Addendum #8 to
Field Sample Plan for Part 2 of the Supplemental Groundwater Remedial Investigation
Former York Naval Ordnance Plant
1425 Eden Road, Springettsbury Township
York, Pennsylvania

Prepared for Harley-Davidson Motor Company Operations, Inc.
March 15, 2013

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Vertical Extent in Suspected Source/DNAPL Areas – Round 2

Subsection 4.2.1.2 of the Field Sampling Plan for Part 2 of the Supplemental Groundwater Remedial Investigation (FSP) (GSC, April 2012) describes the drilling program associated with six areas of the York Naval Ordnance Plant (fYNOP or Site) for determining the vertical extent of chemicals of concern (COCs) in the groundwater beneath the Site. The staged investigation described in the FSP indicates that well placement and depth will be dependent on observations and results of prior work done at the Site, including groundwater sampling of the newly installed wells during Round 1 of the current investigation. The FSP specifies that a second, and possibly third, well would be drilled adjacent to the first well in the cluster if laboratory results indicate that concentrations of volatile organic compounds (VOCs) have not decreased vertically in the deep wells drilled in Round 1 to concentrations approaching the Medium Specific Concentrations (MSCs) for residential groundwater and water levels in those wells do not indicate an upward vertical hydraulic gradient.

Six wells were drilled at the Site to initiate Round 1 of the vertical extent investigation: MW-136A through MW-141A. A map showing well locations is attached as Figure 1. These wells were drilled and sampled in accordance with the FSP and the associated Addendums #1 (GSC, June 2013) and #5, Revision 1 (GSC, November 16, 2013). The wells were installed during a six month period from July 2012 to January 2013, and during drilling, numerous stacked solution openings were encountered in the upper approximately 200 feet, making the installations difficult, time-consuming and costly.

Vertical groundwater gradients and volatile organic compounds (VOCs) concentrations were determined for the newly installed wells. Based on these Round 1 results, this addendum identifies the locations at which additional vertical delineation is recommended and modifies the drilling, well installation, testing and sampling methods planned for the deeper vertical investigations. Methods have been modified as a result of the subsurface conditions encountered during the first round of drilling in an attempt to expedite and improve the drilling and testing procedures.

Results of Round 1

Data obtained from each of the wells drilled during Round 1 is summarized in Table 1, attached. The summarized data table includes the vertical groundwater gradient, well yield, concentrations of specific chemicals tetrachloroethene (PCE), trichloroethene (TCE) and cis-1,2-dichloroethene (cis-1,2DCE), and the monitoring depth of each well. Knowledge of the vertical gradient is important for determining whether COCs would be carried deeper in the diffuse fractured rock aquifer flow system with downward vertical flow of groundwater, or if the depth of aqueous COCs migration would be limited by an upward gradient. In addition, well yields of l gallon per minute or less, as are observed in wells MW-136A, MW-138A, MW-139A, MW-140A, and MW-141A, indicate relatively little movement and transport of groundwater containing COCs at the depths monitored by each well. This data was used to determine whether drilling deeper is warranted at each well location.

Recently installed vertical extent wells MW-138A and MW-141A show both upward vertical gradients and significantly decreased concentrations of Site COCs with depth. While concentrations in neither well are below the MSCs for the CVOCs of concern, the position of the wells together with the observed head potential and chemical concentrations provide sufficient characterization that additional vertical delineation is not recommended. Specifically, cross section A-A’ (attached) shows that the trichloroethene (TCE) concentration in MW-138A (open interval is 260 to 320 feet below ground surface (BGS)) is more than an order of magnitude lower than the TCE concentration in adjacent well MW-113 (screened from 125 to 151 feet BGS). At MW-141A, concentrations of COCs were either at or approaching the MSCs during the January 7, 2013 sampling event (see attached cross section F-F’) and are about an order of magnitude less than concentrations detected in the adjacent shallower well MW-64D.

VOC concentrations in groundwater samples from newly installed wells MW-136A, MW-137A, MW-139A, and MW-140A did not exhibit sufficient decreases which would define the vertical extent; therefore, deeper investigation is warranted.

