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INTERMEDIATE (60%) DESIGN SUBMITTAL

PRE-DESIGN INVESTIGATION REPORT & PRELIMINARY REMEDIAL DESIGN

Operable Unit 2 North Penn Area 5 Superfund Site Unilateral Administrative Order (UAO) Docket No. CERCLA-03-2012-0205DC

Submitted on Behalf of

Stabilus, Inc.
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Project Number PH0013

27 November 2013 (Revised 17 February 2014)

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17 February 2014

Via Email and Federal Express

Ms. Sharon Fang (3H521), Remedial Project Manager
U.S. Environmental Protection Agency – Region III
1650 Arch Street
Philadelphia, PA 19103

Subject: Revised Intermediate (60%) Design Submittal / Pre-Design Investigation Report & Preliminary Remedial Design (Revised 60% Design) dated 17 February 2014, and Responses to 27 January 2014 USEPA Comment Letter
Operable Unit 2 North Penn Area 5 (NP5OU2) Superfund Site
Unilateral Administrative Order (UAO)
Docket No. CERCLA-03-2012-0205DC

Dear Ms. Fang:

On behalf of Stabilus, Inc., please find enclosed three (3) copies of the Revised Intermediate (60%) Design Submittal / Pre-Design Investigation Report & Preliminary Remedial Design dated 17 February 2014 (Revised 60% Design) to fulfill the requirements of Section VI Paragraph 25.b of the Unilateral Administrative Order (UAO) Docket No. CERCLA-03-2012-0205DC dated 26 June 2012, for the interim remedy for Operable Unit 2 (OU2) of the North Penn Area 5 Superfund Site. A redlined version of the Revised 60% Design text was submitted via electronic mail.

RESPONSE TO COMMENTS

Below is a summary of the responses to comments to the 60% Design that were provided by USEPA to in a letter dated 27 January 2014 and were discussed during technical meeting calls on 22 and 23 January 2014 (note: USEPA's comment is presented in italicized text followed by the response):

General Comments

Comment 1: *Treatment of all areas required by the ROD must be included in the design. If Phase 1 is not successful, a schedule and associated deliverables should be committed to here for a Phase 2 process. Insert language in pages 24 & 26.*

Response: Agreed. As noted in the Remedial Design Work Plan dated 29 January 2013 (RDWP), this will be addressed within the Pre-Final Design Submittal (90% Design), which

will present the remedial action (RA) schedule and the deliverables related to the RA. Text on pages 24 and 26 has been modified based upon this understanding.

Comment 2: *Include Phase 1 Failure criteria as agreed upon in our 1/22/14 call: no TCE decrease, no daughter product generation, and the inability to physically inject. If the Phase 1 failure criterion is not triggered, Phase 1 will be optimized using performance metrics as presented in our 1/22/14 call and Phase 2 will be designed accordingly. Add deliverables and schedule for Phase 2 in the design. This design is to address the entire interim remedy.*

Response: Agreed. As defined in the RDWP, the RA schedule is part of the 90% Design. As discussed and as will be described in the 90% Design, the major deliverables will be an Annual Monitoring Report – Year 1 and Year 2, and a Phase 1 EISB Remedy Performance Report following the submission of the Year 2 Annual Monitoring Report which will provide determination of success or a declaration of failure of the Phase 1 EISB Remedy.

Comment 3: *The Basis of Design Report does not provide a project delivery strategy or how RAOs will be met if Phase 2 is not implemented.*

Response: As discussed during the 22 and 23 January 2014 technical calls, the project delivery strategy will be presented within the 90% Design. Additionally, a Revised Basis of Design Report will be included to further refine how the RAOs will be met if Phase 2 is not implemented.

RPM Comments

Comment 4: *Include a Focused Feasibility Study as part of deliverables the "if Phase 1 fails"*

Response: Understood. A Focused Feasibility Study (FFS) will be prepared 90 days following USEPA's approval of Failure Determination of Phase 1 as noted in Section 9 and will be furthered detailed within the 90% Design. The FFS will include assessment of viable OU2 overburden treatment remedies.

Comment 5: *Page 4, §2.1.1 states area located on Stabilus & BAE. Add "in the vicinity of Stabilus & the former BAE facilities and Whistlestop Park."*

Response: Agreed, text has been modified.

Comment 6: *Figures 3 & 4 Label Whistlestop Park and the Former BAE.*

Response: Agreed, Figures 3 and 4 have been revised.

Comment 7: *Figure 6. Draw an open contour to the left of TW49 & TW50 or dash the line and add dashed line to the legend as "approximated extent, not yet confirmed."*

Response: Agreed, Figure 6 has been modified.

Comment 8: *Page 23, fourth bullet states "soil concentrations for VOCs are very low and only slightly exceed the USEPA Region 3,6,9 PGW-MCL value for TCE of 0.0018ppm. SB06 had a TCE concentration of 0.12, which is not "slightly" above the PGW value. Other concentrations are 0.087, 0.037, 0.049 and 0.037. Fix language to be more appropriate.*

Response: Language has been changed as requested.

Comment 8: *Table 6 does not list the unit of the reported data.*

Response: Disagree. Table 6 provides the units of mg/kg.

Comment 9: *Page 35. Design Assumptions should include the assumption that injections will only take place during warm months, therefore heat tracing of construction below the frost line are not considered.*

Response: Agreed. Will be incorporated into the 90% Design.

Comment 10: *Page 36 assumes 50' radius of influence. The performance monitoring network does not appear to cover that assumption.*

Response: As discussed during the 22 and 23 January 2014 technical calls, the 90% Design will present the means by which donor transport within the 50-foot radius of influence will be monitored / confirmed.

Comment 11: *Page 37 text states a 20,000 gallon frac tank. Make Drawings 5 & 6 consistent with this volume.*

Response: The 90% Design drawings will be revised as requested.

Comment 12: *Page 37. Sample and analyze the water pumped from RI-27D both before pumping and after pumping and also sample and analyze the water in the frac tank. Pumping from the aquifer may need to be coordinated with DRBC. State a contaminant threshold (e.g. MCLs) above which the water from RI-27D cannot be used. Provide a contingency plan in case this scenario is triggered.*

Response: The text on Page 37 has been modified. Further details regarding the use of RI-27D, sampling requirements and contingency for water will be provided within the 90% Design.

Comment 13*: Section 5.4. Include details on how the permit equivalencies will be coordinated and met should be elaborated on. As a FYI, our UIC program reviewed the document and*

commented as follows: "the proposed design of the infiltration trenches do meet the definition of "injection wells" since they are deeper than their largest surface dimension. The operator needs to characterize the injection fluid and ensure that the injection process does not negatively impact the ground water or any nearby water wells. If the project proceeds as proposed, please forward me the specifics of the injection process so that it can be inventoried in the UIC data base."

Response: Permit equivalences will be included within the Permitting Requirements Plan as part of the 90% Design.

Comment 14: *Page 39, Section 5.3. Explain how the "Prevent or minimize migration" RAO will be addressed.*

Response: The text on Page 39, Section 5.3 has been modified.

Comment 15: *Additional Specifications (Page 41) may be needed, e.g. excavation, gravel, trenching, geotextile, sediment erosion control, etc.*

Response: Additional Specifications will be included within the Pre-Final Specifications as part of the 90% Design.

Comment 16: *Page 49, Performance Monitoring Reporting. A cumulative summary should be attached to the monthly report as soon as the new data is available.*

Response: The text on Page 49, Section 8.10 has been revised.

Comment 17: *Page 50, RA Schedule. Gantt Chart showing critical path is expected in next submittal.*

Response: Agreed. As outlined in the RDWP, the Pre-Final Construction/Remedial Action Schedule will be provided within the 90% Design. The Phase 2 EISB 90% Design will be submitted within 90 Days from the EISB Remedy Performance Report (ERPR) which will include: Revised Drawings showing the Phase 2 and performance well network; Revised RA schedule; Revised 90% Design which includes revisions as necessary for the expanded application of EISB within the OU2 overburden groundwater aquifer. Further details of the RA schedule will be provided within the 90% Design.

Comment 18: *Page 50, RA Schedule. Will only intermediate bedrock wells be installed in 4th Qtr 2014 or shallow bedrock wells that will not be impacted by the trench construction also?*

Response: Only the intermediate bedrock wells will be installed in the 4th Quarter 2014 under the current schedule. The shallow bedrock well depths will be based upon

information from the installation of the intermediate bedrock wells. Further details relating to the schedule will be presented within the 90% Design

Comment 19: *Page 50, RA Schedule. Provide "decision on success/failure in the 3rd Qtr of 2017" and "Construct Phase 2" for 4th Qtr 2017, thereby allowing the two year of monitoring Phase 2 to end in 4th Qtr 2019. Ten years of annual sampling will be 2019 through 2027.*

Response: As discussed during 22 and 23 January 2014 technical calls, the long term sampling will end in 2027, text has been modified. The decision on success / failure will be refined within the 90% Design.

RPM comments, Appendix H, Design Drawings

Comment 20: *Cover sheet. Label roads so that the location of the Site can be determined.*

Response: Agreed. Will be incorporated into the 90% Design.

Comment 21: *Sheet 2 Delete TW locations. This sheet should be existing Site features; the TW locations are no longer in place. Assign numbers to the topography contours so ground surface can be understood from this figure.*

Response: Agreed. Will be incorporated into the 90% Design.

Comment 22: *Add a Sheet with RD features & summarizing PDI data. This is where TWs locations and TCE contours.*

Response: Agreed. Will be added as part of the 90% Design.

Comment 23: *Drawing 3. Place RI23 & RI25 on sheet as referenced in the design text.*

Response: Agreed. RI23 and RI25 will be added to the design drawings within the 90% Design.

Comment 24: *Drawing 3. The Phase 2 injection trench that is depicted on Drawing 3 does not pass within 50 feet of the 100 ppb TCE contour in multiple areas. This is significant because the design document assumes a 50 foot radius of influence (ROI) for the EVO injection. To implement the remedy as specified in the ROD, injection of the EVO and associated amendments that will be used to achieve the enhanced bioremediation remedy must take place no farther from the 100 ppb TCE contour than the injection ROI. Relying on natural attenuation to address a portion of the contamination within the 100 ppb TCE plume is not in keeping with the requirements of the ROD. Based upon the results from the Phase 1 injection, remaining areas above 100ppb in the overburden are expected to be designed in Phase 2.*

Please add the following note to Drawing 3: "Final placement of the Phase 2 injection trench(es) will be determined based on data from Phase 1 and will be documented on design drawings for Phase 2 of the remedy."

Response: Agreed. The performance monitoring of the Phase 1 trench will be designed to confirm the 50 foot ROI. Modifications to the drawings will be incorporated into the 90% Design.

Comment 25: *Drawing 4. Equipment should be inside a locked fence and a Site sign should be posted.*

Response: Agreed. Will be added as part of the 90% Design.

Comment 26: *Drawing 6 shows the trench at 3.5' wide. Fix the scale if the trench is to be 5' wide. Also, show expected groundwater table elevation on cross section. It's unclear if the groundwater table is expected to be within the pea gravel or above the clean fill/geotextile.*

Response: Agreed. Will be clarified within the 90% Design.

Comment 27: *Drawing 7. Add a contingency that the overburden monitoring wells will be reinstalled if the location drilled is found dry.*

Response: Agreed. Will add a note to the drawing as part of the 90% Design.

Comment 28: *Drawing 7. Unclear if some locations will have both shallow and intermediate wells constructed in the same borehole.*

Response: Shallow and Intermediate wells will be constructed in separate boreholes as detailed in the narrative. The clarified drawings, specifications and schedule will be submitted as part of the 90% Design.

Hydro Comments

Comment 1: *Page 15 and Figs 6 and 7. It is stated here that there are two distinct source areas and two distinct plumes, based presumably on the lower TCE and DCE concentrations in TW04. However, due to the variability over relatively short distances, the orientation of the plume on the Stablius property and the orientation of the bedrock topography, there could be higher concentrations east of this point and west of TW 12. Without this additional information, these conclusions are speculative.*

Response: The data indicates that there are two distinct vintages of TCE, and the TCE and DCE data indicates that the resulting plumes have two areas of elevated concentrations. The lines of evidence supporting two sources were discussed within the narrative including the

CSIA data indicating the clear presence of two vintages of TCE, as well as the historic observations of TCE in this area prior to Stabilus and the two elevated areas of VOCs that have co-mingled over time. As discussed during the 22 and 23 January 2014 technical calls, the language on Page 15 has been modified.

Comment 2: *Page 26 from the general sequence of the EISB provided, it is unclear when well installation and baseline sampling will occur and at what points monitoring will occur.*

Response: Will be clarified within the RA Schedule as part of the 90% Design.

Comments 3: *Page 36. Provide the basis for the 50' radius of influence.*

Response: As discussed during the 22 and 23 January 2014 technical calls, the 50-foot ROI was assumed to afford sufficient injection of buffered EVO that could migrate that distance. The 90% Design will present the means by which donor transport within the 50-foot ROI will be monitored / confirmed.

Comment 4: *Pages 42-44 Please provide the proposed well locations on one of the figures with water elevation contours and contaminant concentrations. No comments can be provided without this information.*

Additionally, it is noted on page 44 that two wells will be completed southwest of the EISB area to assess dip and spread of the EISB within the bedrock. I believe that the dip is to the northwest. Please clarify.

Response: As discussed during the 22 and 23 January 2014 technical calls, a figure showing the proposed well locations with water elevation contours and contaminant concentrations will be provided as part of the 90% Design. The bedrock formation below the OU2 overburden aquifer has a strike of N62^{o}E and a dip of 27°NW.

Comment 5: *Section 8.3.2 Please modify to include work described in section 8.7. Additionally, it is recommended that the intermediate boreholes are installed and tested prior to installing the shallower holes.*

Response: Agreed. As noted in the narrative, the intermediate wells are being installed first to inform the depth for the shallow wells. The geophysics and packer testing are only being completed on the intermediate wells which are also noted within the text. Section references for the geophysics and packer testing have been added to Section 8.3.2.

Comment 6: *Pages 48 and 49. Is the LTM referred to on page 26 the same as this two year monitoring? If these analyses refer to LTM, would it not be possible to determine success or the*

need for amendments before the end of the 2 year monitoring period? The timing of the Phase I RA report should be indicated.

Response: The total of long term monitoring (LTM) is 10 years for EISB monitoring. The first 2 years of LTM will be completed as part of Phase 1, and the remaining 8 years of LTM will be completed as part of Phase 2. A refined RA Schedule will be presented within the 90% Design.

Comment 7 (Requested during 22 and 23 January 2014 technical calls): *Request that RI33S/I be moved south in line with the dip of the fracture, as well as the addition of an intermediate well added to RI35S to assess gradients within bedrock.*

Response: The request to move RI33S/I and addition of RI35I was agreed to during the 22 and 23 January 2014 technical calls. Text within Section 8 has been modified to reflect the addition of RI35I. The drawings will be updated as part of the 90% Design.

ORC Comments

Comment 1: *P.25 states the equipment for the EISB will be placed near the "former loading dock," but then later indicate that area to be on the northwestern side of the building (the left if you are looking at the building from the rear). Please clarify.*

Response: Correct. The EISB remedy will be placed near the "former loading dock". The staging area for the treatment components (tanks, mixing, etc.) will be located northwest of the building as shown on the design drawings. Further clarification will be provided within the 90% Design.

Comment 2: *Last bullet on p.34. does not have a place in a technical document.*

Response: Assume the comment is for Page 35, and yes it does have a place in a technical document, as the addition of a PRP for a second source on that PRPs former property would affect how the remedy is implemented and the schedule of implementation, which is a component of the technical submittal.

HGL Comments

General Comments

Comment 1: *Complete a thorough editorial review, as numerous instances of awkward wording and grammatical errors were observed throughout the document.*

Response: Understood.

Comment 2: *Section 3 presents the soil results but does not evaluate whether the TCE detections could represent historical sources of contamination associated with the plume. Please provide an analysis of the soil data.*

Response: As noted in the RDWP and the FSP, the soils samples were collected to understand the base load of VOCs for EVO and not to understand the origins of the TCE.

Comment 3: *Present a contingency approach that will be used to achieve the RAOs in case Phase 1 results are determined to constitute a failure and Phase 2 is not implemented.*

Response: The contingency approach will be presented within the 90% Design.

Comment 4: *The treatability study data analysis concluded that a buffered EVO amendment is required. For the treatability study, buffering was provided through sodium bicarbonate addition. Section 5 specifies how much EVO solution will be required, but does not discuss how this solution will be buffered. Will sodium bicarbonate or some other buffer be added to the EVO solution to reflect the findings of the treatability study that the buffered amendment outperformed the unbuffered amendment addition. If so, how much buffer will be included in each batch of EVO solution?*

Response: The EVO solution, buffering and other details will be furthered refined within the 90% Design.

Comment 5: *The design radius of influence for the injection trench is 50 feet. Given the low permeability of the soils encountered, this might be optimistic. Additionally, from the description of the overburden monitoring well network in Section 8.2.1, it is not clear that any of the wells will be positioned to confirm that the amendment influence extends 50 feet from the trench. On the contrary, the detail on Drawing 3 of Appendix H indicates that all of the new overburden monitoring wells to be used in Phase 1 are located within 25 feet of the trench. The text in Section 8 indicates that the new overburden wells will all be within 20 feet of the trench. On Drawing 3 in Appendix H wells RI23 and RI25 appear to be farther than 50 feet from the application trench and are placed closer to the trench ends where the document indicates that the affected radius will be smallest. Please describe how the planned monitoring program will confirm the design radius of influence.*

Response: The performance monitoring of the Phase 1 trench will be designed to confirm the 50 foot ROI. As noted within the RDWP, details of the monitoring program will be included within the RA Field Sampling Plan as part of the 90% Design.

Comment 6: *Please indicate how much KB-1 inoculum will be added to the trench and the basis for the quantity.*

Response: As outlined in the RDWP, the details of the KB-1 bioadmendment will be presented within the Operation and Maintenance Plan (O&M Plan) as part of the 90% Design.

Comment 7: *Please indicate how the trench spoils will be managed, including how saturated spoils will be decanted, how spoils will be stockpiled and managed pending waste characterization and disposal, and how backfill will be stockpiled. Further, the site layout map (Drawing 3 of Appendix H) should indicate the location of the spoils management areas and laydown yard.*

Response: As outlined in the RDWP, the management of the waste will be presented within the RA Waste Management Plan as a component of the 90% Design.

Comment 8: *Discuss the potential impact of the trenching on the Constantia building and other surface features. Include a structural analysis of the soil in the area of the building.*

Response: As noted during the 22 and 23 January 2014 technical calls, this will be a component of the RA Contractor's work for locating of the trench in agreement with the building owner (Constania-Colmar, Inc). Further specifications or details surrounding this requirement will be included within the 90% Design.

Comment 9: *Indicate that all wells will be constructed developed, and abandoned in accordance with all applicable Pennsylvania well drilling regulations and EPA guidance for groundwater monitoring well construction.*

Response: This will be clarified within the Pre-Final Specifications submitted as part of the 90% Design.

Comment 10: *Using the analytical results from only one sample to provide the geotechnical characteristics for the entire site is questionable from an engineering standpoint. Consider performing additional geotechnical analyses to ensure that the observed characteristics (particularly permeability) are applicable to the whole site.*

Response: Agreed. This was work completed to verify the visual observations. As discussed during the 22 and 23 January 2014 technical calls, additional geotechnical analysis will be completed as part of the RA implementation.

Specific Comments

Comment 1: *Page 5, Section 2.1.2, first paragraph – The description of the overburden as being between 10 and 40 feet thick appears to be inconsistent with the information contained in Table*

1, Table 7, Figure 9, and Section 2.1.3. Overburden thicknesses listed in Table 1 and derived from Table 7 and Figure 9 show a maximum of approximately 30 feet (at TW-10). Please verify the thickness of the overburden and correct the text as necessary.

Response: Text has been modified. This description was a carry-over from the prior USEPA RI/FS text.

Comment 2: *Page 5, Section 2.1.3, first paragraph – Given that groundwater occurs at the bedrock/overburden interface, the language in this section indicates a maximum overburden depth of 20 feet. Please review the following language and correct/clarify as needed: "The thicker sections of overburden, such as those in the vicinity of the former BAE and former Stabilus properties, have historically contained a saturated zone of approximately 3 to 10 feet in thickness year-round. The depth to groundwater in this overburden unit has historically ranged from 4 to 10 feet below grade."*

Response: The language is correct; as the maximum of those two values is a total of 20 feet (10 saturated zone plus 10 feet depth to groundwater).

Comment 3: *Page 5, Section 2.1.3, second paragraph, first sentence – The overburden groundwater elevations shown on Figures 11, 12, and 13 also decrease moving from northeast to southwest. Provide an explanation of why the potential southwesterly movement of groundwater is being discounted.*

Response: Within the OU2 unconfined aquifer, groundwater flow has both vertical and horizontal components and is generally controlled by the structural surface of the bedrock trough that has been delimited and characterized through the investigations to date. Our interpretation of the groundwater flow directions is based on the depth to water measurements collected in the field during the PDI and on our understanding of the structural features controlling flow. Figures 11, 12 and 13 are representative of the groundwater potentiometric surface at the time of their respective groundwater depth measurements.

Comment 4: *Page 11, Section 3.1, last bullet – Please correct year date 2012 to 2013.*

Response: Corrected.

Comment 5: *Page 12, Section 3.2.1, last paragraph on page – Please explain why step-off locations were not advanced for TW41, TW42, and TW43.*

Response: The field selection of step-off locations was informed through our knowledge of the subsurface structure and conditions in the field in real time. Our approach and the step-off logic were discussed with USEPA and/or their contractors during the PDI. Step-off

locations were not advanced for TW42 and TW43, because proximal locations TW32 and TW44 were dry and are closer to the deeper portion of the bedrock trough. Given the topography of the bedrock, a step-off south of TW44 (TW44A) produced water, and a step off east of TW32 produced water, which aligns with the bedrock trough. Completing a step-off in the other direct push points in this area was not necessary as the depths of refusal continued to become shallower.

Similarly, TW41 was dry and a step-off was not completed as this location was oriented in the direction of bedrock strike and locations at which TCE was not detected.

Comment 6: *Page 13, Section 3.2.2, second paragraph – Consider revising the last sentence of the second paragraph; it is confusing.*

Response: Disagree. Language is clear.

Comment 7: *Page 13, Section 3.2.2, second bullet – Please clarify the meaning of the phrase "stabilized water level greater than 0.3 feet" at the end of the last sentence. Is this intended to mean drawdown greater than 0.3 feet?*

Response: The water level was maintained within 0.3 feet from the starting groundwater elevation. Therefore, drawdown was maintained to be less than 0.3 feet; or as stated in the text, groundwater elevation (i.e., level) was greater than 0.3 feet. Groundwater drawdown is a measure downwards, and groundwater elevation / level is a measure upwards.

Comment 8: *Page 13, Section 3.2.2, first sentence of last paragraph – Replace "observation of first water" with "infiltration of groundwater" to clarify the statement.*

Response: Replaced.

Comment 9: *Page 14, Section 3.2.2, last sentence – Change the word "sampled" to "samples".*

Response: The word in the narrative was already "samples", no change necessary.

Comment 10: *Page 15, Section 3.2.4, second paragraph – Replace "has been delineated as shown on Figure 6" with "is shown on Figure 6." The word "delineation" implies that the plume boundaries have been defined. As shown on Figure 6, the plume is not defined to the TCE MCL west or north of the westernmost sample locations.*

Response: Text has been modified as requested.

Comment 11: *Page 15, Section 3.2.4, third paragraph – Recommend collecting samples north of TW45, which has an unbounded TCE detection of 34 μg/L, north of TW49, and west of TW51.*

Response: The delineation samples recommended within the 60% Design meet the requirements of the UAO / Interim ROD. These additional samples are not necessary to define the 100 µg/L OU2 overburden aquifer treatment zone, and will not be collected.

Comment 12: *Page 15, Section 3.2.4, fourth paragraph – Eliminate this paragraph. The DCE and TCE concentration data do not necessarily indicate the presence of "two distinct sources". There are no gaps in the TCE or DCE plumes, and the single result from TW04 (which shows almost 500 µg/L of TCE and 58 µg/L of DCE) should not be used to conclude that there are two distinct sources. The somewhat lower concentrations at the TW04 location could also be the result of heterogeneity of the bedrock (no fractures in the area) or overburden.*

Response: When taken with the historic data, the CSIA results indicate two vintages of TCE along with the two elevated concentration areas, and further evidenced by knowing TCE concentrations existed in this northwestern corner of the former BAE facility predating Stabilus. There is a strong likelihood of two sources. As discussed during the 22 and 23 January 2014 technical calls, the word "may" was added to the narrative.

Comment 13: *Page 16, Section 3.3.1, first paragraph – Change "no measure" to "no readings".*

Response. Changed.

Comment 14: *Page 17, Section 3.3.3, first paragraph – Delete the word "marginal" from the second sentence. Based on the data on table 6, SSL for TCE was exceeded at locations SB02 through SB09, but the text indicates that the sample from SB01 also exceeded the TCE SSL. Correct the text to reflect or the table so that they are consistent. Separately, the MCL-based SSL is more than an order of magnitude higher than the risk-based groundwater protection SSL. Provide the rationale for using the higher number.*

Response: Changed. As noted during the 22 and 23 January 2014 technical calls, the focus of the soils investigation was to understand the concentration of TCE within soils for remedial action.

Comment 15: *Pages 18 and 19, Section Headings 3.5, 3.5.1, and 3.5.2 – Change "Groundwater Monitoring" to "Groundwater Elevation Monitoring".*

Response: Changed.

Comment 16: *Page 20, Section 3.6, last sentence – Eliminate the word "planned" if the microcosm construction, incubation, sampling, and analysis were carried out as indicated in the 30% design. Otherwise, indicate any method variations and reasons for the variations.*

Response: The word "planned" is appropriate here as the planned approach was documented within the 30% Design which is referred to within this sentence. The details of the executed treatability study were presented within the 60% Design.

Comment 17: *Page 21, Section 3.7, first paragraph, first sentence – Please revise to avoid the implication that the TCE plume boundary has been delineated. As shown on Figure 6, the plume has not been defined to the TCE MCL along its western boundary and north of TW45 and TW49. If delineation is referring only to the 100 µg/L contour, then this definition of delineation needs to be clarified in the report.*

Response: The delineation of TCE to 100 µg/L is the requirement of the UAO and Interim ROD for the implementation of the OU2 overburden aquifer remedy. Text has been modified.

Comment 18: *Page 21, Section 3.7, first paragraph – If groundwater flows predominantly along the overburden/bedrock interface as stated in the text, please explain the groundwater flow directions shown on Figures 11, 12, and 13, which are approximately perpendicular to the trough. This clarification is also important given that groundwater elevations also decrease toward the southwest.*

Response: See response to "Specific Comments – Comment 3".

Comment 19: *Page 21, Section 3.7, first paragraph – Why was a maximum saturated thickness of 5 feet assumed? Section 2.1.3 indicates that saturated zone thickness has been historically between 3 feet and 10 feet. A table or figure with the observed or calculated saturated zone thicknesses should be added to back up this assertion. Comment applies to Section 4.1 and throughout all calculations.*

Response: The range of elevation or potentiometric elevation of groundwater can be as high as 10 feet, but as noted in the text the groundwater flow is predominantly within the lower portion of the overburden aquifer. The groundwater flow zone within the overburden aquifer is believed to be approximately 5 feet on average.

Comment 20: *Page 23, Section 3.8, Bullet 5 – Change "and only slightly exceed the USEPA Region 3, 6, 9 PGW-MCL value for TCE of 0.0018 mg/kg" to "but they exceed the USEPA Region 3, 6, 9 PGW-MCL value for TCE by an order of magnitude or more in multiple areas". Most TCE results are one to two orders of magnitude greater than the stated SSL.*

Response: See response to "Specific Comments – Comment 14".

Comment 21: *Page 25, Section 4.1, first paragraph, second sentence – The buffering solution has been omitted from the amendments. Please modify the text to specify the buffering solution that will be used.*

Response: The buffering solution to be used will be included within the Revised Design Criteria Report as part of the 90% Design. The text has been modified to add the word "buffered" where appropriate when electron donor and EVO are mentioned to avoid confusion.

Comment 22: *Page 25, Section 4.1, first paragraph, third sentence – The text incorrectly indicates that the "extent and location of TCE within the OU2 overburden aquifer is presented on Figure 6." The TCE contamination has only been characterized to the 100 µg/L level and additional TCE contamination is likely present in the overburden but not depicted on Figure 6. Modify the text to reflect this.*

Response: Per the UAO and Interim ROD, the OU2 Overburden Groundwater Aquifer remedy is only required to treat to the 100 µg/L contour; thus, this is a correct statement given the PDI was completed to delineate the area for the RA. The text has been modified.

Comment 23: *Page 25, Section 4.1, first paragraph, fourth sentence – Add the word "proposed" before EISB treatment area.*

Response: Agreed. Text has been modified as requested.

Comment 24: *Pages 25 and 26, Section 4.1, third paragraph – The proposed amendment distribution method does not appear to be the most appropriate to achieve maximum radial distribution. It seems more likely that the amendments will travel downward into bedrock fractures and upward into the disturbed trench materials before they move outward into the undisturbed overburden. While movement along the bedrock/overburden interface is also possible, the document does not describe what mechanism would then drive amendments up into the low permeability contaminated overburden after it has spread along the interface. Please modify the text to address these issues and consider other methods of delivering amendment to the contaminated low permeability overburden areas.*

Response: The trench application is the most appropriate for low permeability soils. As presented during the 6 November 2013 technical meeting the trench approach has the following benefits:

- increase the flux, as more surface area with the overburden aquifer,
- larger interface with lower overburden-bedrock interface zone,
- allow for the gravity displacement of buffered EVO,

- apply buffered EVO over a longer period of time and higher volume, and
- easier re-application and addition of buffered EVO as needed.

Further details regarding the trench application will be included within the Revised Design Criteria Report as part of the 90% Design.

Comment 25: *Page 26, Section 4.1, EISB Implementation Sequence – The buffering solution has been omitted. Please modify the text to specify the buffering solution that will be used, when it will be added, and how much will be added.*

Response: The buffering solution was not omitted by was implied as part of the EVO application based upon the EISB treatability testing results. As discussed during the 22 and 23 January 2014 technical calls, the EISB Implementation Sequence will be modified to clarify the use of a buffering solution within the Revised Design Criteria Report as part of the 90% Design

Comment 26: *Page 27, Section 4.2.2 – Add RCRA requirements as necessary to address possible transportation and disposal of contaminated trench spoils and other waste materials.*

Response: Agreed. Will be included within the Revised Design Criteria Report as part of the 90% Design

Comment 27: *Page 32, Section 4.3.3, first paragraph, last sentence – Indicate whether flushing will be done with water or whether some amendment will be added.*

Response: Details of the timing and amendments will be included within the Operations and Maintenance Manual and Revised Design Criteria Report as part of the 90% Design.

Comment 28: *Page 35, Section 5.1, fourth bullet – The design assumes that water in well RI27D is appropriate for use in preparing the amendment solution. The text should indicate the basis for this assumption. Has testing of this well been completed to confirm this assumption? If not, when will such testing be performed? If so, when was the well sampled, and do the analytical results demonstrate that the groundwater will be suitable for use as makeup water?*

Response: See comments above to "RPM – Comment 12". Will be incorporated into the 90% Design and will be a requirement of the RA Contractor to confirm and have a contingency for water if necessary.

Comment 29: *Page 35, Section 5.1, fifth through eighth bullets – When will these assumptions be confirmed? At the 60% design stage, these factors should be known quantities.*

Response: Per the RDWP, the RD submitted as part of the 60% Design was a Preliminary RD. These assumptions will be confirmed as part of the 90% Design.

Comment 30: *Page 37, Section 5.1.2 – Per page 36, 11.2 EVO batches will be injected through the infiltration trench. After multiple batches have been injected, one batch will be bioaugmented and then the remaining batches will be injected. How will the timing of the bioaugmented batch be determined? Will it be based on field parameter monitoring in the overburden wells located near the trench centerline?*

Response: The KB-1 will be added when the conditions for the OU2 overburden aquifer are sufficiently anaerobic. Details of the timing for the bioaugmented batch will be provided within the Operation and Maintenance Manual as part of the 90% Design.

Comment 31: *Page 38, Section 5.2.1, third paragraph, second sentence – Given that geotechnical analysis was conducted on only one sample from one boring, how was the determination made that the "overburden soil is consistent across the Site"? Provide the basis of this determination.*

Response: Geosyntec advanced borings across the Site and had the benefit of evaluating and observing the properties of the overburden soils at each location. The soils were analyzed at one location to confirm these visual observations and the preponderance of lithological interpretation collected by Geosyntec and other investigations over decades describing soils as silts and clays provides the basis of our statement reading the general consistency of the overburden soils. The low hydraulic conductivity observed during low flow sampling and development of the wells, visual observation of the soil lithology during the completion of the various soil borings, and observation of standing water on the ground surface for days following a rain event confirmed that the soils are of a low permeability.

Comment 32: *Page 38, Section 5.2.1, third paragraph – Describe the lithology and soil characteristics of the "zone of unquantified thickness".*

Response: Text has been added.

Comment 33: *Page 42, Section 8.1 – The first paragraph identifies installation of 10 new overburden wells, but 11 new overburden wells are specified in Section 8.2.1. Please resolve this discrepancy.*

Response: Based upon the 22 and 23 January 2014 technical calls a total of 11 new overburden monitoring wells will be installed. These include 10 performance monitoring wells, and 1 additional well north of the former loading dock area. Therefore, both are correct. 11 new overburden wells will be installed, and 10 of these wells will be used to

monitoring the Phase 1 EISB performance. The text has been modified to provide further clarity.

Comment 34: *Page 43, Section 8.2.1, first bullet – Reword this sentence for clarity. Also, the last well should be 25 ft (not 20 ft) from the centerline of the trench according to Drawing 3 and previous discussions with the PRP.*

Response: Sentence has been reworded. The drawings will be updated as part of the 90% Design.

Comment 35: *Page 45, Section 8.3.2 – Schedule 80 PVC is not required for these well depths. Explain the need for this material.*

Response: Disagree. The deeper wells constructed with Schedule 40 PVC may not run true vertically. Schedule 80 PVC is recommended to minimize the well from bending during installation.

Comment 36: *Page 48, Section 8.8, fifth sentence – Eliminate the sentence, "The success of the remedy as a whole is dependent upon successful distribution of the biostimulant." While the statement is true to some extent, the overall success of the remedy will be to achieve the cleanup requirements specified in the ROD.*

Response: Agreed. Sentence has been deleted.

Comment 37: *Figure 8 – Eliminate the BAE and Stabilus labels from the figure. The data, particularly those from the TW03 and TW06 samples, do not support the assignment of different CSIA results to different companies.*

Response: Disagree. The CSIA results clearly indicate that there at two distinct types of TCE present within the OU2 overburden aquifer. As Stabilus has documentation that they consistently used the same vendor and distributor, the less degraded TCE (~-22) is probably from their operations. The older TCE (~ -19) which is more degraded is from historic operations that were present in the OU2 area prior to Stabilus existence at the Site. Given the only historic operations that existed prior to Stabilus in this area were conducted by BAE, the other source is very likely from BAE. Additionally, there was observed area wide TCE contamination observed in this area within very shallow bedrock within months of Stabilus beginning operations. Given the very low permeability of the overburden aquifer, this TCE is likely from other sources. BAE was the former owner of the Stabilus parcel as well as the Whistlestop Park parcel, which has and currently still has TCE present. Again, the variability in the observation of TCE signature could easily be from historic spills or

releases in the area prior to the addition of the Stabilus release, and comingling of the two TCE plumes with time.

Comment 38: *Appendix H, Drawing 3 – An EISB application well is included outside of the trench on this drawing. Application of amendments through such a well is contrary to the method proposed in Section 4.1. Correct the drawing, or modify the text to be consistent.*

Response: The drawing will be corrected as part of the 90% Design.

Comment 39: *Appendix H, Drawing 6, EISB Trench Details – Please indicate how far above the bedrock the pea gravel will extend on Section A. Also, on Section A, "clean fill" is shown overlying the pea gravel, but on Section B, either "clean fill or excavated soil" is shown overlying the pea gravel. Please ensure consistency between the two sections.*

Response: The drawings will be clarified as part of the 90% Design.

CLOSING

If you have any questions, please do not hesitate to contact me.

Sincerely,

Derek W. Tomlinson, P.E.
Project Coordinator

Attachment: Revised 60% Design dated 17 February 2014
Redline Revised 60% Design dated 17 February 2013 *(via email only)*

cc: Dennis Kutz, PADEP *(via email & 1 hardcopy first class mail)*
M. Joel Bolstein, FoxRothschild
Chris Voci, P.G., Geosyntec
File: PH0013

Geosyntec
consultants

CERTIFICATION

Except as provided below, I certify that the information contained in or accompanying this Intermediate Design Submittal / Pre-Design Investigation Report and Preliminary Remedial Design (60% Design) is true, accurate, and complete.

As to those portions of this 60% Design for which I cannot personally verify their accuracy, I certify under penalty of law that this 60% Design and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature: _____

Name: CRAIG POSPIECH

Company: STABILUS, INC.

Title: CFO

Date: 2.17.14

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Appendix C: Volatile Organic Compounds and General Chemistry Laboratory Analytical Reports – Lancaster Laboratories, Inc.

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Sheet 2: Site Plan – Existing Features

Sheet 3: Site Plan – EISB Application

Sheet 4: Process Flow Diagram

Sheet 5: EISB System Equipment Layout

Sheet 6: EISB Trench Details

Sheet 7: Well Construction Details

LIST OF ACRONYMS

cDCE	cis-1,2-dichloroethene; cis-1,2-dichloroethylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	chemicals of concern
CSI	Construction Specification Institute
CSIA	compound specific isotopes analysis
CSM	conceptual site model
Dhb	Dehalobacter
Dhc	dehalococcoides
DHG	dissolved hydrocarbon gases
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
EISB	enhanced in situ bioaugmentation
EVO	emulsified vegetable oil
feet bgs	feet below ground surface / feet below grade
FS	Feasibility Study
FSP	Field Sampling Plan
ft	feet
HAS	hollow stem auger
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
MNA	monitored natural attenuation
µg/L	microgram per liter
NP5	North Penn Area 5
NPL	National Priorities List
NPWA	North Penn Water Authority
O&M	operation and maintenance
ORP	oxidation-reduction potential
OU	operable unit
OU1	Operable Unit 1

LIST OF ACRONYMS
(continued)

OU2	Operable Unit 2
OU3	Operable Unit 3
PADEP	Pennsylvania Department of Environmental Protection
PCE	tetrachloroethene; tetrachloroethylene; perchloroethene
PDI	pre-design investigation
PFD	process flow diagram
PID	photo-ionization detector
PRP	Potential Responsible Party
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance and quality control
QC	quality control
RA	Remedial Action
RAO	Remedial Action Objectives
RD	Remedial Design
RD/RA	Remedial Design and Remedial Action
RDWP	Remedial Design Work Plan
redox	oxidation-reduction
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
TCE	trichloroethene, trichloroethylene
TEA	terminal electron acceptor
TOC	total organic carbon
UAO	Unilateral Administrative Order
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VC	vinyl chloride

LIST OF ACRONYMS
(continued)

vcrA	vinyl chloride reductase
VOCs	volatile organic compounds
WMP	Waste Management Plan

1 INTRODUCTION

This Intermediate Design Submittal / Preliminary Pre-Design Investigation (PDI) Report and Preliminary Remedial Design (the "60% Design") was prepared by Geosyntec Consultants, Inc. (Geosyntec) on behalf of Stabilus, Inc. (Stabilus), a named Respondent to the Unilateral Administrative Order (UAO) Docket No. CERCLA-03-2012-0205DC dated 26 June 2012 (USEPA, 2012), for the interim remedy selected by the United States Environmental Protection Agency (USEPA) for Operable Unit 2 (OU2) of the North Penn Area 5 Superfund Site in Hatfield and New Britain Townships (aka, Colmar), Montgomery and Bucks Counties, Pennsylvania (the "Site" or "NP5 Site", Figures 1 and 2).

This 60% Design is being submitted to the USEPA pursuant to Section VI Paragraph 25.b of the UAO and as detailed within the 29 January 2013 Remedial Design Work Plan (RDWP; Geosyntec, 2013a). The UAO was issued for the completion of the Remedial Design (RD) and Remedial Action (RA) to implement the 7 September 2011 Record of Decision (Interim ROD) for the enhanced *in situ* bioaugmentation (EISB; USEPA, 2011) interim remedy. The USEPA selected the EISB remedy to address elevated levels of volatile organic compounds (VOCs), which have been historically detected in the OU2 overburden groundwater.

As outlined in the RDWP, this 60% Design is the second of the four submittals of the detailed design sequence. The PDI results and a presentation of the preliminary RD elements are detailed herein. The 60% Design incorporates the elements of the design criteria, basis of design, preliminary design drawings, outline of the design specifications, a performance monitoring well network work plan, and a preliminary construction/remedial action schedule.

1.1 Remedial Design Objectives

The objectives of this 60% Design are to: 1) present the results and findings of the PDI; and 2) provide the major design elements of the selected remedy within the context of the Remedial Action Objectives (RAOs) that were established by USEPA in the OU2 Interim ROD. The RAOs for the interim OU2 EISB remedy are as follows:

- Reduce a source of contamination by restoring groundwater quality in the treatment area of the overburden to maximum contaminant levels (MCLs) established under the Safe Drinking Water Act;
- Prevent or minimize further migration of contaminants from the overburden; and
- Prevent future exposure to contaminated groundwater at concentrations above MCLs.

1.1.1 Pre-Design Investigation Objectives

The PDI was conducted to collect updated data relative to the current nature and extent of VOCs in the OU2 overburden groundwater. These data are used to define the EISB treatment zone,

identify locations of the EISB RA and to aid in the design of the performance monitoring well network.

Additionally, an EISB treatability study was performed as part of the PDI and was required by the ROD to demonstrate the viability of the EISB remedy, to obtain data to support the EISB design and determine the best mix of nutrients and microbial cultures required to optimize biodegradation processes and achieve performance standards in-situ.

1.1.2 Remedy Design Objectives

The primary objectives of the RD are to gather supplemental information at OU2, perform engineering evaluations to support the preparation of construction drawings and specifications to achieve the RAOs through EISB and to meet the other performance standards and requirements set forth in the Interim ROD and UAO, and summarized within the RDWP (see RDWP Section 1.4). The preliminary RD presented herein has been developed with these RAOs and remedy performance standards as the goal of the implemented RA.

1.2 Report Organization

This 60% Design is organized as follows:

- **Section 2**: Background Information. An overview of the OU2 layout, geology, hydrogeology, geology, regulatory history, and historic Site conditions.
- **Section 3**: Pre-Design Investigation Report. Summarizes the results from the OU2 overburden groundwater investigation and EISB treatability study.
- **Section 4**: Preliminary Design Criteria Report. Discusses the approaches, parameters, and assumptions that will be used such that the design of the remedy meets the performance standards of the Interim ROD, UAO and applicable requirements.
- **Section 5**: Basis of Design Report. Provides justifications for the design assumptions and provides a project delivery strategy.
- **Section 6**: Preliminary Remedial Design Drawings. This section presents the preliminary plans and details of the remedy components as well as a list of the drawings to be developed in subsequent design phases.
- **Section 7**: Specifications Outline. Presents an outline of the construction specifications required for each element of the remedy.
- **Section 8**: Performance Monitoring Well Network Work Plan. Presents details regarding the design, locations, construction, and specifications of the overburden and

shallow bedrock monitoring wells to be installed to monitor the performance of the EISB remedy.

- **Section 9**: Preliminary Construction/Remedial Action Schedule. Provides preliminary schedule highlighting the critical path, anticipated sequence, and duration of the major construction and RA-related activities.

- **Section 10**: References.

2 BACKGROUND INFORMATION

Detailed information on the Site history is presented in Section III of the UAO, Section II of the ROD for OU1 and OU3, and Section II of the Interim ROD for OU2 (USEPA, 2011, 2004, and 2012). Background information relative to the OU2 interim remedy is discussed below.

2.1 Site Description

The Site layout and setting, geology and hydrogeology are summarized below.

2.1.1 Layout and Setting

The NP5 Site is located within Hatfield and New Britain Townships, in Montgomery and Bucks Counties, Pennsylvania (Figure 1). NP5 encompasses an area of approximately five square-miles that is generally bounded by Richardson Road to the southeast, Bethlehem Pike (Route 309) to the west, Trewigtown Road to the northwest and Schoolhouse Road to the east (Figure 2). The focus of the Interim ROD and UAO is the area located in the vicinity of Stabilus and the former BAE facilities and Whitlestop Park shown as the OU2 area on Figure 3.

Although the NP5 Site is within an area comprised of commercial and industrial businesses, residences, undeveloped woodland properties, parkland and farmland, the area where the interim remedy is to be performed at OU2 is in the vicinity of the former Stabilus and former BAE industrial properties. The topography within OU2 slopes gently from the northwest and southeast toward the West Branch of the Neshaminy Creek. Large portions of OU2 are relatively flat-lying from grading associated with construction or agriculture. The major surface water bodies in the vicinity of OU2 include the West Branch of the Neshaminy Creek, its Western and Eastern tributaries, and an unnamed tributary to the Neshaminy Creek as shown on Figures 1 and 2.

2.1.2 Geology

The NP5 Site is located within the Triassic Lowlands section of the Piedmont Physiographic Province and is underlain by sedimentary rocks of the Brunswick and Lockatong Formations of the Newark Supergroup. Bedding in the Newark Supergoup generally strikes northeast and dips to the northwest. These formations have been well studied by the United States Geological Survey (USGS) and others through investigations of regional groundwater contamination over the last three decades. The Brunswick and Lockatong Formations are part of a homoclinal structure that strikes northeast to southwest and dips from approximately 20° to 30° to northwest (Bird and Conger, 2002; Riser and Bird, 2003; Bird, 2006). The lower beds of the Brunswick Formation consist of red to reddish brown and gray to greenish-gray mudstones, clay, and mud-shale. The bedding is irregular and wavy. The Lockatong Formation rocks are thinly-bedded and evenly-bedded shale and siltstone that are medium to dark gray and olive to greenish-gray.

Bedrock beneath the Site is mantled with an overburden (regolith) comprised of silt, clay, and some sand. The regolith was formed through the gradational weathering of the underlying sedimentary bedrock. The overburden is typically 10 to 30 feet thick and generally more competent and less permeable with depth. The upper portion of the overburden is typically unsaturated; however saturated conditions do occur within the overburden. Generally, the base of the overburden and the thicker sections of overburden are perennially saturated during normal precipitation conditions. The overburden groundwater within OU2 is the subject unit of the PDI and associated EISB remedy.

Site-specific investigations confirm that the bedrock surface beneath the OU2 overburden forms a trough or shallow basin. This feature is significant with respect to the overburden thickness and the resulting distribution of VOCs in saturated soils. The alignment of the bedrock trough trends along bedrock strike. Highs in bedrock surface elevation straddle the bedrock trough. A high in bedrock surface elevation may also be present along the line of the bedrock trough southwest of the former Pond Area. Further details regarding the trough and the updated conceptual site model are presented in Section 3.7.

2.1.3 Hydrogeology

The overburden is largely unsaturated, but does contain groundwater at its base above the bedrock, especially during periods of higher seasonal recharge. Groundwater originates from infiltration of local precipitation through the overburden into the bedrock fracture network, and eventually discharges to surface water features (i.e., streams, rivers). Bedrock groundwater may also recharge the overburden as evidenced by upward vertical gradients in bedrock monitoring well pairs. The thicker sections of overburden, such as those in the vicinity of the former BAE and former Stabilus properties, have historically contained a saturated zone of approximately 3 to 10 feet in thickness year-round. The depth to groundwater in this overburden unit has historically ranged from 4 to 10 feet below ground surface (feet bgs).

The groundwater flow direction in the OU2 overburden unit is locally variable, with both vertical upwards and downwards flow with flow in a westerly to north-westerly direction. Factors influencing the overburden groundwater flow direction include the permeability of the regolith and the presence of relict rock fabric (former bedrock bedding planes and joints) in the weathered bedrock portions of the overburden. OU2 overburden groundwater may flow horizontally along the interface between the bedrock and the overburden and would thus follow the topography of the bedrock surface until it drains under gravity. Once in the bedrock fracture system, groundwater flows through the vertical joints and horizontal fractures in the shale and siltstone bedrock. Groundwater may occur under confined or unconfined conditions within bedrock depending upon the thickness of the overlying overburden.

The bedrock has low primary porosity, but moderate to high secondary porosity via a network of fractures, bedding-planes, and high-angle joints throughout which groundwater exists and can flow vertically and horizontally. Most of the water-bearing fractures are located within the upper

80 to 100 feet of the surface. The frequency of bedrock fractures generally decreases with depth. The shallow portion of the bedrock aquifer consists of a fracture zone that exists at depths of approximately 90 to 100 feet below the surface. The depth to groundwater in this aquifer has historically varied from 10 to 30 feet bgs. Groundwater flow in this aquifer has been influenced by the local bedrock structure and in response to gradients induced by historic regional pumping. Historically, groundwater in this portion of the aquifer generally flows in a direction similar to topographic gradient generally towards the West Branch Neshaminy Creek and its tributaries. Groundwater flow north of the West Branch Neshaminy Creek is generally southeasterly, and groundwater flow south of the creek is generally northeasterly. Groundwater in this portion of the aquifer eventually discharges to the surface streams or provides recharge to the deeper aquifer system.

The deeper portion of the bedrock aquifer consists of the fracture zone greater than 100 feet below the surface to an approximate maximum depth of 500 feet. The geology and groundwater flow conditions of the deeper portion of the bedrock aquifer are similar to that of the shallower, albeit with fewer water-bearing fractures.

2.2 Overview of OU2 Regulatory History

NP5 was first identified in 1979 with the detection of VOCs in groundwater from North Penn Water Authority (NPWA) supply well NP-21. In 1986, USEPA completed an assessment of contamination in the NP5 area. Based on the results of the 1986 assessment, USEPA proposed the Site to be listed on the National Priorities List (NPL) on 22 January 1987. On 31 March 1989, USEPA finalized the listing of the Site on the NPL. For NP5, three primary areas of groundwater contamination were identified and defined as separate and distinct operable units (OUs). Per the UAO, the general location of OU1, OU2 and OU3 are described as follows:

- **OU1:** located at and in the vicinity of the property located at 305 Richardson Road in Colmar, Pennsylvania, formerly owned and operated by BAE, and currently owned and operated by Sensor and Antenna Systems Lansdale, Inc. (Sensor) with portions that may extend to other properties. USEPA identified BAE as the sole responsible party at OU1;

- **OU2:** located at and in the vicinity of three industrial properties, including the industrial property located at 92 County Line Road in Colmar, Pennsylvania, currently operated by Constantia Colmar, Inc. (Constantia) and formerly operated by Stabilus, the industrial property located at 305 Richardson Road, formerly owned and operated by BAE, and the industrial property located at 4379 County Line Road owned and operated by Kema-Powertest, with portions that may extend to other properties. USEPA issued general or special notice letters for OU2 to Stabilus, BAE, Honeywell, Inc., Kema-Powertest, ZF Sachs Automotive of America, Inc., Constantia, County Line Land Limited, and County Line Land Corporation; and

- **OU3:** located in the vicinity of Advance Lane and Enterprise Lane in Colmar, Pennsylvania. USEPA identified no potential responsible parties (PRPs) for OU3.

USEPA initiated a fund-lead Remedial Investigation and Feasibility Study (RI/FS) in 1998, under which the USEPA studied a five square-mile area that included properties associated with eight commercial businesses. The RI revealed that trichloroethene (TCE) and related VOCs are present in the groundwater at each OU (USEPA, 2002a, 2002b, 2002c, and 2003).

In 2002, USEPA issued a proposed remedial action plan (PRAP) setting forth its preferred remedy for each OU at the Site (USEPA, 2002d). After reviewing the extensive comments submitted during the public comment period, USEPA decided to reassess the preferred remedy for OU2. In June 2004, the USEPA issued a ROD for OU1 and OU3 (USEPA, 2004) to conduct in situ chemical oxidation (ISCO) and pump and treat.

USEPA issued a revised PRAP for interim remedial action at OU2 on 15 September 2008 (Interim PRAP; USEPA, 2008a). The Interim PRAP presented EISB as the interim remedial action for the overburden within OU2 at the former Stabilus property and the former BAE property (Figure 3). The decision by USEPA on the selection of EISB is embodied in the Interim ROD (USEPA, 2011).

The execution of the RD/RA has been required with the issuance of the UAO on 26 June 2012. The RDWP was approved by USEPA on 16 January 2013 (USEPA, 2013a; Geosyntec, 2013a). On 31 May 2013 USEPA approved the Preliminary (30%) Design Submittal / Pre-Design Investigation Work Plan (30% Design; USEPA, 2013b; Geosyntec, 2013b), and on 29 August 2013 USEPA approved the Supplemental PDI Work Plan (Supplemental PDI; USEPA, 2013c; Geosyntec, 2013c).

2.3 Site History

The Site history is well documented within the RI/FS (USEPA, 2002a and 2002b); Supplemental I RI/FS (USEPA, 2002c), Supplemental II RI/FS (USEPA, 2003), PRAP, (USEPA, 2002d), ROD (USEPA, 2004), Interim PRAP (USEPA, 2008a), Interim ROD (USEPA, 2011), and UAO (USEPA, 2012). Specific to the OU2 overburden the two affected properties are the former Stabilus property and the former BAE property. A summary of the ownership history and operations for these two properties follows (USEPA, 2011 and 2012):

- **Former Stabilus Property:** The former Stabilus property encompasses an area of approximately 11 acres. From 1979 to 1998, Stabilus (formerly Stabilus/Gas Springs Company) manufactured gas pistons or shock absorber type “springs” utilized in automobile hatch-backs, gates and trunks. From 1953 to 1979, approximately 4 acres of the southern portion of the property, which is an area included in the interim remedy for OU2, was owned by Tracor Aerospace Systems, Inc./American Electronic Laboratory,

the predecessor to BAE. Constantia Colmar Group, formerly part of H&N Packaging, Inc., has operated on the property since 1999.

- **Former BAE Property:** The former BAE property is a 67-acre property consisting of an electronics manufacturing and testing facility that began operations in 1953. From 1953 to 2008, the property was owned and operated by BAE Systems Information and Electronics Systems, Inc., and is formerly known as Marconi Aerospace Electronic Systems, Inc., Tracor Aerospace Systems, Inc., and American Electronics Laboratory. Historically, the operations included degreasing, anodizing, and nickel, copper, tin, and lead plating. Several buildings on the Site contained operations, which included a plating shop and a plating effluent waste treatment facility and product testing. Since February 2008, Sensor has owned the property and operates as Cobham Defense Electronics.

2.4 Historic Site Conditions

Specific to the OU2 overburden, VOCs were detected in overburden groundwater beneath the former Stabilus property and the former BAE property as presented in the Supplemental II RI/FS (USEPA, 2003) and shown on Figure 3. The 2003 USEPA investigation identified two areas of observed elevated levels of TCE; one near the loading dock of the former Stabilus property; and the other located within the former BAE property near W4 and RI31. A suspected source of TCE identified near the former Stabilus property loading dock has been attributed to a spill caused by Baron Blakeslee, Inc., later Honeywell, which is identified in Section III Paragraph 9.e of the Findings of Fact in the UAO.

Based on a review of the public records for NP5 and as noted in the USEPA-prepared documents, (including the Responsiveness Summary issued by USEPA with the Interim ROD in September 2011 [USEPA, 2011]) USEPA has not identified a specific source for the elevated level of TCE in the overburden on the former BAE property. An objective of the PDI described herein is to resolve the nature and extent of groundwater contamination at OU2, including possible sources heretofore unidentified within the OU2 overburden groundwater.

3 PRE-DESIGN INVESTIGATION (PDI) REPORT

This PDI report presents data relative to the current nature and extent of VOCs in the OU2 overburden groundwater at the Site, and provides the EISB treatability study methods and results. The PDI activities included collection of soil and groundwater samples from the OU2 overburden aquifer and completion of an EISB treatability study. The data presented herein was used to define the EISB treatment zone and informs the planned OU2 overburden groundwater aquifer EISB remedy design and implementation. The information gathered during the PDI was evaluated with the prior RI data to complete the OU2 overburden delineation, provide the basis for a revised OU2 overburden aquifer CSM and to enable the completion of the Preliminary RD for the EISB remedy and performance monitoring well networks.

The PDI Report is organized as follows:

- **Section 3.1.** Field Sampling Schedule. Provides an overview of the tasks completed during each week of the PDI and Supplemental PDI field activities.
- **Section 3.2.** OU2 Overburden Groundwater Sampling. Provides an overview of the groundwater sampling activities including the sampling point installation and observations, summary of the laboratory analytical procedures, and discussion of the results.
- **Section 3.3.** OU2 Overburden Soil Sampling. Provides an overview of the soil sampling activities, summary of laboratory analytical procedures, and discussion of the results.
- **Section 3.4.** OU2 Bedrock Topography. Summarizes the observations of bedrock topography based upon refusal during PDI and Supplemental PDI activities and prior field investigation events.
- **Section 3.5.** OU2 Overburden and Bedrock Groundwater Monitoring. Summary of the synoptic rounds collected of groundwater elevations from the overburden and bedrock wells during the PDI and Supplemental PDI.
- **Section 3.6.** Summary of EISB Treatability Study. An overview of the EISB treatability study results is provided.
- **Section 3.7.** Discussion of Results. Presents a discussion of the results and updating of the conceptual site model (CSM) for the OU2 overburden aquifer.
- **Section 3.8.** Conclusions and Recommendations. Conclusions from the PDI and Supplemental PDI are presented and recommendations for the Preliminary RD and performance monitoring well network are presented.

3.1 Field Sampling Schedule

The PDI field activities required two mobilizations; the first of which occurred from 3 June to 8 July 2013, and the second (Supplemental PDI) from 3 September to 17 September 2013. The Supplemental PDI was necessary to complete the delineation of TCE in the neighboring Whistlestop Park property. Details of the PDI sampling procedures were presented in the 30% Design and the Supplemental PDI (Geosyntec, 2013b and 2013c). The field sampling activities completed during the PDI and Supplemental PDI were as follows:

- Week of 3 June 2013:
  - Sited PDI sampling locations (TW01 to TW40) and located 7 existing monitoring well locations (RI23, RI24, RI25, RI28, RI29, RI30, and RI31).
  - Utility clearance of PDI sampling locations (TW01 to TW40).

- Weeks of 10 and 17 June 2013:
  - Installed and developed monitoring wells TW01 to TW12, including collection of soil samples from TW01/SB01 to TW10/SB10.
  - Completed direct push sampling point locations (TW13 to TW40) from 13 to 21 June 2013, including collection of groundwater samples and abandonment.
  - Collected EISB treatability materials on 17 June 2013, including soil from TW18 and groundwater from TW01 and TW18.

- Weeks of 24 June and 2 July 2013:
  - Collected synoptic round of groundwater elevations from temporary monitoring wells TW01 to TW12 and existing monitoring wells RI23, RI24, RI25, RI28, RI29, and RI30.
  - Collected groundwater samples via low flow methods from temporary monitoring wells TW01 to TW12 and existing monitoring wells RI23, RI24, RI25, RI28, RI29, and RI30.

- Week of 8 July 2013:
  - Completed survey of temporary monitoring wells TW01 to TW12, direct push sampling locations TW13 to TW40, existing monitoring wells within the OU2 overburden groundwater aquifer, and property boundaries.
  - Collected two synoptic rounds of groundwater elevations from temporary monitoring wells TW01 to TW12 and existing OU2 overburden monitoring wells RI23, RI24, RI25, RI28, RI29, and RI30.
  - Completed abandonment of temporary monitoring wells TW01 to TW12.

- Week of 2 September 2013:
  - Site direct push sampling locations TW41 to TW51.

- Completed synoptic round of groundwater elevations of overburden, and shallow and deep bedrock monitoring wells.
- Completed installation and groundwater sampling of direct push sampling point locations TW41 to TW51.

- Week of 9 September 2013:
  - Completed well abandonment of direct push sampling points TW41 to TW51.

- Week of 16 September 2012:
  - Collected synoptic round of groundwater elevations from existing overburden, and shallow and deep bedrock monitoring wells.
  - Completed survey of TW41 to TW51 and remainder of existing monitoring wells within the OU2 groundwater aquifer on former BAE and Whistlestop Park properties.

3.2 OU2 Overburden Groundwater Sampling

A total of 57 sampling locations were installed on the former Stabilus and BAE properties, and Whistlestop Park to delineate VOCs in the OU2 overburden groundwater aquifer. These sampling points supplemented the existing OU2 overburden monitoring wells (RI23, RI24, RI25, RI28, RI29, RI30 and RI31). The locations are shown on Figures 4 and 5, and summarized on Table 1, with soil boring and well construction logs for the TW-series of wells provided in Appendix A. Details of the sampling point installation, groundwater sample collection, laboratory analysis methods, and results are summarized in this section.

3.2.1 Sampling Point Installation

Figure 4 presents the locations of 12 temporary monitoring wells (TW01 to TW12), 39 direct push sampling points (TW13 to TW51), and 6 step off locations (TW26A, TW27A, TW28A, TW29A, TW32A, and TW44A). Soil borings were advanced using a Geoprobe 6620DT direct push track rig by Advanced Drilling, Inc. of Pittstown, New Jersey with oversight by a Geosyntec field scientist.

As summarized on Table 1, many locations were observed to be dry, even after twelve to greater than twenty-four hours after installation. The locations that were dry included: TW26, TW27, TW28, TW28A, TW29, TW32, TW32A, TW41, TW42, TW43, and TW44. These locations were typically at the edge of the bedrock trough feature; thus, aiding in defining the boundaries of the trough feature, which is further discussed in Section 3.4. For the remaining sampling locations, groundwater was typically not observed until the subsurface tooling was advanced to a depth within a few feet on the bedrock surface indicating that most of the OU2 overburden groundwater is near the overburden and bedrock interface under some confining pressure. Further, the first observation of water within most of the temporary monitoring wells and direct push sampling points occurred after a period of twelve hours or more and in some cases the

temporary monitoring wells and direct push sampling points yielded no groundwater. Details for each location are provided in the soil boring and well construction logs in Appendix A.

The PDI groundwater sampling was conducted during a period of record rainfall in southeastern Pennsylvania. Total rainfall data from the Line Lexington Weather Station located 1.5 miles from the former Stabilus property for the months of June 2013 and July 2013 were 12.94 inches and 11.58 inches, respectively (wunderground, 2013), nearly three times the average monthly total precipitation historically observed in this area of 3.98 inches in June and 4.76 inches in July (Weather, 2013). The significant rain events that occurred during the completion of the PDI necessitated modifications to the well construction procedures detailed in the USEPA-approved 30% Design. A 6-inch diameter section of steel casing of approximately 6 to 8-inches in length was inserted into the ground surface and sealed with bentonite at several locations to prevent standing surface water from entering the borehole. Sampling locations installed in the asphalt parking lot were sealed at the surface with a bentonite collar to prohibit surface water from entering the borehole annulus. Further, for temporary monitoring wells (TW01 to TW12), the bentonite seal was extended to ground surface, and for direct push sampling points (TW13 to T51) a bentonite collar around the well point and ground surface was emplaced.

In general, the 30% Design sampling locations were accessed and the temporary monitoring wells (TW01 to TW12) were advanced to the top of bedrock with a few exceptions. TW03 and TW12 were relocated due to refusal (Figure 4). Depth to refusal observed during installation of the temporary monitoring wells is summarized on Table 1, with details of the observations during installation and construction provided in the soil boring and well construction logs in Appendix A. Following well construction, the temporary monitoring wells were allowed to rest for a minimum of 24-hours prior to development following development procedures within the 30% Design.

For direct push sampling points TW13 to TW51, drilling was advanced to top of bedrock and the points were constructed as detailed within the 30% Design, with the addition of a bentonite collar at the surface as noted. Depth to refusal observed during completion of the direct push sampling points is summarized on Table 1, with observations noted during installation and construction provided in the soil boring and well construction logs presented in Appendix A. The direct push sampling points were developed by purging approximately one well volume following installation and prior to sampling in accordance with the 30% Design development procedures.

At temporary monitoring wells or direct push sampling points that were observed to be dry after the 12-hour stabilization period, an additional “step off” boring was advanced at a location approximately 10 feet towards the direction of the bedrock trough center or along the direction of strike. All “step-off” locations were sited in consultation with USEPA’s on-sight representative and achieved consensus with the USEPA project team. A total of six (6) “step-off” locations, direct push sampling points TW26A, TW27A, TW28A, TW29A, TW32A, and TW44A, were advanced due to observed dry conditions (Figure 4). A total of 11 locations were observed to be

dry including: TW26, TW27, TW28, TW28A, TW29, TW32, TW32A, TW41, TW42, TW43, and TW44 (Table 1).

3.2.2 Groundwater Sample Collection

Groundwater samples collected from temporary monitoring wells TW01 to TW12 and existing OU2 overburden groundwater monitoring wells RI23, RI24, RI25, RI28, RI29, and RI30 were collected using low flow sampling procedures in accordance with the 30% Design. Groundwater samples from the direct push sampling points TW13 to TW51 were collected as grab groundwater samples. Due to low groundwater yields observed during completion of the PDI and Supplemental PDI, the 30% Design sampling methods were modified in consultation and field approved by USEPA's field representative. Even with the modifications to the sampling procedures, groundwater sampling was delayed due to the low groundwater yields and the extended groundwater purge times required to collect sufficient groundwater sample volume due to the low permeability of the OU2 overburden aquifer.

Temporary monitoring well locations TW01 through TW12 equilibrated for approximately one week prior to sampling. Low flow groundwater sampling was completed in accordance with the Field Sampling Plan (FSP) of the 30% Design; however, due to the low groundwater yield and low hydraulic conductivity, the low flow sampling protocol was modified. These modifications were necessary because some of the temporary monitoring well screens were not fully saturated, or because groundwater flowed into the wells at rates less than 100 mL/min causing greater than 0.3 feet drawdown. The sampling procedures applied were as follows (low flow log sheets are provided in Appendix B):

- TW03, TW06, TW08, TW09, TW11, RI23, RI24, RI25 and RI29: low flow sampling procedures within the 30% Design were implemented.
- TW07, TW12, TW10, RI28: Due to low yield, well pump placed approximately 0.5 feet from bottom of well and one well volume was purged while maintaining a stabilized water level greater than 0.3 feet.
- TW01, TW02, TW04, and RI30: Due to significant low groundwater yield, wells were purge to dry and allowed to recharge prior to sampling.

