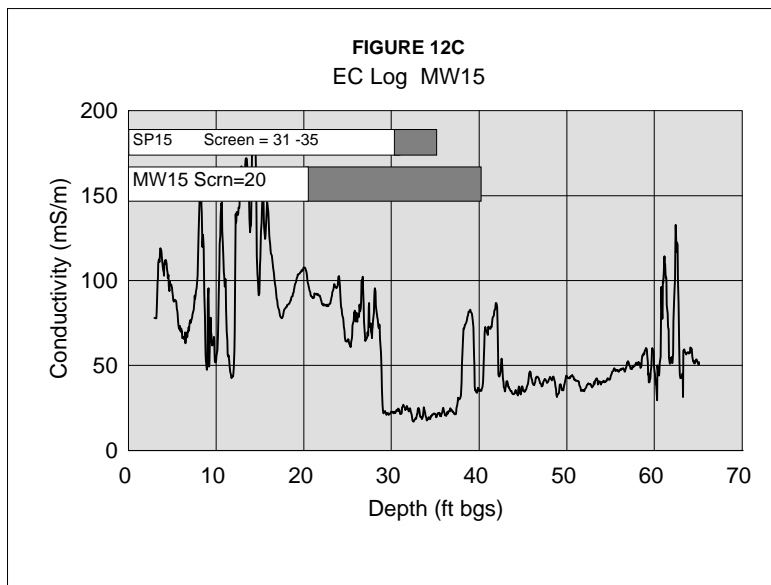
BACKGROUND AND GEOLOGY

Investigation at Site #2 (Figure 4) was initiated after three USTs were removed from a municipal fire station in a small town in central Kansas in 1991. During the initial and follow-up investigations at this site, 15 soil borings and associated monitoring wells were installed (GSI 1993). During the course of these investigations, it was discovered that several chlorinated volatile organic compounds (X-VOC) were present in the groundwater as well as the BTEX and GRO contaminants.

Site #2 is located on Pleistocene alluvial deposits of the Smoky Hill River in central Kansas. The alluvium overlies the shales of the Permian age Wellington formation and may also overlies some remnants of the Cretaceous Age Kiowa shale (Latta 1949). The thickness of the alluvial deposits are about 60- to 70-feet thick in the Site #2 vicinity. Fine-grained silty to sandy clays grade downward into coarse sands and gravels. These alluvial deposits are the primary source of water for towns and cities along the Smoky Hill River. As discussed for Site #1, the Wellington formation is comprised primarily of gray and greenish shales with some maroon and purple beds, and serves as a dependable aquitard throughout the area. The Kiowa shale is comprised of gray to black shales and thick lenticular beds of dark brown, iron-rich sand (Latta 1949).

Electrical conductivity logs (Figures 12a, b, c) were obtained adjacent to the three wells studied at Site #2. Figure 4 shows that these wells lie roughly along a northwest to southeast line from MW14 to MW9 to MW15. The EC logs show that silty to sandy clays with sand rich zones dominate to a depth of about 30 feet in all three logs. At a depth of about 30 feet in all three logs an upper sand layer is present. This sand layer is well defined on the log from the MW15 location (Figure 12c) and extends from a depth of about 29 to 38 feet bgs. At a depth of approximately 40 feet, all three EC logs indicate the presence of a silt-clay layer as evidenced by the increase in electrical conductivity. This layer shows a distinct bifurcation at MW15 (Figure 12c) which is roughly approximated in the other two EC logs. Below this silt-clay layer, the logs from MW9 and MW15 (Figures 11b,c) reveal the presence of a lower sand and gravel layer. The northwestern-most log from MW14 (Figure 11a) shows that several silt-clay lenses are present in the lower sand layer at this location. At all three locations, the EC probe was driven to refusal at the bedrock contact.





Driller's lithologic logs were completed during the well installations (GSI 1993, 1995). The driller's logs were based on 24-inch-long split spoon samples collected at the top of each five-foot interval with the 25- to 27-foot interval being the last interval sampled. These logs generally correlate with the EC logs to that depth, but none of the driller's logs show the presence of the silt-clay layer defined by the EC logs at about 40-foot depth.

SCREEN INTERVALS SELECTED FOR THE SCREEN POINT 15 GROUNDWATER SAMPLERS AT SITE #2

The depths of the PVC monitoring wells at Site #2 (MW9, MW14, and MW15) and their screened intervals are shown on Figures 11a, b, and c. The SP screens at MW14 and MW15 and the mid-level screen at MW9 (SP9-m) were installed to intersect the top portion of the upper sand layer. The SP screens were placed in this interval for the following reasons:

- The sand layer defined by the EC logs at this depth (Figures 12a,b,c) provides good groundwater flow for recharge to the samplers.
- This sand layer may be the primary zone for transport of contaminants at this area.
- This sand layer provides the majority of groundwater flow to the PVC wells.
- This depth interval corresponds to a segment near the center of the PVC well screen interval.

At MW9, SP screens were set at three different depths to look for possible stratification of contaminants within the aquifer. Figure 11b and Table 1 summarize the depths and screen intervals for these SP samplers. These three intervals were selected based on the following:

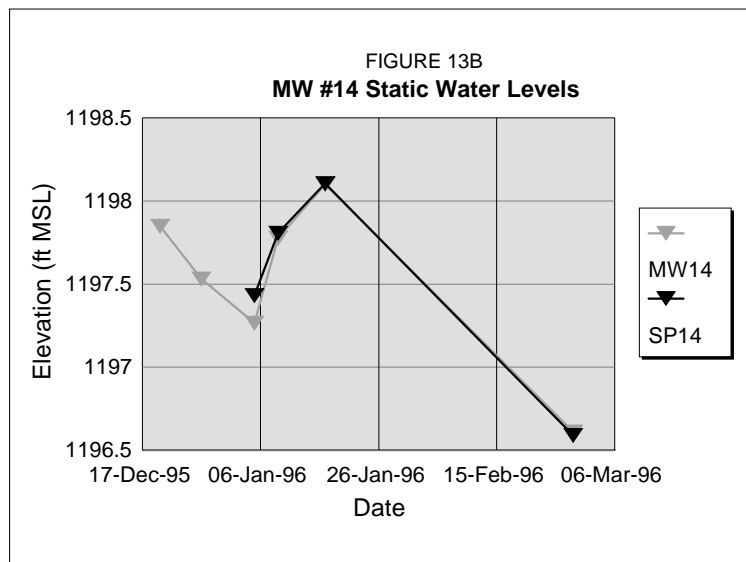
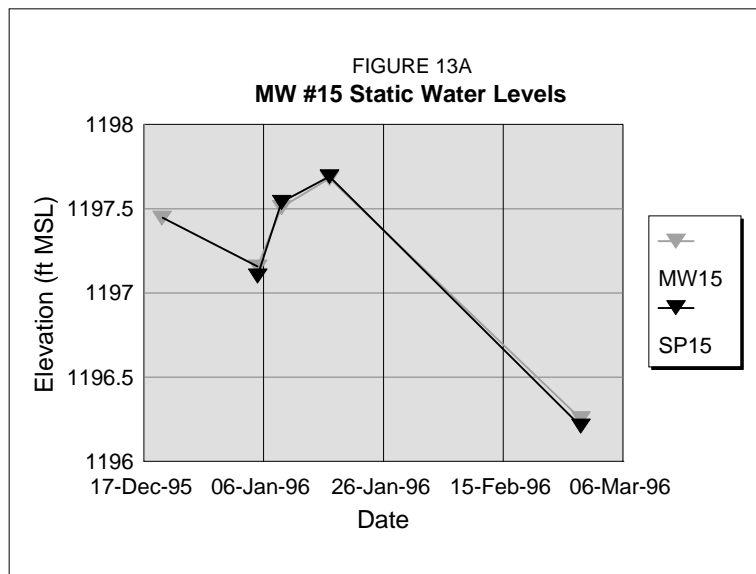
- The shallow level at 24- to 28-feet bgs (SP9-s) is across the SWL (~25ft). This screen will help to determine if the LNAPL components (BTEX and GRO) are concentrated in that interval.
- The mid-level screen at 30- to 34-feet bgs (SP9-m) corresponds with the screen intervals selected for SP14 and SP15.