Round 1 wells were drilled 50 feet below the depth of the deepest well in the immediate vicinity, and then casing was positioned and grouted in place to seal off communication within the upper portion of the aquifer. This methodology is important in the presence of DNAPL, which can migrate quickly down the borehole during drilling. Dissolved CVOCs do not cause the same concern unless there is a strong vertical downgradient and the well is left open longer than is required to complete the well in a manner that isolates discrete water-bearing zones (WBZs). Therefore, the wells will only be left open approximately one month or less. With the exception of MW-136A, wells MW-137A, MW-139A and MW-140A have concentrations less than 1% of the solubility of PCE or TCE. One percent of solubility is often used as a conservative indicator of DNAPL impacts in the aquifer near the location sampled. With concentrations well below 1% of the solubility, the risk of dragging DNAPL down during the drilling process is minimal. For these wells (MW-137A, MW-139A and MW-140A), the process of advancing casing to seal off the upper part of the aquifer prior to deepening the boring is not necessary provided that the multiport samplers with packers are installed in a timely manner to isolate discrete WBZs in the extended borehole.

For well MW-136A, the groundwater concentration of TCE is 0.58% of solubility, and the concentration of PCE is 6.25% of solubility. While exceeding 1% of the solubility of PCE, the low yield of the exposed interval together with the lack of observed fractures during drilling suggests that the high concentrations of PCE reflect back-diffusion from mass stored in the adjoining rock matrix that is impacting a relatively small volume of groundwater stored in and passing through these bedrock fractures. It is GSC's opinion that these concentrations are caused by conditions depicted on Figure 5.1-7 of the Supplemental RI for Groundwater (Part 1) (attached), and that Stage Three on this figure most accurately describes conditions in the deepest portion of the bedrock encountered at the location of MW-136A; i.e., competent fractured rock through which DNAPL has passed, and been diffused into the matrix over the past several decades (represented by the orange-shaded portions within competent fractured rock). Introduction of DNAPL into the aquifer at this location occurred approximately 50 years ago.

While it would not be impossible that DNAPL could have accumulated in a basin-shaped area in a solution feature after a release in the 1960's with residual DNAPL remaining in a solution feature somewhere in the MW-136A area, given that DNAPL was not observed in this well, it is most likely that DNAPL in contact with competent fractured rock (migrating through discrete fractures in the bedrock as opposed to open conduits) is completely diffused into the matrix and all DNAPL is depleted within the monitored interval of MW-136A.[Therefore based on this conceptual model, it is possible that DNAPL could exist in the solution features and sediment above 220 feet, but not likely in the deeper fractured rock portion of the aquifer where well MW-136A is currently open to the aquifer.

Drilling also provided information about karst features in the bedrock. Some degree of bedrock solutioning was encountered during drilling in each of the wells MW-136A through MW-141A in the upper approximately 220'; solution features were not encountered deeper in any of these wells, except at MW-137A. Only MW-137A had an extensive solution opening below 220': a large cavity was encountered from 285' to 296'. Dilution testing of this cavity indicated that the groundwater flow velocity in the conduit is 0.07 feet per minute.

Predrilling Tests

A few tests are recommended prior to drilling deeper at wells MW-136A and MW-137A. The tests will provide information about the competent fractured rock aquifer, and in the case of MW-137A, the interconnection between the deep solution feature and the shallow groundwater extraction system.

1) Shut Down Test - A shutdown test will be conducted to determine the influence of the groundwater extraction system on the water levels in the deep wells. All active extraction wells in the carbonate aquifer (CW-8, CW-9, CW-13, CW-17 and CW-15A) will be shut down. The purpose of this test is to establish the non-pumping vertical gradient in the aquifer, and to develop an indication of connectivity between the extraction system and the deep wells. This is particularly important at MW-136A where interconnectivity between nearby extraction well CW-9 and wells MW-75S&D has been established (Section 2.3 of Supplemental Remedial Investigation Groundwater Report (Part 1), GSC, September 2011). Understanding the vertical gradient prior to deepening this well will assist in interpreting the

migration potential of groundwater in the fractured rock portion of the aquifer in this location. This shutdown test will also provide information that will be used to plan tracer tests involving deep karst features on Site and to the west of the Site.

a) Water level recorders will be placed in the four wells slated for deepening (MW-136A, Mw-137A, MW-139A and MW-140A), wells MW-145A and MW-147A on the eastern levee of Codorus Creek, and in an additional four to six wells near the pumping wells that had been observed during the previous shutdown test conducted in 2008. Recorders currently in wells on the levee and surface water station Codorus Creek 2 will continue to operate.
b) Water levels will be recorded for a period of approximately one week under normal conditions, which includes operation of all extraction wells in the carbonate aquifer.
c) After one week, and in absence of a significant rainfall event, a complete round of water levels of all wells in the carbonate aquifer will be measured, followed by shutdown of all extraction wells in the carbonate aquifer.
d) Water levels in the wells with continuous recorders will be downloaded and reviewed twice weekly.
e) Extraction wells will be restarted after recovery of all wells from pumping appears complete, and water levels appear to have crested, and are responding to individual recharge events or atmospheric conditions, which is estimated to be two weeks. In no case will the extraction system be off for longer than 3 weeks. Prior to restart, a round of water levels in all wells in the carbonate aquifer will be completed.