The observations during low flow sampling reinforced the low permeability observations during the temporary well installation activities and confirm the low hydraulic conductivity of the OU2 overburden aquifer.

Due to slow observation of first water during the installation of the temporary monitoring wells (TW01 to TW12), instead of waiting only 2 hours to sample as outlined in the 30% Design, a minimum period of 12-hours was allowed to pass before sample collection as approved by USEPA's field representative. This was completed to afford more time for water to flow into the

screened interval. If after 12-hours there was still insufficient water, a "step-off" location was installed. If after the second attempt, the direct push location was also dry, no more attempts were made to sample at that location and that location was noted as being dry as summarized on Table 1. To further minimize surface water and precipitation infiltration, the direct push sampling points were covered with a plastic bag, and 5-gallon plastic bucket during the 24-hour stabilization period. For locations with measured water within the direct push sampling point using a depth to water meter, a discrete groundwater sample was collected from the direct push sampling point using a peristaltic pump. Though the samples collected from the direct push locations were grab samples, the pumping rate to collect these samples had to be slowed to account for the low hydraulic conductivity of the OU2 overburden aquifer.

3.2.3 Laboratory Analytical Procedures

Table 1 summarizes PDI and Supplemental PDI locations where field parameters and laboratory samples were collected. As detailed within the 30% Design and Supplemental PDI, groundwater samples were collected from the temporary monitoring well locations TW01 to TW12 and direct push sampling point locations TW13 to TW51 for analysis for VOCs via USEPA Method 8260B SOM 1.2. Additionally, groundwater samples were collected from temporary monitoring well locations TW01 to TW12 for analysis for the following:

- CSIA (C12/C13 Stable Isotopes) via a UT-SIL laboratory specified standard operating procedure (USEPA, 2008b),
- dissolved hydrocarbon gases (DHG; i.e., methane, ethane, and ethene) via USEPA Method RSK 175,
- alkalinity via USEPA Method SM20 4500 H/B,
- anions via USEPA Method 300.0,
- ferrous iron via Hach kit model IR-18C.

Also, groundwater samples were collected from locations TW01 and TW18 for Gene-Trac® quantitative polymerase chain reaction (PCR). The PCR testing is completed to quantify Dhc populations in groundwater.

The University of Toronto Stable Isotope Laboratory (UT-SIL) of Toronto, Ontario, Canada, performed the CSIA analysis. Lancaster Laboratories, Inc. of Lancaster, Pennsylvania analyzed groundwater samples for VOCs, DHG, alkalinity, and anions. SiREM Laboratory of Guelph, Ontario performed the Gene-Trac® PCR testing. Ferrous iron was measured in the field with a Hach color metric test kit (Hach kit model IR-18C).

Field parameters were measured from all the temporary well points and existing shallow overburden wells, as well as most of the direct push sampling points. Field parameters from the

direct push sampling points was not planned to be collected; however, given the low yield observed during the first day of installation activities a field decision was made to collect this supplemental information to further aid in understand the OU2 overburden aquifer conditions. Field parameters including pH, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen (DO) and temperature were collected using an YSI model YSI 600XL field meter and turbidity was measured using a Lamotte model 2020we. The locations where field parameter measurements were collected are listed on Table 1 and the results summarized on Table 2.

3.2.4 Groundwater Results

Laboratory analytical results are summarized on Tables 3, 4, and 5 for VOCs, general chemistry parameters, and CSIA, respectively. Laboratory reports are provided for VOC and General Chemistry in Appendix C, for CSIA results in Appendix D, and for Gene-Trac® results in Appendix E.

The extent of the TCE plume within the OU2 overburden aquifer has been defined as shown on Figure 6. TCE (maximum in TW19 at 7,200 µg/L) and cDCE (maximum in TW27A at 490 µg/L) were the only two compounds that exceeded their respective MCLs of 5 µg/L and 70 µg/L, respectively.

Per request of USEPA during a meeting on 26 September 2013, additional samples will be collected during a future sampling event to verify the western boundary of the TCE plume on the Whistlestop Park parcel near TW49 and TW50.

The groundwater results may indicate that two distinct VOC source areas exist within the OU2 overburden aquifer. The 500 µg/L TCE isoconcentration contour presented on Figure 6 shows two areas of elevated concentration, one near the former Stabilus loading dock and the other on the former BAE facility. This is further supported by the two distinct cDCE plumes observed with the cDCE isoconcentration map on Figure 7.

Differences in the manufacture and weathering of TCE impart unique isotopic signatures to the compound which can be used to discriminate between TCE sources of differing origin or age. The CSIA analytical results suggests the presence of two vintages of TCE within the OU2 overburden groundwater; one in the range of -19 per mil and the other in the range of -22 per mil. The difference in CSIA results is further illustrated on Figure 8.

Historically, the highest TCE concentrations were identified near the loading dock area in 1998. The TCE concentration in this area during the 2013 PDI sampling was 950 µg/L at location TW18. In 1998, this area had a groundwater TCE concentration of 6,720 µg/L (SB26). Based on the most recent analytical results, the elevated levels of TCE have shifted slightly to the northwest over the period of 15 years; thus, the center of TCE mass has migrated in the down dip

direction over time. Currently the elevated TCE concentration is near TW19 at a concentration of 7,200 μg/L (Figure 6).

The degradation of TCE is largely stalled at cDCE based on the Site data to date suggesting that the Site microbiology lacks the requisite organisms in sufficient population to effect the complete degradation of TCE to ethane at the Site scale. This inference is supported by the Gene-Trac® results provided in Appendix E which indicate that there is not a natural presence of Dhc in the OU2 overburden groundwater aquifer. The vcrA analysis was not completed due to the absence of Dhc.

3.3 OU2 Overburden Soil Sampling

To understand the potential demand for EISB and source loading, soil samples were collected along the length of the VOC plume within the OU2 overburden aquifer. The soil borings SB01 to SB10 were collocated with temporary monitoring wells. These locations are shown as TW01/SB01 through TW10/SB10 on Figure 4.

3.3.1 Soil Sample Collection

Soil samples were collected from the 6-inch interval above the weathered bedrock zone. Photoionization detector (PID) readings were measured through the entire vertical profile with no readings above background. VOC samples were collected directly from the acetate liner using a 5-gram Terra-core sampler. The terra-core sampler was weighed before and after sample collection to ensure approximately 5-grams of soil was collected. Soil sampling was completed in accordance with the 30% Design.

Soil boring depths varied between 8 feet bgs to 22 feet bgs. SB10 was the deepest boring at 30 feet bgs; however, SB10 was located at a higher elevation then the majority of the locations and was outside of the bedrock trough.

The soil encountered at each boring consisted mainly of silt and clay and in most cases was dry through the profile until encountering bedrock. Further details of observations are provided in the soil boring logs included as Appendix A.

As part of the Supplemental PDI, a soil sample was collected to measure permeability and other geotechnical soil properties. The geotechnical soil sample was collected from direct push sampling point location TW41 using the acetate liner of the interval just above the bedrock interface. The acetate-lined cored was packed on both ends and capped. The core was transported in a vertical position by the Geosyntec field manager to GAI/GeoSystems Consultants, Inc. in King of Prussia, Pennsylvania to minimize disturbance of the sample.

3.3.2 Laboratory Analytical Procedures

Soils samples were collected for VOC analysis from TW01/SB01 to TW10/SB10, and for geotechnical parameters from location TW41 (see Figure 4).

Samples collected for VOC analysis were analyzed via USEPA Method 5035 SOM 1.2 by Lancaster Laboratories, Inc. of Lancaster, Pennsylvania.

The geotechnical parameters samples were analyzed by GAI/GeoSystems Consultants, Inc. of King of Prussia, Pennsylvania for moisture content, grain size analysis, bulk density, and soil permeability.

3.3.3 Soil Results

The soil analytical results for VOCs collected from SB01 to SB10 are summarized on Table 6. TCE was the only compound detected with exceedence of the USEPA Region 3, 6, 9 Soil Protection of Groundwater (PGW) MCL based soil screening levels (SSLs). The PGW-MCL SSLs of 0.0018 mg/kg for TCE were exceeded in SB01 to SB09, with concentrations ranging from a maximum 0.12 mg/kg at SB-06 (15 to 15.5 feet bgs) to 0.002 mg/kg at SB-09 (12.5 to 13 feet bgs). The soils results do comply with the ARARs, as none of the soil results exceed the PADEP Act 2 soil to groundwater standard of 0.5 mg/kg for TCE within both a residential and nonresidential used aquifer.

Results from the geotechnical analysis on the sample from TW41 reported the following:

- Moisture content was 17.6%
- Bulk density was 92.5 pounds per cubic foot = 1.474 g/cm^3
- Soil permeability was 5.06 x 10^{-8} cm/sec.

The grain size analysis was also reported and is provided along with the geotechnical laboratory report in Appendix F. The geotechnical analysis confirmed the low yield, infiltration, purging and other anecdotal observations of the low permeability of the OU2 overburden aquifer soils.

3.4 OU2 Bedrock Topography

Shallow overburden soil borings were advanced to the top of the bedrock surface. Refusal depths throughout the study area ranged from 8 to 22 feet bgs. The shallow borings (8 to 12 feet bgs) aligned with the sidewalls of the trough, while deeper borings (16 to 22 feet bgs) were within the bedrock trough feature.

To further refine the bedrock trough topography, historic OU2 overburden direct push sampling completion depths and the observed bedrock depths from existing OU2 overburden and bedrock

monitoring wells were added to the topographic analysis. As shown on Figure 9, the bedrock trough feature follows a similar line as the bedrock strike of North 62° East. The base of the trough undulates with bedrock elevation highs to the east and west, as well as under the former BAE pond to the south. Figure 10 presents an overlay of the TCE isoconcentration contours on to the bedrock topography. This figure indicates that the TCE plume trends along the same line as the deepest part of the bedrock trough where groundwater was observed.

3.5 OU2 Overburden and Bedrock Groundwater Elevation Monitoring

Synoptic rounds of groundwater elevations were collected throughout completion of the PDI and Supplemental PDI field activities. Groundwater elevations were collected from the OU2 overburden aquifer on 24 June 2013, 1 July 2013, and 8 July 2013, and from the OU2 bedrock aquifer on 3 September 2013 and 17 September 2013. To aid in development of groundwater elevation contours, temporary monitoring wells and direct push sampling points, as well as the existing OU2 overburden and bedrock monitoring wells were surveyed by Dennis W. Sklar, Inc., a licensed Pennsylvania surveyor. The temporary and existing monitoring wells within the OU2 overburden and bedrock groundwater aquifer that were surveyed are shown on Figures 4 and 5 and are listed as follows:

- Temporary monitoring wells: TW01 to TW12;
- Direct push sampling points: TW13 to TW51, including the “step-off” locations;
- OU2 overburden wells: RI23, RI24, RI25, RI28, RI29, RI30, RI31; and
- OU2 bedrock wells: RI6S/D, RI18S/D, RI19S/D, RI27S/D, RW4S/I/D, RW5S/I/D, RW6S/I/D, W3, W4, W5, W6, W7, W8, and W9.

3.5.1 OU2 Overburden Groundwater Elevation Monitoring

Groundwater elevations with the OU2 overburden aquifer were gauged on 24 June 2013, 1 July 2013, and 8 July 2013. The wells gauged during each event were as follows:

- Temporary monitoring points: TW01 to TW12; and
- Existing OU2 overburden monitoring wells: RI23, RI24, RI25, RI28, RI29, RI30 and RI31.

Groundwater elevation contours and groundwater flow directions derived and interpreted from measurements collected on 24 June 2013, 1 July 2013, and 8 July 2013, are shown on Figures 11, 12 and 13, respectively. Each map shows a groundwater flow toward the northwest. Despite the significant rain that occurred over the study period, only minor changes in the elevations between gauging events were observed. The predominant northwesterly groundwater flow direction persisted throughout June and July 2013. Horizontal gradients in the overburden

ranged from 0.006 ft/ft to 0.024 ft/ft with an average horizontal gradient of 0.01 ft/ft. Infiltration from surface water does occur because small changes in groundwater elevations were noted at approximately 0.5 foot to 1 foot

3.5.2 OU2 Bedrock Groundwater Elevation Monitoring

The OU2 bedrock aquifer was also monitored during completion of the Supplemental PDI. On 3 and 17 September 2013, groundwater elevations were collected from the existing OU2 bedrock wells as follows:

- OU2 shallow bedrock wells: RI18S, RI19S, RI27S, RW4S, RW5S, RW6S, W3, W4, W5, W6, W8, W9;
- OU2 intermediate bedrock wells: RW4I, RW5I, and RW6I; and
- OU2 deep bedrock wells: RI18D, RI19D, RI27D, RW4D, RW5D, and RW6D.

Groundwater gauging results are provided on Table 7. The groundwater elevations contours for the shallow bedrock groundwater for 3 and 17 September 2013 are shown on Figures 14 and 15, respectively; and, for the deep bedrock groundwater for 3 and 17 September 2013 are shown on Figures 16 and 17, respectively. The groundwater flow direction within both the shallow and deep groundwater aquifers is similar to the overburden aquifer, which is generally in a northwesterly direction.

Upward vertical gradients were observed within well nests RW5, RW6 and RI19, with artesian conditions observed in RW6D. Upward gradients were primarily observed in the southeastern portion of the bedrock trough. Downward vertical gradients were observed in RW4, RI18 and RI27, which were mainly along the shallowest sides of the bedrock trough. The locations of these wells are shown on Figure 5, with arrows showing the direction of vertical flow on Figures 14 through 17 relative to the bedrock trough feature.

Note that intermediate bedrock wells RW4I, RW5I and RW6I were locked and could not be opened during the 3 September 2013 gauging event, and only RI5I and RI6I could be opened during the 17 September 2013. Thus insufficient data points were collected to generate a groundwater contour for the intermediate bedrock zone.

3.6 EISB Treatability Study

The EISB treatability study was completed by SiREM Laboratories, Inc. of Guelph, Ontario, Canada. The EISB treatability study report is provided in Appendix G.

Groundwater and soil samples for the EISB treatability study were collected on 17 June 2013, including soil from TW18 and groundwater from TW01 and TW18. The collected groundwater and soils were shipped to SiREM in coolers with the internal temperature maintained at 4°C

under standard chain of custody procedures, and were received by SiREM on 19 June 2013. These materials were used to build the microcosms used as part of the study. The planned microcosm construction, microcosm incubation, sampling and analysis were presented in the 30% Design.

3.6.1 Microcosm Construction

Details of the microcosm construction are presented in Appendix G. After consultation with USEPA, the initial microcosm concentrations were spiked on 28 June 2013 (Day 0) at 1,000 µg/L and 250 µg/L for TCE and cDCE, respectively. These concentrations were based upon the measured values in TW18. Later higher concentrations were measured at temporary monitoring well TW19; thus, after the completion of the initial EISB treatability study, a subsequent TCE concentration spike was conducted on 9 September 2013 (Day 73). TCE concentration was spiked to 10,000 µg/L in the intrinsic controls and emulsified vegetable oil (EVO) amended and KB-1 bioaugmented treatment. The EVO used for the EISB treatability study was Newman Zone. Details of the TCE and cDCE spiking, electron donor addition, and microcosm construction are provided on Table 1 in Appendix G. The study microcosms were as follows:

- Anaerobic sterile control,
- Anaerobic active control,
- EVO amended,
- EVO amended and pH buffered, and
- EVO amended, pH buffered, and KB-1 bioaugmented.

3.6.2 Microcosm Sampling and Analysis

Control and treatment microcosms were sampled weekly or biweekly for analysis of VOCs, DHGs (methane, ethane, ethane), and anions (sulfate, nitrate, nitrite, chloride, phosphate, bromide). Aqueous samples were also collected on a less frequent basis for analysis of volatile fatty acids (lactate, acetate, propionate, formate, butyrate, and pyruvate) and pH. The details of the analytical methods employed by SiREM are discussed in Appendix G.

3.6.3 EISB Treatability Study Results

The results of the EISB Treatability Study indicate that EISB is a viable remedy for the OU2 overburden aquifer. As shown on Figures 2 to 6 in Appendix G the results indicate the following:

- Figure 2 in Appendix G: The anaerobic sterile control microcosms demonstrate stable concentrations of the chlorinated ethenes throughout the study period indicating that there was no significant VOC losses during the study period. The anaerobic sterile control was only spiked with the initial amendment and was not spiked during the second amendment.

- Figure 3 in Appendix G: The anaerobic active control microcosms had stable concentrations of the chlorinated ethenes both during the initial and second amendments. The Day 73 spike in concentration is evident on the graph.

- Figure 4 in Appendix G: The EVO amended microcosms demonstrated some degradation of TCE to cDCE with no further degradation. These microcosms were only spiked during the initial amendment and not spiked during the second amendment.

- Figure 5 in Appendix G: The EVO amended and pH buffered microcosms showed completed degradation of TCE in approximately 60 days and completed degradation of cDCE in 110 days with development of VC and ethene. These results indicate that the aquifer will eventually have the ability to degrade TCE through stimulation pH buffering.

- Figure 6 in Appendix G: The EVO amended, pH buffered, and KB-1 bioaugmented microcosms demonstrated complete degradation of TCE and daughter products within 45 days following addition of KB-1 during the initial amendment testing. For the second amendment, the complete degradation occurred in approximately 35 days. This microcosm showed robust biodegradation even after the spike to 10,000 µg/L.

3.7 Discussion of Results

The OU2 overburden aquifer requiring treatment has been defined through the PDI investigation. USEPA requested verification of the western boundary of the TCE delineation to the west of TW49 and TW50. The verification will be conducted during a future groundwater sampling event. The delineated 100 µg/L TCE isoconcentration contour that defines the EISB treatment area is confined within a bedrock trough that extends for approximately 800 feet and is oriented along the bedrock strike. The saturated thickness within the overburden is approximately five feet; however, field observations during drilling and groundwater elevation monitoring suggest that groundwater occurs and flows predominantly along the interface between the overburden and the bedrock. The trough may be recharged through both infiltration of meteoric precipitation and through the upward flow of bedrock groundwater into the overburden, based on the measured vertical gradients in the bedrock well pairs.

The distribution of TCE within the bedrock trough together with CSIA data suggest that the present day dissolved TCE plume originates from two distinct TCE sources (Figures 6 and 7). The origins of the second source on the former BAE property is likely due to historic uses in the area as shown on Figure 18 and further clarified on Figure 19. These historic sources of TCE

were present prior to Stabilus operations at elevated levels with measured concentrations shown on Figure 18. Over time, these sources have generated dissolved plumes that have comingled and mixed within the saturated portions of the trough. Some of the dissolved VOC mass within the trough may also originate from bedrock groundwater, which based upon the concentrations shown on Figure 18 and potential historic sources shown on Figure 19 could provide explanation for the second TCE source on the former BAE parcel within the OU2 overburden aquifer.

The OU2 overburden aquifer soils are of significantly lower permeability (5.06×10^{-8} cm/sec) than anticipated and as envisioned within the Interim ROD resulting in conditions characterized by low groundwater yield. This low groundwater yield (i.e., hydraulic conductivity) required modification of the sampling program due to low recovery of groundwater samples. This low permeability and low hydraulic conductivity will be problematic for an injection based remedy. Though the soil matrix permeability is low, observations during completion of the soil boring logs indicate that a zone of weathered bedrock and overburden soils just above the bedrock zone is likely the zone of most groundwater flow and transport with the OU2 overburden groundwater aquifer.

The location of the elevated TCE concentration zones near the former Stabilus loading dock and the BAE property, are located within the natural bedrock trough. This trough is dished in shape, with the down gradient side of the TCE levels following the groundwater interface within the bedrock as shown on Figure 10. The EISB application will take advantage of this natural feature by employing a delivery method to maximize connection with the higher permeability zone near the bedrock interface. The concern with the observation of vertical upward gradients from the bedrock to the overburden cannot be overlooked during the completion of the RA, as higher concentrations of TCE may migrate into the trough and re-contaminate the EISB treated overburden aquifer. The performance monitoring network design will consider this potential phenomenon.

Based upon both the Gene-Trac® analysis of Site groundwater and the EISB treatability study results, the OU2 overburden aquifer requires the addition of both a buffered EVO with KB-1 microbial amendment to successfully implement EISB. Though natural degradation of TCE to cDCE is occurring, the reductive dechlorination of chlorinated ethenes is stalled at cDCE. The EISB treatability results indicate that EVO and KB-1 are required to promote the complete dechlorination of TCE in the OU2 groundwater.

3.8 Conclusions and Recommendations

The PDI results indicated the following:

- OU2 overburden soils are of very low permeability and low hydraulic conductivity as observed through standing water for days following rain events, low yield of groundwater during development, purging, and sampling, and confirmed through geotechnical analysis of the soils.

- OU2 overburden aquifer flow is most likely at the interface between the overburden soils and weathered bedrock as observed during completion of the soil borings and direct push sampling points.

- OU2 overburden and bedrock groundwater generally flows in a northwesterly direction with a shallow horizontal gradient in overburden of 0.01 ft/ft and bedrock of 0.043 ft/ft.

- OU2 bedrock groundwater shows both vertical upward and downward gradients of maximum 0.001 ft/ft and 0.01 ft/ft, respectively.

- Soil concentrations for VOCs exceed the USEPA Region 3, 6, 9 PGW-MCL values for TCE of 0.0018 mg/kg.

- The OU2 overburden aquifer does not have sufficient naturally occurring Dhc to sustain reductive dechlorination of TCE to ethene.

- EISB treatability results indicate that EISB using a combination of buffered EVO and KB-1 can treat TCE source concentration of both a 1,000 µg/L and 10,000 µg/L in a period of approximately 45 days or less within a batch experiment.

Recommendations for the RD are as follows:

- The OU2 overburden was of lower permeability than anticipated; thus, the proposed remedy method within the Interim ROD for using direct push injection is not recommended. This is supported by the observed low groundwater yield and overburden aquifer response to the installed sampling points, as well as the very low measurement of soil permeability.

- Given the low permeability and low hydraulic conductivity of the OU2 overburden aquifer, a method that increases both the flux and storage of EISB amendments is recommended.

- Performance monitoring during the completion of the EISB should also have nested bedrock wells to assess and confirm near treatment area vertical migration directions within bedrock considering the origins of potential sources in the OU2 overburden aquifer may be from the bedrock aquifer.

- Per USEPA request, complete verification sampling west of TW49 and TW50 to confirm delineation during a future field sampling event.

- The RD should incorporate the use of buffered EVO and KB-1 microbial cultures, as the OU2 overburden aquifer does not have naturally occurring Dhc.

- Given the uncertainty the low permeability of soils and low hydraulic conductivity presents to success of a remedy like EISB, the RA is recommended to be completed in a phased approach. The initial phase should be of a size that affords the proper monitoring of performance in a targeted zone of elevated TCE concentrations, and the second phase should only be completed if the performance of the first phase is successful.

4 PRELIMINARY DESIGN CRITERIA REPORT

The Preliminary RD criteria include the remedial approach, design parameters, and assumptions required to meet the Interim ROD performance standards in compliance with pertinent codes, ARARs, and good engineering practices. The design requirements and provisions including treatment schemes, rates, performance, monitoring, and operation and maintenance (O&M) requirements for the interim remedy elements are described below.

4.1 Project Description

The Interim ROD selected EISB as the OU2 overburden groundwater remedy. The PDI results have informed the EISB application approach with respect to the requisite biostimulation (buffered electron donor [EVO]) and bioaugmentation (KB-1) amendments and the means by which they will be most effectively distributed in the subsurface. The approximate extent and location of TCE of the area requiring remediation within the OU2 overburden aquifer is presented on Figure 6. The proposed EISB treatment area includes the overburden groundwater with concentrations of TCE greater than 100 µg/L the aerial extent of which is approximately 118,500 square feet. Treatment zone thickness varies with location, and temporally with seasonal precipitation. Based on the results of the PDI work, the maximum overburden saturated thickness is assumed to be approximately 5 feet. Based on the definitions of the TCE extent and treatment zone thickness, the volume to be treated is approximately 177,750 cubic feet (or approximately 1.33 million gallons) assuming an overburden soil porosity of 30-percent.

The EISB remedy is anticipated to be implemented in two phases. The first phase (i.e., Phase 1) will target the area of highest observed TCE concentrations based on the PDI results and will test the efficacy of a batch delivery approach via an infiltration trench installed at the overburden-bedrock interface. If the Phase 1 results indicated that this remedial approach is appropriate, the Phase 2 EISB remedy will be installed to extend the infiltration trench design to address the remainder of the EISB treatment area (within the 100 µg/L TCE isoconcentration contour) beyond the Phase 1 EISB treatment footprint. Details on the performance metrics to assess the efficacy of continuing to Phase 2 will be detailed within the Pre-Final Design Submittal (90% Design).

Should the Phase 1 EISB remedy be deemed unsuccessful through the evaluation of the performance metrics, Phase 2 will be redesigned and the remedial approach will be revised through discussions and consensus with the USEPA. A process for this potential outcome is described in detail in Section 9.

Amendments will be delivered from above-ground tankage under gravity through a trench installed at the base of the saturated overburden at the top of the bedrock surface. The trench will consist of a 5-foot deep interval of highly permeable stone accessible via a series of vertical application wells. The amendments will be prepared at a semi-permanent batch processing and delivery system located on Site and delivered under low pressure to the trench through the

application wells. The amendments will fill the bottom 5 feet of the application trench and subsequently infiltrate into the overburden treatment zone. Amendment dispersion will be driven by the head pressure applied on the application trench under gravity and will create a localized mound in the overburden. Amendment distribution is anticipated to occur predominantly along the weathered bedrock surface. Amendment distribution into the bedrock fracture system will occur where downward vertical hydraulic gradients exist.

Buffered electron donor mixing and metering equipment will be installed proximal to the loading dock of the former Stabilus building to enable semi-continuous amendment delivery over extended time periods. Routine groundwater monitoring will be conducted to chart the growth and expansion of the biologically active treatment zone and will be used to continuously refine the biostimulation and bioaugmentation regime. Further details of the performance monitoring well network are presented in Section 8, with details of the performance metrics for success / failure of Phase 1 will be provided as part of the 90% Design.

The general sequence of the EISB implementation will be as follows:

1. Batch preparation of the buffered EVO solution (electron donor) in a closed-top, above ground tank;

2. Addition of the buffered EVO batch after anaerobic conditions of the electron donor solution are achieved (via deoxygenating organisms within the tank);

3. Overburden groundwater monitoring to assess oxidation-reduction (redox) conditions;

4. Addition of additional batch(es) and perform additional groundwater monitoring to confirm that the requisite redox conditions exist throughout the treatment zone;

5. Addition of bioaugmentation (KB-1) culture to seed in situ population;

6. Preparation of additional buffed EVO batches and injecting until designed volume/distribution conditions are met or otherwise determined to be complete;

7. Continue long-term performance monitoring (2-years), and O&M;

8. Assessment and Reporting of the Phase 1 EISB performance results against the performance metrics including the efficacy of EISB to continue into Phase 2 (note: details of the performance metrics for success / failure of Phase 1 will be provided as part of the 90% Design);

9. If Phase 1 is concluded as successful and continuation unto Phase 2 is deemed appropriate, than install Phase 2 delivery infrastructure;

10. Apply supplemental buffered EVO solutions as needed based on O&M plan requirements;

11. Implement Phase 2 (same as 1 to 8 above);

12. Implement long-term monitoring program;

13. If the Phase 1 is concluded to be unsuccessful, Phase 2 will be redesigned or revised through discussions with the USEPA;

4.2 Design Requirements

The design requirements with respect to the ROD, ARARs, waste streams, amendment additions, bioaugmentation cultures are provided below.

4.2.1 ROD Requirements

The USEPA established RAOs in the OU2 Interim ROD for the interim OU2 EISB remedy as discussed in Section 1.2. A discussion of how the remedy will meet the requirements of the ROD is provided in Section 5.

4.2.2 ARAR Requirements

Below is a summary of the ARARs and the means by which the remedy will meet each requirement:

- Chemical Specific

  - National Primary Drinking Water Standards, 40 C.F.R. §§ 141.50, 141.51, 141.61, 141.62, were promulgated pursuant to the requirements of the Safe Drinking Water Act, 42 U.S.C. §§ 300f through 300j, to set standards for potable water supplies. The primary standards include MCLs and Maximum Contaminant Level Goals (MCLGs), which are enforceable standards for specific contaminants. The MCLs are ARARs for the cleanup of groundwater at the Site. MCLs for the COCs at this Site are set forth in Table 2 in Section IV. The remedy is expected to achieve MCLs in the treatment area of the overburden groundwater as previously described.

  - PADEP has identified the Pennsylvania Land Recycling and Environmental Remediation Standards Act (Act 2), 35 P.S. § 6026.101, et seq., as an ARAR. Act 2 provides for the promulgation of remediation standards for cleanup of contaminated sites in the Commonwealth of Pennsylvania. However, EPA has determined that Act

2's Statewide Health Standards for groundwater do not, on the facts and circumstances of the selected interim remedy, impose any requirements more stringent than the Federal standard.

- Location Specific

  - No location specific ARARs were identified.

- Action Specific

  - Underground Injection Control (UIC) Program, 40 C.F.R. §§ 144.1(g), 144.11, 144.12(a), 144.82, 146.6, 146.7, 146.8, 146.10(c), regulations are applicable to the installation of injection wells and to the in-situ alternatives. The UIC regulations define and establish five classes of injection wells. Generally, Class V wells are shallow discharge or disposal wells, storm water or agricultural drainage systems, or other devices that are used to release fluids into or above an underground source of drinking water. Trenches falls under this classification. In Pennsylvania, USEPA Region III has primacy in matters involving UIC and the PADEP defers to USEPA in implementing the UIC program. The remedy implementation will comply with the requirements of the UIC program for Class V wells and will comply with any permit requirements if deemed applicable by the UIC Program Director.

  - Fugitive Emissions Regulations, 25 Pa. Code §§ 123.1, 123.2, establishes opacity limits for visible air emissions and are applicable to the dust control measures to be employed during all on-site construction work. It is expected that the remedy will comply with this requirement by means of dust control measures during construction activities.

  - The Pennsylvania Erosion and Sediment Control Regulations, 25 Pa. Code §§ 102.4(b), 102.11, 102.22, set forth measures to limit soil erosion during any earth disturbance activities. It is expected that the remedy will comply with this requirement by means of implementation of an erosion and sediment control plan and any applicable permits during construction activities.

  - The Pennsylvania Stormwater Management Act, 32 P.S. § 680.13, requires the implementation of measures to control stormwater runoff during construction and remediation activities. It is expected that the remedy will comply with this requirement by means of implementation of an erosion and sediment control plan and applicable permits during construction activities.

4.2.3 Waste Streams

Wastes generated from the EISB remedy implementation will generally be limited to soils excavated during trench installation and soil cuttings and purge/development water resulting from the installation of wells. Waste streams will be managed following the RA WMP to be prepared as part of the 90% Design. Impacted media generated during the implementation will be transported off-site for disposal. Details of the application trench design and performance monitoring well network are provided in Section 5 and Section 8, respectively.

General construction wastes will also be generated and will be handled and disposed of through a local municipal waste hauler following the RA WMP to be presented in the 90% Design.

Scheduled performance monitoring and occasional O&M operations will generate minimal volumes of wastes which may be impacted with contaminants resulting from sample collection and equipment maintenance and clean-outs. These wastes will be appropriately containerized and transported off-site for disposal following the RA WMP procedures, which will be presented within the 90% Design.

4.2.4 Amendment Addition Parameters

The addition of the electron donor amendment solution will require a variety of parameters be met to ensure the best conditions for the bioaugmentation culture. Microorganisms generate hydrogen though the metabolism of the electron donors and drive the pH into the acidic range; therefore, the amendment will require a buffered stock product that will provide some capacity to buffer against pH changes that could result in suboptimal pH conditions in situ.

Amendment solution is made from a ~50% stock solution provided in intermediate bulk container (IBC) tote or other container and used to prepare a 2.5-5% solution for injection. This is a standard concentration based on Geosyntec's experiential knowledge and has been proven to provide the most effective quantity of electron donor and retain good distribution characteristics. The target volume of the injection will be equal to 10% of the treatment zone effective pore volume.

Maintaining anaerobic conditions is a critical success factor for the EISB remedy. Each batch of buffered EVO solution will be anaerobic prior to delivery. Ubiquitous aerobic organisms ferment the buffered EVO batches within the surface tanks, driving residual oxygen from the make-up water eventually rendering the buffered EVO solution anoxic.

Application pressures will be sufficient to move amendment to the trench/wells and establish a localized mounding condition and radial flow gradient in the overburden groundwater. Application pressure will not be great enough to cause amendment "day-lighting" or trench/well flooding.

Amendment application will be conducted when ambient temperature is above freezing at all times.

4.2.5 Bioaugmentation Culture Addition Parameters

The addition of the bioaugmentation culture is typically a singular event conducted to inoculate the subsurface treatment zone. Once added, and given the appropriate conditions are maintained, the population of the organisms will continue to grow and thrive for the duration of the remedy. Care will be taken to ensure the highest viability of the culture slurry during propagation, transport, and addition into the treatment zone. Knowledge of the amendment distribution characteristics will be considered in the preparation of the procedure for the culture addition to maximize distribution and viability.

Since *Dehalococcoides* (Dhc) bacteria are strict anaerobes and are extremely sensitive to the presence of oxygen, bioaugmentation must exclude oxygen contact. The KB-1 culture will be delivered into the trench via the application wells using distribution line submerged below the water table in each application well. To achieve anoxic conditions, argon gas will be added to the distribution line and bubbled into the application well prior to emplacement of the bioaugmentation culture.

4.3 Performance

Evaluation of the performance of the remedy will be based primarily on the effectiveness to degrade the chlorinated compounds fully to ethene in the overburden groundwater in an acceptable timeframe. Secondary performance indicators are those which suggest that the conditions are favorable for the remedy to perform as designed. Those secondary parameters include those which indicate that conditions in the treatment zone are anaerobic, pH and other water chemistry is optimal, electron donor continues to be available in excess, and that the introduced microbial population is established and thriving. Performance will be monitored on a routine schedule and the results of which will provide insight into the success of the remedy as well as indicators that additional amendments may be required or other modifications are needed. The following sections provide a summary of the proposed performance monitoring evaluations and subsequent operational and maintenance actions which may be required. Details of the success or failure of Phase 1 and decision criteria to be met prior to implementation of Phase 2 will be provided within the 90% Design.

4.3.1 Monitoring

Performance monitoring will be conducted in general by the collection of groundwater samples and analysis for a suite of parameters with the purpose of evaluating the performance of the remedy and to initiate O&M activities. The performance monitoring wells will be a network of wells made up of select existing monitoring wells, as well as new wells and where appropriate, the application wells. The locations of the wells (relative to the application trench / wells) have

been selected to provide the most comprehensive coverage for the evaluation of the distribution of amendment during and subsequent to the implementation. Details regarding the monitoring well network selection, construction, sampling schedule, and performance evaluation criteria are presented in Section 8.

4.3.2 Performance Monitoring Goals

The goals and rationale for each of the EISB remedy performance indicators are described below. The specific monitoring schedule and performance criteria are provided in Section 8, with further details on the performance metrics and the levels that deem success or failure will be developed as part of the 90% Design.

4.3.2.1 Electron Donor Delivery and Distribution

The performance of the EISB remedy is primarily affected by the ability of the application to achieve adequate distribution of buffered EVO in the treatment zone. Buffered EVO injection volume will be used as the initial performance indicator as to the success of the injection program and is an indirect measure of the distribution. Total organic carbon (TOC) concentration in the treatment zone groundwater will be used as a direct measure of the presence and radial extent of the buffered EVO injections. Additionally, trends in concentration and comparative analysis will be used to evaluate donor availability and consumption over the course of the remedy.

4.3.2.2 Groundwater Redox

The redox/ORP is a measure of the tendency of the ground water to be chemically reducing (donate electrons) or oxidizing (accept electrons). The redox conditions are characterized by the terminal electron acceptor (TEA) process occurring in the groundwater as follows:

- Oxic (aerobic) conditions prevail when oxygen can be directly measured and ORP is strongly positive (typically +300 micro volts [mV] to +400 mV).

- Nitrate reduction occurs after most of the oxygen is absent and nitrate is reduced under anaerobic conditions to gaseous forms or may terminate at nitrite.

- Iron and manganese reduction processes are characterized by the reduction of ferric iron (Fe3+) to ferrous iron (Fe2+) and manganese IV (Mn4+) to manganese II (Mn2+), respectively. These TEA processes typically have slightly positive to slightly negative ORP measurements.

- The target in situ TEA processes for EISB are sulfate reduction and methanogenesis. Sulfate is reduced to sulfide, exhibiting an ORP of -200 mV. Methanogenesis occurs when the bacteria that oxidize hydrogen create methane under strongly anaerobic conditions characterized by – 300 mV to -400 mV. The groundwater sampling program

will identify the groundwater redox through direct measurement of ORP and analysis for key TEAs (e.g. nitrate, nitrite, ferrous iron, sulfate, sulfide and methane).

4.3.2.3 Bioaugmentation Survival and Growth

The survival and growth of the KB-1 bioaugmentation culture will be assessed through PCR testing via SiREM's Gene-Trac® Dhc method. This method provides a quantitative measurement of the Dhc present in the groundwater and can thus be used to chart microbial survival, growth and expansions throughout the treatment area.

4.3.2.4 TCE Degradation

TCE is the predominant chlorinated ethene detected in the groundwater and its complete degradation to ethene via reductive dechlorination is the primary goal of the Site EISB remedy. Reductive dechlorination is the sequential replacement of chlorine atoms on the alkene molecule with hydrogen atoms. Under reducing conditions, TCE serves as an electron acceptor and is dechlorinated sequentially to cDCE, vinyl chloride and finally to ethene. The process is mediated by microorganisms that release hydrogen, which replaces chlorine (as chloride) on a chlorinated organic compound molecule. Biologically-mediated reductive dechlorination of VOCs to ethene typically occurs under methanogenic (strongly anaerobic) conditions.

Most aquifer environments contain bacteria that are capable of reductively dechlorinating TCE to cDCE as evidenced by the treatability study control microcosm results. Microorganisms that are capable of mediating this reaction include *Desulfitobacterium*, *Dehalobacter (Dhb) restrictus*, *Desulfuromonas*, *Dehalospirillum multivorans*, and *Dehalococcoides ethenogenes* (Sholz-Muramatsu et al. 1995; Gerritse et al. 1996; Krumholz 1996; Maymo-Gatell et al. 1997; Holliger et al. 1998; Löffler et al. 2000; 2001). However, only cultures that contain Dhc have been shown to dechlorinate cDCE and vinyl chloride to ethene (Maymo-Gatell et al. 1997; Fennell et al. 2001; Duhamel et al 2002; Lendvay et al. 2003).

While reductive dechlorination is the dominant biodegradation mechanism for chlorinated solvents, other degradation mechanisms do occur and may proceed outside of the treatment area. Aerobic co-metabolism is a process where TCE and its daughter products are degraded by an enzyme or cofactor produced during microbial metabolism of another compound. Co-metabolism is limited to chlorinated solvents that have at least one hydrogen atom attached to the carbon (i.e., PCE cannot be co-metabolized). Similarly, cDCE and vinyl chloride can serve as electron donors by bacteria and be directly oxidized. These secondary process may occur in aerobic zones beyond the EISB treatment area and serve to limit migration of the penultimate daughter product vinyl chloride which will temporarily be generated and accumulate during the EISB remedy.

4.3.3 Operation and Maintenance

EVO addition rates will be monitored during each batch along with application trench well depths. This data will be used as a potential indicator of application well and/or trench fouling. In addition, performance monitoring wells will be evaluated for fouling after each sampling event by comparing the withdraw rate and drawdown to previous events. If fouling is determined to be negatively affecting performance, a determination will be made based the circumstances of the situation to rehabilitate a well or trench by means of flushing or other method to restore the conditions to acceptable.

During the course of the remedy performance monitoring activities described in the previous section and in further detail in Section 8, if is determined through TOC monitoring or other indicators, that the electron donor substrate has been consumed to the point that it is potentially a limiting factor or conditions are at risk of becoming aerobic, an evaluation will be made to determine if additional buffered EVO additions are warranted.

General maintenance of the system components will be completed as required and will including routine housekeeping and winterization. These will be completed to ensure that equipment is operable and protected from damage and unnecessary wear.

4.4 Constructability

The success of the remedy implementation is dependent upon the ability to construct the treatment system components. The components are comprised of the distribution system (trenches, application wells, field piping, instrumentation, etc.) and the amendment preparation and mixing and distribution system. Access to the Site will be required to complete site preparation, equipment storage, waste handling, construction, and treatment application activities for the duration of the remedy schedule.

Clearing of trees and brush will be required for Phase 2 implementation in several areas as approximated in the Preliminary RD Drawings (Appendix H). It is approximated that as least 280 linear feet of trench installation will require some clearing. Depending upon the width of clearance required by the trench installation method, the total area cleared is likely to be less than 0.25 acre. Cuttings will managed (i.e., chipped and used as mulch cover or otherwise properly removed from the Site) as part of the remedy implementation.

Preliminary evaluations indicate that the layout of the trench is free of surface and subsurface obstructions or other impedance. Phase 1 trench is located in close proximity to the Constantia-Colmar building. The location of the Phase 1 trench is proposed to be as close to the building as possible without interfering with building operations or compromising the structural integrity of the building. As part of the implementation of the remedy the final location of the trench in proximity to the building will be adjusted to be an adequate distance from the building. This will be determined in consultation with the building owner/operator.

The mixing and distribution system is comprised of a limited number of tanks, pipes, pumps, controls, and storage areas, which require approximately 3,600 square feet of space. Based on a review of the Site layout, the best location for the construction of the aboveground components of the system is an asphalt paved parking area on the northwestern edge of the building. This location provides the space, easy truck access via the facility delivery entrance, flat and competent surface to set tanks, proximity to utilities, and is in close proximity to the Phase 1 trench. As part of the Pre-Final (90%) RD, implementation access for system setup will be coordinated with the facility owner/operator.

Field piping/hose and fittings will be designed and constructed to be modular, flexible, and mobile such that the hoses can be easily moved and/or stored as required between the well locations, around obstructions, and during winter shutdown.

Although limited in quantity, waste storage will require a secured area (possibly within the system equipment area). If additional space is required the southern parking lot can be utilized as required and with approval of Constantia Colmar. Details of the RA WMP will be presented within the 90% Design.

5 BASIS OF DESIGN REPORT

A description of evaluations conducted to select the RD approach, a summary of the calculations completed to support RD assumptions, and a narrative of the draft process flow diagram (PFD) illustrating the overall treatment process is presented below. Additionally, the preliminary design calculations are presented and a summary of how the remedy as designed will meet the RAOs and permit equivalencies followed by a project delivery strategy follows.

5.1 Design Assumptions

The RD is based on certain assumptions regarding the Site, results of the PDI, up scaling of the treatability studies, environmental factors, and constructability. Below is a summary of the primary assumptions made during the Preliminary RD:

- Treatment area size is approximately 118,500 square feet defined by 100 µg/L of TCE in OU2 overburden groundwater water as identified by the PDI.
- Overburden water is present and generally consistent thickness (~5 feet) across the treatment area.
- Distribution of amendment will be successful and have sufficient reach from the centerline (application trench location) of the treatment area.
- Source water (proximal bedrock well) is free of significant contamination and quality is supportive of the remedy.
- Injections will only take place during warm months, therefore heat tracing of construction above the frost line are not considered.
- Site access is made available with reasonable restrictions that are not preventative of the remedy as designed.
- Clearing of trees/brush located in the vicinity of the remedy will be approved.
- Obstructions (above ground or subsurface) that would interfere with the installation or operation of the application trenches are not present.
- Adequate space is available for system construction and operational activities.
- The remedy as designed assumes that if Phase 2 is to be implemented that the Phase 2 remedy will be refined as a result of experiential knowledge gained from Phase 1 implementation.

- If Phase 2 is applied, USEPA may add other PRPs and this will not delay or change the EISB remedy.

5.1.1 Supporting Calculations

Treatment zone volume was determined by the aerial extent of the defined plume and the thickness of the overburden groundwater above the bedrock as follows:

Total Treatment Zone Volume:

$$118{,}500\ sq\ ft\ \times 5\ ft\ = \mathbf{592{,}500\ cu\ ft}$$

Phase 1 Treatment Zone Volume (approx.. ¼ acre): (assumes ~50 foot radius of influence to reach lateral extent of the 100 µg/L TCE area, distribution at ends of trench are assumed to be minimal)

$$(100\ ft\ \times 100\ ft) \times 5\ ft\ = \mathbf{50{,}000\ cu\ ft}$$

Phase 1 treatment zone water volume (assumes porosity of 30%):

$$50{,}000\ cu\ ft\ \times 0.30\ \times \left(7.48\frac{gal}{cu\ ft}\right) = \mathbf{112{,}200\ gal}$$

Based on the Phase 1 treatment zone water volume, the substrate loading (required total volume of EVO amendment) has been calculated based on a targeted EVO concentration in the treatment zone of 1-2%. Assuming an average of ~50% dilution across the treatment zone and constant total water volume, the total EVO solution and concentrations have been calculated. From this, the number of batches and recipe of each batch has been established as presented in the following calculations.

Total EVO solution required:

$$112{,}000\ gal\ \times 50\%\ dilution = \mathbf{56{,}100\ \ gal}$$

$$2\%\ solution \div 50\%\ dilution = \mathbf{4\%\ stock\ solution}$$

$$56{,}100\ total\ amendment\ \div 5{,}000\frac{gal}{batch} = \mathbf{11.2\ batches}$$

Totes per Batch:

$$5000\ gal/batch\ \times 4\%\ target\ batch\ solution \div 50\%\ EVO\ tote\ strength\ \div 250\frac{gal}{tote}$$
$$= \mathbf{1.6\ totes/batch}$$

As discussed elsewhere in this report, radial distribution (as well as rate of infiltration) is driven by a head pressure gradient which is greater than the naturally occurring horizontal groundwater

gradient (0.01 ft/ft). The following calculations identify the minimum target mounding relative to static groundwater levels and the associated application pressure that should be targeted during initial buffered EVO additions.

Targeted groundwater Mounding:

$$0.01\frac{ft}{ft} \times 50ft\ (ROI) = 0.5\ ft\ vertical\ head\ required\ to\ equal\ static\ gradient$$

$0.5\ ft\ water\ head\ \times 50\%\ safety\ factor = \mathbf{1\ ft\ water\ head\ above\ static}$ ***as measured in the application trench.***

Application pressure:

Minimum gravity feed head pressure =
10 ft water *(head above static groundwater level within trench)*
Maximum gravity feed head pressure = 10ft + 12ft (full tank height) = ***22 ft water***

5.1.2 Process Flow Description

A PFD is presented on the Preliminary RD Drawings (Sheet 4 in Appendix H). Source groundwater will be pumped from proximate existing bedrock well (RI-27D) and stored in a 20,000-gallon fractionation tank (frac tank). Bedrock groundwater from RI-27D that will be pumped for use as make-up water for the buffered EVO solution will be tested to confirm that it meets all appropriate quality criteria for subsurface injection. The means and methods for the testing and use of the RI-27D groundwater and potential contingency actions or process will be detailed in the 90% Design. The purpose of the frac tank is to simply provide a sufficient volume of storage of readily available dilution water. For each batch of buffered EVO amendment, dilution water will be pumped from the frac tank to a 5,000-gallon batch mixing tank. Concentrated EVO will be delivered to the Site in 250-gallon IBC totes and individually pumped in the batch mixing tank to get the appropriate concentration of buffered EVO. Each 5,000-gallon batch is mixed by recirculation pumping (or other means) and allowed to rest for a period of time (several days) during which time the indigenous microbes in the source groundwater consume any DO rendering the batch anaerobic. The anaerobic buffered EVO batch is then transferred by means of a manifold and metering equipment through field hoses to the application trench wells/sumps or to a field header with delivery to individual wells via hoses. The delivery of the buffered EVO batch will take place under controlled low pressure (likely hydraulic head of the batch mixing tank) over several days.

Once sufficient buffered EVO (multiple batches) have been delivered and the treatment zone rendered anaerobic, the biostimulant culture slurry (KB-1) will be delivered through the same distribution system by means of in-line addition just after the batch mixing tank. The slurry will prepared in a controlled laboratory setting and shipped to the site in a sealed canister. The slurry

will be ejected from the canister under a controlled procedure to maximize distribution and viability by displacement with compressed inert gas (i.e. argon). The slurry will be injected concurrently with a buffered EVO batch to ensure adequate mixing, distribution, and minimal oxygen pick-up.

Buffered EVO batches follow the biostimulant slurry addition, as previously described, until the prescribed volume has been delivered.

5.2 Remedial Design Approach

The remedial design approach includes the remedial design evaluations, meeting the remedial action objectives, and permit equivalences.

5.2.1 Remedial Design Evaluations

As part of the PDI work, an EISB treatability study was completed to further refine the requirements for design of the EISB remedy. The results of the study are presented in Section 3 and indicate that EISB is applicable at the Site. The EISB treatability study also determined that the Dhc microbes have the ability to degrade TCE to ethene. The native Dhc and VC reducing microbes were not present at the Site; therefore, inoculation by the appropriate microbe consortium (i.e., KB-1) would be required.

Biostimulation by the addition of an electron donor substrate is a required critical component to this remedy. ERM completed a bioaugmentation treatability study, which concluded that EISB was a viable in situ remedial approach for OU2 (ERM, 2004). The conclusions of the 2004 bioaugmentation treatability study indicated: 1) the growth of indigenous microorganisms can be sustained and stimulated through the addition of an electron donor; 2) bioaugmentation is necessary to achieve complete reductive dechlorination of TCE to ethene; and 3) EVO is the best substrate given its longevity within the subsurface.

The delivery method for EISB was evaluated during the development of the Preliminary RD because concerns regarding the soil type (silty-clay) and associated permeability of the treatment area soil are being a limiting factor to the successful distribution of the amendment. PDI results indicate that overburden soil is consistent across the Site and a test performed revealed that permeability is 5.06 E^{-8} cm/sec. This is categorized as a very low permeability and would not normally be considered for a direct injection in situ treatment. As noted in the PDI report, there is a zone of un-quantified thickness that is located at the overburden and bedrock interface which appears to have a higher permeability than the overlying soils and underlying bedrock. This zone is likely the primary migration pathway for overburden water horizontally across the Site. This zone is characterized with increased amounts of angular gravel and/or weather bedrock intermixed with the overburden soils of clay and silty clay. This zone will likely provide the majority of the amendment migration pathways and provide adequate distribution for effective treatment. Because this zone is likely relatively thin, vertical injection points would provide very

limited permeation surface area per point. Therefore, the application of the amendment by addition into trenches would provide significantly greater permeation surface area and was selected over vertical injection points (direct push or wells). Additional benefits of trenches are that they provide for immediate longitudinal distribution and the ability to apply amendment across a greater area with a single connection point thereby simplifying the associated equipment required.

5.3 Meeting Remedial Action Objectives

EISB remedy will meet the conditions of the RAOs within the Interim ROD by the resulting reduction in contaminant mass over time by the breakdown and consumption by the Dhc organisms. As contaminant mass is reduced in the overburden water, equilibrium forces will drive additional mass from the adsorbed fraction found in soils (i.e., matrix diffusion), further decreasing the overall contaminant concentration within the groundwater, but also reducing the mass available to partition into water.

Reduced mass from the absorbed soil fraction resulting from the shift in concentration equilibrium will ultimately prevent or minimize the migration of contaminants by virtue of reducing the availability of mass to partition to transient water.

Following the EISB application, long-term reductions will likely continue as long as conditions are sufficient to maintain a robust population of the Dhc organisms. During this phase of the interim remedy, monitoring will be conducted similar to a monitored natural attenuation program. This phase of the remedy will continue to reduce contaminant concentrations to MCLs. During this time, institutional controls will be implemented to prevent exposure to overburden water at concentrations above MCLs.

The EISB remedy as envisioned in the ROD will mitigate the migration of contaminants through reducing the overall VOC source mass and the extent of the 100 µg/L TCE groundwater plume. Further, treatment at the overburden-bedrock interface through subsurface delivery using the trench design will effectuate treatment at the ultimate overburden discharge area, the bedrock aquifer.

5.4 Permit Equivalencies

The permit equivalencies anticipated being required prior to implementation of the RA in addition to the requirements of the ROD and ARARs is as follows:

- Construction,
- Electrical,
- Earth disturbance, and

- UIC permit.

6 PRELIMINARY DESIGN DRAWINGS

Preliminary plans and details have been prepared for the remedy components. The Preliminary RD plans and drawings included as part of this 60% Design in Appendix H include the following.

- Sheet 1: Title Page
- Sheet 2: Site Plan - Existing Features
- Sheet 3: Site Plan – EISB Application and Performance Monitoring Wells
- Sheet 4: Process Flow/Piping and Instrumentation Diagram
- Sheet 5: EISB System Equipment Layout
- Sheet 6: EISB Trench Details
- Sheet 7: Well Construction Details

No Major revisions are anticipated for the drawing set included as part of this 60% Design, although minor revisions are likely. During the next phase of design, additional drawings will be added to this existing set. The anticipated additional drawings to be amended to the existing set as part of the 90% Design include the following:

- Legend Sheet,
- EISB System Details and Specifications,
- General and Construction Specifications, and
- Sediment and Soil Erosion Control Plan Details.

7 SPECIFICATIONS OUTLINE

Construction specifications will be developed in parallel with the design drawings, and together they will provide for implementation of the remedy. The construction specifications will focus on technical requirements for the work. Standard Construction Specification Institute (CSI) format will be used and include preliminary specifications for construction, installation, site preparation, and fieldwork standards. An outline of the construction specifications anticipated to be developed during the subsequent remedial design phases as follows:

- Section 01500: Temporary Facilities and Controls
- Section 02200: Site Preparation
- Section 02400: Tunneling, Boring and Jacking
- Section 02950: Site Restoration and Rehabilitation
- Section 03050: Basic Concrete Materials and Methods
- Section 03100: Concrete Forms and Accessories
- Section 03600: Grouts
- Section 13200: Storage Tanks
- Section 13400: Measurement and Control Instrumentation
- Section 15200: Process Piping
- Section 16050: Basic Electrical Materials and Methods

8 PERFORMANCE MONITORING WELL NETWORK WORK PLAN

The primary purpose of the performance monitoring well network will be to enable collection of groundwater data from locations within and below the EISB treatment zone, which will be used to evaluate the performance of the proposed remedy upon completion of Phase 1 EISB remedy. This section presents the details for the installation of overburden and bedrock wells, and groundwater monitoring associated with the performance monitoring well network.

8.1 Monitoring Well Network Design

For Phase 1 of the EISB remedy, the performance monitoring well network will be comprised of a series of 16 new monitoring wells, 10 overburden and 6 bedrock (shallow and intermediate) wells, which will be installed on the southwest side of the former Stabilus building (see Sheet 5 in Appendix H). Existing wells that will also be used to monitor performance include RI23, RI25, and RI27S (see Figure 5). The location of each well has been selected based on a combination of considerations, which include distance from the application trench/well points and groundwater flow direction. These locations have been selected to provide the comprehensive coverage for the evaluation of the distribution of amendment during and subsequent to the EISB application. The goal of Phase 1 application of EISB is to provide understanding of the distribution the buffered EVO and KB-1 within both overburden and bedrock, as well as the ability of the EISB remedy to degrade TCE and cDCE in situ. Additionally, the goal of Phase 1 is to understand if EISB can be applied to such a low permeable aquifer. The success of Phase 1 will be necessary and performance goals and metrics met prior to expanding to the larger EISB application in Phase 2.

The location and distribution of performance monitoring wells for Phase 2 of the EISB remedy will be located following completion of the Phase 1 remedy. The final number and spacing of these wells will be finalized following completion of Phase 1 of the EISB remedy, as the data from Phase 1 will aid in defining the distribution and the success of the EISB remedy. The observations during Phase 1 will provide the detail necessary on the number and spacing of performance well during Phase 2, recognizing that the level of detail in performance monitoring during Phase 2 will be sufficiently less. As the goal during Phase 1 is to assess the efficacy of the method of EISB addition and greater detail is needed during Phase 1 to assess the EISB application via trenches prior to potentially expanding to the larger application in Phase 2.

Per the Interim ROD, the performance monitoring well network will be used to document contaminant levels before, during and after the addition of biostimulant and microbial cultures; and, monitoring will also be conduct to evaluate the bioaugmentation processes and achievement of performance standards (see Section 4).

8.2 Monitoring Well Network Layout

The locations of the Phase 1 overburden and bedrock wells are discussed.

8.2.1 Overburden Wells

Existing overburden wells RI23 and RI25 will be used as well as ten (10) new overburden wells will be used to monitor the performance of the EISB remedy. One additional overburden well will be installed as well to assess the area north of the former Stabilus loading dock. The eleven new overburden wells will be installed as follows:

- Six (6) wells will be installed perpendicular to the Phase 1 EISB trench area with wells spaced 3 feet, 10 feet, and 25 feet on either side of the trench, at the center point,
- Two (2) overburden wells will be installed to the south of the main center line at 5 feet on either side of the trench,
- One (1) overburden well will be installed 10 feet off the southern end of the trench, and
- One (1) overburden well will be installed at the northern end of the trench, between the trench and the building. This distance from the trench will be determined in the field.
- One (1) overburden well will be installed up gradient and side gradient to the former Stabilus loading dock area. This distance from the trench will be determined in the field.

8.2.2 Bedrock Wells

Existing bedrock well RI27S will be used as well as 6 new bedrock wells to monitor the performance of the EISB remedy. RI27D is proposed to be used for the EISB water as noted in Section 5. The 6 new bedrock wells proposed comprise three (3) shallow and three (3) intermediate bedrock wells as follows:

- RI33S and RI33I
  - These two wells will be completed in the direction of groundwater flow predicted by the USGS and confirmed by the potentiometric surface maps from the PDI, northwesterly approximately 50 feet from the Phase 1 EISB remedy.
  - The shallow bedrock well (RI33S) will be completed similar to the existing shallow bedrock wells just below the bedrock and overburden interface (approximately 40 to 50 feet bgs).
  - The intermediate well (RI33I) will be completed at approximately 100 to 120 feet bgs, which corresponds to the estimated depth that a bedding plane originating at the former Stabilus loading dock area would intersect this location.
- RI34S and RI34I

- These two wells will be completed in a direction southwest of the Phase 1 EISB remedy to asses both down dip and lateral spread of the EISB within bedrock and installed approximately 50 feet southwest from the Phase 1 EISB remedy near existing overburden well RI23.
- The shallow well (RI34S) will be completed similarly to the other shallow bedrock wells just below the bedrock and overburden interface (approximately 25 to 40 feet bgs).
- The intermediate well (RI34I) will be completed approximately 50 to 70 feet bgs, which corresponds to the estimated depth that a bedding plane originating at the former Stabilus loading dock area would intersect this location.

• RI35S and RI35I

- These two wells will be installed down gradient and down dip and within approximately 10 to 20 feet of the Phase 1 EISB remedy area.
- The shallow well (RI35S) will be completed similarly to the other shallow bedrock wells just below the bedrock and overburden interface (approximately 25 to 40 feet bgs).
- The intermediate well (RI35I) will be completed approximately 50 to 70 feet bgs which corresponds to the estimated depth that a bedding plane originating at the former Stabilus loading dock area would intersect this location.

The second stage of the performance monitoring well network will extend off the former Stabilus property and onto adjacent former BAE and Township property on Whistlestop Park. For Phase 2 EISB, the number, location and spacing of the performance monitoring wells to be used during Phase 2 will be provided during the assessment of Phase 1 remedy. Therefore, these wells are not discussed herein and the work plan for the installation of these wells will be developed and submitted as part of the RA EISB performance evaluation report following Phase 1 of the EISB remedy.

8.3 Monitoring Well Construction

This section summarizes the well installation methods and well construction details that will be used for the performance monitoring well network. Prior to performing any subsurface activities, utility locating will be completed onsite.

8.3.1 Overburden Wells

Overburden wells will be installed using hollow stem auger (HSA) drilling techniques by a Pennsylvania licensed driller. The overburden wells will be advanced with a HSA drill rig using

4 ¼-inch nominal diameter augers to the top of bedrock. In advance of the augers, continuous 2-inch split spoon soil cores will be collected until refusal at the top of bedrock. Field personnel shall note the soil type, color, odor and amount of recovery as described in the FSP within the 30% Design. The cuttings will be screened with a PID and, if elevated readings suggest the potential presence of dense non-aqueous phase liquid (DNAPL), drill cuttings will be tested with a hydrophobic dye (Oil Red O) to screen for the presence of DNAPL. Soil descriptions will be documented as described in the FSP within the 30% Design. Information will be documented in the field logbook and on lithologic boring logs. Soil cuttings and water generated IDW during drilling activities will be collected at the surface and containerized in 55-gallon drums and staged within the onsite waste management area following the procedures within the WMP in the 30% Design.

Upon completion of the 6-inch borehole to the top of bedrock, each overburden well will be completed as follows (see Appendix H for well details):

- 10-foot length of 2-inch diameter 0.010 slot, flush-joint threaded Schedule 40 PVC well screen with end cap;
- 2-inch diameter flush-joint threaded Schedule 40 PVC riser to ground surface with expanding well plug;
- No. 1 sand pack will be placed 6-inches beneath well screen to 2-feet above the top of the well screen.
- 6-inches to 1-foot of No. 00 well sand will be placed above the No.1 sand;
- 2-feet of bentonite chips will be placed above the No. 00 sand and hydrated to provide a seal; and,
- Completed to the surface with bentonite grout, 2-foot by 2-foot concrete pad, and locking flush mount cover.

8.3.2 Bedrock Wells

The three intermediate bedrock monitoring wells (RI33I, RI34I, RI35I) and three shallow bedrock wells (RI33S, RI34S, and RI35S) will be installed as part of the EISB Phase 1 monitoring well network. The target depths for the intermediate wells are approximately 70 feet bgs (R134I and RI35I) to 120 feet bgs (RI33I). Shallow bedrock monitoring wells will be advanced to approximately 50 feet bgs, targeting the first water-bearing interval. Boreholes will be advanced with air-rotary equipment by a Pennsylvania-licensed driller. Drill cuttings will be inspected upon retrieval from the borehole and will be logged by the geologist, who will also record the depths of identified bedrock fractures and observed water-bearing zones. The cuttings will be screened with a PID and, if elevated readings suggest the potential presence of DNAPL, drill cuttings will be tested with a hydrophobic dye (Oil Red O) to screen for the presence of DNAPL.

The intermediate bedrock monitoring wells will be drilled as open boreholes to obtain structural and hydraulic data from the bedrock beneath the EISB treatment area via geophysical logging and packer testing. Borehole packer and geophysical testing methods are discussed in Sections 8.6 and 8.7, respectively. The intermediate wells will be constructed as 2-inch PVC wells after consultation with USEPA and PADEP to select the screened interval. The construction specifications for the shallow bedrock monitoring wells will be based on the intermediate bedrock borehole data with USEPA and PADEP consensus.

At each bedrock monitoring well location, an 8-inch air percussion drill bit will be used to drill through the overburden and into competent bedrock. After the borehole is advanced to approximately 5 feet into competent bedrock, a 6-inch steel casing will be installed and grouted in place from the bottom up using the tremie method, and allowed to cure for a minimum of 12-hours before the advancement of the borehole to the terminal depth. Once the grout has cured, the borehole will be advanced to the terminal depth using a $5^{7/8}$-inch diameter air hammer drill bit.

Cuttings and groundwater generated during drilling will be collected in a containment area installed around the borehole, then transferred into 55-gallon drums or an on-Site roll-off and staged within the on-Site waste management area following the WMP within the 30% Design.

Once all borehole testing has been completed, the intermediate wells will be completed targeting the 10-ft. screened interval at the fracture zone mutually agreed upon by USEPA, the PADEP and the RD Engineer. The well construction will generally be as follows, but may require modification in the field based upon the geophysical and packer testing results (see Appendix H for well details):

- If necessary, filling the base of the open borehole with bentonite grout to target the depth of interest based upon the geophysical and packer testing, and placement of 1-foot of No. 00 well sand;
- 10-foot length of 2-inch diameter 0.010 slot, flush-joint threaded Schedule 80 PVC well screen with end cap;
- 2-inch diameter flush-joint threaded Schedule 80 PVC riser to ground surface with expanding well plug;
- No. 1 sand pack will be placed 6-inches beneath well screen to 2-feet above the top of the well screen.
- 6-inches to 1-foot of No. 00 well sand will be placed above the No.1 sand;
- 2-feet of bentonite chips will be placed above the No. 00 sand and hydrated to provide a seal; and,

- Completed to the surface with bentonite grout, 2-foot by 2-foot concrete pad, and locking flush mount cover.

Following completion of the geophysical and packer testing on the intermediate wells, the shallow bedrock wells will be drilled to their completion depth using a 4-inch air percussion drill bit will be used to drill through the overburden and into competent bedrock to the completion depth and constructed as follows:

- 10-foot length of 2-inch diameter 0.010 slot, flush-joint threaded Schedule 80 PVC well screen with end cap;
- 2-inch diameter flush-joint threaded Schedule 80 PVC riser to ground surface with expanding well plug;
- No. 1 sand pack will be placed 6-inches beneath well screen to 2-feet above the top of the well screen.
- 6-inches to 1-foot of No. 00 well sand will be placed above the No.1 sand;
- 2-feet of bentonite chips will be placed above the No. 00 sand and hydrated to provide a seal; and,
- Completed to the surface with bentonite grout, 2-foot by 2-foot concrete pad, and locking flush mount cover.

8.4 Monitoring Well Development

The new monitoring wells will be developed using surging and over pumping techniques with a 2-inch submersible pump 24 hours after installation. Water quality indicator parameters including temperature, pH, specific conductance, and turbidity will be monitored during well development using a water quality meter and recorded in the field logbook. Development will continue until indicator parameters have stabilized, three well volumes have been removed and, where possible, until development water is clear. Development water will be containerized in 55-gallon drums and staged within the onsite waste management area for later disposal. Information detailing well development will be in accordance with the FSP within the 30% Design.

8.5 Survey of Performance Monitoring Well Network

Upon completion of intrusive activities, and prior to implementation of the Phase 1 EISB remedy, a survey of the newly installed performance monitoring well network will be completed by Pennsylvania-licensed Land Surveyor. The survey will include the horizontal and vertical control referenced to the Pennsylvania State Plan Coordinate System NAD 1983 and NAVD 1988 for all wells installed as part of the performance monitoring well network.

