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Alameda County
Environmental Health

ConocoPhillips
76 Broadway
Sacramento, California 95818

March 15, 2010

Mr. Jerry Wickham
Alameda County Health Agency
1131 Harbor Bay parkway, Suite250
Alameda, California 94502-577

Re: ***Magnesium Sulfate Pilot Application Work Plan***
**Former 76 Service Station # 4186**
**1771 First Street**
**Livermore, CA**

Dear Mr. Wickham:

I declare under penalty of perjury that to the best of my knowledge the information and/or recommendations contained in the attached report is/are true and correct.

If you have any questions or need additional information, please call me at (916) 558-7666.

Sincerely,

Terry L. Grayson
Site Manager
Risk Management & Remediation

SUSTAINABLE STRATEGIES FOR GLOBAL LEADERS

DELTA

March 15, 2010

Mr. Jerry Wickham
Alameda County Health Care Service Agency
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502

**Re: Magnesium Sulfate Pilot Application Work Plan**
76 Service Station No. 4186
1771 First Street
Livermore, California
Fuel Leak case No. RO0000436

Dear Mr. Wickham:

On behalf of ConocoPhillips Company (COP), Delta Consultants (Delta) has prepared this *Magnesium Sulfate Pilot Application Work Plan* in response to Alameda County Healthcare Services Letter to COP dated December 15, 2009, and in concurrence with terms discussed in the December 18, 2009 conference call between Mr. James Barnard (Delta), Mr. Terry Grayson (COP), and Mr. Jerry Wickham (ACHCSA).

Please contact James Barnard at (916) 503-1279 if you have any questions

Sincerely,

**DELTA CONSULTANTS**

James B. Barnard

James Barnard
Senior Project Manager

Cc: Mr. Terry Grayson, ConocoPhillips (electronic copy only)

# MAGNESIUM SULFATE PILOT APPLICATION WORK PLAN

**76 Service Station No. 4186**
**1771 First Street**
**Livermore, California**

**March 15, 2010**

**Prepared for:**

**ConocoPhillips Company**
**76 Broadway**
**Sacramento, California**

The material and data in this report were prepared under the supervision and direction of the undersigned.

**DELTA CONSULTANTS**

Alan Buehler
Staff Geologist

Caitlin Morgan

Caitlin Morgan
Staff Scientist

James B. Barnard

James B. Barnard
Senior Project Manager
California Registered Professional Geologist No. 7478

JAMES B. BARNARD
No. 7478
Expires: 9/10
James B. Barnard

## INTRODUCTION

On behalf of ConocoPhillips, Delta has prepared this work plan for 76 Service Station No. 4186 located at 7850 Amador Valley Boulevard, Livermore, California (Figure 1). The proposed pilot test includes the application of a magnesium sulfate solution to existing monitoring well (U-11), and thereby evaluate the effectiveness of this remediation alternative at the site. Approval to use the existing well U-11 was provided in verbal communication with Mr. Wickham on 2/18/10.

## SITE BACKGROUND AND PREVIOUS ASSESSMENT

The site is an active 76 service station, located on the southwest corner of First Street and N Street (Figure 1). Two 10,000 gallon gasoline underground storage tanks (USTs), four dispenser islands, and a station building are present at the site (Figure 2). The site is located in a generally commercial area.

June 1996: During dispenser piping replacement activities, six soil samples were collected beneath the dispensers and product piping. Total petroleum hydrocarbons as gasoline (TPHg) and benzene, toluene, ethylbenzene, and total xylenes (BTEX) were below the laboratory's indicated reporting limits in all of the samples.

September 1997: A soil gas survey was conducted at the site. Six soil gas probes were advanced and samples were collected at 3 and 15 feet below ground surface (bgs) in the vicinity of the USTs, dispenser islands, and product lines. TPHg was reported in the samples at concentrations ranging from 41 to 4,500 parts per billion (ppb), benzene was reported at concentrations up to 110 ppb, and methyl tert butyl ether (MTBE) was reported at concentrations up to 8,000 ppb. The highest concentrations were reported in the area of the USTs.

June 1998: Three groundwater monitoring wells (U-1 through U-3) were installed at the site to a depth of 34 feet bgs. TPHg, benzene, and MTBE were below laboratory reporting limits in soil samples collected from the well borings. The approximate well locations are shown in Figure 2.