2) Packer Testing of MW-136A – The screened intervals of the multiport sampling system will be placed at discrete WBZs within the well borehole to provide potentiometric head and chemistry data from the WBZs. The open interval in MW-136A from 270’-320’ below ground surface produces approximately one gallon per minute. Observations made during the drilling did not provide a basis for identifying any discrete WBZ that might be contributing to this yield. Identification of the WBZ(s) in this well is important because it would allow appropriate placement of the multilevel sampler and water level sensor after it is deepened. The packer testing is necessary at MW-136A prior to deepening the borehole as explained below.

Because the drilling plan (see below) envisions keeping the borehole filled with drilling mud during deepening of the well, this testing cannot be done after the hole is deepened (this is explained in more detail below). Therefore, in the open interval of MW-136A, a series of pump down tests will be conducted using a single inflatable packer. This single packer will initially be placed 10 feet below the bottom of the steel casing exposing the well bore interval between 270' and 280' bgs. The water level in the well will then be lowered by pumping to a convenient level, say 100' below the static water level. The pump will then be shut off and a transducer will be used to monitor changes in the water level for one hour during recovery. The recovery rate will be calculated using the change in water level and the borehole volume. The packer will then be moved ten feet deeper to 290' bgs, and the test will be repeated. This procedure will be repeated by adding ten foot intervals to the length of exposed borehole above the packer until the entire open borehole is tested. To permit the comparison of results from these tests, the water level will be lowered to the same depth during all of the individual tests. The packer will not be needed to test the last ten feet of borehole.

Modified Drilling and Well Construction Methods

Solution features and stacked caverns were encountered during drilling of wells MW-136A, MW-137A, MW-139A, and MW-140A, making drilling above the target depth time-consuming and costly. To avoid that time and expense in drilling deeper for Round 2 well installation, these existing wells will be deepened rather than drilling additional adjacent wells. In taking this approach, telescoping casing with air rotary drilling, as was done for the Round 1 well installations, is not an option because the existing borehole diameter is too small to add another smaller-diameter pipe to drill through and still have enough annular space to properly seal the outside of the pipe with grout. Therefore, each of these four wells will be deepened by coring at a nominal 4-inch diameter, as described below. Coring also will be advantageous for identifying WBZs and will produce less investigation-derived waste materials for disposal. After deepening each well, multilevel samplers and water level sensors will be placed at discrete intervals within the open borehole to permit discrete sampling of groundwater and measurement of potentiometric levels.

Wells MW-136A, MW-137A, MW-139A, and MW-140A will be deepened using the HQ coring method that produces a 3.77-inch diameter borehole. The core produced using this technique is approximately 2.5 inches in diameter. As conditions permit, the wells will be drilled an additional 150 feet to a total depth of up to 470 feet below ground surface (bgs). The rock core will be logged by a geological scientist and placed into core boxes. Lithology, solution features and their filling materials, fractures, and suspected WBZs will be noted along with observations of CVOC vapors detected by a photoionization detector. Water levels will be measured frequently in order to observe changes in head potential as the boring is advanced. Drilling of MW-137A may require the placement of temporary spin casing to penetrate the solution feature from 282'-291' depth below ground surface, prior to advancing the boring.

The coring fluid for wells MW-137A, MW-139A, and MW-140A will be water. In these wells, if a solution feature is encountered, water quality profiling and dilution testing will be conducted, as described in Addendum 2 of the Field Sampling Plan (FSP). However, as an added precaution against the unlikely potential that DNAPL is present in the upper zone of MW-136A, this well will be advanced using drilling mud as the coring fluid. The mud will be left in the hole during times when the boring is not being advanced. The mud will minimize the potential migration of DNAPL due to the mud's density. The mud will be flushed from the boring just prior to the scheduled installation of the discrete-interval sampling system described below. The use of mud as a precaution against DNAPL migration will preclude water quality profiling and dilution testing during drilling and the application of borehole geophysics and other post-drilling methods to identify WBZs. In addition to the pre-drilling packer tests previously described to identify WBZs in the interval from 270'-320 in MW-136A, examination of cores from this well will be the primary method used to select the locations of discrete intervals for sampling. The value of flushing the boring and conducting water quality profiling, dilution testing, geophysical logging and packer tests to assist in the selection of monitoring intervals will be assessed after the drilling is completed. It is likely that MW-136A will be the last of the wells deepened, and the on-Site experience gained deepening the other borings and installing the multi-level samplers will be considered in decisions made regarding this well.