8.6 Geophysical Logging

Geophysical logging will be performed on the intermediate bedrock monitoring well open boreholes to detect and measure fractures, joints, or other discontinuities and to locate water-bearing zones. The methods will include natural gamma, caliper, fluid temperature, fluid conductivity, heat pulse flow meter, acoustic or optical televiewer, induction and borehole video survey. Earth data Northeast of Exton, Pennsylvania will perform the geophysical logging.

Within 24 hours of the receipt and reduction of the geophysical data for each of the intermediate boreholes, the RD Engineer will confer with USEPA and the PADEP to select the screened interval and confirm the proposed monitoring well specifications for the individual intermediate bedrock monitoring well and associated shallow bedrock monitoring well.

8.7 Packer Testing

Upon completion of the geophysical logging of the open borehole, packer testing will be performed on intermediate bedrock wells RI33I and RI34I on selected fracture intervals to: isolate water bearing zones; collect water samples from discrete fractures; assess vertical head distribution and flow potential; and potentially to determine pressure response of individual fractures in adjacent monitoring wells.

Groundwater samples will be collected from the borehole for VOC analyses during packer testing. Up to three bedrock water-bearing zones encountered during drilling will be isolated during packer testing. The results of the packer testing will be used to select the depth interval for both the intermediate and shallow bedrock wells.

8.8 Performance Monitoring Criteria

Details regarding the criteria by which the performance monitoring results will be evaluated to assess the Phase 1 EISB remedy will be provided as part of the RA FSP within the 90% Design. The rationale for each of the performance monitoring goals is provided in Section 4. In general, the performance indicators for which monitoring will be completed as part of the performance monitoring program can be placed into two categories. The first of which evaluates the successful distribution of the biostimulant (i.e., EVO) and resulting anaerobic and TEA process conditions. The second category includes the criteria which evaluate the health of the introduced microbes and resulting biodegradation. Tables 8 and 9 provide a summary of the criteria that will be used as a guide to evaluate the results of the performance monitoring program. As noted, the details regarding the metrics that deem Phase 1 as success and will be used to demonstrate the efficacy of continuing to Phase 2 will be presented as part of the RA FSP within the 90% Design.

8.9 Performance Monitoring Schedule

Performance indicators for application of Phase 1 of the EISB remedy will be monitored over the course of 2 years. To evaluate the performance indicators, the following parameters will be monitored during the performance monitoring:

- Total organic carbon (TOC) – sampled monthly for 6 months, then quarterly for 2 years
- Water quality parameters – sampled monthly for 6 months, then quarterly for 2 years
- VOCs – sampled quarterly for 2 years
- MNA parameters (nitrate, nitrite, methane, ethane, ethene, sulfate) – sampled quarterly for 2 years
- CSIA – sampled annually for 2 years
- PCR – sampled annually for 2 years.

The results of these parameters will provide insight into the success of the remedy, indicate if additional amendments are necessary, or other modifications are necessary.

Groundwater samples from the performance monitoring well network will be sampled via low flow sampling techniques as will be detailed within the RA FSP within the 90% Design, which will be similar to the techniques presented in the FSP of the 30% Design.

8.10 Performance Monitoring Reporting

Reporting of the performance monitoring results will be completed annually through the completion of the Phase 1 EISB remedy, monthly updates of the available data and performance monitoring results will be cumulatively summarized with each MPR. The reporting will present a summary of the sampling completed, results, and discussion of progress of the EISB remedy. The performance monitoring reporting will continue annually documenting the progress of the RA in achieving the performance metrics. After the second year of performance monitoring, the Phase 1 RA report will provide an evaluation of the Phase 1 RA with respect to the performance metrics. The details regarding the performance metrics that deem Phase 1 as success and will be used to demonstrate the efficacy of continuing to Phase 2 will be presented as part of the RA FSP within the 90% Design.

9 PRELIMINARY CONSTRUCTION/REMEDIAL ACTION SCHEDULE

The preliminary construction and remedial action schedule will meet the requirements within the Interim ROD and UAO. The tentative schedule, which will be further clarified and developed as part of the 90% Design, is as follows:

- 4th Quarter 2014
  - Submit RA Work Plan to USEPA for approval.
  - Install intermediate bedrock performance monitoring well network wells for the Phase 1 EISB remedy.
- 1st Quarter 2015
  - Approval of RA Work Plan
  - Begin construction of Phase 1 EISB remedy
- 2nd Quarter 2015
  - Complete construction of Phase 1 EISB remedy
  - Install overburden and shallow bedrock performance monitoring well network wells for the Phase 1 EISB remedy.
  - Complete direct push sampling points to validate OU2 overburden aquifer delineation west of TW49 and TW50.
- 3rd Quarter 2015 through 3rd Quarter 2017
  - Initiate Phase 1 EISB remedy
  - Conduct performance monitoring of Phase 1 EISB remedy.
- 4th Quarter 2017
  - Report and evaluation of performance of Phase 1 EISB remedy, and provide decision on success or failure of Phase 1 against the performance metrics. If Phase 1 is demonstrated to be unsuccessful and consensus on Phase 1 failure is achieved with the USEPA (via approval of a remedy failure determination letter), the Phase 2 (EISB trench design) will not be completed.
  - Within 90 days of USEPA failure determination approval, a Focused Feasibility Study (FFS) will be completed to identify an alternative RD/RA.

- 1st Quarter 2018
  - If Phase 1 is deemed unsuccessful, a 90% Design will be completed for any active remedy selected through the FFS. The sequence and timing of any alternative RD/RA implementation, including alternative RD/RA pre-design investigation activities, will be developed in the 90% Design
  - If Phase 1 results support a remedy success determination, continuation to Phase 2 EISB remedy, with installation of Phase 2 EISB remedy components.
- 2nd Quarter 2018
  - Continue and finish installation of Phase 2 EISB remedy or continue with alternative RD/RA sequence consistent with the FFS.
- 3rd Quarter 2018 through 3rd Quarter 2020
  - Conduct EISB remedy within Phase 1 and Phase 2 EISB remedy areas or continue with alternative RD/RA sequence consistent with the FFS.
  - Monitor performance of EISB remedy or continue with alternative RD/RA sequence Consistent with the FFS.
  - Phase 2 EISB two year monitoring will end in 4th quarter 2019.
- 2019 through 2027
  - Remaining 8 years of 10-year annual groundwater sampling to monitor long-term performance following completion of EISB remedy.

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TABLES

TABLE 1 - Summary of Collected Samples
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Sample Location	Completed Depth (feet bgs)	Soil			Groundwater							
		VOC	Geo. Params	EISB Study	Field Params	VOC	DHG	MNA	Alkalinity	CSIA	PCR	EISB Study
TW01/SB01	13.50	x			x	x	x	x	x	x	x	x
TW02/SB02	14.00	x			x	x	x	x	x	x		
TW03/SB03	14.00	x			x	x	x	x	x	x		
TW04/SB04	13.00	x			x	x	x	x	x	x		
TW05/SB05	13.00	x			x	x	x	x	x	x		
TW06/SB06	16.00	x			x	x	x	x	x	x		
TW07/SB07	10.00	x			x	x	x	x	x	x		
TW08/SB08	14.00	x			x	x	x	x	x	x		
TW09/SB09	13.50	x			x	x	x	x	x	x		
TW10/SB10	30.00	x			x	x	x	x	x	x		
TW11	14.00				x	x						
TW12	22.00				x	x						
TW13	10.00				x	x						
TW14	13.00				x	x						
TW15	17.00				x	x						
TW16	8.50				x	x						
TW17	17.00				x	x						
TW18	14.00			x	x	x					x	x
TW19	14.00					x						
TW20	13.00					x						
TW21	12.00					x						
TW22	9.50					x						
TW23	17.00				x	x						
TW24	14.00				x	x						
TW25	8.00				x	x						
TW26	10.50				DRY							
TW26A	10.50				x	x						
TW27	8.00				DRY							
TW27A	17.00				x	x						
TW28	7.50				DRY							
TW28A	7.50				DRY							
TW29	8.00				DRY							
TW29A	15.00				x	x						
TW30	22.00				x	x						
TW31	17.50				x	x						
TW32	10.00				DRY							
TW32A	10.00				DRY							
TW33	22.00				x	x						
TW34	16.00				x	x						
TW35	10.00				x	x						
TW36	13.00				x	x						
TW37	15.00				x	x						
TW38	11.00				x	x						
TW39	14.00				x	x						
TW40	18.00				x	x						
TW41	9.00		x		DRY							
TW42	8.50				DRY							
TW43	8.00				DRY							
TW44	6.50				DRY							
TW44A	9.00				x	x						
TW45	8.00				x	x						
TW46	12.00				x	x						
TW47	14.00				x	x						
TW48	14.00				x	x						

TABLE 1 - Summary of Collected Samples
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Sample Location	Completed Depth (feet bgs)	Soil			Groundwater							
		VOC	Geo. Params	EISB Study	Field Params	VOC	DHG	MNA	Alkalinity	CSIA	PCR	EISB Study
TW49	9.00				x	x						
TW50	8.50				x	x						
TW51	13.00				x	x						
RI23	22.71				x	x						
RI24	11.90				x	x						
RI25	13.45				x	x						
RI28	18.07				x	x						
RI29	10.71				x	x						
RI30	8.78				x	x						

Notes
VOC - volatile organic compounds
Geo. Params - geotechnical parameters
EISB Study - enhanced in situ bioaugmentation treatability study
Field Params - field parameters
DHG - dissolved hydrocarbon gases
MNA - monitored natural attenuation parameters
CSIA - compound specific isotope analysis
PCR - ploymerase chain reaction

TABLE 2 - Summary of Field Parameter Readings - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well	Screened Interval (ft bgs)	Intake Depth (ft bgs)	Pumping rate (mL/min)	Temperature (°C)	pH	Specific Conductance (mS/cm)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Turbidity (NTU)	Iron (mg/L)	Initial Water Level (ft bgs)	Initial Water Level with Pump (ft bgs)	Final Water Level (ft bgs)	Date(s) Sampled (d/m/y)	TCE Results (µg/L)
TW01	8.5-13.5	Initial 11, Final 13	50	21.75	5.76	0.974	3.42	203.1	N/A	0	10.05	7.9	8.78	6/24/2013	11
TW02	9-14	Initial 11.5, Final 13.5	50	22.65	5.41	0.174	4.78	259.3	82.1	0	8.35	7.35	Below top of pump	6/25/2013	1,400
TW03	9-14	11.5	90	16.03	4.97	0.344	0.75	303	12.9	0	8.4	8.43	8.5	6/24/2013	1,000
TW04	8-13	Initial 10.5, Final 12.5	100-50	20.83	5.1	0.245	6.58	241.5	71	0	9.45	9.85	11.48 (at top of pump)	6/26/2013, 6/27/2013	460
TW05	8-13	10.5	100	17.34	4.77	0.251	4.75	290	14.9	0	8.74	8.8	8.77	6/25/2013	950
TW06	11-16	13.5	110-80	15.84	4.89	0.169	6.72	508.4	3.9	0	8.31	8.3	8.3	6/26/2013	710
TW07	5-10	7.5	100	15.28	4.98	0.168	3.95	295.4	10.49	0	6.81	6.89	6.89	6/26/2013	760
TW08	8.9-13.9	11.4	100	14.7	5.35	0.091	4.3	301.8	25	0	3.89	3.92	3.92	6/26/2013	18
TW09	8.5-13.5	11	100	15.87	5.36	0.256	1.06	248.7	53.3	0	3.9	3.9	3.9	6/26/2013	14
TW10	25-30	Initial 27.5, Final 28.5	50-80	18.92	6.49	1.167	3.86	-57.3	142	2.0	21	19.9	21	6/28/13, 7/1/13	ND
TW11	9-14	11.5	100-60	20.2	5.32	0.108	1.54	261.7	61.1	0	8.15	8.21	8.3	6/25/2013	5 J
TW12	15.5-20.5	18	75	21.3	5.68	0.294	1.9	-341.3	41.4	0	8.08	8.12	13.3	6/25/2013	3 J
TW13	5-10	NC	NC	22.42	6.34	0.714	8.39	146.2	NC	NC	3.5	NC	NC	6/18/2013	ND
TW14	8-13	NC	NC	21.03	5.98	0.784	7.57	178	NC	NC	4.26	NC	NC	6/18/2013	1 J
TW15	12-17	NC	NC	19.54	6.03	1.205	3.23	-30	NC	NC	5.55	NC	NC	6/18/2013	34
TW16	3.5-8.5	NC	NC	23.6	6.2	0.418	6.54	38.8	NC	NC	4.73	NC	NC	6/18/2013	ND
TW17	12-17	NC	NC	24.25	6.35	0.46	6.03	85.2	NC	NC	5.53	NC	NC	6/18/2013	ND
TW18	9-14	NC	NC	21.78	5.33	0.819	2.67	72	NC	NC	4.72	NC	NC	6/18/2013	950
TW19	9-14	NC	NC	No meter	No meter	No meter	No meter	No meter	No meter	NC	N/A	NC	NC	6/17/2013	7200
TW20	8-13	NC	NC	No meter	No meter	No meter	No meter	No meter	No meter	NC	6.3	NC	NC	6/17/2013	1400
TW21	7-12	NC	NC	No meter	No meter	No meter	No meter	No meter	No meter	NC	7.5	NC	NC	6/17/2013	570
TW22	4.5-9.5	NC	NC	No meter	No meter	No meter	No meter	No meter	No meter	NC	5.9	NC	NC	6/17/2013	7
TW23	12-17	NC	NC	16.64	5.23	0.568	4.28	131.2	NC	NC	6.8	NC	NC	6/18/2013	110
TW24	9-14	NC	NC	No meter	No meter	No meter	No meter	No meter	No meter	NC	9.24	NC	NC	6/17/2013	ND
TW25	3-8	NC	NC	16.34	5.12	0.114	6.55	158.1	NC	NC	5.75	NC	NC	6/18/2013	ND
TW26	3-8	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW26A	5.5-10.5	NC	NC	18	5.36	0.118	6.95	184.5	NC	NC	7.9	NC	NC	6/20/2013	150
TW27	3-8	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW27A	12-17	NC	NC	20.17	5.48	0.389	7.34	212	NC	NC	10.91	NC	NC	6/20/2013	6700
TW28	2.5-7.5	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW28A	2-7	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW29	3-8	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW29A	10-15	NC	NC	19.56	6	0.27	8.15	171.7	NC	NC	NC	NC	NC	6/21/2013	22
TW30	17-22	NC	NC	18.77	5.41	0.092	3.3	143.7	NC	NC	8.3	NC	NC	6/20/2013	1 J
TW31	12.5-17.5	NC	NC	17.1	5.42	0.208	4.66	115.2	NC	NC	8.25	NC	NC	6/20/2013	850
TW32	5-10	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW32A	5-10	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW33	17-22	NC	NC	18.68	5.42	0.068	6.24	213.8	NC	NC	7.5	NC	NC	6/20/2013	ND
TW34	11-16	NC	NC	17.97	5.73	0.153	6.41	214.8	NC	NC	7.73	NC	NC	6/20/2013	380

TABLE 2 - Summary of Field Parameter Readings - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well	Screened Interval (ft bgs)	Intake Depth (ft bgs)	Pumping rate (mL/min)	Temperature (°C)	pH	Specific Conductance (mS/cm)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Turbidity (NTU)	Iron (mg/L)	Initial Water Level (ft bgs)	Initial Water Level with Pump (ft bgs)	Final Water Level (ft bgs)	Date(s) Sampled (d/m/y)	TCE Results (µg/L)
TW35	5-10	NC	NC	14.5	5.97	0.185	7.01	226.6	NC	NC	2.42	NC	NC	6/19/2013	640
TW36	8-13	NC	NC	13.73	5.53	0.135	4.88	235.2	NC	NC	4.98	NC	NC	6/19/2013	400
TW37	10-15	NC	NC	17.49	5.19	0.128	4.59	248	NC	NC	9.6	NC	NC	6/19/2013	ND
TW38	6-11	NC	NC	15.37	5.93	0.181	7.78	163.7	NC	NC	4.3	NC	NC	6/20/2013	ND
TW39	9-14	NC	NC	13.92	5.86	0.607	7.22	213.2	NC	NC	5.09	NC	NC	6/19/2013	6
TW40	13-18	NC	NC	14.35	5.41	0.519	3.08	229.1	NC	NC	4.02	NC	NC	6/19/2013	ND
TW41	4-9	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW42	3.5-8.5	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW43	4-9	NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW44		NC	NC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry	Dry	Dry	Dry
TW44A	4-9	NC	NC	23.40	5.36	0.636	7.44	518.8	45.9	0	6.15	NC	NC	9/5/2013	5 J
TW45	3-8	NC	NC	24.01	6.19	0.556	7.25	444.1	30.2	0	6.27	NC	NC	9/5/2013	34
TW46	7-12	NC	NC	18.21	7.81	0.348	9.46	138.3	48.1	0	11.1	NC	Dry	9/5/2013	250
TW47	9-14	NC	NC	16.78	5.64	0.095	3.94	63.0	NC	0	4.64	NC	NC	9/5/2013	23
TW48	9-14	NC	NC	16.70	5.94	0.241	3.28	-93.2	NC	1.1	4.90	NC	NC	9/5/2013	ND
TW49	4-9	NC	NC	21.74	6.01	0.294	7.96	126.4	34.3	0	3.66	NC	NC	9/5/2013	130
TW50	3.5-8.5	NC	NC	18.50	6.49	0.368	9.66	198.8	34.3	0	6.62	NC	NC	9/5/2013	110
TW51	8-13	NC	NC	18.17	5.85	0.189	8.32	101.7	199	0	5.13	NC	NC	9/5/2013	71
RI23	4-14	10	100	19.53	5.57	0.124	0.56	32.7	8.55	0.8	8.12	8.31	8.35	6/28/2013	28
RI24	5-15	8.5	100	17.76	6.76	0.396	7.81	229	3.81	0	6.05	6.08	6.08	6/28/2013	ND
RI25	4-14	8.75	100	21.79	6.06	0.536	3.55	284.7	10.73	0	6.72	6.75	6.93	6/28/2013	2 J
RI28	14-19	16.5	100	15.83	6	0.169	1.41	54.8	42	1.2	7.88	N/A	10.93	6/28/2013	7
RI29	6.5-11.5	9	100	17.6	5.26	0.144	6.91	287	13.3	0	6.78	6.78	6.78	6/27/2013	ND
RI30	4.9-9.5	7	100	19.78	6.21	0.157	7.24	190.9	22.2	0.5	5.25	4.62	Below top of pump	6/28/2013	ND

Notes
Readings shown are last set readings collected during sampling.
NC - not collected
ND - non Detect
ft bgs - feet below ground surface
mL/min - milliliters per minute
°C - temperature units of degrees centigrade
mS/cm - millisiemens per centimeter
mg/L - milligrams per liter
mV - millivolts
NTU - Nephelometric turbidity units
d/m/y - day/month/year
µg/L - micrograms per liter

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	RI23	RI24	RI25	RI28	RI29	RI30	TW01	TW02	TW03	TW04	TW05	TW06	TW07	TW08	TW09	TW10
Sample Date		6/28/2013	6/28/2013	6/28/2013	6/28/2013	6/27/2013	6/28/2013	6/24/2013	6/25/2013	6/24/2013	6/26/2013	6/25/2013	6/26/2013	6/26/2013	6/26/2013	6/26/2013	6/28/2013
Field Sample Identification		RI23.062813	RI24.062813	RI25.062813	RI28.062813	RI29.062713	RI30.062813	TW01.062413	TW02.062513	TW03.062413	TW04.062613	TW05.062513	TW06.062613	TW07.062613	TW08.062613	TW09.062313	TW10.062813
Volatiles Organic Compounds, VOCs (µg/L)																	
1,1,1-Trichloroethane	200	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	1 j	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2,2-Tetrachloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1,2-Trichloroethane	5	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2-Trichlorotrifluoroethane (Freon 113)		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
1,1-Dichloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1-Dichloroethene	7	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	2 j	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,2,3-Trichlorobenzene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2,4-Trichlorobenzene	70	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dibromo-3-chloropropane	0.2	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
1,2-Dibromoethane	0.05	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichlorobenzene	600	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloroethane	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloropropane	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,3-Dichlorobenzene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dichlorobenzene	75	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dioxane		70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u
2-Hexanone		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u
4-Methyl-2-pentanone		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u
Acetone		6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u
Benzene	5	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Bromochloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromodichloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromoform		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromomethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon disulfide		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon tetrachloride	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Chlorobenzene	100	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Chloroform		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
cis-1,2-Dichloroethene	70	3 j	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.9 j	**270**	**150**	58	**140**	**94**	**100**	1 j	0.8 u	0.8 u
cis-1,3-Dichloropropene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Cumene (Isopropyl benzene)		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Cyclohexane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Cyclohexane, Methyl-		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Dibromochloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Dichlorodifluoromethane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Ethylbenzene	700	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Methyl acetate		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Methyl ethyl ketone (2-Butanone)		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	RI23	RI24	RI25	RI28	RI29	RI30	TW01	TW02	TW03	TW04	TW05	TW06	TW07	TW08	TW09	TW10
Sample Date		6/28/2013	6/28/2013	6/28/2013	6/28/2013	6/27/2013	6/28/2013	6/24/2013	6/25/2013	6/24/2013	6/26/2013	6/25/2013	6/26/2013	6/26/2013	6/26/2013	6/26/2013	6/28/2013
Field Sample Identification		RI23.062813	RI24.062813	RI25.062813	RI28.062813	RI29.062713	RI30.062813	TW01.062413	TW02.062513	TW03.062413	TW04.062613	TW05.062513	TW06.062613	TW07.062613	TW08.062613	TW09.062313	TW10.062813
Volatiles Organic Compounds, VOCs (µg/L)																	
Methyl tert butyl ether		0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Methylene chloride	5	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Styrene	100	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Tetrachloroethene	5	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 j	1 j	0.8 u	1 j	0.8 u	0.8 j	0.8 u	0.8 u	0.8 u
Toluene	1000	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u
trans-1,2-Dichloroethene	100	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	3 j	1 j	0.8 u	2 j	1 j	0.8 u	0.8 u	0.8 u	0.8 u
trans-1,3-Dichloropropene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Trichloroethene	5	**28**	1 u	2 j	**7**	1 u	1 u	**11**	**1,400**	**1000**	**460**	**950**	**710**	**760**	**18**	**14**	1 u
Trichlorofluoromethane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Vinyl Chloride	2	1 u	1 u	1 u	1 u	1 u	1 u	1 u	2 j	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Xylene (m,p)		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (o)		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (Total)	10000	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u

Notes:

-- Not analyzed

Concentrations which exceed the US EPA GW Maximum Contaminant Level (MCLs) are highlighted blue

µg/L - micrograms per liter

Data Qualifiers:

J - Estimated value

U - Non-detectable

R - Rejected/unuseable data

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW11	TW12	TW13	TW14	TW15	TW16	TW17	TW18	TW19	TW20	TW21	TW22	TW23	TW24	TW25
Sample Date		6/25/2013	6/25/2013	6/18/2013	6/18/2013	6/18/2013	6/18/2013	6/18/2013	6/18/2013	6/17/2013	6/17/2013	6/17/2013	6/17/2013	6/18/2013	6/17/2013	6/18/2013
Field Sample Identification		TW11.062513	TW12.062513	TW-13-061813	TW-14-061813	TW-15-061813	TW-16-061813	TW-17-061813	TW-18-061813	TW19-061713	TW20-061713	TW21-061713	TW22-061713	TW-23-061813	TW24-061713	TW-25-061813
Volatiles Organic Compounds, VOCs (µg/L)																
1,1,1-Trichloroethane	200	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2,2-Tetrachloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1,2-Trichloroethane	5	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2-Trichlorotrifluoroethane (Freon 113)		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	10 u	2 u	2 u	2 u	2 u	2 u	2 u
1,1-Dichloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1-Dichloroethene	7	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	1 j	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,2,3-Trichlorobenzene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2,4-Trichlorobenzene	70	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dibromo-3-chloropropane	0.2	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	10 u	2 u	2 u	2 u	2 u	2 u	2 u
1,2-Dibromoethane	0.05	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichlorobenzene	600	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloroethane	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloropropane	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,3-Dichlorobenzene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dichlorobenzene	75	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dioxane		70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	350 uj	70 uj	70 uj	70 uj	70 u	70 uj	70 u
2-Hexanone		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	15 u	3 u	3 u	3 u	3 u	3 u	3 u
4-Methyl-2-pentanone		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	15 u	3 u	3 u	3 u	3 u	3 u	3 u
Acetone		6 u	6 u	6 u	16 j	6 u	6 u	6 u	6 u	30 u	6 u	12 j	6 u	6 u	6 j	6 u
Benzene	5	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	3 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Bromochloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromodichloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromoform		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromomethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon disulfide		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 uj	1 uj	1 uj	1 uj	1 u	1 uj	1 u
Carbon tetrachloride	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Chlorobenzene	100	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Chloroform		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
cis-1,2-Dichloroethene	70	0.8 u	0.8 u	0.8 u	0.8 u	5	0.8 u	0.8 u	**190**	**410**	**240**	**110**	0.8 u	10	0.8 u	0.8 u
cis-1,3-Dichloropropene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Cumene (Isopropyl benzene)		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Cyclohexane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	10 u	2 u	2 u	2 u	2 u	2 u	2 u
Cyclohexane, Methyl-		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Dibromochloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Dichlorodifluoromethane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	10 u	2 u	2 u	2 u	2 u	2 u	2 u
Ethylbenzene	700	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Methyl acetate		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Methyl ethyl ketone (2-Butanone)		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	15 u	3 u	3 u	3 u	3 u	3 u	3 u

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW11	TW12	TW13	TW14	TW15	TW16	TW17	TW18	TW19	TW20	TW21	TW22	TW23	TW24	TW25
Sample Date		6/25/2013	6/25/2013	6/18/2013	6/18/2013	6/18/2013	6/18/2013	6/18/2013	6/18/2013	6/17/2013	6/17/2013	6/17/2013	6/17/2013	6/18/2013	6/17/2013	6/18/2013
Field Sample Identification		TW11.062513	TW12.062513	TW-13-061813	TW-14-061813	TW-15-061813	TW-16-061813	TW-17-061813	TW-18-061813	TW19-061713	TW20-061713	TW21-061713	TW22-061713	TW-23-061813	TW24-061713	TW-25-061813
Volatiles Organic Compounds, VOCs (µg/L)																
Methyl tert butyl ether		0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	3 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Methylene chloride	5	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	10 u	2 u	2 u	2 u	2 u	2 u	2 u
Styrene	100	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Tetrachloroethene	5	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	2 j	4 u	4 j	3 j	0.8 u	0.8 u	0.8 u	0.8 u
Toluene	1000	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	4 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u
trans-1,2-Dichloroethene	100	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	3 j	5 j	4 j	1 j	0.8 u	0.8 u	0.8 u	0.8 u
trans-1,3-Dichloropropene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Trichloroethene	5	5 j	3 j	1 u	1 j	**34**	1 u	1 u	**950**	**7,200**	**1,400**	**570**	**7**	**110**	1 u	1 u
Trichlorofluoromethane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	10 u	2 u	2 u	2 u	2 u	2 u	2 u
Vinyl Chloride	2	1 u	1 u	1 u	1 u	1 u	1 u	1 u	**6**	5 u	1 u	1 u	1 u	1 u	1 u	1 u
Xylene (m,p)		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (o)		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (Total)	10000	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	4 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u

Notes:

-- Not analyzed

Concentrations which exceed the US EPA GW Maximum Contaminant Level (MCLs) are highlighted blue

µg/L - micrograms per liter

Data Qualifiers:

J - Estimated value

U - Non-detectable

R - Rejected/unuseable data

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW26A	TW27A	TW29A	TW30	TW31	TW33	TW34	TW35	TW36	TW37
Sample Date		6/20/2013	6/20/2013	6/21/2013	6/20/2013	6/20/2013	6/20/2013	6/20/2013	6/19/2013	6/19/2013	6/19/2013
Field Sample Identification		TW26A-062013	TW27A-062013	TW29A.062113	TW30-062013	TW31-062013	TW33-062013	TW34-062013	TW35-061913	TW36-061913	TW37-061913
Volatiles Organic Compounds, VOCs (µg/L)											
1,1,1-Trichloroethane	200	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2,2-Tetrachloroethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1,2-Trichloroethane	5	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2-Trichlorotrifluoroethane (Freon 113)		2 u	20 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
1,1-Dichloroethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1-Dichloroethene	7	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,2,3-Trichlorobenzene		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2,4-Trichlorobenzene	70	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dibromo-3-chloropropane	0.2	2 u	20 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
1,2-Dibromoethane	0.05	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichlorobenzene	600	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloroethane	5	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloropropane	5	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,3-Dichlorobenzene		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dichlorobenzene	75	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dioxane		70 u	700 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u
2-Hexanone		3 u	30 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u
4-Methyl-2-pentanone		3 u	30 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u
Acetone		6 u	60 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u
Benzene	5	0.5 u	5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Bromochloromethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromodichloromethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromoform		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromomethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon disulfide		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon tetrachloride	5	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Chlorobenzene	100	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloroethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Chloroform		0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloromethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
cis-1,2-Dichloroethene	70	13	**490**	2 j	0.8 u	**110**	0.8 u	57	**82**	50	0.8 u
cis-1,3-Dichloropropene		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Cumene (Isopropyl benzene)		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Cyclohexane		2 u	20 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Cyclohexane, Methyl-		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Dibromochloromethane		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Dichlorodifluoromethane		2 u	20 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Ethylbenzene	700	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Methyl acetate		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Methyl ethyl ketone (2-Butanone)		3 u	30 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW26A	TW27A	TW29A	TW30	TW31	TW33	TW34	TW35	TW36	TW37
Sample Date		6/20/2013	6/20/2013	6/21/2013	6/20/2013	6/20/2013	6/20/2013	6/20/2013	6/19/2013	6/19/2013	6/19/2013
Field Sample Identification		TW26A-062013	TW27A-062013	TW29A.062113	TW30-062013	TW31-062013	TW33-062013	TW34-062013	TW35-061913	TW36-061913	TW37-061913
Volatiles Organic Compounds, VOCs (µg/L)											
Methyl tert butyl ether		0.5 u	5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Methylene chloride	5	2 u	20 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Styrene	100	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Tetrachloroethene	5	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Toluene	1000	0.7 u	7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u
trans-1,2-Dichloroethene	100	0.8 u	8 u	0.8 u	0.8 u	0.9 j	0.8 u	1 j	0.8 u	0.8 u	0.8 u
trans-1,3-Dichloropropene		1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Trichloroethene	5	**150**	**6,700**	**22**	1 j	**850**	1 u	**380**	**640**	**400**	1 u
Trichlorofluoromethane		2 u	20 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Vinyl Chloride	2	1 u	10 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Xylene (m,p)		0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (o)		0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (Total)	10000	0.8 u	8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u

Notes:

-- Not analyzed

Concentrations which exceed the US EPA GW Maximum Contaminant Level (MCLs) are highlighted blue

µg/L - micrograms per liter

Data Qualifiers:

J - Estimated value

U - Non-detectable

R - Rejected/unuseable data

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW38	TW39	TW40	TW44A	TW45	TW46	TW47	TW48	TW49	TW50	TW51
Sample Date		6/20/2013	6/19/2013	6/19/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013
Field Sample Identification		TW38-062013	TW39-061913	TW40-061913	TW44A-090513	TW45-090513	TW46-090513	TW47-090513	TW48-090513	TW49-090513	TW50-090513	TW51-090513
Volatiles Organic Compounds, VOCs (µg/L)												
1,1,1-Trichloroethane	200	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2,2-Tetrachloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1,2-Trichloroethane	5	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,1,2-Trichlorotrifluoroethane (Freon 113)		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
1,1-Dichloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,1-Dichloroethene	7	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
1,2,3-Trichlorobenzene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2,4-Trichlorobenzene	70	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dibromo-3-chloropropane	0.2	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
1,2-Dibromoethane	0.05	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichlorobenzene	600	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloroethane	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,2-Dichloropropane	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,3-Dichlorobenzene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dichlorobenzene	75	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
1,4-Dioxane		70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u	70 u
2-Hexanone		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u
4-Methyl-2-pentanone		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u
Acetone		6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u	6 u
Benzene	5	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Bromochloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromodichloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromoform		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Bromomethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon disulfide		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Carbon tetrachloride	5	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Chlorobenzene	100	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloroethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Chloroform		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Chloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
cis-1,2-Dichloroethene	70	0.8 u	0.8 u	0.8 u	0.8 u	5	34	2 j	0.8 u	14	16	6
cis-1,3-Dichloropropene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Cumene (Isopropyl benzene)		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Cyclohexane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Cyclohexane, Methyl-		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Dibromochloromethane		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Dichlorodifluoromethane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Ethylbenzene	700	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Methyl acetate		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Methyl ethyl ketone (2-Butanone)		3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u	3 u

TABLE 3 - Summary of VOC Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW38	TW39	TW40	TW44A	TW45	TW46	TW47	TW48	TW49	TW50	TW51
Sample Date		6/20/2013	6/19/2013	6/19/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013	9/5/2013
Field Sample Identification		TW38-062013	TW39-061913	TW40-061913	TW44A-090513	TW45-090513	TW46-090513	TW47-090513	TW48-090513	TW49-090513	TW50-090513	TW51-090513
Volatiles Organic Compounds, VOCs (µg/L)												
Methyl tert butyl ether		0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u	0.5 u
Methylene chloride	5	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Styrene	100	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Tetrachloroethene	5	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Toluene	1000	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u	0.7 u
trans-1,2-Dichloroethene	100	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
trans-1,3-Dichloropropene		1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Trichloroethene	5	1 u	**6**	1 u	5 j	**34**	**250**	**23**	1 u	**130**	**110**	**71**
Trichlorofluoromethane		2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u	2 u
Vinyl Chloride	2	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u
Xylene (m,p)		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (o)		0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u
Xylene (Total)	10000	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u	0.8 u

Notes:

-- Not analyzed

Concentrations which exceed the US EPA GW Maximum Contaminant Level (MCLs) are highlighted blue

µg/L - micrograms per liter

Data Qualifiers:

J - Estimated value

U - Non-detectable

R - Rejected/unuseable data

TABLE 4 - Summary of General Chemistry Analytical Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Identification	US EPA GW MCLs	TW01	TW02	TW02	TW03	TW04	TW05	TW06	TW07	TW08	TW09	TW10
Sample Date		6/24/2013	6/25/2013	6/28/2013	6/24/2013	6/27/2013	6/25/2013	6/26/2013	6/26/2013	6/26/2013	6/26/2013	7/1/2013
Field Sample Identification		TW01.062413	TW02.062513	TW02.062813	TW03.062413	TW04.062713	TW05.062513	TW06.062613	TW07.062613	TW08.062613	TW09.062313	TW10.070113
Dissolved Gases (µg/L)												
Ethane		1.0 u	1.0 u	--	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u	2.0 u
Ethene		1.0 u	1.0 u	--	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u	1.0 u
Methane		3.3 j	3.0 u	--	3.0 u	3.0 u	3.0 u	3.0 u	3.0 u	3.0 u	3.0 u	13,000
General Chemistry (mg/L)												
Chloride		242	62.3	36.4	80.8	24.8	54.5	29.5	32.2	4.9	51.3	28.4
Nitrate	10	1.7	--	0.98	1.4	1.6	0.97	0.89	0.9	0.46 j	0.56	0.25 j
Nitrite	1	0.4 u	--	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u
Sulfate	0	21	11.2	14.3	10.3	23.4	10.3	9.7	8.9	14.7	15.2	3.2 j
Total Alkalinity		52.2	9.4	--	9.6	16.8	8.2	15.9	8.0 j	20.9	22.7	661
Phenolphthalein Alkalinity		0.70 u	0.70 u	--	0.70 u	0.70 u	0.70 u	0.70 u	0.70 u	0.70 u	0.70 u	0.70 u

Notes:

-- Not analyzed

µg/L - micrograms per liter

mg/L - milligrams per liter

Concentrations which exceed the US EPA GW Maximum Contaminant Level (MCLs) are highlighted blue

Data Qualifiers:

j - estimated value

u - non-detectable

TABLE 5 - Summary of Compoud Specific Isotope Analysis Results - Groundwater
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Sample Location	Trichloroethene, TCE	
	Concentration (mg/L)	Carbon Isotope Ratio ($\delta^{13}C$)
TW01	0.01	< d.l.
TW02	3.5	-22
TW03	1.1	-20.1
TW04	0.47	-22.3
TW05	1.3	-19.3
TW06	0.73	-21.6
TW07	0.83	-19.7
TW08	0.02	< d.l.
TW09	0.03	< d.l.
TW10	<0.01	< d.l.

Notes
mg/L - milligrams per liter
<d.l. - below detection limit of CSIA method
CSIA - compound specific isotope analysis
Carbon Isotope Ratio, $\delta^{13}C$ - delta carbon 13, or the ratio of Carbon 13 to 12 (i.e., ^{13}C / ^{12}C)

TABLE 6 - Summary of VOC Analytical Results - Soils
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Soil Boring Location	US EPA Region 3,6,9-Soil Industrial SSLs	**US EPA Region 3,6,9-Soil PGW-MCL-based SSLs**	SB01	SB02	SB03	SB04	SB05	SB06	SB07
Sample Date			6/10/2013	6/10/2013	6/12/2013	6/12/2013	6/12/2013	6/11/2013	6/11/2013
Field Sample Identification			SB01(12.5-13).061013	SB02(13-13.5).061013	SB03(12.5-13).061213	SB04(9.5-10).061213	SB05(12.5-13).061213	SB06(15-15.5).061113	SB07(9.5-10).061113
Sample Depth (ft bgs)			12.5 - 13	13 - 13.5	12.5 - 13	9.5 - 10	12.5 - 13	15 - 15.5	9.5 - 10
VOCs (mg/kg)									
1,1,1-Trichloroethane	38000	0.07	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,1,2,2-Tetrachloroethane	2.8		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,1,2-Trichloroethane	5.3	0.0016	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,1,2-Trichlorotrifluoroethane (Freon 113)	180000		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
1,1-Dichloroethane	17		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,1-Dichloroethene	1100	0.0025	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,2,3-Trichlorobenzene	490		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,2,4-Trichlorobenzene	99	0.2	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dibromo-3-chloropropane	0.069	0.000086	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
1,2-Dibromoethane	0.17	0.000014	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dichlorobenzene	9800	0.58	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dichloroethane	2.2	0.0014	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dichloropropane	4.7	0.0017	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,3-Dichlorobenzene			0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,4-Dichlorobenzene	12	0.072	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
1,4-Dioxane	17		0.079 u	0.083 u	0.086 u	0.087 u	0.082 u	0.079 u	0.090 u
2-Hexanone	1400		0.003 u	0.004 u	0.004 u	0.004 u	0.004 u	0.003 u	0.004 u
4-Methyl-2-pentanone	53000		0.003 u	0.004 u	0.004 u	0.004 u	0.004 u	0.003 u	0.004 u
Acetone	630000		0.010 j	0.018 j	0.010 j	0.012 j	0.010 j	0.011 j	0.009 j
Benzene	5.4	0.0026	0.0006 u	0.0006 u	0.0006 u	0.0006 u	0.0006 u	0.0006 u	0.0006 u
Bromochloromethane	680		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Bromodichloromethane	1.4	0.022	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Bromoform	220	0.021	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Bromomethane	32		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
Carbon disulfide	3700		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Carbon tetrachloride	3	0.0019	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Chlorobenzene	1400	0.068	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Chloroethane	61000		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
Chloroform	1.5	0.022	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Chloromethane	500		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
cis-1,2-Dichloroethene	2000	0.021	0.001 u	0.001 u	0.011	0.002 j	0.006	0.013	0.004 j
cis-1,3-Dichloropropene			0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Cumene (Isopropyl benzene)	11000		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Cyclohexane	29000		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Cyclohexane, Methyl-			0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Dibromochloromethane	3.3	0.021	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Dichlorodifluoromethane	400		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
Ethylbenzene	27	0.78	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Methyl acetate	1000000		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
Methyl ethyl ketone (2-Butanone)	200000		0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u

TABLE 6 - Summary of VOC Analytical Results - Soils
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Soil Boring Location	US EPA Region 3,6,9-Soil Industrial SSLs	**US EPA Region 3,6,9-Soil PGW-MCL-based SSLs**	SB01	SB02	SB03	SB04	SB05	SB06	SB07
Sample Date			6/10/2013	6/10/2013	6/12/2013	6/12/2013	6/12/2013	6/11/2013	6/11/2013
Field Sample Identification			SB01(12.5-13).061013	SB02(13-13.5).061013	SB03(12.5-13).061213	SB04(9.5-10).061213	SB05(12.5-13).061213	SB06(15-15.5).061113	SB07(9.5-10).061113
Sample Depth (ft bgs)			12.5 - 13	13 - 13.5	12.5 - 13	9.5 - 10	12.5 - 13	15 - 15.5	9.5 - 10
VOCs (mg/kg)									
Methyl tert butyl ether	220		0.0006 u	0.0006 u	0.0006 u	0.0006 u	0.0006 u	0.0006 u	0.0006 u
Methylene chloride	960	0.0013	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
Styrene	36000	0.11	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Tetrachloroethene	110	0.0023	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Toluene	45000	0.69	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
trans-1,2-Dichloroethene	690	0.029	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
trans-1,3-Dichloropropene			0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Trichloroethene	6.4	0.0018	0.001 u	**0.006**	**0.087**	**0.037**	**0.049**	**0.12**	**0.037**
Trichlorofluoromethane	3400		0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.002 u	0.003 u
Vinyl Chloride	1.7	0.00069	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Xylene (m,p)			0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Xylene (o)	3000		0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u
Xylene (Total)	2700	9.8	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u

Notes

-- - not analyzed

ft bgs - feet below ground surface

Concentrations which exceed the US EPA Industrial Soil Screening Levels (SSLs) are highlighted **Bronze**

Concentrations which exceed the US EPA Protection of Groundwater -MCL-based Soil Screening Levels (SSLs) are highlighted **Teal**

Data Qualifiers:

j - estimated value

u - non-detectable

TABLE 6 - Summary of VOC Analytical Results - Soils
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Soil Boring Location	US EPA Region 3,6,9-Soil Industrial SSLs	**US EPA Region 3,6,9-Soil PGW-MCL-based SSLs**	SB08		SB09	SB10
Sample Date			6/11/2013	6/11/2013	6/11/2013	6/11/2013
Field Sample Identification			SB08(13-13.5).061113	SB08(13-13.5).061113.DUP	SB09(12.5-13).061113	SB10(29-29.5).061113
Sample Depth (ft bgs)			13 - 13.5	13 - 13.5	12.5 - 13	29 - 29.5
VOCs (mg/kg)						
1,1,1-Trichloroethane	38000	0.07	0.001 u	0.001 u	0.001 u	0.001 u
1,1,2,2-Tetrachloroethane	2.8		0.001 u	0.001 u	0.001 u	0.001 u
1,1,2-Trichloroethane	5.3	0.0016	0.001 u	0.001 u	0.001 u	0.001 u
1,1,2-Trichlorotrifluoroethane (Freon 113)	180000		0.002 u	0.002 u	0.002 u	0.002 u
1,1-Dichloroethane	17		0.001 u	0.001 u	0.001 u	0.001 u
1,1-Dichloroethene	1100	0.0025	0.001 u	0.001 u	0.001 u	0.001 u
1,2,3-Trichlorobenzene	490		0.001 u	0.001 u	0.001 u	0.001 u
1,2,4-Trichlorobenzene	99	0.2	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dibromo-3-chloropropane	0.069	0.000086	0.002 u	0.002 u	0.002 u	0.002 u
1,2-Dibromoethane	0.17	0.000014	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dichlorobenzene	9800	0.58	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dichloroethane	2.2	0.0014	0.001 u	0.001 u	0.001 u	0.001 u
1,2-Dichloropropane	4.7	0.0017	0.001 u	0.001 u	0.001 u	0.001 u
1,3-Dichlorobenzene			0.001 u	0.001 u	0.001 u	0.001 u
1,4-Dichlorobenzene	12	0.072	0.001 u	0.001 u	0.001 u	0.001 u
1,4-Dioxane	17		0.084 u	0.084 u	0.084 u	0.077 u
2-Hexanone	1400		0.004 u	0.004 u	0.004 u	0.003 u
4-Methyl-2-pentanone	53000		0.004 u	0.004 u	0.004 u	0.003 u
Acetone	630000		0.008 u	0.008 u	0.009 j	0.008 u
Benzene	5.4	0.0026	0.0006 u	0.0006 u	0.0006 u	0.0006 u
Bromochloromethane	680		0.001 u	0.001 u	0.001 u	0.001 u
Bromodichloromethane	1.4	0.022	0.001 u	0.001 u	0.001 u	0.001 u
Bromoform	220	0.021	0.001 u	0.001 u	0.001 u	0.001 u
Bromomethane	32		0.002 u	0.002 u	0.002 u	0.002 u
Carbon disulfide	3700		0.001 u	0.001 u	0.001 u	0.001 u
Carbon tetrachloride	3	0.0019	0.001 u	0.001 u	0.001 u	0.001 u
Chlorobenzene	1400	0.068	0.001 u	0.001 u	0.001 u	0.001 u
Chloroethane	61000		0.002 u	0.002 u	0.002 u	0.002 u
Chloroform	1.5	0.022	0.001 u	0.001 u	0.001 u	0.001 u
Chloromethane	500		0.002 u	0.002 u	0.002 u	0.002 u
cis-1,2-Dichloroethene	2000	0.021	0.001 u	0.001 u	0.001 u	0.001 u
cis-1,3-Dichloropropene			0.001 u	0.001 u	0.001 u	0.001 u
Cumene (Isopropyl benzene)	11000		0.001 u	0.001 u	0.001 u	0.001 u
Cyclohexane	29000		0.001 u	0.001 u	0.001 u	0.001 u
Cyclohexane, Methyl-			0.001 u	0.001 u	0.001 u	0.001 u
Dibromochloromethane	3.3	0.021	0.001 u	0.001 u	0.001 u	0.001 u
Dichlorodifluoromethane	400		0.002 u	0.002 u	0.002 u	0.002 u
Ethylbenzene	27	0.78	0.001 u	0.001 u	0.001 u	0.001 u
Methyl acetate	1000000		0.002 u	0.002 u	0.002 u	0.002 u
Methyl ethyl ketone (2-Butanone)	200000		0.005 u	0.005 u	0.005 u	0.004 u

TABLE 6 - Summary of VOC Analytical Results - Soils
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Soil Boring Location	US EPA Region 3,6,9-Soil Industrial SSLs	**US EPA Region 3,6,9-Soil PGW-MCL-based SSLs**	SB08		SB09	SB10
Sample Date			6/11/2013	6/11/2013	6/11/2013	6/11/2013
Field Sample Identification			SB08(13-13.5).061113	SB08(13-13.5).061113.DUP	SB09(12.5-13).061113	SB10(29-29.5).061113
Sample Depth (ft bgs)			13 - 13.5	13 - 13.5	12.5 - 13	29 - 29.5
VOCs (mg/kg)						
Methyl tert butyl ether	220		0.0006 u	0.0006 u	0.0006 u	0.0006 u
Methylene chloride	960	0.0013	0.002 u	0.002 u	0.002 u	0.002 u
Styrene	36000	0.11	0.001 u	0.001 u	0.001 u	0.001 u
Tetrachloroethene	110	0.0023	0.001 u	0.001 u	0.001 u	0.001 u
Toluene	45000	0.69	0.001 u	0.001 u	0.001 u	0.001 u
trans-1,2-Dichloroethene	690	0.029	0.001 u	0.001 u	0.001 u	0.001 u
trans-1,3-Dichloropropene			0.001 u	0.001 u	0.001 u	0.001 u
Trichloroethene	6.4	0.0018	**0.003 j**	**0.003 j**	**0.002 j**	0.001 u
Trichlorofluoromethane	3400		0.002 u	0.002 u	0.002 u	0.002 u
Vinyl Chloride	1.7	0.00069	0.001 u	0.001 u	0.001 u	0.001 u
Xylene (m,p)			0.001 u	0.001 u	0.001 u	0.001 u
Xylene (o)	3000		0.001 u	0.001 u	0.001 u	0.001 u
Xylene (Total)	2700	9.8	0.001 u	0.001 u	0.001 u	0.001 u

Notes

-- - not analyzed

ft bgs - feet below ground surface

Concentrations which exceed the US EPA Industrial Soil Screening Levels (SSLs)

Concentrations which exceed the US EPA Protection of Groundwater -MCL-based Soil Screening Levels (SSLs) are highlighted **Teal**

Data Qualifiers:

j - estimated value

u - non-detectable

TABLE 7 - Summary of Groundwater Elevations - Temporary Wells
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

		24-Jun-13		1-Jun-13		8-Jul-13	
Well Location	**Ground Surface Elevation (ft amsl)**	**Depth to Water (ft bgs)**	**Groundwater Elevation (ft amsl)**	**Depth to Water (ft bgs)**	**Groundwater Elevation (ft amsl)**	**Depth to Water (ft bgs)**	**Groundwater Elevation (ft amsl)**
TW01	296.10	10.05	286.05	7.65	288.45	7.27	288.83
TW02	296.66	8.35	288.31	8.51	288.15	8.10	288.56
TW03	296.47	8.40	288.07	8.46	288.01	8.13	288.34
TW04	297.33	9.27	288.06	1.90	295.43	8.95	288.38
TW05	296.37	8.53	287.84	8.18	288.19	8.30	288.07
TW06	295.19	8.01	287.18	7.90	287.29	7.80	287.39
TW07	293.59	6.64	286.95	6.58	287.01	6.35	287.24
TW08	290.37	3.62	286.75	3.41	286.96	3.38	286.99
TW09	289.44	3.14	286.30	3.69	285.75	3.40	286.04
TW10	312.61	19.87	292.74	20.88	291.73	21.06	291.55
TW11	296.40	6.58	289.82	8.08	288.32	7.75	288.65
TW12	296.34	7.83	288.51	7.84	288.50	7.60	288.74

Notes
ft amsl - feet above mean sea level
ft bgs - feet below groundsurface
GW - groundwater
Water level collected from temporary wells on the following dates:
- 24 June 2013 - prior to low flow groundwater sampling.
- 1 July 2013 - post-low flow groundwater sampling.
- 8 July 2013 - prior to well abandonment.

TABLE 7 - Summary of Groundwater Elevations - Existing Wells
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Well Location	Top of Casing Elevation (ft amsl)	Depth to Bottom (ft btoc)	Depth to Bottom Elevation (ft amsl)	4-Jun-13		24-Jun-13		1-Jul-13		3-Sep-13		3-Sep-13		17-Sep-13	
				Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)	Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)	Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)	Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)	Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)	Depth to Water (ft btoc)	Groundwater Elevation (ft amsl)
Overburden Wells															
RI23	296.39	22.71	273.68	9.07	287.32	8.24	288.15	8.32	288.07	7.95	288.44	9.55	286.84	10.65	285.74
RI24	296.07	11.90	284.17	6.52	289.55	6.02	290.05	6.14	289.93	5.92	290.15	6.76	289.31	7.35	288.72
RI25	295.22	13.45	281.77	7.36	287.86	6.75	288.47	Under water		6.37	288.85	7.95	287.27	9.02	286.2
RI28	297.18	18.07	279.11	8.42	288.76	7.04	290.14	7.8	289.38	7.43	289.75	9.23	287.95	10.30	286.88
RI29	296.72	10.71	286.01	7.13	289.59	6.49	290.23	6.41	290.31	6.35	290.37	7.34	289.38	8.14	288.58
RI30	291.95	8.78	283.17	5.64	286.31	4.9	287.05	Under water		4.64	287.31	6.02	285.93	7.18	284.77
RI31	293.37	8.00	285.37	7.25	286.12	NM	NM	NM	NM	6.35	287.02	7.83	285.54	Dry	
Bedrock Wells - Shallow															
RI18S	293.09	63.41	229.68	NM	NM	NM	NM	NM	NM	NM	NM	6.03	287.06	7.07	286.02
RI19S	294.25	55.75	238.50	NM	NM	NM	NM	NM	NM	NM	NM	4.78	289.47	5.65	288.60
RI27S	298.00	53.90	244.10	NM	NM	NM	NM	NM	NM	NM	NM	12.96	285.04	14.33	283.67
RW4S	292.60	46.98	245.62	NM	NM	NM	NM	NM	NM	NM	NM	7.00	285.60	7.90	284.70
RW5S	296.11	44.85	251.26	NM	NM	NM	NM	NM	NM	NM	NM	10.91	285.20	12.05	284.06
RW6S	297.07	44.81	252.26	NM	NM	NM	NM	NM	NM	NM	NM	7.57	289.50	8.40	288.67
W3	288.43	23.25	265.18	NM	NM	NM	NM	NM	NM	NM	NM	7.30	281.13	8.19	280.24
W4	292.70	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	8.10	284.60
W5	296.27	32.58	263.69	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	13.63	282.64
W6	299.94	31.64	268.3	NM	NM	NM	NM	NM	NM	NM	NM	8.75	291.19	9.35	290.59
W8	290.04	29.30	260.74	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	5.51	284.53
W9	297.26	44.25	253.01	NM	NM	NM	NM	NM	NM	NM	NM	7.16	290.10	9.42	287.84
Bedrock Wells - Intermediate															
RW4I	292.81	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
RW5I	296.26	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	12.81	283.45
RW6I	296.62	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	7.11	289.51	8.00	288.62
Bedrock Wells - Deep															
RI18D	293.09	89.94	203.15	NM	NM	NM	NM	NM	NM	NM	NM	6.31	286.78	7.44	285.65
RI19D	294.29	79.75	214.54	NM	NM	NM	NM	NM	NM	NM	NM	4.81	289.48	5.68	288.61
RI27D	298.01	308.00	-9.99	NM	NM	NM	NM	NM	NM	NM	NM	14.64	283.37	15.78	282.23
RW4D	292.74	300.00	-7.26	NM	NM	NM	NM	NM	NM	NM	NM	9.20	283.54	10.25	282.49
RW5D	296.09	300.00	-3.91	NM	NM	NM	NM	NM	NM	NM	NM	10.75	285.34	11.85	284.24
RW6D	297.00	300.00	-3.00	NM	NM	NM	NM	NM	NM	NM	NM	Artesian		Artesian	

Notes:
Existing wells were re-surveyed by DWS, Inc. on 11 July 2013 and 17 September 2013.
RI31 screened interval was silted in and not included in water level collection.
RI25 and RI30 were under standing water during the 1 July 2013 DTW event and were not measured
Artesian conditions were observed in RW6D on both 3 September 2013 and 17 September 2013 events.
ft amsl - feet above mean sea level
ft btoc - feet below top of casing
NM - not measured

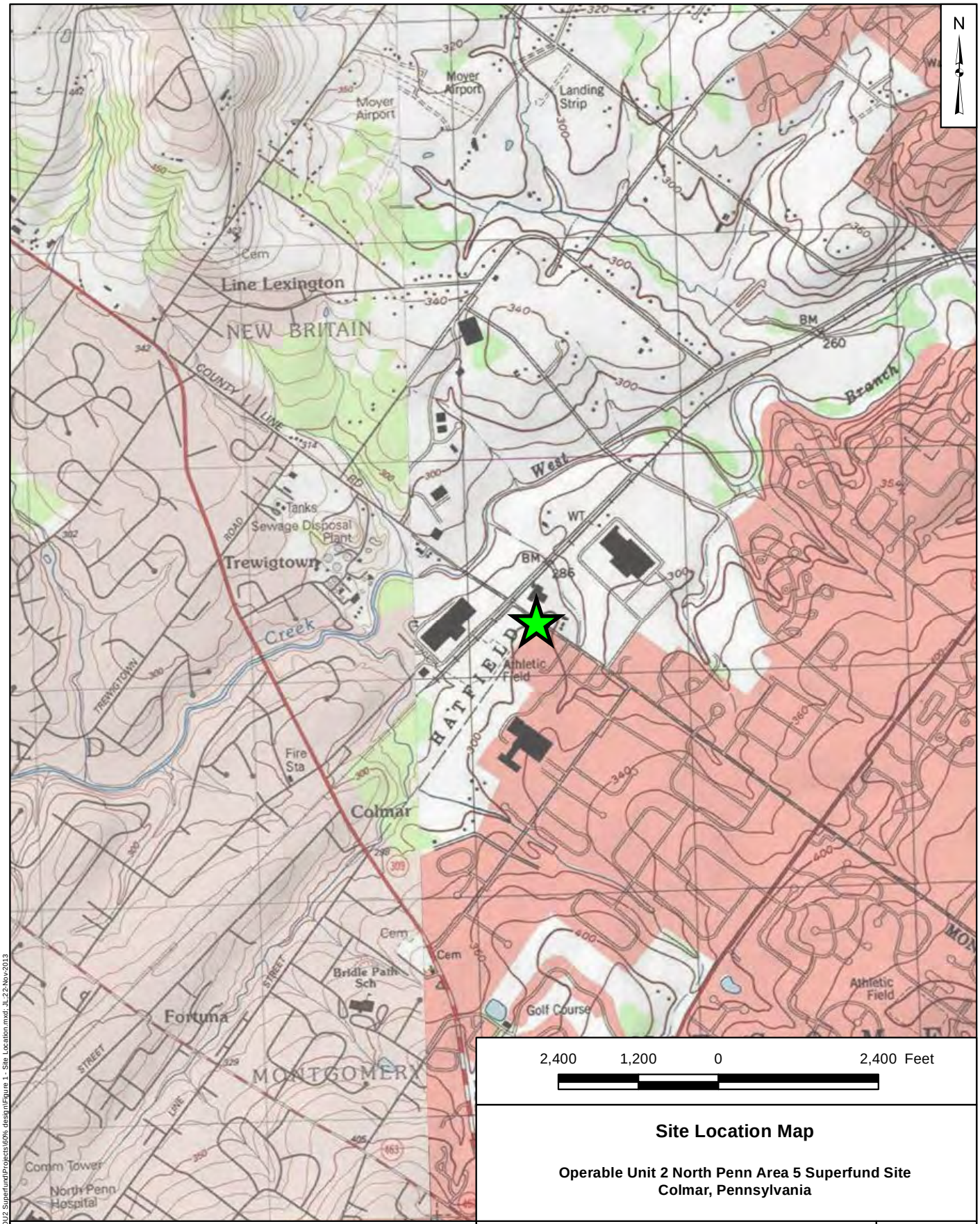
TABLE 8: Biostimulant Implementation Performance Evaluation
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Analysis	Indicator	Evaluation Criteria	Actions
EVO Volume	EVO Distribution	If volume injected is equal to prescribed design volume than distribution is likely successful (indirect indicator). If less than design volume, will require careful evaluation of TOC indicators.	Use TOC data to evaluate distribution mechanics and potentially revise application method.
TOC	Measure of EVO presence/ distribution	Spike of TOC relative to baseline indicative of EVO presence and successful distribution to sample location. In general 100-500 mg/l TOC would be considered a goal target minimum concentration.	No or low initial (pre-bioaugmentation) TOC is indicative of poor or no EVO distribution at sampling location and additional injections should be considered. Decreasing TOC trends after bioaugmentation indicate substrate consumption. Values approaching baseline will be indicative of the need to potentially inject supplemental EVO.
DO	Measure of Anaerobic Status	DO concentrations should indicate a decreasing trend from baseline conditions and approach zero. Anaerobic conditions are indicative of successful EVO distribution at concentrations sufficient to establish the required conditions.	Bioaugmentation should not be completed until DO indicates anaerobic conditions are met in the treatment zone.
MNA	TEA Process	Conditions should be indicative of the TEA process occurring including a decrease in concentrations of nitrate, iron, and sulfate. ORP values should confirm reducing conditions (<-50mV)	Use results in conjunction with dissolved gases results to monitor TEA process and ensure that methanogenic conditions are occurring (required for complete biodegradation of TCE to ethene).

TABLE 9: Biodegradation Performance Evaluation
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Analysis	Indicator	Evaluation Criteria	Actions
pH	pH/buffering	pH results will be monitored closely to ensure that the optimal conditions (6-8.5) are maintained to be supportive of the microbial population. The growth of the microbes results in a natural tendency to reduce pH. Buffering capacity of the formation and as an additive to the EVO formulation prevents significant pH variations.	If pH deviates from the optimal range, an evaluation will be completed to identify corrective action (i.e., buffering additives).
VOCs	COCs Mass Reduction	Successful biodegradation is indicated by parent VOCs with decreasing trends. Degradation products will generally show an increasing concentration trend followed by reduction. Unsuccessful biodegradation would be indicated by no change of parent VOCs and/or evolution of daughter products which stall and do not reduce in concentration over time.	The results will be plotted for observation of trends relative to sample location, duration of remedy, and parent/daughter products including ethene. Predictive evaluations will be completed to estimate time to remedy completion.
PCR	Distribution/Vitality of Microbes	Microbial analysis will indicate Dhc presence and general population health which will provide indication of successful distribution and vitality. Results indicating no presence or population density decreasing trends would be a negative result.	No presence will require an evaluation of the need for additional bioaugmentation. Additionally, a decreasing trend in population density will be evaluated in conjunction with other environmental indicators and the over-all progress of the remedy as this may be die-off resulting from complete degradation of VOCs.
CSIA	Biodegradation Quantification	The result of the CISA will be used to quantitatively assess the degradation process to provide unambiguous evidence of enhanced biodegradation, mechanisms, rate and extent of treatment.	Results will be considered during the planning for Phase 2 EISB implementation.

FIGURES



Site Location Map

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Notes

Base Map: USGS Doylestown(1999) and Telford (1997) 7.5 Minute Quadrangles.

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Figure 1

P:\GIS\GISProjects\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 1 - Site Location.mxd; JL 22-Nov-2013

North Penn Area 5 Site Location Map

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Geosyntec consultants

Figure 2

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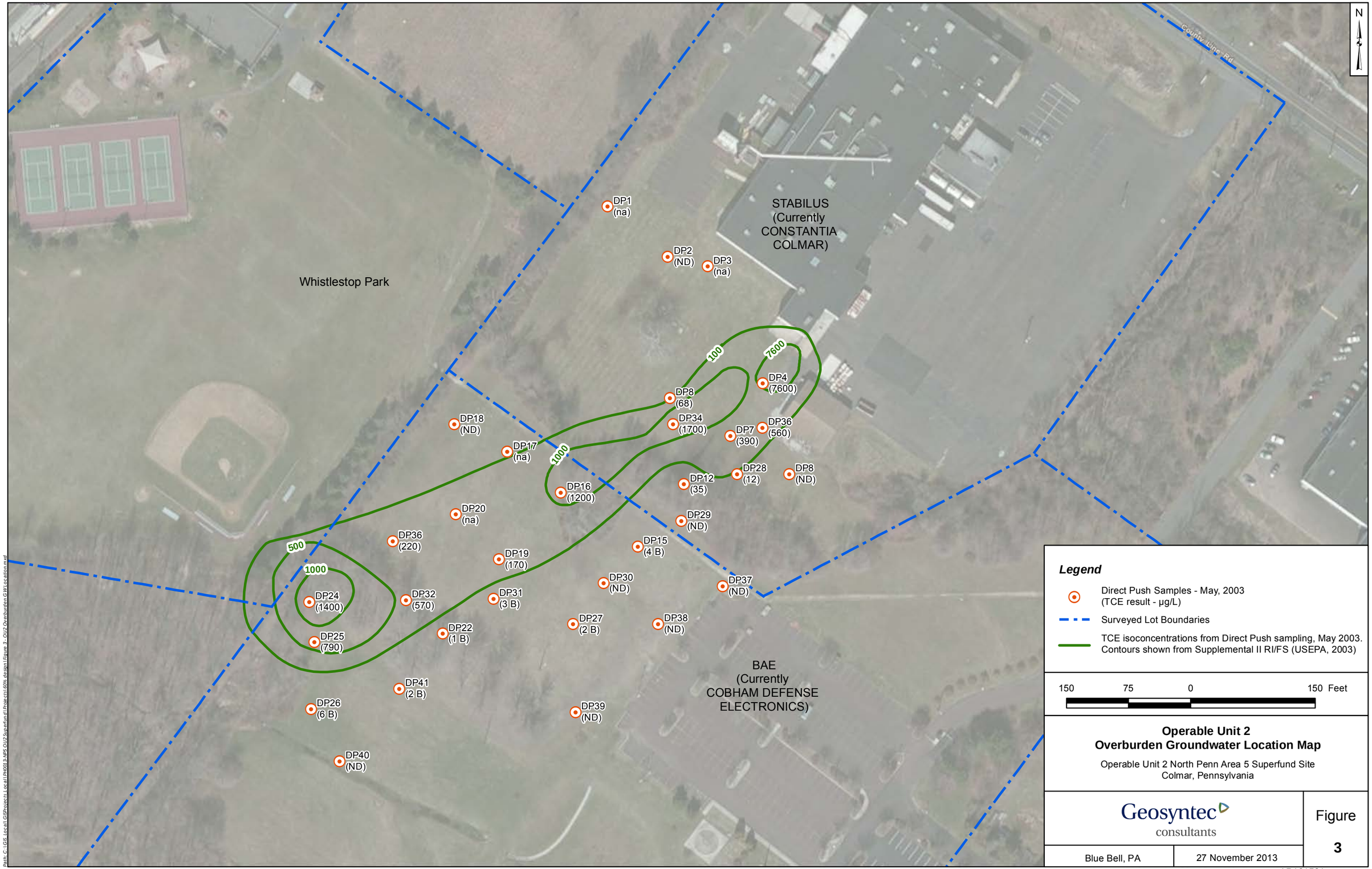
Path: C:\Users\jauchette\Desktop\PA0033-NPS OU2 Superfund\Project\16th design\Figure 2 - Site Map.mxd

AR101500



Operable Unit 2
Overburden Groundwater Location Map

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

Geosyntec consultants

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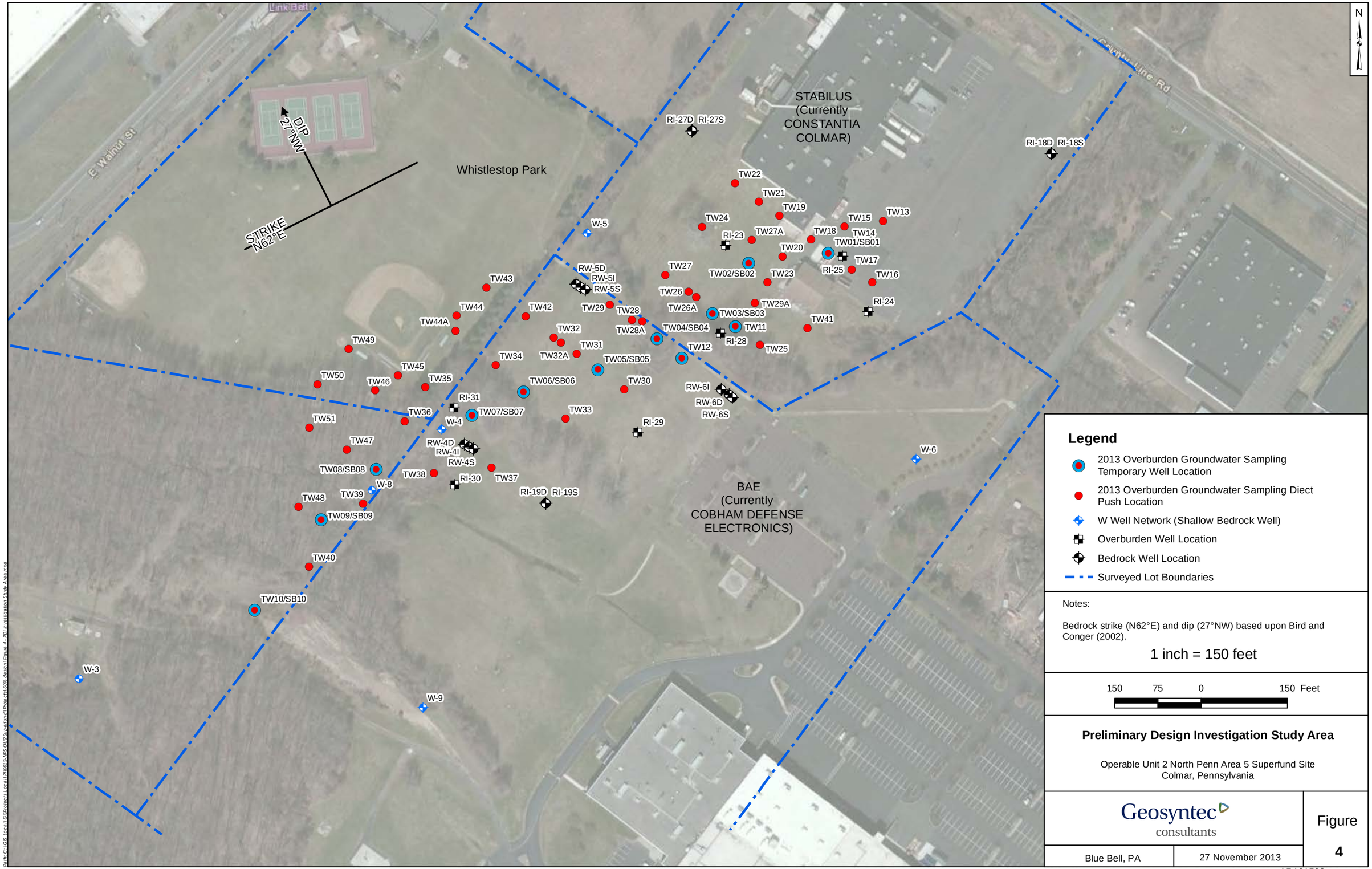
Figure 3

Path: C:\GIS_Local\GISProjects_Local\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 3 - OU2 Overburden GW Location.mxd



Legend

- 2013 Overburden Groundwater Sampling Temporary Well Location
- 2013 Overburden Groundwater Sampling Diect Push Location
- W Well Network (Shallow Bedrock Well)
- Overburden Well Location
- Bedrock Well Location
- Surveyed Lot Boundaries

Notes:

Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

1 inch = 150 feet

150 75 0 150 Feet

Preliminary Design Investigation Study Area

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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Figure 4

Path: C:\GIS_Local\GISProjects\Local\PH003 3-NPS OU2 Superfund\Projects\60% design\Figure 4 - PDI Investigation Study Area.mxd

AR101502

Legend

- Temporary Well Location
- Bedrock Well Location
- Overburden Well Location
- Well Not Used in PDI
- Surveyed Property Boundaries

Notes:
1. W-7 was unable to be field located during survey.
2. RI-6 S/D was not surveyed in 2013 because it was inaccesible - under asphalt pavement.
3. Wells NP-21, NP-87, MW-5, RI-20S, RI-20D, RW-1, RW-2, RW-3, W-1, W-7, W-10, W-12, W-13, W-14 & W-17 are part of the OU2 well network, however, they were not used during the Preliminary Design Investigation (PDI).