- The deep level at 34- to 38-foot bgs (SP9-d) will assist in determining if X-VOCs (DNAPLs) are possibly concentrated in that interval.

SITE #2 RESULTS

Static Water Levels at MW14 and MW15

The SWL measurements made at MW15 and MW14 and the respective SP groundwater samplers, SP15 and SP14, are shown in Figures 13a and 13b. These figures show that initial water level measurements were made at the existing PVC wells about two weeks prior to the installation of the SP samplers. Figures 13a and 13b show that the SWLs measured in the PVC wells and SP samplers during this time period are essentially identical. These figures also show that the response of the PVC wells and SP samplers to the changing water levels are essentially identical. Measurement several weeks later (February 28th) showed that the SWL had dropped noticeably again (Figures 13a, 13b) and both the PVC wells and SP samplers again responded identically.



Static Water Levels at MW9

Figure 13c shows the SWLs measured at MW9 where three SP samplers were installed at different depths. Figure 12a shows the screen intervals for MW9 and the three adjacent SP samplers. All three of the SP samplers show a similar response to the changing water level in the aquifer. But these three samplers show a noticeably different water level than that observed in the adjacent PVC well, MW9.

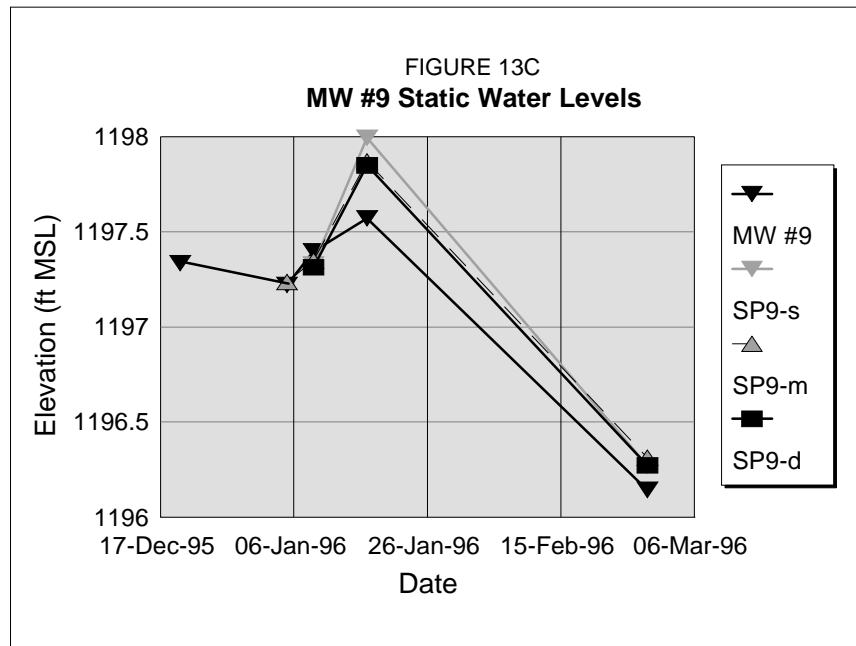
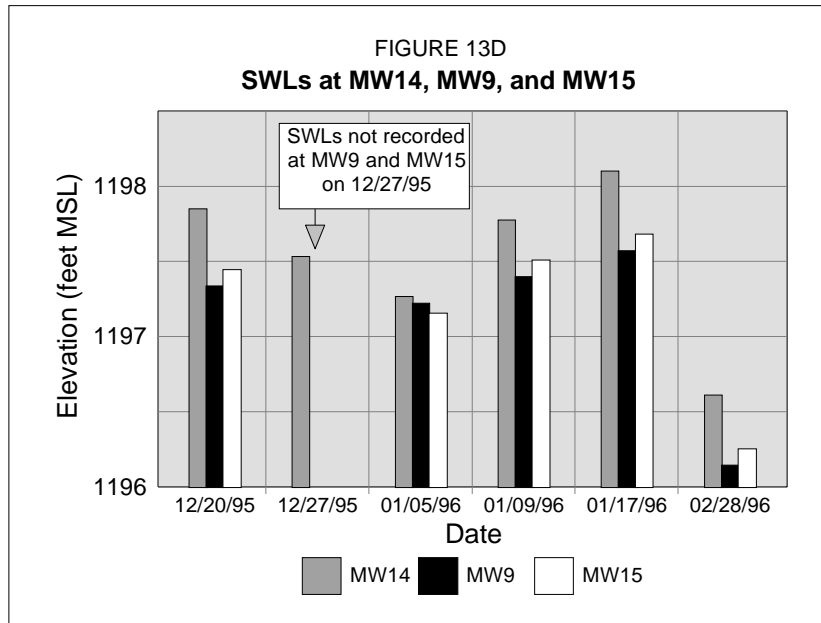


Figure 4 shows that MW9 is located between MW14 and MW15. Evaluation of the local geohydrology for Site #2 (above) showed that the groundwater flow should be to the east-southeast in this alluvial aquifer, and actively pumping municipal wells would increase the gradient in this direction. These conditions indicate that the water level elevation measured at MW9 should be lower than at MW14 and higher than at MW15 at any given time. Figure 13d shows that for the available data, the SWL for MW9 was between those observed at MW14 and MW15 only once. This occurred on January 5th when there was a large decrease in the pumping rate for the municipal wells. On all of the remaining dates when measurements were completed, the SWL elevation at MW9 was lower than the SWL elevations observed at both MW14 and MW15.

