M00146.AR.005919
MCAS CHERRY POINT
5090.3a

TECHNICAL MEMORANDUM IN SITU ENHANCED BIOREMEDIATION PILOT STUDY 16 MONTH 18 MONTH AND 24 MONTH POST INJECTION ACTIVITIES CENTRAL GROUNDWATER PLUME OPERABLE UNIT 1 (OU 1) MCAS CHERRY POINT NC

3/6/2014

CH2M HILL

In Situ Enhanced Bioremediation Pilot Study 16-Month, 18-Month, and 24-Month Post-Injection Activities Update Central Groundwater Plume, Operable Unit 1, Marine Corps Air Station Cherry Point, North Carolina

PREPARED FOR: MCAS Cherry Point Partnering Team

PREPARED BY: CH2M HILL

DATE: March 6, 2014

Introduction

This technical memorandum (TM) presents the 16-month, 18-month, and 24-month post-injection activities and data results for the In Situ Enhanced Bioremediation (ISEB) Pilot Study for Operable Unit (OU) 1 at Marine Corps Air Station (MCAS) Cherry Point, North Carolina (**Figures 1** and **2**) – specifically, the portion of OU1 that has been designated as the Central Groundwater Plume. This TM was prepared under the Naval Facilities Engineering Command (NAVFAC) — Atlantic, Comprehensive Long-term Environmental Action—Navy (CLEAN) 1000 Contract N62470-08-D-1000, Contract Task Order 144. This is the final planned performance monitoring period for this pilot study.

Overview

The *Final Operable Unit 1 Central Groundwater Plume Feasibility Study, Marine Corps Air Station, Cherry Point, North Carolina* (CH2M HILL, 2011a) (2011 Feasibility Study) evaluated potential remedial alternatives to address site-related constituents of concern, herein referred to as volatile organic compounds (VOCs), in groundwater in the Central Groundwater Plume at OU1 – primarily trichloroethene (TCE), 1,2-dichloroethene (DCE), and vinyl chloride (VC). In August 2010, the MCAS Cherry Point Partnering Team agreed to conduct a field-scale pilot study at OU1 to evaluate the site-specific effectiveness of ISEB in a biobarrier type approach. Slow-release emulsified vegetable oil substrate (SRS), a commercially available emulsified vegetable oil (EVO) substrate (Terra Systems, Inc., 2006a), and the bioaugmentation culture TSI DC (same as SDC-9) (Terra Systems, Inc., 2006b) were procured from Terra Systems, Inc., and utilized in this pilot study to enhance the reductive dechlorination process. The pilot study also gathered data necessary for the optimization of full-scale implementation during the Remedial Design (RD) phase. **Figures 3** and **4** provide the locations of the pilot study area within OU1 and the pilot study area injection and monitoring well network, respectively.

Pilot Study Objectives and Goals

The objectives of the ISEB pilot study were to assess the potential effectiveness of the ISEB biobarrier and to optimize the potential full-scale implementation during a future RD of the permanent remedy. The target goals of the ISEB pilot study were as follows:

- Achieve 90 percent reduction of TCE concentrations in the monitoring wells downgradient of the biobarrier
- Achieve 75 percent reduction of overall VOC concentrations in the monitoring wells downgradient of the biobarrier

Since the biobarrier was installed downgradient of the source area due to inaccessibility and access restrictions in the source area, source area contaminant mass is not being treated during the pilot study. Thus, it is anticipated that over time, contaminant and geochemical parameter concentrations within the pilot study area may rebound without continued periodic substrate application.

The seven monitoring wells within the pilot study area were gauged and sampled prior to initiating the pilot study injections. The resulting laboratory analytical data and field geochemical data provided the baseline conditions for the pilot study. The data collected for the 16-month, 18-month, and 24-month post-injection activities were compared to the baseline, 3-month, 6-month, 9-month, and 12-month conditions to evaluate performance against the ISEB pilot study goals.

16-Month, 18-Month, and 24-Month Post-Injection Activities

This TM describes the activities conducted during the 16-month, 18-month, and 24-month post-injection events. The 16-month and 18-month post-injection sampling events were conducted after the 12-month TM recommended the collection of additional groundwater samples to evaluate whether excessive production of methane and proliferation of methane-oxidizing bacteria (MOB) are negatively impacting the *Dehalococcoides* (DHC) population within the pilot study area. The 24-month event was conducted as the final performance monitoring event of the OU1 ISEB pilot study and included wellhead screening and groundwater sampling of the pilot study monitoring wells and soil gas probe installation and screening of the vadose zone downgradient from the performance monitoring wells and upgradient from Building 159. The soil gas probes were installed to assess potential methane migration downgradient from the pilot study area near Building 159.The well construction information for the pilot study injection and groundwater monitoring wells is summarized in **Table 1**. Soil gas probe construction information is provided in **Table 2**. Additional details regarding soil gas probe installation methods are described as follows.

Field activities were conducted in accordance with the protocols and standard operating procedures described in the *Final Master Field Sampling Plan, MCAS Cherry Point, North Carolina* (AGVIQ/CH2M HILL, 2004). Groundwater elevations were determined by opening wells and allowing sufficient time for water levels to equilibrate (approximately 1 hour) before recording the depths to water with a Solinst electronic water-level meter with graduations in increments of 0.01 foot. Soil gas and organic vapors at each wellhead were screened for VOCs, carbon monoxide (CO), hydrogen sulfide (H_2S), and lower explosive limit (LEL) in percent as methane with a Multi-RAE PLUS photoionization detector with a standard 10.7 electron volt lamp and for methane with a Landtec GEM2000 Landfill Gas Analyzer. Groundwater sampling was conducted via the low-flow sampling protocol using the In-Situ Troll 9500 Low-Flow System with the Rugged Dissolved Oxygen optical dissolved oxygen (DO) sensor to monitor for stabilization of groundwater quality parameters of temperature, DO, specific conductivity, pH, and oxidation-reduction potential (ORP) and turbidity using a HANNA Model HI 98703 turbidity meter.

16-Month Post-Injection Activities

After a preliminary review of data collected during the 12-month groundwater sampling event conducted in June 2012, additional groundwater samples were collected in October 2012 from 52GW78 and 52GW79 and analyzed for MOB and soluble methane mono-oxygenase (sMMO) via Method deoxyribonucleic acid (DNA) quantitative polymerase chain reaction (qPCR) to investigate the possibility of aerobic cometabolism of TCE mediated by MOB via sMMO occurring at the site. Additionally, groundwater samples were collected from 52IW08 and 52IW12 and analyzed for DHC to gauge the health of the dechlorinating population in the vicinity of the injection wells upgradient from monitoring wells 52GW78 and 52GW79. Groundwater elevation gauging and biogas wellhead screening were also conducted in the four wells that were sampled.

18-Month Post-Injection Activities

The 18-month groundwater samples were collected in January 2013 from downgradient monitoring wells 52GW80 and 52GW81 and injections wells 52IW09 and 52IW12. Groundwater elevation gauging and biogas wellhead screening were conducted at each of the 14 injection wells and seven pilot study monitoring wells. Groundwater samples were analyzed for the following parameters, using the following methods:

- Select VOCs: SW-846 United States Environmental Protection Agency (USEPA) Method 8260B
- Methane, ethane, ethene (MEE): RSK-175
- Total organic carbon (TOC): SW-846 USEPA Method 9060A

- Volatile fatty acids (VFAs): Method AM23G
- Microbial analysis for DHC, MOB, sMMO, and DHC functional genes *tceA*, *vcrA*, and *bvcA*: Method DNA qPCR

24-Month Post-injection Activities

The 24-month post-injection activities involved groundwater-level gauging of the 14 injection wells and seven pilot study monitoring wells and groundwater sampling of the seven pilot study monitoring wells.

Groundwater Gauging and Wellhead Screening

Groundwater-level gauging was conducted on the 14 injection wells and seven pilot study monitoring wells prior to purging and sampling. When each monitoring well was opened, the air within the well casing was immediately screened for VOCs, CO, H_2S, percent LEL, and methane, and the results were recorded in log books. These gases are generated by bacteria in anaerobic environments from an organic substrate (the EVO injected into the subsurface as part of the pilot study). After each well was opened, the water level was given approximately 1 hour to equilibrate before recording the depth to water with a Solinst electronic water-level meter with graduations in increments of 0.01 foot.

Groundwater Sampling

Groundwater sampling was conducted at the seven pilot study monitoring wells and the samples were analyzed for the following constituents:

- Select VOCs: SW-846 USEPA Method 8260B:
  - 1,1,1-Trichloroethane (TCA)
  - 1,1,2,2-Tetrachloroethane
  - 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)
  - 1,1,2-TCA
  - 1,1-Dichloroethane (DCA)
  - 1,1-DCE
  - 1,2-DCA
  - cis-1,2-DCE
  - trans-1,2-DCE
  - Bromodichloromethane
  - Bromoform
  - Chloromethane
  - Dichlorodifluoromethane (Freon-12)
  - Methylene chloride
  - Tetrachloroethene (PCE)
  - TCE
  - VC
- Field-analyzed natural attenuation indication parameters (NAIPs):
  - Ferrous iron (Hach kit – Phenanthroline Method)
  - Nitrate/nitrite (Hach kit – Cadmium Reduction/Diazotization Method)
  - DO (Chemetrics kit – Rhodazine D Method)
  - Specific conductivity (In-Situ Troll 9500 Water Quality Meter – Methods 2510, USEPA 120.1)
  - pH/ ORP (In-Situ Troll 9500 Water Quality Meter – Method 2580)
  - Temperature (In-Situ Troll 9500 Water Quality Meter – USEPA 170.1)
  - Turbidity (HANNA HI 98703 – USEPA Method 180.1)
- Laboratory-analyzed NAIPs:
  - MEE: RSK-175
  - TOC: SW-846 USEPA Method 9060A
  - VFAs: Method AM23G
  - Microbial analysis for DHC, MOB, sMMO, and DHC functional genes *tceA*, *vcrA*, and *bvcA*: Method DNA qPCR

Soil Gas Probe Installation and Screening

To evaluate the potential for methane accumulation beneath the nearest building downgradient from the pilot study site, four soil gas probes were installed. The soil gas probes were installed as nested pairs with two screened

intervals at approximately 3 and 8 feet below ground surface (bgs) at two locations alongside Building 159, downgradient from the biobarrier (**Figure 4**).

The soil gas probes (AMS, Inc., gas vapor probes) were installed in accordance with the CH2M HILL *Standard Operating Procedure for the Installation of Permanent Soil Gas Probes* (CH2M HILL, 2011b). The soil gas probes were installed by drilling a 1.5-inch diameter borehole through the road running adjacent to Building 159, and then direct-pushing the rod into the subsurface with a hammer drill to the proposed depth. The probe was driven into the subsurface with the 0.25-inch-outside-diameter Teflon tubing connected. The rod was then retracted with a jack, leaving the dedicated stainless steel tip with 1-inch-long #50 mesh screen in the ground and the tubing extending to the surface. Well filter pack sand was poured into the borehole to cover the screen and approximately 6 inches above it, followed by powdered bentonite, which was periodically hydrated as it was applied up to the ground surface. The tubing was capped with a Swagelok gas-tight cap. Newly installed soil gas probes were given 24 hours to allow for the bentonite seal to cure.

After a minimum of 24 hours, the CH2M HILL field team performed a helium leak check on each newly installed probe prior to sampling to ensure that its seal was intact and that samples would not be compromised by ambient air. Three of the probes, OU1-98NS13-08, OU1-98NS14-03, and OU1-98NS14-08, passed the leak check. One probe, OU1-98NS13-03, failed the leak check. This probe was abandoned and a new probe was installed as OU1-98NS13-03R, which passed the leak check. After all probes had passed the leak check, soil gas at each probe was pumped into new Tedlar bags and immediately screened for VOCs, CO, H_2S, LEL as percent methane, methane, carbon dioxide (CO_2), and oxygen (O_2).

16-Month, 18-Month, and 24-Month Post-Injection Results

Groundwater elevation data are included in **Table 1**. Field screening data of soil gas probes are included in **Table 2** and wellhead screening data are included in **Table 3**. It should be noted that some of the data collected in **Tables 2** and **3** were collected with two different instruments with different calibration ranges, so there is some discrepancy between the LEL and methane data collected. Baseline and post-injection VOCs and laboratory-analyzed NAIP data are included in **Table 4** and field-screened NAIP data are included in **Table 5**. Evaluations of VOC concentrations, TOC and VFA concentrations, microbial populations, and the overall favorability of site conditions for enhanced reductive dechlorination (ERD) are included in **Tables 6** through **9**, respectively. Groundwater elevation contour maps are included on **Figures 5** and **6**, exceedances of regulatory screening criteria are shown on **Figures 7** and **8**, and trend graphs are shown on **Figures 9** and **10** for both upper and lower surficial aquifer wells, respectively. As defined in the *Groundwater Treatment Pilot Study, Sampling and Analysis Plan, Operable Unit 1, Marine Corps Air Station, Cherry Point, North Carolina* (CH2M HILL, 2011c), concentrations of groundwater contaminants identified in this pilot study were compared to the lowest of the North Carolina Administrative Code Title 15A, Subchapter 2L Groundwater Quality Standards (NC 2L Standards) and USEPA maximum contaminant levels. For all VOCs, the NC 2L Standard is the more conservative criterion, with the exception of 1,1,2-TCA, which does not have a defined NC 2L Standard. However, this analyte has not been detected during sampling activities. **Figures 11** and **12** show NAIP data for key wells. **Figures 13** and **14** show trends for selected parameters for upper and lower surficial aquifer monitoring wells.

16-Month Post-Injection Results

Results from the 16-month event showed elevated levels of MOB and sMMO in samples collected from downgradient monitoring wells 52GW78 and 52GW79 (approximately 10^7 and 10^3 cells per milliliter [cells/ml], respectively), indicating the potential for TCE aerobic cometabolism to occur. DHC results from samples collected in the upgradient injection wells 52IW08 and 52IW12 ranged from 10^3 to 10^5 cells/ml, indicating that conditions remained conducive for DHC growth near the injection wells. The 16-month additional data, coupled with the data collected during the 12-month post-injection event, showed an overall decrease in DHC populations in the downgradient monitoring wells. These results indicate that the general decline of DHC is potentially due to the transition from anaerobic to a mixed microaerobic and anaerobic environment, growth of MOB, and potential toxic impacts of epoxides (produced by TCE cometabolic degradation) to DHC populations. Additional sampling

was recommended for another subset of monitoring and injection wells to further investigate the potential for TCE cometabolism and the overall decrease of DHC populations.

18-Month Post-Injection Results

Consistent with the 16-month post-injection data, MOB and sMMO concentrations in the four wells sampled in January 2013 indicated the potential for TCE cometabolism. DHC concentrations had generally decreased since the 12-month groundwater sampling event. This may also be a result of overall low VOC concentrations, which have been decreasing steadily since the injections. Each of the functional genes was detected in each of the four samples collected.

Elevated methane concentrations (greater than 100 percent of its LEL) were detected in the wellhead screening of nearly all injection wells and monitoring wells screened within the pilot study area. If accumulated methane enters nearby buildings or enclosed spaces such as sewers via vapor intrusion from soil gas and is diluted, it could potentially create an explosion hazard, as methane poses an immediate fire and explosion hazard at concentrations greater than 5 percent. It was recommended that soil gas probes be installed to evaluate the extent of methane present in soil gas rather than in wellhead screening, which can greatly overestimate the concentration of methane within the vadose zone.

24-Month Post-Injection Results

Groundwater Gauging and Wellhead Screening

Prior to gauging, wellhead screening was conducted for VOCs and biogas generation, and to evaluate the generation of vapor-phase methane. VOCs and H_2S were not measured at concentrations greater than background levels during the 3-month and 6-month events. However, during the 9-month, 12-month, and 24-month sampling events, measureable concentrations of VOCs and H_2S were observed at the wellheads of two injection and monitoring wells, 52GW78 and 52MG79, as shown in **Table 3.** The results of the 24-month sampling event indicated an increase in the percent LEL as methane. Methane readings were also taken with a GEM2000 Landfill Gas Analyzer during the 18-month and 24-month post-injection activities. Methane levels were fairly consistent from 18 to 24 months, with elevated levels of methane observed in all of the injection wells and new monitoring wells and no methane detected in the existing monitoring wells. Vapor-phase methane concentrations at the downgradient monitoring wells were consistently observed at levels higher than the upper explosive limit and LEL concentrations (5 to 15 percent). The CO concentrations in the seven monitoring wells had been steadily increasing until the 12-month event, but steadily decreased from 12 to 24 months post-injection.

Groundwater-level measurements were collected from injection and monitoring wells during the May 2011 baseline event and from monitoring wells during the 3-month, 9-month, and 12-month post-injection events. As the 24-month post-injection event is the final event, groundwater-level measurements were collected from all wells (injection and monitoring) during both the 18-month and 24-month events. Groundwater elevations ranged from 8.02 to 9.33 feet above mean sea level (msl) (9.82 to 12.40 feet bgs) in the upper surficial aquifer and from 7.91 to 9.12 feet above msl (9.92 to 12.55 feet bgs) in the lower surficial aquifer. Gauging data are included in **Table 1**. Groundwater elevation contour maps are included on **Figures 5** and **6**, and show that that the direction of groundwater flow is predominantly west in both the upper and lower surficial aquifers.

Trends for groundwater elevations for the upper and lower surficial aquifers are presented on **Figures 15** and **16**, respectively. These trends were prepared to identify potential outliers within the data set to evaluate the wide range of groundwater elevations observed during gauging events, most notably, those observed in the upper surficial aquifer. Upper surficial aquifer data indicate the potential for significant recharge, possibly due to a localized leak from a nearby water line or from potential infiltration of surface water in the nearby ditch that runs parallel to A Street, immediately adjacent to the biobarrier. Specifically, groundwater elevation changes are more notable at 16GW11, which is screened at a shallower interval than the other pilot study monitoring and injection wells, and is also located in close proximity to the ditch. The groundwater elevation at 52IW13 is also a potential outlier, based on it having the only groundwater elevation that increased between the January and June 2013 groundwater gauging events; all other elevations decreased in the upper surficial aquifer during this timeframe.

In the lower surficial aquifer, groundwater elevations were observed within a much tighter range, with the exception of groundwater elevation data collected from 52IW14. Excluding 52IW14 from the data set, which was measured with a water-level elevation at 9.12 feet above msl, the remaining lower surficial aquifer groundwater elevations ranged from 7.91 to 8.12 feet above msl. Top-of-casing and groundwater elevations were confirmed against the surveyor report; therefore, this result is either an anomaly, the survey information is inaccurate, or there is some other yet unidentified explanation. Additionally, 52IW14 was also the only location where the groundwater elevation in the lower surficial aquifer was observed to increase during the January to June 2013 gauging events. It should be noted that approximately 50 feet north of the 52IW13/52IW14 injection well pair, a fire water system pressure relief line is located, and water is released from this location frequently. The majority of the water runs into the creek behind Building 159; however, it is a potential explanation for the water-level mounding observed at the 52IW13/52IW14 injection well pair.

Based on these results, it is recommended that prior to implementing the RD, a closer examination of the potential reasons for the wide range of groundwater elevations during the pilot study be conducted. Specifically, a pressure test on local water lines could be conducted to identify whether a nearby water line is leaking. Additionally, if water is observed to be ponding within the nearby ditch, engineering controls may be evaluated during the RD to mitigate the significant surface water recharge to the upper surficial aquifer in the immediate vicinity of the biobarrier.

Groundwater Sampling Results

Pilot Study Area 24-Month VOC-Related Results

Upper Surficial Aquifer

As shown in **Table 4** and on **Figures 7** and **9**, concentrations of TCE and total VOCs in samples collected from the upper surficial aquifer have decreased in comparison to the baseline data. In the sample collected from 52GW77, slight increases of all VOCs were observed, indicating some potential rebounding of VOCs; but overall, TCE has been reduced by 88 percent (**Figures 7** and **9** and **Table 6**). Thus, it is likely that the overall VOC reduction of 20 percent is primarily due to increases in TCE daughter products, providing evidence for reductive dechlorination of TCE in the pilot study area in the upper surficial aquifer. Additionally, VOC concentrations in samples collected from 52GW80 have remained low, with an overall TCE removal of 96 percent and total VOC removal of 94 percent.

As shown in the upper half of **Table 6**, the 24-month final sampling results indicate that TCE concentrations have been reduced by 90 percent in the upper surficial aquifer, with a total VOC reduction of only 36 percent, which is due to partial dechlorination of TCE to daughter products (such as cis-1,2-DCE and VC) and some potential rebounding. It should be noted that data collected from both the 3-month and 6-month groundwater sampling events indicated a 98 percent reduction of TCE and a greater than 75 percent reduction of total VOC concentrations in the upper surficial aquifer.

Monitoring well 16GW11 was omitted from this trend analysis because it is an upgradient monitoring well that is intended to be sampled to monitor concentrations entering the biobarrier in the upper surficial aquifer and is, therefore, not representative of VOC reductions achieved by the biobarrier. However, it should be noted that 16GW11 is screened at a slightly shallower interval (12 to 27 feet bgs) than the other upper surficial aquifer monitoring wells (22 to 32 feet bgs), and baseline concentrations from groundwater samples in 16GW11 were one to two orders of magnitude lower than groundwater sampled from 52GW77 and 52GW80. Therefore, VOC concentrations in groundwater sampled from 16GW11 may not necessarily be representative of VOC concentrations entering the biobarrier in the upper surficial aquifer at the same depth as the downgradient monitoring wells.

Lower Surficial Aquifer

VOC concentrations in the lower surficial aquifer have consistently been observed to be higher (by one to two orders of magnitude) than those in the upper surficial aquifer. The lower surficial aquifer VOC concentrations are presented in **Table 4** and on **Figure 8**, and show that cis-1,2-DCE, PCE, trans-1,2-DCE, TCE, and VC were all detected at levels exceeding the NC 2L Standards in samples collected from at least one lower surficial aquifer

monitoring well. VOC trends from samples collected from lower surficial aquifer monitoring wells are shown on **Figure 10**. In general, concentrations of TCE in samples collected from the lower surficial aquifer have decreased in comparison to the baseline data; however, a significant increase in TCE (and cis-1,2-DCE) was observed in the groundwater sample collected from 52GW78 during the 24-month monitoring event, indicating some potential rebound of VOCs in the lower surficial aquifer. Data from samples collected from 52GW79 and 52GW81 indicate a continued decrease in TCE concentrations with an overall decrease of total VOCs, indicating that ongoing reductive dechlorination is occurring in the pilot study area.

As shown in the lower half of **Table 6**, the 24-month final sampling results indicate that TCE concentrations have been reduced by 56 percent in the lower surficial aquifer, with a total VOC reduction of 45 percent, which is due to partial dechlorination of TCE to daughter products (such as cis-1,2-DCE and VC) and some potential rebounding. Data collected during the 3-month groundwater sampling event indicated a total of 86 percent reduction in TCE concentrations and a 41 percent reduction of total VOC concentrations in the lower surficial aquifer. The total VOC concentration removal peaked at 60 percent, following the 9-month groundwater sampling event.

Monitoring well MW53 is an upgradient monitoring well that is monitored for VOC concentrations entering the biobarrier for comparison with the downgradient monitoring wells to evaluate the performance of the biobarrier. MW53 is screened at a slightly deeper interval (44 to 54 feet bgs) than the other lower surficial aquifer monitoring wells (38 to 48 feet bgs). But unlike 16GW11, baseline VOC concentrations in groundwater sampled from MW53 were much more consistent with VOC concentrations observed in the groundwater samples collected from lower surficial aquifer monitoring wells 52GW78, 52GW79, and 52GW81, and are, therefore, likely indicative of the VOC concentrations entering the biobarrier. TCE and VC concentrations in groundwater sampled from MW53 have been fairly constant over the course of the pilot study, but increases in cis-1,2-DCE concentrations have been observed.

Pilot Study Area 24-Month Groundwater ERD Evaluation

Groundwater samples for the seven pilot study monitoring wells were analyzed for the suite of NAIPs previously listed, with results summarized in **Tables 4, 5, 7,** and **8**. Groundwater samples collected from the monitoring wells were field-tested for the NAIPs ferrous iron, nitrate, and nitrite using Hach kits and DO using a Chemetrics kit (**Table 5**). These data are also shown on **Figures 11** and **12**, and trends are shown on **Figures 13** and **14**, for upper surficial and lower surficial aquifer wells, respectively. An evaluation of the TOC and VFA data is included in **Table 7**, microbial analyses are shown in **Table 8**, and an ERD data evaluation is summarized in **Table 9**. As was done for the VOC trend analysis, upgradient monitoring wells 16GW11 and MW53 were omitted from the ERD evaluation.

Upper Surficial Aquifer

As shown in **Table 9** and on **Figure 11**, the 24-month NAIP results in the upper surficial aquifer provide many lines of evidence indicating favorable conditions for ERD of VOCs in the pilot study area. Results for pH, ORP, DO, nitrate, and ferrous iron were all within favorable ranges for ERD requirements.

In general, trends for MEE and microbial analysis show favorable conditions for ERD when the 24-month data are compared to baseline results (**Table 8** and **Figure 11**). Significant biogas (methane) production was observed, with methane concentrations indicative of deep reducing methanogenic conditions within the pilot study area. While ethane continues to be non-detectable in samples collected in the upper surficial aquifer, ethene concentrations have generally increased throughout the pilot study in samples collected from 52GW77, providing further lines of evidence for reductive dechlorination to innocuous end products.

Microbial data show DHC concentrations ranged from 10^1 to 10^3 cells/ml during the 24-month event in the upper surficial aquifer. The data results for the overall DHC concentrations follow similar trends as for the total VOC concentrations observed. For example, in samples collected from 52GW80, where VOC concentrations have been reduced by 94 percent and the total VOCs concentration was 2.7 micrograms per liter (µg/L), DHC concentrations have decreased by two orders of magnitude from baseline. In samples collected from 52GW77, where VOC concentrations have been reduced by 20 percent and the total VOCs concentration was 128 µg/L, DHC

concentrations have increased by over one order of magnitude and the 24-month DHC concentration exceeded baseline DHC levels.

While the data indicate favorable geochemical and modest biological conditions for reductive dechlorination, TOC concentrations have continued to decrease since the 3-month sampling event in both upper surficial aquifer wells. The TOC concentrations at 52GW77 and 52GW80 have dropped to 7.8 and 10 milligrams per liter (mg/L), respectively (**Tables 4** and **7**), which are below the TOC concentration considered ideal for reductive dechlorination (20 mg/L). The rate of this decreasing trend helps to determine the longevity of the substrate and when re-injection should be considered. Based on the results of this 2-year pilot study, it is recommended that for full-scale implementation, re-injection into the upper surficial aquifer should be considered every year to maintain optimum TOC concentrations. Additionally, the injection well radius of influence should be decreased slightly to 10 feet, with the option of potentially adding a second row of injection wells to maintain a wider anaerobic zone if the tighter injection well spacing does not achieve objectives.