300 150 0 300 Feet

OU2 Overburden and Bedrock Monitoring Well Network

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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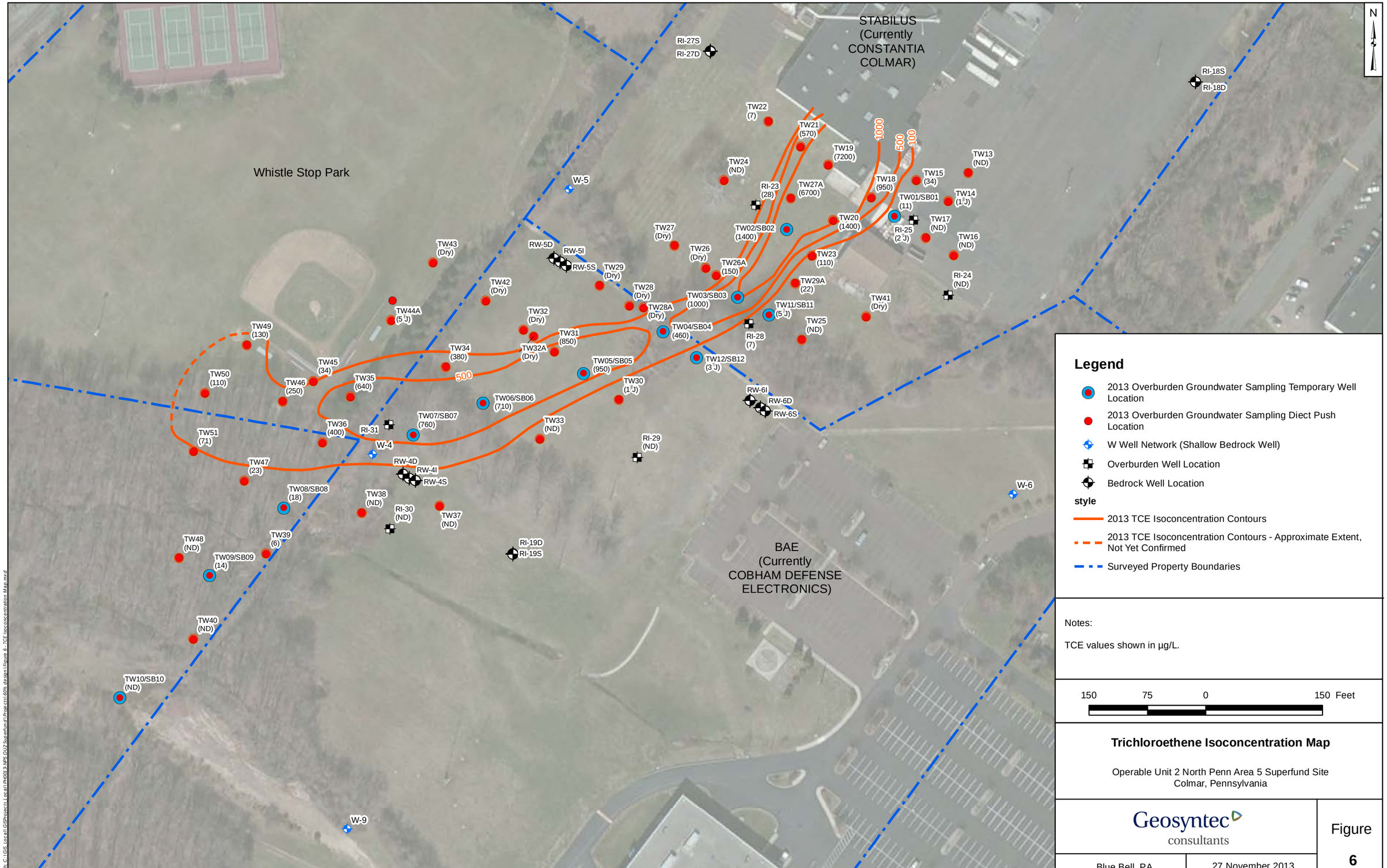
Figure 5

Path: C:\Users\lilichette\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 5 - OU2 OB BR MW Network.mxd

AR101503



Legend

- 2013 Overburden Groundwater Sampling Temporary Well Location
- 2013 Overburden Groundwater Sampling Diect Push Location
- W Well Network (Shallow Bedrock Well)
- Overburden Well Location
- Bedrock Well Location

style

- 2013 TCE Isoconcentration Contours
- 2013 TCE Isoconcentration Contours - Approximate Extent, Not Yet Confirmed
- Surveyed Property Boundaries

Notes:

TCE values shown in µg/L.

150 75 0 150 Feet

Trichloroethene Isoconcentration Map

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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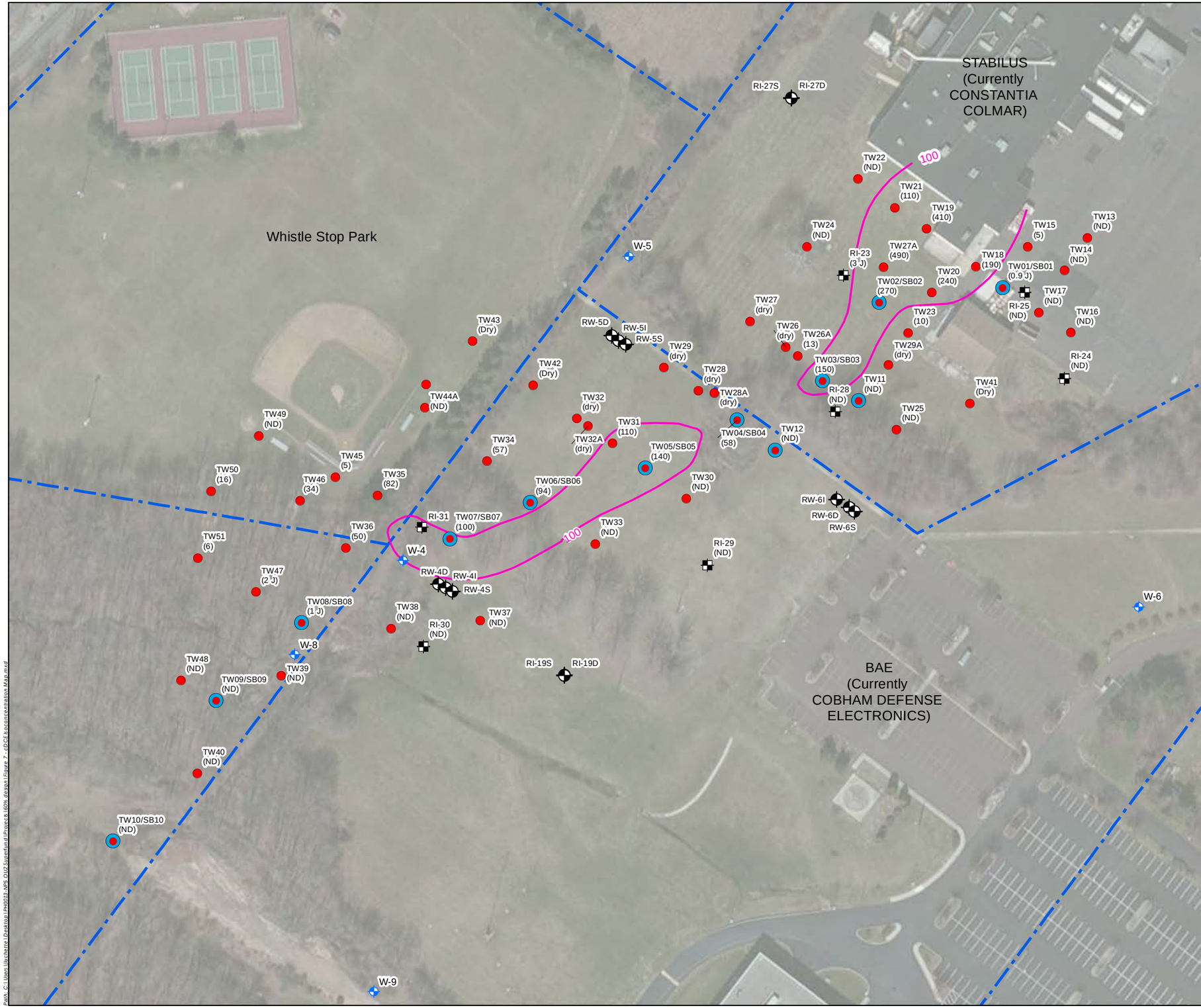
Figure 6

AR101504



Legend

- 2013 Overburden Groundwater Sampling Temporary Well Location
- 2013 Overburden Groundwater Sampling Diect Push Location
- W Well Network (Shallow Bedrock Well)
- Overburden Well Location
- Bedrock Well Location
- 2013 cis-1,2-DCE Isoconcentration Contours
- Surveyed Property Boundaries

Notes:

cis-1,2-DCE values shown in µg/L.

150 75 0 150 Feet

cis-1,2-Dichloroethene Isoconcentration Map

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Colmar, Pennsylvania

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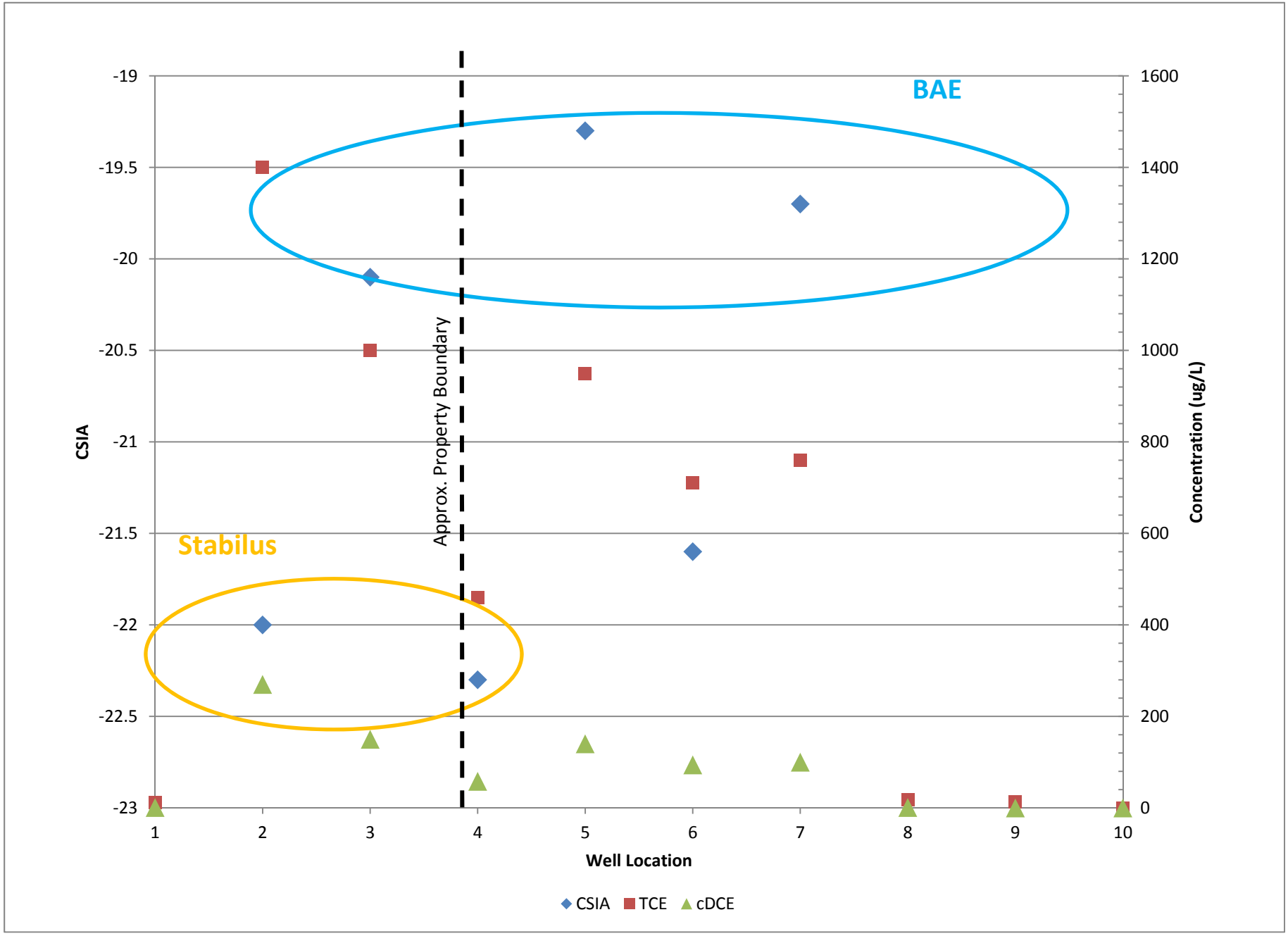
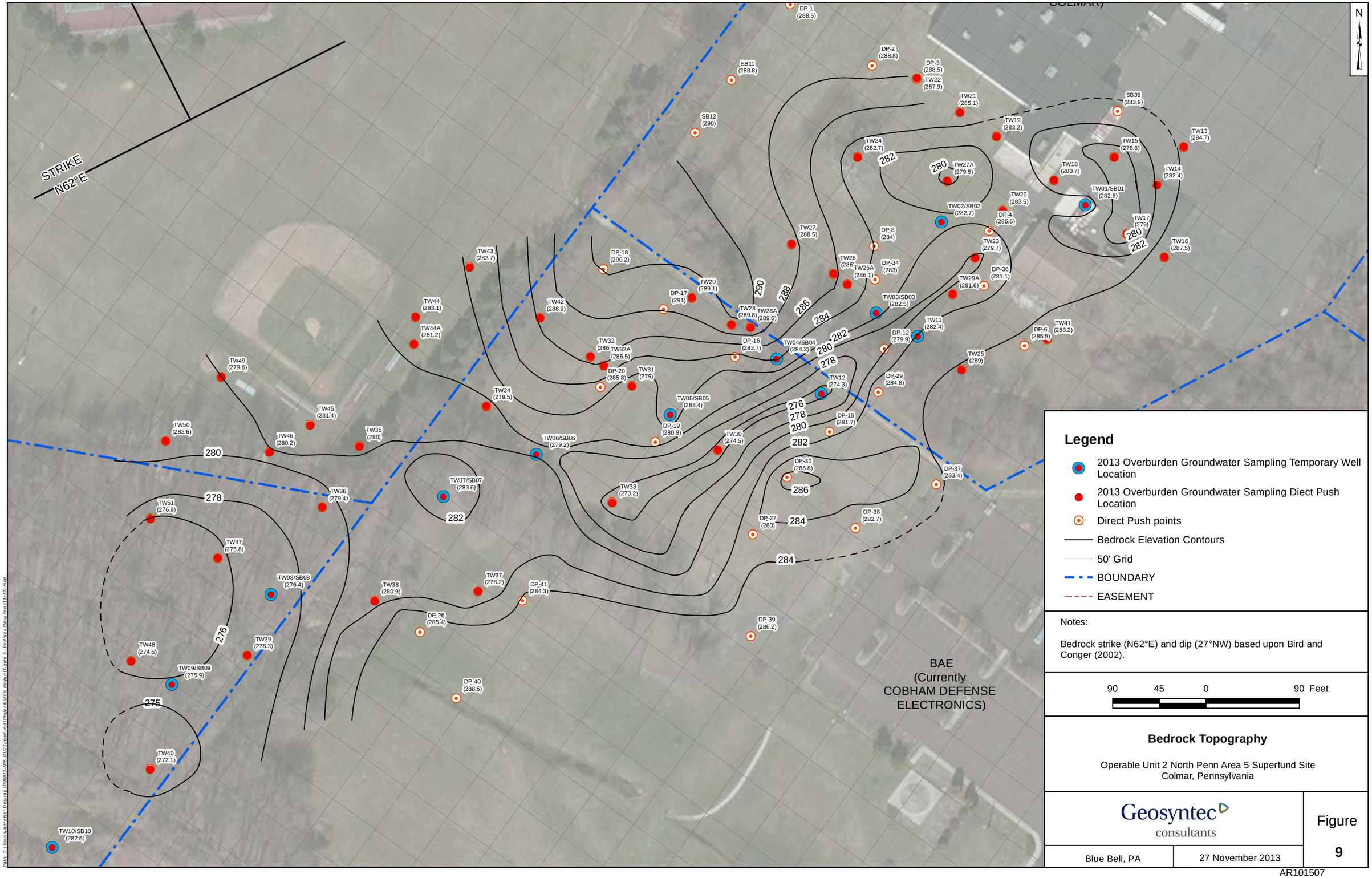
Figure 7

Path: C:\Users\lachette\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 7 - cDCE Isoconcentration Map.mxd

Figure 8 - Summary of Compound Specfic Isotope Analytical Results
Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania



AR101506



Legend

- 2013 Overburden Groundwater Sampling Temporary Well Location
- 2013 Overburden Groundwater Sampling Diect Push Location
- Direct Push points
- Bedrock Elevation Contours
- 50' Grid
- BOUNDARY
- EASEMENT

Notes:

Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

90 45 0 90 Feet

Bedrock Topography

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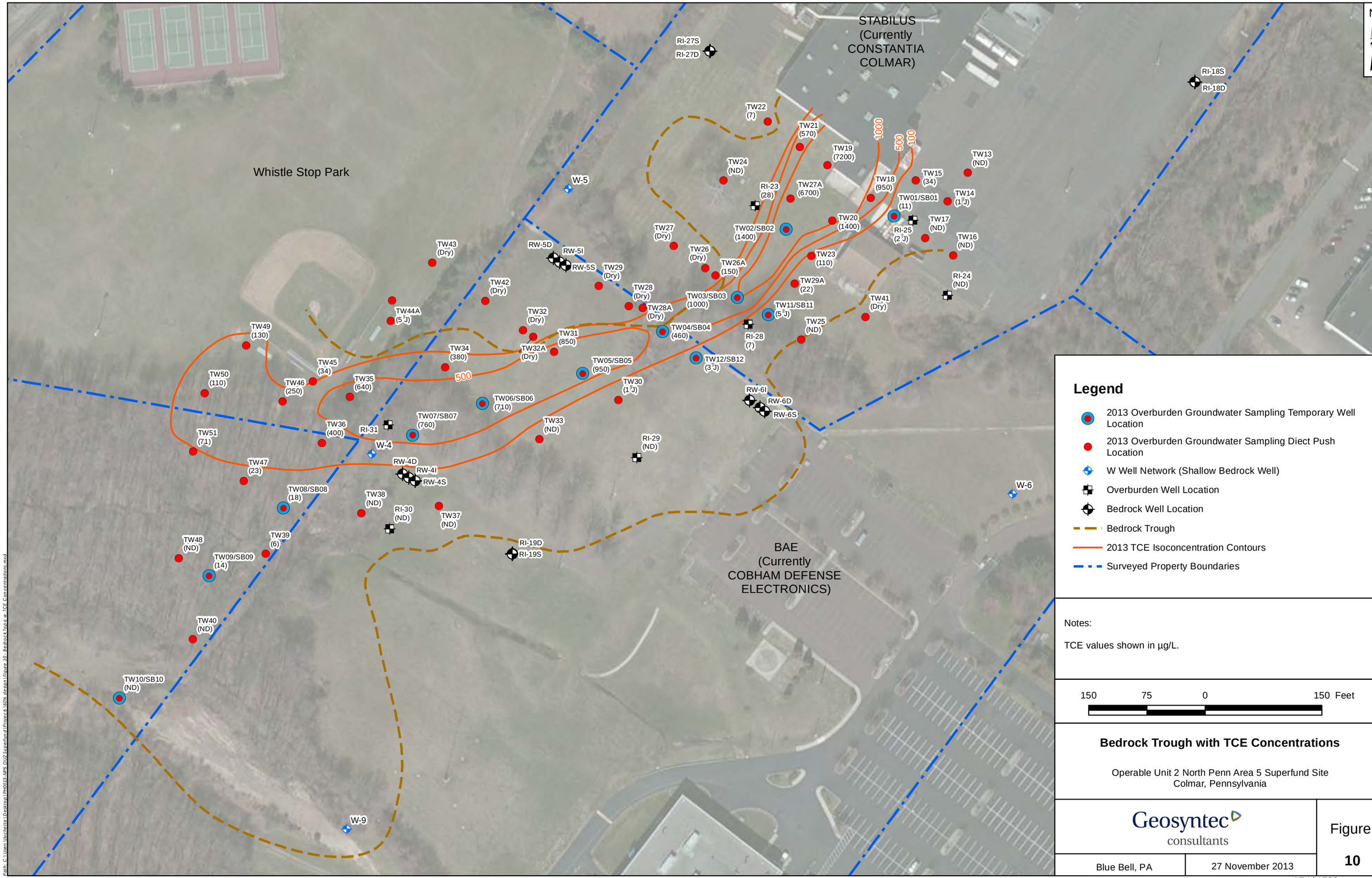
Figure 9

Path: C:\Users\lachette\Desktop\PH0033-NPS OU2 Superfund\Projects\60% design\Figure 9 - Bedrock Elevation (11x17).mxd

AR101507



Legend

- 2013 Overburden Groundwater Sampling Temporary Well Location
- 2013 Overburden Groundwater Sampling Diect Push Location
- W Well Network (Shallow Bedrock Well)
- Overburden Well Location
- Bedrock Well Location
- Bedrock Trough
- 2013 TCE Isoconcentration Contours
- Surveyed Property Boundaries

Notes:

TCE values shown in µg/L.

150 75 0 150 Feet

Bedrock Trough with TCE Concentrations

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Colmar, Pennsylvania

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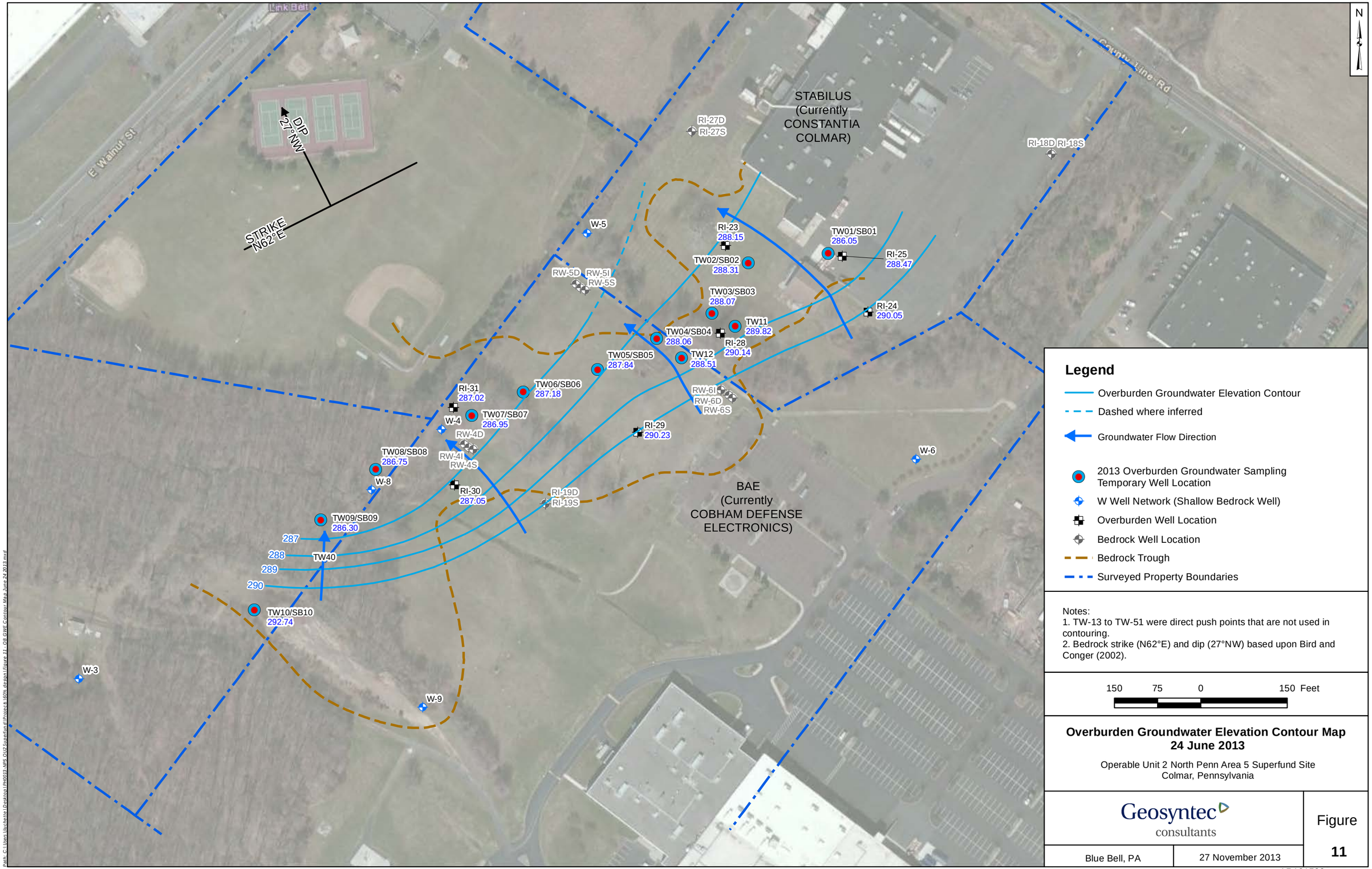
Figure 10

Path: C:\Users\lilichette\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 10 - Bedrock Topo w TCE Concentrations.mxd



Notes:
1. TW-13 to TW-51 were direct push points that are not used in contouring.
2. Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

Overburden Groundwater Elevation Contour Map
24 June 2013

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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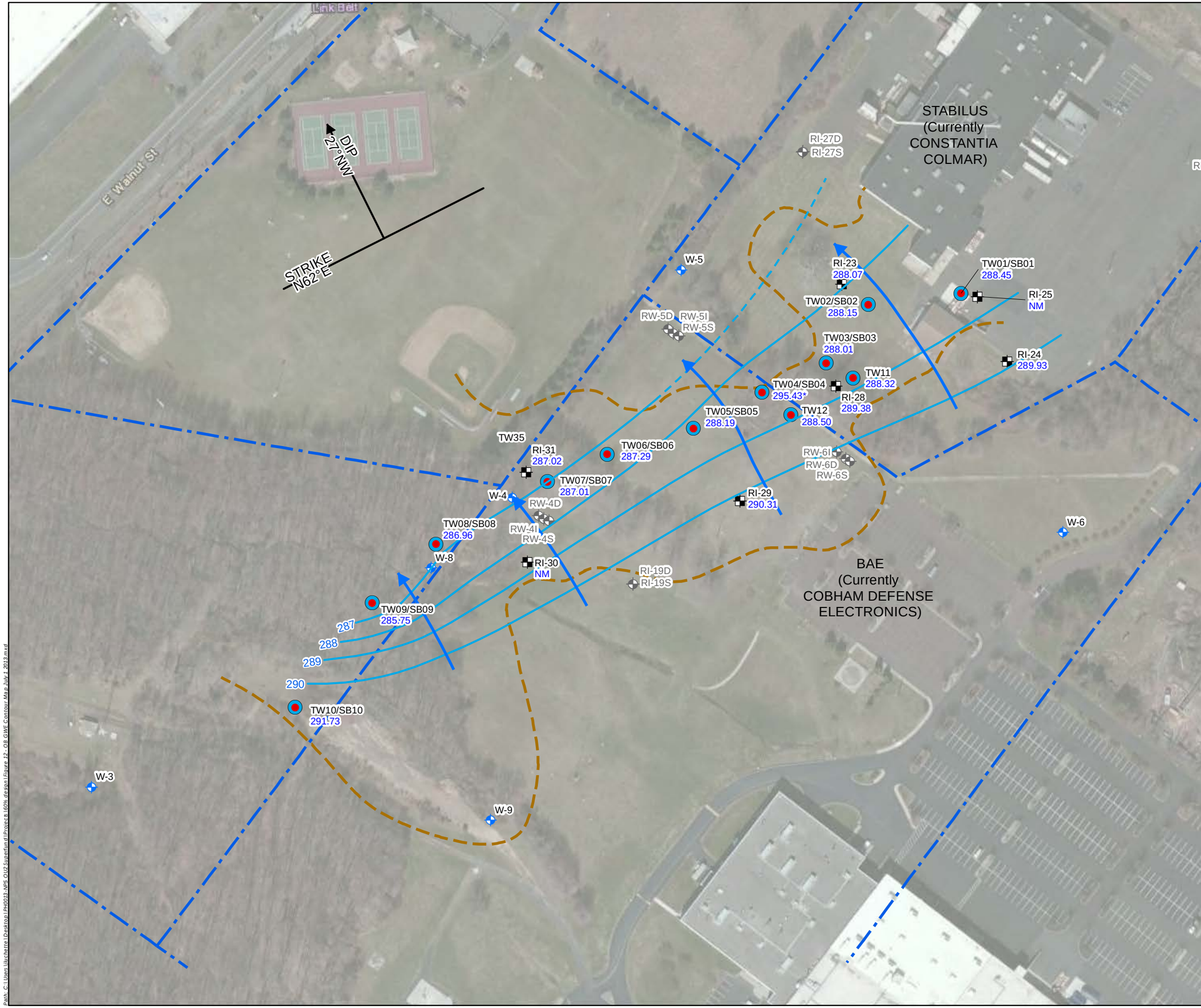
Figure **11**

Path: C:\Users\jlachette\Desktop\PH0013-WP5 OU2 Superfund\Projects\60k design\Figure 11 - OB GWE Contour Map June 24 2013.mxd

AR101509



Legend

- Overburden Groundwater Elevation Contour
- Dashed where inferred
- Groundwater Flow Direction
- 2013 Overburden Groundwater Sampling Temporary Well Location
- W Well Network (Shallow Bedrock Well)
- Overburden Well Location
- Bedrock Well Location
- Bedrock Trough
- Surveyed Property Boundaries

Notes:

NM = not measured, flushmount under water

*Anomalous reading, not used in contouring

Notes:
1. TW-13 to TW-51 were direct push points that are not used in contouring.
2. Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

150 75 0 150 Feet

Overburden Groundwater Elevation Contour Map
1 July 2013

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Colmar, Pennsylvania

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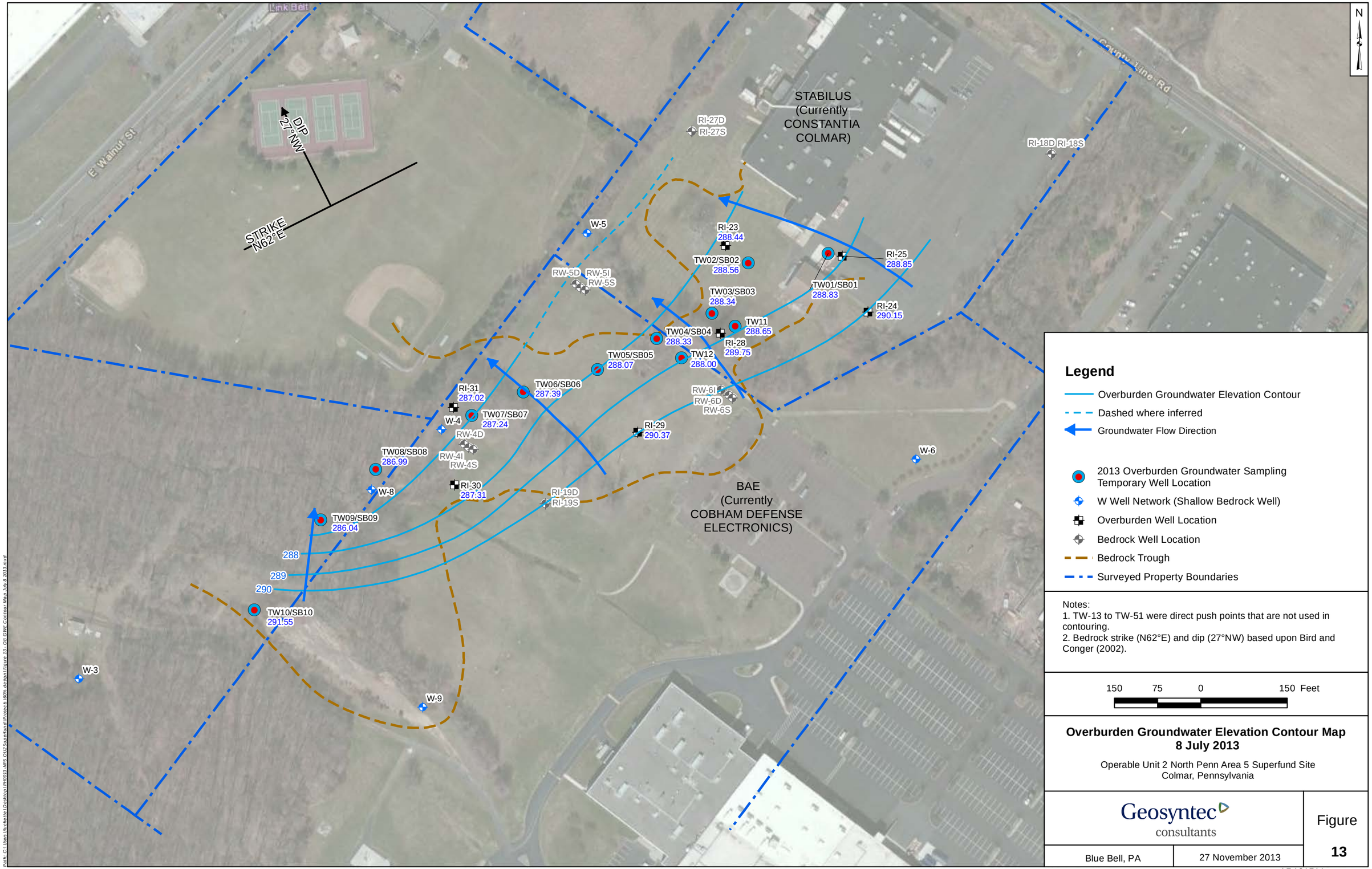
Path: C:\Users\lachette\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 12 - OB GWE Contour Map July 1 2013.mxd

AR101510



Legend

- Overburden Groundwater Elevation Contour
- Dashed where inferred
- Groundwater Flow Direction
- 2013 Overburden Groundwater Sampling Temporary Well Location
- W Well Network (Shallow Bedrock Well)
- Overburden Well Location
- Bedrock Well Location
- Bedrock Trough
- Surveyed Property Boundaries

Notes:
1. TW-13 to TW-51 were direct push points that are not used in contouring.
2. Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

150 75 0 150 Feet

Overburden Groundwater Elevation Contour Map
8 July 2013

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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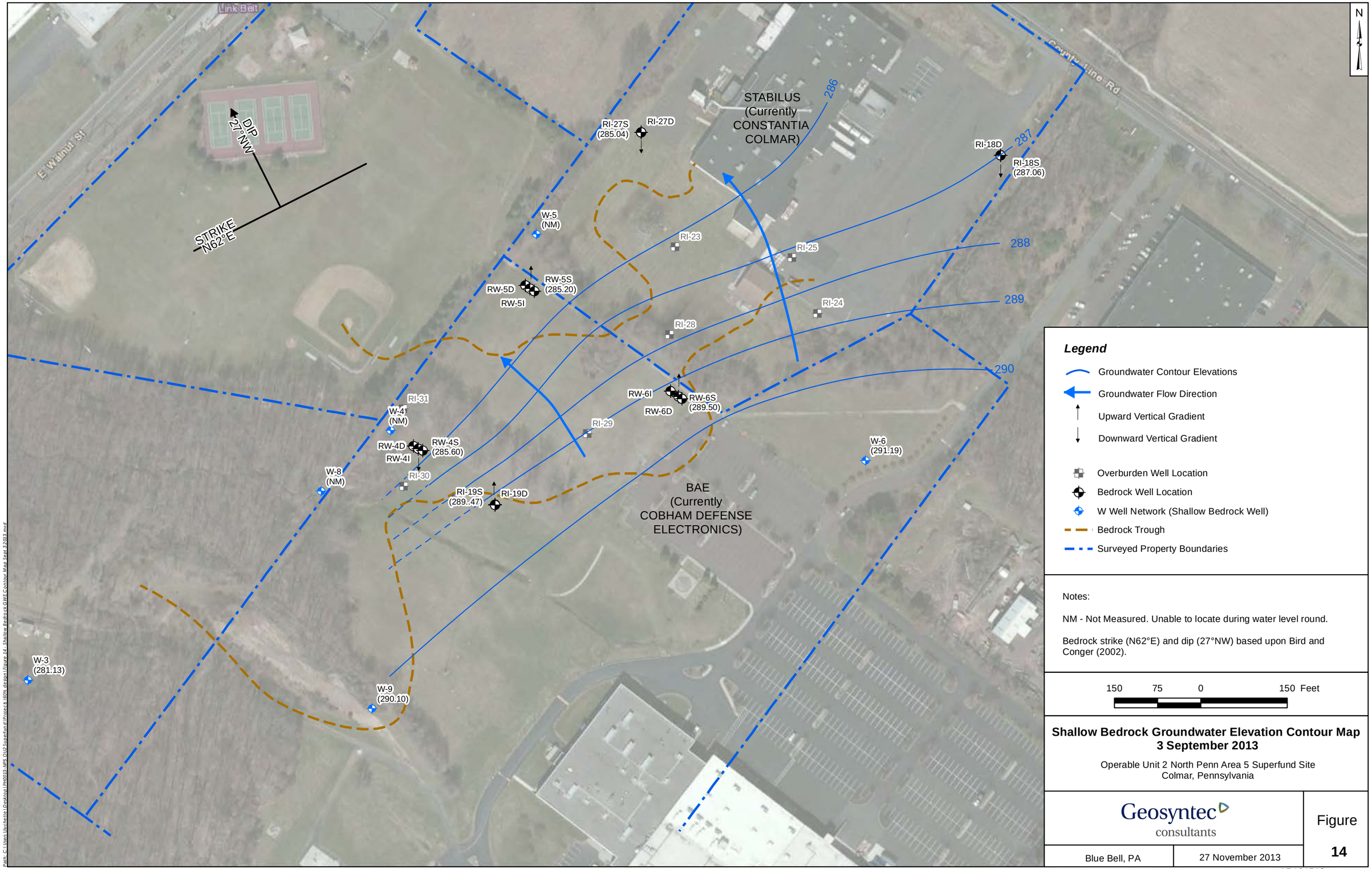
Figure 13

Path: C:\Users\jlachette\Desktop\PH0013-WP5 OU2 Superfund\Projects\60% design\Figure 13 - OB GWE Contour Map July 8 2013.mxd

AR101511



Legend

- Groundwater Contour Elevations
- Groundwater Flow Direction
- Upward Vertical Gradient
- Downward Vertical Gradient
- Overburden Well Location
- Bedrock Well Location
- W Well Network (Shallow Bedrock Well)
- Bedrock Trough
- Surveyed Property Boundaries

Notes:

NM - Not Measured. Unable to locate during water level round.

Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

150 75 0 150 Feet

Shallow Bedrock Groundwater Elevation Contour Map
3 September 2013

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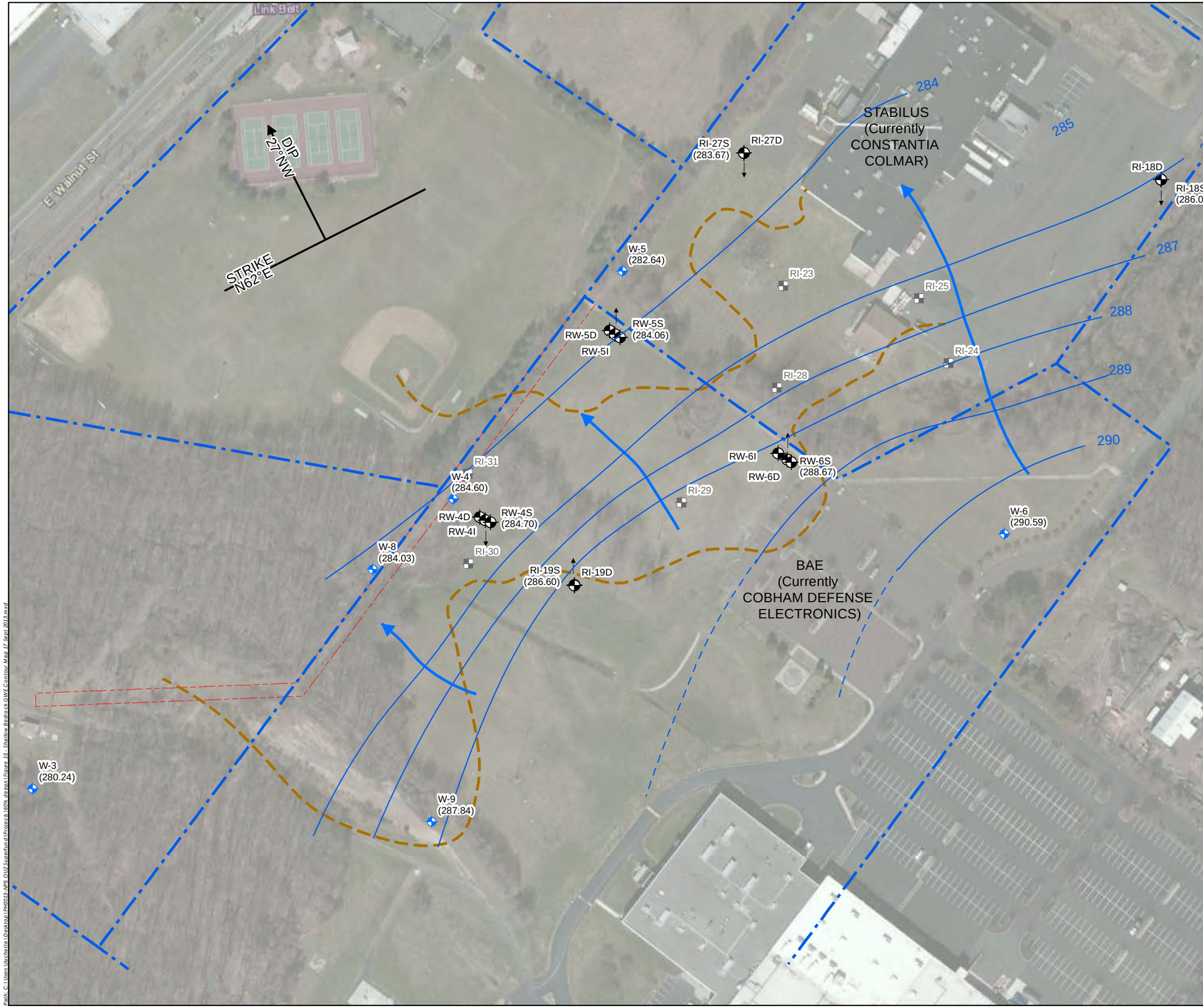
Figure **14**

Path: C:\Users\lkechette\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 14 - Shallow Bedrock GWE Contour Map Sept 3 2013.mxd

AR101512



Legend

- Groundwater Contour Elevations
- Groundwater Flow Direction
- Upward Vertical Gradient
- Downward Vertical Gradient
- Overburden Well Location
- Bedrock Well Location
- W Well Network (Shallow Bedrock Well)
- Bedrock Trough
- BOUNDARY
- EASEMENT

Notes:

Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

150 75 0 150 Feet

Shallow Bedrock Groundwater Elevation Contour Map
17 September 2013

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Colmar, Pennsylvania

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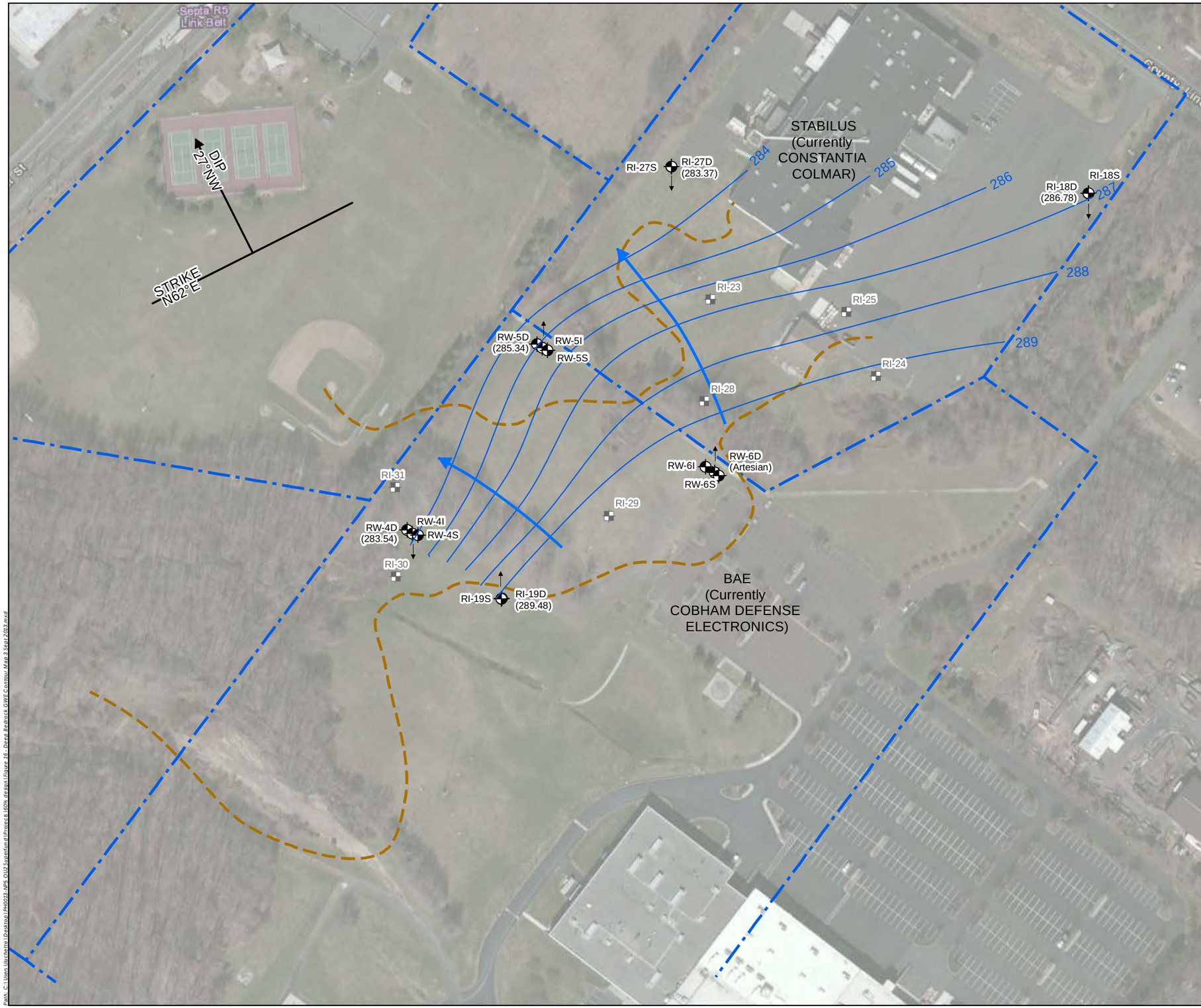
Figure **15**

AR101513

Path: C:\Users\jlaschette\Desktop\PN0013-NPS OU2 Superfund\Projects\60% design\Figure 15 - Shallow Bedrock GWE Contour Map 17 Sept 2013.mxd



Legend

- Groundwater Contour Elevations
- Groundwater Flow Direction
- Upward Vertical Gradient
- Downward Vertical Gradient
- Overburden Well Location
- Bedrock Well Location
- Bedrock Trough
- Surveyed Property Boundaries

Notes:

Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

150 75 0 150 Feet

Deep Bedrock Groundwater Elevation Contour Map
3 September 2013

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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Figure **16**

Path: C:\Users\lachetra\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 16 - Deep Bedrock GWE Contour Map 3 Sept 2013.mxd

Legend

- Groundwater Contour Elevations
- Groundwater Flow Direction
- Upward Vertical Gradient
- Downward Vertical Gradient
- Overburden Well Location
- Bedrock Well Location
- Bedrock Trough
- Surveyed Property Boundaries

Notes:

Bedrock strike (N62°E) and dip (27°NW) based upon Bird and Conger (2002).

150 75 0 150 Feet

Deep Bedrock Groundwater Elevation Contour Map
17 September 2013

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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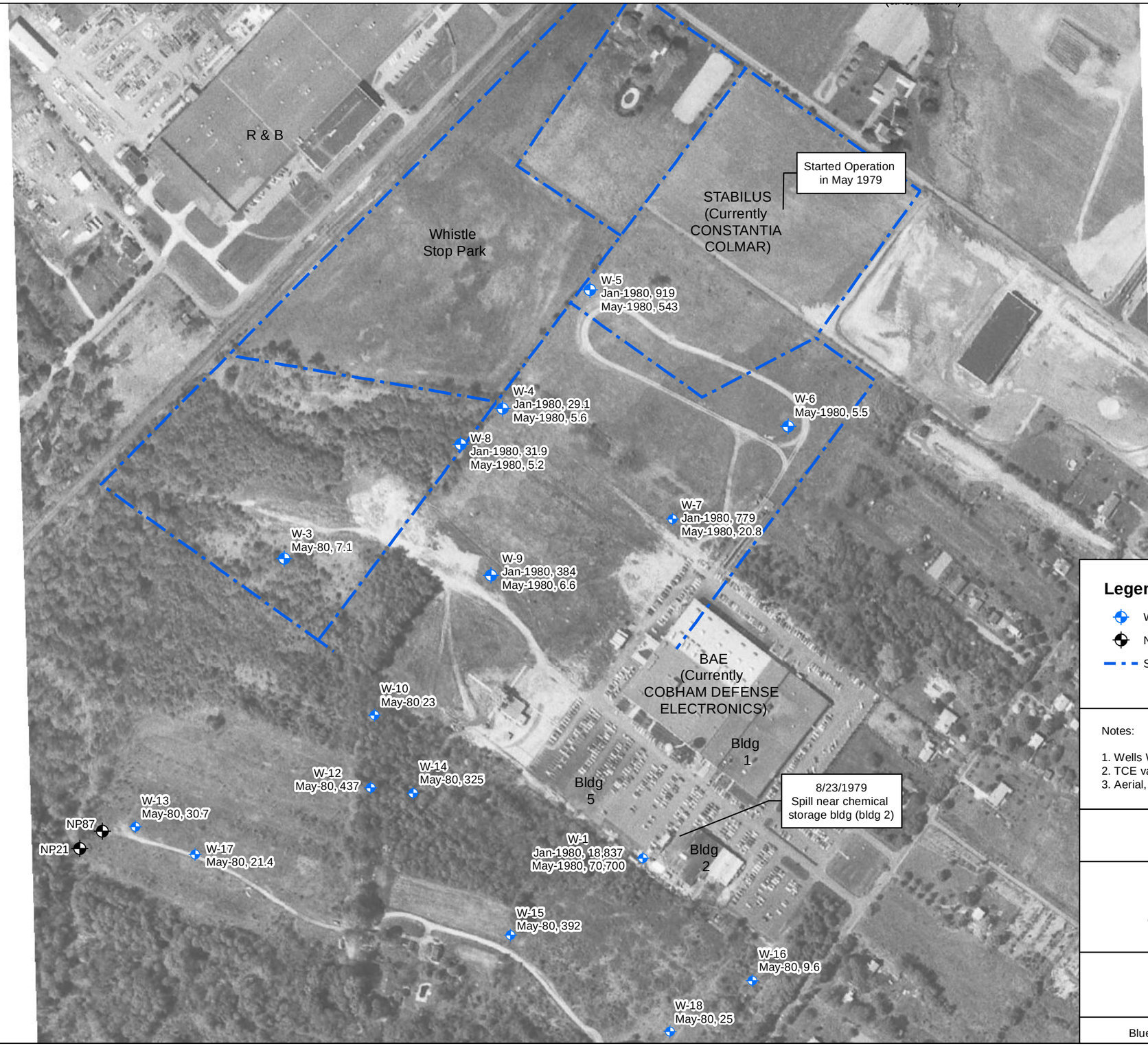
Figure **17**

Path: C:\Users\lachetra\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 17 - Deep Bedrock GWE Contour Map 17 Sept 2013.mxd

AR101515



Legend

- W Well Network (Shallow Bedrock Wells)
- NPWA Well Location
- Surveyed Property Boundaries

Notes:

1. Wells W-15 and W-18 locations are approximate.
2. TCE values shown in µg/L.
3. Aerial, 1969, from Historic Aerials.com

300 150 0 300 Feet

TCE Concentrations
1980 W Well Network

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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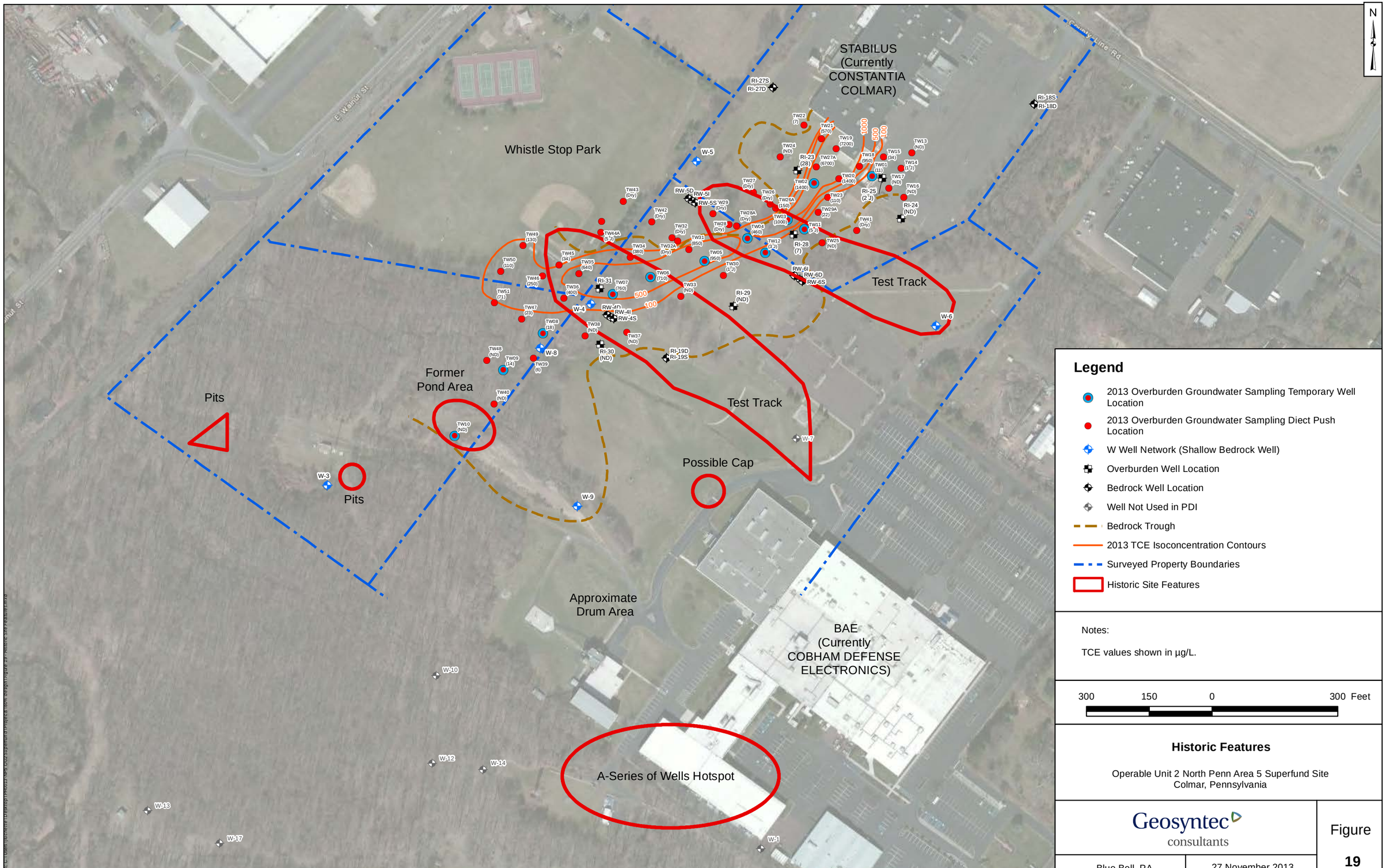
Path: C:\Users\jlachette\Desktop\PH0013-NPS OU2 Superfund\Projects\60% design\Figure 18 - W Well Network Historic TCE.mxd



Historic Features

Operable Unit 2 North Penn Area 5 Superfund Site
Colmar, Pennsylvania

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Figure 19

AR101517

APPENDIX A
Soil Boring and Well Construction Logs

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BORING LOG

BORING NO. TW-01/SB-01

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3 in	X Logged	N: 352093.66 E: 2667815.50	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.10 x Surveyed Estimated		DATE: 6/10/2013	
SURFACE CONDITIONS: asphalt			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Well Diagram
0-5	5/4.5	0-0.5: ASPHALT 0.5-3 ft: Brown, grey mottling, slightly cohesive, dry, CLAYEY SILT 3-4.5 ft: Brown, softer, some moisture, CLAYEY SILT, trace gravel, angular gravel	0.5 ft 0.5 1.5 ft 0.4 0.6 2.5 ft 0.4 0.6 3.5 ft 0.5 0.4 4.5 ft		
5-10	5/4	5-7 ft: Brown, some black organic staining, CLAYEY SILT, some fine gravel, angular, 7-9 ft: Red brown, stiff towards bottom, dry, SILTY CLAY, sub angular gravel	5.5 ft 0.9 1.2 6.5 ft 1.7 2 7.5 ft 1.4 1.4 8.5 ft 1.3 9.5 ft		
10-15	5/2.5	11-13 ft: Red brown, stiff, dry, SILTY CLAY, trace angular weathered rock Refusal at 13.5ft	10.5 ft 0.6 0.6 11.5 ft 0.6 0.5 12.5 ft 13.5 ft 14.5 ft	SB01 (12.5-13)_061013 (1415)	
15-20			15.5 ft 16.5 ft 17.5 ft 18.5 ft 19.5 ft		

Notes: MM collected 6L ground water for treatablility 6/17/13
EPA Duplicate sample SB)1 (12.5-13)_061013_D

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 6.5 ft to base of well
	00 choker sand from 6.0 ft to 6.5 ft
	Grout from 6 ft bgs to surface
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW-02/SB-02

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3 in	X Logged	N: 352076.79 E: 2667676.89	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.66 x Surveyed Estimated		DATE: 6/10/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/4	0-1 ft: Brown, soft, slightly moist, CLAY, trace silt, some orange material	0.5 ft 0 0		
		1-2 ft: Lighter brown, soft, slightly plastic, slightly moist, CLAY	1.5 ft 0 0		
		2-5 ft: Lighter brown, some gray mottling, not very cohesive, dry, CLAY	2.5 ft 0 0		
			3.5 ft 0 0		
			4.5 ft 0 0		
5-10	5/5	5-6.5 ft: Brown, very wet, CLAY, some small amounts of gravel	5.5 ft 0 0		
			6.5 ft 0 0		
		6.5-7 ft: Brown, some gray mottling, moist, CLAY			
		7-7.5 ft: Brown, some gray mottling, cohesive, very moist, CLAY	7.5 ft 0.3 0		
		7.5-9 ft: Brown, gray mottling, dry, CLAY	8.5 ft 0 0.4		
		9-10 ft: Brown, slightly red, dry, CLAY	9.5 ft 0.3 0.6		
10-15	4/1.5	10-12.5 ft: Soil stuck in rod	10.5 ft		
			11.5 ft		
			12.5 ft		
		12.5-13.5 ft: Light brown, weathered BEDROCK	0		
		13.5-14 ft: Gray, brown BEDROCK	13.5 ft 0 0	SB02(13-13.5)_061013	
15-20		Refusal at 14ft	14.5 ft		
			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes: 10-14' core got stuck in rod. Driller hammered out approximately 1.5' of soil, which is logged above.