A dedicated Waterloo multilevel sampling system will be installed in the deepened wells. Waterloo system sampling ports and water level transducers will be installed in selected WBZs to collect groundwater samples and measure potentiometric levels. The discrete monitoring points will be separated from each other using water-tight expandable packers positioned at appropriate intervals within the borehole. The packers contain an expandable hydrophilic substance that is proprietary to Solinst with outer materials made of natural rubber/Kevlar/natural rubber which should be compatible with the dissolved VOC concentrations in the groundwater. A typical Waterloo system installation with packers is shown in the attached Waterloo product information. If present, up to four WBZs in each well will be identified by the geologist for this discrete interval monitoring. Each borehole will be geophysically logged, as described in the FSP, Section 4.2.4.13 to aid in identifying WBZs. Methodologies to be used prior to drilling MW-136A, such as packer testing, and other borehole geophysical methods such as caliper and optical logging and heat pulse flow meter may also be used to identify discrete WBZs in the three other wells. A combination of observations from the drill cores, drilling conditions, geophysical logging, and the tests mentioned above will be used to select discrete intervals most likely to represent WBZs spaced throughout the open interval of each well bore.

Well Development and Permeability Testing

Each interval containing a sampling port and a transducer will be developed by over-pumping and stressing the discrete interval, while monitoring field parameters as described in Section 4.2.4.4 of the FSP. Dedicated Solinst Double Valve Pumps will be used for well development and sampling. The Double Valve Pump operates by using an Electronic Control Unit to apply pressure from a compressed nitrogen or air source to the pump's Drive Line. The pressure needed is calculated based on the depth to static water level, multiplied by 0.43, with 10 psi added. Cycles of pressure and venting are applied to the pump and water in the Sample Line is expelled at the surface in a gentle pulsating flow.

After development is completed, each interval will be tested for yield/permeability. This information will be used to plan sampling procedures and to quantify the hydraulic conductivity of the lower portion of the fractured rock matrix. After the interval is allowed to recover to natural head potential from the development, it will be pumped at a rate that establishes a constant drawdown, if possible. This rate will be held for approximately five minutes with water levels recorded continuously using a Geokon LC-2 or equivalent.

The pump will then be stopped, and the water level allowed to recover to within 90% of the pre-test level in order to measure the hydraulic conductivity of the interval. After recovery, the interval will be pumped to quickly drawdown the water level to simulate a pulse test or bail test. The well will be pumped until a head differential (drawdown) of one to five feet is established to simulate the range of head differential produced during a bail test. Then, pumping will cease, and water head potential recovery will be recorded using the water level transducer and a continuous recorder. Permeability will be calculated using standard slug test methodology (Hvorslev [1951]).

Groundwater Monitoring

If necessary, elevations will be resurveyed, or the reference point will be established for each discrete interval water level transducer from the previous survey. Potentiometric levels will be measured for each discrete interval.

Prior to groundwater sample collection, stagnant water will be purged from the borehole interval. Purging of the intervals may be done concurrently for all discrete monitoring intervals and the purged water will be containerized for transfer to the Site groundwater treatment system. The field parameters of pH, conductivity, temperature, dissolved oxygen, and turbidity will be measured during purging as described in subsections 4.2.4.7.1 and 4.2.4.7.2 of the FSP. Groundwater samples from each interval will be collected and submitted to Test America Pittsburgh for analysis of VOCs using Method 8260B.

Intervals will be re-sampled two weeks later, following Addendum 1 of the FSP.