Lower Surficial Aquifer

As shown in **Tables 5**, **7, 8,** and **9** and on **Figures 12** and **14**, post-injection NAIP results in the lower surficial aquifer generally indicate favorable geochemical conditions for ERD of VOCs in the pilot study area. Results for ORP, DO, nitrate, and ferrous iron were all within favorable ranges for ERD requirements. The pH readings are slightly unfavorable, below 6 in samples collected from 52GW78 and 52GW79. However, the pH has been steadily increasing since the 3-month sampling event in samples collected at these locations. Since an acidic pH can significantly jeopardize the health and performance of DHC, pH buffering and adjustment should be considered in future, full-scale ISEB implementation.

Trends for MEE and microbial analysis primarily show favorable conditions for ERD when the 24-month data are compared to baseline results (**Table 9** and **Figures 12** and **14**). Significant biogas (methane) production has been observed, with methane concentrations indicative of deep reducing methanogenic conditions within the pilot study area. Methane levels were observed to peak around the 12-month sampling event and were shown to decrease in all three downgradient monitoring wells at the 24-month event. Additionally, MOB concentrations appear to be leveling-off or decreasing.

While ethane and ethene continue to be non-detectable in samples collected from 52GW81, DHC concentrations have continued to be observed at favorable levels for ERD since the 12-month sampling event. In samples collected from 52GW78 and 52GW79, detectable levels of either or both ethene and ethane have been observed despite lower than ideal concentrations of DHC (10^1 cells/ml). Additionally, all DHC functional genes have been detected in all three downgradient lower surficial groundwater monitoring wells.

As discussed in previous TMs, one potential reason for the overall decrease in the DHC population (orders of magnitude) since the 3-month sampling event in samples collected from monitoring wells 52GW78 and 52GW79 was the overall decrease in pH that was observed. Since some increases in concentrations of TCE daughter products cis-1,2-DCE and VC have also been observed, this has provided some evidence for the occurrence of biotic reductive dechlorination in the lower surficial aquifer. However, the possibility that the decline in the DHC population was due to the excessive proliferation of MOB was also considered based on the results of the 16-month, 18-month, and 24-month groundwater sampling events. MOB mainly function and grow aerobically, and only trace amounts of DO are sufficient for their growth because of their great affinity to O_2. Both the proliferation of MOB and presence of elevated concentrations of toluene dioxygenases indicate the presence of microaerobic zones or microzones within the overall reducing environment. MOB utilize methane for growth via mono-oxygenases (MMO), which fortuitously mediate cometabolic oxidation of TCE. This process produces TCE epoxide as an intermediate, which reacts with and damages intracellular cell protein and DNA of bacteria (Henry and Grbic-Galic, 1991). It is possible that the DHC may have been susceptible to the toxicity of epoxide, and therefore, were unable to proliferate.

The 24-month and additional 16-month and 18-month samples were analyzed for MOB and MMO to investigate the activity of the MOB and provide indirect evidence of this hypothesis – that population decreases of DHC and other anaerobes can be at least partially attributed to the toxicity of epoxide from aerobic cometabolism of TCE

mediated by MOB via MMO. These results are included in **Table 4** and also summarized in **Table 8**. The high MOB population, along with elevated concentrations of MMO in monitoring wells downgradient of the injection wells, indicate a good potential for aerobic cometabolism of TCE at the site. Additionally, the high to modest populations of DHC observed in the two injection wells that were sampled at 16 months indicate that conditions near the injection wells remained conducive to the dechlorinating microbial population. The significant depression of DHC observed in the downgradient monitoring wells indicates that the conditions at the leading edge of the ERD zone of influence might be inhibitive to DHC, presumably due to transition from anaerobic to a mixed microaerobic and anaerobic environment, growth of MOBs, and potential toxic impacts of epoxide.

TOC and VFA concentrations have either remained fairly constant or have increased in comparison to the 3-month data (**Table 7**), which provides evidence that the injected ERD substrate continues to be available for ERD. Based on the results of this 2-year pilot study, it is recommended that for full-scale implementation, re-injection into the lower surficial aquifer should be considered every 1 to 2 years to maintain optimum TOC concentrations. Additionally, the injection well radius of influence should be decreased slightly to 10 feet, with the option of potentially adding a second row of injection wells to maintain a wider anaerobic zone if the tighter injection well spacing does not achieve objectives.

Soil Gas Probe Screening Results

On June 6, 2013, after passing the leak checks, all soil gas probes were screened for VOCs, CO, H_2S, LEL as percent methane, methane, CO_2, and O_2. As shown in **Tables 2** and **3**, methane levels were observed to be significantly lower in the vadose zone than at the wellheads, and methane concentrations were consistently higher in the deeper (8 feet bgs) portion of the vadose zone, with one soil gas result indicating methane concentrations greater than the LEL. Although methane concentrations were observed at levels below the LEL in the shallow 3-foot-bgs soil gas probes, measurable levels of methane, CO, VOCs, and depressed O_2 levels were observed. Based on these initial results, an additional methane screening of the soil gas probes is recommended, and a more comprehensive vapor intrusion investigation is recommended for the downgradient Building 159 to assess potential methane accumulation beneath the building.

Conclusions and Recommendations

In summary, the conclusions for the 24-month post-injection groundwater sampling event and ISEB pilot study as a whole are as follows:

- The overall pilot study results demonstrate that ISEB biobarrier is a suitable remedy for the OU1 Central Groundwater Plume.
- While the total TCE and VOC reduction goal was not met at all monitoring wells after 24 months, the pilot study results provided valuable information for implementation of an effective, full-scale design.
- The TCE reduction goal of 90 percent has been met in the upper surficial aquifer, but TCE reduction has only reached 56 percent in the lower surficial aquifer. The apparent lower removal in the lower surficial aquifer may be due to an increase in the VOC concentrations entering the biobarrier in conjunction with the observed decline of the dechlorinating microbial population. While individual wells have achieved over 90 percent reductions in TCE during the pilot test period (52GW81), indicating that the ERD process can be effectively implemented at the site, full-scale implementation will need to incorporate precautionary measures to mitigate microbial losses.
- At 24 months, the total VOC concentration reductions in the upper and lower surficial aquifers have not reached the reduction goal of 75 percent, primarily related to the accumulation of TCE daughter products and some potential rebounding. The maximum total VOC reduction was observed at 81 percent in the upper surficial aquifer at 3 months and at 60 percent in the lower surficial aquifer at 9 months. Total VOC concentration reduction goals were met at individual monitoring wells 52GW80 and 52GW81.

- Although increases in pH and DHC have been observed since the 9-month sampling event, the pH continued to stay below its optimal range in the lower surficial aquifer, which might be a reason for the suppression of DHC. Addition of a buffering agent should be considered for full-scale implementation of ISEB.
- Based on the observed attenuation of TOC after 24 months in the upper and lower surficial aquifers, a higher EVO dose or second injection would likely offer some benefits with regard to ERD performance and TOC longevity. Optimizing the SRS dosage should be considered for full-scale implementation of ISEB, with substrate injections recommended every year for the upper surficial and every 1 to 2 years for the lower surficial aquifer. Additionally, the injection well radius of influence should be decreased slightly to 10 feet, with the option of potentially adding a second row of injection wells to maintain a wider anaerobic zone if the buffering and tighter injection well spacing does not achieve objectives.
- Although methane concentrations were observed at levels below the LEL in the shallow 3-foot-bgs soil gas probes, measurable levels of methane, CO, VOCs, and depressed O_2 levels were observed. Based on the initial soil gas screening results, an additional methane screening of the soil gas probes is recommended, and a more comprehensive methane screening evaluation is recommended for downgradient Building 159 to assess potential methane accumulation beneath the building. Soil gas monitoring for potential methane migration should also be considered for full-scale implementation of ISEB.

References

AGVIQ/CH2M HILL Joint Venture 1 (AGVIQ/CH2M HILL). 2004. *Final Master Field Sampling Plan*, *Marine Corps Air Station Cherry Point, Cherry Point, North Carolina*. November.

CH2M HILL. 2011a. *Final Operable Unit 1 Central Groundwater Plume Feasibility Study*, *Marine Corps Air Station, Cherry Point, North Carolina.* August.

CH2M HILL. 2011b. *Standard Operating Procedure for the Installation of Permanent Soil Gas Sampling Probes*. December.

CH2M HILL. 2011c. *Groundwater Treatment Pilot Study, Sampling and Analysis Plan, Operable Unit 1, Marine Corps Air Station, Cherry Point, North Carolina*. March.

Henry, S.M., and D. Grbic-Galic. 1991. Influence of endogenous and exogenous electron donors and trichloroethylene oxidation toxicity on trichloroethylene oxidation by methanotrophic cultures from a groundwater aquifer. *Appl. Environ. Microbiol.* 57(l):236-244.

Terra Systems, Inc. 2006a. *SRS Emulsified Vegetable Oil (EVO) Substrate United States Patent# RE40,448, Product Specifications*. http://www.terrasystems.net/Products/products_SRS.htm.

Terra Systems, Inc. 2006b. *TSI DC Bioaugmentation Culture, Product Specifications*. http://www.terrasystems.net/Products/products_TSI_DC.htm.

Tables

TABLE 1

Construction Information and Groundwater Elevation Data

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	Measured Well Depth (ft bgs)	Top of Casing Elevation (feet msl)	Ground Surface Elevation (feet msl)	Groundwater Elevation May 2011 (ft msl)	Groundwater Elevation September 2011 (ft msl)	Groundwater Elevation December 2011 (ft msl)	Groundwater Elevation March 2012 (ft msl)	Groundwater Elevation June 2012 (ft msl)	Groundwater Elevation October 2012 (ft msl)	Groundwater Elevation January 2013 (ft msl)	Depth to Groundwater June 2013 (ft bgs)	Groundwater Elevation June 2013 (ft msl)
Injection Well Pairs	OU1-52IW01	Upper	36	15	20 - 35	35.7	20.39	20.70	7.84	NM	NM	NM	NM	NM	8.59	12.40	8.30
	OU1-52IW02	Lower	51	15	35 - 50	50.2	20.38	20.46	7.63	NM	NM	NM	NM	NM	8.23	12.55	7.91
	OU1-52IW03	Upper	36	15	20 - 35	35.4	20.17	20.22	7.82	NM	NM	NM	NM	NM	8.37	11.99	8.23
	OU1-52IW04	Lower	51	15	35 - 50	48.7	20.11	20.24	7.66	NM	NM	NM	NM	NM	8.22	12.28	7.96
	OU1-52IW05	Upper	36	15	20 - 35	35.3	19.53	19.84	7.89	NM	NM	NM	NM	NM	9.01	11.02	8.82
	OU1-52IW06	Lower	51	15	35 - 50	50.0	19.61	19.86	7.70	NM	NM	NM	NM	NM	8.29	11.86	8.00
	OU1-52IW07	Upper	36	15	21 - 36	36.0	19.44	19.63	8.08	NM	NM	NM	NM	NM	9.33	10.60	9.03
	OU1-52IW08	Lower	46	15	30 - 45	45.2	19.40	19.59	7.73	NM	NM	NM	NM	8.60	8.28	11.59	8.00
	OU1-52IW09	Upper	36	15	20 - 35	35.0	19.31	19.52	8.27	NM	NM	NM	NM	NM	9.46	10.56	8.96
	OU1-52IW10	Lower	48	15	32 - 47	46.9	19.32	19.46	7.77	NM	NM	NM	NM	NM	8.33	11.42	8.04
	OU1-52IW11	Upper	36	15	20 - 35	35.6	18.95	19.16	8.05	NM	NM	NM	NM	NM	8.75	10.52	8.64
	OU1-52IW12	Lower	46	15	30 - 45	44.4	19.28	19.35	7.81	NM	NM	NM	NM	8.58	8.38	11.28	8.07
	OU1-52IW13	Upper	36	15	20 - 35	36.0	18.60	18.60	8.07	NM	NM	NM	NM	NM	8.60	9.82	8.78
	OU1-52IW14	Lower	46	15	30 - 45	45.2	19.00	19.04	7.84	NM	NM	NM	NM	NM	8.39	9.92	9.12
Newly Installed Monitoring Wells	OU1-52GW77	Upper	33	10	22 - 32	31.8	19.66	20.06	7.80	8.51	8.24	7.87	7.66	NM	8.73	11.81	8.25
	OU1-52GW78	Lower	49	10	38 - 48	47.8	19.57	19.86	7.72	7.66	7.53	7.65	7.37	8.56	8.45	11.74	8.12
	OU1-52GW79	Lower	49	10	38 - 48	48.3	19.72	19.86	7.74	7.61	7.52	7.62	7.37	8.57	8.34	11.85	8.01
	OU1-52GW80	Upper	33	10	22 - 32	32.8	19.64	19.75	8.08	8.89	8.46	8.42	7.99	NM	9.38	11.73	8.02
	OU1-52GW81	Lower	49	10	38 - 48	48.9	19.67	19.65	7.77	7.67	7.59	7.67	7.42	NM	8.35	11.60	8.05
Existing Monitoring	16GW11	Upper	27	15	12 - 27	26.5	22.64	21.17	8.69	8.99	8.59	8.66	8.29	NM	9.90	11.84	9.33
	MW53	Lower	54	10	44 - 54	54.6	22.40	20.54	7.56	7.72	7.58	7.65	7.42	NM	8.37	12.44	8.10

Notes:

Groundwater gauging completed on June 3, 2013

[a] 4-inch diameter with 0.020-inch slot Vee-wire Schedule (Sch.) 40 PVC screen for injection wells

[b] 2-inch diameter 0.010-inch machine slot Sch. 40 PVC screen for monitoring wells

bgs - below ground surface

msl - mean sea level

ft - feet

ft bgs - feet below ground surface

TABLE 2

Building 159 Exterior Soil Gas Probe Screening Sheet

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Soil Gas Probe ID	Depth (ft bgs)	Interval [1] (ft bgs)	VOCs[2] (ppm)	CO[2] (ppm)	H_2S[2] (ppm)	LEL[2] (%)	Methane[3] %	CO_2[3] %	Oxygen[3] %	Helium[4] ppm	Comments
OU1-98NS13-03R	3	2.9 - 3	0.6	3	0	33	1.1	2.4	14.8	0	Pass Leak Check
OU1-98NS13-08	8	7.9 - 8	14.7	55	--	>100	4.4	4.8	2.6	0	Pass Leak Check
OU1-98NS14-03	3	2.9 - 3	14.9	5	0	40	2.5	11.4	1.6	0	Pass Leak Check
OU1-98NS14-08	8	7.9 - 8	0.9	1	0	>100	9.1	10.1	0.7	0	Pass Leak Check

Notes:

[1]Screen interval is 1-inch

[2]VOCs, CO, H_2S, and LEL collected with MultiRAE PLUS Photoionization Detector (Model PGM-50)

[3]Methane, CO_2, and oxygen collected with a Landtec Landfill Gas Analyzer (Model GEM2000)

[4]Helium leak check performed with Helium Radiodetection Meter (Model MGD-2002)

CO - carbon monoxide

CO_2 - carbon dioxide

H_2S - hydrogen sulfide

"R" indicates re-installation location, initial location failed leak check.

Screening completed on 6/6/13

ppm - parts per million

TABLE 3

Baseline and Post-Injection Biogas Data

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study Well Type	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	VOCs (ppm)[1]								H_2S (ppm)[1]							
						Baseline	3-Month	6-Month	9-Month	12-Month	16-Month	18-Month	24-Month	Baseline	3-Month	6-Month	9-Month	12-Month	16-Month	18-Month	24-Month
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	< 0.1	NM	NM	NM	NM	NM	< 0.1	0.80	< 1	NM	NM	NM	NM	NM	24	33
	OU1-52IW02	Lower	50	15	35 - 50	< 0.1	NM	NM	NM	NM	NM	4.0	2.5	< 1	NM	NM	NM	NM	NM	51	< 0.1
	OU1-52IW03	Upper	35	15	20 - 35	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	16	51
	OU1-52IW04	Lower	50	15	35 - 50	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	18	12
	OU1-52IW05	Upper	35	15	20 - 35	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	1.0	5.0
	OU1-52IW06	Lower	50	15	35 - 50	< 0.1	NM	NM	NM	NM	NM	< 0.1	9.40	< 1	NM	NM	NM	NM	NM	93	41
	OU1-52IW07	Upper	35	15	21 - 36	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	1.0	< 0.1
	OU1-52IW08	Lower	50	15	30 - 45	< 0.1	NM	NM	NM	NM	1.5	< 0.1	0.40	< 1	NM	NM	NM	NM	1.5	5.0	21
	OU1-52IW09	Upper	35	15	20 - 35	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	25	3.0
	OU1-52IW10	Lower	50	15	32 - 47	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	46	25
	OU1-52IW11	Upper	35	15	20 - 35	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	52	16
	OU1-52IW12	Lower	50	15	30 - 45	< 0.1	NM	NM	NM	NM	12.6	< 0.1	< 0.1	< 1	NM	NM	NM	NM	33.9	1.0	< 0.1
	OU1-52IW13	Upper	35	15	20 - 35	< 0.1	NM	NM	NM	NM	NM	< 0.1	< 0.1	< 1	NM	NM	NM	NM	NM	< 0.1	< 0.1
	OU1-52IW14	Lower	50	15	30 - 45	< 0.1	NM	NM	NM	NM	NM	< 0.1	1.50	< 1	NM	NM	NM	NM	NM	198	155
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1
	52GW78	Lower	48	10	38 - 48	< 0.1	< 0.1	< 0.1	3.5	2.5	1.5	< 0.1	1.1	< 0.1	0.1	< 0.1	1.0	3.0	0.0	< 0.1	65
	52GW79	Lower	48	10	38 - 48	< 0.1	< 0.1	< 0.1	< 0.1	0.3	1.0	3.7	4.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.00	89	24
	52GW80	Upper	32	10	22 - 32	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NM	4.0	1.0
	52GW81	Lower	48	10	38 - 48	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NM	29	< 0.1
Existing Monitoring	16GW11	Upper	27	15	12 - 27	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1
	MW53	Lower	54	10	44 - 54	< 0.1	< 0.1	< 0.1	0.4	< 0.1	NM	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	NM	< 0.1	< 0.1

Notes:

[1]Wellhead screening for VOCs, H_2S, LEL, and CO collected with MultiRAE PLUS Photoionization Detector (Model PGM-50)

[2]Methane wellhead screening collected with a Landtec Landfill Gas Analyzer (Model GEM2000)

[3]Methane data via Method RSK-175 on aqueous samples

ft bgs - feet below ground surface

NM - not measured

ppm - parts per million

J - Analyte present, value may or may not be accurate or precise

TABLE 3

Baseline and Post-Injection Biogas Data

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study Well Type	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	%LEL (Methane)[1]								Methane[2] (%)		Methane[3] (µg/L)						
						Baseline	3-Month	6-Month	9-Month	12-Month	16-Month	18-Month	24-Month	18-Month	24-Month	Baseline	3-Month	6-Month	9-Month	12-Month	18-Month	24-Month
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	< 1	NM	NM	NM	NM	NM	> 100	> 100	65.2	61.2	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW02	Lower	50	15	35 - 50	< 1	NM	NM	NM	NM	NM	> 100	35	17.0	22.4	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW03	Upper	35	15	20 - 35	< 1	NM	NM	NM	NM	NM	> 100	> 100	54.6	75.0	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW04	Lower	50	15	35 - 50	< 1	NM	NM	NM	NM	NM	> 100	> 100	58.2	73.5	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW05	Upper	35	15	20 - 35	< 1	NM	NM	NM	NM	NM	> 100	> 100	55.1	60.7	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW06	Lower	50	15	35 - 50	< 1	NM	NM	NM	NM	NM	> 100	> 100	75.5	60.8	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW07	Upper	35	15	21 - 36	< 1	NM	NM	NM	NM	NM	> 100	> 100	67.3	76.6	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW08	Lower	50	15	30 - 45	< 1	NM	NM	NM	NM	>100	> 100	> 100	80.2	66.9	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW09	Upper	35	15	20 - 35	< 1	NM	NM	NM	NM	NM	> 100	> 100	62.0	81.8	NM	NM	NM	NM	NM	18,000	NM
	OU1-52IW10	Lower	50	15	32 - 47	< 1	NM	NM	NM	NM	NM	> 100	> 100	57.4	75.8	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW11	Upper	35	15	20 - 35	< 1	NM	NM	NM	NM	NM	> 100	> 100	87.7	62.6	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW12	Lower	50	15	30 - 45	< 1	NM	NM	NM	NM	>100	> 100	> 100	79.5	72.4	NM	NM	NM	NM	NM	21,000	NM
	OU1-52IW13	Upper	35	15	20 - 35	< 1	NM	NM	NM	NM	NM	> 100	> 100	65.5	77.0	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW14	Lower	50	15	30 - 45	< 1	NM	NM	NM	NM	NM	> 100	> 100	75.4	70.0	NM	NM	NM	NM	NM	NM	NM
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	< 1	< 1	< 1	90	> 90	NM	> 100	> 100	79.3	64.9	700	7,300	18,000	17,000	14,000	NM	15,000
	52GW78	Lower	48	10	38 - 48	< 1	< 1	< 1	5.0	> 90	17	> 100	> 100	56.6	65.7	180	1,900	3,300	11,000	13,000	NM	10,000
	52GW79	Lower	48	10	38 - 48	< 1	< 1	< 1	< 1	70	15	> 100	> 100	34.8	45.0	130	170	1,500	3,600	12,000	NM	8,100
	52GW80	Upper	32	10	22 - 32	< 1	2.4	0.2	> 90	> 90	NM	> 100	> 100	88.9	87.0	700	6,000	19,000	17,000	19,000	15,000	20,000
	52GW81	Lower	48	10	38 - 48	< 1	< 1	< 1	> 90	> 90	NM	> 100	15	46.7	9.1	610	2,600	7,000	15,000	15,000	11,000	6,500
Existing Monitoring	16GW11	Upper	27	15	12 - 27	< 1	< 1	< 1	< 1	< 1	NM	< 1	< 1	< 1	< 1	8.2 J	4.2 J	11	7.7 J	41	41	230
	MW53	Lower	54	10	44 - 54	< 1	< 1	< 1	< 1	< 1	NM	< 1	< 1	< 1	< 1	52	78	79	98	95	95	88

Notes:

[1]Wellhead screening for VOCs, H_2S, LEL, and CO collected with MultiRAE PLUS P

[2]Methane wellhead screening collected with a Landtec Landfill Gas Analyzer (Mod

[3]Methane data via Method RSK-175 on aqueous samples

ft bgs - feet below ground surface

NM - not measured

ppm - parts per million

J - Analyte present, value may or may not be accurate or precise

TABLE 3

Baseline and Post-Injection Biogas Data

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study Well Type	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	CO (ppm)							
						Baseline	3-Month	6-Month	9-Month	12-Month	16-Month	18-Month	24-Month
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	NM	NM	NM	NM	NM	NM	17	5.0
	OU1-52IW02	Lower	50	15	35 - 50	NM	NM	NM	NM	NM	NM	85	6.0
	OU1-52IW03	Upper	35	15	20 - 35	NM	NM	NM	NM	NM	NM	8.0	4.0
	OU1-52IW04	Lower	50	15	35 - 50	NM	NM	NM	NM	NM	NM	10	3.0
	OU1-52IW05	Upper	35	15	20 - 35	NM	NM	NM	NM	NM	NM	5.0	< 1
	OU1-52IW06	Lower	50	15	35 - 50	NM	NM	NM	NM	NM	NM	635	118
	OU1-52IW07	Upper	35	15	21 - 36	NM	NM	NM	NM	NM	NM	10	13
	OU1-52IW08	Lower	50	15	30 - 45	NM	NM	NM	NM	NM	< 1	< 1	4.0
	OU1-52IW09	Upper	35	15	20 - 35	NM	NM	NM	NM	NM	NM	< 1	2.0
	OU1-52IW10	Lower	50	15	32 - 47	NM	NM	NM	NM	NM	NM	< 1	2.0
	OU1-52IW11	Upper	35	15	20 - 35	NM	NM	NM	NM	NM	NM	< 1	3.0
	OU1-52IW12	Lower	50	15	30 - 45	NM	NM	NM	NM	NM	20	< 1	1.0
	OU1-52IW13	Upper	35	15	20 - 35	NM	NM	NM	NM	NM	NM	55	15
	OU1-52IW14	Lower	50	15	30 - 45	NM	NM	NM	NM	NM	NM	63	19
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	< 1	0.1	< 1	< 1	22.0	NM	8.0	1.0
	52GW78	Lower	48	10	38 - 48	< 1	0.1	< 1	< 1	122	< 1	25	1.0
	52GW79	Lower	48	10	38 - 48	< 1	3.0	< 1	< 1	4.0	< 1	< 1	2.0
	52GW80	Upper	32	10	22 - 32	< 1	18	< 1	2	6.0	NM	1.0	7.0
	52GW81	Lower	48	10	38 - 48	< 1	6.0	9.0	< 1	55	NM	< 1	3.0
Existing Monitoring	16GW11	Upper	27	15	12 - 27	< 1	0.1	< 1	< 1	1.0	NM	< 1	< 1
	MW53	Lower	54	10	44 - 54	< 1	0.1	< 1	< 1	< 1	NM	< 1	< 1

Notes:

[1]Wellhead screening for VOCs, H_2S, LEL, and CO collected with MultiRAE PLUS P

[2]Methane wellhead screening collected with a Landtec Landfill Gas Analyzer (Mod