The anomalously low SWLs at MW9 as compared to MW14 and MW15 (Figure 13d), together with the difference in the SWL elevations between MW9 and all three adjacent SP samplers (Figure 13c), suggested that there was some influence on the hydraulic head at MW9. Figure 12b shows that MW9 completely penetrates a two-foot thick silt-clay layer present at a depth of 36 to 38 feet at this location. None of the SP samplers at MW9 completely penetrates this clay layer (SP9-d partially penetrates this layer). And as Figures 12a and 12c show, neither MW14 or MW15, nor SP14 or SP15 fully penetrates the same silt-clay layer which is present at a depth of about 40 feet at these two locations.



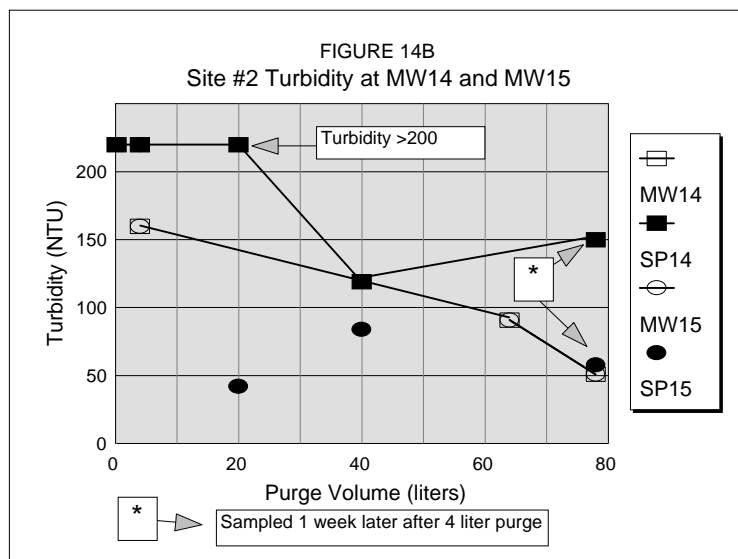
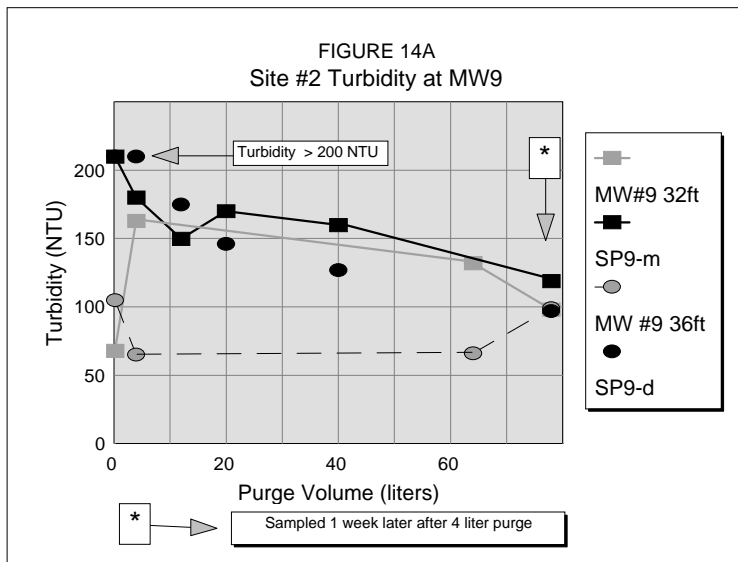
Based on this geologic information and hydrologic information discussed above, it appears that the silt-clay layer present at about 40 foot depth forms an areally extensive aquitard, and that the hydraulic head below this layer is measurably lower than the hydraulic head above this layer. This indicates that contaminated groundwater above this aquitard is actively flowing through MW9 into the lower sand layer (lower aquifer) at this location.

This situation also explains why the potentiometric surface mapped at Site #2 (Figure 4) is so convoluted and not a simple unidirectional gradient as expected for an unconfined alluvial aquifer. Some of the wells used to measure the SWLs apparently penetrate this aquitard while others do not. Because of this, the wells are measuring either the hydraulic head in the unconfined zone above the clay layer or a combination of the hydraulic head from the zones both above and below the aquitard.

Turbidity Measurements at Site #2

Results for sample turbidity measured in nephelometric turbidity units (NTU) at Site #2 are summarized in Figures 14a and 14b. Figure 14a shows the results for samples collected from MW9 at depths of 32-feet and 36-feet bgs. These depths correlate with the centers of screen intervals for the SP9-m and SP9-d samplers (Table 1). The depth discrete samples for turbidity were collected using the tubing check valve system described earlier (Figure 5). The purge volume scheme used for each SP groundwater sampler and PVC well is summarized in Table 3.

The SP samplers were developed only by purging with the tubing check valve system. Recharge for the SP9-s sampler was very slow because of the fine-grained formation present across its screened interval of 24- to 28-feet bgs (see Figure 12b). Due to the very slow recharge from this portion of the formation, it was not possible to purge large volumes from SP9-s to collect samples for turbidity measurements at increasing purge volumes.



At all of the locations, the groundwater samples from the SP samplers were very turbid (>200 NTU) at the minimal purge volume of 200 milliliters. Both the SP9-m and SP9-d samplers show a decreasing trend in turbidity as the purge volume increases (Figure 14a). The decreasing trend in turbidity for both SP9-m and SP9-d continued when they were sampled about a week after initial purging. The turbidity values measured in samples from MW09 at 32-foot depth are similar to those in SP9-m. The turbidity measured in samples from MW09 at 36 feet are somewhat lower than that observed in SP9-d.