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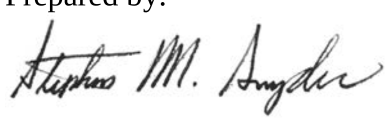

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Senior Associate and Hydrogeologist

References

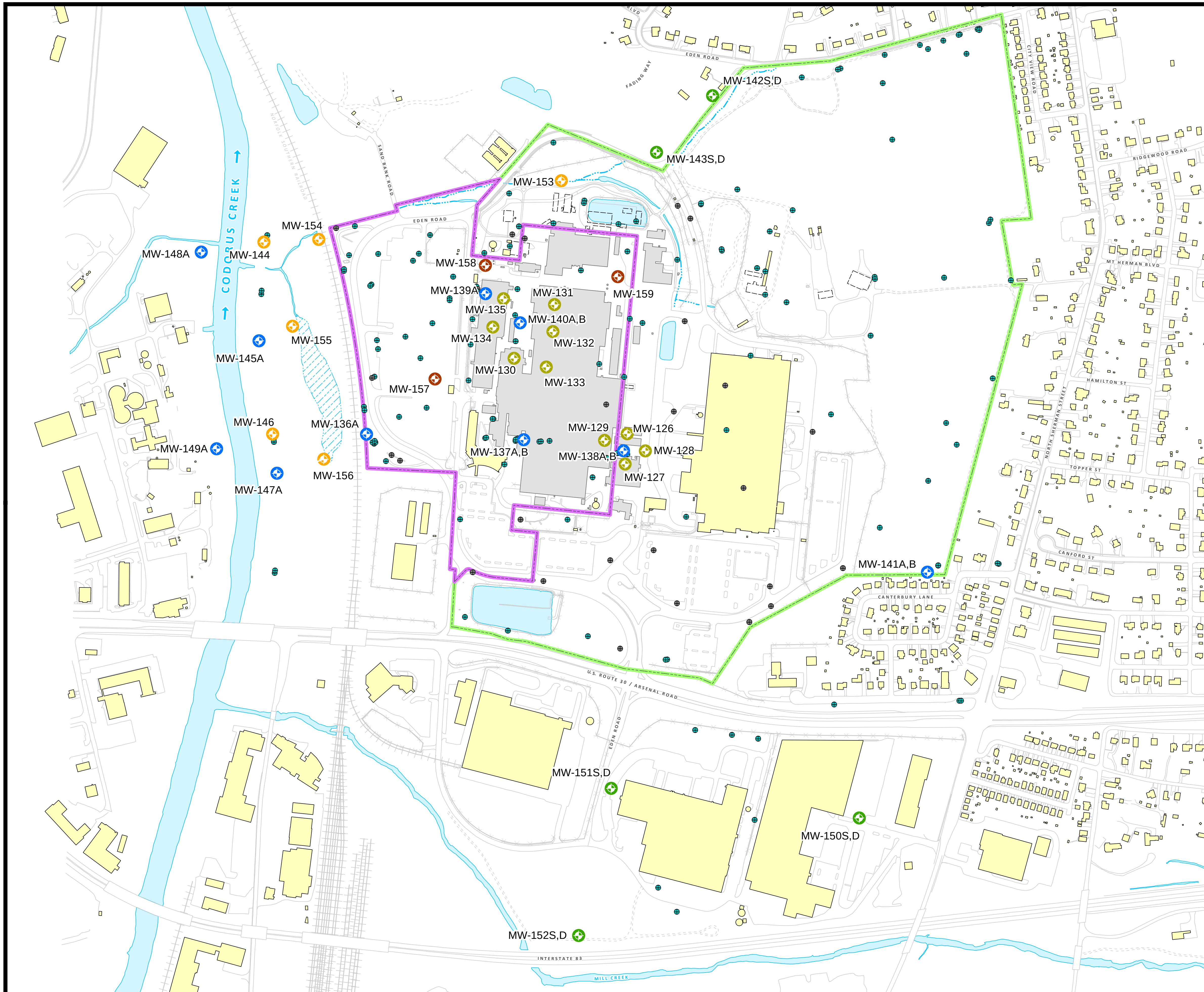
GSC, 2011. Supplemental Remedial Investigation Groundwater Report (Part 1) Former York Naval Ordnance Plant, September.

GSC, 2012. Field Sampling Plan (FSP) for Part 2 of the Supplemental Groundwater Remedial Investigation, April.

Hvorslev, M. J. 1951. Time Lag and Soil Permeability in Groundwater Observations. U.S. Army Corps Engr. Waterway Experiment Station Bulletin 36, Vicksburg, Miss.