[3]Methane data via Method RSK-175 on aqueous samples

ft bgs - feet below ground surface

NM - not measured

ppm - parts per million

J - Analyte present, value may or may not be accurate or precise

TABLE 4

Baseline and Post-Injection

Groundwater VOC and NAIP Detections

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Station ID	**Screening Criteria**	16GW11 - Upper Surficial Aquifer (Upgradient)								OU1-MW53 - Lower Surficial Aquifer (Upgradient)						
Sample ID		16GW11-052511	U1-16GW11-06091	U1-16GW11-0921	OU1-16GW11-092911	U1-16GW11-12121	16GW11-031312	16GW11-061912	16GW11-060413	MW53-052511	J1-MW53-0609	OU1-MW53-09201	OU1-GW53-121311	MW53-031312	MW53-061912	MW53-060413
Sample Date		05/25/11	06/09/11	09/21/11	09/29/11	12/12/11	03/13/12	06/19/12	06/04/13	05/25/11	06/09/11	09/20/11	12/13/11	03/13/12	06/19/12	06/04/13
Chemical Name																
Volatile Organic Compounds (UG/L)																
1,1,2,2-Tetrachloroethane	0.2	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	6	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	7	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	**0.93 J**	NA	**1.6**	**1.4**	0.5 U	**1.3**	**1.2**
1,2-Dichloroethene (total)	70	**8.4**	NA	**1.8 J**	NA	1 U	1 U	**1.3 J**	1 U	**510**	NA	**940**	**910**	**1,100**	**820**	**830**
cis-1,2-Dichloroethene	70	**7.7**	NA	1.8 B	NA	0.5 U	0.5 U	**1.3**	0.5 U	**400**	NA	**610**	**650**	**780**	**700**	**690**
Methylene chloride	5	2.5 U	NA	2.5 U	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Tetrachloroethene	0.7	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	**1.5**
trans-1,2-Dichloroethene	100	**0.72 J**	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	**120**	NA	**190**	**200**	**200**	**170**	**160**
Trichloroethene	3	1.2 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	**610**	NA	**680**	**580**	**630**	**620**	**500**
Vinyl chloride	0.03	**1.2 J**	NA	1 U	NA	1 U	1 U	1 U	1 U	**1.5 J**	NA	**2.8**	**1.8 J**	**2.6**	1 U	**1.2 J**
Wet Chemistry																
Ethane	--	2 U	NA	2 U	NA	2 U	2 U	2 U	2 U	**3.9 J**	NA	**6.1 J**	**6.1 J**	**7.1 J**	**6.4 J**	**5 J**
Ethene	--	2 U	NA	2 U	NA	2 U	2 U	2 U	2 U	2 U	NA	2 U	2 U	2 U	2 U	2 U
Methane	--	**8.2 J**	NA	**4.2 J**	NA	**11**	**7.7 J**	**41**	**230**	**52**	NA	**78**	**79**	**98**	**95**	**88**
3-Methylbutanoic acid	--	NA	NA	NA	NA	NA	NA	0.044 U	NA	NA	NA	NA	NA	NA	0.044 U	NA
4-(2-Methyl-4-chlorophenoxy)butyric acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetate	--	NA	NA	NA	NA	NA	NA	**0.019 J**	**0.18 J**	NA	NA	NA	NA	NA	**0.022 J**	**0.16 J**
Butyrate	--	0.05 U	NA	0.05 U	NA	0.05 U	0.05 U	0.004 U	0.1 U	0.05 U	NA	0.05 U	0.05 U	0.05 U	0.004 U	0.1 U
Formic acid	--	**0.061 J**	NA	**0.09 J**	NA	**0.06 J**	0.1 U	**0.045 J**	**0.27**	**0.066 J**	NA	**0.096 J**	**0.07 J**	**0.02 J**	**0.039 J**	**0.31**
Hexanoic Acid	--	NA	NA	NA	NA	NA	NA	0.006 U	NA	NA	NA	NA	NA	NA	0.006 U	NA
Lactic Acid	--	**0.12**	NA	**0.27**	NA	**0.13**	**0.038 J**	**0.078 J**	0.2 U	**0.15**	NA	**0.21**	**0.085 J**	**0.082 J**	**0.062 J**	**0.49**
Nitrate/Nitrite	--	NA	NA	NA	NA	**0.41**	NA	NA	NA	NA	NA	NA	0.025 U	NA	NA	NA
Pentanoic Acid	--	NA	NA	NA	NA	NA	NA	0.012 U	NA	NA	NA	NA	NA	NA	0.012 U	NA
Propionic Acid	--	**0.052**	NA	**0.075**	NA	**0.025 J**	**0.11**	0.007 U	0.1 U	**0.07**	NA	**0.13**	**0.025 J**	**0.01 J**	0.007 U	0.1 U
Pyruvate	--	0.15 U	NA	0.15 U	NA	0.15 U	0.15 U	0.033 U	0.1 U	0.15 U	NA	0.15 U	0.15 U	0.15 U	0.033 U	**0.67**
Sulfate	250	**14**	NA	**16**	NA	**38**	**29**	**17**	NA	**1.3**	NA	**15**	**16**	**15**	**15**	NA
Sulfide	--	0.75 U	NA	0.75 U	NA	0.75 U	**0.8 J**	**0.7 J**	NA	**1**	NA	**0.8 J**	0.75 U	**1.2**	**0.85 J**	NA
Total organic carbon (TOC)	--	**1.4**	**7.1**	**1.9**	NA	**2.1**	**1.5**	**1.5**	**1.1**	**1.6**	**2.4**	**1.7**	**1.5**	**1.5**	**1.6**	**1.3**
General Microbial Analyses (CELLS/ML)																
Dehalococcoides	--	**14.2**	NA	NA	**0.6 J**	**11.8**	**6.9**	**5.1**	50 U	**196**	NA	**0.9**	**210**	**584**	**21.2**	**8.1**
Dehalobacter	--	**9,330**	NA	NA	**213**	**142**	**3.3**	**3.7**	NA	**3,290**	NA	2.4 U	**370**	**21.4**	**4.5**	NA
Desulfuromonas	--	**2.8**	NA	NA	**6.5**	1 U	1 U	1 U	NA	**4,100**	NA	**170**	**2,200**	**253**	**1,920**	NA
Methane Oxidizing Bacteria	--	NA	NA	NA	**17,800,000**	**5,090,000**	NA	NA	**9,000,000**	NA	NA	**559,000**	**221,000**	NA	NA	**8,490,000**
Soluble Methane Monooxygenase	--	NA	NA	NA	NA	NA	NA	NA	**1,410**	NA	NA	NA	NA	NA	NA	**2,140**
Toluene Dioxygenase	--	NA	NA	NA	**32,800**	**32,100**	NA	NA	NA	NA	NA	0.8 U	1 U	NA	NA	NA
DHC Functional Genes (CELLS/ML)																
BAV1 R-Dase	--	NA	NA	NA	NA	NA	0.5 U	0.5 U	50 U	NA	NA	NA	NA	**23.8**	**10.5**	**44.4**
TCE R-Dase	--	NA	NA	NA	NA	NA	0.5 U	0.5 U	50 U	NA	NA	NA	NA	**0.5 J**	0.5 U	50 U
VC R-Dase	--	NA	NA	NA	NA	NA	**0.2 J**	0.5 U	50 U	NA	NA	NA	NA	**1.9**	0.5 U	50 U

Notes:

Exceeds one or more criteria

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

D - Compound identified in an analysis at a secondary dilution factor

J - Analyte present, value may or may not be accurate or precise

M - Duplicate injection precision criteria not met

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

CELLS/ML - Cells per milliliter

MG/L - Milligrams per liter

UG/L - Micrograms per liter

TABLE 4

Baseline and Post-Injection

Groundwater VOC and NAIP Detections

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Station ID	**Screening Criteria**	52GW77 - Upper Surficial Aquifer											
Sample ID		OU1-52GW77-052511	OU1-52GW77D-05251	OU1-52GW77-061011	OU1-52GW77-092011	OU1-52GW77D-09201	OU1-52GW77-121211	OU1-52GW77D-12121	OU1-52GW77-031412	OU1-52GW77D-03141	OU1-52GW77-061812	OU1-52GW77D-06181	OU1-52GW77-060413
Sample Date		05/25/11	05/25/11	06/10/11	09/20/11	09/20/11	12/12/11	12/12/11	03/14/12	03/14/12	06/18/12	06/18/12	06/04/13
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1,2,2-Tetrachloroethane	0.2	0.5 U	0.5 U	NA	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
1,1-Dichloroethane	6	**0.53 J**	**0.29 J**	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**1.3**
1,1-Dichloroethene	7	**0.43 J**	**0.44 J**	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**0.42 J**
1,2-Dichloroethene (total)	70	**100**	**110**	NA	**25**	**24**	**32**	**32**	**44**	**44**	**80**	**75**	**91**
cis-1,2-Dichloroethene	70	**93**	**100**	NA	**24**	**23**	**32**	**32**	**42**	**42**	**74**	**70**	**83**
Methylene chloride	5	2.5 U	2.5 U	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Tetrachloroethene	0.7	0.5 U	0.5 U	NA	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
trans-1,2-Dichloroethene	100	**7.7**	**8.3**	NA	**1.6**	**1.7**	0.5 U	0.5 U	**2.3**	**2.2**	**5.9**	**5**	**8.3**
Trichloroethene	3	**29**	**31**	NA	**0.77 J**	1.3 B	**0.72 J**	**0.72 J**	0.5 U	0.5 U	**0.92 J**	**1**	**3.6**
Vinyl chloride	0.03	**20**	**20**	NA	**8.7**	**9**	**14**	**15**	**17**	**19**	**28**	**26**	**31**
Wet Chemistry													
Ethane	--	2 U	NA	NA	2 U	NA	2 U	NA	2 U	NA	2 U	NA	2 U
Ethene	--	**2.5 J**	NA	NA	**1.5 J**	NA	**1.4 J**	NA	**4.7 J**	NA	**9.8 J**	NA	**12**
Methane	--	**700**	NA	NA	**7,300**	NA	**18,000**	NA	**17,000**	NA	**14,000**	NA	**15,000**
3-Methylbutanoic acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.044 U	NA	NA
4-(2-Methyl-4-chlorophenoxy)butyric acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetate	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.063 J**	NA	**0.17 J**
Butyrate	--	0.05 U	NA	NA	**17 D**	NA	**0.54**	NA	0.05 U	NA	0.004 U	NA	0.1 U
Formic acid	--	**0.099 J**	NA	NA	**1.6 D**	NA	**0.68 J**	NA	**0.048 J**	NA	**0.061 J**	NA	**0.36**
Hexanoic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006 U	NA	NA
Lactic Acid	--	**0.25**	NA	NA	**6 D**	NA	1 U	NA	**0.13**	NA	0.01 U	NA	0.2 U
Nitrate/Nitrite	--	NA	NA	NA	NA	NA	0.12 U	NA	NA	NA	NA	NA	NA
Pentanoic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.012 U	NA	NA
Propionic Acid	--	0.05 U	NA	NA	**60 D**	NA	**2.5**	NA	**0.022 J**	NA	**0.027 J**	NA	0.1 U
Pyruvate	--	0.15 U	NA	NA	**1.2 D**	NA	**0.47 J**	NA	0.15 U	NA	0.033 U	NA	0.1 U
Sulfate	250	**13**	NA	NA	0.5 U	NA	1 U	NA	**0.97 J**	NA	**0.85 J**	NA	NA
Sulfide	--	0.75 U	NA	NA	0.75 U	NA	7.5 U	NA	0.75 U	NA	15 U	NA	NA
Total organic carbon (TOC)	--	**5.2**	NA	**10**	**130**	NA	**53**	NA	**10**	NA	**12**	NA	**7.8**
General Microbial Analyses (CELLS/ML)													
Dehalococcoides	--	**1,780**	NA	NA	**7.2**	NA	**13,600**	NA	**380**	NA	**8.1 J**	NA	**98,200**
Dehalobacter	--	**96,100**	NA	NA	**102,000**	NA	**2,220**	NA	**880**	NA	**15.7 J**	NA	NA
Desulfuromonas	--	**20**	NA	NA	**116**	NA	1 U	NA	3.1 U	NA	20 U	NA	NA
Methane Oxidizing Bacteria	--	NA	NA	NA	**92,600,000**	NA	**5,510,000**	NA	NA	NA	NA	NA	**679,000**
Soluble Methane Monooxygenase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1 U
Toluene Dioxygenase	--	NA	NA	NA	**69,200**	NA	1 U	NA	NA	NA	NA	NA	NA
DHC Functional Genes (CELLS/ML)													
BAV1 R-Dase	--	NA	NA	NA	NA	NA	NA	NA	1.5 U	NA	10 U	NA	**70**
TCE R-Dase	--	NA	NA	NA	NA	NA	NA	NA	**24.3**	NA	10 U	NA	**66,000**
VC R-Dase	--	NA	NA	NA	NA	NA	NA	NA	**3.5**	NA	10 U	NA	**65,200**

Notes:

Exceeds one or more criteria

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

D - Compound identified in an analysis at a secondary dilution factor

J - Analyte present, value may or may not be accurate or precise

M - Duplicate injection precision criteria not met

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

CELLS/ML - Cells per milliliter

MG/L - Milligrams per liter

UG/L - Micrograms per liter

TABLE 4

Baseline and Post-Injection

Groundwater VOC and NAIP Detections

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Station ID	**Screening Criteria**	52GW78 - Lower Surficial Aquifer								52GW79 - Lower Surficial Aquifer								
Sample ID		1-52GW78-0521	1-52GW78-0609	U1-52GW78-09201	U1-52GW78-12131	1-52GW78-0311	1-52GW78-0619	U1-52GW78-10041	U1-52GW78-06041	1-52GW79-0521	-52GW79-0610	U1-52GW79-0921	U1-52GW79-09291	U1-52GW79-12131	U1-52GW79-0313	U1-52GW79-0618	U1-52GW79-10041	U1-52GW79-06051
Sample Date		05/25/11	06/09/11	09/20/11	12/13/11	03/14/12	06/18/12	10/04/12	06/04/13	05/25/11	06/10/11	09/21/11	09/29/11	12/13/11	03/13/12	06/18/12	10/04/12	06/05/13
Chemical Name																		
Volatile Organic Compounds (UG/L)																		
1,1,2,2-Tetrachloroethane	0.2	0.5 U	NA	0.5 U	0.5 U	250 U	0.5 UC	NA	1 U	0.5 U	NA	2 U	NA	2 U	0.5 U	0.5 U	NA	1 U
1,1-Dichloroethane	6	**1.3**	NA	**0.85 J**	**1.1**	250 U	0.5 U	NA	**0.95 J**	**1.2**	NA	**2.5 J**	NA	**1.8 J**	**0.94 J**	**1.7**	NA	**0.56 J**
1,1-Dichloroethene	7	**2.5**	NA	**1.1**	**1.6**	250 U	**0.47 J**	NA	**1.4 J**	**2.3**	NA	**2.3 J**	NA	**3.5 J**	0.5 U	**2.3**	NA	**2**
1,2-Dichloroethene (total)	70	**1,300**	NA	**700**	**920**	**440 J**	**380 MM**	NA	**1,000**	**1,300**	NA	**2,400**	NA	**1,700**	**1,100**	**1,200**	NA	**1,200**
cis-1,2-Dichloroethene	70	**1,200**	NA	**580**	**910**	**440 J**	**290 MM**	NA	**970**	**1,200**	NA	**2,200**	NA	**1,500**	**640**	**1,300**	NA	**1,100**
Methylene chloride	5	2.5 U	NA	**3.2 J**	2.5 U	1,200 U	2.5 U	NA	5 U	2.5 U	NA	10 U	NA	10 U	2.5 U	2.5 U	NA	5 U
Tetrachloroethene	0.7	0.5 U	NA	0.5 U	0.5 U	250 U	0.5 U	NA	1 U	0.5 U	NA	2 U	NA	2 U	0.5 U	0.5 U	NA	1 U
trans-1,2-Dichloroethene	100	**110**	NA	**54**	**140**	250 U	**68**	NA	**92**	**80**	NA	**86**	NA	**120**	**95**	**160**	NA	**110**
Trichloroethene	3	**720**	NA	**11**	**74**	**180 J**	**160 M**	NA	**400**	**480**	NA	**46**	NA	**250**	**480**	**420**	NA	**280**
Vinyl chloride	0.03	**23**	NA	**59**	**54**	500 U	**6.5**	NA	**13**	**20**	NA	**74**	NA	**80**	**33**	1 U	NA	**25**
Wet Chemistry																		
Ethane	--	**4.1 J**	NA	**4.3 J**	**3.8 J**	200 U	2 U	NA	**2.6 J**	**3.2 J**	NA	**5.8 J**	NA	**4.4 J**	**7.1 J**	**4 J**	NA	**2 J**
Ethene	--	2 U	NA	**4.4 J**	**1.7 J**	200 U	2 U	NA	**1.8 J**	**1.1 J**	NA	**2.9 J**	NA	**3.3 J**	**3.6 J**	**1.1 J**	NA	**2 J**
Methane	--	**180**	NA	**1,900**	**3,300**	**11,000**	**13,000**	NA	**10,000**	**130**	NA	**170**	NA	**1,500**	**3,600**	**12,000**	NA	**8,100**
3-Methylbutanoic acid	--	NA	NA	NA	NA	NA	**0.54**	NA	NA	NA	NA	NA	NA	NA	NA	**0.41**	NA	NA
4-(2-Methyl-4-chlorophenoxy)butyric acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetate	--	NA	NA	NA	NA	NA	**180**	NA	**130**	NA	NA	NA	NA	NA	NA	**140**	NA	**170**
Butyrate	--	0.05 U	NA	**34 D**	**8.4**	**16**	**18**	NA	**18**	0.05 U	NA	**11 D**	NA	**9.9**	**9.4**	**14**	NA	**27**
Formic acid	--	**0.11**	NA	**2.1 D**	**0.56 J**	**1.5**	**1.9**	NA	1 U	**0.17**	NA	**1.3 D**	NA	**0.61 J**	**0.54**	**1.1**	NA	1 U
Hexanoic Acid	--	NA	NA	NA	NA	NA	**12**	NA	NA	NA	NA	NA	NA	NA	NA	**8.9**	NA	NA
Lactic Acid	--	**0.28**	NA	**12 D**	1 U	**0.54**	**0.48**	NA	2 U	**0.16**	NA	**0.64 J**	NA	1 U	**0.24**	**0.39**	NA	4 U
Nitrate/Nitrite	--	NA	NA	NA	0.025 U	NA	NA	NA	NA	NA	NA	NA	NA	0.025 U	NA	NA	NA	NA
Pentanoic Acid	--	NA	NA	NA	NA	NA	**3.8**	NA	NA	NA	NA	NA	NA	NA	NA	**0.24**	NA	NA
Propionic Acid	--	0.05 U	NA	**60 D**	**9.2**	**37**	**23**	NA	1 U	**0.064**	NA	**28 D**	NA	**10**	**12**	**7.7**	NA	1 U
Pyruvate	--	0.15 U	NA	**1.9 D**	**0.58 J**	**0.63**	**1.1 J**	NA	0.1 U	0.15 U	NA	**0.51**	NA	**0.73 J**	**0.42**	**0.46**	NA	1 U
Sulfate	250	**35**	NA	0.5 U	0.5 U	**0.71 J**	**0.31 J**	NA	NA	**28**	NA	**7**	NA	0.5 U	**0.56 J**	**0.5 J**	NA	NA
Sulfide	--	0.75 U	NA	**0.95 J**	0.75 U	0.75 U	**1**	NA	NA	0.75 U	NA	0.75 U	NA	**1.6**	**1.7**	**3**	NA	NA
Total organic carbon (TOC)	--	**2.3**	**3,100**	**190**	**81**	**3,300**	**180**	NA	**77**	**1.7**	**22**	**97**	NA	**86**	**71**	**100**	NA	**100**
General Microbial Analyses (CELLS/ML)																		
Dehalococcoides	--	**39.7**	NA	**10,300**	**60.8**	**16.7**	**94.4**	NA	**42.9**	**861**	NA	NA	**21,600**	**84,000**	**3.2**	**526**	NA	**14.8**
Dehalobacter	--	**10,500**	NA	**368,000**	**11.9**	**181**	**498**	NA	NA	**19,300**	NA	NA	**3,360,000**	**4,880**	**119**	**135**	NA	NA
Desulfuromonas	--	**12.2**	NA	**2,650**	1 U	13 U	**0.9 J**	NA	NA	**215**	NA	NA	**25.2**	1 U	1.5 U	0.9 U	NA	NA
Methane Oxidizing Bacteria	--	NA	NA	**115,000,000**	**1,570,000**	NA	NA	**57,100,000**	**30,300,000**	NA	NA	NA	**824,000,000**	**22,800,000**	NA	NA	**49,400,000**	**13,400,000**
Soluble Methane Monooxygenase	--	NA	NA	NA	NA	NA	NA	**4,770**	1.2 U	NA	NA	NA	NA	NA	NA	NA	**4,710**	1 U
Toluene Dioxygenase	--	NA	NA	**2,080,000**	**1,150**	NA	NA	NA	NA	NA	NA	NA	**1,200,000**	**5,080**	NA	NA	NA	NA
DHC Functional Genes (CELLS/ML)																		
BAV1 R-Dase	--	NA	NA	NA	NA	**9.7**	**0.4 J**	NA	**70**	NA	NA	NA	NA	NA	0.7 U	0.5 U	NA	**4.5**
TCE R-Dase	--	NA	NA	NA	NA	**18.4**	**1.5**	NA	**28.9**	NA	NA	NA	NA	NA	**4.2**	**554**	NA	**1.82**
VC R-Dase	--	NA	NA	NA	NA	6.5 U	**0.6 J**	NA	**16.7**	NA	NA	NA	NA	NA	0.7 U	**346**	NA	**11.6**

Notes:

Exceeds one or more criteria

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

D - Compound identified in an analysis at a secondary dilution factor

J - Analyte present, value may or may not be accurate or precise

M - Duplicate injection precision criteria not met

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

CELLS/ML - Cells per milliliter

MG/L - Milligrams per liter

UG/L - Micrograms per liter

TABLE 4

Baseline and Post-Injection

Groundwater VOC and NAIP Detections

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Station ID	**Screening Criteria**	52GW80 - Upper Surficial Aquifer												52GW81 - Lower Surficial Aquifer								
Sample ID		52GW80-05	52GW80-06	52GW80-09	U1-52GW80-0929	52GW80-121	-52GW80-12131	-52GW80-1213	-52GW80-03	52GW80-06	U1-52GW80-0115	U1-52GW80-0605	2GW80P-0	-52GW81-052	52GW81-06	52GW81-09	U1-52GW81-0929	U1-52GW81-1213	52GW81-03	52GW81-06	U1-52GW81-0115	U1-52GW81-0605
Sample Date		05/25/11	06/10/11	09/21/11	09/29/11	12/13/11	12/13/11	12/13/11	03/13/12	06/18/12	01/15/13	06/05/13	06/05/13	05/25/11	06/10/11	09/21/11	09/29/11	12/13/11	03/14/12	06/18/12	01/15/13	06/05/13
Chemical Name																						
Volatile Organic Compounds (UG/L)																						
1,1,2,2-Tetrachloroethane	0.2	0.5 U	NA	0.5 U	NA	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	6	0.5 U	NA	0.5 U	NA	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**1.2**	NA	**0.56 J**	NA	**0.7 J**	**0.71 J**	**0.69 J**	0.5 U	0.5 U
1,1-Dichloroethene	7	0.5 U	NA	0.5 U	NA	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**3.7**	NA	**0.7 J**	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethene (total)	70	**31**	NA	**3**	NA	**1 J**	NA	NA	**5.6**	**8.3**	**0.34 J**	**1.6 J**	**1.6 J**	**1,600**	NA	**260**	NA	**190**	**530**	**390**	**14**	**200 J**
cis-1,2-Dichloroethene	70	**30**	NA	**3**	NA	**1**	NA	NA	**5.3**	**7.8**	**0.34 J**	**1.6**	**1.6**	**1,500**	NA	**250**	NA	**140**	**350**	**330**	**13**	**130 J**
Methylene chloride	5	2.5 U	NA	2.5 U	NA	2.5 U	NA	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	NA	2.5 U	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Tetrachloroethene	0.7	0.5 U	NA	0.5 U	NA	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	**1.6**	NA	0.5 U	NA	0.5 U	NA	NA	**0.32 J**	**0.49 J**	0.5 U	0.5 U	0.5 U	**34**	NA	**42**	NA	**50**	**44**	**49**	**1.4**	**64 J**
Trichloroethene	3	**9.6**	NA	0.5 U	NA	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U	**0.34 J**	0.5 U	**440**	NA	**14**	NA	**15**	**35**	**58**	**0.8 J**	**42**
Vinyl chloride	0.03	**3.1**	NA	1 U	NA	**0.82 J**	NA	NA	**1.9 J**	**3**	1 U	**0.72 J**	**0.74 J**	**28**	NA	**13**	NA	1 U	**12**	1 U	**8.3**	**9**
Wet Chemistry																						
Ethane	--	2 U	NA	2 U	NA	2 U	NA	NA	2 U	2 U	2 U	2 U	NA	**3.1 J**	NA	**1.9 J**	NA	2 U	2 U	2 U	2 U	2 U
Ethene	--	2 U	NA	2 U	NA	2 U	NA	NA	2 U	2 U	**2.2 J**	2 U	NA	**2.6 J**	NA	**1.7 J**	NA	2 U	2 U	2 U	2 U	2 U
Methane	--	**700**	NA	**6,000**	NA	#####	NA	NA	**17,000**	**19,000**	**15,000**	**20,000**	NA	**610**	NA	**2,600**	NA	**7,000**	**15,000**	**15,000**	**11,000**	**6,500**
3-Methylbutanoic acid	--	NA	NA	NA	NA	NA	NA	NA	NA	**0.86**	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.44**	NA	NA
4-(2-Methyl-4-chlorophenoxy)butyric acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.62**	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1**	NA
Acetate	--	NA	NA	NA	NA	NA	NA	NA	NA	**120**	NA	**9.8**	NA	NA	NA	NA	NA	NA	NA	**81**	NA	**50**
Butyrate	--	0.05 U	NA	**67 D**	NA	**18**	NA	NA	**11**	**3.8**	NA	**0.18 J**	NA	0.05 U	NA	**8.5 D**	NA	**7.1**	**16**	**9.8**	NA	**4.6**
Formic acid	--	**0.094 J**	NA	**13 D**	NA	**3.2**	NA	NA	**1.8**	**1.6**	**0.16 J**	**0.37**	NA	**0.19**	NA	**1.2 D**	NA	**0.57 J**	**0.76**	**1.2**	0.25 U	0.1 U
Hexanoic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	**0.56**	NA	NA	NA	NA	NA	NA	NA	NA	NA	**5.7**	NA	NA
Lactic Acid	--	0.1 U	NA	**10 D**	NA	1 U	NA	NA	**0.38**	**2.1**	0.1 U	0.5 U	NA	**0.21**	NA	**1 D**	NA	1 U	**0.61**	**0.79**	0.25 U	2.5 U
Nitrate/Nitrite	--	NA	NA	NA	NA	0.12 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.02 J**	NA	NA	NA	NA
Pentanoic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	**0.086**	NA	NA	NA	NA	NA	NA	NA	NA	NA	**4.9**	NA	NA
Propionic Acid	--	**0.08**	NA	**320 D**	NA	**85**	NA	NA	**11**	**3.9**	**0.28**	**0.13 J**	NA	**0.06**	NA	**28 D**	NA	**5.4**	**20**	**28**	**0.96**	1.2 U
Pyruvate	--	0.15 U	NA	**8.5**	NA	**5.3**	NA	NA	**0.83**	**0.26**	0.1 U	0.1 U	NA	0.15 U	NA	**0.4**	NA	**0.57 J**	**0.66**	**1.3 J**	0.25 U	0.1 U
Sulfate	250	**9.2**	NA	0.5 U	NA	0.5 U	NA	NA	**0.86 J**	**0.51 J**	NA	NA	NA	**27**	NA	0.5 U	NA	0.5 U	**0.69 J**	**1.8**	NA	NA
Sulfide	--	0.75 U	NA	0.75 U	NA	7.5 U	NA	NA	0.75 U	15 U	NA	NA	NA	0.75 U	NA	**1.1**	NA	0.75 U	**2.3**	**2**	NA	NA
Total organic carbon (TOC)	--	**3.4**	**1,800**	**450**	NA	**220**	NA	NA	**140**	**73**	**24**	**10**	NA	**4.5**	**1,600**	**120**	NA	**72**	**100**	**110**	**52**	**36**
General Microbial Analyses (CELLS/ML)																						
Dehalococcoides	--	**2,200**	NA	NA	**40.3**	NA	**84,400**	**30,900**	**340**	**166**	**538**	**42.8**	NA	**672**	NA	NA	**9,130**	**16,900**	**27.8**	**2,940**	**1,390**	**2,760**
Dehalobacter	--	**561**	NA	NA	**342,000**	NA	**1,940**	**617**	**4,570**	**4,970**	NA	NA	NA	**464,000**	NA	NA	**864,000**	**173**	**1,040**	**502**	NA	NA
Desulfuromonas	--	**4.4**	NA	NA	**0.7 J**	NA	**213**	1.4 U	3.7 U	3.3 U	NA	NA	NA	**65.9**	NA	NA	**3.1**	**12.1**	2.2 U	6.9 U	NA	NA
Methane Oxidizing Bacteria	--	NA	NA	NA	**511,000,000**	NA	**40,300,000**	**4,910,000**	NA	NA	**61,400,000**	**29,100,000**	NA	NA	NA	NA	**1,110,000,000**	**10,500,000**	NA	NA	**132,000,000**	**20,900,000**
Soluble Methane Monooxygenase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	**299,000**	**5,350**	NA	NA	NA	NA	NA	NA	NA	NA	**142,000**	**3,860**
Toluene Dioxygenase	--	NA	NA	NA	**138,000**	NA	**26,300**	**1,730**	NA	NA	NA	NA	NA	NA	NA	NA	**574,000**	**13,500**	NA	NA	NA	NA
DHC Functional Genes (CELLS/ML)																						
BAV1 R-Dase	--	NA	NA	NA	NA	NA	NA	NA	**2.4**	1.6 U	**451**	**42.9**	NA	NA	NA	NA	NA	NA	**10.4**	**1,050**	**1,270**	**19,800**
TCE R-Dase	--	NA	NA	NA	NA	NA	NA	NA	1.9 U	**55.3**	**321**	**8.72**	NA	NA	NA	NA	NA	NA	1.1 U	**7.3**	**80**	**1**
VC R-Dase	--	NA	NA	NA	NA	NA	NA	NA	**0.5 J**	**46.9**	**38.4**	**13.3**	NA	NA	NA	NA	NA	NA	**0.6 J**	**17.6**	**90**	**26.3**