May 2000: A site conceptual model (SCM) was completed for the site. The groundwater flow velocity was calculated to estimate plume travel time to the nearest down-gradient receptor. Groundwater velocity was calculated to be 46 feet per year. It was concluded that hydrocarbon impact to groundwater appears to fluctuate with the rise and fall of the groundwater surface beneath the site.

February 2001: Two additional monitoring wells (U-4 and (U-5) were installed. The monitoring wells were installed to depths of 45 feet bgs (U-4) and 47 feet bgs (U-5). TPHg, BTEX, and MTBE were below laboratory reporting limits in soil samples collected from the well boring. TPHg and benzene were below laboratory reporting limits in the initial groundwater samples collected from wells U-4 and U-5; however, MTBE was reported at concentrations of 38.2 and 55.4

micrograms per liter (ug/L) respectively. The approximate well locations are shown in Figure 2.

December 2001: Two additional monitoring wells (U-6 and U-7) and eight ozone injection sparge wells (SP-1 through SP-4, SP-5/5S, SP-6S, SP-7S, and SP-8/8S) were installed at the site. The monitoring wells were installed to 45 feet bgs. The sparge points in wells SP-1 through SP-4 were installed to a depth of 45 feet bgs. The sparge points in wells SP-6S and SP-7S were installed to a shallower depth of 25 feet bgs. The remaining two sparge wells each contained dual-nested sparge points installed to 25 feet bgs (SP-5S and SP-8S) and 45 feet bgs (SP-5 and SP-8). An ozone microsparge system was then installed and began operation in December 2001. The system injected ozone into the 10 sparge points. Approximate locations are shown in Figure 2.

April 2006: Seven borings (B-1 through B-7) were advanced at the site. Three boreholes were advanced at each location. The initial borehole was advanced to record a Cone Penetrometer Test (CPT) log of subsurface lithology. The second borehole was advanced for the purpose of collecting soil samples for observation and laboratory analysis, and to collect discrete groundwater samples at depths of approximately 38 feet to 44 feet bgs. The third borehole was advanced to collect discrete groundwater samples at approximately 57 to 65 feet bgs. Three general stratigraphic zones were identified: an upper zone from 36 to 43 feet bgs, a middle clay zone from 43 to 55 feet bgs, and a lower zone from 55 to the maximum depth of 65.5 feet bgs explored. Soil samples from various depths were submitted for laboratory analysis. TPHg was reported in five upper zone, six clay zone, and three lower zone soil samples at concentrations of 700 milligrams per kilogram (mg/kg). MTBE was reported in three upper zone, three clay zone, and two lower zone samples at concentrations up to 0.29 mg/kg. Benzene was reported in three clay zone soil samples at concentrations up to 1.3 mg/kg. TPHg was reported in all of the 14 groundwater samples collected at concentrations up to 26,000 ug/L. Benzene was reported in five upper zone, and six lower zone groundwater samples at concentration up to 510 ug/L. MTBE was reported in four upper zone and six lower zone groundwater samples at concentrations up to 1,100 ug/L.

March 2007: Two additional on-site borings (B-8 and B-9) and one off-site boring (B-10) were advanced using a CPT rig. The borings were advanced to further evaluate the vertical extent of impacted groundwater to the base of the lowermost sand and gravel unit, to evaluate groundwater quality in the lowermost sand and gravel unit down-gradient of the site, and to evaluate the presence of a clay layer underlying the lowermost coarse-grained soils which may represent a regional aquitard. Four soil samples were collected for laboratory analysis from off-site boring B-10. MTBE was reported in two of the samples at concentrations up to 0.016 mg/kg; TPHg and benzene were below laboratory reporting limits in all of the soil samples collected for analysis. TPHg (200 ug/L), benzene (0.94 ug/L), and MTBE (7.1 ug/L) were reported in the groundwater samples collected at 79 to 83 feet bgs from boring B-8. TPHg, BTEX, and fuel oxygenates were below laboratory reporting limits in the groundwater samples collected at 78 to 88 feet bgs from boring B-9. A low concentration of MTBE (0.73 ug/L) was reported in groundwater samples collected at 66 to 70 feet bgs from boring B-10, and a low concentration of toluene (1.4 ug/L) was reported in the groundwater sample collected between 83 to 87 feet bgs from boring B-10. Based on the results of the investigation, soil and groundwater in the area of off-site boring B-10 did not appear to be significantly impacted, groundwater within the lowermost sand and gravel unit in the area of boring B-8 was slightly impacted, and groundwater within the lowermost sand and gravel unit in the area of B-9 was not impacted.