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 8.5 ft to base of well
	00 choker sand from 7.5 ft to 8.5 ft
	Grout from 4.0 ft to 7.5 ft bgs
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW03/SB03

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3 in	X Logged	N: 351989.10 E: 2667613.88	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.47 x Surveyed Estimated		DATE: 6/12/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Brown, wet, CLAY, some organics	0.5 ft 0		
		0.5-4 ft: Brown, light brown and grey mottling, slightly moist, CLAY and SILT	0.1		
			1.5 ft 0.1		
			0.1		
			2.5 ft 0.1		
			0.1		
			3.5 ft 0		
4-8	4/4	4-8 ft: Brown, some light brown mottling, wet from sloughing, CLAY and SILT, some rounded gravel	4.5 ft 0.1		
			0.1		
			5.5 ft 0.1		
			0.1		
			6.5 ft 0.1		
			0		
			7.5 ft 0		
8-12	4/3.5	8- 9.5 ft: Brown, some light brown mottling, very wet from sloughing, CLAY and SILT, some rounded gravel	8.5 ft 0.1		
			0.1		
			9.5 ft 1.4		
		9.5-11 ft: Brown, dry, SILT, some sand, some rounded gravel	0.5		
			10.5 ft 0.1		
			1.0		
		11-12 ft: Angular GRAVEL, some brown silt	11.5 ft 1.1		
12-16	4/2.5	12-13 ft: Brown, dark brown mottiling, moist, SILT and CLAY	12.5 ft 0.1	SB03(12.5-13)_061213 (1435)	
			0.8		
		13-14 ft: Brown, SILT and CLAY, large amounts of weathered angualr rock	13.5 ft 1.6		
		Refusal at 14	14.5 ft		
			15.5 ft		

Notes:

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 8.5 ft to base of well
	00 choker sand from 8.0 ft to 8.5 ft
	Grout from 8.0 ft to ground surface
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW04/SB04

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351945.24 E: 2667517.96	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.33 x Surveyed Estimated		DATE: 6/12/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/4	0-1.5 ft: Brown, soft, moist, CLAY, some organics	0.5 ft 0.1 0.4		
		1.5-2.5 ft:Light brown, soft, moist, CLAY	1.5 ft 0.1 0.6		
		2.5-4 ft: Brown, some black and light brown mottling, dry, CLAYand SILT	2.5 ft 0.5 0.8 3.5 ft 0.5		
		4-5 ft: Red brown, some black and orange mottling, slighlty moist, CLAY and SILT	4.5 ft		
5-10	5/5	5-10 ft: Red brown, CLAY and SILT, small amount of angular gravel	5.5 ft 0.5 0.7 6.5 ft 0.6 0.6 7.5 ft 1.4 0.6 8.5 ft 0.7		
			9.5 ft	SB04(9.5-10)_061213 (1015)	
10-15	5/0	Liner stuck in core, could not recover sample. Refusal at 13 ft.	10.5 ft 11.5 ft 12.5 ft 13.5 ft 14.5 ft		
15-20			15.5 ft 16.5 ft 17.5 ft 18.5 ft 19.5 ft		

Notes:

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 7.5 ft to base of well
	00 choker sand from 7.0 ft to 7.5 ft
	Grout from 7.0 ft bgs to ground surface.
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW05/SB05

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT; OLE DIAMETER: 3 in	X Logged	N: 351891.38 E: 2667415.17	
CORE DIAMETER: 2 in; DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.37 x Surveyed Estimated		DATE: 6/12/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5 ft: Brown, moist, CLAY, some organics	0.5 ft: 0.2		
		0.5-3 ft: Light brown, slightly moist, CLAY, some silt	0.2		
			1.5 ft: 0.2		
			0.1		
			2.5 ft: 0		
			0		
		3-5 ft: Brown and red brown, some grey mottling, CLAY, some silt	3.5 ft: 0.2		
			0.2		
			4.5 ft: 0.3		
5-10	5/5	5-5.5 ft: Light brown, some red brown, CLAY, some silt	5.5 ft: 0.1		
		5.5-10 ft: Red brown, dry, CLAY AND SILT, some small angular gravel	0.1		
			6.5 ft: 0.2		
			0.8		
			7.5 ft: 6.3		
			2.5		
			8.5 ft: 1.7		
			1.6		
			9.5 ft		
10-15	5/3.5	10-13 ft: Red brown, dry, SILT, some clay, some angular weathered rock	10.5 ft: 1.6		
			3.8		
			11.5 ft: 7.8		
			7.2		
			12.5 ft: 11.4	SB05(12.5-13)_061213 (0835)	
			0.9		
		Refusal at 13 ft	13.5 ft		
			14.5 ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 7.5 ft to base of well
	00 choker sand from 7.0 ft to 7.5 ft
	Grout from 7.0 ft bgs to ground surface.
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW06/SB06

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351853.09 E: 2667286.15	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 295.19 x Surveyed Estimated		DATE: 6/11/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5 ft: Brown, soft, CLAY, some organics	0		
		0.5-1 ft: Brown, moist, CLAY	0.5 ft 0.1		
		1-2 ft: Brown, slightly moist, CLAY, some silt	0.1		
			1.5 ft 0.1		
		2-5 ft: Red brown, CLAY, some gravel, small silt	0.1		
			2.5 ft 0.1		
			0.1		
			3.5 ft 0.1		
			0.1		
			4.5 ft		
5-10	5/3.5	5-7.5 ft: Brown CLAY and SILT	0.1		
			5.5 ft 0.1		
			0.1		
			6.5 ft 0.1		
			0.2		
		7.5-10 ft: Red brown, dry, SILT, some clay	7.5 ft 0.1		
			8.5 ft		
			9.5 ft		
10-15	5/3.5	10-12 ft: Brown, CLAY, some silt	0.0		
			10.5 ft 0.1		
			8.3		
			11.5 ft 3.1		
		12-15 ft: Red brown, dry, SILT, some clay, some angular gravel	7.4		
			12.5 ft 0.5		
			13.5 ft		
			14.5 ft		
15-20	5/2	15-16 ft: Red brown, SILT, small pieces of weathered angular rock	0.8	SB06(15-15.5)_061113 (1605)	
			15.5 ft 1.3		
		Refusal at 16 ft	4.9		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 10.5 ft to base of well
	00 choker sand from 9.5 ft to 10.5 ft
	Grout from 9.5 ft bgs to ground surface.
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW07/SB07

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351812.31 E: 2667196.48	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 293.59 x Surveyed Estimated		DATE: 6/11/2013	
SURFACE CONDITIONS: grass/standing water			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/4.5	0-0.5 ft:Dark brown, soft, CLAY, some organics	0.5 ft 0.7		
		0.5-0.7 ft: Brown, moist, SILTY CLAY	0.6		
		0.7-1.5 ft: Light brown, moist, CLAY, trace silt	1.5 ft 0.7		
		1.5-5 ft: Red brown, some light brown, dry, SILT, some clay, some angular gravel	0.9		
			2.5 ft 0.7		
			0.7		
			3.5 ft 0.8		
			1.2		
			4.5 ft 0.7		
5-10		5-10 ft: Brown, dry, SILT, some clay, some weathered angular gravel (first 3 inches slough)	5.5 ft 0.5		
			2.4		
			6.5 ft 5.3		
			2.4		
			7.5 ft 11.6		
			3.4		
			8.5 ft		
			9.5 ft	SB07(9.5-10)_061113 (1450)	
10-15	5/1.5	10-10.5 ft: Brown, SILT, some clay, weathered angular gravel (12 inches slough)	10.5 ft 4.4		
			2.6		
		Refusal at 10.5 ft	11.5 ft 2.5		
			12.5 ft		
			13.5 ft		
			14.5 ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes: Collected EPA and EPA Dup (1500) at 9.5-10ft

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 4.0 ft to base of well
	00 choker sand from 3.0 ft to 4.0 ft
	Grout from 3.0 ft bgs to ground surface.
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW08/SB08

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT; OLE DIAMETER: 3 in	X Logged	N: 351718.35 E: 2667030.11	
CORE DIAMETER: 2 in; DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 290.37 x Surveyed Estimated		DATE: 6/11/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/4.5	0-0.5 ft: Dark brown, moist, CLAY, some organic material	0.9		
		0.5-1.5 ft: Light brown, some grey mottling, dry, CLAY, some silt	0.5		
			0.6		
		1.5-1.7 ft: Brown, large angular GRAVEL	0.3		
		1.7-5 ft: Brown and grey, dry, SILT, some clay	0.5		
			0.7		
			0.4		
			0.4		
5-10	5/5	5-5.5 ft: Brown, some grey, CLAY, some silt	0.3		
		5.5-6.5 ft: Reddish brown, dry, SILT, some clay	0.4		
			0.6		
		6.5-7.5 ft: Light brown, SILT, large angular gravel	0.4		
			0.5		
		7.5-9.5 ft: Reddish brown, dry,SILT, some clay, large angular weathered rock	0.4		
			0.4		
			0.3		
			0.4		
		9.5-10 ft: Brown, dry, SILT, small weathered angular gravel			
10-15	5/5	10-14 ft: Brown, SILT, large angular weathered gravel. 3ft of 10-15 sleeve sloughed down	0.5		
			0.6		
			0.7		
			0.3		
				SB08(13-13.5)_061113 (1350)	
		Refusal at 14 feet			
15-20					

Notes: Collected DUP_061113

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 8.5 ft to base of well
	00 choker sand from 6.5 ft to 8.5 ft
	Grout from 6.5 ft bgs to ground surface.
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW09/SB-09

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT; OLE DIAMETER: 3 in	X Logged	N: 351631.14 E: 2666934.61	
CORE DIAMETER: 2 in; DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 289.44 x Surveyed Estimated		DATE: 6/11/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/3.5	0.5-1.5 ft: Brown soft, cohesive, CLAY 0-1.5 ft wet from surface water	0.5 ft: 0; 0.5		
		1.5-3.5 ft: Brown, red and grey mottling, slightly sitiff, dryer as deeper, CLAY, some organic material at bottom	1.5 ft: 0.4; 0.4; 2.5 ft: 0.6; 0.2		
			3.5 ft; 4.5 ft		
5-10	5/4.5	5-6.5 ft: Sloughed	5.5 ft: 0; 0.2		
		6.5-7 ft: Brown, SILTY CLAY, some angular gravel	6.5 ft: 0.4; 0.4		
		7-9.5 ft: Red brown, dry, weathered SILT and CLAY	7.5 ft: 0.4; 0; 8.5 ft: 0		
		9.5-10 ft: Brown, grey mottling, dry, CLAY, sub angular gravel, weathered,	9.5 ft		
10-15	5/4.5	10-13 ft:Brown, stiff to slightly stiff, SILTY CLAY, large weathered gravel	10.5 ft: 0.0; 0.0; 11.5 ft: 0.3; 0.0		
			12.5 ft	SB09(12.5-13)_061113 (1135)	
		13-13.5 ft: Brown weathered BEDROCK. Refusal at 13.5 ft	13.5 ft		
			14.5 ft		
15-20			15.5 ft; 16.5 ft; 17.5 ft; 18.5 ft; 19.5 ft		

Notes:

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 8.5 ft to base of well
	00 choker sand from 7.5 ft to 8.5 ft
	Grout from 4 ft bgs to 7.5 ft bgs.
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW10/SB10

SHEET 1 OF 2

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	x Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	x Logged	N:351474.04 E: 2666819.02	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	x Installed	GEOLOGIST A. Rowan	
GROUND ELEV.: 312.61 x Surveyed Estimated		DATE: 6/11/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5 ft: Brown, moist, CLAY, some organics 0.5-2.5 ft: Brown, dry, CLAY, some angular gravel, some silt 2.5-3 ft: Brown, grey mottling, not cohesive, dry, CLAYEY SILT 3-3.5 ft: Brown, moist, CLAY, some angular gravel 3.5-5 ft: Brown, dry, CLAY, some angular gravel	0.5 ft: 0.5 0.5 1.5 ft: 0.5 0.6 2.5 ft: 0.6 0.7 3.5 ft: 1.0 0.7 4.5 ft: 0.5		
5-10	5/5	5-5.5 ft:Brown, CLAY, some gravel, some silt 5.5-6 ft: Brown, CLAY, some silt, large angular gravel 6-8.5 ft: Brown, some grey, CLAY, some angular gravel, some large bedrock 8.5-10 ft: Brown, CLAY, some silt, some small gravel	5.5 ft: 0.8 0.8 6.5 ft: 0.8 1.6 7.5 ft: 1.4 1.9 8.5 ft: 1.8 0.9 9.5 ft: 1.0		
10-15	5/5	10-11 ft: Brown, CLAY, some angular gravel, some silt 11-15 ft: Brown, firm, slightly moist, CLAY, trace silt	10.5 ft: 2.0 3.0 11.5 ft: 1.3 2.4 12.5 ft: 2.7 2 13.5 ft: 1.5 1.3 14.5 ft: 1.4		
15-20	5/3	15-16 ft: Brown, dry, CLAY, some silt 16-17 ft: Sllightly darker brown, dry, CLAY WITH SILT 17-20 ft: Brown, tight, moist, CLAY, sporadic large angular gravel	15.5 ft: 1.2 3.0 16.5 ft: 1.5 1.4 17.5 ft: 1.7 1.2 18.5 ft: 19.5 ft:	Refusal 3ft into 15-20 depth	
20-25	5/3	20-20.5 ft: Sloughed in wet 20.5-21.5 ft: Brown, wet, CLAY, some angular gravel 21.5-23 ft: Brown, moist, CLAY, some angular gravel 23-25 ft: Brown, slightly moist, CLAY, some small gravel,	20.5ft: 1.5 1.1 21.5ft: 8.9 4.0 22.5ft: 2.5 23.5ft: 24.5ft:		

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BORING LOG

BORING NO. TW10/SB10

SHEET 1 OF 2

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	x Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	x Logged	N:351474.04 E: 2666819.02	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	x Installed	GEOLOGIST A. Rowan	
GROUND ELEV.: 312.61 x Surveyed Estimated		DATE: 6/11/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
25-30	5/5	25-27 ft: Brown, very wet, CLAY, some small angular gravel	25.5ft 1.0		
			1.3		
			26.5ft 1.1		
			1.1		
		27-28 ft: Brown, wet, CLAY, some small angular gravel	27.5ft 1.1		
			1.2		
		28-29 ft: Brown, moist, CLAY, some small gravel	28.5ft 1.2		
		29-29.2 ft: Black, angular GRAVEL no odor	1.1		
		29.2-29.5 ft: Red brown, CLAY some small gravel	1.1	SB10(29-29.5)_061113	
		29.5-30 ft: Brown and orange, some grey mottling, dry CLAY AND SILT	29.5ft		

Notes: Collected SB10(29-29.5)_061113MS, SB10(29-29.5)_061113 MSD, 3 sets VOCs

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 24.5 ft to base of well
	00 choker sand from 20.0 ft to 24.5 ft
	Grout from 8 ft bgs to 7 ft bgs
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW11

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351966.78 E: 2667654.06	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.40 x Surveyed Estimated		DATE: 6/10/2013	
SURFACE CONDITIONS: grass/standing water			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/4	0-1.5 ft: Brown, soft, slightly moist, CLAY, trace organics,	0.5 ft 0.9		
			0.8		
			1.5 ft 0.6		
		1.5-2.5 ft: Brown, soft, dry, CLAY, trace silt	0.6		
			2.5 ft 0.5		
		2.5-4.5 ft: Brown,grey mottling, not cohesive, dry, CLAYEY SILT	0.6		
			3.5 ft 0.6		
			4.5 ft		
		4.5-5 ft:Brown, soft, cohesive CLAY			
5-10	5/3.5	5- 8.5 ft: Brown, stiff, dry, CLAY, trace angular gravel	5.5 ft 0.7		
			0.6		
			6.5 ft 0.6		
			0.6		
			7.5 ft 0.6		
			0.6		
			8.5 ft		
		8.5-10 ft: Red brown, dry to slightly moist, CLAYEY SILT, small angular gravel			
			9.5 ft		
10-15	5/2.5	10-13 ft: Red brown, dry, SILT, trace clay, trace weathered rock,angular fragments	10.5 ft 1.0		
			1.0		
			11.5 ft 1.0		
			1.0		
			12.5 ft		
		Refusal at 14 ft	13.5 ft		
			14.5 ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

Well construction notes:

Well diameter:	1 inch
Riser:	Sch 40 solid PVC
Screen:	Sch 40 PVC 0.010-inch slot
Annular fill materials:	#1 filter sand pack from 8.5 ft to base of well
	00 choker sand from 8.0 ft to 8.5 ft
	Grout from 8 ft bgs to 7 ft bgs
Surface completion:	Locking, PVC stick up riser

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BORING LOG

BORING NO. TW12

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351911.54 E: 2667560.88	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	X MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.34 x Surveyed Estimated		DATE: 6/12/2013	
SURFACE CONDITIONS:			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/3.5	0-0.5 ft: Brown, wet, CLAY, angular gravel 0.5-1 ft: Brown, soft, moist, CLAY 1-5 ft: Red brown, some brown mottling, CLAY and SILT	0.5 ft 0 0 1.5 ft 0 0 2.5 ft 0 0 3.5 ft 0 4.5 ft		
5-10	5/3.5	5- 10 ft: Brown, light brown and red mottling, SILT, some clay	5.5 ft 0 0 6.5 ft 0 0 7.5 ft 0 0 8.5 ft 0 9.5 ft		
10-15	5/4	10-15 ft: Brown, light brown and red mottling, SILT, some clay	10.5 ft 0 0 11.5 ft 0 0 12.5 ft 0 0 13.5 ft 0 0 14.5 ft		
15-20	5/3.5	15-20 ft: Brown, light brown and red mottling, SILT, some clay	15.5 ft 0 0 16.5 ft 0 0 17.5 ft 0 0 18.5 ft 0 19.5 ft		
20-25	5/1	20-22 ft: Brown, light brown and red mottling, hard, SILT, some clay. Could not remove liner. Recoverd approximately 1 ft of soil (20 - 22 ft). Refusal at 22 ft. Well diameter: 1 inch Riser: Sch 40 solid PVC Screen: Sch 40 PVC 0.010-inch slot Annular fill materials: #1 filter sand pack from 20.5 ft to base of well 00 choker sand from 14.0 ft to 15.0 ft Grout from 14 ft bgs to ground surface	20.5ft 0 0 21.5ft 22.5 23.5 24.5		

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BORING LOG

BORING NO. TW13

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352149.37 E: 2667910.36	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 294.72 x Surveyed Estimated		DATE: 6/14/2013	
SURFACE CONDITIONS: asphalt/parking lot			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-1 ft: Asphalt 1-4 ft: Brown, some grey mottling, slightly moist, CLAY, some silt	0.5 ft 0.2 0.2 1.5 ft 0.2 0.2 2.5 ft 0.2 0.2 3.5 ft 0.2		0.2 ppm PID background
4-8	4/4	4-6 ft: Brown, some black mottling, slightly moist, CLAY, some silt 6-6.5 ft: Red brown, slightly moist, CLAY, some silt 6.5-7.5 ft: Red brown, dry, SILT, large amounts of small to large sub-angular gravel 7.5-8 ft: Red brown, slightly moist, CLAY, some silt	4.5 ft 0.2 0.2 5.5 ft 0.2 0.2 6.5 ft 0.2 0.2 7.5 ft 0.2		
8-12	4/2	8-9 ft: Red brown, slightly moist, CLAY, some silt 9-10 ft: Red brown, dry, SILT, large amounts of sub angular small to large weathered rock	8.5 ft 0.3 0.3 9.5 ft 0.3 0.3 10.5 ft 11.5 ft		0.3 ppm PID background
12-16			12.5 ft 13.5 ft 14.5 ft 15.5 ft		
16-20			16.5 ft 17.5 ft 18.5 ft 19.5 ft		

Notes:

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BORING LOG

BORING NO. TW14

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352112.78 E: 2667884.62	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 295.35 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: asphalt/parking lot			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5 ft: Asphalt	0.5 ft 0.2		PID background 0.2 ppm
			0.2		
		0.5-4 ft: Brown, red hue, cohesive, slightly moist, clay	1.5 ft 0.2		
			0.2		
			2.5 ft 0.2		
			0.2		
		4-4.25 ft: Brown, red hue, cohesive, slightly moist, CLAY	3.5 ft 0.2		
		4.25-5 ft: grey clay			
4-8	4/4		4.5 ft 0.2		
			0.2		
		5-8 ft: Brown,some black/grey mottling, slightly moist, CLAY and SILT	5.5 ft 0.2		
			0.2		
			6.5 ft 0.2		
			0.2		
			7.5 ft 0.2		
8-12	4/4	8-9.5 ft: Red brown, slightly moist, CLAY and SILT	8.5 ft 0.2		
			0.2		
			9.5 ft 0.2		
		9.5-12 ft: Red brown, dry, SILT, large amount of angular weathered rock small to large in size	0.2		
			10.5 ft 0.2		
		12-13 ft: Red brown, dry, SILT, large amount of angular weathered rock small to large in size	0.2		
			11.5 ft		
12-16		Refusal at 13'	12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW15

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352139.50 E: 2667843.43	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 295.60 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: asphalt/parking lot			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5 ft: ASPHALT	0.5 ft 0.2		0.2 ppm PID background
		0.5-3 ft: Red brown, slightly moist, CLAY, some silt	0.2		
			1.5 ft 0.2		
		3-4 ft: Grey, some brown, slightly moist, CLAY with trace silt	0.2		
			2.5 ft 0.2		
			0.2		
		4-6 ft: Brown, some grey, slightly moist, CLAY and SILT	3.5 ft 0.2		
4-8	4/4	6-6.5 ft: Brown, some grey, slightly moist, CLAY and SILT	4.5 ft 2.4		
		6.5-8 ft: Red brown, slightly moist, CLAY, some silt, small amount of round small gravel	2.6		
			5.5 ft 1.0		
			1.8		
		8-8.5 ft: Slough	6.5 ft 1.2		
		8.5-10 ft: Red brown, slightly moist, CLAY, some silt, small amount of round gravel	2.4		
			7.5 ft 3.1		
8-12	4/4	10-11 ft: Red brown, moist, SILT, some clay large amount of medium sub angular gravel	8.5 ft 0.2		
			0.3		
		11-12 ft: Brown, moist, CLAY and SILT, small amount of small sub-angular gravel	9.5 ft 1.2		
			1.2		
		12-13 ft: Brown, moist, CLAY and SILT, small amount of small sub-angular gravel	10.5 ft 0.3		
			0.3		
			11.5 ft 0.6		
12-16	4/4	13-16 ft: Brown, wet, SILT, large amount of small to large sub-angular gravel	12.5 ft 0.2		
			0.2		
			13.5 ft 0.2		
			0.2		
		16-17 ft: Brown to light brown, wet, SILT with large amount of small sub-angular gravel	14.5 ft 0.2		
			0.2		
			15.5 ft 0.2		
16-20		Refusal at 17ft	16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW16

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352043.02 E: 2667891.62	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.00 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: asphalt/parking lot			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5 ft: Asphalt	0.2		PID background 0.2 ppm
		0.5-4 ft: Brown, slightly moist, clay, some silt	0.5 ft 0.2		
			0.2		
			1.5 ft 0.2		
		4-5.5 ft: Brown, slightly moist, CLAY, some silt	0.2		
			2.5 ft 0.2		
			0.2		
			3.5 ft 0.2		
4-8	4/4	5.5-7 ft: Brown, SILT and CLAY, large amount of large angular and sub angular weathered rock	0.2		
			4.5 ft 0.2		
			0.2		
		7-8 ft: Dark brown, slightly moist, SILT, some clay, some small to medium sub-angular weathered rock	5.5 ft 0.2		
			0.2		
		8-9 ft: Dark brown, slightly moist, SILT, some clay, some large weathered rock	6.5 ft 0.2		
			0.2		
			7.5 ft 0.2		
8-12	4/2	Refusal at 8.5	0		1.5' sloughed in
			8.5 ft		
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		

Notes:

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BORING LOG

BORING NO. TW17

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352065.68 E: 2667855.70	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.03 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: asphlat/parking lot			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-1 ft: Asphalt	0.5 ft 0.2		
			0		
		1-2 ft: Grey, some brown, cohesive, slightly moist, CLAY	1.5 ft 0		
			0		
		2-4 ft: Brown, slightly moist, clay, some silt	2.5 ft 0		
			0		
			3.5 ft 0		
4-8	4/4	4-6 ft: Brown, slightly orange hue, wet from 4-5 possibly from shallower depth, CLAY, some silt	4.5 ft 0		
			0		
			5.5 ft 0		
			0		
		6-8 ft: Brown, moist, CLAY, some silt	6.5 ft 0		
			0		
			7.5 ft 0		
8-12	4/4	8-11.5 ft: Brown, some black and orange brown mottling, slightly moist, CLAY and SILT, small amount of rounded gravel	8.5 ft 0.1		PID background 0.1 ppm
			0.1		
			9.5 ft 0.1		
			0.1		
			10.5 ft 0.1		
			0.1		
			0.1		
		11.5-12 ft: Red brown, slightly moist, CLAY AND SILT, some rounded gravel	11.5 ft		
12-16	4/4	12-14 ft: Red brown, wet from sloguh, CLAY and SILT, some rounded gravel	12.5 ft 0.2		1.5 sloughed in
			0.2		
			13.5 ft 0.2		PID background 0.2 ppm for 12-16 depth
			0.2		
		14-16 ft: Red brown, dry, SILT, some clay, some small and medium sub-angular gravel	14.5 ft 0.2		
			0.2		
			15.5 ft 0.2		
16-20	4/4	16-18 ft: Red brown, dry, SILT, some clay, some small and medium sub-angular gravel	16.5 ft		
			17.5 ft		
		18-19 ft: Red brown, dry, SILT, some clay, large amount of small to large sub-angular weathered rock	18.5 ft		
		Refusal at 19'	19.5 ft		Refusal at 19'

Notes:

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BORING LOG

BORING NO. TW19

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352159.46 E: 2667730.08	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.21 x Surveyed Estimated		DATE: 6/14/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4		Soft dug 5' on 06/10/13	0.5 ft		
			1.5 ft		
			2.5 ft		
			3.5 ft		
4-8	4/4	4-6 ft: Brown, wet- sloughed, CLAY	4.5 ft 0		
			0		
			5.5 ft 0		
			0		
		6-8 ft: Brown, some light mottling, moist, CLAY, some silt	6.5 ft 0		
			0		
			7.5 ft 0		
8-12	4/2.5	8-12 ft: Brown and light brown, black mottling, dry, CLAY and SILT	8.5 ft 0		
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16		First 1.5 ft sloughed	12.5 ft 0		
		12-16 ft: Brown, SILT and CLAY. Refusal at 16'	13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW20

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352087.91 E: 2667736.07	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.54 x Surveyed Estimated		DATE: 6/14/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4		Soft Dug 06/10/13 5'	0.5 ft 1.5 ft 2.5 ft 3.5 ft		
4-8	4/4	4-6 ft: Slough 6-8 ft: Red brown, black mottling, moist, CLAY, some silt	4.5 ft 5.5 ft 6.5 ft 1.1 1.0 7.5 ft 3.9		
8-12	4/4	8-12 ft: Red brown, some black mottling,slightly moist, CLAY, some red brown silt, small amount of small gravel, some dry, sub angular small gravel	8.5 ft 9.5 ft 11.8 10.5 ft 1.7 1.6 11.5 ft 2.4		1.5' slough
12-16	4/1.5	12-12.3 ft: Red brown, some black mottling, slightly moist, CLAY, some red brown silt, small amount of small gravel, some dry sub angular small gravel 12.3-12.4 ft:Dark brown, dry, SILT, large amounts of medium to large angular weathered rock 12.4-13 ft: Brown, dry, SILT, small angular weathered rock. Refusal at 13'	2.6 12.5 ft 13.5 ft 14.5 ft 15.5 ft		0.5' slough
16-20			16.5 ft 17.5 ft 18.5 ft 19.5 ft		

Notes:

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BORING LOG

BORING NO. TW21

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352182.82 E: 2667694.59	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.09 x Surveyed Estimated		DATE: 6/14/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5 ft: Brown, very moist, CLAY, some small angular gravel, some organics	0.5 ft 0		
		0.5-1 ft: Brown, some grey mottling, slightly moist, CLAY and SILT	0		
		1-2 ft: Red brown, black mottling, slightly moist, CLAY and SILT	1.5 ft 0		
			0		
		2-2.5 ft: Light brown, some grey mottling, slightly moist, CLAY and SILT	2.5 ft 0		
		2.5-4 ft: Brown, some black mottling, slightly moist, CLAY and SILT	0		
			3.5 ft 0		
4-8	4/4	4-7.5 ft: Brown, some black mottling, slightly moist, CLAY and SILT	4.5 ft 0		
			0		
			5.5 ft 0		
			0		
			6.5 ft 0		
			0		
			0		
		7.5-8 ft: Red brown, some black mottling, slightly moist, SILT, some clay, some angular gravel	7.5 ft		
8-12	4/4	8-9 ft: Red brown, some black mottling, slightly moist, SILT, some clay, some angular gravel	8.5 ft 0		
			0		
		9-11 ft: Red brown, some black mottling, dry, SILT, some clay, large amounts of weathered angular rock	9.5 ft 0		
			0		
			10.5 ft 0		
			0		
		11-12 ft: Red brown, SILT, large amount of angular weathered rock, trace clay	11.5 ft 0		
12-16		12-12.17 ft: Red brown, SILT, large amount of angular weathered rock, trace clay	12.5 ft 0		
		Refusal at 12.17ft	13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW22 2nd Attempt

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N:352215.39 E: 2667653.07	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.42 x Surveyed Estimated		DATE: 6/14/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5 ft: Brown, moist, CLAY, large angular gravel, some organics	0.5 ft 0		
		0.5-1 ft: Brown, CLAY, some large angular red gravel	0		
		1-2.25 ft: Red brown, some grey mottling, dry, CLAY and SILT	1.5 ft 0		
			0		
		2.25-2.5 ft: Dark brown, slightly moist, CLAY and SILT	2.5 ft 0		
		2.5-3 ft: Light brown, slightly moist, CLAY and SILT	0		
		2.5-4 ft: Brown, large amount of grey, slightly moist, CLAY and SILT	3.5 ft 0		
4-8	4/4	4-5.5 ft: Brown, some grey mottling, slighly moist, CLAY AND SILT	4.5 ft 0		
			0		
		5.5-8 ft: Red brown, some gre mottling, SILT, some clay	5.5 ft 0		
			0		
			6.5 ft 0		
			0		
			7.5 ft 0		
8-12	4/1.5	8-9.5 ft: Red brown, dry, SILT, weathered angular rock	8.5 ft 0		
			0		
		Refusal at 9.5	9.5 ft 0		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW23

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352042.74 E: 2667709.35	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.73 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Brown, moist, CLAY, some organcis, some large angular gravel	0.2 (0.5 ft)		PID background 0.2 ppm
		0.5-1 ft: Brown, slightly moist, CLAY, some silt	0.2		
			0.2 (1.5 ft)		
		1-1.5 ft: Light brown, some grey, slightly moist, CLAY, some silt	0.2		
		1.5-4 ft: Orange-brown, CLAY some grey, slightly moist, some silt	0.2 (2.5 ft)		
			0.2		
			0.2 (3.5 ft)		
4-8	4/4	4-6 ft: Orange-brown, some grey, slightly moist, CLAY, some silt	0.1 (4.5 ft)		PID background 0.1 ppm
			0.1		
			0.1 (5.5 ft)		
			0.1		
		6-8 ft: Red brown,moist, CLAY, some silt	0.1 (6.5 ft)		
			0.1		
			0.1 (7.5 ft)		
8-12	4/4	8-11 ft: Red brown, moist, CLAY, some silt	0.2 (8.5 ft)		PID background 0.2 ppm
			0.7		
			3.3 (9.5 ft)		
			0.4		
			0.7 (10.5 ft)		
			1.4		
		11-12 ft: Red brown, dry, SILT, some clay, small amount of rounded medium gravel	1.7 (11.5 ft)		
12-16	4/4	12-14 ft: Red brown, dry, SILT, some clay, small amount of rounded medium gravel	0.6 (12.5 ft)		PID background 0.1 ppm
			0.4		
			2.1 (13.5 ft)		
			1.2		
		14-14.5 ft: Red brown, wet, CLAY and SILT, large amounts of large angular weathered rock	0.5 (14.5 ft)		
		14.5-16 ft: Red brown, dry, SILT, trace clay, large amount of small to medium angular weathered rock	0.8		
			2.0 (15.5 ft)		
16-20	4/1	16-17 ft: Red brown, wet, SILT, trace clay, large amount of small to medium angular weathered rock	0.4 (16.5 ft)		
			1.1		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW24

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352139.47 E: 2667595.99	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.72 x Surveyed Estimated		DATE: 6/14/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/2.5	0-1.5 ft: Brown, very moist, CLAY, some organics	0.5 ft 0		
			0		
			1.5 ft 0		
		1.5-1.9 ft: Brown, soft, moist, CLAY	0		
		1.9-2 ft: Large angular black rock and some smaller pieces (1.9-2)	2.5 ft 0		
		2-3 ft: Brown, soft, moist, CLAY	0		
		3-4 ft: Brown clay and silt, some black mottling, a few pieces of large angular black rock, slightly moist	3.5 ft 0		
4-8	4/4	4-5 ft: Brown, SILT, some clay, some small to medium angular rock	4.5 ft 0		
			0		
		5-6 ft: Red brown, dry, SILT, some clay, large amount of large to medium angular weathered red rock	5.5 ft 0		
			0		
		6-7.5 ft: Brown and light brown clay and silt, some mall angular rock, slightly moist	6.5 ft 0		
			0		
			7.5 ft 0		
		7.5-8 ft: Light brown, SILT, large amounts of rounded weathered rock			
8-12	4/4	8-9 ft: Brown, wet, CLAY, some silt	8.5 ft 0		
			0		
		9- 11.5 ft: Light brown/yellow, dry, some weathered rounded and sub-angular GRAVEL	9.5 ft 0		
			0		
			10.5 ft 0		
			0		
			11.5 ft 0		
		11.5-12 ft: Brown/yellow, dry, some weathered angular GRAVEL			
12-16	4/3.5	12-14 ft: Brown, SILT, trace clay, large amount of sub-angular rock	12.5 ft 0		1.5' slough
			0		
			13.5 ft 0		
		Refusal at 14'	0		
			14.5 ft 0		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW25

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351934.65 E: 2667696.21	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.95 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Dark brown, moist, CLAY, some silt, organics	0.1		Background 0.2 ppm
		0.5-1 ft: Brown, moist, CLAY, some silt	0.5 ft 0.1		
		1-4 ft: Red brown, moist, CLAY, some silt	0.1		
			1.5 ft 0.2		
			0.1		
			2.5 ft 0.2		
			0.1		
			3.5 ft		
4-8	4/4	4-5 ft: Red brown, moist, CLAY, some silt	0.1		Background 0.1 ppm
			4.5 ft 0.1		
		5-6 ft; Brown, slightly moist, CLAY and SILT, some small sub-angular gravel	0.1		
			5.5 ft 0.1		
		6-6.5 ft: Brown, slightly moist, CLAY and SILT, large amounts of medium angular gravel	0.1		
			6.5 ft		
		6.5-8 ft: Light brown, dry, SILT, large amount of weathered angular rock	0.1		
			0.1		
			7.5 ft		
8-12	4/2"	8-8.17 ft: Light brown, dry, SILT, large amount of weathered angular rock	8.5 ft		
		Refusal at 8.17 ft			
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW26

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352026.88 E: 2667572.58	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: AR	
GROUND ELEV.: 296.55 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Brown, moist, CLAY, some organics	0.5 ft 0.1		PID background 0.1 ppm
		0.5-1 ft: Light brown, moist, CLAY	0.1		
		1-2.5 ft: Brown, dry, CLAY, some silt	1.5 ft 0.1		
			0.1		
			2.5 ft 0.1		
		2.5-4 ft: Red brown, slightly moist, CLAY and SILT	0.1		
			3.5 ft 0.1		
4-8	4/4	4-4.5 ft: Red brown, slightly moist, CLAY and SILT	4.5 ft 1.5		
		4.5-5.5 ft: Red brown, moist, CLAY, some silt	0.9		
			5.5 ft 0.2		
		5.5-6 ft: Red brown, SILT, some clay, large amount of large angular	0.2		
		6-7.5 ft: Red brown, slightly moist, CLAY, some silt	6.5 ft 0.3		
			0.3		
			7.5 ft 0.1		
		7.5-8 ft: Red brown, dry, SILT, some clay, dry, some sub angular			
8-12			8.5 ft		Refusal at 8ft
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW26A

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352017.27 E: 2667585.92	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.64 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5ft: Dark brown, moist, CLAY, some organics	0.1		PID bakcground 0.1 due to exhaust from rig, wind caused it to go up to 0.4 ppm
		0.5-2.5ft: Light brown, slightly moist, CLAY, some silt	0.5 ft 0.1		
			1.5 ft 0.1		
			0.1		
			2.5 ft 0.1		
		2.5-4ft: Light brown with grey and orange, slightly moist, CLAY, some silt	0.1		
			3.5 ft 0.1		
4-8	4/4	4-8ft: Red brown, dry, CLAY and SILT, some medium angular weathered rock at 7'	4.5 ft 0.1		
			0.1		
			5.5 ft 0.1		
			0.1		
			6.5 ft 0.1		
			0.1		
			7.5 ft 0.1		
8-12	4/2.5	8-10.5ft: Red brown, dry, SILT, small to large angular and rounded weathered rock	8.5 ft 0		PID background 0ppm as rig is off
			0		
			9.5 ft 0		
			0		
		Refusal at 10.5 ft	10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW27

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352055.72 E: 2667532.25	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.46 x Surveyed Estimated		DATE: 6/17/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Brown, moist, CLAY, some organics	0.1		PID background 0.1 ppm
		0.5-3.5 ft: Red brown, dry, CLAY, some silt	0.5 ft 0.1		
			0.1		
			1.5 ft 0.1		
			0.1		
			2.5 ft 0.1		
			0.1		
			0.1		
		3.5-4 ft: Red brown, dry, CLAY, some silt, some medium sub-angular gravel	3.5 ft		
4-8	4/4	4-6 ft: Red brow, dry, CLAY, some silt, some medium sub-angular gravel	0.1		
			4.5 ft 0.1		
			0.1		
			5.5 ft 0.1		
		6-7 ft: Red brown, SILT, large amount of medium to large sub-angular weathered rock	0.1		
			6.5 ft 0.1		
		7-8 ft: Red brown, dry, SILT and large amount of small to medium sub angular weathered rock	0.1		
			7.5 ft		
8-12	4/2	8-8.17 ft: Red brown dry, SILT and large amount of small to medium sub angular weathered rock	0		
			8.5 ft		
		Refusal at 8.17ft			
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW27A

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352116.43 E: 2667682.11	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.53 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5ft: Dark brown, moist, CLAY, organics	0.1		PID background 0.1 ppm
		0.5-1.5ft: Brown, moist, CLAY	0.5 ft 0.1		
			0.1		
		1.5-2ft: Grey, orange mottling, moist, CLAY	1.5 ft 0.1		
		2-4ft: Equal parts grey and orange, red from 3'5"-3'7", dry, CLAY, some silt	0.1		
			2.5 ft 0.1		
			0.1		
			3.5 ft		
4-8	4/4	4-8ft: Brown with some grey, orange, and black throughought, slightly moist, CLAY, some silt	0.1		
			4.5 ft 0.1		
			0.1		
			5.5 ft 0.1		
			0.1		
			6.5 ft 0.1		
			0.1		
			7.5 ft		
8-12	4/4	8-9.5ft: Brown with some grey, orange, and black throughouth, slightly moist, CLAY, some silt	0.1		
			8.5 ft 0.1		
			0.1		
		9.5-11ft: Brown, dry, SILT, large amount of weathered small to large sub-angular rock	9.5 ft 0.1		
			0.1		
			10.5 ft 0.1		
		11-12ft: Brown, dry, CLAY and SILT, some small rounded gravel	11.5 ft 0.1		
12-16	4/4	12-13ft: Brown, some dark brown and orange, slighlty moist, CLAY, some silt	0.2		
			12.5 ft 1.3		
		13-14.5ft: Red clay and light brown, dry, SILT, large amount of small to large sub-angular weathere rock	0.6		
			13.5 ft 3.0		
			0.8		
		14.5-15ft: Brown and red brown, slightly moist, CLAY and SILT, large amount of small to medium weathered angular rock	14.5 ft 8.1		
		15-16ft: Red brown, slightly moist, CLAY and SILT, some small to medium sub angular weathered rock	9.6		
			15.5 ft		
16-20	4/1	16-17ft: Light grey, dry, SILT, large amount of small to large sub-angular weathered rock	2.2		
			16.5 ft		
		Refusal at 17ft	17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW28

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351987.05 E: 2667.474	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.35 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5ft: Dark brown, moist, CLAY, organics 0.5-4ft: Brown, moist, CLAY and SILT, some medium sized angular weathered rock	0.5 ft 0		
			0		
			1.5 ft 0		
			0		
			2.5 ft 0		
			0		
			3.5 ft 0		
4-8	4/4	4-7ft: Red brown silt, some clay, large amount of small to large angular and sub-angular weathered rock, dry	4.5 ft		0.5ft slough
			5.5 ft		
			6.5 ft		
		Refusal at 7.5'	7.5 ft		
8-12			8.5 ft		
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW28A

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351975.54 E: 2667492.43	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.12 x Surveyed Estimated		DATE: 6/20/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5ft: Black GRAVEL (from path)	0		
		0.5-2ft: Brown, moist, CLAY, some organics	0.5ft 0.2		
			0.2		
			1.5 ft 0.3		
		2-4ft: Red brown, dry, SILT, trace clay, large amount of weathered small to large sub-angular and angular weathered rock	0.2		
			2.5 ft 0		
			0		
			3.5 ft		
4-8	4/4	4-5.5ft: Red brown, dry, SILT, trace clay, large amount of weathered small to large sub-angular and angular weathered rock	0		1ft sloughed black gravel
			4.5 ft 0		
			0		
		5.5-7ft: Red brown, dry, SILT, large amount of small to medium sub-angular and angular weahtered rock	5.5 ft 0		
			0		
			6.5 ft 0		
		Refusal at 7ft			
			7.5 ft		
8-12			8.5 ft		
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW29

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352004.01 E: 2667435.83	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.09 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-1ft: Dark brown, moist, CLAY, some organics	0.5 ft 0.1		
			0.1		
		1-2.5ft: Brown, moist, CLAY, some silt, moist	1.5 ft 0.1		
			0.2		
			2.5 ft 0.1		
			0.2		
		2.5-4ft: Brown, some grey, dry, CLAY and SILT	3.5 ft 0.1		
4-8	4/4	4-5ft: Brown, some grey, moist, CLAY and SILT	4.5 ft 0.1		PID background 0.1 ppm
			0.1		
		5-7ft: Red brown, slightly moist, CLAY and SILT	5.5 ft 0.1		
			0.1		
			6.5 ft 0.1		
			0.1		
		7-8ft: Red brown, dry, SILT, some clay, large amount of weathere angular rock, small to large sized (last 4" entirely rock)	7.5 ft 0.2		
8-12			8.5 ft		Refusal at 8ft
			9.5 ft		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW29A

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 352007.16 E: 2667687.50	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.61 x Surveyed Estimated		DATE: 6/20/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5ft: Dark brown, moist, CLAY, organics	0.5ft 0		
		0.5-1ft: Dark brown, moist, CLAY, organics	0		
		1-1.5ft: Light brown, moist, CLAY, moist	1.5 ft 0		
		1.5-4ft: Orange-brown, some grey, slightly moist, CLAY, some silt	0		
			2.5 ft 0		
			0		
			3.5 ft 0		
4-8	4/4	4-4.5ft: Orange-brown, some grey, slightly moist, CLAY, some silt	4.5 ft 0		
		4.5-7.5ft: Brown, some light brown and orange hues, slightly moist, CLAY, some silt	0		
			5.5 ft 0		
			0		
			6.5 ft 0		
			0		
			7.5 ft 0		
		7.5-8ft: Red brown, dry, CLAY, some silt			
8-12	4/4	8-10ft: Red brown, dry, CLAY, some silt	8.5 ft 0		
			0		
			9.5 ft 0		
			0		
		10-12ft: Red brown, dry, SILT and CLAY, some small to medium sub-angular weathered rock	10.5 ft 0		
			0		
			11.5 ft 0		
12-16	4/3	12-15ft: Red brown, dry, SILT and CLAY, some small to medium sub-angular weathered rock	12.5 ft 0		
			0		
			13.5 ft 0		
			0		
			14.5 ft 0		
			0		
		15-16ft: Red brown, dry, SILT, trace clay, large amount of small to large sub-angular and angular weathered rock	15.5 ft 0		Refusal at 15ft
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW30

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351857.28 E: 2667460.95	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.48 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-1ft:Dark brown, moist, CLAY, some organics	0.5 ft 0		
			0		
		1-3ft: Brown, moist, CLAY, some silt	1.5 ft 0		
			0		
			2.5 ft 0		
			0		
		3-4ft: Brown, slightly moist, CLAY, some silt, one large sub angular piece of rock approximately 3.5"	3.5 ft 0		
4-8	4/4	4-5.5ft: Brown, some light brown mottling, moist, CLAY, some silt	4.5 ft 0.1		PID background 0.1 ppm
			0.1		
		5.5-7.5ft: Red brown, CLAY, some silt, small amount of small rounded gravel	5.5 ft 0.1		
			0.1		
			6.5 ft 0.1		
			0.1		
		7.5-8ft: Dark brown, slightly moist, CLAY, some silt	7.5 ft 0.1		
8-12	4/4	8-10ft: Dark brown, slightly moist, CLAY, some silt, small amount of small rounded gravel	8.5 ft 0.1		
			0.1		
			9.5 ft 0.1		
			0.1		
		10-11ft: Dark brown and orange, slightly moist, CLAY, some silt	10.5 ft 0.1		
			0.1		
		11-12ft: Brown, yellow hue, slightly moist, CLAY and SILT	11.5 ft 0.1		
12-16	4/4	12-13.5ft: Dark brown, yellow brown and brown hues, moist, CLAY, some silt	12.5 ft 0.1		
			0.1		
		13.5-16ft: Brown, some orange hues, moist, SILT, some clay, large amount of small to large sub-angular to angular weathered rock	13.5 ft 0.1		
			0.1		
			14.5 ft 0.1		
			0.1		
			15.5 ft 0.1		
16-20	4/2.5	16-20ft: Brown, wet, SILT, large amount of small to large sub angular and angular weathered rock	16.5 ft 0.1		
			0.1		
			17.5 ft 0.1		
			0.1		
			18.5 ft 0.1		
			0.1		
			19.5 ft 0.1		
20-24	4/3.5	20-22ft: Brown, wet, SILT, some clay, lare amount of small to medium sub-angular to angular weathered rock, wet (1.5ft of this depth slough)	20.5ft 0.1		
			0.1		
			21.5ft 0.1		
		Refusal at 22'	0.1		
			22.5ft		
			23.5ft		

Notes:

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BORING LOG

BORING NO. TW31

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351919.06 E: 2667378.15	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.46 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5ft: Dark brown, moist, CLAY, some organics	0.1		PID background 0.1 ppm
		0.5-2ft: Light brown, slightly moist, CLAY, some silt	0.5 ft 0.1		
			0.1		
			1.5 ft 0.1		
		2-4ft: Red brown, dry, CLAY, some silt	0.1		
			2.5 ft 0.1		
			0.1		
			3.5 ft		
4-8	4/4	4-7ft: Red brown, dry, CLAY, some silt, some medium sized sub-angular gravel	0.2		PID background 0.2 ppm
			4.5 ft 0.2		
			0.2		
			5.5 ft 0.2		
			0.2		
			6.5 ft 0.2		
		7-8ft: Red brown, dry, CLAY and SILT	7.5 ft 0.2		
8-12	4/4	8-11ft: Red brown, dry, CLAY and SILT, some small to large sub-angular gravel	0.4		PID background 0.4 ppm
			8.5 ft 0.4		
			0.4		
			9.5 ft 0.4		
			0.4		
			10.5 ft 2.0		
		11-12ft: Red brown, slightly moist, CLAY and SILT, some small to large sub-angular gravel	11.5 ft 4.2		
12-16	4/4	12-14ft: Red brown, slightly moist, CLAY and SILT, some small to large sub-angular gravel	12.5 ft		
			1.6		
			13.5 ft 3.0		
			2.0		
		14-15ft: Red brown, dry, SILT, some clay, small to alrge sub-angular weathered rock	14.5 ft 3.6		
			1.9		
		15-16ft: Red brown, moist, CLAY, some silt	15.5 ft 5.0		
16-20	4/3	16-17.5ft: Brown, wet, CLAY and SILT, large amount of small to large sub angular and angular weathered rock	16.5 ft		1.5ft at 16-20 depth slough
		Refusal at 17.5'	17.5 ft 0.1		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW32

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351947.01 E: 2667338.30	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.46 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5ft: Dark brown, moist, CLAY, some organics	0.5 ft 0		
		0.5-3.5ft: Brown, some black mottling, dry, CLAY, some silt	0		
			1.5 ft 0		
			0		
			2.5 ft 0		
			0		
			3.5 ft 0		
		3.5-4ft: Brown, some black mottling, red hue, dry, CLAY, some silt			
4-8	4/4	4-4.5ft: Brown, some black mottling, red hue, dry, CLAY, some silt	4.5 ft 0		
		4.5-8ft: Reddish brown, dry, CLAY, yellow brown silt, weathered rock, large amount of small to large rounded, sub-angular and angular weathered rock	0		
			5.5 ft 0		
			0		
			6.5 ft 0		
			0		
			7.5 ft 0		
8-12	4/3	8-10ft: Reddish brown, dry, CLAY, yellow brown silt, weathered rock, large amount of small to large rounded, sub-angular and angular weathered rock	8.5 ft 0		1 ft slough
			0		
			9.5 ft 0		
		Refusal at 10ft	0		
			10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW32A

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER:	X Logged	N: 351938.50 E: 2667351.13	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 296.46 x Surveyed Estimated		DATE: 6/20/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5ft: Dark brown, moist, CLAY, organics	0.4		
		0.5-1ft: Light brown, moist, CLAY	0.5ft 0		
		1-3ft: Brown, some orange hues, CLAY, some silt	1.5 ft 0		
			0		
			2.5 ft 0		
			0		
		3-4ft: Brown and red-brown, moist, CLAY, some silt	3.5 ft 0		
4-8	4/4	4-7ft: Brown and red-brown, moist, CLAY, some silt	4.5 ft 0		
			0		
			5.5 ft 0		
			0		
			6.5 ft 0		
			0		
		7-8ft: Red brown, dry, SILT, trace clay, large amount of small to medium sub-angular gravel	7.5 ft 0		
8-12	4/3	8-9.75ft: Red brown, dry, SILT, trace clay, large amount of small to medium sub-angular gravel	8.5 ft 0		~1ft sloughed
			0		
			9.5 ft 0		
		Refusal at 9.75ft	0		
			10.5 ft 0		
			0		
			11.5 ft 0		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW33

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351806.62 E: 2667359.15	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 295.17 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-0.5 ft: Dark brown, moist, CLAY, some organics	0.5 ft 0		
		0.5-3 ft: Light brown, moist, CLAY	0		
			1.5 ft 0		
			0		
			2.5 ft 0		
			0		
		3-4 ft: Brown, some black and light brown mottling, moist, CLAY, trace silt	3.5 ft 0		
4-8	4/4	4-8 ft: Brown, some black and grey mottling, orange hue, moist, CLAY, some silt	4.5 ft 0		
			0		
			5.5 ft 0		
			0		
			6.5 ft 0		
			0		
			7.5 ft 0		
8-12	4/4	8-11.5 ft: Brown, some black and grey mottlilng, orange hue, moist, CLAY, some silt	8.5 ft 0		
			0		
			9.5 ft 0		
			0		
			10.5 ft 0		
			0		
		11.5-12 ft: Brown, some black and grey mottling, orange hue, moist, CLAY, some silt, some medium sized weathered sub-angular gravel	11.5 ft 0		
12-16	4/4	12-15.5 ft: Brown, black and grey mottling, orange hue, moist, CLAY,some silt, some medium sized weathered sub-angular gravel	12.5 ft 0		
			0		
			13.5 ft 0		
			0		
			14.5 ft 0		
			0		
		15.5-6 ft: Dark brown, moist, CLAY and SILT, large amount of small to medium rounded gravel	15.5 ft 0		
16-20	4/4	16-18 ft: Brown, wet, CLAY and SILT, some small sub-angular gravel	16.5 ft 0		
			0		
			17.5 ft 0		
			0		
		18-20 ft: Brown,, light brown and orange hues, moist, CLAY and SILT, large amount of small rounded gravel	18.5 ft 0		
			0		
			19.5 ft 0		
20-24	4/4	20-22.5 ft: Brown, very moist, CLAY and SILT, very large amount of small to large sub-angular rock	20.5ft 0		2ft of 20-24 depth slough, very wet
			0		
			21.5ft 0		
			0		
		Refusal at 22'	22.5ft 0		
			0		
			23.5ft 0		

Notes:

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BORING LOG

BORING NO. TW34

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351899.31 E: 2667237.85	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 295.52 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Dark brown, moist, CLAY, some organics	0.5 ft 0		
		0.5-1 ft: Light brown, moist, CLAY	0		
		1-4 ft: Brown, slightly moist, CLAY and SILT	1.5 ft 0		
			0		
			2.5 ft 0		
			0		
			3.5 ft 0		
4-8	4/4	4-6.5 ft: Brown, some light brown, slightly moist, CLAY and SILT, some large sub-angular gravel	4.5 ft 0		
			0		
			5.5 ft 0		
			0		
			6.5 ft 0		
		6.5-8 ft: Light brown, some red brown, slighlty moist, CLAY and SILT, some large angular gravel	0		
			7.5 ft 0		
8-12	4/4	8-11 ft: Light brown, yellow hue, dry, SILT, large amount of weathered angular gravel, some red clay	8.5 ft 0		
			0		
			9.5 ft 0		
			0		
			10.5 ft 0		
			0		
		11-12 ft: Light brown, orange hue, dry, SILT, large amount of weathered angular gravel, some red clay	11.5 ft 0		
12-16	4/4	12-12.5 ft: Light brown, orange hue, moist, SILT, large amount of weathered angular gravel, some red clay	12.5 ft 0		
		12.5-15.5 ft: Yellow brown, dry, SILT, large amount of weathered large sub-angular gravel,	0		
			13.5 ft 0		
			0		
			14.5 ft 0		
			0		
			0		
		15.5-15.8 ft: Yellow brown, moist, SILT, large amount of weathered large sub-angular gravel	15.5 ft		Refusal at 15'10"
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW35

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351861.00 E: 2667115.34	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 289.96 x Surveyed Estimated		DATE: 6/18/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3	0-0.5 ft: Dark brown, moist, CLAY, some organics	0.5 ft 0		
		0.5-2.5 ft: Dark brown, moist, CLAY, trace silt	0		
			1.5 ft 0		
			0		
			2.5 ft 0		
		2.5-4 ft: Orange-brown, red hues, moist, CLAY, some silt, small amount of small gravel	0		
			3.5 ft 0		
4-8	4/4	4-6 ft: Red brown and light brown, slightly moist, CLAY, some silt	4.5 ft 0.4		PID readings may have been influenced by exhaust
			0.1		
			5.5 ft 1,8		
			2.5		
		6-7.5 ft: Light brown, SILT, some clay, large amount of weahtered large rounded rock	6.5 ft 3.8		
			1.5		
			3.1		
		7.5-8 ft: Light brown, orange hues, SILT, some clay, large amount of weathered large rounded rock	7.5 ft		
8-12	4/2.5	8-9 ft: Light brown, orange hues, SILT, some clay, large amount of weathered large rounded rock	8.5 ft		0.5ft slough
		9-10 ft: Light brown SILT, weathered rock, large amount of large sub-angular rock	9.5 ft		
		Refusal at 10ft	10.5 ft		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW36

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351801.95 E: 2667079.52	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 292.45 x Surveyed Estimated		DATE: 6/18/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3	0-0.5 ft: Dark brown, soft, moist, clay, some organics	0.5		Backgrounnd 0.6 ppm
		0.5-1.5 ft: Light brown, moist, CLAY	0.5 ft 0.6		
			0.6		
		1.5-4 ft: Brown, some grey, dry, CLAY and SILT	1.5 ft 0.6		
			0.6		
			2.5 ft 0.6		
			3.5 ft 0.6		
4-8	4/4	4-7 ft: Brown, some orange hues, slightly moist, CLAY and SILT	0		
			4.5 ft 0		
			0		
			5.5 ft 0		
			0		
			6.5 ft 0.6		
		7-8 ft: Brown, some red hues, moist, SILT, some clay	7.5 ft 0.8		
8-12	4/4	8-11.5 ft: Brown, moist, SILT, large amount of medium sub-angular gravel, weathered rock	8.5 ft 0.8		
			0.6		
			9.5 ft 9.7		
			0.9		
			10.5 ft 7.9		
			8.7		
		11.5-12 ft: Light brown, some red hues, slightly moist, SILT, medium sub-angular gravel	11.5 ft		
12-16	4/1	12-13 ft: Brown, SILT, large amount of weathered sub angular rock	12.5 ft 14.6		
			1.3		
		Refusal at 13ft	13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW37

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351720.87 E: 2667229.97	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 293.20 x Surveyed Estimated		DATE: 6/18/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/4	0-0.5 ft: Dark brown, moist, CLAY,organics	0.5		Background 0.5 ppm for PID
		0.5-4 ft: Brown, some black and light brown mottling, slightly moist, CLAY, some silt	0.5		
			0.5 (1.5 ft)		
			0.5		
			0.5 (2.5 ft)		
			0.5		
			0.5 (3.5 ft)		
4-8	4/4	4-8 ft: Red brown, some orange grown, slightly moist, CLAY, some silt	0 (4.5 ft)		
			0		
			0 (5.5 ft)		
			0		
			0 (6.5 ft)		
			0		
			0 (7.5 ft)		
8-12	4/3.5	8-10 ft: Red brown, moist, CLAY and SILT, large amount of weathered sub-angular rock	0.2 (8.5 ft)		Background 0.2 ppm for PID
			0.2		
			0.2 (9.5 ft)		
			0.2		
		10-11 ft: Red brown, dry, CLAY and SILT, large amount of weathered sub- angular rock	0.2 (10.5 ft)		
			0.2		
		11-12 ft: Red brown, moist, SILT, trace clay, large amount of weathered sub-angular rock	0.2 (11.5 ft)		
12-16	4/3	12-13 ft: Red brown, moist, SILT, trace clay, large amount of weathered sub-angular rock (first 1' slough)	0.2 (12.5 ft)		
			0.2		
		13-15 ft: Brown, orange hues, SILT, some small sub-angular gravel	0.2 (13.5 ft)		
			0.2		
			0.2 (14.5 ft)		
		Refusal at 15'	0.2		
			15.5 ft		Refusal at 15'
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW38

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351711.76 E: 2667130.21	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 291.89 x Surveyed Estimated		DATE: 6/19/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3'8"	0-0.5 ft: Dark brown, moist, CLAY, some organics	0.5 ft 0		
		0.5-2 ft: Brown, slightly moist, CLAY, some silt, small amount of medium rounded gravel	0		
			1.5 ft 0		
			0		
		2-4 ft: Light brown, slightly moist, CLAY and SILT	2.5 ft 0		
			0		
			3.5 ft 0		
4-8	4/4	4-4.5 ft: Light brown, slightly moist, CLAY and SILT	4.5 ft 0		
		4.5-7 ft: Red brown, slightly moist, CLAY, some silt, some small to medium sub-angular gravel	0		
			5.5 ft 0		
			0		
			6.5 ft 0		
			0		
		7-8 ft: Red brown, dry, SILT and CLAY	7.5 ft 0		
8-12	4/3	8-8.5 ft: Orange brown, dry, SILT and CLAY, large amount of small to large sub-angular gravel	8.5 ft 0		
		8.5-9 ft: Light orange brown, dry, SILT and CLAY, large amount of small to large sub-angular gravel	0		
		9-11 ft: Red brown, dry, SILT and CLAY, large amoount of small to large sub-angular gravel	9.5 ft 0		
			0		
			10.5 ft 0		
		Refusal at 11ft	0		
			11.5 ft		
12-16			12.5 ft		
			13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW39

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351659.29 E: 2667007.19	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 290.33 x Surveyed Estimated		DATE: 6/18/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-1 ft: Dark brown, moist, CLAY, organics	0.5 ft 0 0		When wind blows geoprobe exhaust towards PID, background 0.2 ppm.
		1-1.5ft: Dark brown, moist, CLAY with some silt, organics	1.5 ft 0 0		
		1.5-3.5 ft: Light brown, grey and orange-brown mottling, moist, CLAY	2.5 ft 0 0		
		3.5-4 ft: Orange brown and grey, moist, CLAY, trace silt	3.5 ft 0		
4-8	4/4	4-6 ft: Red brown,light brown also present, dry, SILT, trace clay, some medium sub angular gravel	4.5 ft 0 0 5.5 ft 0 0		
		6-6.5 ft: Grey and orange-brown, dry, CLAY and SILT, some medium weathered angular gravel	6.5 ft 0		
		6.5-8 ft: Brown/Light brown clay and silt, slightly moist, small amount of small sub-angular gravel	0 7.5 ft 0		
8-12	4/4	8-10.5 ft: Red brown and orange brown, slightly moist, CLAY and SILT, some small to medium rounded gravel	8.5 ft 0 0 9.5 ft 0 0 10.5 ft 0		
		10.5-12 ft: Light brown silt, some clay, some small sub-angular weathered rock, dry	0 11.5 ft 0		
12-16		12-12.5 ft: Light brown, dry, SILT, some clay, some small sub-angular weathered rock	12.5 ft		
		12.5-14 ft: Brow, dry, SILT, large amount of weathered rounded and sub-angular rock - small and medium sized			
		Refusal at 14ft	13.5 ft		
			14.5 ft		
			15.5 ft		
16-20			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW40

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT OLE DIAMETER: 3 in	X Logged	N: 351549.58 E: 2666913.33	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 290.13 x Surveyed Estimated		DATE: 6/18/2013	
SURFACE CONDITIONS: grass			

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-4	4/3.5	0-1 ft: Brown, moist, CLAY some organics	0.5 ft 0 0		
		1-2 ft: Light brown, moist, CLAY, some silt	1.5 ft 0 0		
		2-4 ft: Red brown, dry, CLAY and SILT	2.5 ft 0 0 3.5 ft 0		
4-8	4/4	4-6.5 ft: Brown, slightly, moist, CLAY and SILT	4.5 ft 0 0 5.5 ft 0 0 6.5 ft 0		
		6.5-7.5 ft: Light brown and grey, slightly moist, CLAY, some silt	0 7.5 ft 0		
		7.5-8 ft: Orange brown clay, slightly moist, SILT, small amount of rounded gravel			
8-12	4/3	8-8.5 ft: Orange brown clay, slightly moist, SILT, small amount of rounded gravel	8.5 ft 0.4		
		8.5-9.5 ft: Brown, moist, CLAY and SILT	0.2 9.5 ft 0		
		9.5-10.5 ft: Brown, very moist, SILT, large amount small to medium sub-angular gravel	0 0 10.5 ft 0		
		10.5-11 ft: Brown, moist, SILT, some clay, small amount of small rounded gravel			
		11-12 ft: Light grey, moist, CLAY, small amount of small rounded gravel at least 2"	11.5 ft 0		
12-16	4/4	12-14.5 ft: Light brown, some orange brown and grey mottling, moist, CLAY, some silt	12.5 ft 0 0 13.5 ft 0 0 14.5 ft 0		12-16 depth wet from slough
		14.5-16 ft: Grey, moist, CLAY, trace silt (Note: last three inches had a blue tint and second two inches had a red tint, no odor)	0 15.5 ft 0		
16-20	4/2	16-16.8 ft: Grey, moist, CLAY, trace silt	16.5 ft		
		16.8- 17 ft: Orange brown, moist, CLAY and SILT			
		17-17.25 ft: Grey, SILT, large amount of small rounded gravel			
		17.25-17.4 ft: Orange brown, moist, SILT and CLAY, small amount of small rounded gravel	17.5 ft		
		17.4-18 ft: Grey, moist, CLAY, some silt	18.5 ft		
		Refusal at 18ft			
			19.5 ft		

Notes:

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BORING LOG

BORING NO. TW42

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351984.48 E: 2667289.61	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 297.44 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: grassy area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-1ft: Brown, slightly moist SILT, some organics	0.5 ft 0.3		
			0.3		
		1-4ft: Light brown, some grey, firm, slightly moist SILT	1.5 ft 0.3		
			0.3		
			2.5 ft 0.3		
			0.3		
			3.5 ft 0.3		
			0.3		
		4-5ft: Light brown, some grey, firm, slightly moist SILT, some large sub-angular rock	4.5ft 0.3		
5-10	5/5	5-6ft: Brown, dry, weathered rock, large angular GRAVEL, some brown silt	5.5 ft 0.2		PID Background 0.2 ppm
			0.2		
		6-8.5ft: Grey, fine, dry SAND and large amount of weathered rock - small to medium angular gravel	6.5 ft 0.2		
			0.2		
			7.5 ft 0.2		
			0.2		
		Refusal at 8.5ft	8.5 ft		
			9.5ft		
10-15			10.5 ft		
			11.5 ft		
			12.5 ft		
			13.5 ft		
			14.5ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5ft		

Notes:

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BORING LOG

BORING NO. TW43

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 352033.65 E: 2667221.47	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 290.73 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS:

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5ft: Brown, slightly moist SILT, some organics	0.5		PID Background 0.5 ppm
		0.5-2ft: Red brown, slightly moist SILT and CLAY, large amount of small to large sub-angular gravel	0.5		
			0.5		
			0.5		
		2-5ft: Red brown, fine, slightly moist SAND and SILT, large amount of small to medium sub-angular gravel (weathered rock)	0.5		
			0.5		
			0.5		
			0.5		
			0.5		
5-10	5/3.5	5-8ft: Red brown, fine, dry SAND and SILT, large amount of sub-angular small to medium gravel (weathered rock)			0.5ft slough
		Refusal 8ft			
10-15					
15-20					

Notes:

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BORING LOG

BORING NO. TW44

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351985.24 E: 2667169.64	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 289.61 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: baseball field

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-1ft: Brown, sllightly moist SILT, some organics	0.5 ft 0.3		PID Background 0.3 ppm
			0.3		
		1-2.5ft: Red brown, dry SILT, large amounts of weathered rock - large angular gravel	1.5 ft 0.3		
			0.3		
			2.5 ft 0.3		
		2.5-3.5ft: Red brown, fine, dry SAND, large amounts of sub-angular gravel (weathered rock)	0.3		
			3.5 ft 0.3		
		3.5-5ft: Light grey, fine SAND, large amounts of small to medium sub-angular gravel (weathered rock)	0.3		
			4.5ft 0.3		
5-10	5/2.5	5-5.5ft: Brown, fine SAND, large amount of sub-angular small to medium gravel (weathered)	5.5 ft 0.3		1ft slough
		5.5-6ft: Dark red and brown, dry CLAY, large amount of medium sub-	0.3		
		6-6.5ft: Light brown, fine, dry SAND, small sub-angular gravel (weathered rock)	6.5 ft 0.3		
		Refusal at 6.5ft			
			7.5 ft		
			8.5 ft		
			9.5ft		
10-15			10.5 ft		
			11.5 ft		
			12.5 ft		
			13.5 ft		
			14.5ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5ft		

Notes:

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BORING LOG

BORING NO. TW44A

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351959.21 E: 2667168.01	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 290.19 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: baseball field

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-1ft: Brown, slightly moist SILT, some organics, large rock at 1ft	0.5 ft 0.4		PID Background 0.4 ppm
			0.4		
		1-5ft: Brown, slightly moist SILT, trace red-brown and orange-brown silt, large amount of sub-angular medium gravel	1.5 ft 0.4		
			0.4		
			2.5 ft 0.4		
			0.4		
			3.5 ft 0.4		
			0.4		
			4.5ft 0.4		
5-10	5/4	5-7ft: Brown, fine, dry SAND and SILT, medium amount of medium to large sub-angular gravel, trace red-brown clay	5.5 ft 0.4		
			0.4		
			6.5 ft 0.4		
			0.4		
		7-7.5ft: Dark brown, fine, wet SAND and large amount of small angular gravel	7.5 ft 0.4		
		7.5-8.5ft: Brown, fine, dry SAND and large amounts of medium to large sub-angular gravel (weathered rock)	0.4		
			0.4		
		8.5-9ft: Grey-brown, fine, dry SAND, large amounts of small to large sub-angular gravel (weathered rock)	8.5 ft		
		Refusal at 9ft	9.5ft		
10-15			10.5 ft		
			11.5 ft		
			12.5 ft		
			13.5 ft		
			14.5ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5ft		

Notes:

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BORING LOG

BORING NO. TW45

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351881.40 E: 2667067.98	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 289.44 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: grassy area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-1ft: Brown, slightly moist SILT, some organics, some clay	0.5		PID Background 0.5 ppm (close to rig
			0.5		
		1-2ft: Reddish brown, slightly moist SILT, some organics, some clay	0.5		
			0.5		
		2-4ft: Brown to light brown, tight, slighlty moist SILT, some clay	0.5		
			0.5		
			0.5		
			0.5		
		4-5ft: Light brown, fine, dry SAND, large amount of medium sub-angular gravel (weathered rock)	0.5		
5-10	5/3	5-6ft: Brown, fine, dry SAND and large amounts of sub-angular small to medium gravel (weathered rock)	0.5		
		6-7.5ft: Light brown to grey, fine, dry SAND and large amount of large angular weathered rock - apparent bedrock	0.5		
			0.5		
			0.5		
		7.5-8ft: Brown fine, dry SAND, some small sub-angular gravel (weathered rock)	0.5		
		Refusal at 8ft			
10-15					
15-20					

Notes:

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BORING LOG

BORING NO. TW46

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351855.17 E: 2667028.63	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 292.19 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: wooded area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/4.5	0-0.5ft: Brown, slightly moist SILT, some organics	0.5		PID Background 0.5 ppm (close to rig
		0.5-3.5ft: Brown, some black mottling, dry SILT, some clay	0.5 ft 0.5		
			1.5 ft 0.5		
			0.5		
			2.5 ft 0.5		
			0.5		
			3.5 ft 0.5		
		3.5-5ft: Red brown, some black mottling, tight, dry SILT and CLAY	0.5		
			4.5ft 0.5		
5-10	5/5	5-5.5ft: Red brown, some black mottling, tight, dry SILT and CLAY	0.6		
		5.5-6ft: Red brown, fine, slightly moist SAND and large amount of small to medium sub-angular gravel (weathered rock)	5.5 ft 1.4		
		6-6.5ft: Red brown, fine, slightly firm, slightly moist SILT and CLAY	6.5 ft 0.6		
		6.5-9ft: Red brown, fine, dry SAND and large amount of small to medium sub-angular gravel (weathered rock)	1.2		
			7.5 ft 0.6		
			0.6		
			8.5 ft 0.6		
			0.6		
		9-9.5ft: Brown, slightly firm, dry SILT and CLAY	1.0		
		9.5-10ft: Red brown, fine, dry SAND and large amount of large angular gravel (weathered rock)	9.5ft		
10-15	5/3.5	10-10.5ft: Red brown, fine, dry SAND and large amount of large angular gravel (weathered rock)	10.5 ft		
		10.5-11ft: Red brown, slightly soft, slightly moist SILT and CLAY			
		11-11.5ft: Red brown, fine, dry SAND, large amount of small angular gravel (weathered rock)	11.5 ft		
		11.5-11'11": Red brown, slightly moist SILT and CLAY			
		11'11"-12ft: Brown, dry, medium sized angular gravel (weathered rock)	12.5 ft		
		Refusal at 12ft			
			13.5 ft		
			14.5ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5ft		

Notes:

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BORING LOG

BORING NO. TW47

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351752.89 E: 2666978.85	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 289.73 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS:

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5ft: Brown, slightly moist SILT, some organics	0.5		PID Background 0.5 ppm (close to rig
		0.5-3ft: Light brown, some grey, slightly firm, slightly moist SILT and CLAY	0.5		
			0.5 (1.5 ft)		
			0.5		
			0.5 (2.5 ft)		
			0.5		
		3-3.5ft: Grey, slightly moist SILT, some clay	0.5 (3.5 ft)		
		3.5-5ft: Brown and grey, slightly firm, slightly moist SILT and CLAY	0.5		
			0.5 (4.5ft)		
5-10	5/4.5	5-8ft: Red brown, moist SILT, large amounts of medium to large rounded gravel	0.6 (5.5 ft)		
			0.6		
			0.9 (6.5 ft)		
			0.6		
			0.6 (7.5 ft)		
			0.7		
		8-9ft: Red brown, moist SILT and CLAY, small amount of small sub-angular gravel	0.6 (8.5 ft)		
			0.6		
		9-9.5ft: Red brown, soft, very moist CLAY	0.9		
		9.5-10ft: Red brown, slightly moist SILT, some clay, large amount of medium sub-angular gravel	(9.5ft)		
10-15	5/4	10-14ft: Red brown, very wet SILT, large amount of small to large sub-angular gravel	(10.5 ft)		
			(11.5 ft)		
			(12.5 ft)		
		Refusal at 14ft	(13.5 ft)		
			(14.5ft)		
15-20			(15.5 ft)		
			(16.5 ft)		
			(17.5 ft)		
			(18.5 ft)		
			(19.5ft)		

Notes:

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BORING LOG

BORING NO. TW48

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351653.80 E: 2666895.14	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 288.58 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: wooded area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-1ft: Brown, soft, slightly moist CLAY and SILT, some organics	0.5		PID Background 0.5 ppm
			0.5 ft 0.5		
		1-2ft: Light brown, grey, and orange brown, soft, slightly moist SILT, some clay	0.5		
			1.5 ft 0.5		
		2-3ft: Grey and orange brown, soft, slightly moist SILT, some clay	0.5		
			2.5 ft 0.5		
		3-5ft: Brown, firm, slightly moist SILT and CLAY	0.5		
			3.5 ft 0.5		
			4.5ft 0.5		
5-10	5/5	5-8ft: Red brown, slightly firm, slightly moist SILT and CLAY	0.5		PID Background 0.5-0.6 ppm
			5.5 ft 0.5		
			0.5		
			6.5 ft 0.5		
			0.5		
			7.5 ft 0.5		
		8-9ft: Brown, yellow-brown, and grey, dry SILT, some clay	0.5		
			8.5 ft 0.5		
		9-10ft: Brown and reddish brown, slightly moist SILT, large amount of sub-angular large gravel (weathered rock)	0.5		
			9.5ft		
10-15	5/5	10-10.5ft: Brown and reddish brown, slightly moist SILT, large amount of sub-angular large gravel (weathered rock)	0.5		PID Background 0.5-0.6 ppm
			10.5 ft		
		10.5-12ft: Brown, fine SAND and SILT, large amount of small to large rounded to sub-angular gravel (weathered rock)	0.5		
			0.5		1ft of 10-15 depth slough
			11.5 ft 0.5		
		12-14ft: Grey SILT and large amount of rounded large gravel (weathered rock)	0.5		
			12.5 ft 0.5		
		Refusal at 14ft	0.5		
			13.5 ft		
			14.5ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5ft		

Notes:

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BORING LOG

BORING NO. TW49

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351927.70 E: 2666982.22	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 288.65 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: wooded area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5ft: Brown, slightly moist SILT, some organics	0.6		PID Background 0.6 ppm
		0.5-1ft: Dark brown and reddisth brown, slightly moist SILT, some clay	0.5 ft 0.6		
		1-3.5ft: Reddish brown, firm, dry SILT, trace clay, trace orange-brown silt	1.5 ft 0.6		
			0.6		
			2.5 ft 0.6		
			0.6		
			3.5 ft 0.6		
		3.5-4ft: Light brown, dry SILT, trace clay	0.6		
		4-5ft: Light brown, fine, dry SAND and SILT, large amount of medium to large sub-angular gravel (weathered rock)	4.5ft 0.6		
5-10	5/4	5-5.5ft: Brown, wet SILT, large amount of medium sub-angular gravel	0.6		0.5ft slough
			5.5 ft		
		5.5-9ft: Light brown and grey, dry SILT, large amount of sub-angular medium and small gravel (weathered rock)	0.8		PID Background 0.6 ppm
			1.1		
			6.5 ft 0.8		
			1.2		
			7.5 ft 0.8		
			0.7		
			8.5 ft		
		Refusal at 9ft			
			9.5ft		
10-15			10.5 ft		
			11.5 ft		
			12.5 ft		
			13.5 ft		
			14.5ft		
15-20			15.5 ft		
			16.5 ft		
			17.5 ft		
			18.5 ft		
			19.5ft		

Notes:

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BORING LOG

BORING NO. TW50

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351865.90 E: 2666928.53	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 291.11 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: wooded area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5ft: Brown, slightly moist SILT, some organics	0.5		PID Background 0.5 ppm
		0.5-2ft: Brown and some orange, slightly moist SILT	0.5		
			0.5		
			0.5		
		2-4ft: Brown, orange brown and grey, slightly moist SILT, trace clay	0.5		
			0.5		
			0.5		
			0.5		
		4-5ft: Brown and reddish brown, slightly moist SILT, trace clay	0.5		
5-10	5/4	5-6.5ft: Brown, dry SILT, large amount of large rounded gravel	0.6		0.5ft slough
			0.6		PID Background 0.6 ppm
			0.6		
		6.5-8ft: Brown, some light brown SILT, trace clay, medium amount of small to medium sub-angular gravel	0.6		
			0.6		
			0.6		
		8-8.5ft: Brown and grey, fine SAND, large amount of small to medium round gravel (weathered rock)			
		Refusal 8.5ft			
10-15					
15-20					

Notes:

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BORING LOG

BORING NO. TW51

SHEET 1 OF 1

DRILLING CO.: Advanced Drilling	Status:	SITE: North Penn 5, Colmar, PA	Borehole Location Sketch Map
METHOD & TOOLS: Direct Push Geoprobe	X Drilled	PROJECT NO.: PH0013	
RIG: Geoprobe 6620 DT BOREHOLE DIAMETER: 3in	X Logged	N: 351790.84 E: 2666913.71	
CORE DIAMETER: 2 in DRILLER: Craig Jablonski	MW Installed	GEOLOGIST: A. Rowan	
GROUND ELEV.: 289.93 x Surveyed Estimated		DATE: 9/4/2013	

SURFACE CONDITIONS: wooded area

Depth (ft. bgs)	Rec. % (Dr./Rec.)	Lithologic Description	PID (ppm)	Sample ID	Comments
0-5	5/5	0-0.5ft: Brown, slightly moist SILT, some organics	0.5		PID Background 0.5 ppm
		0.5-2.5ft: Light brown, slightly moist SILT, trace clay	0.5		
			0.5		
			0.5		
			0.5		
		2.5-3ft: Grey and light brown, slightly moist SILT, trace clay	0.5		
		3-4ft: Brown, slightly moist SILT, trace clay	0.5		
			0.5		
		4-5ft: Light brown and brown, slightly moist SILT, trace clay	0.5		
5-10	5/5	5-6.5ft: Brown, slightly moist SILT, some clay, some sub-angular medium gravel	0.5		
			1.2		
			0.5		
		6.5-7ft: Brown, slightly firm, slightly moist SILT and CLAY	0.6		
		7-8.5ft: Red brown, firm, slightly moist CLAY, some silt	0.7		
			0.7		
			0.6		
		8.5-10ft: Red brown, moist SILT, some clay, large amount of small to medium sub-angular gravel	0.6		
			1.0		
10-15	5/3.5	10-10.5ft: Red brown, moist SILT, large amount of sub-angular gravel (weathered rock)	0.6		PID Background 0.6ppm
		10.5-12ft: Red brown, fine, dry SAND and SILT, large amount of small to large sub-angular and angular gravel (weathered rock)	0.6		
			0.6		
			0.6		
		12-12.5ft: Red brown, moist SILT and CLAY, some small sub-angular gravel (weathered rock)	0.8		
		12.5-13ft: Red brown, fine SAND and SILT, large amount of small to medium sub-angular gravel (weathered rock)			
		Refusal at 13ft			
15-20					

Notes:

APPENDIX B
Groundwater Sampling Low Flow Logs

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	24-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-01	Well Depth:	13.5 feet	Screened/Open Interval:	8.5 - 13.5 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	11, 13	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	10.05	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
9:25	x		5.76	NA	0.974	NA	203.1	NA	3.42	NA		NA	21.75	NA	50	7.90

Comments: Sample TW01_062413 collected at 1155

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	24-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-02	Well Depth:	14 feet	Screened/Open Interval:	9 - 14 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	11.5, 13.5, 11.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.35	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
10:20	x		5.41	NA	0.174	NA	259.3	NA	4.78	NA	82.1	NA	22.65	NA	50	9.34

Comments: Sample TW02_062413 collected at 0815

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	24-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-03	Well Depth:	14 feet	Screened/Open Interval:	9 - 14 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	11.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.4	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
14:20	x		5.22	NA	0.373	NA	344.2	NA	1.41	NA	86.5	NA	18.05	NA	90	8.50
14:25	x		5.1	0.12	0.36	3.6%	330.5	13.7	1.12	26%	76.8	13%	17.39	4%	90	8.50
14:30	x		5.08	0.02	0.32	12.5%	324.1	6.4	0.85	32%	41.9	83%	17.14	1.5%	90	8.50
14:35	x		5.05	0.03	0.35	-8.6%	317	7.1	1.6	-47%	36.4	15%	16.94	1.2%	90	8.50
14:40	x		5.02	0.03	0.346	1.2%	315.3	1.7	1.15	39%	23.9	52%	16.58	2%	90	8.50
14:45	x		4.99	0.03	0.345	0.3%	311	4.3	0.9	28%	20.1	19%	16.32	1.6%	90	8.50
14:50	x		4.98	0.01	0.344	0.3%	307.2	3.8	0.78	15%	17.7	14%	16.18	0.9%	90	8.50
14:55	x		4.98	0.00	0.344	0.0%	304.9	2.3	0.79	-1%	14.1	26%	16.08	0.6%	90	8.50
15:00	x		4.97	0.01	0.344	0.0%	303	1.9	0.75	5%	12.9	9%	16.03	0.3%	90	8.50
15:05		x														

Comments: Sample TW03_062413 collected at 1505

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	6/25/2013, 6/26/13, 6/27/13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-04	Well Depth:	13 feet	Screened/Open Interval:	8 - 13 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	10.5, 12.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	9.45	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
10:30	x		5.04	NA	0.314	NA	221.9	NA	6.74	NA	105.2	NA	24.2	NA	100	
10:40	x		5.1	-0.06	0.245	28.2%	241.5	-19.6	6.58	2%	71	48%	20.83	16%	100	

Comments: Sample TW04_062613 collected at 1145 (VOCs and CSIA). Sample TW04_062713 collected at 0800 (DHG, alkalinity, anions)
Water level was below the top of the pump and could not be recorded.

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	25-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-05	Well Depth:	13 feet	Screened/Open Interval:	8 - 13 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	12.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.74	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
14:00	x		4.83	NA	0.264	NA	199.7	NA	5.42	NA	73.2	NA	19.93	NA	100	8.85
14:05	x		4.69	0.14	0.256	3.1%	239.9	-40.2	5.32	2%	37.7	94%	18.7	7%	100	8.55
14:10	x		4.68	0.01	0.253	1.2%	277.9	-38	4.95	7%	N/A		17.53	6.7%	100	8.55
14:15	x		4.68	0.00	0.252	0.4%	278.3	-0.4	4.93	0%	14.9		17.5	0.2%	100	8.55
14:20	x		4.7	-0.02	0.251	0.4%	283	-4.7	4.68	5%	N/A		17.58	0%	100	8.55
14:25	x		4.77	-0.07	0.251	0.0%	290	-7	4.75	-1%	N/A		17.34	1.4%	100	8.55
14:30		x														

Comments: Sample TW05_062513 collected at 1430

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

AR101580

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	26-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-06	Well Depth:	16 feet	Screened/Open Interval:	11 - 16 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	13.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.31	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
8:55	x		4.9	NA	0.174	NA	266.1	NA	4.21	NA	79.9	NA	17.75	NA	80	8.30
9:00	x		4.56	0.34	0.17	2.4%	297.8	-31.7	4.4	-4%	56.4	42%	17.1	4%	90	8.28
9:05	x		4.34	0.22	0.168	1.2%	331.8	-34	4.6	-4%	33.8	67%	16.55	3.3%	110	8.33
9:10	x		4.17	0.17	0.167	0.6%	384.8	-53	4.83	-5%	28.9	17%	16.38	1.0%	80	8.30
9:15	x		4.44	-0.27	0.167	0.0%	429.4	-44.6	4.95	-2%	15.4	88%	16.34	0%	80	8.30
9:20	x		4.57	-0.13	0.167	0.0%	432.5	-3.1	4.98	-1%	12.6	22%	16.19	0.9%	80	8.30
9:25	x		4.69	-0.12	0.166	0.6%	443.3	-10.8	5.01	-1%	11.1	14%	16.16	0.2%	80	8.29
9:30	x		4.76	-0.07	0.167	-0.6%	448.3	-5	5.03	0%	11.29	-2%	16.02	0.9%	80	8.29
9:35	x		4.78	-0.02	0.166	0.6%	458.2	-9.9	5.07	-1%	7.87	43%	15.76	1.6%	80	8.29
9:40	x		4.79	-0.01	0.166	0.0%	468.2	-10	5.04	1%	7.42	6%	15.88	-0.8%	80	8.29
9:45	x		4.8	-0.01	0.166	0.0%	479.8	-11.6	5.02	0%	7.09	5%	15.85	0.2%	80	8.30
9:50	x		4.8	0.00	0.166	0.0%	489.6	-9.8	5	0%	5.77	23%	15.89	-0.3%	80	8.30
9:55	x		4.8	0.00	0.166	0.0%	496	-6.4	4.99	0%	5.13	12%	15.95	-0.4%	80	8.30
10:00	x		4.77	0.03	0.166	0.0%	507	-11	6.87	-27%	6.53	-21%	15.91	0.3%	80	8.29
10:05	x		4.83	-0.06	0.167	-0.6%	509.5	-2.5	6.77	1%	5.1	28%	15.83	0.5%	80	8.30

Comments: Sample TW06_062613 collected at 1015

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	26-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-07	Well Depth:	10 feet	Screened/Open Interval:	5 - 10 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	7.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	6.81	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
9:00	x		5.13	NA	0.171	NA	261.8	NA	4.79	NA	74.9	NA	16.24	NA	100	6.89
9:05	x		4.77	0.36	0.169	1.2%	286.8	-25	4.31	11%	61.6	22%	15.93	2%	100	6.89
9:10	x		4.92	-0.15	0.168	0.6%	285.2	1.6	4.1	5%	36.4	69%	15.68	1.6%	100	6.89
9:15	x		4.96	-0.04	0.168	0.0%	286.7	-1.5	4.03	2%	26.1	39%	15.55	0.8%	100	6.89
9:20	x		4.95	0.01	0.168	0.0%	292.5	-5.8	3.96	2%	14.2	84%	15.42	1%	100	6.89
9:25	x		4.97	-0.02	0.168	0.0%	293.8	-1.3	3.95	0%	11.5	23%	15.44	-0.1%	100	6.89
9:30	x		4.98	-0.01	0.168	0.0%	295.4	-1.6	3.95	0%	10.49	10%	15.28	1.0%	100	6.89

Comments: Sample TW07_062613 collected at 0935

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	26-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-08	Well Depth:	13.9 feet	Screened/Open Interval:	8.9 - 13.9 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	11.4	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	3.89	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
14:15	x		5.62	NA	0.11	NA	220.1	NA	4.86	NA	340	NA	16.08	NA	100	3.92
14:20	x		5.27	0.35	0.099	11.1%	262	-41.9	4.94	-2%	255	33%	15.34	5%	100	3.92
14:25	x		5.36	-0.09	0.094	5.3%	273.6	-11.6	5.09	-3%	25	920%	15.09	1.7%	100	3.92
14:30	x		5.36	0.00	0.094	0.0%	276.8	-3.2	5.04	1%	19	32%	15.03	0.4%	100	3.92
14:35	x		5.36	0.00	0.093	1.1%	282.4	-5.6	4.7	7%	NM		14.99	0%	100	3.92
14:40	x		5.36	0.00	0.092	1.1%	289.2	-6.8	4.55	3%	NM		14.81	1.2%	100	3.92
14:45	x		5.34	0.02	0.092	0.0%	293.6	-4.4	4.47	2%	NM		14.7	0.7%	100	3.92
14:50	x		5.36	-0.02	0.092	0.0%	298.9	-5.3	4.34	3%	NM		14.74	-0.3%	100	3.92
14:55	x		5.35	0.01	0.092	0.0%	299.7	-0.8	4.32	0%	NM		14.75	-0.1%	100	3.92
15:00	x		5.35	0.00	0.091	1.1%	301.8	-2.1	4.3	0%	NM		14.7	0.3%	100	3.92
15:05		x														

Comments: Sample TW08-062613 collected at 1505

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	26-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 90s		

Monitoring Well #	TW-09	Well Depth:	13.5 feet	Screened/Open Interval:	8.5 - 13.5 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	11	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	3.9	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
11:20	x		5.37	NA	0.261	NA	226.7	NA	1.86	NA	314	NA	15.32	NA	100	3.90
11:25	x		5.36	0.01	0.259	0.8%	231.8	-5.1	1.38	35%	280	12%	15.13	1%	100	3.90
11:30	x		5.37	-0.01	0.258	0.4%	236.7	-4.9	1.69	-18%	128	119%	15.00	0.9%	100	3.90
11:35	x		5.37	0.00	0.257	0.4%	239.7	-3	1.39	22%	88.9	44%	15.11	-0.7%	100	3.90
11:40	x		5.37	0.00	0.256	0.4%	241.1	-1.4	1.24	12%	75.4	18%	15.14	0%	100	3.90
11:45	x		5.37	0.00	0.256	0.0%	242.6	-1.5	1.2	3%	78.1	-3%	15.28	-0.9%	100	3.90
11:50	x		5.36	0.01	0.256	0.0%	245.8	-3.2	1.19	1%	54.9	42%	15.27	0.1%	100	3.90
11:55	x		5.35	0.01	0.256	0.0%	246.7	-0.9	1.09	9%	46.0	19%	15.56	-1.9%	100	3.90
12:00	x		5.36	-0.01	0.256	0.0%	248.1	-1.4	1.06	3%	53.3	-14%	15.71	-1.0%	100	3.90
12:05	x		5.36	0.00	0.256	0.0%	248.7	-0.6	1.06	0%	N/A		15.87	-1.0%	100	3.90
12:10	x															
12:15		x														

Comments: Sample TW09-062613 collected at 1215

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	6/27/2013, 6/28/13, 7/1/13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 80s		

Monitoring Well #	TW-10	Well Depth:	30 feet	Screened/Open Interval:	25 - 30 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	27.5, 28.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	21	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
9:40	x		6.62	NA	1.337	NA	-61.2	NA	52.3	NA	222	NA	19.87	NA	100	24.50
13:30	x		6.48	0.14	1.322	1.1%	-81.9	20.7	6.93	655%	202	10%	23.4	-15%	50	
8:10	x		6.49	-0.01	1.167	13.3%	57.3	-139.2	3.86	80%	142	42%	18.92	23.7%	50	

Comments: Sample TW10_062813 collected at 1155 (VOCs, CSIA). SampleTW10_070113 collected at 0928 (DHG, alkalinity, anions)
Water level was below the top of the pump and could not be recorded.

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	25-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather			

Monitoring Well #	TW-11	Well Depth:	14 feet	Screened/Open Interval:	9 - 14 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	11.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.15	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
8:40	x		5.00	NA	0.117	NA	257.4	NA	1.81	NA	7	NA	20.72	NA	60	8.30
8:45	x		5.17	-0.17	0.115	1.7%	253	4.4	1.55	17%	136	-95%	20.51	1%	60	8.30
8:50	x		5.28	-0.11	0.114	0.9%	249.4	3.6	1.52	2%	126	8%	20.51	0.0%	60	8.30
8:55	x		5.33	-0.05	0.111	2.7%	253.8	-4.4	1.53	-1%	85.1	48%	20.40	0.5%	60	8.30
9:00	x		5.34	-0.01	0.109	1.8%	257.1	-3.3	1.58	-3%	73.1	16%	20.42	0%	60	8.30
9:05	x		5.32	0.02	0.108	0.9%	261.7	-4.6	1.54	3%	61.1	20%	20.20	1.1%	60	8.30
9:10		x														

Comments: Sample TW11_062513 collected at 9:10 MS/MSD

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	25-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather			

Monitoring Well #	TW-12	Well Depth:	20.5 feet	Screened/Open Interval:	15.5 - 20.5 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	18	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.12	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
10:20	x		6.09	NA	0.392	NA	-340.1	NA	4.85	NA		NA	20.67	NA	75	
10:25	x		6.08	0.01	0.392	0.0%	-356.7	16.6	3.12	55%			20.07	3%	75	12.20
10:30	x		6.07	0.01	0.393	-0.3%	-365	8.3	3.58	-13%			19.85	1.1%	75	12.80
10:35	x		6.05	0.02	0.389	1.0%	-375.4	10.4	3.23	11%	1004	-100%	19.87	-0.1%	75	13.00
10:40	x		6.04	0.01	0.384	1.3%	-378.4	3	3.05	6%	1082	-7%	20.02	-1%	75	13.36
10:45	x		6.04	0.00	0.379	1.3%	-378.6	0.2	2.88	6%			20.3	-1.4%	75	13.35
10:50	x		5.97	0.07	0.364	4.1%	-367.5	-11.1	2.6	11%			20.6	-1.5%	75	13.30
10:55	x		5.93	0.04	0.358	1.7%	-374.5	7	1.74	49%	830.0	-100%	20.75	-0.7%	75	13.30
11:00	x		5.89	0.04	0.346	3.5%	-364	-10.5	1.71	2%			20.80	-0.2%	75	13.30
11:05	x		5.88	0.01	0.341	1.5%	-377.5	13.5	1.73	-1%			21.02	-1.0%	75	13.30
11:10	x		5.83	0.05	0.332	2.7%	-373.4	-4.1	1.73	0%			20.99	0.1%	75	13.30
11:15	x		5.8	0.03	0.325	2.2%	-368.2	-5.2	1.78	-3%			21.1	-0.5%	75	13.30
11:20	x		5.78	0.02	0.32	1.6%	-363	-5.2	1.77	1%			20.87	1.1%	75	13.30
11:25	x		5.78	0.00	0.314	1.9%	-359.8	-3.2	1.76	1%			21.03	-0.8%	75	13.30
11:30	x		5.76	0.02	0.308	1.9%	-357.1	-2.7	1.8	-2%			21.32	-1.4%	75	13.30
11:35	x		5.73	0.03	0.301	2.3%	-350.3	-6.8	1.86	-3%			21.25	0.3%	75	13.30
11:40	x		5.69	0.04	0.297	1.3%	-341.3	-9	1.85	1%			21.3	-0.2%	75	13.30
11:45	x		5.68	0.01	0.294	1.0%	-341.3	0	1.9	-3%	41.4	-100%	21.3	0.0%	75	13.30

Comments: Sample TW12_062513 collected at 1150

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	28-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather			

Monitoring Well #	RI-23	Well Depth:	22.71 feet	Screened/Open Interval:	4 - 14 ft
Well Permit #		Well Diameter:	4 inches		

PID Readings:	Background	ppm	Pump intake depth:	10	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	8.12	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
12:05	x		5.42	NA	0.126	NA	36.3	NA	0.85	NA	7.93	NA	20.2	NA	100	8.31
12:10	x		5.51	-0.09	0.125	0.8%	32.9	3.4	0.63	35%	7.49	6%	20.1	0%	100	8.32
12:15	x		5.55	-0.04	0.124	0.8%	32.8	0.1	0.54	17%	7.85	-5%	19.91	1.0%	100	8.34
12:20	x		5.55	0.00	0.124	0.0%	33.5	-0.7	0.52	4%	8.55	-8%	19.56	1.8%	100	8.36
12:25	x		5.57	-0.02	0.124	0.0%	32.7	0.8	0.56	-7%	8.55	0%	19.53	0%	100	8.37
12:30		x														

Comments: Sample RI23_062813 collected at 1230

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	28-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 80s		

Monitoring Well #	RI-24	Well Depth:	11.9 feet	Screened/Open Interval:	5 - 15 ft
Well Permit #		Well Diameter:	4 inches		

PID Readings:	Background	ppm	Pump intake depth:	8.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	6.05	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
9:05	x		6.82	NA	0.401	NA	212.7	NA	7.88	NA	8.26	NA	17.92	NA	100	6.08
9:10	x		6.77	0.05	0.4	0.3%	217.3	-4.6	7.95	-1%	2.92	183%	17.62	2%	100	6.08
9:15	x		6.78	-0.01	0.399	0.3%	220.7	-3.4	7.88	1%	2.62	11%	17.66	-0.2%	100	6.08
9:20	x		6.77	0.01	0.397	0.5%	226.4	-5.7	7.85	0%	2.48	6%	17.89	-1.3%	100	6.08
9:25	x		6.76	0.01	0.396	0.3%	229	-2.6	7.81	1%	3.81	-35%	17.76	1%	100	6.08
9:30		x														

Comments: Sample RI24_062813 collected at 0930

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	28-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 80s		

Monitoring Well #	RI-25	Well Depth:	13.45 feet	Screened/Open Interval:	4 - 14 ft
Well Permit #		Well Diameter:	4 inches		

PID Readings:	Background	ppm	Pump intake depth:	8.75	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	6.72	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
10:35	x		6.48	NA	0.494	NA	173.5	NA	4.23	NA	11.4	NA	21.82	NA	100	6.75
10:40	x		6.2	0.28	0.496	-0.4%	200.9	-27.4	3.94	7%	11.1	3%	21.38	2%	100	6.80
10:45	x		6.16	0.04	0.505	-1.8%	223.7	-22.8	4.03	-2%	11.2	-1%	21.3	0.4%	100	6.85
10:50	x		6.13	0.03	0.511	-1.2%	236.1	-12.4	3.79	6%	11.2	0%	21.64	-1.6%	100	6.87
10:55	x		6.12	0.01	0.513	-0.4%	244.5	-8.4	3.69	3%	11.69	-4%	21.56	0%	100	6.89
11:00	x		6.10	0.02	0.518	-1.0%	259.1	-14.6	3.82	-3%	11.97	-2%	21.58	-0.1%	100	6.89
11:05	x		6.07	0.03	0.524	-1.1%	270.6	-11.5	3.79	1%	11.15	7%	21.82	-1.1%	100	6.91
11:10	x		6.08	-0.01	0.528	-0.8%	280	-9.4	3.53	7%	11.4	-2%	21.48	1.6%	100	6.92
11:15	x		6.08	0.00	0.534	-1.1%	282.2	-2.2	3.55	-1%	10.78	6%	21.68	-0.9%	100	6.92
11:20	x		6.06	0.02	0.536	-0.4%	284.7	-2.5	3.55	0%	10.73	0%	21.79	-0.5%	100	6.93
11:25		x														

Comments: Sample RI25_062813 collected at 1125

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	28-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 80s		

Monitoring Well #	RI-28	Well Depth:	18.07 feet	Screened/Open Interval:	14 - 19 ft
Well Permit #		Well Diameter:	4 inches		

PID Readings:	Background	ppm	Pump intake depth:	16.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	7.88	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
14:50	x		6.71	NA	0.349	NA	-22.8	NA	2.77	NA	66	NA	17.51	NA	100	12.70
14:55	x		6.5	0.21	0.334	4.5%	-6.4	-16.4	2.17	28%	74.6	-12%	17.08	3%	100	13.00
15:00	x		6.42	0.08	0.295	13.2%	7.4	-13.8	1.91	14%	76	-2%	16.76	1.9%	100	13.00
15:05	x		6.19	0.23	0.2	47.5%	35.7	-28.3	1.41	35%	116	-34%	16.01	4.7%	100	12.90
15:10	x		6	0.19	0.169	18.3%	54.8	-19.1	1.41	0%	42	176%	15.83	1%	100	12.80
15:15		x														

Comments: Sample RI28_062813 collected at 1515

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	27-Jun-13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 80s		

Monitoring Well #	RI-29	Well Depth:	18.71 feet	Screened/Open Interval:	14 - 19 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	16.5	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	6.78	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
11:05	x		5.85	NA	0.156	NA	204.8	NA	6.14	NA	40	NA	19.02	NA	100	6.78
11:20	x		5.36	0.49	0.147	6.1%	251.5	-46.7	6.56	-6%	10.56	279%	18.68	2%	100	6.80
11:25	x		5.33	0.03	0.146	0.7%	253.4	-1.9	6.66	-2%	1.95	442%	18.61	0.4%	100	6.78
11:30	x		5.29	0.04	0.146	0.0%	262.6	-9.2	6.79	-2%	-90	102%	18.17	2.4%	100	6.78
11:35	x		5.26	0.03	0.145	0.7%	273.3	-10.7	6.83	-1%	-90	0%	18.04	1%	100	6.78
11:40	x		5.26	0.00	0.145	0.0%	280.2	-6.9	6.88	-1%	13.3	-777%	17.8	1.3%	100	6.78
11:45	x		5.25	0.01	0.144	0.7%	284.6	-4.4	6.96	-1%	-88	115%	17.68	0.7%	100	6.78
11:50	x		5.26	-0.01	0.144	0.0%	287	-2.4	6.91	1%	-90.0	2%	17.6	0.5%	100	6.78
11:55		x														

Comments: Sample RI29_062713 collected at 1155

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

Field Meaurements
Low Flow Sampling Log

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Site	North Penn 5	Consulting Firm:	Geosyntec
Date	6/27/2013, 6/28/13	Field Personnel:	M. Mraw / A. Rowan
Weather	Sunny, 80s		

Monitoring Well #	RI-30	Well Depth:	8.78 feet	Screened/Open Interval:	6.5 - 11.5 ft
Well Permit #		Well Diameter:	1 inches		

PID Readings:	Background	ppm	Pump intake depth:	7	ft below TOC
	Beneath Outer Cap	ppm	DTW before pump install:	5.25	ft below TOC
	Beneath Inner Cap	ppm	Make/model of pump:		

Time	Purging	Sampling	pH		Specific Conductivity (mS/cm)		ORP (mV)		DO (mg/L)		Turbidity (NTU)		Temp (°C)		Pumping Rate (ml/min)	DTW (ft below TOC)
			Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change	Reading	Change		
14:57	x		7.31	NA	0.169	NA	80.1	NA	5.43	NA	35.3	NA	26.3	NA	100	
9:10	x		6.21	1.10	0.157	7.6%	190.9	-110.8	7.24	-25%	22.2	59%	19.78	33%	50	

Comments: Sample RI30_062813 collected at 1415
Water level was below the top of the pump and could not be recorded.

Parameters have stabilized when 3 consecutive readings are within ± 0.1 for pH, ±3% for Specific Conductivity and Temp, ± 10mV for ORP, and ± 10% for DO and Turbidity

AR101593

APPENDIX C
Volatile Organic Compounds and General Chemistry Laboratory Analytical Reports Lancaster Laboratories, Inc.

Lancaster Laboratories, Inc.
Analytical Reports / Data Packages
were submitted separately on CD-ROM
with the original hardcopy.

APPENDIX D
CSIA Laboratory Report
University of Toronto Stable Isotope Laboratory

Stable Isotope Laboratory
University of Toronto

July 26 2013

Sandra Dworatzek
SIREM
130 Research Lane, Suite 2
Guelph, Ontario
Canada, N1G 5G3
Phone: 519-515-0839
sdworatzek@siremlab.com

Dear Sandra,

Please find below the results of the analyses you requested from the Stable Isotope Laboratory. All $\delta^{13}C$ values are expressed with respect to v-PDB international standard. Errors are ± 0.5 permil and incorporate both accuracy and reproducibility.

	TCE	
	Conc. (ppm)	$\delta^{13}C$
TW01	0.01	< d.l.
TW02	3.50	-22.0
TW03	1.10	-20.1
TW04	0.47	-22.3
TW05	1.30	-19.3
TW06	0.73	-21.6
TW07	0.83	-19.7
TW08	0.02	< d.l.
TW09	0.03	< d.l.
TW10	<0.01	< d.l.

Concentrations in milligrams per liter supplied by client.
b.d. means below detection limit for isotope analyses

Analyses and results are provided for exclusive use of the client named. The client accepts complete responsibility for any use or interpretation of the results.

Sincerely,

Dr. B. Sherwood Lollar
Director, Stable Isotope Laboratory
bslollar@chem.utoronto.ca

Earth Sciences Centre, 22 Russell Street, Toronto, Ontario, Canada M5S 3B1
bslollar@chem.utoronto.ca; Telephone 416-978-0770 Fax 416-978-3938

APPENDIX E
Gene-Trac® Laboratory Report
SiREM Laboratories, Inc.

SiREM
Leading Science · Lasting Solutions

130 Research Lane, Ste 2
Guelph ON N1G 5G3
(519) 822-2265

Certificate of Analysis: Gene-Trac® *Dehalococcoides* Assay

Customer: Derek Tomlinson & Michelle Mirigliano, Geosyntec Consultants

SiREM Reference: S-2874

Project: North Penn 5 OU2

Report Date: 2-Jul-13

Customer Reference: PH0013.08

Data Files: MyiQ-DHC-QPCR-1020
MyiQ-DB-DHC-QPCR-0386
DHC-UP-0753

Table 1a: Test Results

Customer Sample ID	SiREM Sample ID	Sample Collection Date	Sample Matrix	Percent Dhc *	*Dehalococcoides* Enumeration/Liter **
TW01/TW18	DHC-9432	17-Jun-13	Groundwater	NA	6×10^3 U, I

Notes:

* Percent *Dehalococcoides* (Dhc) in microbial population. This value is calculated by dividing the number of Dhc 16S ribosomal ribonucleic acid (rRNA) gene copies by the total number of bacteria as estimated by the mass of DNA extracted from the sample. Range represents normal variation in Dhc enumeration.

** Based on quantitation of Dhc 16S rRNA gene copies. Dhc are generally reported to contain one 16S rRNA gene copy per cell; therefore, this number is often interpreted to represent the number of Dhc cells present in the sample.

J The associated value is an estimated quantity between the method detection limit and quantitation limit.
U Not detected, associated value is the quantitation limit.
B Analyte was also detected in the method blank.
NA Not applicable as *Dehalococcoides* not detected and/or quantifiable DNA not extracted from the sample.
I Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
E Extracted genomic DNA was not detected in the sample.

Analyst: Jen Wilkinson
Jen Wilkinson
Senior Laboratory Technician

Approved: Ximena Druar
Ximena Druar, B.Sc.
Genetic Testing Coordinator

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Guelph ON N1G 5G3
(519) 822-2265

Certificate of Analysis: Gene-Trac® *Dehalobacter* Assay

Customer: Derek Tomlinson & Michelle Mirigliano, Geosyntec Consultants

SiREM Reference: S-2874

Project: North Penn 5 OU2

Report Date: 2-Jul-13

Customer Reference: PH0013.08

Data Files: iQ5-DHB-QPCR-0248
iQ-DB-DHB-QPCR-0067

Table 1b: Test Results

Customer Sample ID	SiREM Sample ID	Sample Collection Date	Sample Matrix	Percent Dhb*	*Dehalobacter* 16S rRNA Gene Copies/Liter
TW01/TW18	DHB-0806	17-Jun-13	Groundwater	NA	6×10^3 U, I

Notes:

* Percent Dehalobacter (Dhb) in microbial population. This value is calculated by dividing the number of Dhb 16S ribosomal ribonucleic acid (rRNA) gene copies by the total number of bacteria as estimated by the mass of DNA extracted from the sample. Range represents normal variation in Dhb enumeration.

J The associated value is an estimated quantity between the method detection limit and quantitation limit.
U Not detected, associated value is the quantitation limit.
B Analyte was also detected in the method blank.
NA Not applicable as *Dehalobacter* not detected and/or quantifiable DNA not extracted from the sample.
I Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
E Extracted genomic DNA was not detected in the sample.

Analyst: Jen Wilkinson
Jen Wilkinson
Senior Laboratory Technician

Approved: Ximena Druar
Ximena Druar, B.Sc.
Genetic Testing Coordinator

Table 2: Detailed Test Parameters, Test Reference S-2874

Customer Sample ID	TW01/TW18
SiREM Dhc Sample ID	DHC-9432
SiREM Dhb Sample ID	DHB-0806
Date Received	19-Jun-13
Sample Temperature	10 ºC
Filtration Date	20-Jun-13
Volume Used for DNA Extraction	200 mL
DNA Extraction Date	21-Jun-13
DNA Concentration in Sample (extractable)	3289 ng/L
PCR Amplifiable DNA	ND
Dhc qPCR Date Analyzed	26-Jun-13
Dhb qPCR Date Analyzed	26-Jun-13
qPCR Controls (see Tables 3 & 4)	Passed
Comments	Sample not tested for *vcrA* as it was ND for Dhc.

Notes:

Refer to Tables 3 & 4 for detailed results of controls.
°C = degrees Celsius
Dhb = *Dehalobacter*
Dhc = *Dehalococcoides*
PCR = polymerase chain reaction
qPCR = quantitative PCR
ng/L = nanograms per liter
mL = milliliters
DNA = Deoxyribonucleic acid

Table 3: Gene-Trac Dhc Control Results, Test Reference S-2874

Laboratory Control	Analysis Date	Control Description	Spiked Dhc 16S rRNA Gene Copies per Liter	Recovered Dhc 16S rRNA Gene Copies per Liter	Comments
Positive Control Low Concentration	26-Jun-13	qPCR with KB1 genomic DNA (CSLD-0658)	8.4×10^4	1.2×10^5	- -
Positive Control High Concentration	26-Jun-13	qPCR with KB1 genomic DNA (CSHD-0658)	1.2×10^7	1.7×10^7	- -
DNA Extraction Blank	26-Jun-13	DNA extraction sterile water (FB-1968)	0	2.6×10^3 U	- -
Negative Control	26-Jun-13	Tris Reagent Blank (TBD-0617)	0	2.6×10^3 U	- -

Notes:

Dhc = *Dehalococcoides*

DNA = Deoxyribonucleic acid

qPCR = quantitative PCR

16S rRNA = 16S ribosomal ribonucleic acid

U Not detected, associated value is the quantitation limit.

Table 4: Gene-Trac Dhb Control Results, Test Reference S-2874

Laboratory Control	Analysis Date	Control Description	Spiked Dhb 16S rRNA Gene Copies per Liter	Recovered Dhb 16S rRNA Gene Copies per Liter	Comments
Positive Control Low Concentration	26-Jun-13	qPCR with ACT3 genomic DNA (CSLDB-0208)	1.3×10^5	1.2×10^5	- -
Positive Control High Concentration	26-Jun-13	qPCR with ACT3 genomic DNA (CSHDB-0208)	1.3×10^7	1.6×10^7	- -
DNA Extraction Blank	26-Jun-13	DNA extraction sterile water (FB-1968)	0	2.6×10^3 U	- -
Negative Control	26-Jun-13	Tris Reagent Blank	0	2.6×10^3 U	- -

Notes:

qPCR = quantitative PCR

Dhb = *Dehalobacter*

DNA = Deoxyribonucleic acid

16S rRNA = 16S ribosomal ribonucleic acid

U Not detected, associated value is the quantitation limit.

№ 2423

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www.siremlab.com

Page 1 of 1

Lab # S-2814

Project Name: NorthPenn 5 OU2
Project #: PH0013.08
Project Manager: D. Tomlinson / M. Mirigliano
Email Address: dtomlinson@geosyntec.com / mmirigliano@geosyntec.com
Company: Geosyntec Consultants
Address: 1787 Sentry Pkwy West Bldg 18, Ste 120 Blue Bell, PA
Phone #: 267 464 2800
Fax #:
Sampler's Signature: M. Mirigliano
Sampler's Printed Name: Michelle Mirigliano

Analysis

Preservative Key: 0. None; 1. HCl; 2. Other ____; 3. Other ____

Customer Sample ID	Sampling Date	Sampling Time	Matrix	# of Containers	Gene-Trac Dhc	Gene-Trac VC	Gene-Trac Dhb	Treatability	Other Information
TW01/TW18	6/17/13	0830	SO	10				X	Soil for EISB study
TW01/TW18	6/17/13	1000	GW	2	X	X	X	X	B-00277

Cooler Condition: GOOD
Cooler Temperature: 10°C
Custody Seals: Yes ☑ No ☐

Billing Information
P.O. #: PH0013.08
Bill To: Derek Tomlinson

Turnaround Time Requested
Normal ☒
Rush ☐

For Lab Use Only
Proposal #: ____

Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature: M. Mirigliano	Signature: Danielle Mayer	Signature:	Signature:	Signature:	Signature:
Printed Name: M. Mirigliano	Printed Name: DANIELLE MAYER	Printed Name:	Printed Name:	Printed Name:	Printed Name:
Firm: Geosyntec	Firm: SiREM LAB	Firm:	Firm:	Firm:	Firm:
Date/Time: 6/17/13 1600	Date/Time: JUNE 19/2013 3:15	Date/Time:	Date/Time:	Date/Time:	Date/Time:

AR101605

Distribution: White - Return to Originator: Yellow - Lab Copy: Pink - Retained by Client

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Guelph ON N1G 5G3
(519) 822-2265

SiREM Technical Note 1.5:

Guidelines for Interpretation of Gene-Trac® Test Results

This document provides technical background information and guidelines for interpreting the results for the following Gene-Trac® assays:

(1) Gene-Trac® Dhc
(2) Gene-Trac® VC
(3) Gene-Trac® Dhb

SiREM Technical Note 1.4 - *Quantitative Gene-Trac® Assay Test Procedure and Reporting Overview* provides detailed information on Gene-Trac® test procedures and reporting. Explanation of data qualifiers and commonly used notes is provided as Appendix A. Table 1 provides a brief interpretation for some common scenarios, more detailed interpretation information is provided in the following sections.

Table 1: Common Gene-Trac® Test Result Scenarios and Interpretation

Gene-Trac® Dhc (*Dehalococcoides*)	Gene-Trac® VC (*vcrA*)	Gene-Trac® Dhb (*Dehalobacter*)	Interpretation
>1 x10^7/L	**>1 x10^7/L**	Not Analyzed	Complete dechlorination to ethene likely as Dhc high and *vcrA* high
1 x10^7/L	**Not Detected**	Not Analyzed	VC accumulation possible as *vcrA* negative
Not Detected	**Not Detected**	Not Analyzed	Dhc negative/ lack of dechlorination or *cis*-DCE accumulation likely
Not Analyzed	Not Analyzed	**1 x10^6/L**	Dhb positive,potential for biodegradation of 1,1,1-TCA, 1,2-DCA, carbon tetrachloride and chloroform, PCE and TCE to *cis*-DCE
Not Analyzed	Not Analyzed	**Not Detected**	Biodegradation of 1,1,1-TCA, carbon tetrachloride and chloroform not expected as Dhb negative

Gene-Trac® Dhc -Total *Dehalococcoides* Test

Background:

Gene-Trac® Dhc is a quantitative PCR (qPCR) test for total *Dehalococcoides* (Dhc) microbes that targets Dhc specific sequences of the 16S ribosomal ribonucleic acid (rRNA) gene, a gene commonly used to indentify microbes. Dhc are the only known microorganisms capable of complete dechlorination of chloroethenes (i.e., tetrachloroethene, trichloroethene, cis-1,2-dichloroethene [cis-DCE] and vinyl chloride) to non-toxic ethene. Gene-Trac® Dhc may also be used to assess the in situ growth of Dhc containing bioaugmentation cultures such as KB-1®.

Negative Gene-Trac® Dhc Test Results (U qualified)

A non-detect in the Gene-Trac® Dhc assay (e.g., 4,000U) indicates that Dhc were not detected in the sample. The absence of Dhc is frequently associated with a lack of complete dechlorination or incomplete dechlorination of chlorinated ethenes. Where Dhc are absent the accumulation of cis-DCE is commonly observed, particularly after addition of electron donors. Bioaugmentation with Dhc containing cultures, such as KB-1®, is commonly used to improve bioremediation performance at sites that lack an indigenous Dhc population.

Positive Gene-Trac® Dhc Test Results

The detection of Dhc has been correlated with the complete biological dechlorination of chlorinated ethenes to ethene at contaminated sites (Hendrickson et al., 2002). A positive Gene-Trac® Dhc test indicates that Dhc DNA was detected in the sample and is encouraging for dechlorination of chlorinated ethenes to ethene. Note not all Dhc are capable of conversion of vinyl chloride to ethene; this capability can be determined by the Gene-Trac® VC test (see Section 2) which is commonly performed as a follow-on analysis after positive Gene-Trac® Dhc tests. In most cases Dhc must be present at sufficient concentrations in order for significant dechlorination to be observed, guidelines for expected impacts at various Dhc concentrations are indicated below.

Values of 10^4 Dhc gene copies per liter (or lower): indicates that the sample contains low concentrations of Dhc which may indicate that site conditions are suboptimal for high rates of dechlorination. Increases in Dhc concentrations at the site may be possible if conditions are optimized (e.g., electron donor addition).

Values of 10^5-10^6 Dhc gene copies per liter: indicates the sample contains moderate concentrations of Dhc which may, or may not, be associated with observable dechlorination activity (i.e., detectable ethene).

Values at or above 10^7 Dhc gene copies per liter: indicates that the sample contains high concentrations of Dhc that are often associated with high rates of dechlorination (Lu et al., 2006) and the production of ethene.

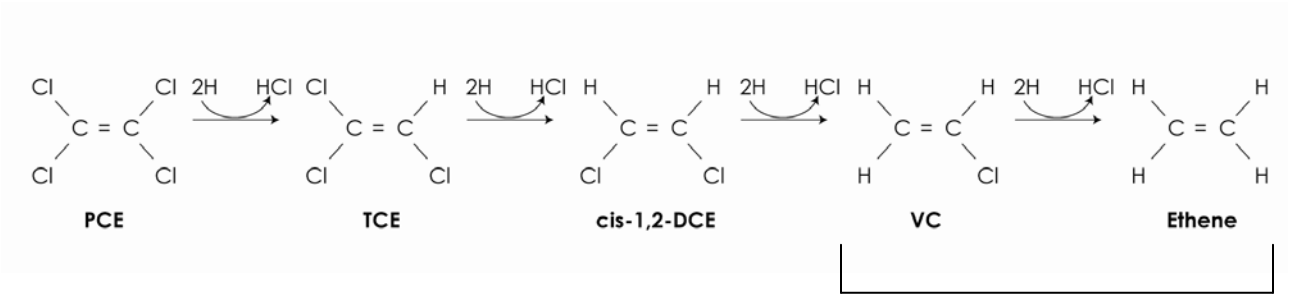
Values of 10^9 Dhc gene copies per liter are generally the highest observed for groundwater samples with rare exceptions.

Gene-Trac® VC- Vinyl Chloride Reductase (*vcrA*) Test

Background

Gene-Trac® VC is a qPCR test for the vinyl chloride reductase (*vcrA*) gene that codes for a Dhc enzyme that converts (VC) to ethene, a critical step in reductive dechlorination of chlorinated ethenes. Gene-Trac® VC is commonly used where Gene-Trac® Dhc test results are positive to confirm that the Dhc detected are capable of complete dechlorination to ethene.#

The vinyl chloride reductase gene (*vcrA)* (Müller et al., 2004) produces an enzyme that is found in many (but not all) Dhc and is reported to be the most common identified VC reductase in the environment (van der Zaan et al., 2010).



Key activity of vinyl chloride reductase vcrA gene/enzyme

Interpretation of Gene-Trac® VC Results

Detect in Gene-Trac® VC Test

A detect in the Gene-Trac® VC test indicates that a Dhc population has the *vcrA* gene and the prospects for complete dechlorination to ethene are good. As a minimal requirement, *vcrA* copies exceeding 10^5/L combined with observed increases over time (i.e., cell growth) are required for robust VC dechlorination (van der Zaan et al., 2010). Also the guidelines for detection of ethene provided under Gene-Trac® Dhc are conservative for interpretation of Gene-Trac® VC (i.e., > 1 x10^7 gene copies/L indicate a high likelihood of detection of ethene). In one study, more than 90% of samples where *vcrA* enumeration exceeded 1 x10^7 gene copies/L had detectable ethene (Dennis, 2009). In cases where *vcrA* gene copies are lower the likelihood of detectable ethene decreases.

Non-Detect in Gene-Trac® VC Test (U qualified)

A non-detect in the Gene-Trac® VC test indicates that *vcrA* gene sequences in the sample are below the detection limit of the assay (typically 4 x 10^3 *vcrA* gene copies/L). This indicates VC accumulation (VC stall) is possible. Note negative Gene-Trac® VC test results do not indicate with 100% certainty that a VC-stall will occur as there are other vinyl chloride reductase genes, such as *bvcA* (van der Zaan et al., 2010) that also convert VC to ethene.

Comparing Gene-Trac® VC and Gene-Trac® Dhc Test Results

Sites may contain different types of Dhc populations. At some sites the Dhc population is homogenous while other sites have Dhc populations that are mixtures of different types of Dhc. This can lead to differing results for Gene-Trac® Dhc and Gene-Trac® VC.

In many cases, the numerical results of Gene-Trac® VC test are identical to those obtained in the Gene-Trac® Dhc test, indicating that the entire Dhc population contains the *vcrA* gene. In other cases, Gene-Trac® VC results may differ significantly (i.e., more than an order or magnitude) from the total Dhc for a number of reasons.

Table 3 provides some common scenarios for Gene-Trac® VC and Gene-Trac® Dhc test results. In general, where Gene-Trac® VC results are non-detect, or significantly lower than Gene-Trac® Dhc, accumulation of VC is more likely.

Table 2: Interpretation of Gene-Trac® VC in Relation to Gene-Trac® Dhc

Gene-Trac® Dhc (16S rRNA gene copies/ L)	Gene-Trac® VC (*vcr*A gene copies/L)	Results Summary	Interpretation	Potential Site Implications
2×10^8 /L	3×10^8/L	Total Dhc and *vcrA* are ~the same (within 3-fold)	Entire Dhc population has *vcrA* gene	Potential for complete dechlorination high. VC stall unlikely-sites with *vcr*A above 1×10^7/L typically have detectable ethene
1×10^8/L	Non-detect	Total Dhc high; *vcrA* non-detect	High concentration of Dhc and entire population lacks the *vcrA* gene	Likelihood for VC accumulation high as *vcrA* non-detect
1×10^8/L	1×10^6 /L	Total Dhc is significantly higher (100 fold) than *vcrA*	*Dhc* population consists of different types, some with the *vcrA* gene (~1%) and some without (~99%)	VC-accumulation possible; Dhc/*vcrA* proportions may change over course of remediation
1×10^6/L	1×10^8/L	*vcrA* orders of magnitude higher than Dhc	Significantly higher *vcrA* may indicate the presence of populations of non-Dhc microorganisms with *vcrA* like genes	Potential for VC-stall likely low

Gene-Trac® Dhb-Total *Dehalobacter* Test

Gene-Trac® Dhb is a qPCR test targeting the 16S rRNA gene sequences unique to *Dehalobacter* (Dhb). Dhb are implicated in the biodegradation of 1,1,1-trichloroethane (to chloroethane), 1,1,2-trichloroethane and 1,2-dichloroethane to ethene (Grostern and Edwards, 2006) and chloroform (to dichloromethane) (Grostern et al., 2010) as well as incomplete dechlorination of PCE and TCE to cis-DCE (Holliger et al.,1998). Gene-Trac® Dhb may also be used as a tool to assess the impact of bioaugmentation with the KB-1® Plus cultures which contain high concentrations of Dhb.

Positive Gene-Trac® Dhb Test Results (Detects)

A positive Gene-Trac® Dhb indicates that a member of the *Dehalobacter* (Dhb) genus was detected in the sample. The detection of Dhb indicates that some or all of the dechlorination activities attributed to Dhb may be present at the subject site. Increasing concentrations of Dhb are indicative of increased potential to degrade some or all of these compounds.

Note: the Gene-Trac® Dhb test will not differentiate the type of Dhb*;* therefore, observations of the specific biodegradation pathways and end products based on chemical analytical methods in conjunction with Gene-Trac® Dhb will increase the interpretability of Gene-Trac® Dhb results.

Note: Dhb have been reported to contain multiple copies (up to 4 per cell) of the 16S rRNA gene (Grostern and Edwards, 2008). This means that, unlike Dhc, there is not a 1:1 ratio between the 16S rRNA gene copy and the number of Dhb cells in a sample. Calculating the number of Dhb cells requires dividing the Gene-Trac® Dhb test result by the 16S rRNA gene copy number (often 3-4 copies/cell).

Non-detect Gene-Trac® Dhb Results (U qualified)

In cases where Gene-Trac® Dhb is not detected (e.g., 4,000U) this indicates that *Dehalobacter* species were not identified in the sample and that anaerobic reductive dechlorination of 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA or chloroform, which are dechlorinated by *Dehalobacter*, may not be observed. This activity can be introduced at sites through the addition of bioaugmentation cultures containing *Dehalobacter* such as KB-1® Plus.

Key Elements of Gene-Trac® Data

Gene-Trac® test results include two key values (a) Target Gene Enumeration, an enumeration of target gene sequence by quantitative PCR (e.g. "Dhc Enumeration" "Dhb 16S Gene Copies" or "*vcrA* gene copies") and (b) Target gene percent (e.g. "Percent Dhc"), an estimated percentage of the microbial population comprised by microbes harboring the target gene and other microbes present in sample. Further explanation of these values is provided below.

a) Target Gene Enumeration

This value is the concentration of Dhc or Dhb 16S rRNA or *vcrA* gene copies detected in the sample. Results may be reported as either gene copies per liter (for groundwater) or per gram (for soil). In general, the greater the number of gene copies in a sample the greater the likelihood of related dechlorination activity. Dhc 16S gene copies are typically equivalent to the number of Dhc as they have 1 gene copy per cell this is not necessarily true for Dhb or *vcrA* which have the potential be present in multiple gene copies per cell. Guidelines for relating target gene presence and concentration to observable dechlorination activity for groundwater samples are provided below in previous sections.

b) Target Gene Percent (%Dhc, %Dhb, %*vcrA*)

This value estimates the percentage of the target gene (e.g., %Dhc) relative to other microorganisms in the sample based on the formulas/assumptions presented below. For example, %Dhc is a measure of the predominance of Dhc and, in general, the higher this percentage the better.

$$\%Dhc = \frac{\text{Number Dhc}}{\text{Number Dhc} + \text{Number other Bacteria}}$$

Where:

$$\text{Number other Bacteria} = \frac{\text{Total DNA in sample (ng)} - \text{DNA attributed to Dhc (ng)}}{*4.0 \times 10^{-6}\ \text{ng DNA per bacterial cell}}$$

*Paul and Clark, (1996).

Percent Dhc (and % *vcrA*) values can range from very low fractions of percentages, in samples with low numbers of Dhc and a high number of other bacteria (incompletely colonized by Dhc), to greater than 50% in Dhc enriched locations (highly colonized by Dhc).

In addition to determining the predominance of the target gene target gene percent is also useful for interpretation of Dhc counts from different sampling locations, or the same location over time. For example, the %Dhc value can be used to correct Dhc counts where samples are biased due to non-representative sampling. Example 1 illustrates a hypothetical scenario where the %Dhc value improved data interpretation.

Example 1, use of %Dhc to interpret enumeration data

Table 2 presents results from MW-1 sampled in April, May and June. Based on the Dhc enumeration alone one would conclude that the concentration of Dhc held steady between April and May; however, the %Dhc indicates the proportion of Dhc actually increased from April to May and the unchanged count in May could be a case of low biomass recovery during sampling or other losses such as sample degradation in transit. The higher raw count and the higher percentage of Dhc in June confirm the trend of increasing Dhc concentrations over time.

Table 3: Use of % Dhc* Value to Diagnose Sampling Bias

Sample	Dhc Enumeration	%Dhc	Interpretation Based on %Dhc
MW-1, April	1.0×10^5/Liter	0.1%	Dhc is a low proportion of total microbial population
MW-1, May	1.0×10^5/Liter	1%	Dhc proportion increased 10-fold from April. Dhc enumeration was unchanged possibly due to low biomass recovery from monitoring well, non-biased sample would be $[(1.0/0.1) \times 1.0 \times 10^5] = 1.0 \times 10^6$/Liter
MW-1, June	1.0×10^7/Liter	10%	Dhc has increased 100-fold from April and confirms May sample was likely low biased

**Note: the above approach is also applicable to the "%vcrA" and "%Dhb" values provided on their respective test certificates*

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Appendix A: Data Qualifiers

Data Qualification

Data qualifiers and notes are used to clarify Gene-Trac® test results. Additional explanation beyond that provided on the test certificate is provided below.

"**U" Not detected, associated value is the quantitation limit.** Indicates that the target gene (microbe) was not detected in the sample above the quantitation limit of the assay. Note the quantitation limit value can change between samples as the volume filtered can vary; thus, a sample in which 100 ml was tested would have a 5–fold higher quantification limit compared with a sample in which 500 ml was tested.

"J" The associated value is an estimated quantity between the method detection limit and quantitation limit. Indicates that the target gene was conclusively detected but the concentration is below the quantitation limit where it cannot be accurately quantified.

"I" Sample inhibited the test reaction. This means universal primers were incapable of amplifying DNA from this sample. The inability to amplify with universal primers suggests that the sample may be imparting matrix interference. Matrix interference is commonly attributed to humic compounds, polyphenols and metals. Non-detects with an "I" qualifier are more likely to be false negative.

"B" Analyte was also detected in the method blank. Indicates that DNA was detected in a method blank or negative control; detectable contamination of the blanks with microbes or DNA containing the gene of interest is not uncommon as the test reaction is extremely sensitive. In most cases, blank contamination is at a very low level relative to test results (often orders of magnitude lower). In these cases, blank contamination is not relevant to interpretation of test results. The potential of test samples being contaminated (i.e. false positives) should be considered in cases where blank results are within 1 order of magnitude of test results.

APPENDIX F
Geotechnical Laboratory Report
GAI/GeoSystems Consultants, Inc.

gai consultants
transforming ideas into reality

GAI Consultants,Inc
Construction Materials Testing Laboratory
470 Drew Court King of Prussia, PA 19406
Ph: 610.731.0430
Fax: 610.731.0435
www.gaiconsultants.com

Material Test Report

Report No: MAT:F131547.00-S001
Issue No: 1

Client: Geosyntec Consultants, Inc.
1781 Sentry Pkwy., Bldg 18, Suite 120
Blue Bell, PA, 19422

Project: Geosyntec Consultants - Lab Testing

Job No: F131547.00

This laboratory is accredited by the American Association of State Highway and Transportation Officials (AASHTO). The tests reported have been completed in accordance with the terms of the accreditation.

AASHTO Accreditation: 1173

Date of Issue: 9/24/2013
Approved Signatory: Deb Klinger

Sample Details

Boring No:
Field Sample No: 0905-1-Client
Sample Depth:
Date Sampled: 9/5/2013
Sampled By: Client
Date Submitted: 9/5/2013
Sample Location: North Penn 5 OV2

Bulk Density - 92.5 pcf

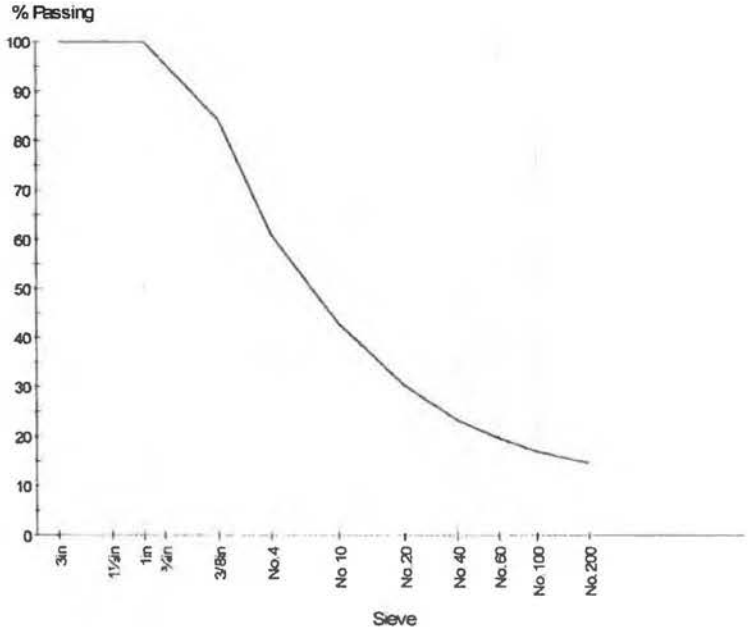
Sample Description:

Brown coarse to fine SAND and GRAVEL, little fines
As received Moisture Content = 17.6%

Grading: Particle Size Analysis of Soils Sieve & Wash#200 (ASTM D 422 2007)

Date Tested: 9/19/2013

Particle Size Distribution



Sieve Size	% Passing	Limits
3in	100	
1½in	100	
1in	100	
¾in	96	
3/8in	84	
No.4	61	
No.10	43	
No.20	30	
No.40	23	
No.60	20	
No.100	17	
No.200	15	

COBBLES	GRAVEL		SAND			FINES (14.6%)	
(0.0%)	Coarse (4.5%)	Fine (34.6%)	Coarse (17.9%)	Medium (19.7%)	Fine (8.9%)	Silt	Clay

D85: 9.8699 **D60:** 4.5279 **D50:** 2.7899
D30: 0.8345 **D15:** 0.0847 **D10:** N/A

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Measurement of Hydraulic Conductivity (ASTM D 5084-03 Method F)

Boring No.:
Sample No.: Sample 1
Depth (ft)

Sample Type: Remolded

Initial			Final		
Mass	1087.20	g.	Mass	1089.52	g.
Length	5.409	in.	Length	5.389	in.
Diameter	2.825	in.	Diameter	2.832	in.
Volume	0.0194	ft^3	Volume	0.0194	ft^3
Water Content	19.4	%	Water Content	19.6	%
Dry Unit Weight	102.4	pcf	Dry Unit Weight	102.4	pcf
Saturation (init.)	86.0		Saturation	87.1	
Porosity(Init.)	0.3690		Porosity(Final.)	0.3690	

Type of Permeant Liquid Used: De-Aired Water

Effective Consolidation Stress: 5

Initial hydraulic gradient: 18.2
Final hydraulic gradient: 17.1

Specific Gravity 2.60

Confining Pressure 75 psi
Back Pressure 70 psi

Temp 21 °C

Corrected Hydraulic Conductivity (k_{20}) @ $5.06X10^{-08}$ cm/sec

Soil Description: Light brown silty sand

Project No.	2013G364	Client:	GAI	Remarks:
Project:	North Penn 5	Date:	15-Oct-13	

Measurement of Hydraulic Conductivity

GeoSystems Consultants, Inc.

APPENDIX G
EISB Treatability Study
SiREM Laboratories, Inc.