Both MW14 and MW15 show a consistent trend in turbidity (Figure 14b). Both of these wells were sampled at about the same level in the upper sand layer of the formation at Site #2 (Figures 12a,c). SP14 produced higher turbidity samples than MW14. The formation at MW14 contains more clay lenses than at other Site #2 locations (Figure 12a), and this may contribute some to the turbidity of the samples from SP14. Additional development

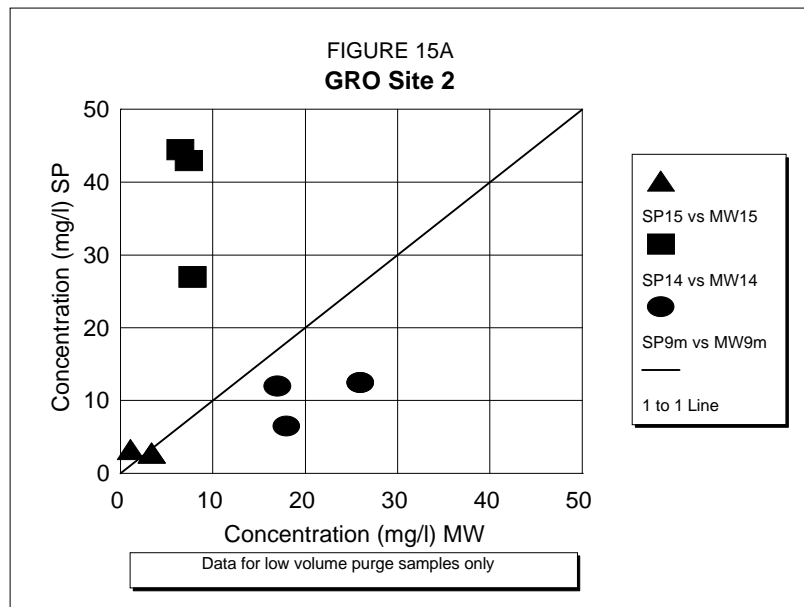
would be needed at SP14 to achieve lower turbidity. The turbidity measured at SP15 (Figure 14b) after 20 liters were purged from the sampler is below or very near the turbidity observed at MW15

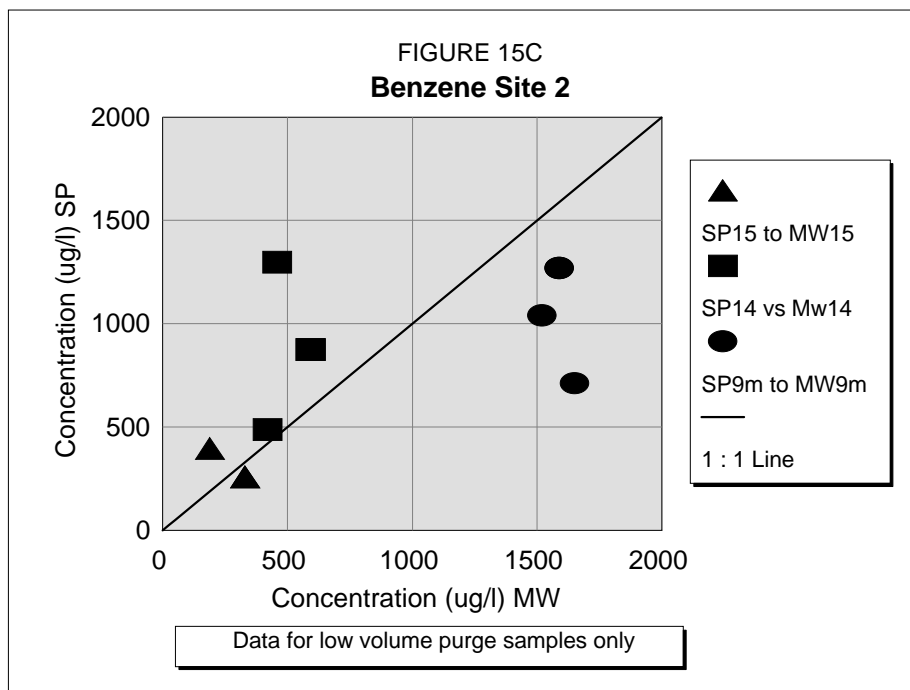
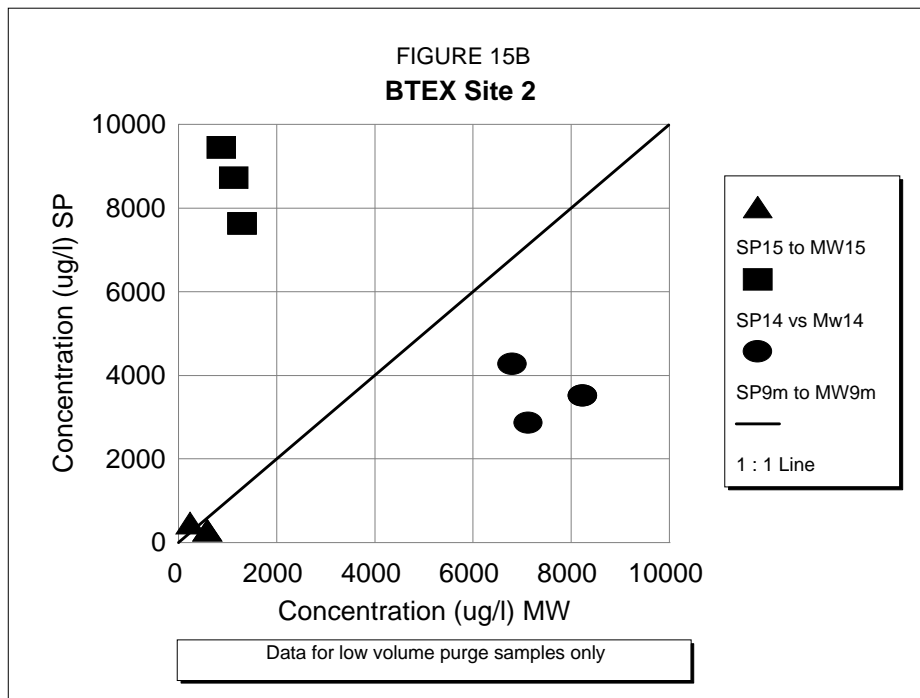
Overall, this information suggests that turbidity of groundwater samples collected from SP samplers can approach similar turbidity as that obtained from many PVC wells if proper development of the sampler is conducted. The screen slot on the stainless steel SP sampler screens of 0.004 inches minimizes the movement of fine sands and silts into the sampler. This allows for natural formation development to occur during the purging process in many unconsolidated formations. Natural formation development is an accepted alternative to installing a filter pack when specific formation conditions are met (EPA 1991, 1992). Surging with a simple surge block may further improve the sample turbidity when required.