Addendum #8

Attachments



LEGEND

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- Proposed Vertical Extent Wells
- Proposed Shallow & Deep Pairs
- Proposed Shallow Air Rotary
- Proposed Shallow Boring in Overburden
- Proposed Stratigraphic Boring
- Abandoned Wells
- Active Wells
- West Campus Property Line
- East Campus Property Line
- Existing Building to Remain
- Demolished
- Demolished/Slab Removed
- Railroad
- Road (Paved)
- Road Curb
- Road (Unpaved)
- Walkway
- Fenceline

Scale (feet)
0 140 280 560

Figure 1

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Addendum 1 FSP (Part 2)
Proposed Well Installations

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TABLE 1 - ADDENDUM # 8
FYNOP GWRI Part 2 Drilling Program Review
Vertical Extent Investigations Well Summary

Well	PCE Concentration (µg/l)	TCE Concentration (µg/l)	cis-1,2-TCE Concentration (µg/l)	Depth (ft)	Yield (gpm)	Gradient*
136A	15,000	8,100	1,000u	270-320	1	↓
137A	13j	510	1,000	280-298	300	↑→
138A	0.42j	52	37	260-320	0.14	↑
139A	110	440	860	270-320	0.8	↑
140A	300	1,100	900	195-305	0.25	→
141A	6.2	4.6	0.48	200-300	0.1	↑

* Under pumping conditions

Location ID (Wells Installed 2012)
Top of Open Interval FtBGS - Bottom of Open Interval FtBGS (Open Interval Thickness)
Trichloroethene and Tetrachloroethylene
Event #1
Event #2
Event #3

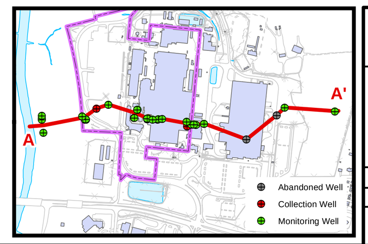
Location ID
Top of Open Interval FtBGS - Bottom of Open Interval FtBGS (Open Interval Thickness)
Trichloroethene and Tetrachloroethylene
A. 2007 Key Well (May-June 2007)
B. 2008 Sup RI Rnd 1 (April-May 2008)
C. 2008 Sup RI Rnd 2 (September-October 2008)
D. 2009 Key Well (June-July 2009)
E. 2010 Key Well (June-July 2010)
F. 2011 Key Well (June 2011)

Legend

- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- cis-1,2-Dichloroethene (cis-12DCE)
- Vinyl Chloride (VC)
- 1,1-Dichloroethene (11DCE)
- 1,1-Dichloroethane (11DCA)
- 1,1,1-Trichloroethane (TCA)
- Open Interval
- Well
- Void
- Overburden
- Limestone/Dolostone
- Sandstone/Quartzite

Notes:

- 1.79 Groundwater Elevation Measured on February 11, 2013
- NM Groundwater Elevation Not Measured
- 0.07 Feet/Min Borehold Point Dilution Test Result



Former York Naval Ordnance Plant
1425 Eden Road, York, PA 17402

Cross Section A-A'