Prepared for:

Geosyntec Consultants, Inc.
600 West Germantown Pike, Suite 400
Plymouth Meeting, PA
19462

Laboratory Biotreatability Study to Evaluate Remediation of Chlorinated VOCs in Groundwater

NP5 OU2, Colmar, PA

Prepared by:

130 Research Lane, Suite 2
Guelph, Ontario N1G 5G3

SiREM Ref: PH 0013.08

30 September 2013

siremlab.com

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LIST OF ABBREVIATIONS

CA	chloroethane
cDCE	*cis*-1,2-dichloroethene
CO_2	carbon dioxide
cVOC	chlorinated volatile organic compound
Dhb	*Dehalobacter*
Dhc	*Dehalococcoides*
°C	degrees Celsius
°C/min	degrees Celsius per minute
DHG	dissolved hydrocarbon gases
ERD	enhanced reductive dechlorination
GC	gas chromatograph
Geosyntec	Geosyntec Consultants
g	grams
IC	ion chromatograph
µg/L	micrograms per liter
µL	microliter
min	minutes
mg/L	milligrams per liter
mL	milliliters
mL/min	milliliters per minute
mM	millimolar
mmol/bottle	millimoles per bottle
mV	millivolts
mZVI	micro scale zero valent iron
NZ	Newman Zone®
ORP	oxidation reduction potential
PCE	tetrachloroethene
%	percent
QL	quantitation limit
qPCR	quantitative polymerase chain reaction
RPM	revolutions per minute
rRNA	16 S ribosomal ribonucleic acid
SiREM	SiREM Laboratory
TCE	trichloroethene
VC	vinyl chloride
vcrA	vinyl chloride reductase
VFA	volatile fatty acid

1. INTRODUCTION

Geosyntec Consultants (Geosyntec) retained SiREM Laboratory (SiREM) to perform a laboratory biotreatability study to assess the potential for in situ bioremediation of chlorinated volatile organic compounds (cVOCs) in groundwater at the NP5 OU2, Colmar, PA site (Site). The purpose of the study was to assess anaerobic biodegradation of the Site contaminants, namely, chlorinated ethenes (trichloroethene [TCE] and cis-1,2-dichloroethene [cDCE]).

Site groundwater and geological materials (TW01/TW18) used for this study were collected on 17 June 2013 and were received by SiREM on 19 June 2013.

Refer to Appendix A for the chain of custody documentation received with the materials.

The remainder of this report contains a summary of key biodegradation processes (Section 1.1), the experimental materials and methods (Section 2), and report references (Section 3).

1.1 Summary of Biodegradation Processes

Biological degradation products of TCE and *c*DCE include VC and the fully dechlorinated end product ethene. Figure 1 contains degradation pathways for the chlorinated ethenes.

Natural attenuation processes can occur in situ and are often mediated by indigenous microbial populations present at contaminated sites. Enhanced reductive dechlorination (ERD), can in certain cases, be achieved by stimulating the indigenous microbial populations through the addition of electron donors. Bioaugmentation is the process in which a microbial population known to promote ERD or other biodegradation processes is introduced to groundwater to enhance the rate or extent of biodegradation. KB-1® is a natural microbial consortium containing microorganisms (including *Dehalococcoides* [*Dhc*]) known to be responsible for mediating the complete dechlorination of tetrachloroethene (PCE), TCE, cDCE, and VC to ethene (Major et al., 2002; Duhamel et al., 2002). KB-1® is used to introduce *Dhc* and complete dechlorination activity to sites exhibiting slow or incomplete dechlorination of chlorinated ethene compounds.

2. MATERIALS AND METHODS

The following sections describe the materials and methods used for microcosm construction and incubation (Section 2.1), and microcosm sampling and analysis (Section 2.2).

2.1 Microcosm Construction and Incubation

Biotreatability microcosms were constructed in a disposable anaerobic glove bag containing the Site groundwater and all the materials required to construct all treatment and control microcosms. The glove bag was purged with nitrogen gas in order to create an anaerobic environment and to protect any microorganisms present in the site materials from oxygen exposure. During microcosm construction, the Site water was mixed thoroughly to ensure reproducibility between replicates.

Microcosms were constructed by filling sterile 250 milliliter (mL) (nominal volume) screw cap Boston round clear glass bottles (Systems Plus, New Hamburg, ON) with 60 grams (g) of homogenized soil and 200 mL of Site groundwater. The bottles were capped with Mininert™ closures to allow repetitive sampling with minimal VOC loss and to allow nutrient amendment, as needed, throughout the incubation period. The controls and treatments were constructed in triplicate. Table 1 summarizes the details of microcosm construction and the amendments used for the treatment and control microcosms for each phase of the study.

Anaerobic sterile control microcosms were constructed to quantify potential abiotic and experimental VOC losses from the microcosms. The sterile controls were constructed by autoclaving the Site geologic materials at 121 degrees Celsius (°C) and 15 pounds per square inch pressure for 45 to 60 minutes (min). After autoclaving, the sterile control microcosms were returned to the anaerobic chamber, filled with 200 mL of Site groundwater and amended with mercuric chloride and sodium azide as described in Table 1.

All microcosms were sampled and incubated in an anaerobic chamber (Coy Laboratory Products, Grass Lake, MI) filled with an atmosphere of approximately 80 percent (%) nitrogen, 10% carbon dioxide (CO_2) and 10% hydrogen (Linde Gases, Guelph, ON). Hydrogen in the anaerobic chamber functions to scavenge trace oxygen via a palladium catalyst. Anaerobic conditions in the anaerobic chamber were verified using an indicator containing resazurin (Sigma, St. Louis, MO) in a mineral medium, which turns pink in the presence of oxygen. During quiescent incubation, all microcosms were covered to minimize photodegradation, and stored horizontally to minimize cVOC losses via the (submerged) Mininert™ closure. Microcosms were incubated for a period of up to 250 days at approximately 22 °C (room temperature).

The first microcosm of each treatment and control was amended with resazurin (Sigma, St. Louis, MO) to monitor redox conditions. Resazurin turns from pink to clear in the absence of oxygen and can be used to indicate the on-set of reducing conditions.

Geosyntec specified that the initial TCE and cDCE concentrations in the microcosms should be 1.0 milligrams per liter (mg/L) and 0.25 mg/L respectively to represent concentrations measured at the Site. The initial TCE and cDCE concentrations measured in the prepared microcosms were not at these target concentrations; therefore on 28 June 2013 (Day 0), the microcosms were amended with TCE and cDCE to reach the target concentrations in the microcosms.

Newman Zone® (NZ) (RNAS, Brooklyn Center, MN) was the selected electron donor evaluated in the study. Treatment microcosms were amended with NZ on 28 June 2013 (Day 0).

Bioaugmentation may improve the extent and rate of TCE and cDCE dechlorination. Microcosms are typically bioaugmented after reducing conditions required by the KB-1® culture are achieved. Suitable reducing conditions are typically achieved after electron donor addition and are indicated by oxidation reduction potentials [ORP] less than -75 millivolts [mV], and are assessed qualitatively by both changes in the resazurin indicator color (from pink to clear) and the on-set of sulfate reduction. Both of these conditions were observed in the electron donor

amended treatments by 25 July 2013 (Day 27), at which time the electron donor amended microcosms were bioaugmented with KB-1®.

On 3 September 2013, complete dechlorination of TCE and cDCE to ethene was observed in the NZ amended and KB-1 bioaugmented treatment. Geosyntec requested that these microcosms be respiked with TCE to a target concentration of 10 mg/L. On 9 September 2013 (Day 73) the intrinsic controls and NZ amended and KB-1 bioaugmented treatment were spiked with TCE to a target concentration of 10 mg/L.

Details of TCE and cDCE spiking, electron donor addition, resazurin amendment and bioaugmentation are provided in Table 1.

2.2 Microcosm Sampling and Analysis

2.2.1 Microcosm Sampling

Aqueous samples were collected from the control and treatment microcosms on a weekly to biweekly (i.e., every two weeks) basis for analysis of cVOCs, dissolved hydrocarbon gases (DHGs – ethene, ethane, and methane) and anions (table 3A, 3B) (sulfate, nitrate, nitrite, chloride, phosphate, bromide). Aqueous samples were also collected on a less frequent basis for analysis of volatile fatty acids (table 4A, 4B) (VFAs – lactate, acetate, propionate, formate, butyrate and pyruvate) and pH (table 5A, 5B). The microcosms were sampled using gas-tight 1 mL Hamilton glass syringes. Separate sets of syringes were used for the bioaugmented and non-bioaugmented treatments to minimize the potential for transfer of KB-1® Plus microorganisms from bioaugmented to non-bioaugmented treatments. Syringes were cleaned with acidified water (pH ~2) and rinsed 10 times with deionized water between samples to ensure that VOCs and microorganisms were not transferred between different samples or treatments. The analytical methods employed by SiREM are described below.

2.2.2 Analysis of cVOCs and Dissolved Hydrocarbon Gases

This section describes the methods used to quantify the cVOCs and DHGs. The quantitation limits (QL) for the chlorinated ethenes, chlorinated ethanes and DHGs were typically 10 micrograms per liter (µg/L) in the microcosms based on the lowest concentration standards that were included in the linear calibration trend.

Aqueous cVOC and DHG concentrations in the microcosms and reactors were measured using a Hewlett-Packard (Hewlett Packard 7890) gas chromatograph (GC) equipped with an auto sampler (Hewlett Packard G1888) programmed to heat each sample vial to 75°C for 45 minutes (min.) prior to headspace injection into a GSQ Plot column (0.53 millimeters x 30 meters, J&W) and a flame ionization detector. Sample vials were heated to ensure that all VOCs in the aqueous sample would partition into the headspace. The injector temperature was 200°C, and the detector temperature was 250°C. The oven temperature was programmed as follows: 35°C for 2 min, increased to 100°C at 50 degrees Celsius per minute (°C/min), then increased to

185°C at 25°C/min and held at 185°C for 6.80 min. The carrier gas was helium at a flow rate of 11 milliliters per minute (mL/min).

After withdrawing a 1 mL sample (as described in section 2.2.1), the sample was injected into a 10 mL auto sampler vial containing 5.0 mL of acidified deionized water (pH ~2). The water was acidified to inhibit microbial activity between microcosm sampling and GC analysis. The vial was sealed with an inert Teflon®-coated septum and aluminium crimp cap for automated injection of 3 mL of headspace onto the GC. One VOC standard was analyzed with each set of samples to verify the instrument five-point calibration curve. Calibration was performed using external standard solutions (Sigma, St Louis, MO), where known volumes of standard solutions were added to acidified water in auto sampler vials and analyzed as described above for microcosm samples. Data were integrated using Chemstation Software (Agilent Technologies, Santa Clara, CA).

2.2.3 Analysis of Anions and Total Volatile Fatty Acids

Anions and total VFA analysis was performed on a Dionex DX-600 ion chromatograph (IC) equipped with a Dionex AS-40 auto sampler and an AS18 column, the sample loop volume was 25 L. An isocratic separation was performed using 33 millimolar (mM) reagent grade sodium hydroxide (Fisher Scientific, Ottawa, ON) eluent for 13 min. One standard was analyzed with each set of samples tested in order to verify the seven-point calibration using external standards of known concentrations. External standards were prepared gravimetrically using chemicals of the highest purity available (Sigma St Louis, MO or Bioshop, Burlington, ON). Data were integrated using Peaknet Chromatography software (Dionex, Oakville, ON). The QLs were as follows: 0.07 mg/L total VFA, 0.07 mg/L chloride, 0.09 mg/L nitrite, 0.09 mg/L nitrate, 0.07 mg/L sulfate, 0.07 mg/L phosphate and 0.08 mg/L bromide. The total VFA value includes lactate, formate, acetate, propionate, pyruvate and butyrate (valerate has not been confirmed). The VFA method described below (Section 2.2.4) is used to quantify individual VFAs.

2.2.4 Analysis of Volatile Fatty Acids

Individual VFAs (lactate, acetate, propionate, formate, butyrate and pyruvate) analysis was performed on a Dionex DX-600 IC equipped with a Dionex AS-40 auto sampler and an AS11-HC column, the sample loop volume was 25 microliters (µL). A gradient separation was performed using the following eluent profile; 1.0 mM sodium hydroxide for 8.0 min to 15 mM at 18.0 min and proceeding to 30 mM at 28.0 min. with a flow rate of 1.5 mL/min. Calibration was performed using external standards of known concentrations. One standard was analysed with each set of samples to verify the instrument's seven-point calibration curve produced using external standards of known concentrations. External standards were prepared gravimetrically using chemicals of the highest purity available (Sigma St Louis, MO or Bioshop, Burlington, ON). Data were integrated using Peaknet chromatography software (Dionex, Oakville, ON). The QLs were as follows: lactate 0.40 mg/L, acetate 0.54 mg/L, propionate 0.31 mg/L, formate 0.23 mg/L, butyrate 0.41 mg/L and pyruvate 0.69 mg/L.

A 0.5 mL sample was withdrawn (as described in section 2.2.1), after which the sample was placed in a 1.5 mL micro-centrifuge tube. Samples were centrifuged for five minutes at 13,000 revolutions per minute (RPM) in a microcentrifuge to remove solids. The supernatant was removed, diluted 50-fold in deionized water and placed in a Dionex auto sampler vial with a cap that filters the sample during automated injection onto the IC.

2.2.5 Analysis of pH

The pH measurements were performed using an Oakton pH spear with a combination pH electrode (Oakton, Vernon Hills, IL). A 0.5 mL sample was taken (as described in section 2.2.1), the vial was removed from the glove box and the pH was measured on the lab bench. The pH spear was calibrated at each sampling event according to the manufacturer's instructions using pH 4.0, 7.0 and 10 standards.

2.2.6 Gene Trac® *Dehalococcoides* and Vinyl Chloride Reductase Testing

Gene-Trac® quantitative polymerase chain reaction (qPCR) testing was performed in this study to quantify and characterize *Dhc* microorganisms known to facilitate the dechlorination of PCE to ethene.

The Gene-Trac® *Dhc* test quantifies the total *Dhc* population by targeting the 16S ribosomal ribonucleic acid (rRNA) gene whereas the Gene-Trac® VC test targets the Dhc vinyl chloride reductase (*vcrA*) gene. The *vcrA* gene is present in only a subset of Dhc populations and is a functional gene responsible for complete dechlorination of cDCE and VC to ethene (Mueller et al., 2004). There is a strong correlation between the presence of vcrA and complete dechlorination of chloroethenes to non-toxic ethene.

On 18 October 2013, at the endpoint of the study, 15 mL samples were collected from the intrinsic controls, the NZ amended treatment and the NZ amended and KB-1 bioaugmented treatment. Each sample was made up of a 5 mL sample from each of the 3 replicates combined in 15 mL centrifuge tube. The three samples were submitted for Gene-Trac® *Dhc* and VC testing. Refer to Appendix C for the Gene-Trac test certificates.

3. RESULTS

Tables 2 - 5 provide cVOC, ethene, ethane, methane, anion, VFA, and pH data from the control and treatment microcosms over the incubation period for the study. All cVOC, ethene, ethane, and methane concentrations are presented in units of mg/L and millimoles per microcosm bottle (mmol/bottle) to demonstrate mass balances on a molar basis. Concentrations were converted from mg/L to mmol/bottle using Henry's Law as demonstrated in Appendix B. GeneTrac reports are provided in Appendix C. Dehalococcoides and vcrA Gene-Trac® results are summarized in Table 6. Figures 2 - 6 present trends in the concentrations of cVOCs, ethene, and ethane in the control and treatment microcosms over the incubation period for the study.

4. REFERENCES

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TABLES

TABLE 1: SUMMARY OF MICROCOSM STUDY CONTROLS, TREATMENT AND AMENDMENTS
NP5 OU2, Colmar, PA

Treatment/Control	Assigned bottle Number	Number of Microcosms	Geologic Material (g)	Groundwater (mL)	Headspace (mL)	Rezasurin	Sodium Azide	Mercuric Chloride	VOCs	Newman Zone	Buffer	KB-1®
Anaerobic Sterile Control	1 to 3	3	60	200	20	Amend first replicate with 100 µL of resazurin.	Amended with 0.5 mL of a 5% solution on Day -1.	Amended with 2.8 mL of a 2.7% solution on Day -1.	Spiked with 91 µL saturated solution of TCE and 5 µL saturated solution of cDCE to a final concentrations of 1.0 mg/L and 0.25 mg/L on Day 0.	NA	NA	NA
Anaerobic Active Control	4 to6	3	60	200	20	Amend first replicate with 100 µL of resazurin.	NA	NA	Spiked with 91 µL saturated solution of TCE and 5 µL saturated solution of cDCE to a final concentrations of 1.0 mg/L and 0.25 mg/L on Day 0. Spiked with 1.3 µL of NEAT TCE on day 73.	NA	NA	NA
Newman Zone	7 to9	3	60	200	20	Amend first replicate with 100 µL of resazurin.	NA	NA	Spiked with 91 µL saturated solution of TCE and 5 µL saturated solution of cDCE to a final concentrations of 1.0 mg/L and 0.25 mg/L on Day 0.	Amended with 445 µL of NZ to a target concentration of 0.1 % as oil on Day 0.	NA	NA
Newman Zone & Buffer	10 to 12	3	60	200	20	Amend first replicate with 100 µL of resazurin.	NA	NA	Spiked with 91 µL saturated solution of TCE and 5 µL saturated solution of cDCE to a final concentrations of 1.0 mg/L and 0.25 mg/L on Day 0.	Amended with 445 µL of NZ to a target concentration of 0.1 % as oil on Day 0.	Amended with 1.0 mL of a saturated sodium bicarbonate solution to adjust pH to a target of 6.8 -7.2 on Day 0.	NA
Newman Zone, Buffer & Bioaugmentation	13 to 15	3	60	200	20	Amend first replicate with 100 µL of resazurin.	NA	NA	Spiked with 91 µL saturated solution of TCE and 5 µL saturated solution of cDCE to a final concentrations of 1.0 mg/L and 0.25 mg/L on Day 0. Spiked with 1.4 µL of NEAT TCE on day 73.	Amended with 445 µL of NZ to a target concentration of 0.1 % as oil on Day 0.	Amended with 1.0 mL of a saturated sodium bicarbonate solution to adjust pH to a target of 6.8 -7.2 on Day 0.	Bioaugmented with 0.5 mL KB-1® on Day 27.

Notes:

cDCE - cis-dichloroethene
% - percent
µL - microliters
TCE - trichloroethene
g - grams
mg/L - milligrams per liter
mL - milliliters
NA - not applicable
NZ - Newman Zone
VOCs - volatile organic carbons

Treatment	Date	Day	Replicate	Bottle	Chlorinated Ethenes					Chlorinated Ethanes	Methane and Electron Donors	Comment
					TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	Methane	
					mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	
Anaerobic Sterile Control	25-Jun-13	-3										Poisoned with mercuric chloride and sodium azide.
												Amended first replicate with resazurin.
	28-Jun-13	0										Spiked with TCE and cDCE to target concentrations of 1.0 and 0.25 mg/L respectively.
			ANSC-1	1	0.99	0.38	<0.010	<0.010	--	<0.010	0.027	
			ANSC-2	2	1.0	0.36	<0.010	<0.010	--	<0.010	0.027	
			ANSC-3	3	0.96	0.36	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.98	0.37	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		2.8E-05	3.1E-05	0.0E+00	0.0E+00	--	0.0E+00	2.0E-05	
			Average Total mmoles		**0.0016**	**0.00078**	**ND**	**ND**	**2.4E-03**	**ND**	**0.0013**	
	12-Jul-13	14	ANSC-1	1	0.92	0.40	<0.010	<0.010	--	<0.010	0.029	
			ANSC-2	2	0.96	0.37	<0.010	<0.010	--	<0.010	0.029	
			ANSC-3	3	0.93	0.36	<0.010	<0.010	--	<0.010	0.031	
			Average Concentration (mg/L)		0.94	0.38	ND	ND	--	ND	0.030	
			Standard Deviation (mmoles)		3.6E-05	5.1E-05	0.0E+00	0.0E+00	--	0.0E+00	3.8E-05	
			Average Total mmoles		**0.0015**	**0.00080**	**ND**	**ND**	**2.3E-03**	**ND**	**0.0014**	
	06-Aug-13	39	ANSC-1	1	0.84	0.36	<0.010	<0.010	--	<0.010	0.029	
			ANSC-2	2	0.89	0.35	<0.010	<0.010	--	<0.010	0.029	
			ANSC-3	3	0.74	0.30	<0.010	<0.010	--	<0.010	0.030	
			Average Concentration (mg/L)		0.82	0.34	ND	ND	--	ND	0.029	
			Standard Deviation (mmoles)		1.3E-04	7.4E-05	0.0E+00	0.0E+00	--	0.0E+00	2.9E-05	
			Average Total mmoles		**0.0013**	**0.00072**	**ND**	**ND**	**2.0E-03**	**ND**	**0.0014**	
	17-Oct-13	111	ANSC-1	1	0.81	0.37	<0.010	<0.010	--	<0.010	0.028	
			ANSC-2	2	0.84	0.34	<0.010	<0.010	--	<0.010	0.029	
			ANSC-3	3	0.87	0.35	<0.010	<0.010	--	<0.010	0.032	
			Average Concentration (mg/L)		0.84	0.35	ND	ND	--	ND	0.030	
			Standard Deviation (mmoles)		5.2E-05	3.0E-05	0.0E+00	0.0E+00	--	0.0E+00	9.4E-05	
			Average Total mmoles		**0.0013**	**0.00074**	**ND**	**ND**	**2.0E-03**	**ND**	**0.0014**	
Anaerobic Active Control	25-Jun-13	-3										Amended first replicate with resazurin.
	28-Jun-13	0										Spiked with TCE and cDCE to target concentrations of 1.0 and 0.25 mg/L respectively.
			ANAC-1	4	0.97	0.37	<0.010	<0.010	--	<0.010	0.028	
			ANAC-2	5	0.98	0.36	<0.010	<0.010	--	<0.010	0.029	
			ANAC-3	6	1.0	0.36	<0.010	<0.010	--	<0.010	0.029	
			Average Concentration (mg/L)		0.99	0.36	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		4.2E-05	1.2E-05	0.0E+00	0.0E+00	--	0.0E+00	2.7E-05	
			Average Total mmoles		**0.0016**	**0.00077**	**ND**	**ND**	**2.4E-03**	**ND**	**0.0013**	
	12-Jul-13	14	ANAC-1	4	0.90	0.36	<0.010	<0.010	--	<0.010	0.028	
			ANAC-2	5	0.85	0.32	<0.010	<0.010	--	<0.010	0.030	
			ANAC-3	6	0.94	0.36	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.90	0.35	ND	ND	--	ND	0.029	
			Standard Deviation (mmoles)		7.4E-05	4.4E-05	0.0E+00	0.0E+00	--	0.0E+00	7.0E-05	
			Average Total mmoles		**0.0014**	**0.00074**	**ND**	**ND**	**2.1E-03**	**ND**	**0.0013**	
	06-Aug-13	39	ANAC-1	4	0.86	0.36	<0.010	<0.010	--	<0.010	0.026	
			ANAC-2	5	0.77	0.31	<0.010	<0.010	--	<0.010	0.059	
			ANAC-3	6	0.90	0.35	<0.010	<0.010	--	<0.010	0.026	
			Average Concentration (mg/L)		0.84	0.34	ND	ND	--	ND	0.037	
			Standard Deviation (mmoles)		1.1E-04	5.9E-05	0.0E+00	0.0E+00	--	0.0E+00	8.8E-04	
			Average Total mmoles		**0.0014**	**0.00072**	**ND**	**ND**	**2.1E-03**	**ND**	**0.0017**	
	09-Sep-13	73										Spiked with TCE to a target concentration of 10 mg/L.
			ANAC-1	4	0.79	0.38	0.012	<0.010	--	<0.010	0.028	
			ANAC-2	5	0.71	0.31	0.011	<0.010	--	<0.010	0.077	
			ANAC-3	6	0.89	0.37	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.8	0.35	0.0076	ND	--	ND	0.044	
			Standard Deviation (mmoles)		1.5E-04	7.4E-05	2.3E-05	0.0E+00	--	0.0E+00	1.3E-03	
			Average Total mmoles		**0.0013**	**0.00075**	**2.7E-05**	**ND**	**2.1E-03**	**ND**	**0.0020**	
	12-Sep-13	76	ANAC-1	4	11	0.36	<0.010	<0.010	--	<0.010	0.028	
			ANAC-2	5	11	0.31	<0.010	<0.010	--	<0.010	0.076	
			ANAC-3	6	13	0.35	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		12	0.34	ND	ND	--	ND	0.044	
			Standard Deviation (mmoles)		2.0E-03	5.4E-05	0.0E+00	0.0E+00	--	0.0E+00	1.3E-03	
			Average Total mmoles		**0.019**	**0.00072**	**ND**	**ND**	**2.0E-02**	**ND**	**0.0020**	
	17-Sep-13	81	ANAC-1	4	14	0.35	<0.010	<0.010	--	<0.010	0.032	
			ANAC-2	5	14	0.32	<0.010	<0.010	--	<0.010	0.077	
			ANAC-3	6	17	0.34	<0.010	<0.010	--	<0.010	0.024	

Treatment	Date	Day	Replicate	Bottle	Chlorinated Ethenes					Chlorinated Ethanes	Methane and Electron Donors	Comment
					TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	Methane	
					mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	
Anaerobic Active Control Cont'd	17-Sep-13		**Average Concentration (mg/L)**		15	0.34	ND	ND	--	ND	0.044	
			Standard Deviation (mmoles)		2.8E-03	2.9E-05	0.0E+00	0.0E+00	--	0.0E+00	1.3E-03	
			Average Total mmoles		**0.024**	**0.00072**	**ND**	**ND**	**2.5E-02**	**ND**	**0.0021**	
	17-Oct-13	111	ANAC-1	4	14	0.36	<0.010	<0.010	--	<0.010	0.027	
			ANAC-2	5	13	0.31	<0.010	0.012	--	<0.010	0.076	
			ANAC-3	6	15	0.34	<0.010	<0.010	--	<0.010	0.026	
			Average Concentration (mg/L)		14	0.33	ND	0.004	--	ND	0.043	
			Standard Deviation (mmoles)		1.4E-03	4.9E-05	0.0E+00	9.1E-05	--	0.0E+00	1.3E-03	
			Average Total mmoles		**0.022**	**0.00071**	**ND**	**5.3E-05**	**2.3E-02**	**ND**	**0.0020**	
Newman Zone	25-Jun-13	-3										Amended first replicate with resazurin.
	28-Jun-13	0										Spiked with TCE and cDCE to target concentrations of 1.0 and 0.25 mg/L respectively.
												Amended with Newman Zone to a target concentration of 0.1% as oil.
			NZ-1	7	0.78	0.34	<0.010	<0.010	--	<0.010	0.027	
			NZ-2	8	0.78	0.34	<0.010	<0.010	--	<0.010	0.027	
			NZ-3	9	0.69	0.34	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.75	0.34	ND	ND	--	ND	0.027	
			Standard Deviation (mmoles)		8.1E-05	5.6E-06	0.0E+00	0.0E+00	--	0.0E+00	1.2E-05	
			Average Total mmoles		**0.0012**	**0.00072**	**ND**	**ND**	**1.9E-03**	**ND**	**0.0013**	
	12-Jul-13	14	NZ-1	7	0.69	0.33	<0.010	<0.010	--	<0.010	0.029	
			NZ-2	8	0.67	0.33	<0.010	<0.010	--	<0.010	0.028	
			NZ-3	9	0.67	0.34	<0.010	<0.010	--	<0.010	0.029	
			Average Concentration (mg/L)		0.68	0.34	ND	ND	--	ND	0.029	
			Standard Deviation (mmoles)		2.1E-05	7.9E-06	0.0E+00	0.0E+00	--	0.0E+00	2.9E-05	
			Average Total mmoles		**0.0011**	**0.00071**	**ND**	**ND**	**1.8E-03**	**ND**	**0.0013**	
	23-Jul-13	25	NZ-1	7	0.69	0.36	<0.010	<0.010	--	<0.010	0.029	
			NZ-2	8	0.46	0.53	<0.010	<0.010	--	<0.010	0.028	
			NZ-3	9	0.64	0.33	<0.010	<0.010	--	<0.010	0.029	
			Average Concentration (mg/L)		0.60	0.41	ND	ND	--	ND	0.029	
			Standard Deviation (mmoles)		2.0E-04	2.3E-04	0.0E+00	0.0E+00	--	0.0E+00	2.6E-05	
			Average Total mmoles		**0.00096**	**0.00086**	**ND**	**ND**	**1.8E-03**	**ND**	**0.0013**	
	06-Aug-13	39	NZ-1	7	0.62	0.39	<0.010	<0.010	--	<0.010	0.028	
			NZ-2	8	<0.010	1.1	<0.010	<0.010	--	<0.010	0.027	
			NZ-3	9	0.62	0.33	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.41	0.59	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		5.7E-04	8.7E-04	0.0E+00	0.0E+00	--	0.0E+00	3.9E-05	
			Average Total mmoles		**0.00066**	**0.0013**	**ND**	**ND**	**2.0E-03**	**ND**	**0.0013**	
	27-Aug-13	60	NZ-1	7	<0.010	1.3	<0.010	<0.010	--	<0.010	0.31	
			NZ-2	8	<0.010	1.0	<0.010	<0.010	--	<0.010	0.028	
			NZ-3	9	0.51	0.44	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.17	0.91	ND	ND	--	ND	0.12	
			Standard Deviation (mmoles)		4.8E-04	9.0E-04	0.0E+00	0.0E+00	--	0.0E+00	7.4E-03	
			Average Total mmoles		**0.00027**	**0.0019**	**ND**	**ND**	**2.2E-03**	**ND**	**0.0056**	
	17-Oct-13	111	NZ-1	7	<0.010	1.3	<0.010	<0.010	--	<0.010	1.5	
			NZ-2	8	0.010	1.0	<0.010	<0.010	--	<0.010	1.1	
			NZ-3	9	0.20	0.81	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.069	1.1	ND	ND	--	ND	0.90	
			Standard Deviation (mmoles)		1.8E-04	5.8E-04	0.0E+00	0.0E+00	--	0.0E+00	3.6E-02	
			Average Total mmoles		**0.00011**	**0.0022**	**ND**	**ND**	**2.3E-03**	**ND**	**0.042**	
Amended with Newman Zone and Buffered with NaHCO3.	25-Jun-13	-3										Amended first replicate with resazurin.
	28-Jun-13	0										Spiked with TCE and cDCE to target concentrations of 1.0 and 0.25 mg/L respectively.
												Amended with Newman Zone to a target concentration of 0.1% as oil.
			NZ/buff-1	10	0.78	0.33	<0.010	<0.010	--	<0.010	0.027	
			NZ/buff-2	11	0.67	0.32	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff-3	12	0.72	0.33	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.73	0.33	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		8.9E-05	9.2E-06	0.0E+00	0.0E+00	--	0.0E+00	3.9E-05	
			Average Total mmoles		**0.0012**	**0.00069**	**ND**	**ND**	**1.9E-03**	**ND**	**0.0013**	
	12-Jul-13	14	NZ/buff-1	10	0.60	0.32	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff-2	11	0.64	0.32	<0.010	<0.010	--	<0.010	0.029	
			NZ/buff-3	12	0.58	0.41	<0.010	<0.010	--	<0.010	0.028	

Treatment	Date	Day	Replicate	Bottle	Chlorinated Ethenes					Chlorinated Ethanes	Methane and Electron Donors	Comment
					TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	Methane	
					mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	
Amended with Newman Zone and Buffered with NaHCO3 Cont'd	12-Jul-13		**Average Concentration (mg/L)**		0.61	0.35	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		5.6E-05	1.0E-04	0.0E+00	0.0E+00	--	0.0E+00	1.7E-05	
			Average Total mmoles		**0.00097**	**0.00074**	**ND**	**ND**	**1.7E-03**	**ND**	**0.0013**	
	23-Jul-13	25	NZ/buff-1	10	0.030	1.0	<0.010	<0.010	--	<0.010	0.027	
			NZ/buff-2	11	0.61	0.38	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff-3	12	0.013	1.0	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.22	0.80	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		5.4E-04	7.8E-04	0.0E+00	0.0E+00	--	0.0E+00	2.3E-05	
			Average Total mmoles		**0.00035**	**0.0017**	**ND**	**ND**	**2.1E-03**	**ND**	**0.0013**	
	06-Aug-13	39	NZ/buff-1	10	<0.010	1.1	<0.010	<0.010	--	<0.010	0.026	
			NZ/buff-2	11	0.62	0.44	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff-3	12	<0.010	1.0	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.21	0.84	ND	ND	--	ND	0.027	
			Standard Deviation (mmoles)		5.8E-04	7.5E-04	0.0E+00	0.0E+00	--	0.0E+00	4.3E-05	
			Average Total mmoles		**0.00033**	**0.0018**	**ND**	**ND**	**2.1E-03**	**ND**	**0.0013**	
	27-Aug-13	60	NZ/buff-1	10	<0.010	1.0	<0.010	<0.010	--	<0.010	0.027	
			NZ/buff-2	11	0.019	1.2	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff-3	12	<0.010	0.99	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.0062	1.1	ND	ND	--	ND	0.027	
			Standard Deviation (mmoles)		1.7E-05	2.6E-04	0.0E+00	0.0E+00	--	0.0E+00	2.5E-05	
			Average Total mmoles		**0.000010**	**0.0023**	**ND**	**ND**	**2.3E-03**	**ND**	**0.0013**	
	17-Oct-13	111	NZ/buff-1	10	<0.010	<0.010	<0.010	0.13	--	<0.010	0.026	
			NZ/buff-2	11	<0.010	<0.010	0.97	<0.010	--	<0.010	0.031	
			NZ/buff-3	12	0.032	<0.010	0.02	0.13	--	<0.010	0.026	
			Average Concentration (mg/L)		0.011	ND	0.33	0.085	--	ND	0.028	
			Standard Deviation (mmoles)		2.9E-05	0.0E+00	1.9E-03	9.7E-04	--	0.0E+00	1.3E-04	
			Average Total mmoles		**0.000017**	**ND**	**0.0012**	**0.0011**	**2.3E-03**	**ND**	**0.0013**	
Amended with Newman Zone, Buffered with NaHCO3 and Bioaugmented with KB-1.	25-Jun-13	-3										Amended first replicate with resazurin.
	28-Jun-13	0										Amended with Newman Zone to a target concentration of 0.1% as oil.
												Spiked with TCE and cDCE to target concentrations of 1.0 and 0.25 mg/L respectively.
			NZ/buff/KB-1-1	13	0.66	0.34	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff/KB-1-2	14	0.84	0.35	<0.010	<0.010	--	<0.010	0.027	
			NZ/buff/KB-1-3	15	0.74	0.34	<0.010	<0.010	--	<0.010	0.027	
			Average Concentration (mg/L)		0.75	0.34	ND	ND	--	ND	0.027	
			Standard Deviation (mmoles)		1.4E-04	1.1E-05	0.0E+00	0.0E+00	--	0.0E+00	1.7E-05	
			Average Total mmoles		**0.0012**	**0.00073**	**ND**	**ND**	**1.9E-03**	**ND**	**0.0013**	
	12-Jul-13	14	NZ/buff/KB-1-1	13	0.65	0.33	<0.010	<0.010	--	<0.010	0.027	
			NZ/buff/KB-1-2	14	0.66	0.36	<0.010	<0.010	--	<0.010	0.027	
			NZ/buff/KB-1-3	15	0.39	0.58	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.57	0.42	ND	ND	--	ND	0.028	
			Standard Deviation (mmoles)		2.5E-04	2.9E-04	0.0E+00	0.0E+00	--	0.0E+00	2.4E-05	
			Average Total mmoles		**0.00090**	**0.00090**	**ND**	**ND**	**1.8E-03**	**ND**	**0.0013**	
	23-Jul-13	25	NZ/buff/KB-1-1	13	0.099	0.92	<0.010	<0.010	--	<0.010	0.028	
			NZ/buff/KB-1-2	14	<0.010	1.0	<0.010	<0.010	--	0.01	0.063	
			NZ/buff/KB-1-3	15	0.20	0.83	<0.010	<0.010	--	<0.010	0.028	
			Average Concentration (mg/L)		0.10	0.93	ND	ND	--	0.0035	0.040	
			Standard Deviation (mmoles)		1.6E-04	2.2E-04	0.0E+00	0.0E+00	--	1.2E-04	9.3E-04	
			Average Total mmoles		**0.00016**	**0.0020**	**ND**	**ND**	**2.2E-03**	**0.000069**	**0.0018**	
	25-Jul-13	27										Bioaugmented with KB-1.
	30-Jul-13	32	NZ/buff/KB-1-1	13	0.020	1.0	0.012	<0.010	--	<0.010	0.029	
			NZ/buff/KB-1-2	14	<0.010	1.0	0.026	<0.010	--	<0.010	0.028	
			NZ/buff/KB-1-3	15	0.011	1.0	0.017	<0.010	--	<0.010	0.029	
			Average Concentration (mg/L)		0.010	1.0	0.018	ND	--	ND	0.028	
			Standard Deviation (mmoles)		1.6E-05	1.2E-05	2.4E-05	0.0E+00	--	0.0E+00	2.7E-05	
			Average Total mmoles		**0.000016**	**0.0022**	**6.4E-05**	**ND**	**2.3E-03**	**ND**	**0.0013**	
	06-Aug-13	39	NZ/buff/KB-1-1	13	<0.010	0.89	0.12	<0.010	--	<0.010	0.032	
			NZ/buff/KB-1-2	14	<0.010	0.92	0.11	<0.010	--	<0.010	0.038	
			NZ/buff/KB-1-3	15	<0.010	0.97	0.058	<0.010	--	<0.010	0.037	
			Average Concentration (mg/L)		ND	0.93	0.096	ND	--	ND	0.036	
			Standard Deviation (mmoles)		0.0E+00	8.8E-05	1.2E-04	0.0E+00	--	0.0E+00	1.4E-04	
			Average Total mmoles		**ND**	**0.0020**	**0.00034**	**ND**	**2.3E-03**	**ND**	**0.0017**	
	20-Aug-13	53	NZ/buff/KB-1-1	13	<0.010	0.12	0.12	0.12	--	<0.010	0.028	
			NZ/buff/KB-1-2	14	<0.010	0.098	0.079	0.14	--	<0.010	0.18	
			NZ/buff/KB-1-3	15	<0.010	0.48	0.27	0.029	--	<0.010	0.029	

Treatment	Date	Day	Replicate	Bottle	Chlorinated Ethenes					Chlorinated Ethanes	Methane and Electron Donors	Comment
					TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	Methane	
					mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	
Amended with Newman Zone, Buffered with NaHCO3 and Bioaugmented with KB-1 Cont'd			**Average Concentration (mg/L)**		ND	0.24	0.16	0.097	--	ND	0.081	
			Standard Deviation (mmoles)		0.0E+00	4.6E-04	3.6E-04	7.8E-04	--	0.0E+00	4.2E-03	
			Average Total mmoles		**ND**	**0.00050**	**0.00056**	**0.0013**	**2.4E-03**	**ND**	**0.0037**	
	27-Aug-13	60	NZ/buff/KB-1-1	13	<0.010	0.014	0.033	0.12	--	<0.010	0.043	
			NZ/buff/KB-1-2	14	<0.010	<0.010	0.020	0.13	--	<0.010	0.49	
			NZ/buff/KB-1-3	15	<0.010	0.11	0.15	0.11	--	<0.010	0.047	
			Average Concentration (mg/L)		ND	0.040	0.066	0.12	--	ND	0.19	
			Standard Deviation (mmoles)		0.0E+00	1.2E-04	2.4E-04	1.7E-04	--	0.0E+00	1.2E-02	
			Average Total mmoles		**ND**	**8.5E-05**	**0.00023**	**0.0016**	**1.9E-03**	**ND**	**0.0090**	
	03-Sep-13	67	NZ/buff/KB-1-1	13	<0.010	<0.010	<0.010	0.12	--	<0.010	0.084	
			NZ/buff/KB-1-2	14	<0.010	0.015	<0.010	0.14	--	<0.010	1.3	
			NZ/buff/KB-1-3	15	0.012	<0.010	<0.010	0.14	--	<0.010	0.13	
			Average Concentration (mg/L)		0.0040	0.0050	ND	0.14	--	ND	0.49	
			Standard Deviation (mmoles)		1.1E-05	1.8E-05	0.0E+00	1.6E-04	--	0.0E+00	3.1E-02	
			Average Total mmoles		**6.4E-06**	**1.1E-05**	**ND**	**0.0018**	**1.8E-03**	**ND**	**0.023**	
	09-Sep-13	73										Spiked with TCE to a target concentration of 10 mg/L.
			NZ/buff/KB-1-1	13	<0.010	0.018	<0.010	0.12	--	<0.010	0.20	
			NZ/buff/KB-1-2	14	0.011	<0.010	<0.010	0.14	--	<0.010	2.1	
			NZ/buff/KB-1-3	15	<0.010	<0.010	<0.010	0.13	--	<0.010	0.45	
			Average Concentration (mg/L)		0.0037	0.0061	ND	0.13	--	ND	0.91	
			Standard Deviation (mmoles)		1.0E-05	2.2E-05	0.0E+00	8.7E-05	--	0.0E+00	4.7E-02	
			Average Total mmoles		**0.0000060**	**1.3E-05**	**ND**	**0.0017**	**1.7E-03**	**ND**	**0.042**	
	12-Sep-13	76	NZ/buff/KB-1-1	13	7.8	0.3	0.078	0.14	--	<0.010	0.28	
			NZ/buff/KB-1-2	14	4.7	1.4	0.17	0.14	--	<0.010	2.1	
			NZ/buff/KB-1-3	15	2.3	3.1	0.29	0.15	--	<0.010	0.58	
			Average Concentration (mg/L)		4.9	1.6	0.18	0.14	--	ND	0.98	
			Standard Deviation (mmoles)		4.4E-03	3.1E-03	3.6E-04	9.7E-05	--	0.0E+00	4.4E-02	
			Average Total mmoles		**0.0079**	**0.0034**	**0.00062**	**0.0019**	**1.4E-02**	**ND**	**0.045**	
	20-Sep-13	84	NZ/buff/KB-1-1	13	0.93	7.8	1.8	0.20	--	<0.010	0.37	
			NZ/buff/KB-1-2	14	0.53	7.0	2.2	0.21	--	<0.010	2.5	
			NZ/buff/KB-1-3	15	0.42	4.5	2.8	0.41	--	<0.010	1.4	
			Average Concentration (mg/L)		0.63	6.4	2.3	0.27	--	ND	1.4	
			Standard Deviation (mmoles)		4.3E-04	3.7E-03	1.8E-03	1.6E-03	--	0.0E+00	4.9E-02	
			Average Total mmoles		**0.0010**	**0.014**	**0.0080**	**0.0036**	**2.7E-02**	**ND**	**0.066**	
	17-Oct-13	111	NZ/buff/KB-1-1	13	<0.010	<0.010	0.011	1.3	--	<0.010	1.2	
			NZ/buff/KB-1-2	14	0.017	<0.010	<0.010	1.1	--	<0.010	4.5	
			NZ/buff/KB-1-3	15	<0.010	<0.010	<0.010	1.4	--	<0.010	4.6	
			Average Concentration (mg/L)		0.0057	ND	0.0035	1.3	--	ND	3.5	
			Standard Deviation (mmoles)		1.6E-05	0.0E+00	2.2E-05	1.7E-03	--	0.0E+00	8.9E-02	
			Average Total mmoles		**9.1E-06**	**ND**	**1.2E-05**	**0.017**	**1.7E-02**	**ND**	**0.16**	

Notes:

cDCE - cis-dichloroethene
TCE - trichloroethene
mmoles - millimoles
mg/L - milligrams per liter
mmoles/bottle - millimoles per bottle
ND - not detected
VC - vinyl chloride

TABLE 3: SUMMARY OF MICROCOSM ANION RESULTS
NP5 OU2, Geosyntec

Treatment	Date	Day	Treatment Replicate	Bottle #	Total VFAs	Chloride	Nitrite-N	Nitrate-N	Sulfate	Phosphate
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Anaerobic Sterile Control	28-Jun-13	0	ANSC-1	1	21	273	<0.09	14	13	0.67
			ANSC-2	2	20	290	<0.09	16	15	<0.07
			ANCS-3	3	21	311	<0.09	17	17	<0.07
			Average Concentration		**20**	**291**	**ND**	**16**	**15**	**0.67**
	12-Jul-13	14	ANSC-1	1	7	259	<0.09	13	15	<0.07
			ANSC-2	2	9	281	<0.09	15	18	<0.07
			ANCS-3	3	8	276	<0.09	15	16	<0.07
			Average Concentration		**8**	**272**	**ND**	**14**	**17**	**ND**
	6-Aug-13	39	ANSC-1	1	20	353	<0.09	17	23	<0.07
			ANSC-2	2	17	331	<0.09	17	21	<0.07
			ANCS-3	3	17	326	<0.09	17	21	<0.07
			Average Concentration		**18**	**337**	**ND**	**17**	**22**	**ND**
	17-Oct-13	111	ANSC-1	1	7.2	279	<0.09	12	18	<0.07
			ANSC-2	2	5.7	296	<0.09	13	19	<0.07
			ANCS-3	3	5.8	278	<0.09	12	18	<0.07
			Average Concentration		**6.2**	**284**	**ND**	**12**	**18**	**ND**
Anaerobic Active Control	28-Jun-13	0	ANAC-1	4	19	202	<0.09	0.76	14	<0.07
			ANAC-2	5	21	226	<0.09	0.70	15	<0.07
			ANAC-3	6	19	219	<0.09	0.81	13	<0.07
			Average Concentration		**20**	**216**	**ND**	**0.76**	**14**	**ND**
	12-Jul-13	14	ANAC-1	4	4.8	211	<0.09	1.2	17	<0.07
			ANAC-2	5	4.8	214	<0.09	1.1	19	<0.07
			ANAC-3	6	4.9	204	<0.09	1.1	16	<0.07
			Average Concentration		**4.9**	**210**	**ND**	**1.1**	**17**	**ND**
	6-Aug-13	39	ANAC-1	4	14	233	<0.09	0.25	21	<0.07
			ANAC-2	5	15	252	<0.09	0.39	23	<0.07
			ANAC-3	6	15	242	<0.09	0.37	22	<0.07
			Average Concentration		**15**	**242**	**ND**	**0.33**	**22**	**ND**
	17-Oct-13	111	ANAC-1	4	8.3	221	<0.09	0.11	22	<0.07
			ANAC-2	5	5.3	228	<0.09	0.066	20	<0.07
			ANAC-3	6	4.0	229	<0.09	0.12	20	<0.07
			Average Concentration		**5.9**	**226**	**ND**	**0.10**	**21**	**ND**
Newman Zone	28-Jun-13	0	NZ-1	7	76	184	<0.09	0.61	13	<0.07
			NZ-2	8	90	212	<0.09	0.66	15	<0.07
			NZ-3	9	93	219	0.22	0.96	17	<0.07
			Average Concentration		**86**	**205**	**0.07**	**0.74**	**15**	**ND**
	12-Jul-13	14	NZ-1	7	14	206	<0.09	0.97	11	<0.07
			NZ-2	8	12	199	<0.09	1.0	12	<0.07
			NZ-3	9	12	217	<0.09	1.0	15	<0.07
			Average Concentration		**13**	**207**	**ND**	**1.0**	**13**	**ND**
	23-Jul-13	25	NZ-1	7	12	228	<0.09	0.32	0.44	<0.07
			NZ-2	8	8.6	234	<0.09	0.11	0.28	<0.07
			NZ-3	9	8.5	213	<0.09	0.24	0.94	<0.07
			Average Concentration		**9.6**	**225**	**ND**	**0.22**	**0.55**	**ND**
	6-Aug-13	39	NZ-1	7	17	225	<0.09	0.35	0.83	<0.07
			NZ-2	8	19	246	<0.09	0.53	1.3	<0.07
			NZ-3	9	15	244	<0.09	0.23	0.75	<0.07
			Average Concentration		**17**	**238**	**ND**	**0.37**	**0.96**	**ND**
	17-Oct-13	111	NZ-1	7	24	225	<0.09	0.10	2.4	<0.07
			NZ-2	8	41	237	<0.09	<0.09	1.8	<0.07
			NZ-3	9	3.5	231	<0.09	<0.09	5.6	<0.07
			Average Concentration		**23**	**231**	**ND**	**0.035**	**3.3**	**ND**
Amended with Newman Zone and Buffered with NaHCO3.	28-Jun-13	0	NZ/buff-1	10	96	225	<0.09	0.68	16	<0.07
			NZ/buff-2	11	89	224	<0.09	0.74	17	<0.07
			NZ/buff-3	12	91	223	<0.09	0.67	16	<0.07
			Average Concentration		**92**	**224**	**ND**	**0.70**	**17**	**ND**
	12-Jul-13	14	NZ/buff-1	10	6.7	219	<0.09	1.0	15	<0.07
			NZ/buff-2	11	7.6	242	<0.09	1.1	30	<0.07
			NZ/buff-3	12	7.5	210	<0.09	1.6	15	<0.07
			Average Concentration		**7.3**	**224**	**ND**	**1.2**	**20**	**ND**
	23-Jul-13	25	NZ/buff-1	10	5.8	199	<0.09	0.11	10	<0.07
			NZ/buff-2	11	3.3	240	<0.09	0.11	24	<0.07
			NZ/buff-3	12	5.9	221	<0.09	0.25	11	<0.07
			Average Concentration		**5.0**	**220**	**ND**	**0.16**	**15**	**ND**
	6-Aug-13	39	NZ/buff-1	10	16	214	<0.09	0.26	15	<0.07
			NZ/buff-2	11	16	234	<0.09	0.37	23	<0.07
			NZ/buff-3	12	17	242	<0.09	0.39	14	<0.07
			Average Concentration		**16**	**230**	**ND**	**0.34**	**17**	**ND**
	17-Oct-13	111	NZ/buff-1	10	67	221	<0.09	<0.09	2.7	<0.07
			NZ/buff-2	11	45	216	<0.09	0.11	1.9	<0.07
			NZ/buff-3	12	29	231	<0.09	<0.09	1.8	<0.07
			Average Concentration		**47**	**223**	**ND**	**0.036**	**2.1**	**ND**
Amended with Newman Zone, Buffered with NaHCO3 and Bioaugmented with KB-1®.	28-Jun-13	0	NZ/buff/KB-1-1	13	89	214	<0.09	0.62	17	<0.07
			NZ/buff/KB-1-2	14	91	223	<0.09	0.73	17	<0.07
			NZ/buff/KB-1-3	15	91	220	<0.09	0.70	17	<0.07
			Average Concentration		**90**	**219**	**ND**	**0.69**	**17**	**ND**
	12-Jul-13	14	NZ/buff/KB-1-1	13	9.2	204	<0.09	1.1	15	<0.07
			NZ/buff/KB-1-2	14	11	200	<0.09	1.0	15	<0.07
			NZ/buff/KB-1-3	15	11	204	<0.09	1.1	16	<0.07
			Average Concentration		**10**	**203**	**ND**	**1.0**	**15**	**ND**
	23-Jul-13	25	NZ/buff/KB-1-1	13	5.8	236	<0.09	0.10	13	<0.07
			NZ/buff/KB-1-2	14	6.6	221	<0.09	0.70	8.5	<0.07
			NZ/buff/KB-1-3	15	8.0	246	<0.09	2.1	19	<0.07
			Average Concentration		**6.8**	**234**	**ND**	**1.0**	**13**	**ND**
	30-Jul-13	32	NZ/buff/KB-1-1	13	36	233	<0.09	<0.09	22	<0.07
			NZ/buff/KB-1-2	14	36	225	<0.09	<0.09	14	<0.07
			NZ/buff/KB-1-3	15	36	226	<0.09	<0.09	17	<0.07
			Average Concentration		**36**	**228**	**ND**	**ND**	**18**	**ND**
	6-Aug-13	39	NZ/buff/KB-1-1	13	18	199	<0.09	0.29	17	<0.07
			NZ/buff/KB-1-2	14	17	238	<0.09	0.24	8.4	<0.07
			NZ/buff/KB-1-3	15	14	238	<0.09	0.26	18	<0.07
			Average Concentration		**16**	**225**	**ND**	**0.26**	**15**	**ND**
	17-Oct-13	111	NZ/buff/KB-1-1	13	148	243	<0.09	<0.09	1.0	<0.07
			NZ/buff/KB-1-2	14	242	250	<0.09	<0.09	2.0	<0.07
			NZ/buff/KB-1-3	15	175	242	<0.09	0.12	2.5	<0.07
			Average Concentration		**188**	**245**	**ND**	**0.039**	**1.8**	**ND**

Notes:
VFAs - total volatile fatty acids, calibrated as lactate but may include other VFAs such as formate, acetate, propionate, pyruvate and butyrate
< - compound not detected, the associated value is the detection limit
mg/L - milligrams per litre
ND - not detected
- number

TABLE 4: SUMMARY OF MICROCOSM VFA RESULTS

NP5 OU2, Geosyntec

Treatment	Date	Day	Treatment Replicate	Bottle number	Lactate mg/L	Acetate mg/L	Propionate mg/L	Formate mg/L	Butyrate mg/L	Pyruvate mg/L
Newman Zone	28-Jun-13	0	NZ-1	7	67	1.8	<0.31	0.43	<0.41	<0.69
			NZ-2	8	72	1.6	<0.31	0.49	<0.41	<0.69
			NZ-3	9	71	1.8	<0.31	0.76	<0.41	<0.69
			Average Concentration		**70**	**1.7**	**ND**	**0.56**	**ND**	**ND**
	6-Aug-13	39	NZ-1	7	<0.39	1.4	<0.31	0.37	<0.41	<0.69
			NZ-2	8	<0.39	1.7	<0.31	0.43	<0.41	<0.69
			NZ-3	9	<0.39	<0.54	<0.31	0.39	<0.41	<0.69
			Average Concentration		**ND**	**1.0**	**ND**	**0.40**	**ND**	**ND**
	17-Oct-13	111	NZ-1	7	<0.39	24	<0.31	<0.22	5.5	<0.69
			NZ-2	8	<0.39	51	<0.31	<0.22	3.6	<0.69
			NZ-3	9	<0.39	4.2	<0.31	<0.22	3.6	<0.69
			Average Concentration		**ND**	**26**	**ND**	**ND**	**4.3**	**ND**
Amended with Newman Zone and Buffered with NaHCO3.	28-Jun-13	0	NZ/buff-1	10	75	1.6	<0.31	0.49	<0.41	<0.69
			NZ/buff-2	11	64	1.6	<0.31	0.43	<0.41	<0.69
			NZ/buff-3	12	72	1.7	<0.31	0.49	0.43	<0.69
			Average Concentration		**70**	**1.6**	**ND**	**0.47**	**0.14**	**ND**
	6-Aug-13	39	NZ/buff-1	10	<0.39	<0.54	<0.31	0.41	<0.41	<0.69
			NZ/buff-2	11	<0.39	<0.54	<0.31	0.43	<0.41	<0.69
			NZ/buff-3	12	<0.39	<0.54	<0.31	0.45	<0.41	<0.69
			Average Concentration		**ND**	**ND**	**ND**	**0.43**	**ND**	**ND**
	17-Oct-13	111	NZ/buff-1	10	<0.39	77.9	0.51	1.5	3.1	<0.69
			NZ/buff-2	11	<0.39	44.8	4.8	<0.22	<0.41	<0.69
			NZ/buff-3	12	<0.39	31.2	<0.31	1.6	0.75	<0.69
			Average Concentration		**ND**	**51**	**1.8**	**1.0**	**1.3**	**ND**
Amended with Newman Zone, Buffered with NaHCO3 and Bioaugmented with KB-1®.	28-Jun-13	0	NZ/buff/KB-1-1	13	77	2.1	<0.31	0.64	<0.41	<0.69
			NZ/buff/KB-1-2	14	81	2.0	<0.31	0.61	<0.41	<0.69
			NZ/buff/KB-1-3	15	79	2.8	<0.31	0.87	<0.41	<0.69
			Average Concentration		**79**	**2.3**	**ND**	**0.71**	**ND**	**ND**
	6-Aug-13	39	NZ/buff/KB-1-1	13	<0.39	<0.54	<0.31	0.45	<0.41	<0.69
			NZ/buff/KB-1-2	14	<0.39	<0.54	<0.31	0.42	<0.41	<0.69
			NZ/buff/KB-1-3	15	<0.39	<0.54	<0.31	33	<0.41	<0.69
			Average Concentration		**ND**	**ND**	**ND**	**11**	**ND**	**ND**
	17-Oct-13	111	NZ/buff/KB-1-1	13	<0.39	163	1.2	1.1	6.0	<0.69
			NZ/buff/KB-1-2	14	<0.39	215	1.7	1.9	<0.41	<0.69
			NZ/buff/KB-1-3	15	<0.39	188	2.4	1.8	9.5	<0.69
			Average Concentration		**ND**	**189**	**1.8**	**1.6**	**4.7**	**ND**

Notes:

mg/L - milligrams per liter
ND - not detected
< - compound not detected, the associated value is the detection limit

TABLE 5: SUMMARY OF MICROCOSM pH RESULTS
NP5 OU2, Geosyntec

Treatment	Date	Day	Treatment Replicate	Bottle #	pH
Anaerobic Sterile Control	28-Jun-13	0	ANSC-1	1	5.98
			ANSC-2	2	5.71
			ANCS-3	3	5.66
			Average		**5.78**
	12-Jul-13	14	ANSC-1	1	5.88
			ANSC-2	2	5.82
			ANCS-3	3	5.80
			Average		**5.83**
	6-Aug-13	39	ANSC-1	1	6.23
			ANSC-2	2	6.28
			ANCS-3	3	6.24
			Average		**6.25**
	17-Oct-13	111	ANSC-1	1	6.27
			ANSC-2	2	6.17
			ANCS-3	3	6.24
			Average		**6.23**
Anaerobic Active Control	28-Jun-13	0	ANAC-1	4	5.71
			ANAC-2	5	5.66
			ANAC-3	6	5.71
			Average		**5.69**
	12-Jul-13	14	ANAC-1	4	5.90
			ANAC-2	5	5.91
			ANAC-3	6	5.91
			Average		**5.91**
	6-Aug-13	39	ANAC-1	4	6.28
			ANAC-2	5	6.24
			ANAC-3	6	6.32
			Average		**6.28**
	17-Sep-13	81	ANAC-1	4	6.27
			ANAC-2	5	6.26
			ANAC-3	6	6.25
			Average		**6.26**
	17-Oct-13	111	ANAC-1	4	6.31
			ANAC-2	5	6.33
			ANAC-3	6	6.30
			Average		**6.31**
Newman Zone	28-Jun-13	0	NZ-1	7	5.71
			NZ-2	8	5.70
			NZ-3	9	5.68
			Average		**5.70**
	12-Jul-13	14	NZ-1	7	6.22
			NZ-2	8	6.28
			NZ-3	9	6.31
			Average		**6.27**
	23-Jul-13	25	NZ-1	7	6.78
			NZ-2	8	6.89
			NZ-3	9	6.85
			Average		**6.84**
	6-Aug-13	39	NZ-1	7	6.54
			NZ-2	8	6.57
			NZ-3	9	6.60
			Average		**6.57**
	27-Aug-13	60	3DME-1	7	6.75
			3DME-2	8	6.78
			3DME-3	9	6.74
			Average		**6.76**
	17-Oct-13	111	3DME-1	7	6.65
			3DME-2	8	6.69
			3DME-3	9	6.62
			Average		**6.65**
Amended with Newman Zone and Buffered with NaHCO3.	28-Jun-13 Start	0	NZ/buff-1	10	5.73
			NZ/buff-2	11	5.71
			NZ/buff-3	12	5.78
			Average		**5.74**
	Amended with 1.0 mL saturated $NaHCO_3$				
	28-Jun-13 End	0	NZ/buff-1	10	6.79
			NZ/buff-2	11	6.83
			NZ/buff-3	12	6.91
			Average		**6.84**
	5-Jul-13 start	7	NZ/buff-1	10	6.75
			NZ/buff-2	11	--
			NZ/buff-3	12	--
			Average		**--**
	Amended with 0.25 mL saturated $NaHCO_3$				
	5-Jul-13 End	7	NZ/buff-1	10	6.93
			NZ/buff-2	11	6.88
			NZ/buff-3	12	6.81
			Average		**6.87**
	12-Jul-13 start	14	NZ/buff-1	10	6.73
			NZ/buff-2	11	6.74
			NZ/buff-3	12	6.75
			Average		**6.74**
	Amended with 0.25 mL saturated $NaHCO_3$				
	12-Jul-13 End	14	NZ/buff-1	10	6.91
			NZ/buff-2	11	6.89
			NZ/buff-3	12	6.98
			Average		**6.93**
	23-Jul-13	25	NZ/buff-1	10	7.05
			NZ/buff-2	11	7.04
			NZ/buff-3	12	7.09
			Average		**7.06**
	6-Aug-13	39	NZ/buff-1	10	6.82
			NZ/buff-2	11	6.86
			NZ/buff-3	12	6.94
			Average		**6.87**
	27-Aug-13	60	NZ/buff-1	10	6.79
			NZ/buff-2	11	6.80
			NZ/buff-3	12	6.78
			Average		**6.79**
	17-Oct-13	111	NZ/buff-1	10	6.88
			NZ/buff-2	11	6.89
			NZ/buff-3	12	6.95
			Average		**6.91**

TABLE 5: SUMMARY OF MICROCOSM pH RESULTS
NP5 OU2, Geosyntec

Treatment	Date	Day	Treatment Replicate	Bottle #	pH
Amended with Newman Zone, Buffered with NaHCO3 and Bioaugmented with KB-1®.	28-Jun-13 Start	0	NZ/buff/KB-1-1	13	5.75
			NZ/buff/KB-1-2	14	5.71
			NZ/buff/KB-1-3	15	5.75
			Average		**5.74**
	Amended with 1.0 mL saturated $NaHCO_3$				
	28-Jun-13 End	0	NZ/buff/KB-1-1	13	7.02
			NZ/buff/KB-1-2	14	6.92
			NZ/buff/KB-1-3	15	6.98
			Average		**6.97**
	Amended with 0.25 mL saturated $NaHCO_3$				
	5-Jul-13	7	NZ/buff/KB-1-1	13	6.92
			NZ/buff/KB-1-2	14	6.93
			NZ/buff/KB-1-3	15	6.91
			Average		**6.92**
	12-Jul-13 start	14	NZ/buff/KB-1-1	13	6.75
			NZ/buff/KB-1-2	14	6.76
			NZ/buff/KB-1-3	15	6.75
			Average		**6.75**
	Amended with 0.25 mL saturated $NaHCO_3$				
	12-Jul-13 end	14	NZ/buff/KB-1-1	13	6.97
			NZ/buff/KB-1-2	14	6.94
			NZ/buff/KB-1-3	15	6.96
			Average		**6.96**
	23-Jul-13	25	NZ/buff/KB-1-1	13	7.09
			NZ/buff/KB-1-2	14	7.09
			NZ/buff/KB-1-3	15	7.04
			Average		**7.07**
	6-Aug-13	39	NZ/buff/KB-1-1	13	6.92
			NZ/buff/KB-1-2	14	6.91
			NZ/buff/KB-1-3	15	6.98
			Average		**6.94**
	27-Aug-13	60	NZ/buff/KB-1-1	13	6.9
			NZ/buff/KB-1-2	14	6.89
			NZ/buff/KB-1-3	15	6.88
			Average		**6.89**
	17-Sep-13	81	NZ/buff/KB-1-1	13	6.78
			NZ/buff/KB-1-2	14	6.77
			NZ/buff/KB-1-3	15	6.77
			Average		**6.77**
	17-Oct-13	111	NZ/buff/KB-1-1	13	6.86
			NZ/buff/KB-1-2	14	6.85
			NZ/buff/KB-1-3	15	6.87
			Average		**6.86**

Notes:
$NaHCO_3$ - Sodium Biocarbonate

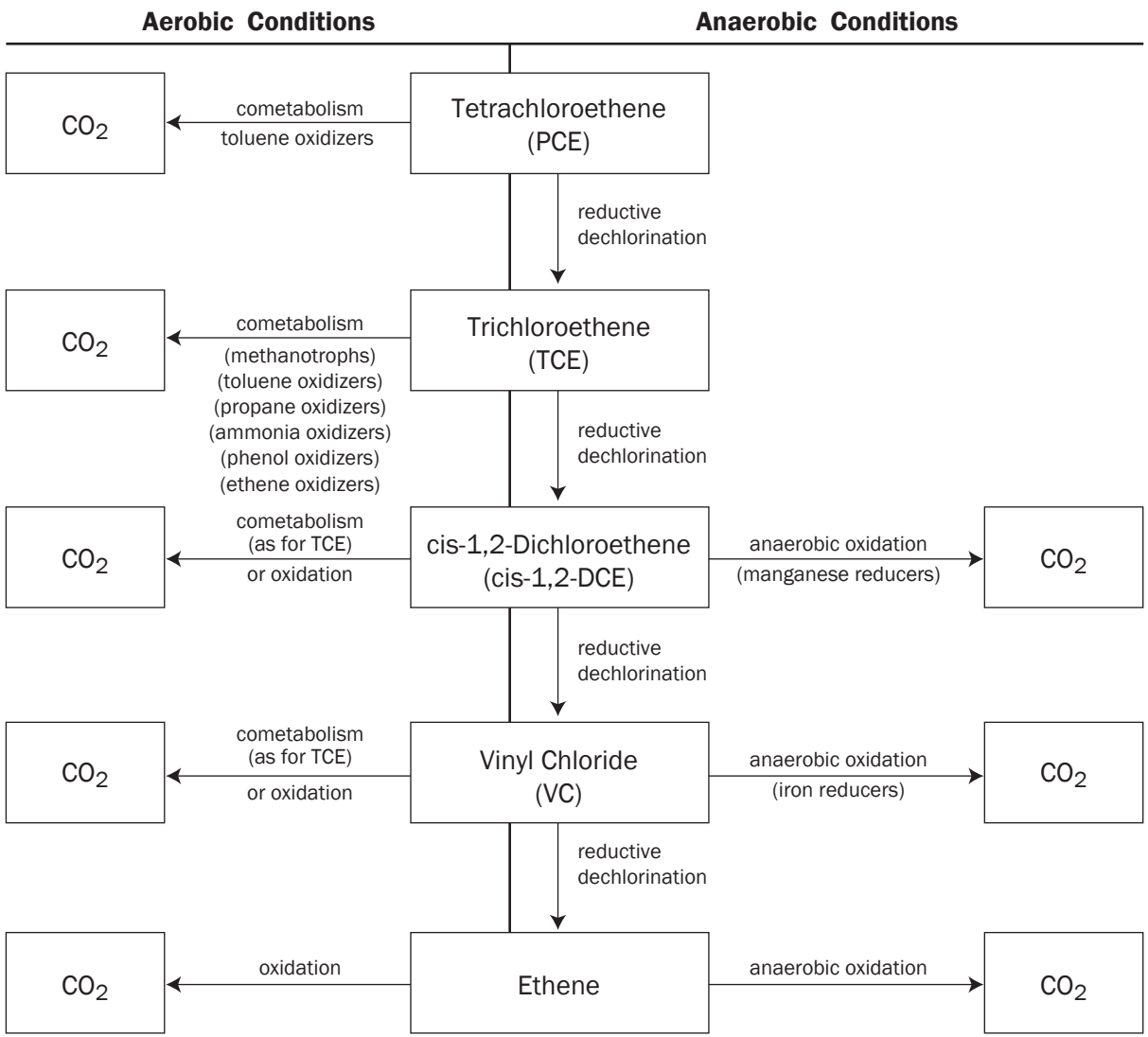
TABLE 6: SUMMARY OF GENE-TRAC RESULTS
NP5 OU2, Colmar, PA

		gene copies per liter			
Sample/Treatment ID	**Date**	**Dhc**	**qualifier**	**vcrA**	**qualifier**
Baseline GW	6/17/2013	6.30E+03	U, I	NA	
Anaerobic active control	10/18/2013	4.00E+04	J	9.00E+04	U, C
Newman Zone & Buffer	10/18/2013	3.00E+08		7.00E+07	
Newman Zone, Buffer & Bioaugmentation	10/18/2013	3.00E+09		3.00E+09	

Notes: C - Correction factor applied to correct for non-specific PCR amplification products, value is an estimated quantity.
I - Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
J - The associated value is an estimated quantity between the method detection limit and quantitation limit.
NA - Not applicable as vcrA not detected and/or quantifiable DNA not extracted from the sample.
U - Not detected, associated value is the quantification limit.