March 2007: Oxygen injection testing was performed in the sparge wells to evaluate radius of influence and to evaluate the effectiveness of the existing system. As described in our Additional Subsurface Assessment Report, dated April 26, 2007, the testing suggested a ROI of between 10 to 15 feet around the wells on average, but perhaps greater in some area. This system has been inactive for the past year due to concerns about the injection of ozone causing oxidation of trivalent chromium [Cr (III)] into hexavalent chromium [Cr (VI)].

September and October of 2008: Delta installed eight more groundwater monitoring wells. Wells U-8 through U-11 were deemed Middle Zone Monitoring Wells, and installed to depths ranging from 45 to 50 feet bgs. The middle zone wells were constructed as 2 inch diameter wells with 10 foot screen intervals. Wells U-12 through U-15 were deemed Lower Zone Monitoring Wells, and installed to depths ranging from 71.5 to 75 feet bgs. The lower zone wells were constructed as 4 inch diameter wells with 10 foot screened intervals, and with 12 inch diameter steel conductor casing from surface to between 52 to 57 feet bgs.

Quarterly monitoring of the site wells has been performed since July 1998. Historically, the groundwater flow direction has varied from north to southwest. The depth to groundwater has varied from 21.62 to 46.31 feet bgs.

## SUBSURFACE CONDITIONS

The site is underlain by sand and gravel to a depth of approximately 20 feet bgs. This is underlain by a clay layer from approximately 20 to 35 feet bgs with a sandy layer from approximately 35 to 45 feet bgs. There is another clay layer from approximately 40 feet bgs to a maximum explored depth of 50 feet bgs.

## PROPSED BIODEGRADATION ENHANCEMENT TEST

Delta has recently been awarded a patent for the application of sulfate with respect to accelerating the cleanup of soil and groundwater. With microbes and dissolved iron (ferric iron) present, the introduction of magnesium sulfate solution ($MgSO_4$) into hydrocarbon-impacted groundwater, yields the following reaction:

Petroleum Hydrocarbon + $MgSO_4$ + Dissolved Iron → Iron Sulfide+$H_20$+$MgCO_3$+$CO_2$

Delta proposes to conduct a pilot test on the southeastern portion of the service station property just south of the UST pit. This pilot test will involve the introduction of sulfate compounds into groundwater monitoring well U-11 in order to replenish the electron acceptors in the southern vicinity of the site. The proposed application well (U-11) was chosen for is central location in the plume, and also its close proximity to ozone sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10,. The ozone sparge points in addition to other nearby "U" named monitoring wells will be used to determine the radius of influence. Current monitoring well and injection well locations are included on Figure 2.

During the course of the pilot test, Delta will monitor and analyze the above-listed compound application well (U-11), as well as surrounding sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10, for petroleum hydrocarbon constituents and magnesium sulfate compounds. Delta will then evaluate the analytical results in order to assess if electron acceptors in the groundwater at the southeast portion of the site have been sufficiently replenished to stimulate enhanced biodegradation of petroleum hydrocarbons.

## Sulfate in the Hydrocarbon Biodegradation Process

Recent case studies show that, in anaerobic conditions, microbes utilize sulfate as a terminal electron acceptor in the process of hydrocarbon biodegradation in groundwater. Although other terminal-electron accepting processes (TEAPs) may occur simultaneously during hydrocarbon degradation (with the utilization of nitrates/nitrate, manganese, iron, and oxygen), data suggests that sulfate reduction may be the most important TEAP in the active reduction of hydrocarbons (Dale R. Van Stempvoort, James Armstrong, and Bernhard Mayer, 2007).

Anaerobic sulfate reduction within dissolved BTEX plumes can be observed in sulfate trends. Where depleted concentrations of sulfate (<10 mg/L) are present within the plume core; where slightly depleted sulfate concentrations exist on the plume fringe; and where more abundant sulfate levels (consistent with background concentrations) are present in uncontaminated areas just beyond the plume edge, anaerobic sulfate reduction is occurring. (Lyle Bruce, Jim Cuthbertson, Arati Kolhatkar, J. Scott Ziegler, and Brent Graves, 2007).