Notes:

Exceeds one or more criteria

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

D - Compound identified in an analysis at a secondary dilution factor

J - Analyte present, value may or may not be accurate or precise

M - Duplicate injection precision criteria not met

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

CELLS/ML - Cells per milliliter

MG/L - Milligrams per liter

UG/L - Micrograms per liter

TABLE 4

Baseline and Post-Injection

Groundwater VOC and NAIP Detections

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Station ID	**Screening Criteria**	OU1-52IW01		OU1-52IW02	OU1-52IW03	OU1-52IW04	OU1-52IW05	OU1-52IW06	OU1-52IW07	OU1-52IW08		OU1-52IW09		OU1-52IW10	OU1-52IW11	OU1-52IW12			OU1-52IW13	OU1-52IW14
Sample ID		1-52IW01-052	1-52IW01D-052	1-52IW02-052	1-52IW03-052	1-52IW04-052	1-52IW05-052	1-52IW06-052	1-52IW07-052	1-52IW08-052	1-52IW08-100	1-52IW09-052	U1-52IW09-0115	1-52IW10-052	1-52IW11-052	1-52IW12-052	1-52IW12-100	U1-52IW12-0115	1-52IW13-052	1-52IW14-052
Sample Date		05/24/11	05/24/11	05/25/11	05/24/11	05/23/11	05/23/11	05/23/11	05/24/11	05/23/11	10/04/12	05/24/11	01/15/13	05/23/11	05/24/11	05/22/11	10/04/12	01/15/13	05/24/11	05/22/11
Chemical Name																				
Volatile Organic Compounds (UG/L)																				
1,1,2,2-Tetrachloroethane	0.2	0.5 U	0.5 U	**0.5**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	6	**2.9**	**3.1**	**0.42 J**	**0.75 J**	**1**	0.5 U	**0.24 J**	0.5 U	**0.7 J**	NA	0.5 U	0.5 U	**2.1**	0.5 U	**0.32 J**	NA	0.5 U	0.5 U	**0.96 J**
1,1-Dichloroethene	7	**0.67 J**	**0.6 J**	**1.2**	0.5 U	**1.8**	0.5 U	**0.7 J**	0.5 U	**1.3**	NA	0.5 U	0.5 U	0.5 U	0.5 U	**0.93 J**	NA	0.5 U	0.5 U	**2.2**
1,2-Dichloroethene (total)	70	**100**	**110**	**620**	**70**	**910**	**44**	**250**	**23**	**420**	NA	**8.5**	1 U	**3,600**	**25**	**480**	NA	**15**	**160**	**760**
cis-1,2-Dichloroethene	70	**96**	**100**	**510**	**64**	**870**	**41**	**240**	**22**	**400**	NA	**8.2**	0.5 U	**3,500**	**25**	**480**	NA	**13**	**150**	**750**
Methylene chloride	5	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	NA	2.5 U	2.5 U	2.5 U
Tetrachloroethene	0.7	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	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	**7.5**	**7.8**	**110**	**6.2**	**38**	**3.2**	**8.4**	**1.3**	**11**	NA	**0.29 J**	0.5 U	**56**	**0.83 J**	**6.6**	NA	**1.3**	**5.4**	**9.5 J**
Trichloroethene	3	**15**	**14**	**770**	**5.1**	**330**	**5.3**	**130**	**4.4**	**62**	NA	**0.94 J**	0.5 U	**540**	**5.4**	**140**	NA	**0.81 J**	**12**	**100**
Vinyl chloride	0.03	**20**	**20**	**3.1**	**12**	**22**	**11**	**16**	**6.1**	**24**	NA	**1.7 J**	1 U	**110**	**3**	**8.4**	NA	**8.9**	**59**	**64**
Wet Chemistry																				
Ethane	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2 U	NA	NA	NA	NA	2 U	NA	NA
Ethene	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2 U	NA	NA	NA	NA	**4.4 J**	NA	NA
Methane	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**18,000**	NA	NA	NA	NA	**21,000**	NA	NA
3-Methylbutanoic acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-(2-Methyl-4-chlorophenoxy)butyric acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.18 J**	NA	NA	NA	NA	**4.4**	NA	NA
Acetate	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Butyrate	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formic acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.24**	NA	NA	NA	NA	0.25 U	NA	NA
Hexanoic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1 U	NA	NA	NA	NA	0.25 U	NA	NA
Nitrate/Nitrite	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentanoic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionic Acid	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.27**	NA	NA	NA	NA	**0.53**	NA	NA
Pyruvate	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1 U	NA	NA	NA	NA	0.25 U	NA	NA
Sulfate	250	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfide	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total organic carbon (TOC)	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**21**	NA	NA	NA	NA	**52**	NA	NA
General Microbial Analyses (CELLS/ML)																				
Dehalococcoides	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	**222,000**	NA	**3.25**	NA	NA	NA	**2,880**	**221**	NA	NA
Dehalobacter	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Desulfuromonas	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methane Oxidizing Bacteria	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**4,090,000**	NA	NA	NA	NA	**97,000,000**	NA	NA
Soluble Methane Monooxygenase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**179,000**	NA	NA	NA	NA	**128,000**	NA	NA
Toluene Dioxygenase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DHC Functional Genes (CELLS/ML)																				
BAV1 R-Dase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**20 J**	NA	NA	NA	NA	**75.6**	NA	NA
TCE R-Dase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**24.4**	NA	NA	NA	NA	**111**	NA	NA
VC R-Dase	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1.6**	NA	NA	NA	NA	**129**	NA	NA

Notes:

Exceeds one or more criteria

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

D - Compound identified in an analysis at a secondary dilution factor

J - Analyte present, value may or may not be accurate or precise

M - Duplicate injection precision criteria not met

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

CELLS/ML - Cells per milliliter

MG/L - Milligrams per liter

UG/L - Micrograms per liter

TABLE 5

Baseline and Post-Injection Field Analyzed Natural Attenuation Indication Parameters

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

						Temperature (°C)								Conductivity (mS/cm)							
Pilot Study Well Type	**Well ID**	**Surficial Aquifer Zone**	**Total Well Depth (ft bgs)**	**Screen[a,b] Length (ft)**	**Screen Interval (ft bgs)**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	20.62	NM	NM	NM	NM	NM	NM	NM	0.415	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW02	Lower	50	15	35 - 50	24.00	NM	NM	NM	NM	NM	NM	NM	0.462	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW03	Upper	35	15	20 - 35	19.81	NM	NM	NM	NM	NM	NM	NM	0.447	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW04	Lower	50	15	35 - 50	22.47	NM	NM	NM	NM	NM	NM	NM	0.473	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW05	Upper	35	15	20 - 35	20.12	NM	NM	NM	NM	NM	NM	NM	0.621	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW06	Lower	50	15	35 - 50	20.62	NM	NM	NM	NM	NM	NM	NM	0.720	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW07	Upper	35	15	21 - 36	20.31	NM	NM	NM	NM	NM	NM	NM	0.391	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW08	Lower	50	15	30 - 45	20.84	NM	NM	NM	NM	22.86	NM	NM	0.507	NM	NM	NM	NM	0.451	NM	NM
	OU1-52IW09	Upper	35	15	20 - 35	21.45	NM	NM	NM	NM	NM	19.91	NM	0.509	NM	NM	NM	NM	NM	0.469	NM
	OU1-52IW10	Lower	50	15	32 - 47	20.59	NM	NM	NM	NM	NM	NM	NM	0.396	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW11	Upper	35	15	20 - 35	19.41	NM	NM	NM	NM	NM	NM	NM	0.407	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW12	Lower	50	15	30 - 45	19.58	NM	NM	NM	NM	22.55	20.81	NM	0.389	NM	NM	NM	NM	0.542	0.566	NM
	OU1-52IW13	Upper	35	15	20 - 35	20.45	NM	NM	NM	NM	NM	NM	NM	1.530	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW14	Lower	50	15	30 - 45	20.41	NM	NM	NM	NM	NM	NM	NM	0.489	NM	NM	NM	NM	NM	NM	NM
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	20.07	22.47	22.12	20.74	26.54	NM	NM	22.37	2.378	0.930	1.821	0.784	0.844	NM	NM	0.697
	52GW78	Lower	48	10	38 - 48	23.53	22.09	20.80	22.37	24.09	22.46	NM	22.88	2.410	0.380	0.272	0.366	0.476	0.431	NM	0.390
	52GW79	Lower	48	10	38 - 48	21.80	22.60	20.19	20.24	25.53	22.85	NM	24.03	0.415	0.218	0.263	0.267	0.338	0.362	NM	0.412
	52GW80	Upper	32	10	22 - 32	19.86	22.45	20.83	20.76	23.54	NM	20.89	21.82	3.876	1.276	1.174	0.912	0.818	NM	0.531	0.463
	52GW81	Lower	48	10	38 - 48	22.98	22.69	20.10	21.32	23.93	NM	21.17	21.71	0.568	0.413	0.614	0.560	0.543	NM	0.556	0.498
Existing Monitoring Wells	16GW11	Upper	27	15	12 - 27	20.96	24.22	19.61	20.27	21.63	NM	NM	21.56	0.281	0.338	0.332	0.325	0.312	NM	NM	0.304
	MW53	Lower	54	10	44 - 54	22.46	23.42	22.08	22.25	23.97	NM	NM	21.86	0.464	0.463	0.465	0.459	0.459	NM	NM	0.442

Notes:
DO - dissolved oxygen
ft bgs - feet below ground surface
°C - degrees Celcius
mS/cm - milliSiemens per centimeter
mg/L - milligrams per liter
SU - scientific units
mV - milliVolts
NTUs - nephelometric turbidity units
Ferrous Iron - Hach kit - Phenanthroline Method
Nitrate/Nitrite - Hach kit - Cadmium Reduction/Diazotization Method
DO - Chemetrics kit - Rhodazine D™ Method or In-Situ Optical DO Sensor

TABLE 5

Baseline and Post-Injection Field Analyzed Natural Attenuation Indication Parameters

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

						pH								Turbidity (NTUs)							
Pilot Study Well Type	**Well ID**	**Surficial Aquifer Zone**	**Total Well Depth (ft bgs)**	**Screen[a,b] Length (ft)**	**Screen Interval (ft bgs)**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	5.88	NM	NM	NM	NM	NM	NM	NM	11.8	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW02	Lower	50	15	35 - 50	6.96	NM	NM	NM	NM	NM	NM	NM	7.00	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW03	Upper	35	15	20 - 35	6.12	NM	NM	NM	NM	NM	NM	NM	14.6	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW04	Lower	50	15	35 - 50	6.11	NM	NM	NM	NM	NM	NM	NM	8.83	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW05	Upper	35	15	20 - 35	6.48	NM	NM	NM	NM	NM	NM	NM	3.02	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW06	Lower	50	15	35 - 50	6.55	NM	NM	NM	NM	NM	NM	NM	41.9	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW07	Upper	35	15	21 - 36	6.37	NM	NM	NM	NM	NM	NM	NM	18.9	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW08	Lower	50	15	30 - 45	6.27	NM	NM	NM	NM	5.74	NM	NM	4.85	NM	NM	NM	NM	28.0	NM	NM
	OU1-52IW09	Upper	35	15	20 - 35	6.35	NM	NM	NM	NM	NM	6.25	NM	7.22	NM	NM	NM	NM	NM	6.20	NM
	OU1-52IW10	Lower	50	15	32 - 47	6.16	NM	NM	NM	NM	NM	NM	NM	14.6	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW11	Upper	35	15	20 - 35	6.36	NM	NM	NM	NM	NM	NM	NM	22.6	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW12	Lower	50	15	30 - 45	6.28	NM	NM	NM	NM	5.90	6.15	NM	1.25	NM	NM	NM	NM	12.5	9.80	NM
	OU1-52IW13	Upper	35	15	20 - 35	6.40	NM	NM	NM	NM	NM	NM	NM	6.85	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW14	Lower	50	15	30 - 45	6.35	NM	NM	NM	NM	NM	NM	NM	8.70	NM	NM	NM	NM	NM	NM	NM
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	6.38	6.56	6.56	6.39	6.09	NM	NM	6.37	17.6	1.08	5.04	4.00	5.81	NM	NM	24.7
	52GW78	Lower	48	10	38 - 48	6.46	5.18	5.68	5.71	5.91	5.68	NM	5.94	24.0	50.0	4.49	160	46.0	7.66	NM	37.6
	52GW79	Lower	48	10	38 - 48	6.65	5.37	5.43	5.59	5.62	5.61	NM	5.60	13.5	80.2	5.38	1.26	25.1	11.7	NM	9.94
	52GW80	Upper	32	10	22 - 32	6.29	6.14	6.31	6.35	6.42	NM	6.37	6.34	8.97	14.3	21.7	6.1	6.29	NM	4.03	2.41
	52GW81	Lower	48	10	38 - 48	6.62	5.88	6.53	6.42	6.31	NM	6.70	6.59	24.0	40.1	21.9	9.8	69.1	NM	38.4	9.90
Existing Monitoring Wells	16GW11	Upper	27	15	12 - 27	6.43	6.41	6.56	6.58	6.35	NM	NM	6.52	36.0	4.84	1.04	2.57	1.20	NM	NM	0.43
	MW53	Lower	54	10	44 - 54	6.99	7.05	6.93	6.95	8.85	NM	NM	6.98	21.8	6.87	1.72	1.75	3.22	NM	NM	7.03

Notes:
DO - dissolved oxygen
ft bgs - feet below ground surface
°C - degrees Celcius
mS/cm - milliSiemens per centimeter
mg/L - milligrams per liter
SU - scientific units
mV - milliVolts
NTUs - nephelometric turbidity units
Ferrous Iron - Hach kit - Phenanthroline Method
Nitrate/Nitrite - Hach kit - Cadmium Reduction/Diazotization Method
DO - Chemetrics kit - Rhodazine D™ Method or In-Situ Optical DO Sensor

TABLE 5

Baseline and Post-Injection Field Analyzed Natural Attenuation Indication Parameters

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

						ORP (mV)								DO (mg/L)							
Pilot Study Well Type	**Well ID**	**Surficial Aquifer Zone**	**Total Well Depth (ft bgs)**	**Screen[a,b] Length (ft)**	**Screen Interval (ft bgs)**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	44	NM	NM	NM	NM	NM	NM	NM	0.05	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW02	Lower	50	15	35 - 50	-58	NM	NM	NM	NM	NM	NM	NM	0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW03	Upper	35	15	20 - 35	-40	NM	NM	NM	NM	NM	NM	NM	0.19	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW04	Lower	50	15	35 - 50	-7.0	NM	NM	NM	NM	NM	NM	NM	<0.025	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW05	Upper	35	15	20 - 35	-114	NM	NM	NM	NM	NM	NM	NM	9.00	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW06	Lower	50	15	35 - 50	-109	NM	NM	NM	NM	NM	NM	NM	0.03	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW07	Upper	35	15	21 - 36	-92	NM	NM	NM	NM	NM	NM	NM	<0.025	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW08	Lower	50	15	30 - 45	-35	NM	NM	NM	NM	-106.0	NM	NM	<0.025	NM	NM	NM	NM	0.06	NM	NM
	OU1-52IW09	Upper	35	15	20 - 35	-45	NM	NM	NM	NM	NM	-159	NM	<0.025	NM	NM	NM	NM	NM	<0.025	NM
	OU1-52IW10	Lower	50	15	32 - 47	-23	NM	NM	NM	NM	NM	NM	NM	<0.025	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW11	Upper	35	15	20 - 35	-81	NM	NM	NM	NM	NM	NM	NM	<0.025	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW12	Lower	50	15	30 - 45	-54	NM	NM	NM	NM	-41.5	-92.0	NM	<0.025	NM	NM	NM	NM	0.11	<0.025	NM
	OU1-52IW13	Upper	35	15	20 - 35	-48	NM	NM	NM	NM	NM	NM	NM	<0.025	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW14	Lower	50	15	30 - 45	-37	NM	NM	NM	NM	NM	NM	NM	0.06	NM	NM	NM	NM	NM	NM	NM
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	-57	-128	-150	-98	-135	NM	NM	-86	<0.025	<0.025	0.25	0.05	0.05	NM	NM	<0.025
	52GW78	Lower	48	10	38 - 48	-13	-214	-135	-24	-113	-63.4	NM	-64	<0.025	0.20	<0.1	0.10	0.05	0.09	NM	<0.025
	52GW79	Lower	48	10	38 - 48	-71	-81	-130	-13	-217	-27.4	NM	-112	<0.025	<0.025	<0.1	<0.025	<0.025	0.13	NM	<0.025
	52GW80	Upper	32	10	22 - 32	-40	-121	-92	9	-109	NM	-102	-90	<0.025	<0.025	<0.1	<0.025	0.05	NM	<0.025	<0.025
	52GW81	Lower	48	10	38 - 48	4	-277	-169	-187	-185	NM	-171	-173	0.05	<0.025	<0.1	<0.025	0.10	NM	<0.025	<0.025
Existing Monitoring Wells	16GW11	Upper	27	15	12 - 27	47	-69	193	104	88	NM	NM	107	5.02	1.0	1.0	1.0	0.54	NM	NM	0.20
	MW53	Lower	54	10	44 - 54	-95	-86	-149	-93	-90	NM	NM	-51	0.20	0.10	0.01	0.50	0.64	NM	NM	0.30

Notes:
DO - dissolved oxygen
ft bgs - feet below ground surface
°C - degrees Celcius
mS/cm - milliSiemens per centimeter
mg/L - milligrams per liter
SU - scientific units
mV - milliVolts
NTUs - nephelometric turbidity units
Ferrous Iron - Hach kit - Phenanthroline Method
Nitrate/Nitrite - Hach kit - Cadmium Reduction/Diazotization Method
DO - Chemetrics kit - Rhodazine D™ Method or In-Situ Optical DO Sensor

TABLE 5

Baseline and Post-Injection Field Analyzed Natural Attenuation Indication Parameters

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

						Ferrous Iron (mg/L)								Nitrate (mg/L)							
Pilot Study Well Type	**Well ID**	**Surficial Aquifer Zone**	**Total Well Depth (ft bgs)**	**Screen[a,b] Length (ft)**	**Screen Interval (ft bgs)**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	2.2	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW02	Lower	50	15	35 - 50	2.6	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW03	Upper	35	15	20 - 35	4.2	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW04	Lower	50	15	35 - 50	1.8	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW05	Upper	35	15	20 - 35	4.9	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW06	Lower	50	15	35 - 50	4.0	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW07	Upper	35	15	21 - 36	5.1	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW08	Lower	50	15	30 - 45	2.0	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW09	Upper	35	15	20 - 35	3.6	NM	NM	NM	NM	NM	3.6	NM	<1	NM	NM	NM	NM	NM	4.4	NM
	OU1-52IW10	Lower	50	15	32 - 47	<0.2	NM	NM	NM	NM	NM	NM	NM	4.4	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW11	Upper	35	15	20 - 35	5.0	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW12	Lower	50	15	30 - 45	2.0	NM	NM	NM	NM	NM	2.6	NM	<1	NM	NM	NM	NM	NM	<1	NM
	OU1-52IW13	Upper	35	15	20 - 35	3.6	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW14	Lower	50	15	30 - 45	3.6	NM	NM	NM	NM	NM	NM	NM	<1	NM	NM	NM	NM	NM	NM	NM
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	3.2	5.0	4.0	3.0	3.5	NM	NM	3.0	<1	<1	<1	<1	<1	NM	NM	20
	52GW78	Lower	48	10	38 - 48	2.6	4.0	1.2	1.8	1.8	NM	NM	1.8	13.2	<1	<1	<1	<1	NM	NM	12
	52GW79	Lower	48	10	38 - 48	1.5	3.0	1.5	1.0	2.0	NM	NM	1.8	<1	13.2	<1	<1	<1	NM	NM	<1
	52GW80	Upper	32	10	22 - 32	2.8	5.0	2.0	1.0	4.5	NM	3.4	3.0	<1	<1	<1	<1	<1	NM	4.4	<1
	52GW81	Lower	48	10	38 - 48	3.0	2.2	1.5	2.0	0.9	NM	2.4	2.2	<1	<1	<1	<1	<1	NM	<1	<1
Existing Monitoring Wells	16GW11	Upper	27	15	12 - 27	0.1	<0.2	0.5	<0.2	0.5	NM	NM	<0.2	<1	<1	<1	<1	<1	NM	NM	8.8
	MW53	Lower	54	10	44 - 54	2.0	2.0	2.2	0.6	1.0	NM	NM	1.4	<1	17.6	<1	1.3	<1	NM	NM	4.4

Notes:
DO - dissolved oxygen
ft bgs - feet below ground surface
°C - degrees Celcius
mS/cm - milliSiemens per centimeter
mg/L - milligrams per liter
SU - scientific units
mV - milliVolts
NTUs - nephelometric turbidity units
Ferrous Iron - Hach kit - Phenanthroline Method
Nitrate/Nitrite - Hach kit - Cadmium Reduction/Diazotization Method
DO - Chemetrics kit - Rhodazine D™ Method or In-Situ Optical DO Sensor

TABLE 5

Baseline and Post-Injection Field Analyzed Natural Attenuation Indication Parameters

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

						Nitrite (mg/L)							
Pilot Study Well Type	**Well ID**	**Surficial Aquifer Zone**	**Total Well Depth (ft bgs)**	**Screen[a,b] Length (ft)**	**Screen Interval (ft bgs)**	**Baseline**	**3-Month**	**6-Month**	**9-Month**	**12-Month**	**16-Month**	**18-Month**	**24-Month**
Injection Well Pairs	OU1-52IW01	Upper	35	15	20 - 35	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW02	Lower	50	15	35 - 50	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW03	Upper	35	15	20 - 35	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW04	Lower	50	15	35 - 50	0.23	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW05	Upper	35	15	20 - 35	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW06	Lower	50	15	35 - 50	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW07	Upper	35	15	21 - 36	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW08	Lower	50	15	30 - 45	0.17	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW09	Upper	35	15	20 - 35	0.33	NM	NM	NM	NM	NM	0.2	NM
	OU1-52IW10	Lower	50	15	32 - 47	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW11	Upper	35	15	20 - 35	<0.01	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW12	Lower	50	15	30 - 45	0.20	NM	NM	NM	NM	NM	<0.01	NM
	OU1-52IW13	Upper	35	15	20 - 35	0.20	NM	NM	NM	NM	NM	NM	NM
	OU1-52IW14	Lower	50	15	30 - 45	<0.01	NM	NM	NM	NM	NM	NM	NM
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	0.23	0.17	<0.01	<0.01	<0.01	NM	NM	0.33
	52GW78	Lower	48	10	38 - 48	0.10	0.07	<0.01	<0.01	<0.01	NM	NM	0.33
	52GW79	Lower	48	10	38 - 48	<0.01	<0.01	<0.01	<0.01	<0.01	NM	NM	0.27
	52GW80	Upper	32	10	22 - 32	0.23	0.23	<0.01	<0.01	<0.01	NM	0.23	0.20
	52GW81	Lower	48	10	38 - 48	<0.01	<0.01	<0.01	<0.01	<0.01	NM	<0.01	0.23
Existing Monitoring Wells	16GW11	Upper	27	15	12 - 27	<0.01	<0.01	<0.01	<0.01	<0.01	NM	NM	<0.01
	MW53	Lower	54	10	44 - 54	<0.01	<0.01	<0.01	<0.01	<0.01	NM	NM	0.167

Notes:
DO - dissolved oxygen
ft bgs - feet below ground surface
°C - degrees Celcius
mS/cm - milliSiemens per centimeter
mg/L - milligrams per liter
SU - scientific units
mV - milliVolts
NTUs - nephelometric turbidity units
Ferrous Iron - Hach kit - Phenanthroline Method
Nitrate/Nitrite - Hach kit - Cadmium Reduction/Diazotization Method
DO - Chemetrics kit - Rhodazine D™ Method or In-Situ Optical DO Sensor