AR101640

FIGURES



Pathways for the Degradation of Chlorinated Ethenes

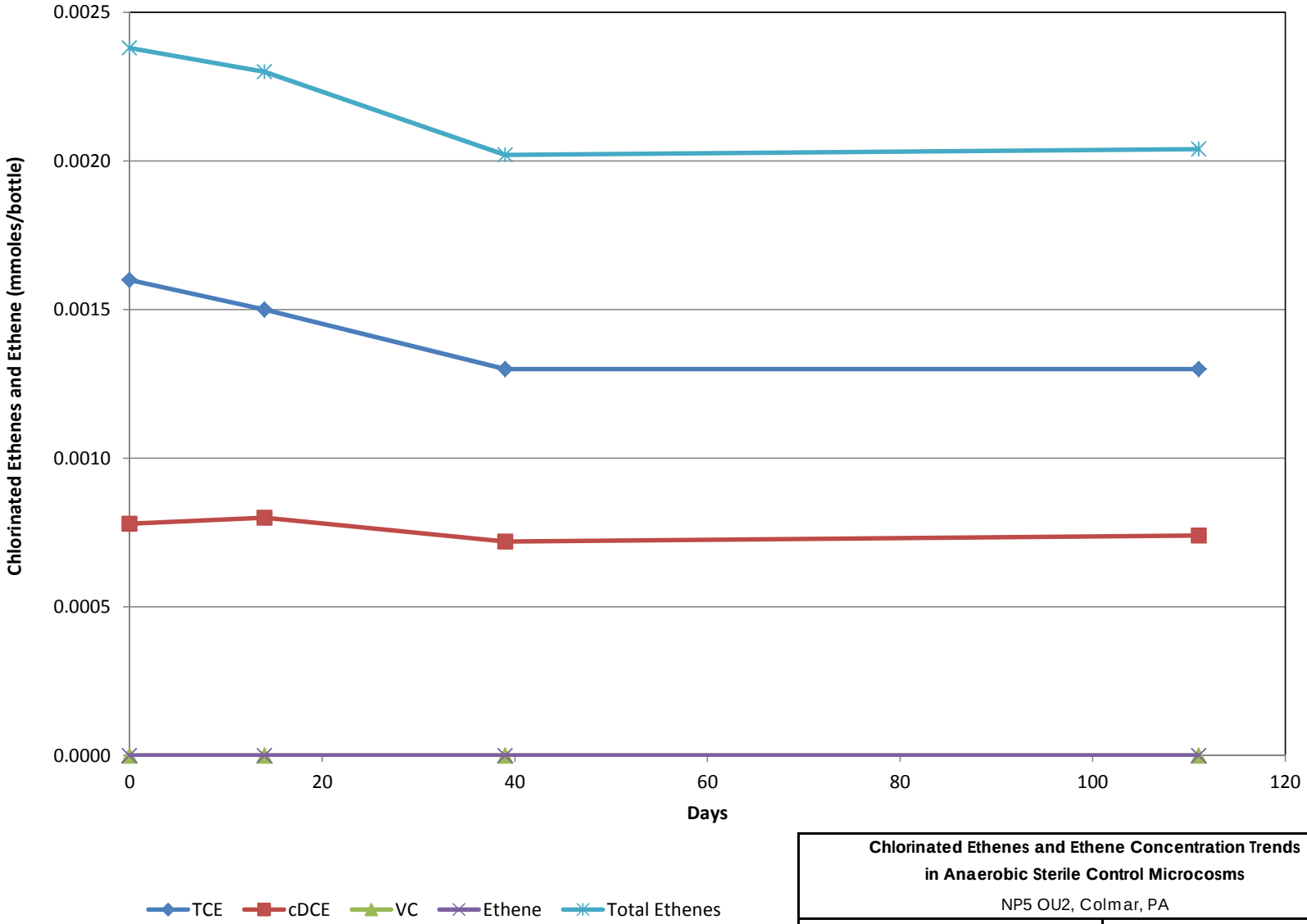
SiREM

30-Sept-13

Figure: **1**

AR101642

pathways_chlorinated ethenes.ai



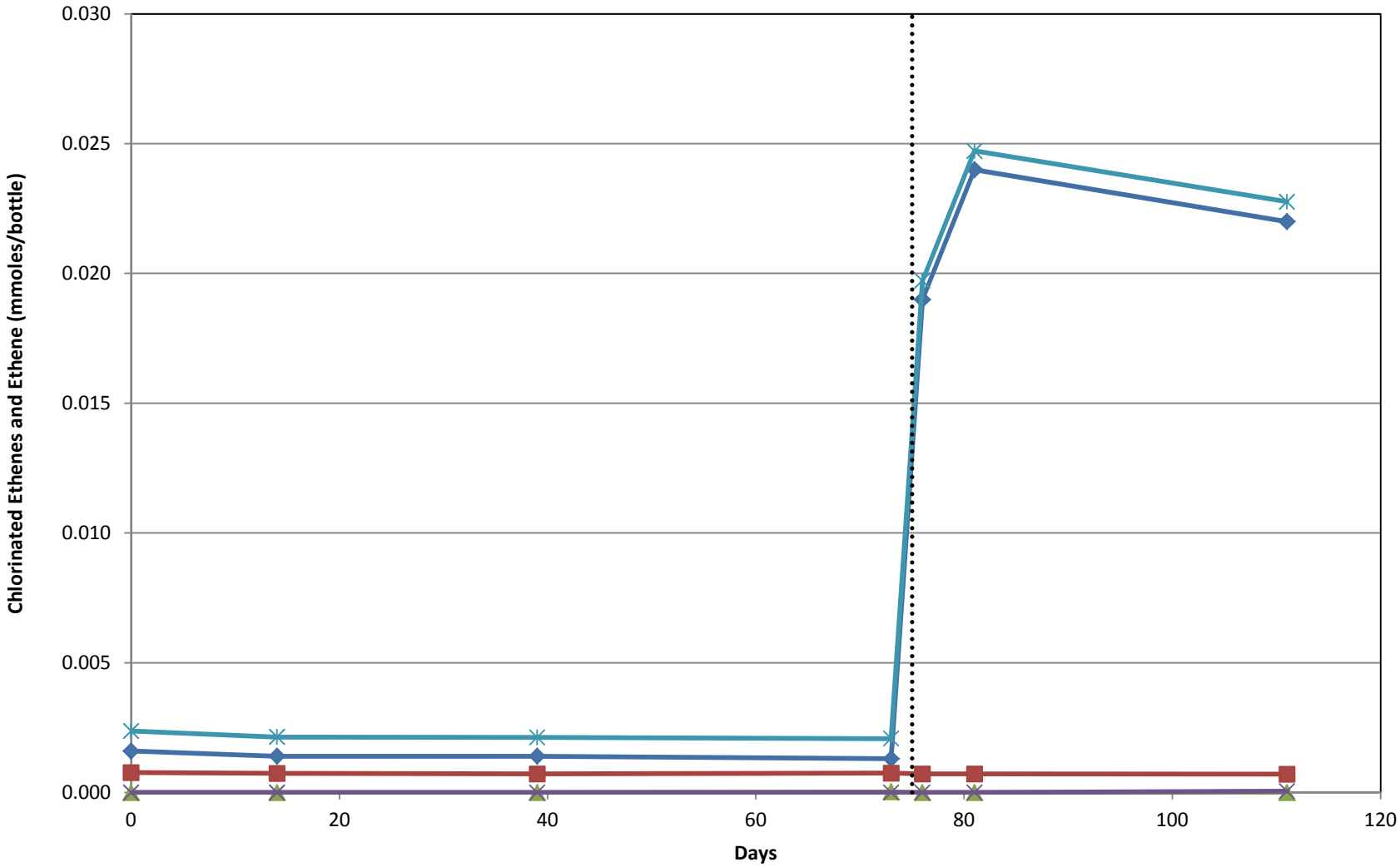
Chlorinated Ethenes and Ethene Concentration Trends in Anaerobic Sterile Control Microcosms

NP5 OU2, Colmar, PA

SiREM

30-Sep-13

Figure: **2**



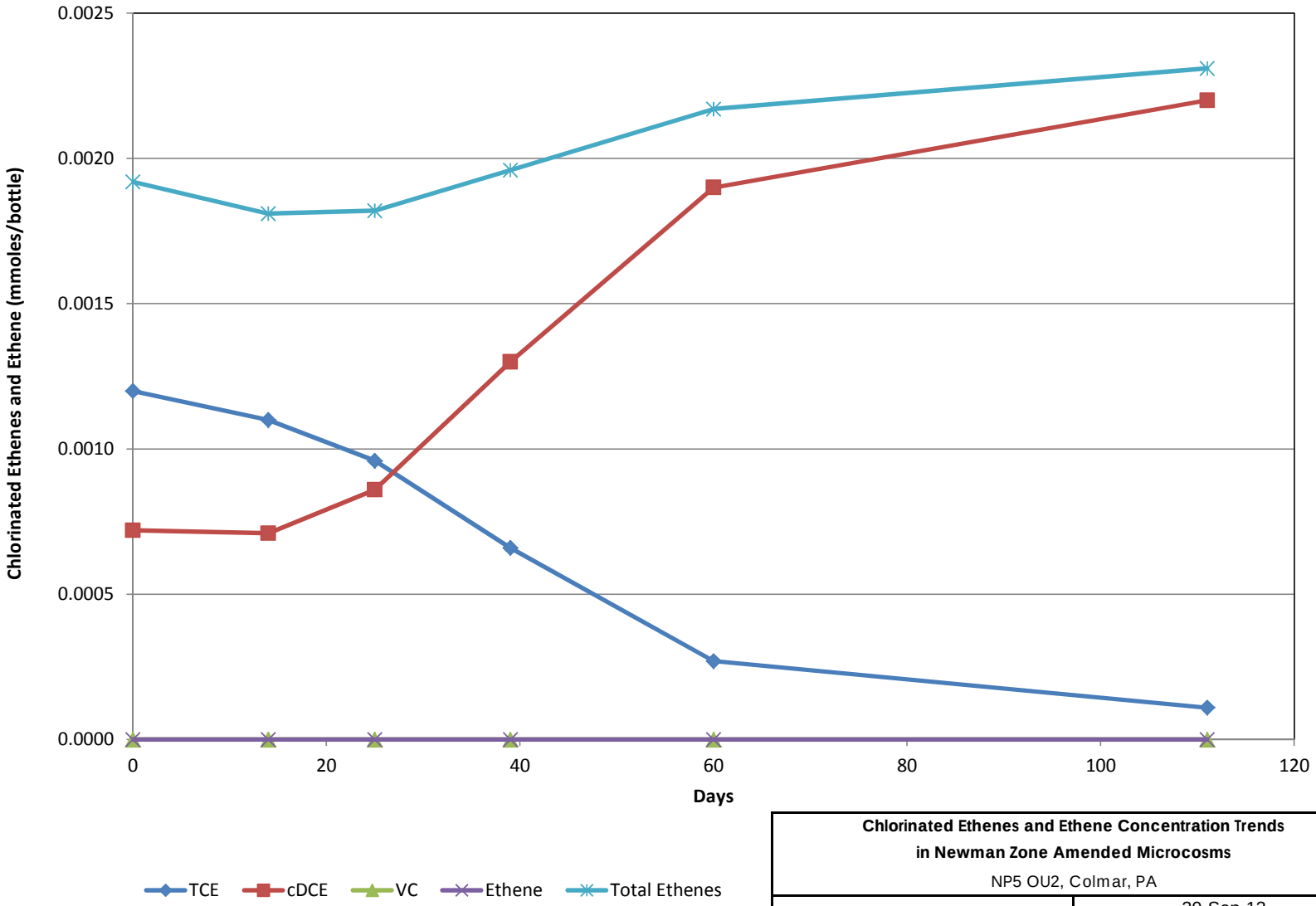
Chlorinated Ethenes and Ethene Concentration Trends in Anaerobic Active Control Microcosms

NP5 OU2, Colmar, PA

SiREM

30-Sep-13

Figure: **3**



Chlorinated Ethenes and Ethene Concentration Trends in Newman Zone Amended Microcosms

NP5 OU2, Colmar, PA

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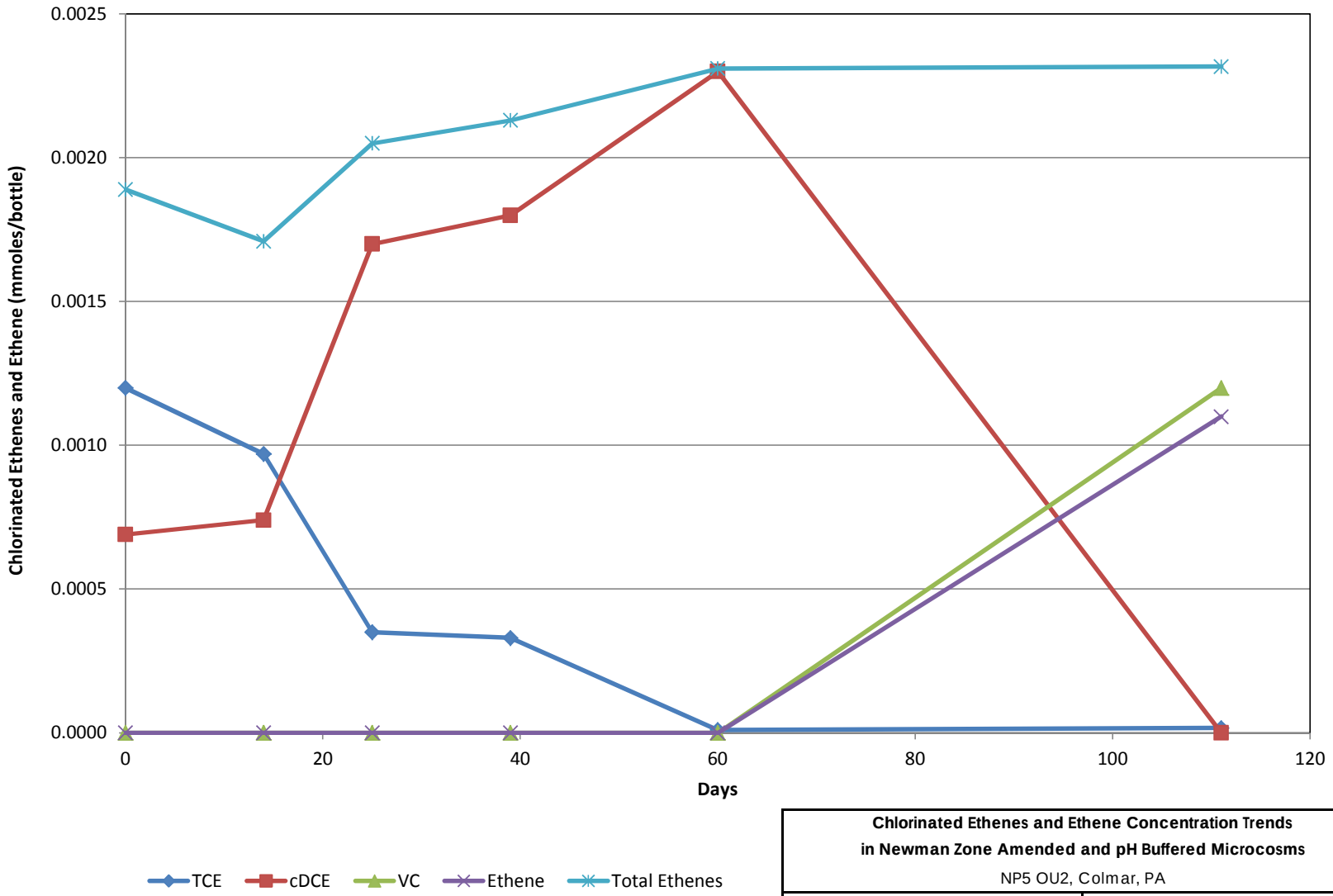
30-Sep-13

Figure: **4**



Chlorinated Ethenes and Ethene Concentration Trends in Newman Zone Amended and pH Buffered Microcosms

NP5 OU2, Colmar, PA

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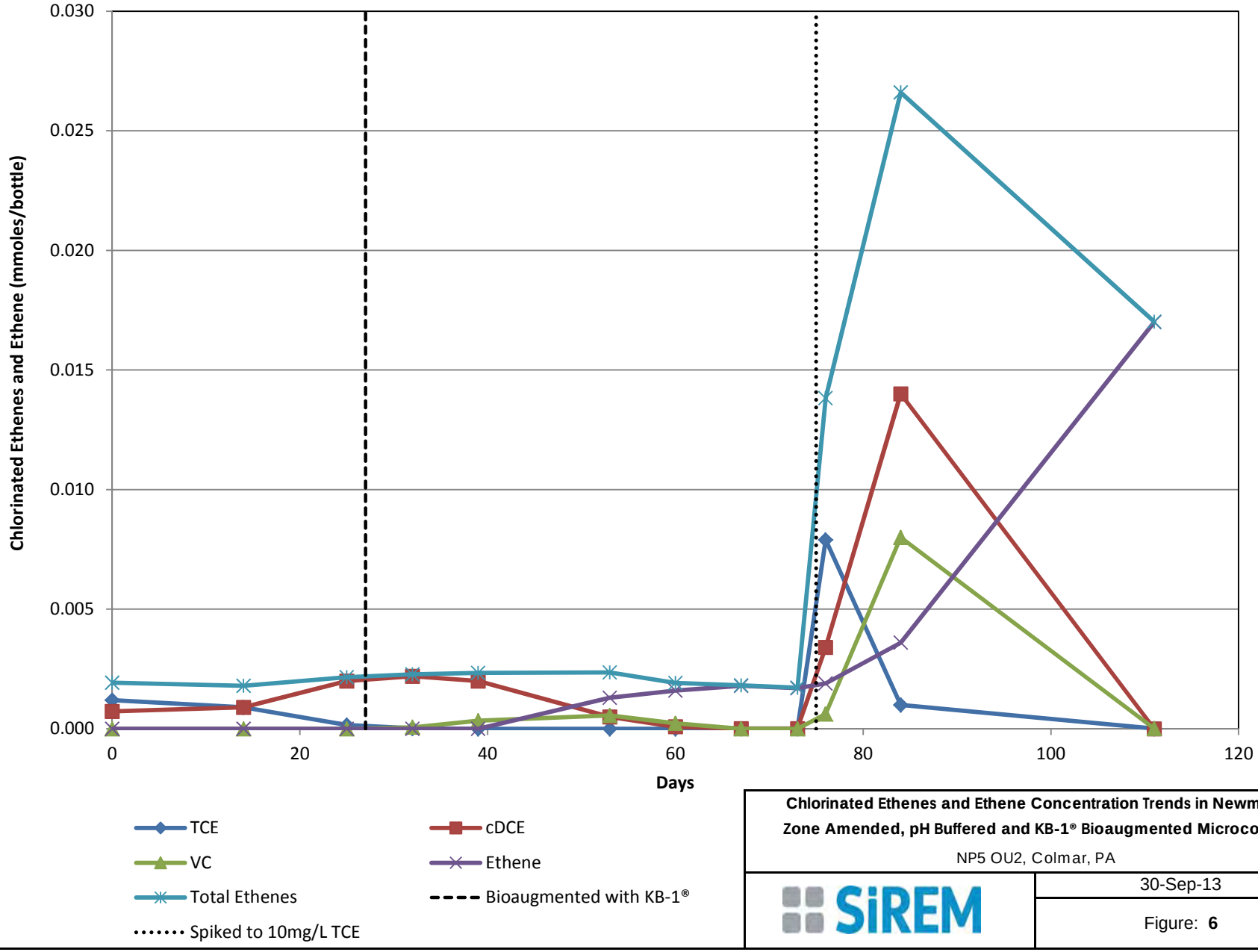
30-Sep-13

Figure: **5**



Chlorinated Ethenes and Ethene Concentration Trends in Newman Zone Amended, pH Buffered and KB-1® Bioaugmented Microcosms

NP5 OU2, Colmar, PA

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30-Sep-13

Figure: **6**

APPENDIX A: Chain of Custody Documentation

№ 2423

SiREM
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Chain-of-Custody Form

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www.siremlab.com

Page 1 of 1

Lab # S-2814

Project Name	NorthPenn 5 OU2
Project #	PH0013.08
Project Manager	D. Tomlinson / M. Mirigliano
Email Address	dtomlinson@geosyntec.com / mmirigliano@geosyntec.com
Company	Geosyntec Consultants
Address	1787 Sentry Pkwy West Bldg 18, Ste 120 Blue Bell, PA
Phone #	267 464 2800
Fax #	
Sampler's Signature	M. Mirigliano
Sampler's Printed Name	Michelle Mirigliano

Analysis

Preservative Key
0. None
1. HCl
2. Other
3. Other

Customer Sample ID	Sampling Date	Sampling Time	Matrix	# of Containers	Gene-Trac Dhc	Gene-Trac VC	Gene-Trac Dhb	Treatability	Other Information
TW01/TW18	6/17/13	0830	SO	10				X	Soil for EISB study
TW01/TW18	6/17/13	1000	GW	2	X	X	X	X	B-00277

Cooler Condition:	Sample Receipt: GOOD
Cooler Temperature:	10°C
Custody Seals:	Yes ☑ No ☐

Billing Information	
P.O. #	PH0013.08
Bill To:	Derek Tomlinson

Turnaround Time Requested
Normal ☒
Rush ☐

For Lab Use Only
Proposal #:

Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature: M. Mirigliano	Signature: Danielle Mayer	Signature:	Signature:	Signature:	Signature:
Printed Name: M. Mirigliano	Printed Name: DANIELLE MAYER	Printed Name:	Printed Name:	Printed Name:	Printed Name:
Firm: Geosyntec	Firm: SiREM LAB	Firm:	Firm:	Firm:	Firm:
Date/Time: 6/17/13 1600	Date/Time: JUNE 19/2013 3:15	Date/Time:	Date/Time:	Date/Time:	Date/Time:

AR101649

Distribution: White - Return to Originator: Yellow - Lab Copy: Pink - Retained by Client

APPENDIX B: Henry's Law Calculation

The following Henry's Law calculation was used to convert aqueous concentrations (Table 2A) to total mmoles of each analyte per microcosm bottle (Figures 3 to 6):

$$\text{Total mmoles} = \frac{C_{liq} \times (V_{liq} + H \times V_{gas})}{\text{Molecular Weight (mg/mmol)}}$$

Where

C_{liq} = liquid concentration (mg/L)
V_{liq} = liquid volume (0.225 L) per bottle
V_{gas} = headspace volume (0.025 L) per bottle
H = Henry's Law constant (dimensionless)

The Henry's Law constants used are summarized in the table below.

Analyte	Henry's Law Constant [a] (dimensionless)
Trichloroethene	0.48
cis-1,2-dichloroethene	0.31
1,1-dichloroethene	1.04
Vinyl chloride	0.95
Ethene	8.76
1,1,1-trichlorolethane	1.13
1,1-dichloroethane	0.23
chloroethane	0.48
Ethane	20.42
Methane	27.2

[a] Source: Montgomery, J.H. 2000. *Groundwater Chemicals Desk Reference, Third Edition.* CRC Press LLC, Boca Raton, FL.

Appendix C: GeneTrac® Reports

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130 Research Lane, Ste 2
Guelph ON N1G 5G3
(519) 822-2265

Certificate of Analysis: Gene-Trac® *Dehalococcoides* Assay

Customer: Derek Tomlinson & Michelle Mirigliano, Geosyntec Consultants

SiREM Reference: S-2874

Project: North Penn 5 OU2

Report Date: 2-Jul-13

Customer Reference: PH0013.08

Data Files: MyiQ-DHC-QPCR-1020
MyiQ-DB-DHC-QPCR-0386
DHC-UP-0753

Table 1a: Test Results

Customer Sample ID	SiREM Sample ID	Sample Collection Date	Sample Matrix	Percent Dhc *	*Dehalococcoides* Enumeration/Liter **
TW01/TW18	DHC-9432	17-Jun-13	Groundwater	NA	6×10^3 U, I

Notes:

* Percent *Dehalococcoides* (Dhc) in microbial population. This value is calculated by dividing the number of Dhc 16S ribosomal ribonucleic acid (rRNA) gene copies by the total number of bacteria as estimated by the mass of DNA extracted from the sample. Range represents normal variation in Dhc enumeration.

** Based on quantitation of Dhc 16S rRNA gene copies. Dhc are generally reported to contain one 16S rRNA gene copy per cell; therefore, this number is often interpreted to represent the number of Dhc cells present in the sample.

J The associated value is an estimated quantity between the method detection limit and quantitation limit.
U Not detected, associated value is the quantitation limit.
B Analyte was also detected in the method blank.
NA Not applicable as *Dehalococcoides* not detected and/or quantifiable DNA not extracted from the sample.
I Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
E Extracted genomic DNA was not detected in the sample.

Analyst: Jen Wilkinson
Jen Wilkinson
Senior Laboratory Technician

Approved: Ximena Druar
Ximena Druar, B.Sc.
Genetic Testing Coordinator

SiREM
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130 Research Lane, Ste 2
Guelph ON N1G 5G3
(519) 822-2265

Certificate of Analysis: Gene-Trac® *Dehalobacter* Assay

Customer: Derek Tomlinson & Michelle Mirigliano, Geosyntec Consultants

SiREM Reference: S-2874

Project: North Penn 5 OU2

Report Date: 2-Jul-13

Customer Reference: PH0013.08

Data Files: iQ5-DHB-QPCR-0248
iQ-DB-DHB-QPCR-0067

Table 1b: Test Results

Customer Sample ID	SiREM Sample ID	Sample Collection Date	Sample Matrix	Percent Dhb*	*Dehalobacter* 16S rRNA Gene Copies/Liter
TW01/TW18	DHB-0806	17-Jun-13	Groundwater	NA	6×10^3 U, I

Notes:

* Percent Dehalobacter (Dhb) in microbial population. This value is calculated by dividing the number of Dhb 16S ribosomal ribonucleic acid (rRNA) gene copies by the total number of bacteria as estimated by the mass of DNA extracted from the sample. Range represents normal variation in Dhb enumeration.

J The associated value is an estimated quantity between the method detection limit and quantitation limit.
U Not detected, associated value is the quantitation limit.
B Analyte was also detected in the method blank.
NA Not applicable as *Dehalobacter* not detected and/or quantifiable DNA not extracted from the sample.
I Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
E Extracted genomic DNA was not detected in the sample.

Analyst: Jen Wilkinson
Jen Wilkinson
Senior Laboratory Technician

Approved: Ximena Druar
Ximena Druar, B.Sc.
Genetic Testing Coordinator

Table 2: Detailed Test Parameters, Test Reference S-2874

Customer Sample ID	TW01/TW18
SiREM Dhc Sample ID	DHC-9432
SiREM Dhb Sample ID	DHB-0806
Date Received	19-Jun-13
Sample Temperature	10 ºC
Filtration Date	20-Jun-13
Volume Used for DNA Extraction	200 mL
DNA Extraction Date	21-Jun-13
DNA Concentration in Sample (extractable)	3289 ng/L
PCR Amplifiable DNA	ND
Dhc qPCR Date Analyzed	26-Jun-13
Dhb qPCR Date Analyzed	26-Jun-13
qPCR Controls (see Tables 3 & 4)	Passed
Comments	Sample not tested for *vcrA* as it was ND for Dhc.

Notes:

Refer to Tables 3 & 4 for detailed results of controls.
°C = degrees Celsius
Dhb = *Dehalobacter*
Dhc = *Dehalococcoides*
PCR = polymerase chain reaction
qPCR = quantitative PCR
ng/L = nanograms per liter
mL = milliliters
DNA = Deoxyribonucleic acid

Table 3: Gene-Trac Dhc Control Results, Test Reference S-2874

Laboratory Control	Analysis Date	Control Description	Spiked Dhc 16S rRNA Gene Copies per Liter	Recovered Dhc 16S rRNA Gene Copies per Liter	Comments
Positive Control Low Concentration	26-Jun-13	qPCR with KB1 genomic DNA (CSLD-0658)	8.4×10^4	1.2×10^5	- -
Positive Control High Concentration	26-Jun-13	qPCR with KB1 genomic DNA (CSHD-0658)	1.2×10^7	1.7×10^7	- -
DNA Extraction Blank	26-Jun-13	DNA extraction sterile water (FB-1968)	0	2.6×10^3 U	- -
Negative Control	26-Jun-13	Tris Reagent Blank (TBD-0617)	0	2.6×10^3 U	- -

Notes:

Dhc = *Dehalococcoides*

DNA = Deoxyribonucleic acid

qPCR = quantitative PCR

16S rRNA = 16S ribosomal ribonucleic acid

U Not detected, associated value is the quantitation limit.

Table 4: Gene-Trac Dhb Control Results, Test Reference S-2874

Laboratory Control	Analysis Date	Control Description	Spiked Dhb 16S rRNA Gene Copies per Liter	Recovered Dhb 16S rRNA Gene Copies per Liter	Comments
Positive Control Low Concentration	26-Jun-13	qPCR with ACT3 genomic DNA (CSLDB-0208)	1.3×10^5	1.2×10^5	- -
Positive Control High Concentration	26-Jun-13	qPCR with ACT3 genomic DNA (CSHDB-0208)	1.3×10^7	1.6×10^7	- -
DNA Extraction Blank	26-Jun-13	DNA extraction sterile water (FB-1968)	0	2.6×10^3 U	- -
Negative Control	26-Jun-13	Tris Reagent Blank	0	2.6×10^3 U	- -

Notes:

qPCR = quantitative PCR

Dhb = *Dehalobacter*

DNA = Deoxyribonucleic acid

16S rRNA = 16S ribosomal ribonucleic acid

U Not detected, associated value is the quantitation limit.

№ 2423

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Chain-of-Custody Form

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www.siremlab.com

Page 1 of 1

Lab # S-2814

Project Name: NorthPenn 5 OU2
Project #: PH0013.08
Project Manager: D. Tomlinson / M. Mirigliano
Email Address: dtomlinson@geosyntec.com / mmirigliano@geosyntec.com
Company: Geosyntec Consultants
Address: 1787 Sentry Pkwy West Bldg 18, Ste 120 Blue Bell, PA
Phone #: 267 464 2800
Fax #:
Sampler's Signature: M. Mirigliano
Sampler's Printed Name: Michelle Mirigliano

Analysis

Preservative Key: 0. None; 1. HCl; 2. Other ____; 3. Other ____

Customer Sample ID	Sampling Date	Sampling Time	Matrix	# of Containers	Gene-Trac Dhc	Gene-Trac VC	Gene-Trac Dhb	Treatability	Other Information
TW01/TW18	6/17/13	0830	SO	10				X	Soil for EISB study
TW01/TW18	6/17/13	1000	GW	2	X	X	X	X	B-00277

Cooler Condition: GOOD
Cooler Temperature: 10°C
Custody Seals: Yes ☑ No ☐

Billing Information
P.O. #: PH0013.08
Bill To: Derek Tomlinson

Turnaround Time Requested
Normal ☒
Rush ☐

For Lab Use Only
Proposal #: ____

Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature: M. Mirigliano	Signature: Danielle Mayer	Signature:	Signature:	Signature:	Signature:
Printed Name: M. Mirigliano	Printed Name: DANIELLE MAYER	Printed Name:	Printed Name:	Printed Name:	Printed Name:
Firm: Geosyntec	Firm: SiREM LAB	Firm:	Firm:	Firm:	Firm:
Date/Time: 6/17/13 1600	Date/Time: JUNE 19/2013 3:15	Date/Time:	Date/Time:	Date/Time:	Date/Time:

Distribution: White - Return to Originator: Yellow - Lab Copy: Pink - Retained by Client

AR101658

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Guelph ON N1G 5G3
(519) 822-2265

Certificate of Analysis: Gene-Trac® *Dehalococcoides* Assay

Customer: Derek Tomlinson, Geosyntec Consultants
Project: NP5 OU2
Customer Reference: S-2891

SiREM Reference: S-2998
Report Date: 30-Oct-13
Data Files: iQ5-DHC-QPCR-1048
iQ5-DB-DHC-QPCR-0413

Table 1a: Test Results

Customer Sample ID	SiREM Sample ID	Sample Collection Date	Sample Matrix	Percent Dhc *	*Dehalococcoides* Enumeration/Liter **
NP5-ANAC-181013	DHC-9736	18-Oct-13	Microcosm	0.0004 - 0.001 %	4×10^4 J
NP5-NZB-181013	DHC-9737	18-Oct-13	Microcosm	2 - 5 %	3×10^8
NP5-NZBK-181017	DHC-9738	18-Oct-13	Microcosm	18 - 45 %	3×10^9

Notes:

* Percent *Dehalococcoides* (Dhc) in microbial population. This value is calculated by dividing the number of Dhc 16S ribosomal ribonucleic acid (rRNA) gene copies by the total number of bacteria as estimated by the mass of DNA extracted from the sample. Range represents normal variation in Dhc enumeration.

** Based on quantification of Dhc 16S rRNA gene copies. Dhc are generally reported to contain one 16S rRNA gene copy per cell; therefore, this number is often interpreted to represent the number of Dhc cells present in the sample.

J The associated value is an estimated quantity between the method detection limit and quantitation limit.
U Not detected, associated value is the quantification limit.
B Analyte was also detected in the method blank.
NA Not applicable as *Dehalococcoides* not detected and/or quantifiable DNA not extracted from the sample.
I Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
E Extracted genomic DNA was not detected in sample.

Analyst: J. Wilkinson
Jennifer Wilkinson
Senior Laboratory Technician

Approved: Ximena Druar
Ximena Druar, B.Sc.
Genetic Testing Coordinator

SiREM
Leading Science · Lasting Solutions

130 Research Lane, Ste 2
Guelph ON N1G 5G3
(519) 822-2265

Certificate of Analysis: Gene-Trac® VC, Vinyl Chloride Reductase (*vcrA*) Assay

Customer: Derek Tomlinson, Geosyntec Consultants
Project: NP5 OU2
Customer Reference: S-2891

SiREM Reference: S-2998
Report Date: 30-Oct-13
Data Files: iQ5-VC-QPCR-0595
VC-QPCR-check-gel-0610
iQ5-DB-VC-QPCR-0321

Table 1b: Test Results

Customer Sample ID	SiREM Sample ID	Sample Collection Date	Sample Matrix	Percent *vcrA* *	Vinyl Chloride Reductase (*vcrA*) Gene Copies/Liter
NP5-ANAC-181013	VCR-4236	18-Oct-13	Microcosm	NA	9×10^4 U,C
NP5-NZB-181013	VCR-4237	18-Oct-13	Microcosm	0.5 - 1 %	7×10^7
NP5-NZBK-181017	VCR-4238	18-Oct-13	Microcosm	17 - 42 %	3×10^9

Notes:

* Percent *vcrA* in microbial population. This value is calculated by dividing the number of vinyl chloride reductase A (*vcrA)* gene copies quantified by the total number of bacteria estimated to be in the sample based on the mass of DNA extracted from the sample. Range represents normal variation in enumeration of *vcrA*.

J The associated value is an estimated quantity between the method detection limit and quantitation limit.
U Not detected, associated value is the quantification limit.
B Analyte was also detected in the method blank.
NA Not applicable as *vcrA* not detected and/or quantifiable DNA not extracted from the sample.
I Sample inhibited the test reaction based on inability to PCR amplify extracted DNA with universal primers.
C Correction factor applied to correct for non-specific PCR amplification products, value is an estimated quantity.

Analyst: J. Wilkinson
Jennifer Wilkinson
Senior Laboratory Technician

Approved: Ximena Druar
Ximena Druar, B.Sc.
Genetic Testing Coordinator

Table 2: Detailed Test Parameters, Gene-Trac Test Reference S-2998

Customer Sample ID	NP5-ANAC-181013	NP5-NZB-181013	NP5-NZBK-181017
SiREM Dhc Sample ID	DHC-9736	DHC-9737	DHC-9738
SiREM *vcrA* Sample ID	VCR-4236	VCR-4237	VCR-4238
Date Received	18-Oct-13	18-Oct-13	18-Oct-13
Sample Temperature	NA	NA	NA
Filtration Date	22-Oct-13	22-Oct-13	22-Oct-13
Volume Used for DNA Extraction	15 mL	15 mL	15 mL
DNA Extraction Date	24-Oct-13	24-Oct-13	24-Oct-13
DNA Concentration in Sample (extractable)	8400 ng/L	29100 ng/L	30550 ng/L
PCR Amplifiable DNA	Detected	Detected	Detected
Dhc qPCR Date Analyzed	25-Oct-13	25-Oct-13	25-Oct-13
***vcrA* qPCR Date Analyzed**	28-Oct-13	28-Oct-13	28-Oct-13
Laboratory Controls (see Tables 3 & 4)	Passed	Passed	Passed
Comments	- -	- -	- -

Notes:

Refer to Tables 3 & 4 for detailed results of controls.
°C = degrees Celsius
DNA = Deoxyribonucleic acid
NA = not applicable
PCR = polymerase chain reaction
qPCR = quantitative PCR
Dhc = *Dehalococcoides*
ng/L = nanograms per liter
mL = milliliters
vcrA = vinyl chloride reductase

Table 3: Gene-Trac Dhc Control Results, Test Reference S-2998

Laboratory Control	Analysis Date	Control Description	Spiked Dhc 16S rRNA Gene Copies per Liter	Recovered Dhc 16S rRNA Gene Copies per Liter	Comments
Positive Control Low Concentration	25-Oct-13	qPCR with KB1 genomic DNA (CSLD-0686)	1.1×10^5	1.0×10^5	--
Positive Control High Concentration	25-Oct-13	qPCR with KB1 genomic DNA (CSHD-0686)	1.4×10^7	9.3×10^6	--
DNA Extraction Blank	25-Oct-13	DNA extraction sterile water (FB-2049)	0	2.6×10^3 U	--
Negative Control	25-Oct-13	Tris Reagent Blank (TBD-0645)	0	2.6×10^3 U	--

Notes:

Dhc = *Dehalococcoides*

DNA = Deoxyribonucleic acid

qPCR = quantitative PCR

16S rRNA = 16S ribosomal ribonucleic acid

U Not detected, associated value is the quantification limit.

Table 4: Gene-Trac VC Control Results, Test Reference S-2998

Laboratory Control	Analysis Date	Control Description	Spiked *vcrA* reductase Gene Copies per Liter	Recovered *vcrA* reductase Gene Copies per Liter	Comments
Positive Control Low Concentration	28-Oct-13	qPCR with KB1 genomic DNA (CSLV-0463)	1.0×10^5	8.2×10^4	--
Positive Control High Concentration	28-Oct-13	qPCR with KB1 genomic DNA (CSHV-0463)	1.3×10^7	1.1×10^7	--
DNA Extraction Blank	28-Oct-13	DNA extraction sterile water (FB-2049)	0	2.6×10^3 U	--
Negative Control	28-Oct-13	Tris Reagent Blank (TBV-0434)	0	2.6×10^3 U	--

Notes:

DNA = Deoxyribonucleic acid

qPCR = quantitative PCR

16S rRNA = 16S ribosomal ribonucleic acid

U Not detected, associated value is the quantification limit.

vcrA = vinyl chloride reductase

APPENDIX H
Preliminary Remedial Design Drawings

Sheet 1: Title Sheet

Sheet 2: Site Plan – Existing Features

Sheet 3: Site Plan – EISB Application

Sheet 4: Process Flow Diagram

Sheet 5: EISB System Equipment Layout

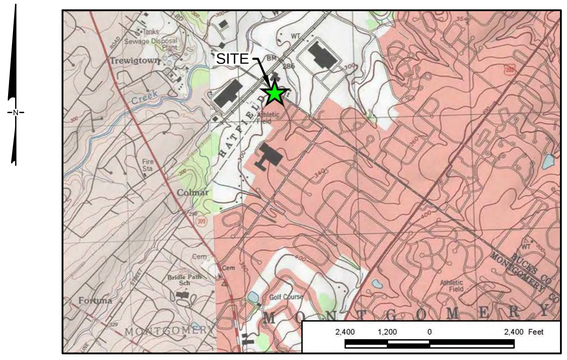
Sheet 6: EISB Trench Details

Sheet 7: Well Construction Details

PRELIMINARY REMEDIAL DESIGN
60% DESIGN SUBMITTAL

OPERABLE UNIT 2
NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

NOVEMBER 2013



VICINITY MAP

LIST OF DRAWINGS

DRAWING No.	DESCRIPTION
1	COVER SHEET
2	SITE PLAN - EXISTING FEATURES
3	SITE PLAN - EISB APPLICATION
4	PROCESS FLOW/PIPING AND INSTRUMENTATION DIAGRAM
5	EISB SYSTEM EQUIPMENT LAYOUT
6	EISB TRENCH DETAILS
7	WELL CONSTRUCTION DETAILS

PREPARED FOR:

STABILUS, INC.
1201 TULIP DRIVE
GASTONIA, NC 28052

PREPARED BY: Geosyntec consultants

1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

DRAFT 60% DESIGN DRAWINGS

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: COVER SHEET

PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-001
REVIEWED BY:		DRAWING NO.:	1 OF 7
APPROVED BY:			

SIGNATURE

DATE

AR101665

LEGEND

- BOUNDARY LINE
- RIGHT OF WAY LINE
- EASEMENT LINE
- EXISTING TREELINE
- WELL LOCATION (NON-OVERBURDEN)
- WELL LOCATION (OVERBURDEN)
- GROUNDWATER SAMPLING LOCATION (OVERBURDEN)
- GROUNDWATER SAMPLING LOCATION (OVERBURDEN)/ TEMPORARY WELL LOCATION
- GROUNDWATER SAMPLING LOCATION (OVERBURDEN)/ TEMPORARY WELL LOCATION & SOIL BORING LOCATION

NOTES:

1. WELL LOCATIONS AND SITE BOUNDARIES SURVEYED ON 7/11/2013 AND 9/17/2013, PROVIDED BY DENNIS W. SKLAR, PLS, LICENSE NO. SUO75154. HORIZONTAL DATUM: PENNSYLVANIA STATE PLANE SOUTH, NAD 83. VERTICAL DATUM: NAVD 88.

0 60' 120'
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: SITE PLAN - EXISTING FEATURES

PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-002
REVIEWED BY:		DRAWING NO.:	2 OF 7
APPROVED BY:			

SIGNATURE

DATE

DRAFT 60% DESIGN DRAWINGS

1 / 3 PLAN
PHASE I EISB TRENCH AREA
SCALE: 1" = 20'

DRAFT 60% DESIGN DRAWINGS

LEGEND

- BOUNDARY LINE
- RIGHT OF WAY LINE
- EASEMENT LINE
- EXISTING TREELINE
- WELL LOCATION (NON-OVERBURDEN)
- WELL LOCATION (OVERBURDEN)
- GROUNDWATER SAMPLING LOCATION (OVERBURDEN)
- GROUNDWATER SAMPLING LOCATION (OVERBURDEN)/ TEMPORARY WELL LOCATION
- GROUNDWATER SAMPLING LOCATION (OVERBURDEN)/ TEMPORARY WELL LOCATION & SOIL BORING LOCATION
- TCE CONTOURS
- CDCE CONTOURS
- BEDROCK TROUGH
- ABOVE GROUND FLEXIBLE HOSE/PIPE (PROPOSED)
- EISB PHASE I TRENCH (PROPOSED)
- EISB PHASE II TRENCH (PROPOSED)
- EISB APPLICATION WELL (PROPOSED)
- PERFORMANCE MONITORING WELL (OVERBURDEN) (PROPOSED)
- PERFORMANCE MONITORING WELL (SHALLOW/INTERMEDIATE BEDROCK) (PROPOSED)

NOTES:

1. PROPOSED REMEDIATION EQUIPMENT AREA LOCATED ON EXISTING ASPHALT AREA, CONSISTING OF FRAC TANK, AMENDMENT MIX TANK, AND PUMPS/CONTROLS/INSTRUMENTATION.
2. PHASE I TRENCH INSTALLED VIA TRADITIONAL EXCAVATION/BACKFILL METHODS.
3. PHASE II TRENCH INSTALLED VIA DEWIND ONE-PASS TECHNOLOGY.
4. PHASE II PERFORMANCE MONITORING WELL NETWORK WILL BE ESTABLISHED UPON RESULTS OF PHASE I EISB PERFORMANCE. PHASE II APPLICATION WELLS SHOWN AT 60-FOOT SPACING, BUT WILL BE ADJUSTED BASED ON RESULTS OF PHASE I IMPLEMENTATION.
5. WELL LOCATIONS AND SITE BOUNDARIES SURVEYED ON 7/11/2013 AND 9/17/2013, PROVIDED BY DENNIS W. SKLAR, PLS, LICENSE NO. SU075154. HORIZONTAL DATUM: PENNSYLVANIA STATE PLANE SOUTH, NAD 83. VERTICAL DATUM: NAVD 88.

0 60' 120'
SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: SITE PLAN - EISB APPLICATION

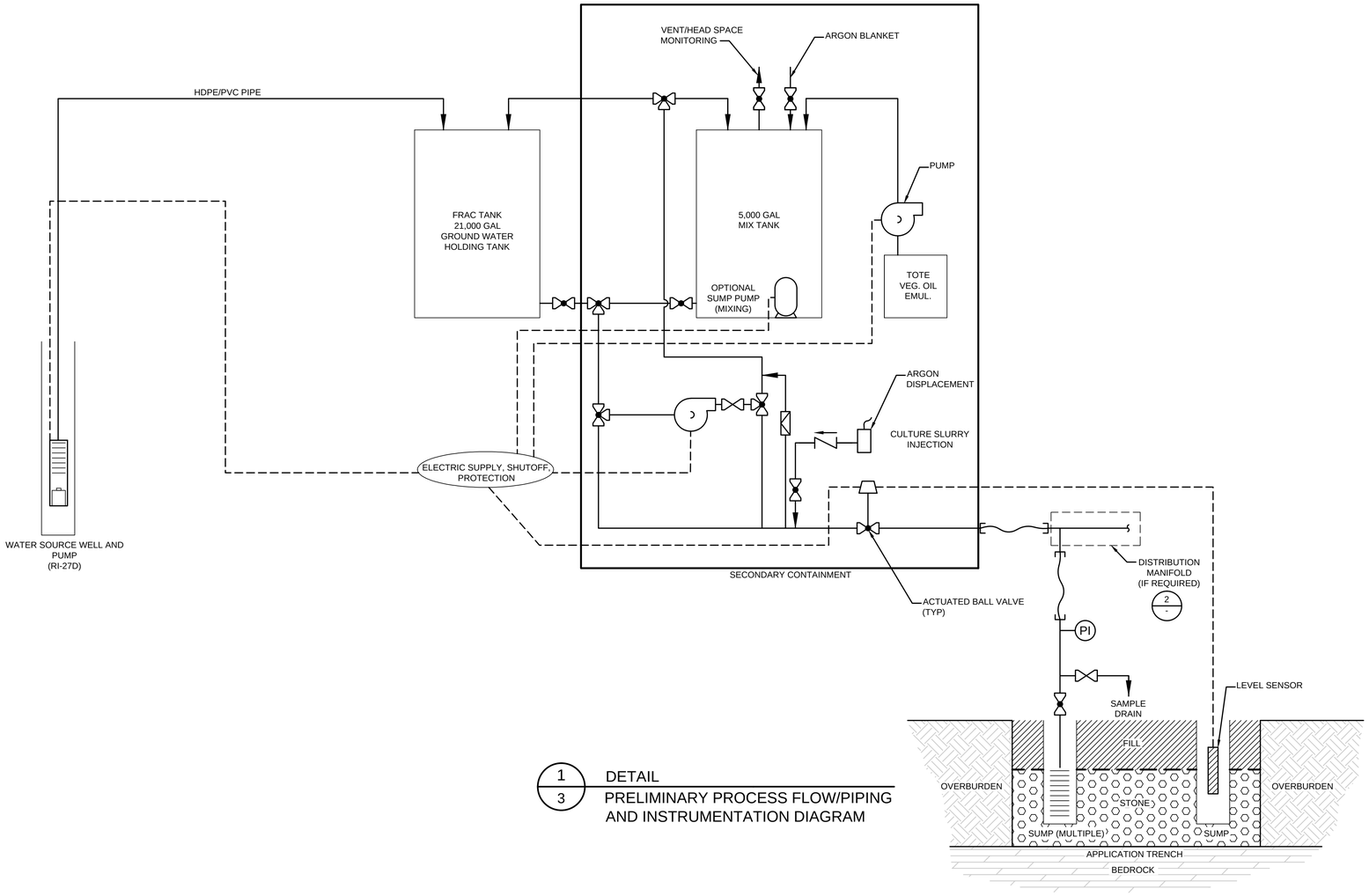
PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-003
REVIEWED BY:		DRAWING NO.:	3 OF 7
APPROVED BY:			

SIGNATURE

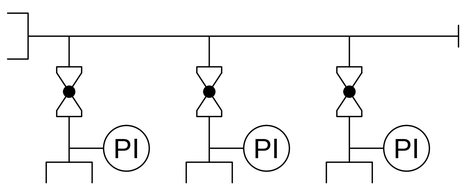
DATE



1/3 DETAIL
PRELIMINARY PROCESS FLOW/PIPING AND INSTRUMENTATION DIAGRAM

SYMBOL LEGEND

- BALL VALVE
- GATE VALVE
- CHECK VALVE
- PROCESS PIPE (PVC)
- ELECTRICAL/SIGNAL WIRE(S)
- PI — PRESSURE INDICATOR
- HOSE CONNECTION
- PUMP
- HOSE
- RUPTURE DISK



2/3 DETAIL
DISTRIBUTION MANIFOLD

DRAFT 60% DESIGN DRAWINGS

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: PROCESS FLOW/PIPING AND INSTRUMENTATION DIAGRAM

PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

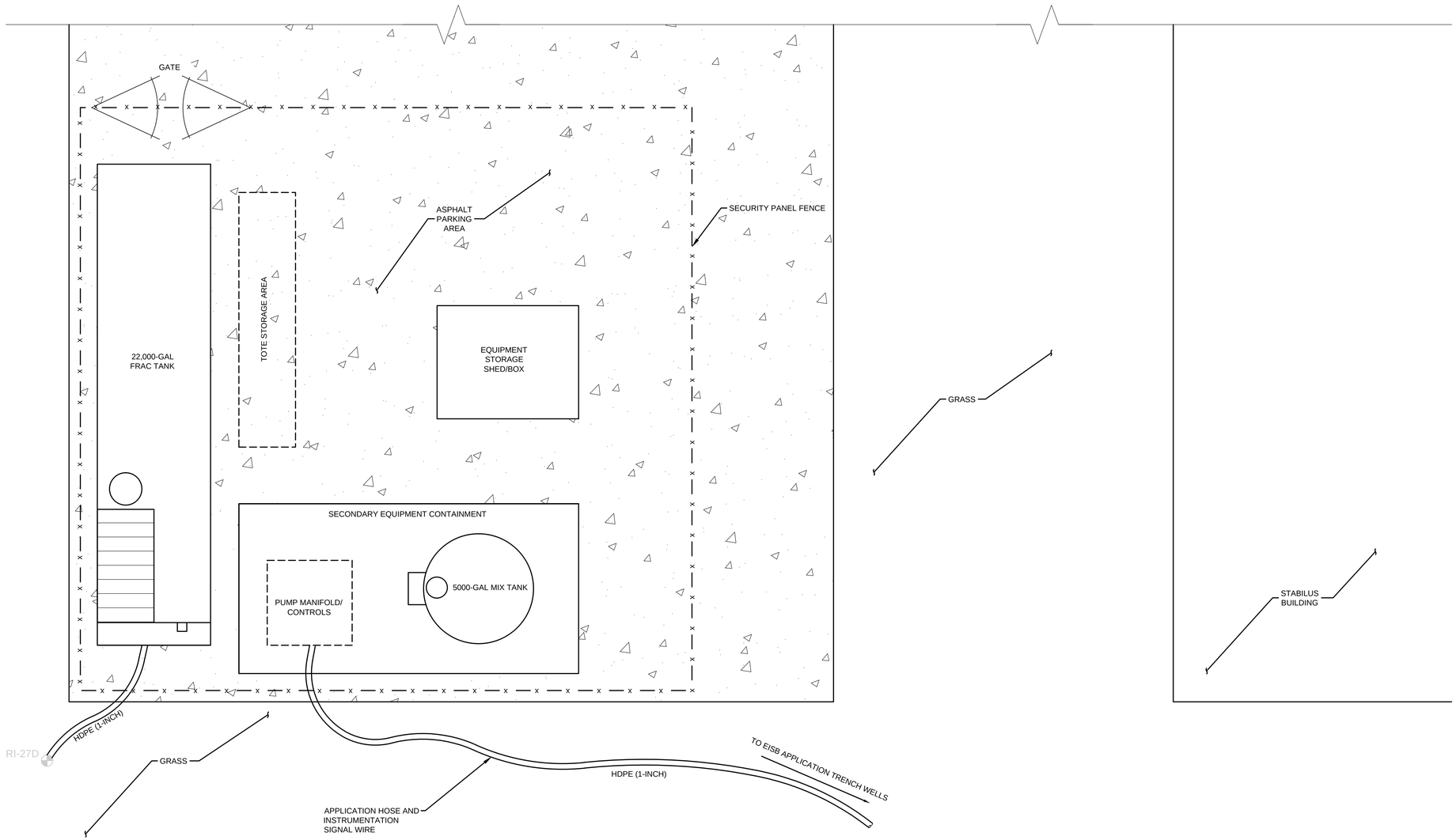
SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-004
REVIEWED BY:		DRAWING NO.:	4 OF 7
APPROVED BY:			

SIGNATURE

DATE

AR101668



1/3 DETAIL
PRELIMINARY EQUIPMENT LAYOUT

NOTES:

1. DESIGN ASSUMES THAT ELECTRICAL POWER SUPPLY IS AVAILABLE AND IN CLOSE PROXIMITY TO THE EQUIPMENT.

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: EISB SYSTEM EQUIPMENT LAYOUT

PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

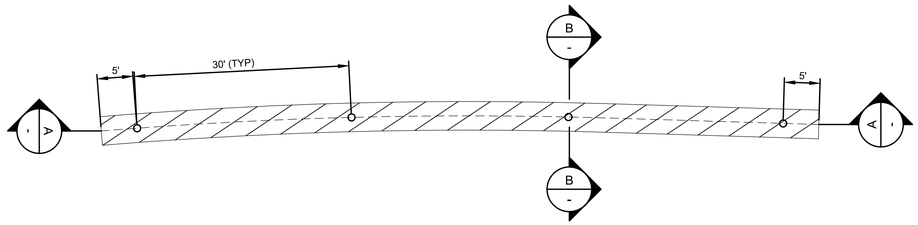
SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-006
REVIEWED BY:		DRAWING NO.:	5 OF 7
APPROVED BY:			

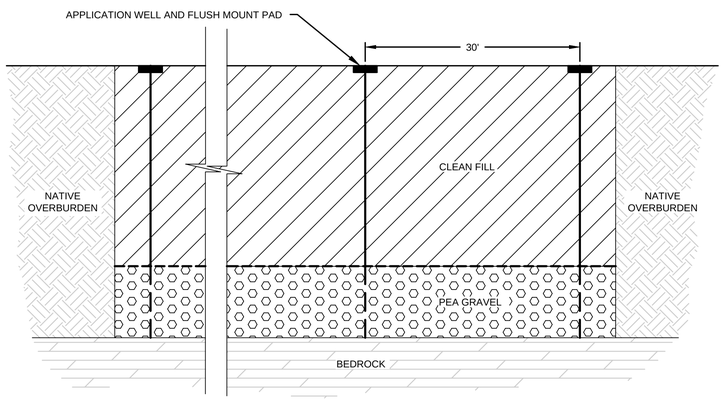
SIGNATURE

DATE

DRAFT 60% DESIGN DRAWINGS

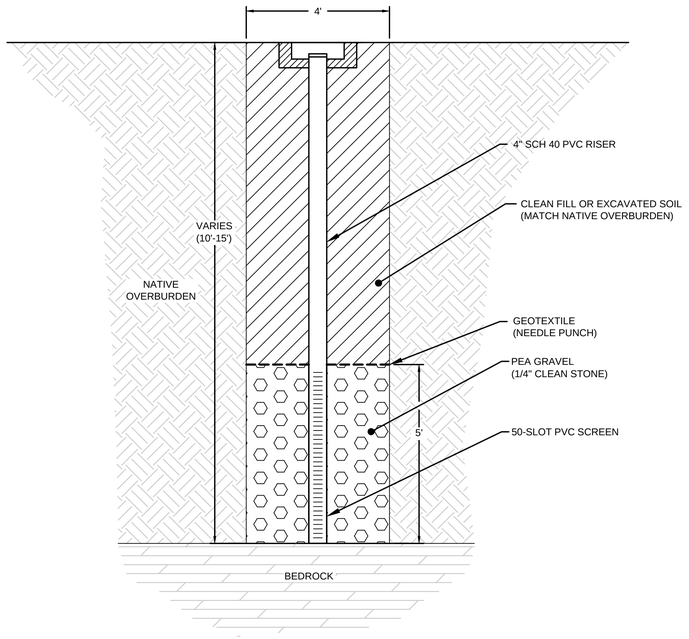


PLAN
SCALE: 1" = 10'

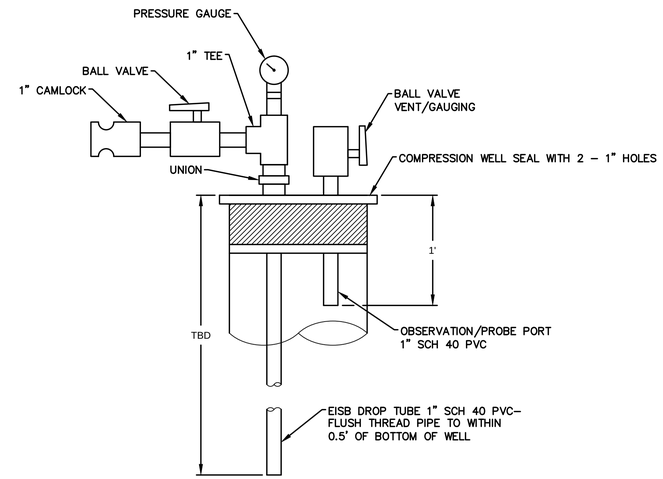


SECTION A
VERTICAL EXAGGERATION (2x)

1/3 DETAIL
PHASE I EISB APPLICATION TRENCH



SECTION B
SCALE: 1" = 4'



2/3 DETAIL
APPLICATION WELLHEAD

NOTES:

1. TOTAL DEPTH OF TRENCH WELLS VARY BASED ON ACTUAL DEPTH TO TOP OF BEDROCK.
2. DETAILS SHOWN SPECIFICALLY FOR PHASE I TRENCH. PHASE II TRENCH WILL BE INSTALLED WITH A ONE-PASS TRENCHER TECHNOLOGY TO SPECIFICATIONS SIMILAR TO THE PHASE I TRENCH.
3. PHASE I TRENCH WILL BE INSTALLED WITH EXCAVATOR.
4. TRENCH WILL BE INSTALLED TO DEPTH THAT REACHES COMPETENT BEDROCK BY SCOURING WEATHERED MATERIAL AT OVERBURDEN/BEDROCK INTERFACE.

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: EISB TRENCH DETAILS

PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

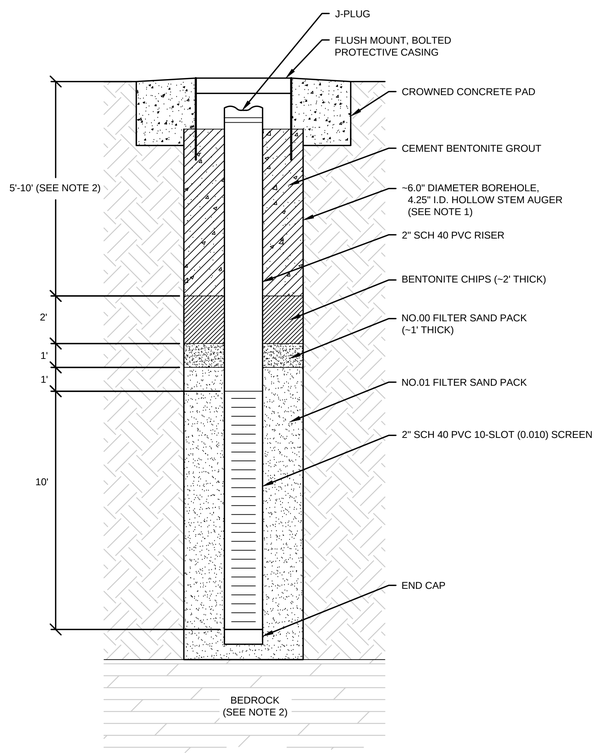
SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-007
REVIEWED BY:		DRAWING NO.:	6 OF 7
APPROVED BY:			

SIGNATURE

DATE

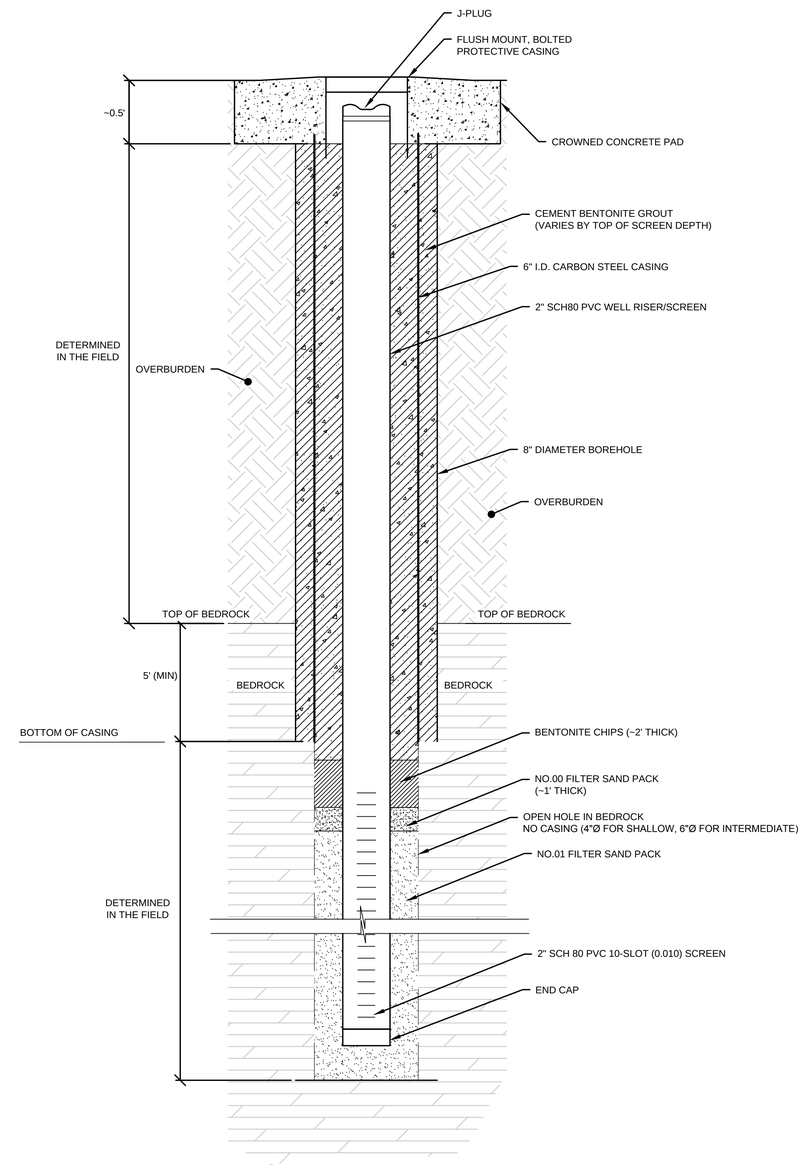
DRAFT 60% DESIGN DRAWINGS



NOTES:

1. ASSUMES WELL INSTALLATION VIA HOLLOW STEM AUGER. BOREHOLE DIAMETER MAY CHANGE IN ACCORDANCE WITH DRILLING METHOD.
2. OVERBURDEN WELLS TO BE INSTALLED AT BASE OF AQUIFER FOLLOWING REFUSAL OF THE DRILLING METHOD ON BEDROCK.

1/3 DETAIL
PERFORMANCE MONITORING WELL - OVERBURDEN



NOTES:

1. INTERMEDIATE BEDROCK WELL SCREENED INTERVAL WILL BE DETERMINED BY GEOPHYSICAL TESTING. BENTONITE GROUT AND FILTER PACK MAY BE INSTALLED AT DEPTH BELOW BOTTOM OF DESIGNATED SCREEN INTERVAL.

2/3 DETAIL
PERFORMANCE MONITORING WELL - SHALLOW/INTERMEDIATE BEDROCK

DRAFT 60% DESIGN DRAWINGS

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1787 SENTRY PARKWAY WEST BUILDING 18
SUITE 120 BLUE BELL, PA 19422-2200
PHONE: 267-464-2800

TITLE: WELL CONSTRUCTION DETAILS

PROJ: OPERABLE UNIT 2
PRELIMINARY REMEDIAL DESIGN - 60% DESIGN SUBMITTAL

SITE: NORTH PENN AREA 5 SUPERFUND SITE
COLMAR, PENNSYLVANIA

DESIGNED BY:	JWR	DATE:	NOVEMBER 2013
DRAWN BY:	TSJ	PROJECT NO.:	PH0013
CHECKED BY:		FILE:	0013-008
REVIEWED BY:		DRAWING NO.:	7 OF 7
APPROVED BY:			

SIGNATURE

DATE

AR101671