In a 2001 study conducted by Dale R. Van Stempvoort, et al., periodic replenishment of sulfate, resulting from the infiltration of snowmelt (carrying dissolved sulfate from soils) through the vadose zone and into the aquifer, played a key role in the biodegradation of petroleum hydrocarbons.

Two cases studies are provided as Appendix B.

### Site Specific Sulfate Conditions

Groundwater monitoring and sampling results from the fourth quarter 2009 indicate that the core of the petroleum hydrocarbon plume is located central to the site, in vicinity of the dispenser islands, with maximum concentrations of Benzene and MTBE located slightly south; primarily in the vicinity of the current UST pit. Fourth quarter 2009 laboratory analyses indicate that there is a favorable correlation between sulfate concentrations and contaminant concentrations (except at U-10) in the intermediate zone.

In addition, chromium VI concentrations are ND in the intermediate zone wells which are targeted for sulfate enhancement. The maximum TPHg concentration reported in groundwater is 8,800 parts per billion (ppb) reported in on site well U-9 (just south of First Street).

Historical groundwater analytical data from monitoring and sampling events is included as Appendix C.

## MAGNESIUM SUFATE APPLICATION PILOT TEST FIELD ACTIVITIES

### Pre-Field Activities

Before commencing field activities Delta will prepare a Health and Safety Plan (HASP) in accordance with state and federal requirements for use during on-site assessment activities. In addition, all appropriate permits will be obtained through the Zone 7 Water Agency prior to scheduling the field work.

### Field Activities

Delta proposes to introduce a pre-mixed solution of Epsom salt and tap water into well U-11. This well and the surrounding area comprise a target source area approximately 120 feet wide by 120 feet long by 8 feet thick. Based on a review of the logs from previous borings at the site, a gravelly clayey sand/sandy clayey gravel layer extends to approximately from 35 to 40 feet bgs. Well U-11 is screened from35-45 feet bgs.

In consideration of on site conditions (including constituent concentrations, known soil types, and lithology) the desired target level for sulfate concentrations will be approximately 200 mg/L to 300 mg/L. To achieve this desired level an initial application of 100 gallons of 29% magnesium sulfate/tap water solution (approximately 300 pounds of Epsom salts) into well U-11 is proposed. The grade of magnesium sulfate to be used is sufficiently pure (99.82%), so as not to introduce unwanted substances into the groundwater.

Prior to the introduction of magnesium sulfate solution into U-11, Delta will measure depth to water and electrical conductivity and collect (background) grab groundwater samples from the sulfate application well as well as sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10. These samples will be analyzed for total sulfate by EPA Method 300.0, total magnesium by EPA Method 6010B, TPHg and TPHd by EPA Method 8015M and BTEX and MTBE by EPA Method 8260B.

During the course of application, Delta will continue to monitor for various biodegradation parameters and electron acceptors including specific conductivity, dissolved oxygen (DO), oxygen reducing potential (ORP), pH, and temperature in sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10.

The total volume of solution will be introduced using a Grunfos®-type pump to control flow rate into U-11 at an approximate one gallon per minute rate. Should significant increases in groundwater elevation and/or conductivity be observed in sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10, the MgSO4 solution application rate will be reduced.

To monitor the dispersion of the magnesium sulfate solution and to assess sulfate levels in groundwater, depth to water and electrical conductivity will be measured during application in sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10 at thirty minute intervals for a period of two hours. After a period of two hours, Delta field staff will make the determination in the field to decrease or maintain the sampling intervals until the completion of application activities.

Following the introduction of the sulfate solution, a second sample collection will occur from sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10, which will be analyzed for total magnesium and total sulfate.

Following the addition of magnesium sulfate solution as part of the proposed pilot test, ferrous iron, total magnesium and total sulfate will be added to the on-going quarterly/semi-annual monitoring and sampling analytical suite for sparge points sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10,. Sulfate concentrations in U-4 will be used for background comparison, while observed concentrations in U-10 will be used to evaluate the down-gradient effect of the introduction of sulfate compounds.

### Proposed Schedule of Initial Pilot Test Activities:

- **Week 1**: Introduction of magnesium sulfate compounds to replenish electron acceptors into monitoring well U-11.
- **Week 2:** Sample collection and laboratory analysis of groundwater from sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10, for magnesium sulfate compounds introduced during week 1 (total sulfate by EPA Method 300.0 and total magnesium by EPA Method 6010B). Well U-4 will be used to evaluate the potential down-gradient influence of the magnesium sulfate application.