TABLE 6

VOC Data Evaluation

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Upper Surficial Aquifer

VOCs	Screening Criteria	Baseline (May 2011) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	3-month (September 2011) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	Percent VOC Reduction at 3 months	6-month (December 2011) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	Percent VOC Reduction at 6 months	9-month (March 2012) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	Percent VOC Reduction at 9 months
1,1,2,2-Tetrachloroethane	0.2	0.5 U	2 of 2	0.5 U	--	0.5 U	0.5 U	2 of 2	0.5 U	--	0.5 U	--	0.5 U	2 of 2	0.5 U	--	0.5 U	--	0.5 U	2 of 2	--	--	0.5 U	--
1,1-Dichloroethane	6	0.5 U	52GW80	0.53 J	52GW77	0.5	0.5 U	2 of 2	0.5 U	--	0.5 U	100%	0.5 U	2 of 2	0.5 U	--	0.5 U	100%	0.5 U	2 of 2	--	--	0.5 U	100%
1,1-Dichloroethene	7	0.5 U	52GW80	0.44 J	52GW77	0.5 U	0.5 U	2 of 2	0.5 U	--	0.5 U	100%	0.5 U	2 of 2	0.5 U	--	0.5 U	100%	0.5 U	2 of 2	--	--	0.5 U	100%
cis-1,2-Dichloroethene	70	30	52GW80	**100**	52GW77	**130**	3.0 B	52GW80	24	52GW77	27	79%	1.0	52GW80	32	52GW77	33	75%	5.3	52GW80	42	52GW77	47.3	64%
Methylene chloride	5	2.5 U	2 of 2	--	--	0.5 U	2.5 U	2 of 2	2.5 U	--	2.5 U	--	2.5 U	2 of 2	2.5 U	--	2.5 U	--	2.5 U	2 of 2	2.5 U	--	2.5 U	--
trans-1,2-Dichloroethene	100	1.6	52GW80	8.3	52GW77	10	0.5 U	52GW80	1.7	52GW77	1.7	83%	0.5 U	2 of 2	0.5 U	--	0.5 U	100%	0.32 J	52GW80	2.3	52GW77	2.62	74%
Trichloroethene	3	**9.6**	52GW80	**31**	52GW77	**40.6**	0.5 U	52GW80	0.77 B	52GW77	0.77	98%	0.5 U	52GW80	0.72 J	52GW77	0.72	98%	0.5 U	2 of 2	--	--	0.5 U	100%
Vinyl Chloride	0.03	**3.1**	52GW80	**20**	52GW77	**23.1**	1 U	52GW80	**9**	52GW77	**9.0**	61%	**0.82**	52GW80	**15**	52GW77	**15.8**	32%	**1.9 J**	52GW80	**19**	52GW77	**20.9**	10%
Total VOCs						205					38.5	**81%**					49.5	**76%**					70.8	**65%**

Lower Surficial Aquifer

VOCs	Screening Criteria	Baseline (May 2011) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	3-month (September 2011) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	Percent VOC Reduction at 3 months	6-month (December 2011) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	Percent VOC Reduction at 6 months	9-month (March 2012) Minimum Value	Minimum Location	Maximum Value	Maximum Location	Total VOCs	Percent VOC Reduction at 9 months
1,1,2,2-Tetrachloroethane	0.2	0.5 U	3 of 3	--	--	0.5 U	0.50 U	3 of 3	0.50 U	--	0.5 U	--	0.5 U	52GW81	5 U	52GW78	2.5 U	--	0.5 U	2 of 3	250 U	52GW78	0.5 U	--
1,1-Dichloroethane	6	1.2	2 of 3	1.3	52GW78	3.7	0.56 J	52GW81	2.5 J	52GW79	3.9	100%	0.7 J	52GW78	1.8 J	52GW79	3.6	100%	250 U	52GW78	0.94 J	52GW79	1.65	100%
1,1-Dichloroethene	7	2.3	52GW79	3.7	52GW81	8.5	0.70 J	52GW81	2.3 J	52GW79	4.1	100%	0.5 U	52GW81	3.5 J	52GW79	4.6	100%	0.5 U	2 of 3	250 U	52GW78	0.5 U	100%
cis-1,2-Dichloroethene	70	**1,200**	2 of 3	**1,500**	52GW81	**3,900**	250	52GW81	2,200	52GW79	**3,030**	22%	**140**	52GW81	**1,500**	52GW79	**2,550**	35%	**350**	52GW81	**640**	52GW79	**1,430**	63%
Methylene chloride	5	2.5 U	3 of 3	--	--	2.5 U	2.5 U	2 of 3	3.2 J	52GW78	3.2	--	2.5 U	2 of 3	10 U	52GW79	2.5 U	--	2.5 U	2 of 3	1,200 U	52GW78	2.5 U	--
trans-1,2-Dichloroethene	100	34	52GW81	**110**	52GW78	224	42	52GW81	86	52GW79	182	19%	50	52GW81	**140**	52GW79	**310**	-38%	250 U	52GW78	**140**	52GW79	**184**	18%
Trichloroethene	3	**440**	52GW81	**720**	52GW78	**1,640**	11	52GW78	46	52GW79	71	96%	**15**	52GW81	**250**	52GW79	**339**	79%	**35**	52GW81	**480**	52GW79	**695**	58%
Vinyl Chloride	0.03	**20**	52GW79	**28**	52GW81	**71**	13	52GW81	74	52GW79	146	-106%	1 U	52GW81	**80**	52GW79	**134**	-89%	500 U	52GW78	**33**	52GW79	**45**	37%
Total VOCs						5,847					3,440	**41%**					3,341	**43%**					2,356	**60%**

Notes:

All concentrations in micrograms per liter
Bold value indicates exceedance
16GW11 or MW53 not included in data evaluation
µg/L - micrograms per liter
U - Compound analyzed for but not detected
J - Reported value is estimated
B - Analyte not detected above the level reported in blanks
VOCs - Volatile organic compounds

TABLE 6

VOC Data Evaluation

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

							Upper Surficial Aquifer											
		Baseline (May 2011)					**12-month (June 2012)**						**24-month (June 2013)**					
VOCs	**Screening Criteria**	**Minimum Value**	**Minimum Location**	**Maximum Value**	**Maximum Location**	**Total VOCs**	**Minimum Value**	**Minimum Location**	**Maximum Value**	**Maximum Location**	**Total VOCs**	**Percent VOC Reduction at 12 months**	**Minimum Value**	**Minimum Location**	**Maximum Value**	**Maximum Location**	**Total VOCs**	**Percent VOC Reduction at 24 months**
1,1,2,2-Tetrachloroethane	0.2	0.5 U	2 of 2	0.5 U	--	0.5 U	0.5 U	2 of 2	--	--	0.5 U	--	0.5 U	2 of 2	--	--	0.5 U	--
1,1-Dichloroethane	6	0.5 U	52GW80	0.53 J	52GW77	0.5	0.5 U	2 of 2	--	--	0.5 U	100%	0.5 U	52GW80	1.3	52GW77	1.3	-145%
1,1-Dichloroethene	7	0.5 U	52GW80	0.44 J	52GW77	0.5 U	0.5 U	2 of 2	--	--	0.5 U	100%	0.5 U	52GW80	0.42 J	52GW77	0.42	5%
cis-1,2-Dichloroethene	70	30	52GW80	**100**	52GW77	**130**	7.8	52GW80	**74**	52GW77	**81.8**	37%	1.6	52GW80	**83**	52GW77	**84.6**	35%
Methylene chloride	5	2.5 U	2 of 2	--	--	0.5 U	2.5 U	2 of 2	--	--	0.5 U	--	2.5 U	2 of 2	--	--	0.5 U	--
trans-1,2-Dichloroethene	100	1.6	52GW80	8.3	52GW77	10	0.49 J	52GW80	5.9	52GW77	6.5	35%	0.5 U	52GW80	8.3	52GW77	8.3	16%
Trichloroethene	3	**9.6**	52GW80	**31**	52GW77	**40.6**	0.5 U	52GW80	1	52GW77	1.5	98%	0.34 J	52GW80	**3.6**	52GW77	**3.9**	90%
Vinyl Chloride	0.03	**3.1**	52GW80	**20**	52GW77	**23.1**	**3**	52GW80	**28**	52GW77	**31.5**	-34%	**0.74 J**	52GW80	**31**	52GW77	**31.7**	-37%
Total VOCs						205					120	**41%**					130	**36%**

							Lower Surficial Aquifer											
		Baseline (May 2011)					**12-month (June 2012)**						**24-month (June 2013)**					
VOCs	**Screening Criteria**	**Minimum Value**	**Minimum Location**	**Maximum Value**	**Maximum Location**	**Total VOCs**	**Minimum Value**	**Minimum Location**	**Maximum Value**	**Maximum Location**	**Total VOCs**	**Percent VOC Reduction at 12 months**	**Minimum Value**	**Minimum Location**	**Maximum Value**	**Maximum Location**	**Total VOCs**	**Percent VOC Reduction at 24 months**
1,1,2,2-Tetrachloroethane	0.2	0.5 U	3 of 3	--	--	0.5 U	0.5 U	2 of 3	1 U	52GW78	1 U	--	0.5 U	52GW81	1 U	2 of 3	1 U	--
1,1-Dichloroethane	6	1.2	2 of 3	1.3	52GW78	3.7	0.5 U	52GW78	1.7	52GW79	2.4	100%	0.5 U	52GW81	0.95 **J**	52GW78	1.5	59%
1,1-Dichloroethene	7	2.3	52GW79	3.7	52GW81	8.5	0.5 U	52GW81	5 U	52GW79	2.8	--	0.5 U	52GW81	2	52GW79	3.4	60%
cis-1,2-Dichloroethene	70	**1,200**	2 of 3	**1,500**	52GW81	**3,900**	**290 MM**	52GW78	**1,300**	52GW79	**1,920**	51%	**130 M**	52GW81	**1,100**	52GW79	**2,200**	44%
Methylene chloride	5	2.5 U	3 of 3	--	--	2.5 U	5 U	52GW78	25 U	52GW79	25 U	--	2.5 U	52GW81	5 U	2 of 3	5 U	--
trans-1,2-Dichloroethene	100	34	52GW81	**110**	52GW78	224	**49**	52GW81	**160**	52GW79	277	-24%	64 M	52GW81	**110**	52GW79	266	-19%
Trichloroethene	3	**440**	52GW81	**720**	52GW78	**1,640**	**58**	52GW81	**420**	52GW79	**638**	61%	**42**	52GW81	**400**	52GW78	**722**	56%
Vinyl Chloride	0.03	**20**	52GW79	**28**	52GW81	**71**	1 U	2 of 3	**6.5**	52GW78	**6.5**	91%	**9**	52GW81	**25 J**	52GW79	**47**	34%
Total VOCs						5,847					2,847	**51%**					3,240	**45%**

Notes:

All concentrations in micrograms per liter
Bold value indicates exceedance
16GW11 or MW53 not included in data evaluation
µg/L - micrograms per liter
U - Compound analyzed for but not detected
J - Reported value is estimated
B - Analyte not detected above the level reported in blanks
VOCs - Volatile organic compounds

TABLE 7

TOC and VFA Data Evaluation

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study Well Type	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	Closest Injection Well*	Distance to Closest Injection Well (ft)	TOC (mg/L)								VFAs (mg/L)						
								Baseline	Post-Injection	3-Month	6-Month	9-Month	12-Month	18-Month	24-Month	Baseline	3-Month	6-Month	9-Month	12-Month	18-Month	24-Month
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	OU1-52IW05	18.4	5.2	10	130	53	10	12	NM	7.8	0.35	85.8	4.19	0.20	0.09	NM	0.53
	52GW78	Lower	48	10	38 - 48	OU1-52IW08	12.3	2.3	3,100	190	81	3,300	180	NM	77	0.39	110	18.7	55.7	44.5	NM	148
	52GW79	Lower	48	10	38 - 48	OU1-52IW10	15.5	1.7	22	97	86	71	100	NM	100	0.39	41.5	21.2	22.6	23.7	NM	197
	52GW80	Upper	32	10	22 - 32	OU1-52IW09	12.7	3.4	1,800	450	220	140	73	24	10	0.17	419	112	25.0	11.7	1.06	10.5
	52GW81	Lower	48	10	38 - 48	OU1-52IW12	11.0	4.5	1,600	120	72	100	110	52	36	0.46	39.1	13.6	38.0	41.1	1.96	54.6
Existing Monitoring Wells	16GW11	Upper	27	15	12 - 27	OU1-52IW03	11.4	1.4	7.1	1.9	2.1	1.5	1.5	NM	1.1	0.23	0.44	0.22	0.15	0.12	NM	0.45
	MW53	Lower	54	10	44 - 54	OU1-52IW04	10.5	1.6	2.4	1.7	1.5	1.5	1.6	NM	1.3	0.29	0.44	0.18	0.11	0.10	NM	1.63

Notes:
*Closest injection well screened in same aquifer as monitoring well
ft - feet
bgs - below ground surface
mg/L - milligrams per liter

TABLE 8

Microbial Population Evaluation

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study Well Type	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	Closest Injection Well*	Distance to Closest Injection Well (ft)	DHC (cells/mL)							DHC Functional Genes at 12-months (cells/mL)											
															tceA				*vcrA*				*bvcA*			
								Baseline	3-Month	6-Month	9-Month	12-Month	18-Month	24-Month	9-Month	12-Month	18-Month	24-Month	9-Month	12-Month	18-Month	24-Month	9-Month	12-Month	18-Month	24-Month
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	IW05	18.4	1,780	7.2	2,220	380	8.1 J	NA	98,200	24.3	10 U	NA	66,000	3.5	10 U	NA	65,200	1.5 U	10 U	NA	0.7
	52GW78	Lower	48	10	38 - 48	IW08	12.3	39.7	10,300	11.9	16.7	94.4	NA	42.9	18.4	1.5	NA	28.9	6.5 U	0.6 J	NA	16.7	9.7	0.4 J	NA	0.7
	52GW79	Lower	48	10	38 - 48	IW10	15.5	861	21,600	4,880	3	526	NA	14.8	4.2	554	NA	1.82	0.7 U	346	NA	11.6	0.7 U	0.5 U	NA	4.5
	52GW80	Upper	32	10	22 - 32	IW09	12.7	2,200	40.3	1,940	340	166	538	42.8	1.9 U	55.3	321	8.72	0.5 J	46.9	38.4	13.3	2.4	1.6 U	451	42.9
	52GW81	Lower	48	10	38 - 48	IW12	11.0	672	9,130	173	28	2,940	1,390	2,760	1.1 U	7.3	0.8	1.0	0.6 J	17.6	0.9	26.3	10.4	1,050	1,270	19,800
Existing Monitoring	16GW11	Upper	27	15	12 - 27	IW03	11.4	14.2	0.6 J	11.8	6.9	5.1	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.2 J	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U
	MW53	Lower	54	10	44 - 54	IW04	10.5	196	0.9	370	584	21.2	NA	8.1	0.5 J	0.5 U	NA	0.5 U	1.9	0.5 U	NA	0.5 U	23.8	10.5	NA	44.4

Notes:
*Closest injection well screened in same aquifer as monitoring well
DHC - *Dehalococcoides*
tceA gene - encodes the TCE reductase enzyme responsible for reductive dechlorination of TCE to cis-1,2-DCE in some strains of DHC
vcrA gene - encodes the VC reductase enzyme responsible for reductive dechlorination of cis-1,2-DCE and VC by DHC sp. strain VS
bvcA gene - encodes the VC reductase enzyme responsible for reductive dechlorination of VC to ethene by DHC sp. str. BAV1
MOB - Methane Oxidizing Bacteria (Methanotrophs) - presence indicates potential for cometabolic oxidation of TCE under aerobic conditions in the presence of methane
sMMO - soluble methane monooxygenase - indiciative of potential for cometabolism of TCE under aerobic conditions
ft - feet
bgs - below ground surface
mL - milliliter

TABLE 8

Microbial Population Evaluation

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Pilot Study Well Type	Well ID	Surficial Aquifer Zone	Total Well Depth (ft bgs)	Screen[a,b] Length (ft)	Screen Interval (ft bgs)	Closest Injection Well*	Distance to Closest Injection Well (ft)	Methane (µg/L)							MOB (cells/mL)						sMMO (cells/mL)		
								Baseline	3-Month	6-Month	9-Month	12-Month	18-Month	24-Month	Baseline	3-Month	6-Month	16-Month	18-Month	24-Month	16-Month	18-Month	24-Month
Newly Installed Monitoring Wells	52GW77	Upper	32	10	22 - 32	IW05	18.4	700	7,300	18,000	17,000	14,000	NA	15,000	62,600	92,600,000	5,510,000	NA	NA	6,790,000	NA	NA	1.0 U
	52GW78	Lower	48	10	38 - 48	IW08	12.3	180	1,900	3,300	11,000	13,000	NA	10,000	805	115,000,000	1,570,000	57,100,000	NA	30,300,000	4,770	NA	1.2 U
	52GW79	Lower	48	10	38 - 48	IW10	15.5	130	170	1,500	3,600	12,000	NA	8,100	58,900	824,000,000	22,800,000	49,400,000	NA	13,400,000	4,710	NA	1.0 U
	52GW80	Upper	32	10	22 - 32	IW09	12.7	700	6,000	19,000	17,000	19,000	15,000	20,000	274,000	511,000,000	40,300,000	NA	61,400,000	29,100,000	NA	299,000	5,350
	52GW81	Lower	48	10	38 - 48	IW12	11.0	610	2,600	7,000	15,000	15,000	11,000	6,500	53,500	1,110,000,000	10,500,000	NA	132,000,000	20,900,000	NA	142,000	3,860
Existing Monitoring	16GW11	Upper	27	15	12 - 27	IW03	11.4	8.2 J	4.2 J	11	7.7 J	41	NA	230	8,500	17,800,000	5,090,000	NA	NA	9,000,000	NA	NA	1,410
	MW53	Lower	54	10	44 - 54	IW04	10.5	52	78	79	98	95	NA	88	2,340	559,000	221,000	NA	NA	8,490,000	NA	NA	2,140

Notes:
*Closest injection well screened in same aquifer as monitoring well
DHC - *Dehalococcoides*
tceA gene - encodes the TCE reductase enzyme responsible for reductive dechlorination of TCE to cis-1,2-DCE in some strains of DHC
vcrA gene - encodes the VC reductase enzyme responsible for reductive dechlorination of cis-1,2-DCE and VC by DHC sp. strain VS
bvcA gene - encodes the VC reductase enzyme responsible for reductive dechlorination of VC to ethene by DHC sp. str. BAV1

MOB - Methane Oxidizing Bacteria (Methanotrophs) - presence indicates potential for cometabolic oxidation of TCE under aerobic conditions in the presence of methane
sMMO - soluble methane monooxygenase - indiciative of potential for cometabolism of TCE under aerobic conditions
ft - feet
bgs - below ground surface
mL - milliliter

TABLE 9

ERD Data Evaluation - 24-Month Sample Summary

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Upper Surficial Aquifer						
NAIP	**Lines of Evidence for ERD**	**Minimum Value**	**Minimum Value Location**	**Maximum Value**	**Maximum Value Location**	**Favorable/Unfavorable**
pH	Greater than 5; Less than 9	6.34	52GW80	6.37	52GW77	Favorable
ORP (mV)	Less than +50 mV (favorable) Less than -100 mV (ideal)	-90	52GW80	-86	52GW77	Favorable
DO (mg/L)	Non-detect	<0.025	2 of 2 locations	--	--	Favorable
Nitrate (mg/L)	Less than 1.0 mg/L	<1	52GW80	0.33	52GW77	Favorable
Ferrous Iron (Fe^{2+}) (mg/L)	Measurable Levels	3.0	2 of 2 locations	--	--	Favorable
Methane (µg/L)	Concentrations increase above background over time	15,000	52GW77	20,000	52GW80	Favorable to unfavorable; concentrations increased above background levels, but levels are high and could inhibit ERD
Ethane (µg/L)		2 U	2 of 2 locations	--	--	Unfavorable; concentrations not detected above background levels
Ethene (µg/L)		2 U	52GW80	12	52GW77	Unfavorable to favorable; concentrations increased above background concentrations in one well
TOC (mg/L)	Increase above background	7.8	52GW77	10	52GW80	Unfavorable; concentrations have decreased to, or just above, background levels
VFAs (sum of all VFAs; mg/L)	Initial increase above background then decrease over time as substrate is utilized by microbes	0.530	52GW77	10.5	52GW80	Unfavorable; concentrations have decreased to, or just above, background levels
Dehalococcoides (cells per mL)	Increase above background over time as ERD substrate and VOCs are utilized	42.8	52GW80	98,200	52GW77	Unfavorable to Favorable; concentrations are less than 1E3 cells/mL in samples from 52GW80, but at favorable concentrations at 52GW77

Notes:
16GW11 not included in data evaluation
ERD - Enhanced reductive dechlorination
mg/L - micrograms per liter
mg/L - milligrams per liter
mL - milliliters
mV - milliVolts
NAIP - Natural Attenuation Indication Parameter
NTUs - nephelometric turbidity units
SU - scientific units
VFAs - volatile fatty acids

TABLE 9

ERD Data Evaluation - 24-Month Sample Summary

OU1 Biobarrier Pilot Study

Marine Corps Air Station Cherry Point

Cherry Point, North Carolina

Lower Surficial Aquifer

NAIP	Lines of Evidence for ERD	Minimum Value	Minimum Value Location	Maximum Value	Maximum Value Location	Favorable/Unfavorable
pH	Greater than 5; Less than 9	5.60	52GW79	6.59	52GW81	Favorable to unfavorable where pH is below 6 (2 of 3 locations)
ORP (mV)	Less than +50 mV (favorable) Less than -100 mV (ideal)	-173	52GW81	-64	52GW78	Ideal to favorable
DO (mg/L)	Non-detect	<0.025	3 of 3 locations	--	--	Favorable
Nitrate (mg/L)	Less than 1.0 mg/L	<1	2 of 3 locations	12	52GW78	Favorable
Ferrous Iron (Fe^{2+}) (mg/L)	Measurable Levels	1.8	2 of 3 locations	2.2	52GW81	Favorable
Methane (µg/L)	Concentrations increase above background over time	6,500	52GW81	10,000	52GW78	Favorable to unfavorable; concentrations increased above background levels, but levels are high and could inhibit ERD
Ethane (µg/L)		2 U	52GW81	2.6 J	52GW78	Favorable to unfavorable; concentrations detected in 2 of 3 samples
Ethene (µg/L)		2 U	52GW81	2.0 J	52GW79	Favorable to unfavorable; concentrations detected in 2 of 3 samples
TOC (mg/L)	Increase above background	36	52GW81	100	52GW79	Favorable
VFAs (sum of all VFAs; mg/L)	Initial increase above background then decrease over time as substrate is utilized by microbes	54.6	52GW81	197	52GW79	Favorable; concentrations continue to increase over time
Dehalococcoides Population (cells per mL)	Increase above background over time as ERD substrate and VOCs are utilized	14.8	52GW79	2,760	52GW81	Unfavorable to Favorable; concentrations are less than 1E3 cells/mL in samples from 52GW79, but at favorable concentrations at 52GW81

Notes:
MW53 not included in data evaluation
ERD - Enhanced reductive dechlorination
mg/L - micrograms per liter
mg/L - milligrams per liter
mL - milliliters
mV - milliVolts
NAIP - Natural Attenuation Indication Parameter
NTUs - nephelometric turbidity units
SU - scientific units
VFAs - volatile fatty acids

Figures

Legend

- Cities
- Rivers and Streams
- Military Installation
- County Boundary

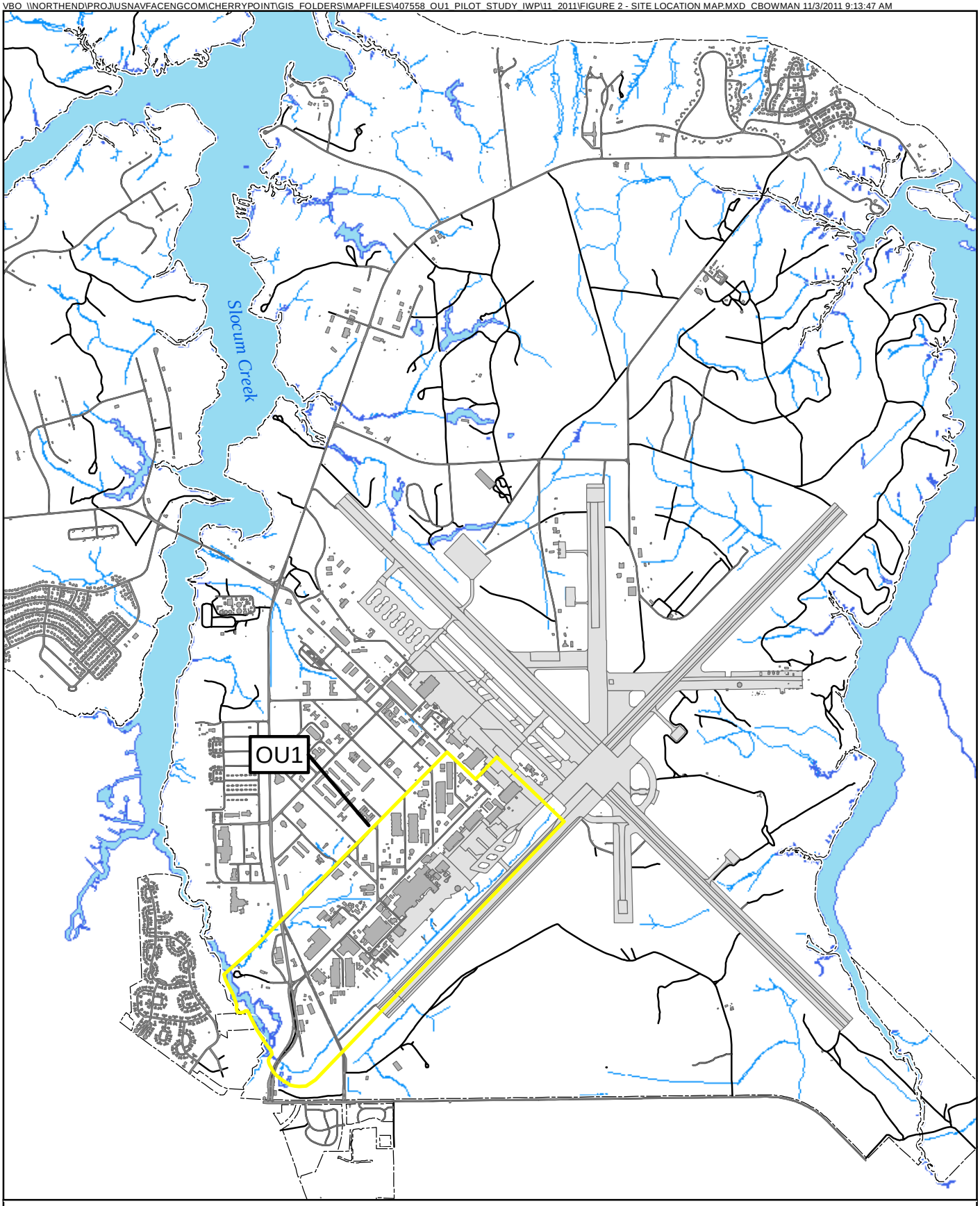
N
W E
S

0 20,000 40,000
Feet

Figure 1
Base Location Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHERRYPOINT\GIS_FOLDERS\MAPFILES\407558_OU1_PILOT_STUDY_IWP\11_2011\FIGURE 2 - SITE LOCATION MAP.MXD CBOWMAN 11/3/2011 9:13:47 AM