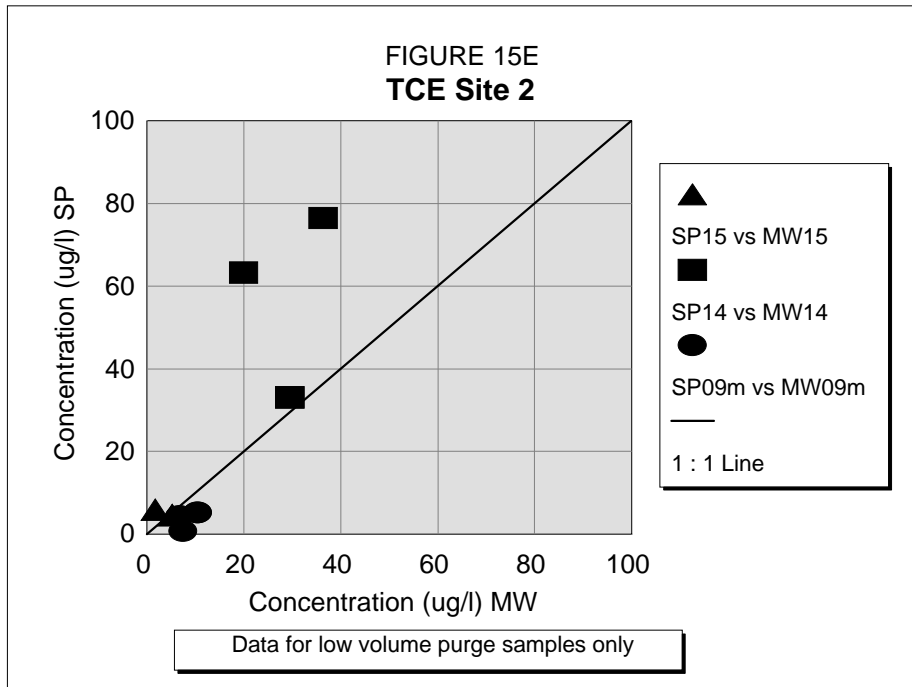
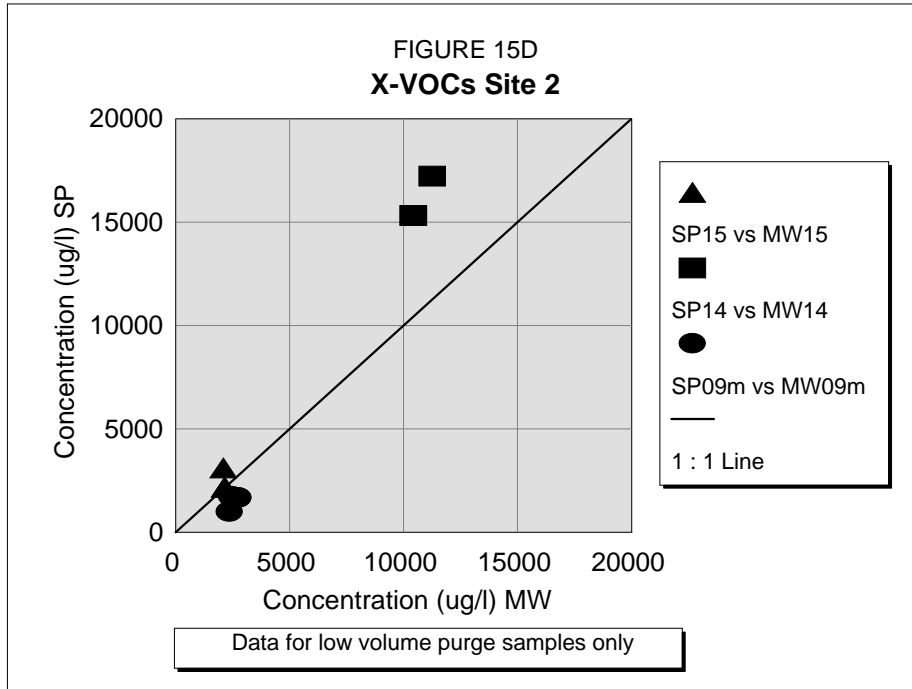
BTEX, GRO, and X-VOCs at Site #2

Organic analysis results for the low volume purge samples (200 milliliters to 4 liters) at Site #2 from the paired SP samplers and monitoring wells are plotted against each other in Figures 15a through 15e. All purging and sampling for these low volume purge samples was conducted with the tubing check valve system. Figures 15a (GRO), 15b (BTEX), and 15c (benzene) all show very similar distribution of the data points relative to the one-to-one line. All of the results for SP14 vs MW14 are above the one-to-one line. The results for SP9-m vs MW9-m are below the one-to-one line. Results for SP15 vs MW15 all lie close to the one-to-one line. Results for the total X-VOCs and TCE at Site #2 (Figures 15d, 15e) show a very similar trend for these parameters. The consistent grouping of the data for each paired SP sampler and monitoring well on the one-to-one plots indicates that location specific conditions control the results measured for the paired devices. These location-specific conditions may include:

- where the 40-inch long SP screen is placed in the formation relative to the 15- to 20-foot length PVC monitoring well screen
- local heterogeneities within the formation itself
- local heterogeneities of contaminant distribution within the formation
- localized flow within the aquifer or between zones in the formation

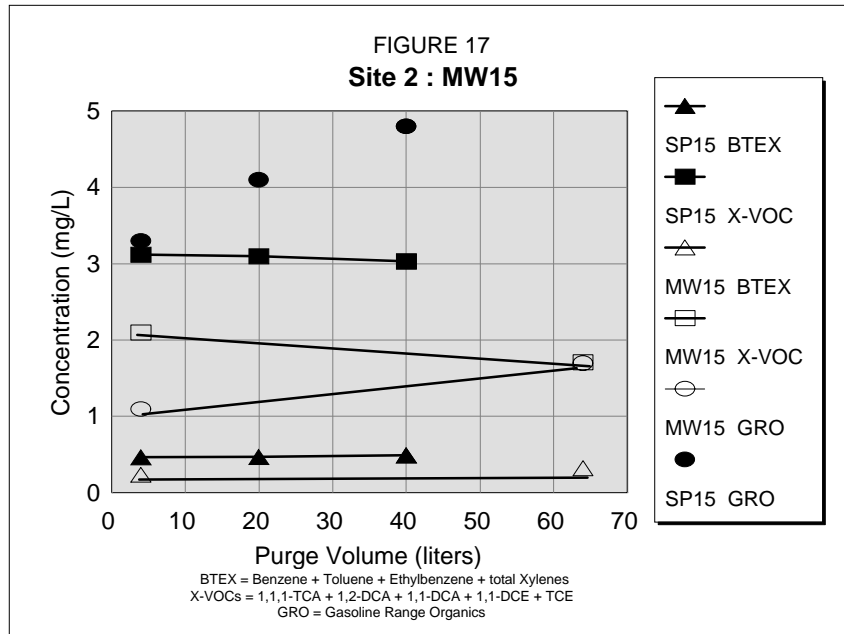
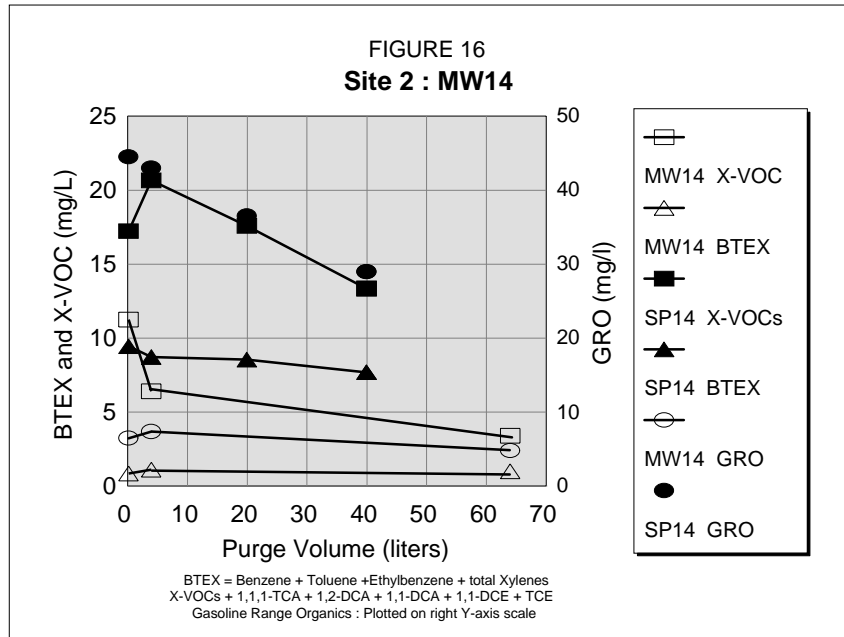