- **Week 3**: *(Time allowed for laboratory analysis).*
- **Week 4**: Application of additional magnesium sulfate concentrations if sulfate levels in well U-11 from initial application are below the target concentration of between 200 mg/L and 300 mg/L. Amounts added will be calculated using concentrations observed from initial sulfate application. If samples collected during week 2 indicate sulfate concentrations are within target range, additional samples will be collected from sparge points sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10 for total sulfate by EPA Method 300.0, total magnesium by EPA Method 6010B, TPHg and TPHd by EPA Method 8015M, and BTEX and MTBE by EPA Method 8260B.
- **Week 5**: If additional magnesium sulfate compounds are introduced during week 4, collect samples from sparge points sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10 for total sulfate by EPA Method 300.0, total magnesium by EPA Method 6010B, TPHg and TPHd by EPA Method 8015M, and BTEX and MTBE by EPA Method 8260B. If no additional magnesium sulfate compounds are introduced during week 4, no activities are proposed for week 5.
- **Week 6**: *(Time allowed for laboratory analysis).*
- **Week 7**: Application of additional magnesium sulfate if sulfate levels in well U-11 from initial application or any subsequent application are below the target concentration of between 200 mg/L and 300 mg/L based on samples collected during week 4 or week 5. If samples collected during week 4 or week 5 indicate sulfate concentrations are within target range, additional samples will be collected from sparge points sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10 for total sulfate by EPA Method 300.0, total magnesium by EPA Method 6010B, TPHg and TPHd by EPA Method 8015M, and BTEX and MTBE by EPA Method 8260B.
- **Week 8**: If additional magnesium sulfate compounds are introduced during week 7, collect samples from sparge points sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10 for total sulfate by EPA Method 300.0, total magnesium by EPA Method 6010B, TPHg and TPHd by EPA Method 8015M, and BTEX and MTBE by EPA Method 8260B. If no additional magnesium sulfate compounds are introduced during week 7, no activities are proposed for week 8.
- **Week 9**: Sample collection and laboratory analysis of groundwater from monitoring sparge points sparge points SP-8, SP-2 and SP-5, and monitoring wells U-8 and U-10 for total sulfate by EPA Method 300.0, total magnesium and Chrome VI by EPA Method 6010B, TPHg and TPHd by EPA Method 8015M, and BTEX and MTBE by EPA Method 8260B.

**NOTE:**

- If sulfate concentrations in well U-11 remain below the desired range of 200 mg/L to 300 mg/L, additional applications of magnesium sulfate compounds may be required. If this additional application is needed, remaining activities may be deferred until the required additional applications are performed and confirmation testing performed.
- After week 9 activities and receipt of analytical testing results, Delta proposes to prepare and submit a report summarizing the sulfate application activities and the initial effect on groundwater chemistry at the site.

## DISPOSAL OF WASTEWATER

Wastewater generated during field activities will be placed into properly labeled 55-gallon Department of Transportation (DOT)-approved steel drum and stored on the service station site. Composite samples of the wastewater will be collected and submitted to a California-certified laboratory where they will be analyzed for TPHg, BTEX, and MTBE by EPA Test Method 8260B.

## REPORTING

Following completion of the field work and receipt of analytical results, a site investigation report will be prepared and submitted within 60 days. The report will present the details of the boring activities, including copies of boring permits, and details of disposal activities and copies of disposal documents. Required electronic submittals will be uploaded to the State GeoTracker database.

## LIMITATONS

The recommendations contained in this report represent Delta's professional opinions based upon the currently available information and are arrived at in accordance with currently acceptable professional standards. This report is based upon a specific scope of work requested by the client. The Contract between Delta and its client outlines the scope of work, and only those tasks specifically authorized by that contract or outlined in this report were performed. This report is intended only for the use of Delta's Client and anyone else specifically listed on this report. Delta will not and cannot be liable for unauthorized reliance by any other third party. Other than as contained in this paragraph, Delta makes no express or implied warranty as to the contents of this report.