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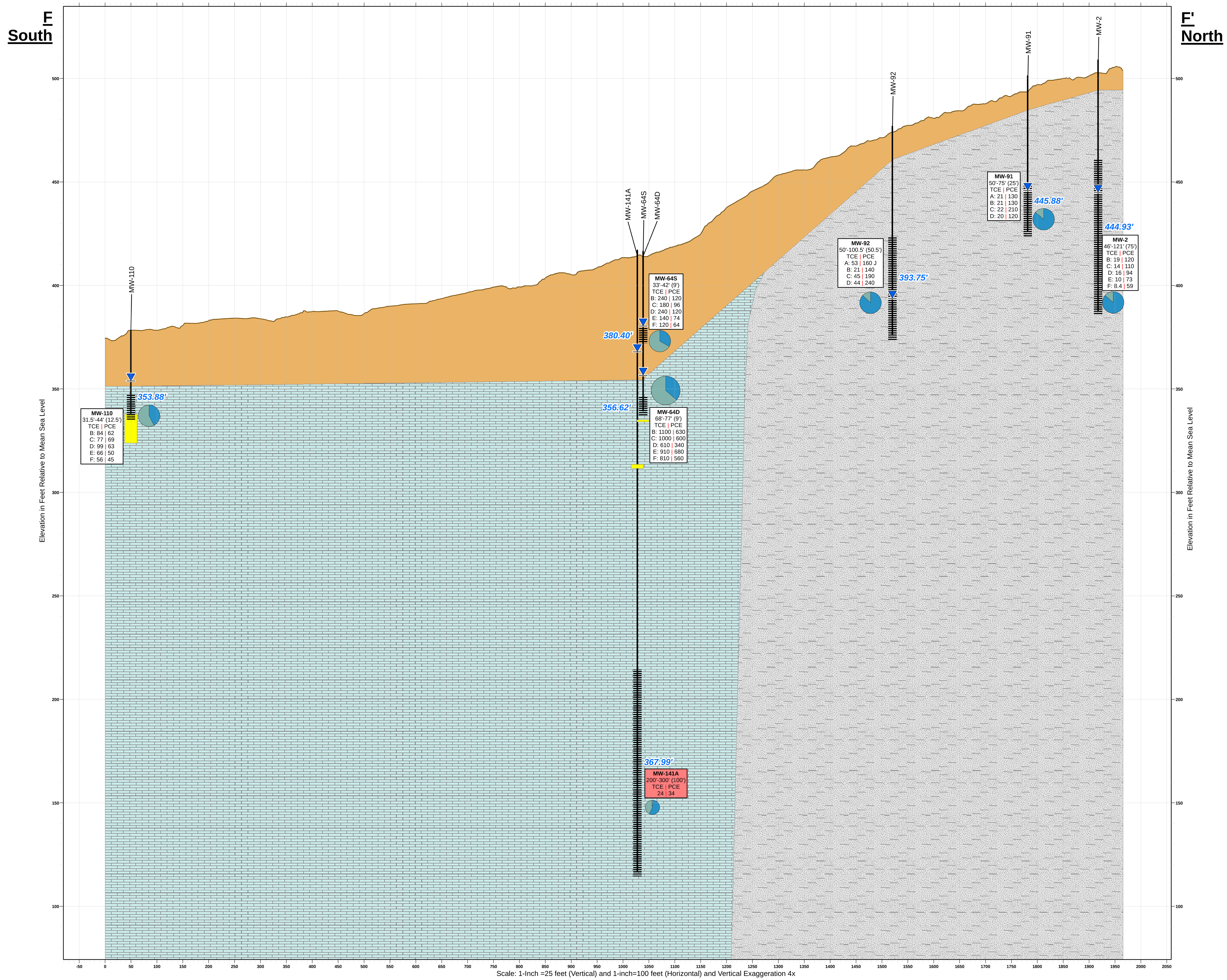


Location ID (Wells Installed 2012)
Top of Open Interval FtBGS - Bottom of Open Interval FtBGS (Open Interval Thickness)
Trichloroethene and Tetrachloroethylene
Event #1
Event #2
Event #3

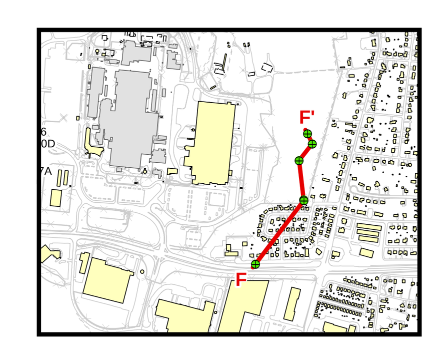
Location ID
Top of Open Interval FtBGS - Bottom of Open Interval FtBGS (Open Interval Thickness)
Trichloroethene and Tetrachloroethylene
A. 2007 Key Well (May-June 2007)
B. 2008 Sup RI Rnd 1 (April-May 2008)
C. 2008 Sup RI Rnd 2 (September-October 2008)
D. 2009 Key Well (June-July 2009)
E. 2010 Key Well (June-July 2010)
F. 2011 Key Well (June 2011)

Legend

- Water Level
- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- cis-1,2-Dichloroethene (cis-12DCE)
- Vinyl Chloride (VC)
- 1,1-Dichloroethene (11DCE)
- 1,1-Dichloroethane (11DCA)
- 1,1,1-Trichloroethane (TCA)
- Open Interval
- Void
- Well
- Overburden
- Limestone/Dolostone
- Sandstone/Quartzite

Notes:

1.79 Groundwater Elevation Measured on December 7, 2012
NM Groundwater Elevation Not Measured
0.07 Feet/Min Borehold Point Dilution Test Result



Former York Naval Ordnance Plant
1425 Eden Road, York, PA 17402

Cross Section F-F'