MW14 and MW15

Analytical results for the organic parameters vs purge volume for the MW14 and MW15 locations at Site #2 are given in Figures 16 and 17, respectively. These figures show that samples from the SP devices generally have slightly higher concentrations for these analytes when compared to the paired PVC monitoring well but the concentrations are within the same order of magnitude. They also show that these parameters, BTEX, GRO, or X-VOCs, show a similar trend in the PVC well and adjacent SP sampler. So that if the parameter shows a decreasing, increasing, or approximately stable concentration in the PVC well as the purge volume increases, then the adjacent SP sampler shows about the same trend, but at slightly higher concentrations.

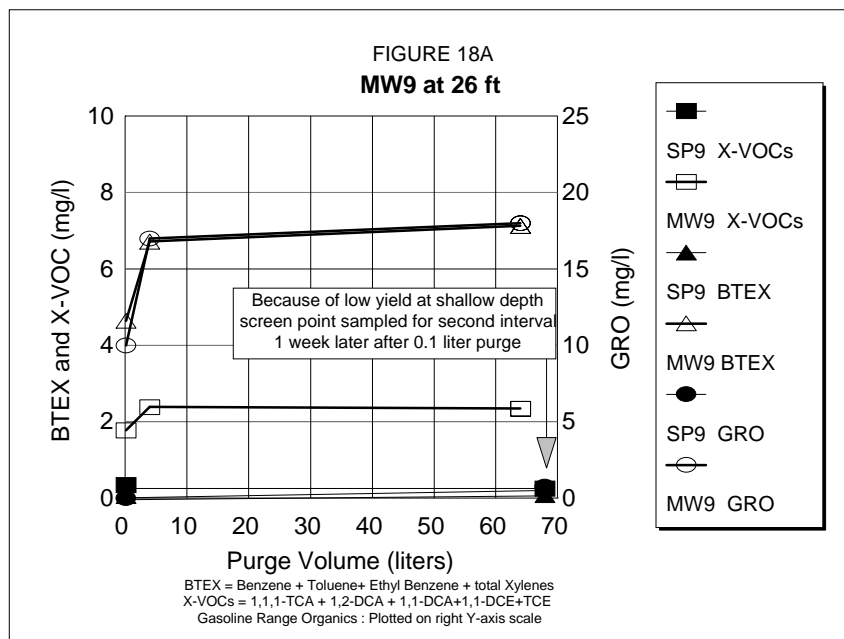


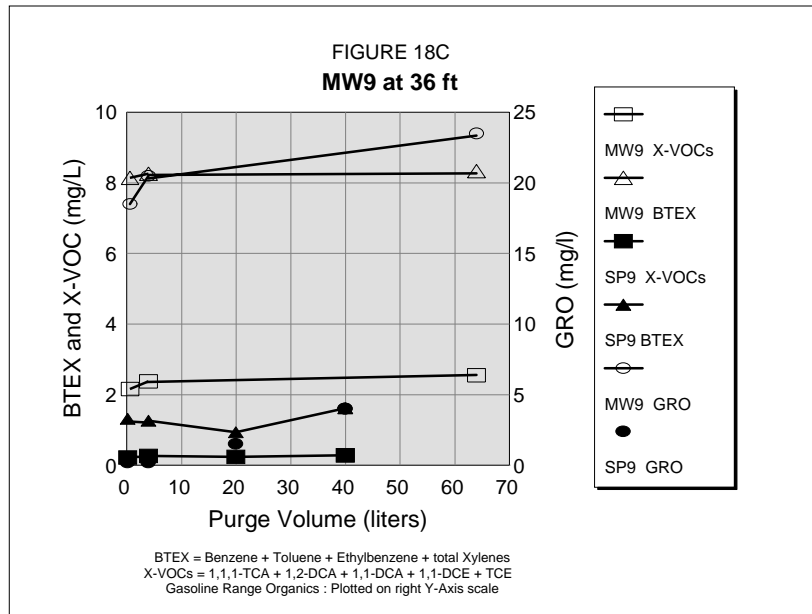
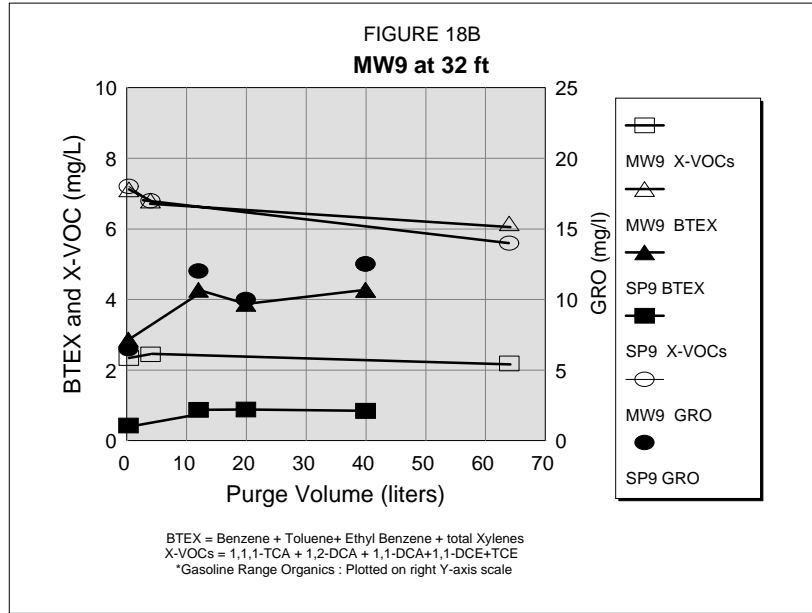
The SP groundwater samplers at MW14 and MW15 were installed in the upper portion of the upper sand layer at both locations (Figures 12a, 12c). The analytical results shown in Figures 16 and 17 suggest that this zone of the aquifer is the most contaminated and may also be the primary zone of contaminant transport. Bias in the concentration of analytes measured in groundwater samples collected from long screen wells as compared to short screen wells, similar to that observed here, has been investigated before. This type of sample bias, caused by mixing, has been attributed to well-bore flow in the long screen wells (Church and Granato 1996, Gibs et al. 1993, Reilly et al. 1989). The 20 foot length screens on MW14 and MW15 will allow uncontaminated groundwater (or groundwater with lower contaminant concentrations) from other zones in the aquifer to mix with water from the upper zone of the upper sand unit (Figure 12a, 12c). This mixing process would result in the lower contaminant concentrations observed in the samples from the PVC wells as compared to samples from the adjacent SP groundwater samplers since the SP samplers are screened in the most contaminated portion of the aquifer.