Legend

- OU Boundary
- Base Boundary
- Buildings
- Runway
- Road
- Surface Water

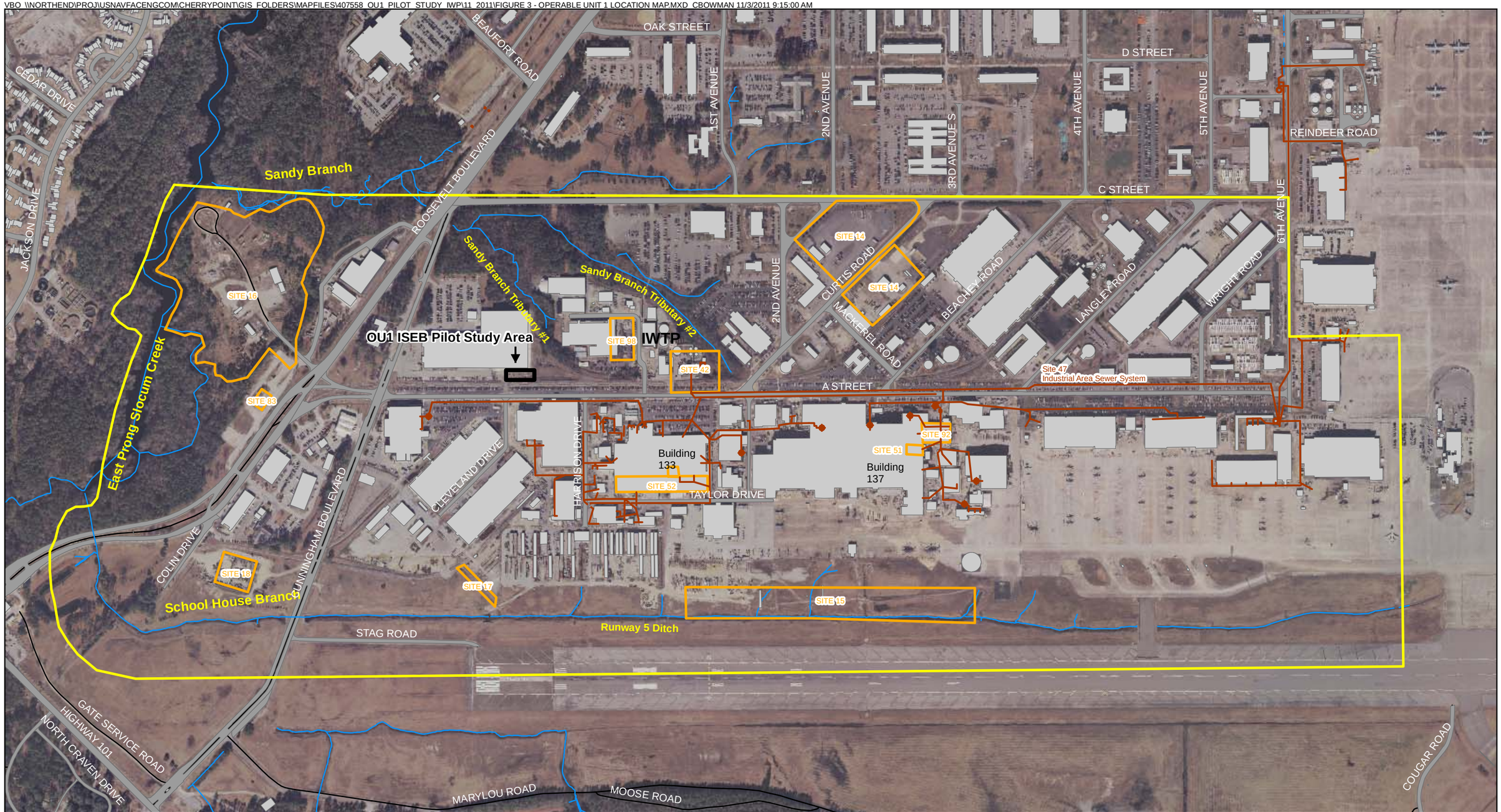
N
W E
S

0 1,500 3,000
Feet

Figure 2
OU1 Location Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHERRYPOINT\GIS_FOLDERS\MAPFILES\407558_OU1_PILOT_STUDY_IWP\11_2011\FIGURE 3 - OPERABLE UNIT 1 LOCATION MAP.MXD CBOWMAN 11/3/2011 9:15:00 AM



Legend

- Surface Water
- Industrial Area Sewer System
- In-Situ Enhanced Bioremediation Pilot Study Area
- Site Boundary
- OU1 Boundary
- Existing Buildings

IWTP - Industrial Wastewater Treatment Plant

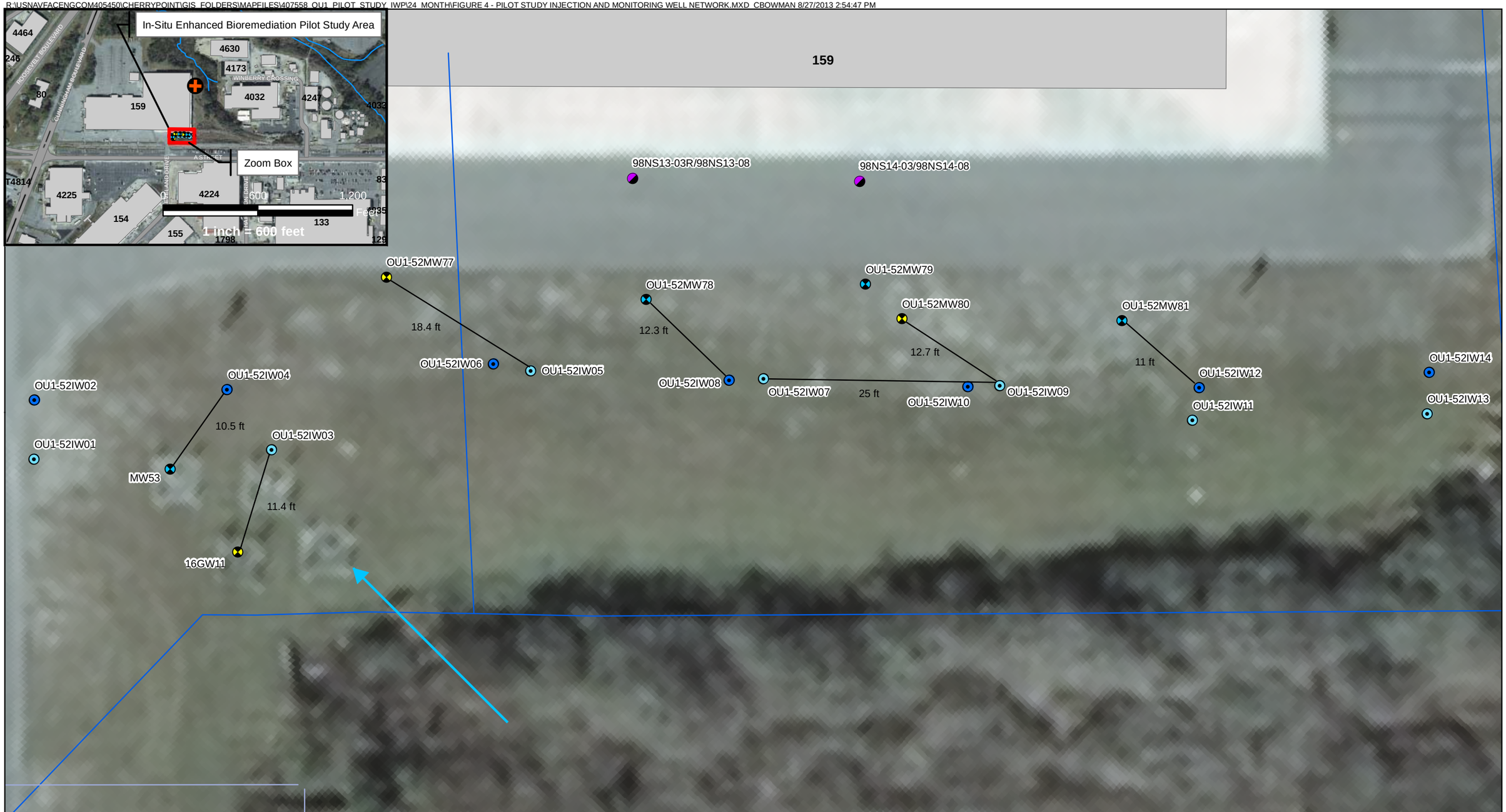
N W E S

0 600 1,200 Feet

Figure 3
Sites Within OU1
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNAVFACENGCOM405450\CHERRYPOINT\GIS_FOLDERS\MAPFILES\407558_OU1_PILOT_STUDY_IWP\24_MONTH\FIGURE 4 - PILOT STUDY INJECTION AND MONITORING WELL NETWORK.MXD CBOWMAN 8/27/2013 2:54:47 PM



Legend

- Soil Gas Sample Location
- Monitoring Well - Lower Surficial Aquifer
- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Electrical Cable Line
- Industrial Waste Line
- Storm Sewer Line
- Water Line
- Groundwater Flow Direction
- Existing Buildings

N W E S

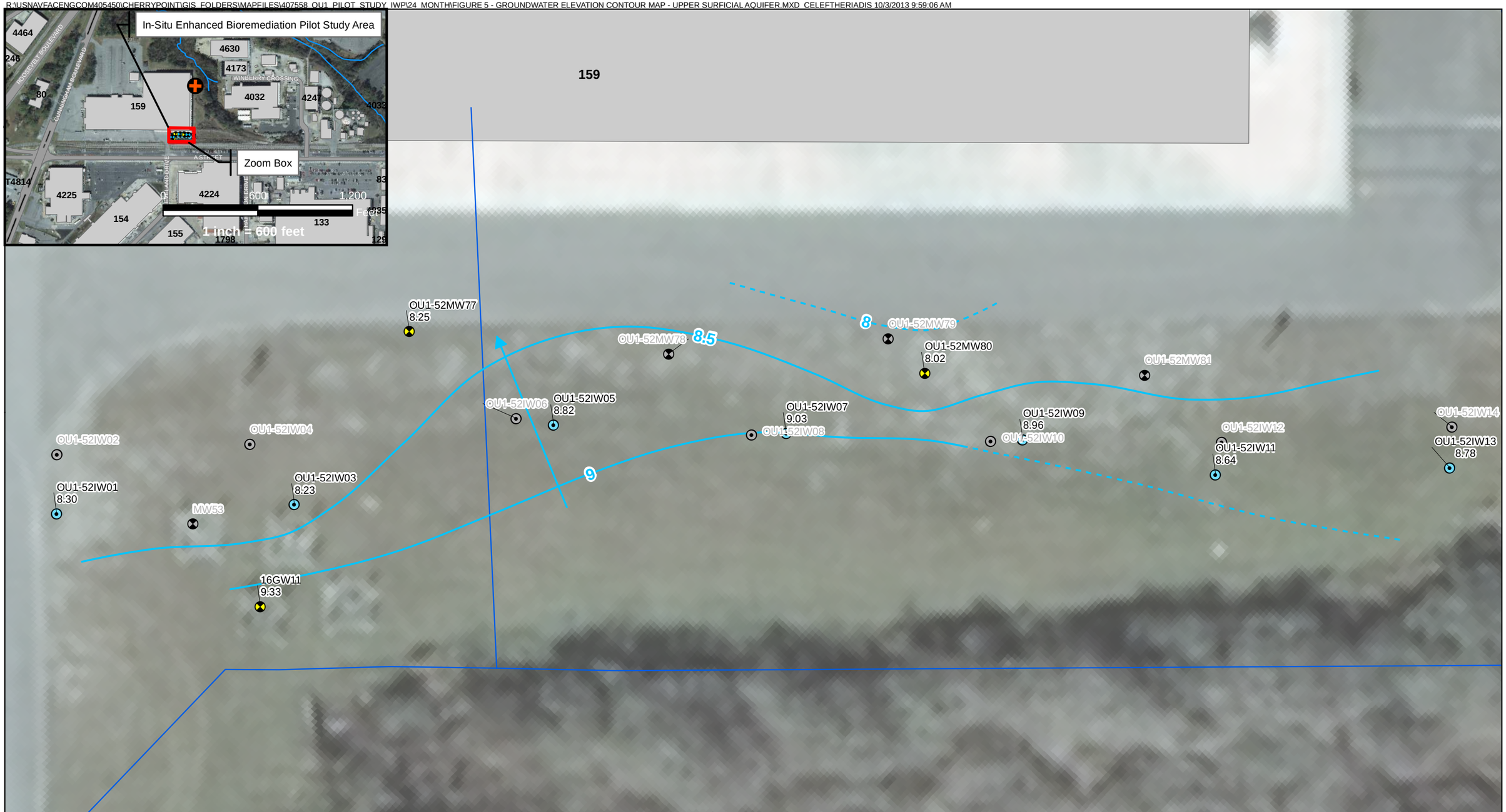
0 10 20 Feet

1 inch = 10 feet

Figure 4
OU1 ISEB Pilot Study Injection and Monitoring Well Network
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNAVFACENGCOM405450\CHERRYPOINT\GIS_FOLDERS\MAPFILES\407558_OU1_PILOT_STUDY_IWP\24_MONTH\FIGURE 5 - GROUNDWATER ELEVATION CONTOUR MAP - UPPER SURFICIAL AQUIFER.MXD CELEFTHERIADIS 10/3/2013 9:59:06 AM



Legend

- Monitoring Well - Lower Surficial Aquifer
- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Groundwater Elevation Contour
- Groundwater Elevation Contour (inferred)
- Groundwater Flow Direction
- Water Line
- Existing Buildings

Notes:
- Groundwater elevation data in feet above mean sea level.
- Gauging data collected June 3, 2013

N W E S

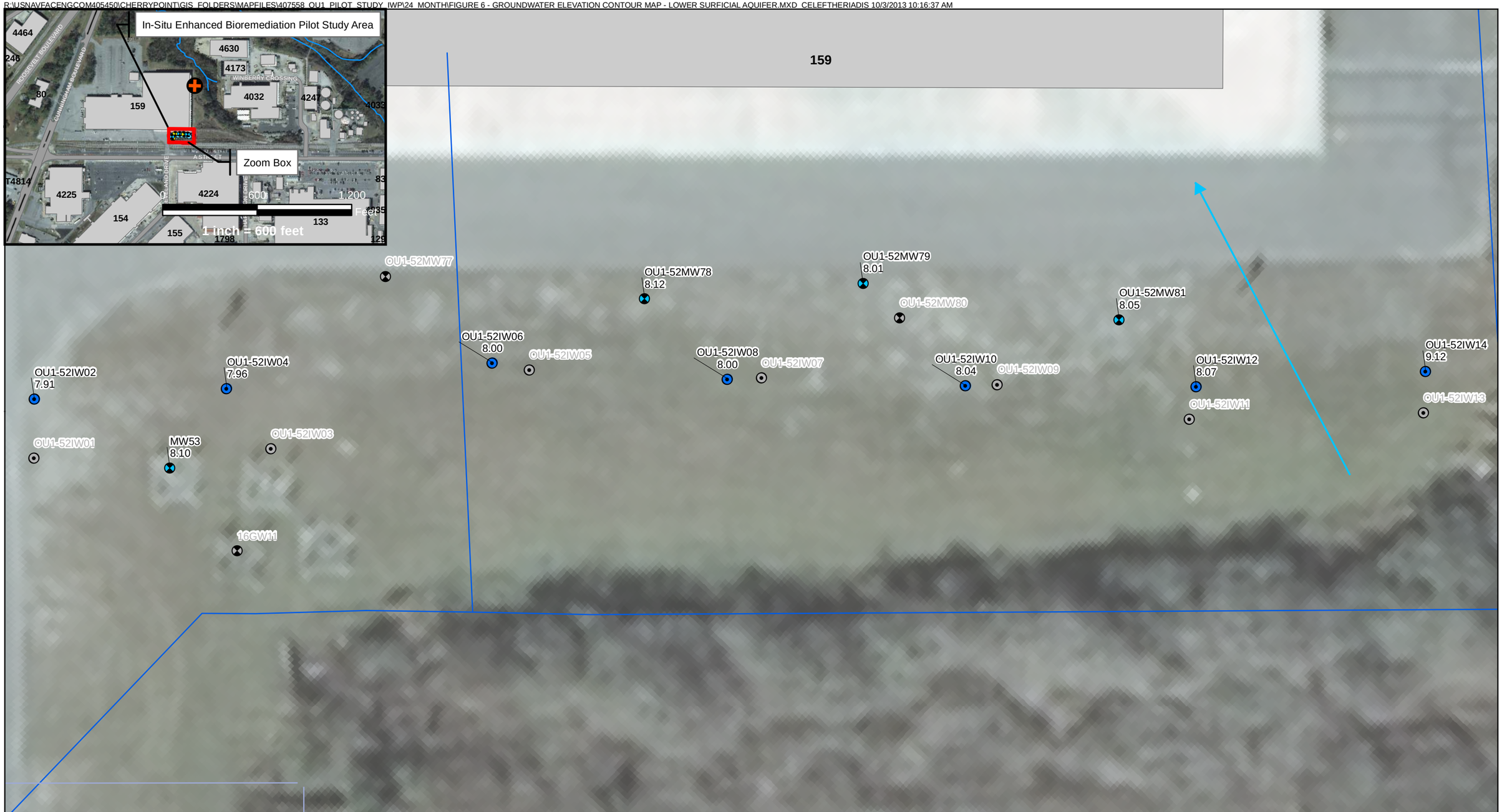
0 10 20 Feet

1 inch = 10 feet

Figure 5
Groundwater Elevation Contour Map - Upper Surficial Aquifer
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNAVFACENGCOM405450\CHERRYPOINT\GIS_FOLDERS\MAPFILES\407558_OU1_PILOT_STUDY_IWP\24_MONTH\FIGURE 6 - GROUNDWATER ELEVATION CONTOUR MAP - LOWER SURFICIAL AQUIFER.MXD CELEFTHERIADIS 10/3/2013 10:16:37 AM



Legend

- Monitoring Well - Lower Surficial Aquifer
- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Water Line
- Existing Buildings

Notes:
- Groundwater elevation data in feet above mean sea level.
- Gauging data collected June 3, 2013

W N S E

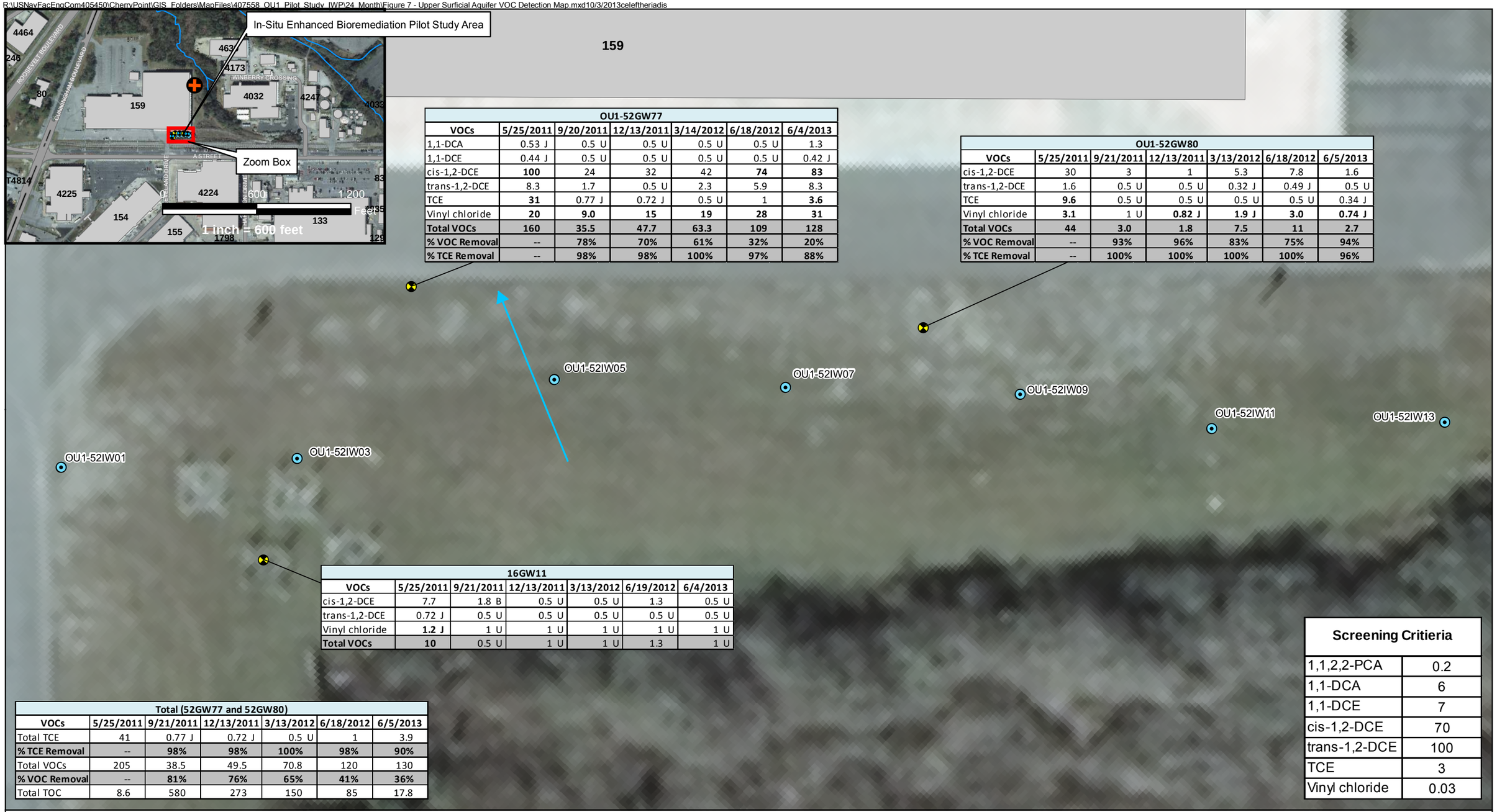
0 10 20 Feet

1 inch = 10 feet

Figure 6
Groundwater Elevation Contour Map - Lower Surficial Aquifer
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 7 - Upper Surficial Aquifer VOC Detection Map.mxd10/3/2013celeftheriadis



OU1-52GW77						
VOCs	5/25/2011	9/20/2011	12/13/2011	3/14/2012	6/18/2012	6/4/2013
1,1-DCA	0.53 J	0.5 U	0.5 U	0.5 U	0.5 U	1.3
1,1-DCE	0.44 J	0.5 U	0.5 U	0.5 U	0.5 U	0.42 J
cis-1,2-DCE	**100**	24	32	42	**74**	**83**
trans-1,2-DCE	8.3	1.7	0.5 U	2.3	5.9	8.3
TCE	**31**	0.77 J	0.72 J	0.5 U	1	**3.6**
Vinyl chloride	**20**	**9.0**	**15**	**19**	**28**	**31**
Total VOCs	**160**	**35.5**	**47.7**	**63.3**	**109**	**128**
% VOC Removal	--	**78%**	**70%**	**61%**	**32%**	**20%**
% TCE Removal	--	**98%**	**98%**	**100%**	**97%**	**88%**

OU1-52GW80						
VOCs	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/18/2012	6/5/2013
cis-1,2-DCE	30	3	1	5.3	7.8	1.6
trans-1,2-DCE	1.6	0.5 U	0.5 U	0.32 J	0.49 J	0.5 U
TCE	**9.6**	0.5 U	0.5 U	0.5 U	0.5 U	0.34 J
Vinyl chloride	**3.1**	1 U	**0.82 J**	**1.9 J**	**3.0**	**0.74 J**
Total VOCs	**44**	**3.0**	**1.8**	**7.5**	**11**	**2.7**
% VOC Removal	--	**93%**	**96%**	**83%**	**75%**	**94%**
% TCE Removal	--	**100%**	**100%**	**100%**	**100%**	**96%**

16GW11						
VOCs	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/19/2012	6/4/2013
cis-1,2-DCE	7.7	1.8 B	0.5 U	0.5 U	1.3	0.5 U
trans-1,2-DCE	0.72 J	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl chloride	**1.2 J**	1 U	1 U	1 U	1 U	1 U
Total VOCs	**10**	0.5 U	1 U	1 U	1.3	1 U

Total (52GW77 and 52GW80)						
VOCs	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/18/2012	6/5/2013
Total TCE	41	0.77 J	0.72 J	0.5 U	1	3.9
% TCE Removal	--	**98%**	**98%**	**100%**	**98%**	**90%**
Total VOCs	205	38.5	49.5	70.8	120	130
% VOC Removal	--	**81%**	**76%**	**65%**	**41%**	**36%**
Total TOC	8.6	580	273	150	85	17.8

Screening Critieria	
1,1,2,2-PCA	0.2
1,1-DCA	6
1,1-DCE	7
cis-1,2-DCE	70
trans-1,2-DCE	100
TCE	3
Vinyl chloride	0.03

Legend

- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings

Notes:
All VOC concentrations given in micrograms per liter (µg/L)
All VOC exceedances of NC 2L Standards are in **bold** text
1,1,2,2-PCA - 1,1,2,2-Tetrachloroethane
1,1-DCA - 1,1-Dichloroethane
1,1-DCE - 1,1-Dichloroethene
cis-1,2-DCE - cis-1,2-Dichloroethene
trans-1,2-DCE - trans-1,2-Dichloroethene
TCE - Trichloroethene

B - Analyte not detected above the level reported in blanks
J - Analyte present. Value may or may not be accurate or precise
U - The material was analyzed for, but not detected
*Maximum value of native and duplicate sample is shown
M - Compound failed in the MS or MSD. (native sample only)
MM - Compound failed in the MS and MSD. (native sample only)
Screening criteria are the more conservative values of the NC 2L (April 2013) or MCL standards