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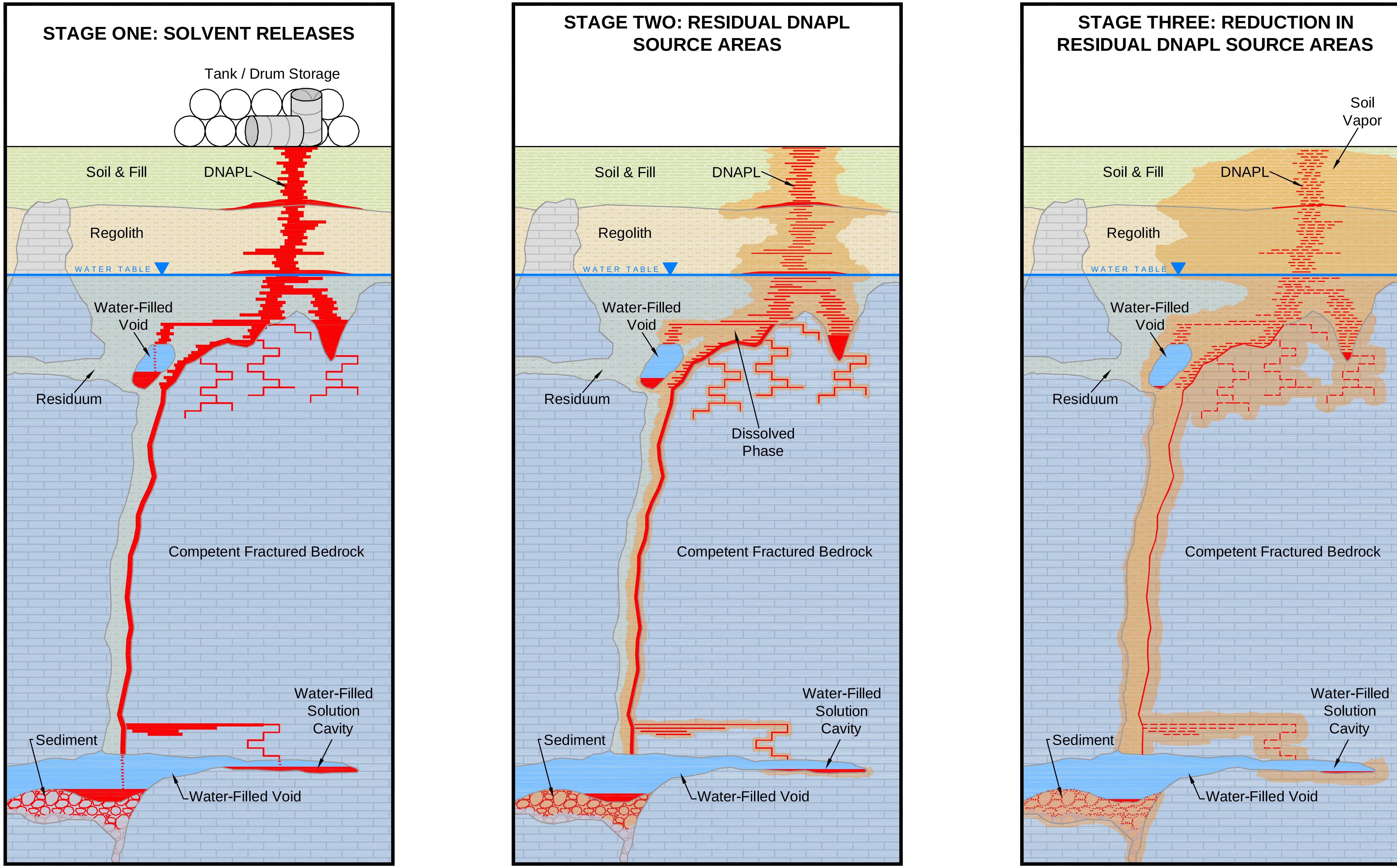
Figure 5.1-7 Conceptual Model of DNAPL Fate and Transport in a Karst Aquifer



DNAPL penetration through soil fill, residual soil, and infilled voids, caverns, and cutters within epikarst layer in carbonate bedrock. DNAPL accumulation zones form at top of residual soil within the capillary fringe above the historical water table at the top of cutters infilled with fine-grained soils, and near the base of cutters, caverns, and voids within the carbonate bedrock.

DNAPL penetration has ceased. Development of residual DNAPL zones and high soil and bedrock concentrations due to processes of diffusion and sorption of CVOC mass from DNAPL pathways and accumulation zones. DNAPL may be transported from accumulation zones and suspended sediment during medium to high turbulent flow in water-filled solution cavities. DNAPL also dissolves and migrates with groundwater.

Majority of CVOC mass has spread into soil and bedrock due to diffusion. Localized DNAPL presence in areas of greatest initial accumulation. Reversed diffusion from the soil and bedrock into groundwater provides a continuing source of CVOCs to the groundwater.

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