MW9

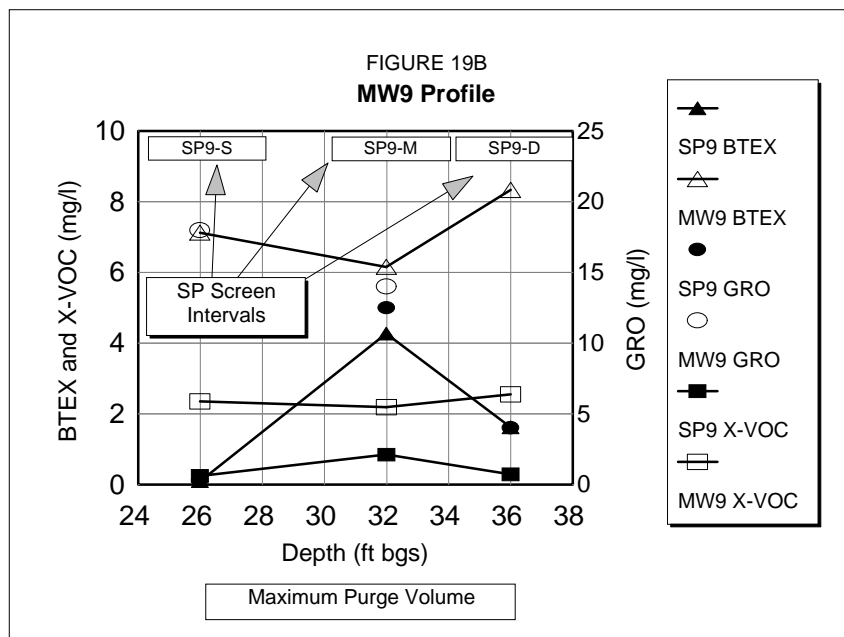
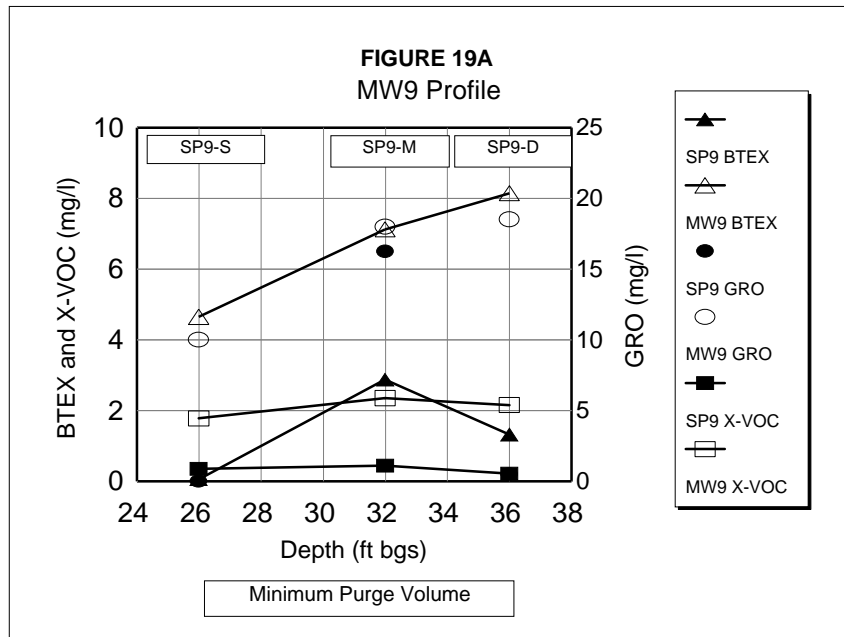
The depths and screen intervals of MW9 and the three SP samplers (SP9-s, SP9-m, SP9-d) at the MW9 location are shown on Figure 12b and listed in Table 1. Figures 18a, 18b, and 18c give the plots of the sample analyses from MW9 and the three adjacent SP samplers versus purge volume. These plots show that all three SP samplers installed at MW9 yielded samples with lower analyte concentrations than the corresponding depth interval sampled in MW9. This is the opposite condition as that observed at MW14 and MW15 where the SP samplers yielded sample concentrations consistently above those in the adjacent PVC well.

Figure 18a shows that there is a large increase in the analyte concentrations in MW9 at the 26-foot level as the purge volume increases. Figure 18b reveals that the analyte concentrations in MW9 at the 32-foot level decrease as the purge volume increases. Conversely, the analyte concentrations in SP9-m show an increasing trend as the purge volume increases. At the 36-foot level, both the SP sampler (SP9-d) and MW9 show an increase in analyte concentrations with increasing purge volume.





Figures 19a (minimum purge volume) and 19b (maximum purge volume) provide profile plots of the analytical results versus depth from MW9 and the three adjacent SP9 samplers. The results of the SP samplers in both of these plots clearly show that the highest level of contaminants occur at the 32-foot level (SP9-m) within the formation being sampled. This is consistent with the observations at MW14 and MW15 where the SP samplers screened at this interval produced samples with higher analyte concentrations than the long screened wells.



The BTEX compounds and GRO show different responses to increasing purge volume at each depth sampled in MW9 (Figures 18a, 18b, 18c, 19a, 19b). The BTEX and GRO concentrations are highest at the 36-foot depth in MW9, and the concentrations increase slightly as the purge volume increases. Most notably, at the 32-foot depth, the BTEX concentrations show a decrease as the purge volume increases while at the 26-foot depth the BTEX concentrations show a distinct increase as the purge volume increases. The observed changes in analyte concentrations in samples from MW9 and the fact that the SP samplers yield consistently lower concentrations may be explained as the result of at least two influences on the PVC well. These influences are:

- 1) The hydraulic effect caused by the PVC well screen completely penetrating the silt-clay layer/aquitard (Figure 12b) beneath the upper sand unit
- 2) Mixing of groundwater in the long screen well bore as purging progresses.