N W E S

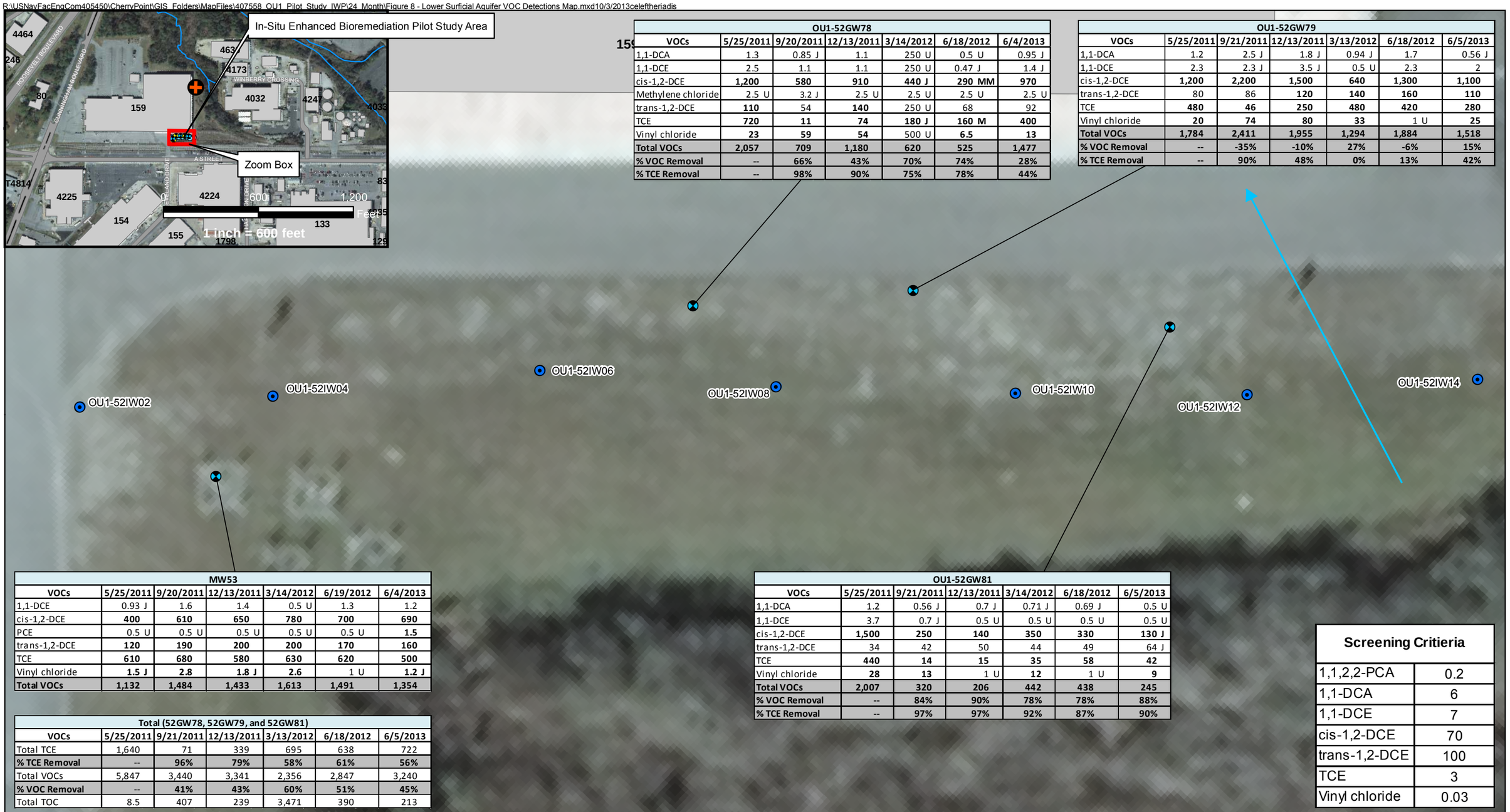
0 10 20 Feet

1 inch = 10 feet

Figure 7
Upper Surficial Aquifer VOC Detections Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 8 - Lower Surficial Aquifer VOC Detections Map.mxd10/3/2013celeftheriadis



OU1-52GW78						
VOCs	5/25/2011	9/20/2011	12/13/2011	3/14/2012	6/18/2012	6/4/2013
1,1-DCA	1.3	0.85 J	1.1	250 U	0.5 U	0.95 J
1,1-DCE	2.5	1.1	1.1	250 U	0.47 J	1.4 J
cis-1,2-DCE	**1,200**	**580**	**910**	**440 J**	**290 MM**	**970**
Methylene chloride	2.5 U	3.2 J	2.5 U	2.5 U	2.5 U	2.5 U
trans-1,2-DCE	**110**	54	**140**	250 U	68	92
TCE	**720**	**11**	**74**	**180 J**	**160 M**	**400**
Vinyl chloride	**23**	**59**	**54**	500 U	**6.5**	**13**
Total VOCs	**2,057**	**709**	**1,180**	**620**	**525**	**1,477**
% VOC Removal	--	**66%**	**43%**	**70%**	**74%**	**28%**
% TCE Removal	--	**98%**	**90%**	**75%**	**78%**	**44%**

OU1-52GW79						
VOCs	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/18/2012	6/5/2013
1,1-DCA	1.2	2.5 J	1.8 J	0.94 J	1.7	0.56 J
1,1-DCE	2.3	2.3 J	3.5 J	0.5 U	2.3	2
cis-1,2-DCE	**1,200**	**2,200**	**1,500**	**640**	**1,300**	**1,100**
trans-1,2-DCE	80	86	**120**	**140**	**160**	**110**
TCE	**480**	**46**	**250**	**480**	**420**	**280**
Vinyl chloride	**20**	**74**	**80**	**33**	1 U	**25**
Total VOCs	**1,784**	**2,411**	**1,955**	**1,294**	**1,884**	**1,518**
% VOC Removal	--	**-35%**	**-10%**	**27%**	**-6%**	**15%**
% TCE Removal	--	**90%**	**48%**	**0%**	**13%**	**42%**

MW53						
VOCs	5/25/2011	9/20/2011	12/13/2011	3/14/2012	6/19/2012	6/4/2013
1,1-DCE	0.93 J	1.6	1.4	0.5 U	1.3	1.2
cis-1,2-DCE	**400**	**610**	**650**	**780**	**700**	**690**
PCE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**1.5**
trans-1,2-DCE	**120**	**190**	**200**	**200**	**170**	**160**
TCE	**610**	**680**	**580**	**630**	**620**	**500**
Vinyl chloride	**1.5 J**	**2.8**	**1.8 J**	**2.6**	1 U	**1.2 J**
Total VOCs	**1,132**	**1,484**	**1,433**	**1,613**	**1,491**	**1,354**

OU1-52GW81						
VOCs	5/25/2011	9/21/2011	12/13/2011	3/14/2012	6/18/2012	6/5/2013
1,1-DCA	1.2	0.56 J	0.7 J	0.71 J	0.69 J	0.5 U
1,1-DCE	3.7	0.7 J	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-DCE	**1,500**	**250**	**140**	**350**	**330**	**130 J**
trans-1,2-DCE	34	42	50	44	49	64 J
TCE	**440**	**14**	**15**	**35**	**58**	**42**
Vinyl chloride	**28**	**13**	1 U	**12**	1 U	**9**
Total VOCs	**2,007**	**320**	**206**	**442**	**438**	**245**
% VOC Removal	--	**84%**	**90%**	**78%**	**78%**	**88%**
% TCE Removal	--	**97%**	**97%**	**92%**	**87%**	**90%**

Total (52GW78, 52GW79, and 52GW81)						
VOCs	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/18/2012	6/5/2013
Total TCE	1,640	71	339	695	638	722
% TCE Removal	--	**96%**	**79%**	**58%**	**61%**	**56%**
Total VOCs	5,847	3,440	3,341	2,356	2,847	3,240
% VOC Removal	--	**41%**	**43%**	**60%**	**51%**	**45%**
Total TOC	8.5	407	239	3,471	390	213

Screening Critieria	
1,1,2,2-PCA	0.2
1,1-DCA	6
1,1-DCE	7
cis-1,2-DCE	70
trans-1,2-DCE	100
TCE	3
Vinyl chloride	0.03

Legend

- Monitoring Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings

Notes:
All VOC concentrations given in micrograms per liter (µg/L)
All VOC exceedances of NC 2L Standards are in **bold** text
1,1,2,2-PCA - 1,1,2,2-Tetrachloroethane
1,1-DCA - 1,1-Dichloroethane
1,1-DCE - 1,1-Dichloroethene
cis-1,2-DCE - cis-1,2-Dichloroethene
trans-1,2-DCE - trans-1,2-Dichloroethene
TCE - Trichloroethene

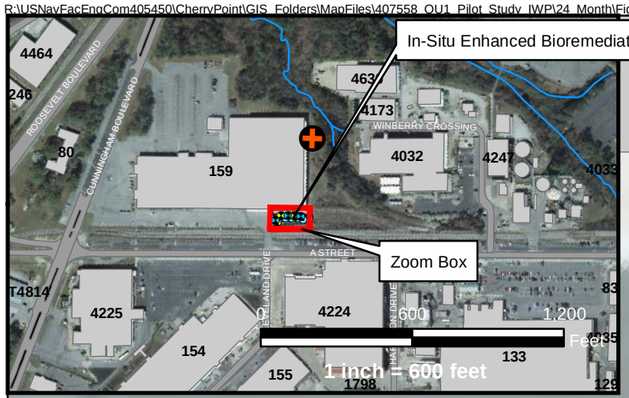
J - Analyte present. Value may or may not be accurate or precise
U - The material was analyzed for, but not detected
Screening criteria are the more conservative values of the NC 2L (April 2013) or MCL standards.

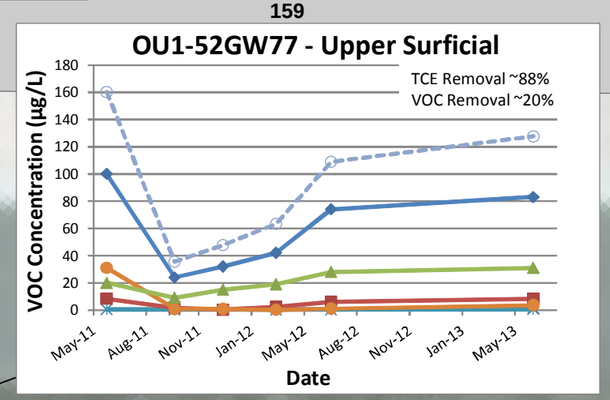
N
0 10 20 Feet
1 inch = 10 feet

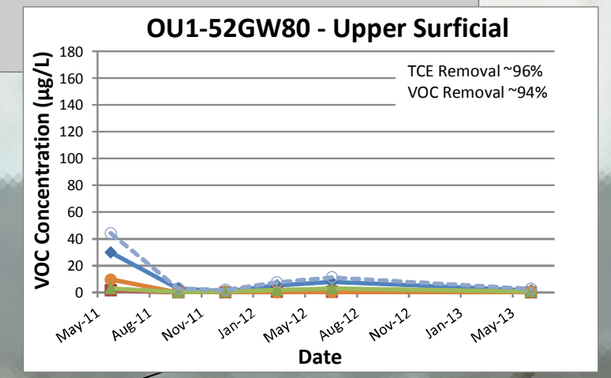
Figure 8
Lower Surficial Aquifer VOC Detections Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

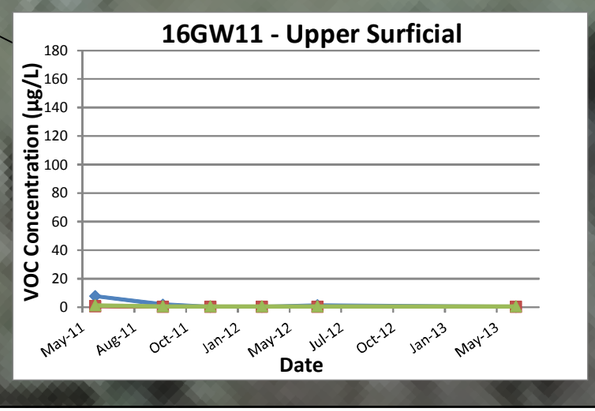
CH2MHILL.

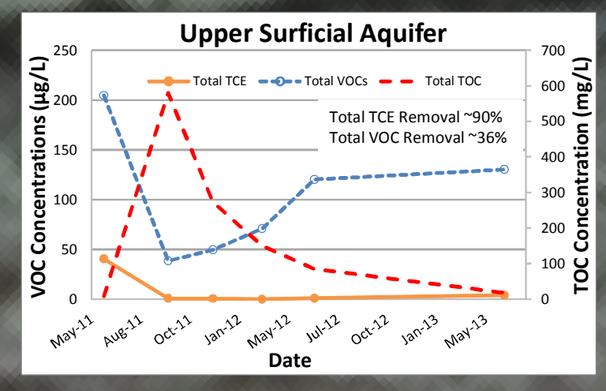
R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 9 - Upper Surficial Aquifer VOC Trends Map.mxd10/3/2013celeftheriadis











Screening Critieria	
1,1-DCA	6
1,1-DCE	7
cis-1,2-DCE	70
trans-1,2-DCE	100
TCE	3
Vinyl chloride	0.03

Legend

- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings
- Trichloroethene
- 1,1-Dichloroethane
- 1,1-Dichloroethene
- cis-1,2-Dichlorethene
- trans-1,2-Dichloroethene
- Vinyl Chloride
- VOCs

Notes:
-Screening criteria are the more conservative values of the NC 2L (April 2013) or MCL standards

N W E S

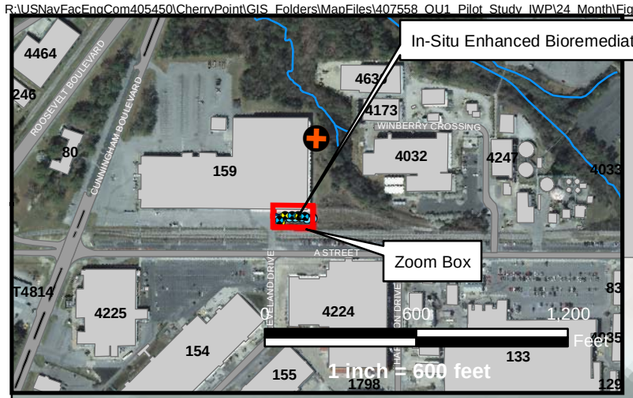
0 10 20 Feet

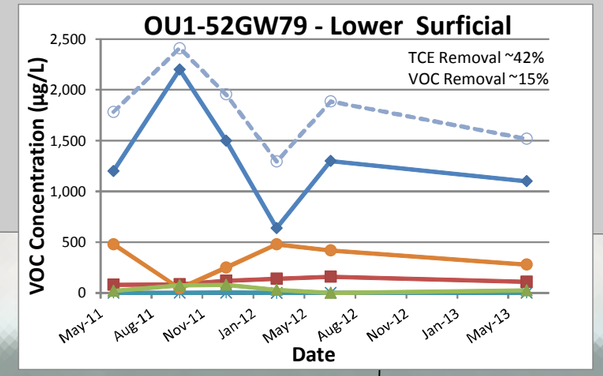
1 inch = 10 feet

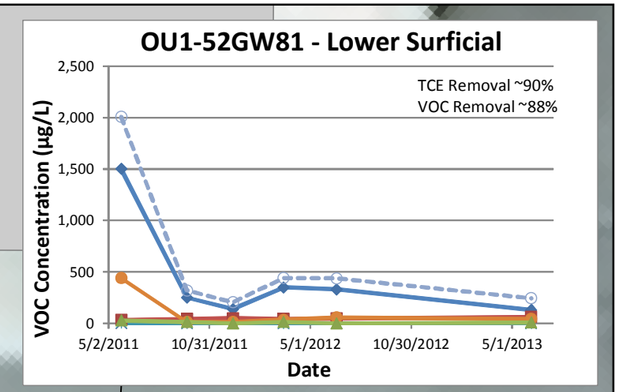
Figure 9
Upper Surficial Aquifer VOC Trends Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 10 - Lower Surficial Aquifer VOC Trends Map.mxd10/3/2013celeftheriadis

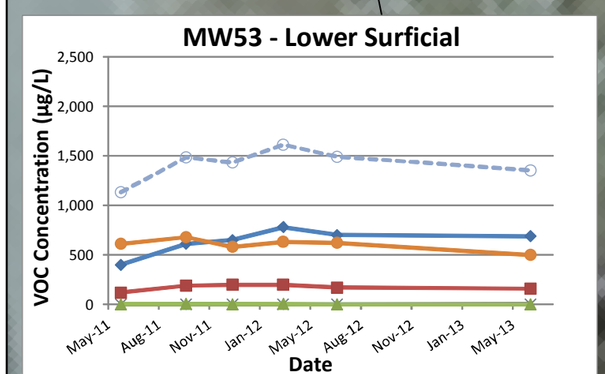


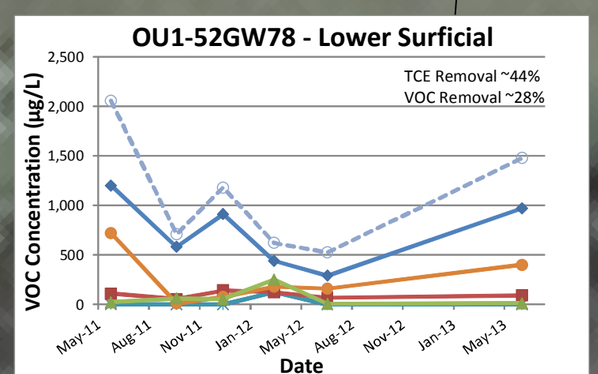


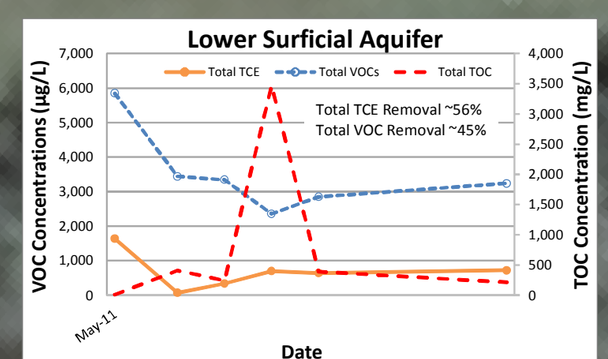


159

OU1-52IW02
OU1-52IW04
OU1-52IW06
OU1-52IW08
OU1-52IW10
OU1-52IW12
OU1-52IW14







Screening Critieria	
1,1-DCA	6
1,1-DCE	7
cis-1,2-DCE	70
trans-1,2-DCE	100
TCE	3
Vinyl chloride	0.03

Legend

- Monitoring Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings
- Trichloroethene
- 1,1-Dichloroethane
- 1,1-Dichloroethene
- cis-1,2-Dichlorethene
- trans-1,2-Dichloroethene
- Vinyl Chloride
- VOCs

Notes:
-Screening criteria are the more conservative values of the NC 2L (April 2013) or MCL standards

N W E S

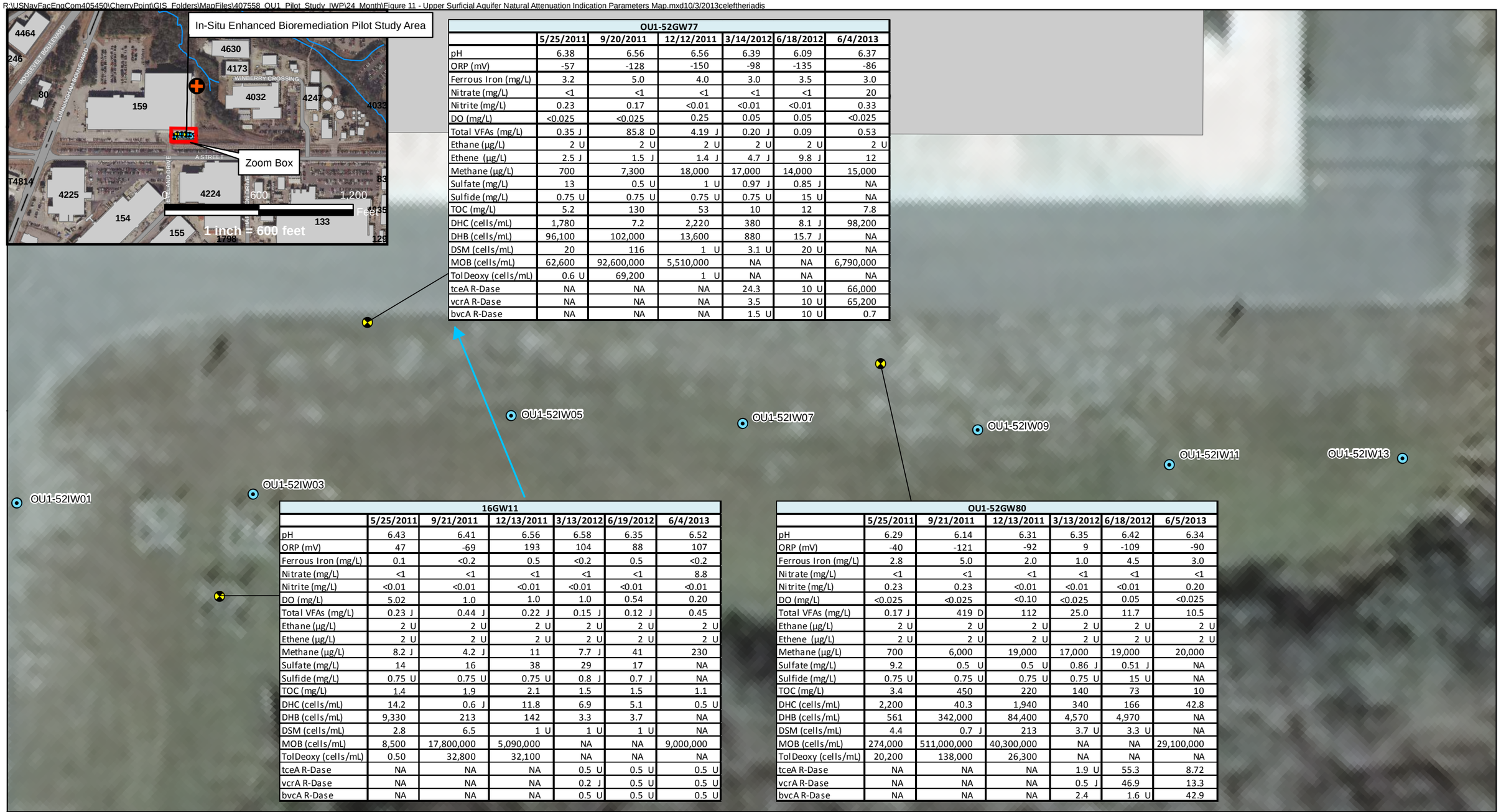
0 10 20 Feet

1 inch = 10 feet

Figure 10
Lower Surficial Aquifer VOC Trends Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 11 - Upper Surficial Aquifer Natural Attenuation Indication Parameters Map.mxd10/3/2013celeftheriadis



OU1-52GW77	5/25/2011	9/20/2011	12/12/2011	3/14/2012	6/18/2012	6/4/2013
pH	6.38	6.56	6.56	6.39	6.09	6.37
ORP (mV)	-57	-128	-150	-98	-135	-86
Ferrous Iron (mg/L)	3.2	5.0	4.0	3.0	3.5	3.0
Nitrate (mg/L)	<1	<1	<1	<1	<1	20
Nitrite (mg/L)	0.23	0.17	<0.01	<0.01	<0.01	0.33
DO (mg/L)	<0.025	<0.025	0.25	0.05	0.05	<0.025
Total VFAs (mg/L)	0.35 J	85.8 D	4.19 J	0.20 J	0.09	0.53
Ethane (µg/L)	2 U	2 U	2 U	2 U	2 U	2 U
Ethene (µg/L)	2.5 J	1.5 J	1.4 J	4.7 J	9.8 J	12
Methane (µg/L)	700	7,300	18,000	17,000	14,000	15,000
Sulfate (mg/L)	13	0.5 U	1 U	0.97 J	0.85 J	NA
Sulfide (mg/L)	0.75 U	0.75 U	0.75 U	0.75 U	15 U	NA
TOC (mg/L)	5.2	130	53	10	12	7.8
DHC (cells/mL)	1,780	7.2	2,220	380	8.1 J	98,200
DHB (cells/mL)	96,100	102,000	13,600	880	15.7 J	NA
DSM (cells/mL)	20	116	1 U	3.1 U	20 U	NA
MOB (cells/mL)	62,600	92,600,000	5,510,000	NA	NA	6,790,000
TolDeoxy (cells/mL)	0.6 U	69,200	1 U	NA	NA	NA
tceA R-Dase	NA	NA	NA	24.3	10 U	66,000
vcrA R-Dase	NA	NA	NA	3.5	10 U	65,200
bvcA R-Dase	NA	NA	NA	1.5 U	10 U	0.7

16GW11	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/19/2012	6/4/2013
pH	6.43	6.41	6.56	6.58	6.35	6.52
ORP (mV)	47	-69	193	104	88	107
Ferrous Iron (mg/L)	0.1	<0.2	0.5	<0.2	0.5	<0.2
Nitrate (mg/L)	<1	<1	<1	<1	<1	8.8
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
DO (mg/L)	5.02	1.0	1.0	1.0	0.54	0.20
Total VFAs (mg/L)	0.23 J	0.44 J	0.22 J	0.15 J	0.12 J	0.45
Ethane (µg/L)	2 U	2 U	2 U	2 U	2 U	2 U
Ethene (µg/L)	2 U	2 U	2 U	2 U	2 U	2 U
Methane (µg/L)	8.2 J	4.2 J	11	7.7 J	41	230
Sulfate (mg/L)	14	16	38	29	17	NA
Sulfide (mg/L)	0.75 U	0.75 U	0.75 U	0.8 J	0.7 J	NA
TOC (mg/L)	1.4	1.9	2.1	1.5	1.5	1.1
DHC (cells/mL)	14.2	0.6 J	11.8	6.9	5.1	0.5 U
DHB (cells/mL)	9,330	213	142	3.3	3.7	NA
DSM (cells/mL)	2.8	6.5	1 U	1 U	1 U	NA
MOB (cells/mL)	8,500	17,800,000	5,090,000	NA	NA	9,000,000
TolDeoxy (cells/mL)	0.50	32,800	32,100	NA	NA	NA
tceA R-Dase	NA	NA	NA	0.5 U	0.5 U	0.5 U
vcrA R-Dase	NA	NA	NA	0.2 J	0.5 U	0.5 U
bvcA R-Dase	NA	NA	NA	0.5 U	0.5 U	0.5 U

OU1-52GW80	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/18/2012	6/5/2013
pH	6.29	6.14	6.31	6.35	6.42	6.34
ORP (mV)	-40	-121	-92	9	-109	-90
Ferrous Iron (mg/L)	2.8	5.0	2.0	1.0	4.5	3.0
Nitrate (mg/L)	<1	<1	<1	<1	<1	<1
Nitrite (mg/L)	0.23	0.23	<0.01	<0.01	<0.01	0.20
DO (mg/L)	<0.025	<0.025	<0.10	<0.025	0.05	<0.025
Total VFAs (mg/L)	0.17 J	419 D	112	25.0	11.7	10.5
Ethane (µg/L)	2 U	2 U	2 U	2 U	2 U	2 U
Ethene (µg/L)	2 U	2 U	2 U	2 U	2 U	2 U
Methane (µg/L)	700	6,000	19,000	17,000	19,000	20,000
Sulfate (mg/L)	9.2	0.5 U	0.5 U	0.86 J	0.51 J	NA
Sulfide (mg/L)	0.75 U	0.75 U	0.75 U	0.75 U	15 U	NA
TOC (mg/L)	3.4	450	220	140	73	10
DHC (cells/mL)	2,200	40.3	1,940	340	166	42.8
DHB (cells/mL)	561	342,000	84,400	4,570	4,970	NA
DSM (cells/mL)	4.4	0.7 J	213	3.7 U	3.3 U	NA
MOB (cells/mL)	274,000	511,000,000	40,300,000	NA	NA	29,100,000
TolDeoxy (cells/mL)	20,200	138,000	26,300	NA	NA	NA
tceA R-Dase	NA	NA	NA	1.9 U	55.3	8.72
vcrA R-Dase	NA	NA	NA	0.5 J	46.9	13.3
bvcA R-Dase	NA	NA	NA	2.4	1.6 U	42.9