Hydraulic Effect

The hydraulic head in the lower sand unit is lower than in the upper sand unit. This is evident from the anomalously low SWLs measured in MW9 (Figures 13c, 13d) and discussed above. The flow of water from the upper sand unit through the well bore into the lower sand unit caused by the difference in hydraulic head will continually replenish the contaminated water in the MW9 monitoring well. This flow would tend to keep the chemical oxygen demand (COD) elevated within the well and minimize the effect of any biodegradation that would normally occur within the well bore and immediately surrounding formation. This hydraulic effect causing the flow of contaminated water through the monitoring well could explain why the analyte concentrations are consistently higher in the MW9 well samples from all three levels as compared to the adjacent SP groundwater samplers. Additional investigation would be required to fully substantiate this model.

Increasing Purge Volume and Mixing Inside MW9

The BTEX compounds and GRO show different responses to increasing purge volume at each depth sampled in MW9 (Figures 18a, 18b, 18c, 19a, 19b) as discussed above. Comparing Figures 19a and 19b clearly shows that as the purge volume increases in MW9 the analyte concentrations increase at the 26-foot level and decrease at the 32-foot level. This indicates that as the purge volume increases, the water from lower portions of the formation and well bore mixes with that in the upper portion of the well bore causing the increase in BTEX concentrations observed at the 26-foot level and the decrease observed at the 32-foot level.

A more detailed study and additional sampling would be required to quantitatively confirm the model of well bore mixing and hydraulic effects on analyte concentrations discussed for MW9. But, the available analytical and geohydrologic information supports this model for effects causing the differences observed between samples from the PVC well and the SP samplers at the MW9 location. This model is also consistent with previous work studying the effects of mixing on water quality samples from wells with long screen intervals (Church and Granato 1996, Gibs et al. 1993, Reilly et al. 1989).

IV. SUMMARY AND CONCLUSIONS

Selection of the appropriate screen interval is probably the single largest influence on obtaining a valid water quality sample, whether the investigator is using Geoprobe's Screen Point 15 groundwater sampler or installing traditional monitoring wells. Use of the electrical conductivity logging system with targeted soil core sampling is an important part of the site evaluation to define the geohydrology of the subsurface prior to the installation of any groundwater monitoring device. Also, test installations of the Screen Point 15 groundwater sampler to define the static water level and formation zones capable of yielding water is very useful. Field screening (using a hand held PID or field GC) of soil core samples and/or groundwater samples from test Screen Point 15 installations will also aid in selecting the appropriate screen interval(s) at the area under investigation.

This study has shown that when properly installed, the Screen Point 15 groundwater sampler can provide accurate water level measurements, equivalent to those obtained from traditionally installed two-inch diameter PVC monitoring wells. Results of the water level measurements at Site #2 also indicated that the Screen Point 15 can be used to measure changing water levels in a dynamic system. Appropriate installation of this groundwater sampler can also be used to determine if different zones within a formation have differing hydraulic head pressures.

Turbidity measurements were made on samples from four Screen Point 15 samplers during the purging/development process at Site #2. The results show that after sufficient purging, the Screen Point 15 devices can provide samples of comparable turbidity encountered in many monitoring wells installed during UST investigations. The 0.004-inch slots on the stainless steel, wire-wound screens of the Screen Point 15 sampler and the use of a simple surge block to further enhance natural formation development, may allow for even lower turbidity samples to be collected from some formations.

Analysis of samples from Site #1 for BTEX (benzene, toluene, ethylbenzene, total xylenes) and GRO (gasoline range organics) shows that paired Screen Point 15 samplers and conventional monitoring wells yield groundwater samples with similar analyte concentrations. Evaluation of the results from Site #1 revealed that whichever paired monitoring device (Screen Point 15 or PVC monitoring well) initially yielded free product consistently had higher concentrations of the analytes for the duration of the project. The data plots also showed that the analyte concentrations converged to very similar values during the course of the project. Heterogeneity of contaminant distribution in the fine-grained formation at Site #1, where the free product is probably present as isolated blebs and stringers, most likely led to the random occurrence of free product in the monitoring devices at that site.

Analytical results for the Screen Point 15 samplers installed adjacent to MW14 and MW15 at Site #2 are very similar to the paired monitoring wells. These two Screen Point samplers showed slightly higher analyte concentrations for BTEX, GRO, and the selected chlorinated volatile organics (X-VOCs) tested for at this site. Evaluation of the geohydrology at Site #2 indicated this was because the Screen Point 15 samplers' shorter 40-inch screens were set in the most contaminated zone of the formation. While the much longer 20-foot screens of the existing PVC monitoring wells were screened across portions of the formation with lower contaminant concentrations. This led to dilution of the contaminants in these long screened wells with water from relatively 'clean zones' in the formation and the resulting lower analyte concentrations in the PVC monitoring wells. Unfortunately, the use of long screen monitoring wells can lead to the spread of contaminants to portions of a formation previously not contaminated.

The conditions encountered at MW9 at Site #2 proved to be very interesting. Plotting the well screen against the electrical conductivity log revealed that this monitoring well penetrated a clay layer about two-feet thick. This clay layer (or aquitard) separated an upper sand layer (upper aquifer) from a lower sand layer (lower aquifer). Evaluation of the static water levels from MW9, the three adjacent Screen Point samplers, and MW14 and MW15 at Site #2 revealed that the hydraulic head in the lower aquifer was about 0.4-feet below that in the upper aquifer. Because of this condition, contaminated water from the upper aquifer was continually flowing through MW9 which is behaving as a conduit through the aquitard into the lower aquifer. This condition resulted in MW9 having similar, but slightly higher, contaminant concentrations at all three levels which were screened by the three adjacent Screen Point 15 samplers.

Use of the Screen Point 15 groundwater sampler to conduct initial groundwater investigations during response activities, site assessments, or remedial investigations is a valid and cost-effective process. These groundwater evaluations can determine if further groundwater investigation or remediation is necessary. If further investigation is necessary, results from the Screen Point 15 samples can be used to assist in determining appropriate locations and screen intervals for permanent monitoring devices.

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Biographical Sketch

Wesley McCall, Environmental Geologist

Mr. McCall earned his B.S. in Geology from Clemson University in 1982 and his M.S. in Geology from the University of Missouri-Columbia in 1987. Shortly after completing his M.S., he began work as an environmental consultant on federal, state, and private contracts. Mr. McCall joined Geoprobe® Systems in May of 1995 where he is involved with applications research and technical support.

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