Legend

- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings

Notes:
µg/L - micrograms per liter
mg/L - milligrams per liter
mL - milliliters
mV - milliVolts
SU - scientific units
VFAs - volatile fatty acids
D - Compound identified in an analysis as a secondary dilution factor
J - Analyte present. Value may or may not be accurate or precise
U - The material was analyzed for, but not detected

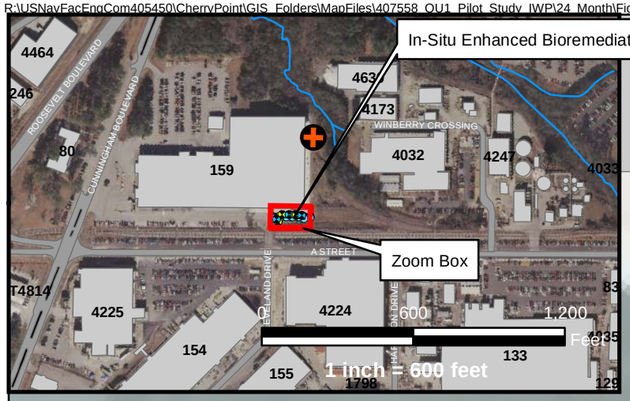
DHB - *Dehalobacter*
DHC - *Dehalococcoides*
DSM - *Desulfuromonas*
MOB - Methane Oxidizing Bacteria
TolDeoxy - Toluene Deoxygenase
R-Dase - Reductive Dehalogenase

0 10 20 Feet
1 inch = 10 feet

Figure 11
Upper Surficial Aquifer Natural Attenuation Indication Parameters Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 12 - Lower Surficial Aquifer Natural Attenuation Indication Parameters Map.mxd9/13/2013celeftheriadis



OU1-52GW79	5/25/2011	9/20/2011	12/13/2011	3/13/2012	6/18/2012	6/5/2013
pH	6.65	5.37	5.43	5.59	5.62	5.60
ORP (mV)	-71	-81	-130	-13	-217	-112
Ferrous Iron (mg/L)	1.5	3.0	1.5	1.0	2.0	1.8
Nitrate (mg/L)	<1	13.2	<1	<1	<1	<1
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.27
DO (mg/L)	<0.025	<0.025	<0.10	<0.025	<0.025	<0.025
Total VFAs (mg/L)	0.39	41.5 D	21.2 J	22.6	23.7	197
Ethane (µg/L)	3.2 J	5.8 J	4.4 J	7.1 J	4 J	2 J
Ethene (µg/L)	1.1 J	2.9 J	3.3 J	3.6 J	1.1 J	2 J
Methane (µg/L)	130	170	1,500	3,600	12,000	8,100
Sulfate (mg/L)	28	7	0.5 U	0.56 J	0.5 J	NA
Sulfide (mg/L)	0.75 U	0.75 U	1.6	1.7	3.0	NA
TOC (mg/L)	1.7	97	86	71	100	100
DHC (cells/mL)	861	21,600	4,880	3.2	526	14.8
DHB (cells/mL)	19,300	3,360,000	84,000	119	135	NA
DSM (cells/mL)	215	25.2	1 U	1.5 U	0.9 U	NA
MOB (cells/mL)	58,900	824,000,000	22,800,000	NA	NA	13,400,000
TolDeoxy (cells/mL)	6,690	1,200,000	5,080	NA	NA	NA
tceA R-Dase	NA	NA	NA	4.2	554	1.82
vcrA R-Dase	NA	NA	NA	0.7 U	346	11.6
bvcA R-Dase	NA	NA	NA	0.7 U	0.5 U	4.5

MW53	5/25/2011	9/20/2011	12/13/2011	3/13/2012	6/19/2012	6/4/2013
pH	6.99	7.05	6.93	6.95	8.85	6.98
ORP (mV)	-95	-86	-149	-93	-90	-51
Ferrous Iron (mg/L)	2.0	2.0	2.2	0.6	1.0	1.4
Nitrate (mg/L)	<1	17.6	<1	1.3	<1	4.4
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.167
DO (mg/L)	0.20	0.10	0.01	0.50	0.64	0.30
Total VFAs (mg/L)	0.29 J	0.44 J	0.18 J	0.11 J	0.10 J	1.63
Ethane (µg/L)	3.9 J	6.1 J	6.1 J	7.1 J	6.4 J	5.0 J
Ethene (µg/L)	2 U	2 U	2 U	2 U	2 U	2 U
Methane (µg/L)	52	78	79	98	95	88
Sulfate (mg/L)	1.3	15	16	15	15	NA
Sulfide (mg/L)	1	0.8 J	0.75 U	1.2	0.85 J	NA
TOC (mg/L)	1.6	1.7	1.5	1.5	1.6	1.3
DHC (cells/mL)	196	0.9	370	584	21.2	8.1
DHB (cells/mL)	3,290	2.4 U	210	21.4	4.5	NA
DSM (cells/mL)	4,100	170	2,200	253	1,920	NA
MOB (cells/mL)	2,340	559,000	221,000	NA	NA	8,490,000
TolDeoxy (cells/mL)	0.5 U	0.8 U	1 U	NA	NA	NA
tceA R-Dase	NA	NA	NA	0.5 J	0.5 U	0.5 U
vcrA R-Dase	NA	NA	NA	1.9	0.5 U	0.5 U
bvcA R-Dase	NA	NA	NA	23.8	10.5	44.4

OU1-52GW78	5/25/2011	9/20/2011	12/13/2011	3/14/2012	6/18/2012	6/4/2013
pH	6.46	5.18	5.68	5.71	5.91	5.94
ORP (mV)	-13	-214	-135	-24	-113	-64
Ferrous Iron (mg/L)	2.6	4.0	1.2	1.8	1.8	1.8
Nitrate (mg/L)	13.2	<1	<1	<1	<1	12
Nitrite (mg/L)	0.10	0.07	<0.01	<0.01	<0.01	0.33
DO (mg/L)	<0.025	0.20	<0.10	0.10	0.05	<0.025
Total VFAs (mg/L)	0.39	110 D	18.7 J	55.7	44.5 J	148
Ethane (µg/L)	4.1 J	4.3 J	3.8 J	200 U	2 U	2.6 J
Ethene (µg/L)	2 U	4.4 J	1.7 J	200 U	2 U	1.8 J
Methane (µg/L)	180	1,900	3,300	11,000	13,000	10,000
Sulfate (mg/L)	35	0.5 U	0.5 U	0.71 J	0.31 J	NA
Sulfide (mg/L)	0.75 U	0.95 J	0.75 U	0.75 U	1	NA
TOC (mg/L)	2.3	190	81	3,300	180	77
DHC (cells/mL)	39.7	10,300	11.9	16.7	94.4	42.9
DHB (cells/mL)	10,500	368,000	60.8	181	498	NA
DSM (cells/mL)	12	2,650	1 U	13 U	0.9 J	NA
MOB (cells/mL)	805	115,000,000	1,570,000	NA	NA	30,300,000
TolDeoxy (cells/mL)	0.5 U	2,080,000	1,150	NA	NA	NA
tceA R-Dase	NA	NA	NA	18.4	1.5	28.9
vcrA R-Dase	NA	NA	NA	6.5 U	0.6 J	16.7
bvcA R-Dase	NA	NA	NA	9.7	0.4 J	0.7

OU1-52GW81	5/25/2011	9/21/2011	12/13/2011	3/13/2012	6/18/2012	6/4/2013
pH	6.62	5.88	6.53	6.42	6.31	6.59
ORP (mV)	4.0	-277	-169	-187	-185	-173
Ferrous Iron (mg/L)	3.0	2.2	1.5	2.0	0.9	2.2
Nitrate (mg/L)	<1	<1	<1	<1	<1	<1
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.23
DO (mg/L)	0.05	<0.025	<0.10	<0.025	0.1	<0.025
Total VFAs (mg/L)	0.46	39.1 D	13.6 J	38.0	41.1 J	54.6
Ethane (µg/L)	3.1 J	1.9 J	2 U	2 U	2 U	2 U
Ethene (µg/L)	2.6 J	1.7 J	2 U	2 U	2 U	2 U
Methane (µg/L)	610	2,600	7,000	15,000	15,000	6,500
Sulfate (mg/L)	27	0.5 U	0.5 U	0.69 J	1.8	NA
Sulfide (mg/L)	0.75 U	1.1	0.75 U	2.3	2.0	NA
TOC (mg/L)	4.5	120	72	100	110	36
DHC (cells/mL)	672	9,130	173	27.8	2,940	2,760
DHB (cells/mL)	464,000	864,000	16,900	1,040	502	NA
DSM (cells/mL)	65.9	3.1	12.1	2.2 U	6.9 U	NA
MOB (cells/mL)	53,500	1,110,000,000	10,500,000	NA	NA	20,900,000
TolDeoxy (cells/mL)	0.5 U	574,000	13,500	NA	NA	NA
tceA R-Dase	NA	NA	NA	1.1 U	7.3	1
vcrA R-Dase	NA	NA	NA	0.6 J	17.6	26.3
bvcA R-Dase	NA	NA	NA	10.4	1,050	19,800

Legend

- Monitoring Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings

Notes:
Microbial samples in groundwater from 16GW11, 52GW79, 52GW80, and 52GW81 were collected on 9/29/11
µg/L - micrograms per liter
mg/L - milligrams per liter
mL - milliliters
mV - milliVolts
SU - scientific units
VFAs - volatile fatty acids

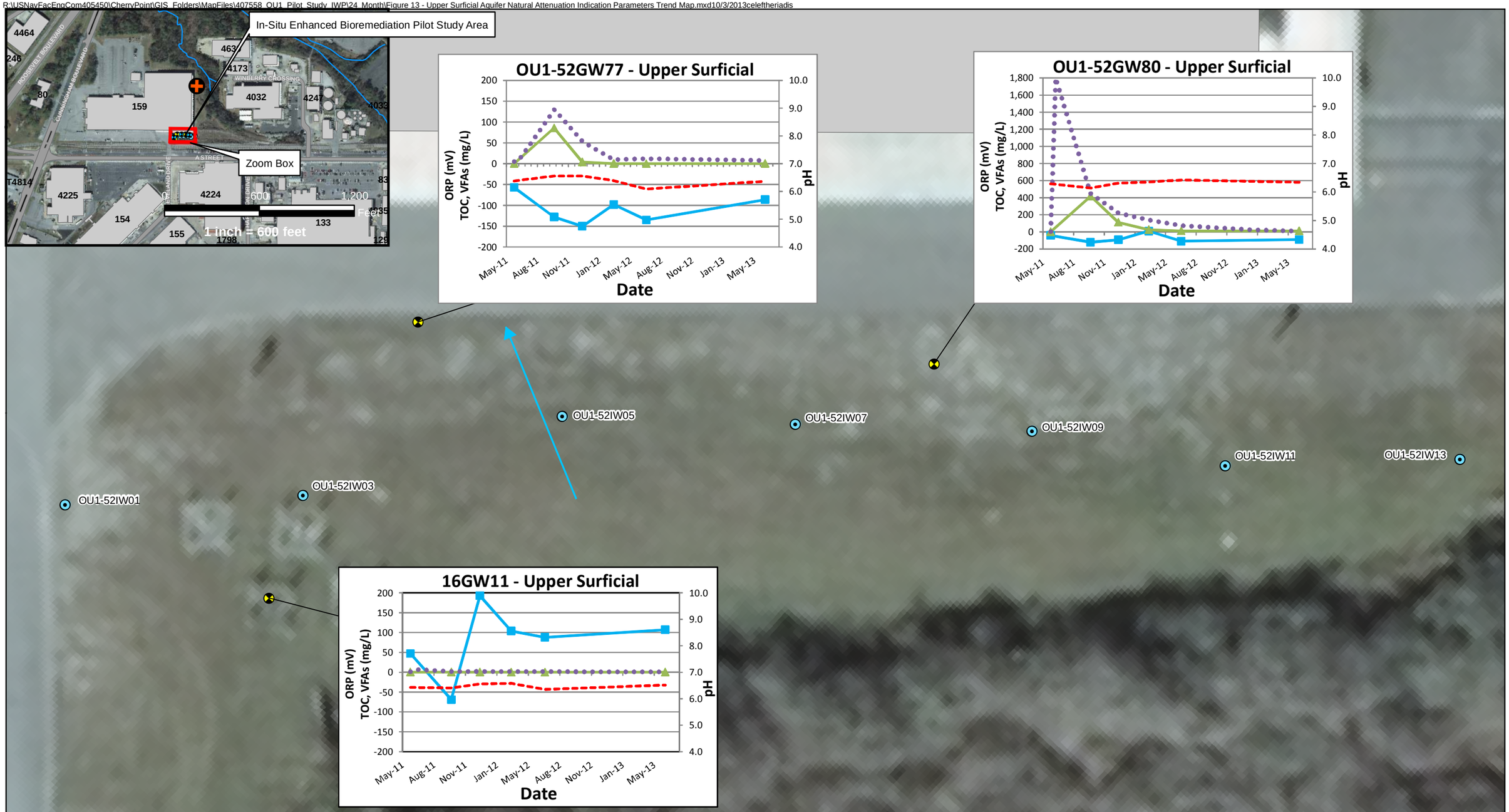
D - Compund identified in an analysis as a secondary dilution factor
J - Analyte present. Value may or may not be accurate or precise
U - The material was analyzed for, but not detected
DHB - *Dehalobacter*
DHC - *Dehalococcoides*
DSM - *Desulfuromonas*
MOB - Methane Oxidizing Bacteria
TolDeoxy - Toluene Deoxygenase
R-Dase - Reductive Dehalogenase

Figure 12
Lower Surficial Aquifer Natural Attenuation Indication Parameters Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

W N S E
0 10 20 Feet
1 inch = 10 feet

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 13 - Upper Surficial Aquifer Natural Attenuation Indication Parameters Trend Map.mxd10/3/2013celeftheriadis



Legend

- Monitoring Well - Upper Surficial Aquifer
- Pilot Study Injection Well - Upper Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings
- pH
- ORP
- TOC
- VFAs

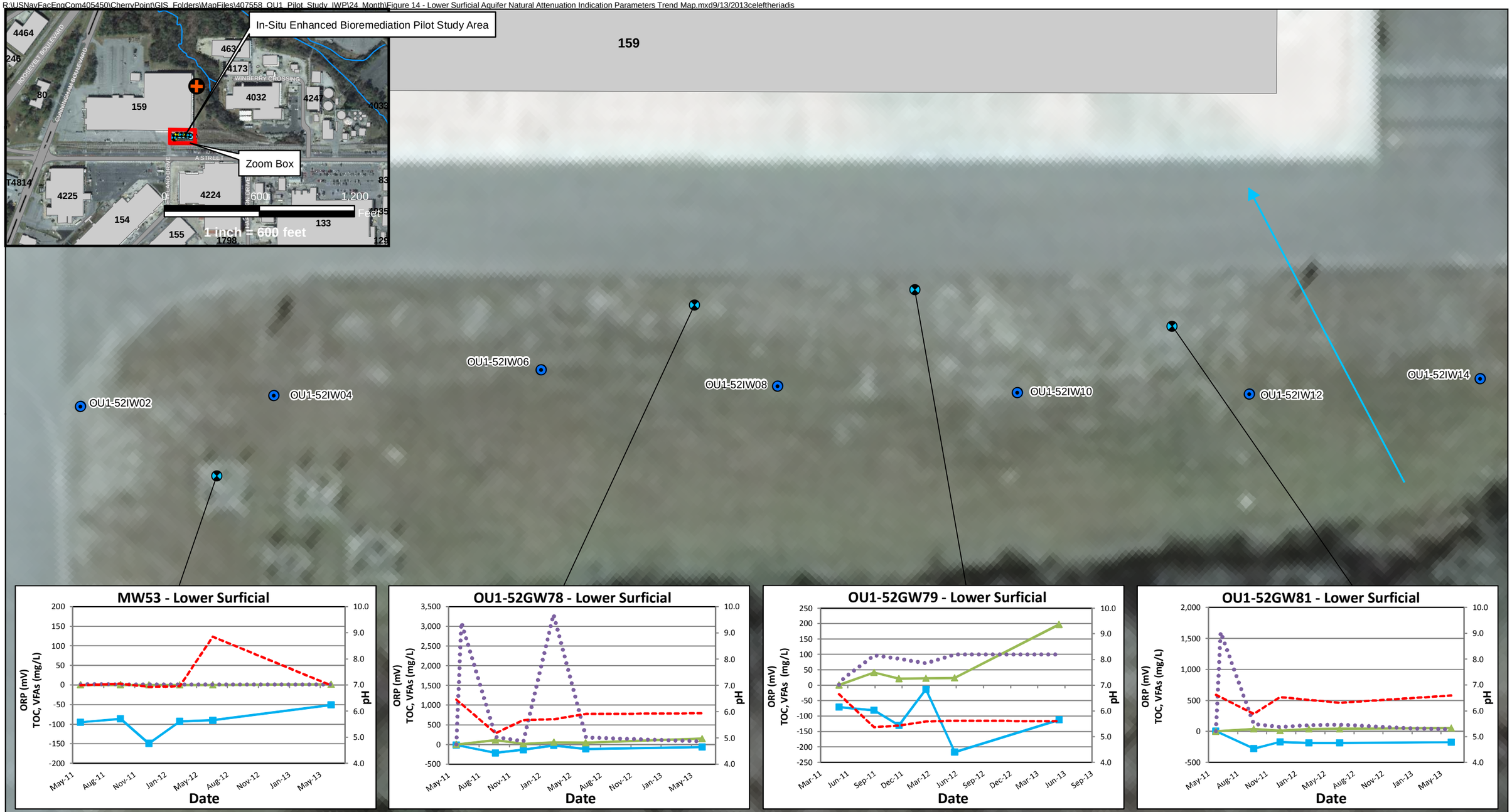
Figure 13
Upper Surficial Aquifer Natural Attenuation Indication Parameters Trend Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

0 10 20 Feet

1 inch = 10 feet

CH2MHILL.

R:\USNavFacEngCom405450\CherryPoint\GIS_Folders\MapFiles\407558_OU1_Pilot_Study_IWP\24_Month\Figure 14 - Lower Surficial Aquifer Natural Attenuation Indication Parameters Trend Map.mxd9/13/2013celeftheriadis



Legend

- Monitoring Well - Lower Surficial Aquifer
- Pilot Study Injection Well - Lower Surficial Aquifer
- Fire Hydrant
- Groundwater Flow Direction
- Existing Buildings
- pH
- ORP
- TOC
- VFAs

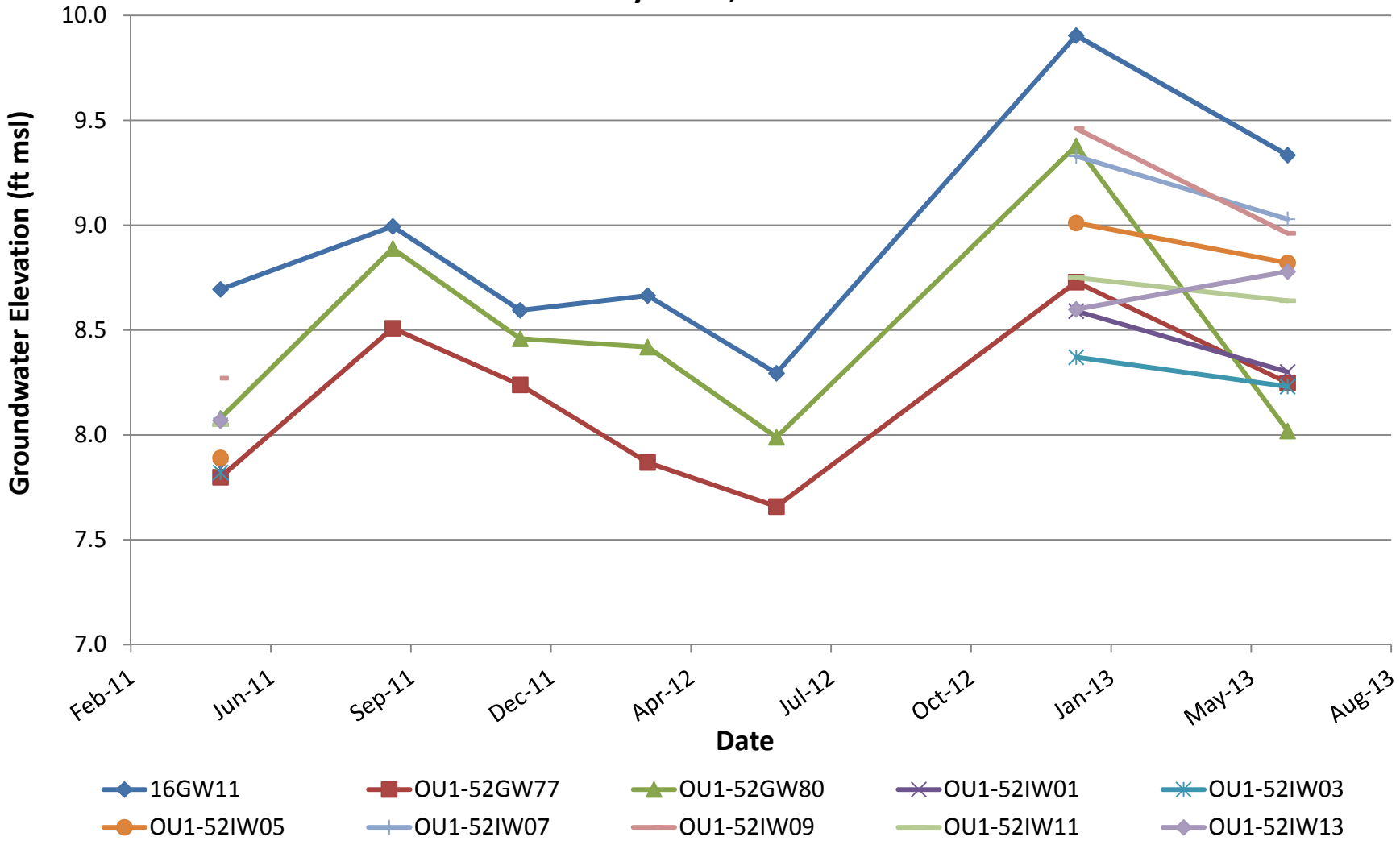
Figure 14
Lower Surficial Aquifer Natural Attenuation Indication Parameters Trend Map
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina

0 10 20 Feet

1 inch = 10 feet

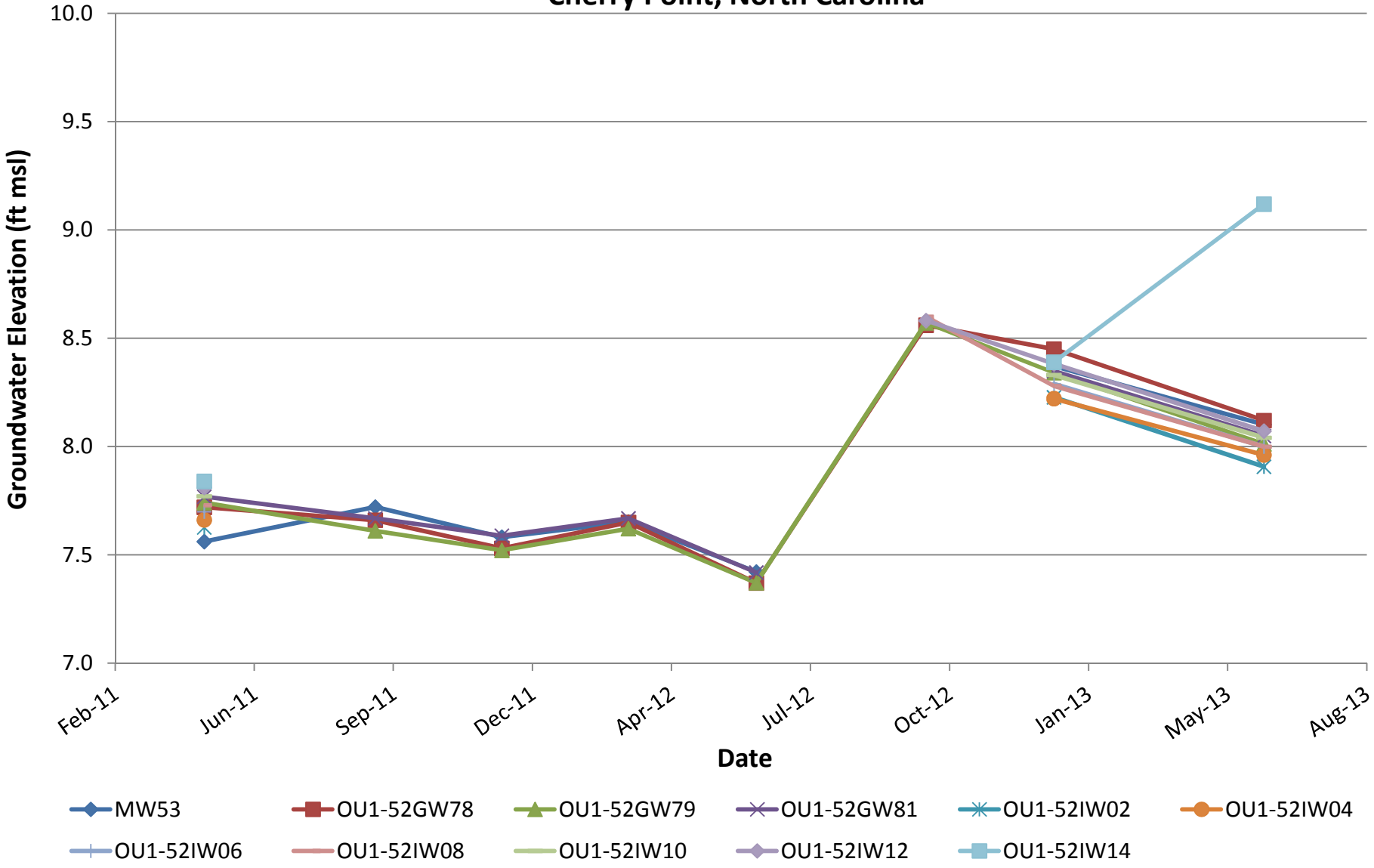
CH2MHILL.

Figure 15
Groundwater Elevation Trends - Upper Surficial Aquifer
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina



CH2MHILL.

Figure 16
Groundwater Elevation Trends - Lower Surficial Aquifer
Marine Corps Air Station Cherry Point
Cherry Point, North Carolina



CH2MHILL.