******

# FIGURES

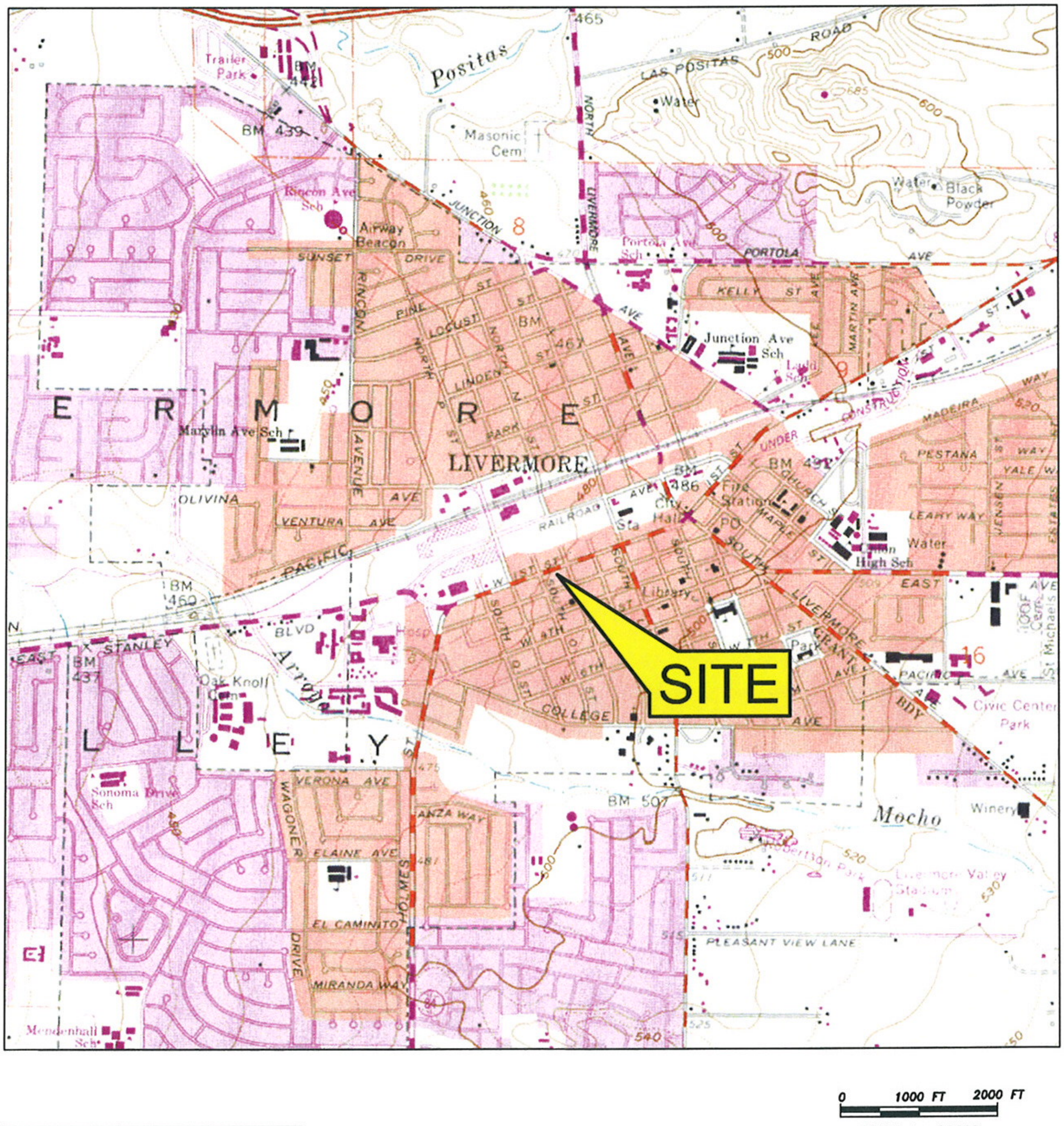

FIGURE 1

SITE LOCATION MAP

76 STATION NO. 4186
1771 FIRST STREET
LIVERMORE, CA

| | |
|---|---|
| PROJECT NO.<br>C104-186 | DRAWN BY<br>MC 12/28/05 |
| FILE NO.<br>Site Locator 4186 | PREPARED BY<br>MC |
| REVISION NO.<br>1 | REVIEWED BY |

Delta Environmental Consultants, Inc.

SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC MAP, CALABASAS QUADRANGLE, 1967

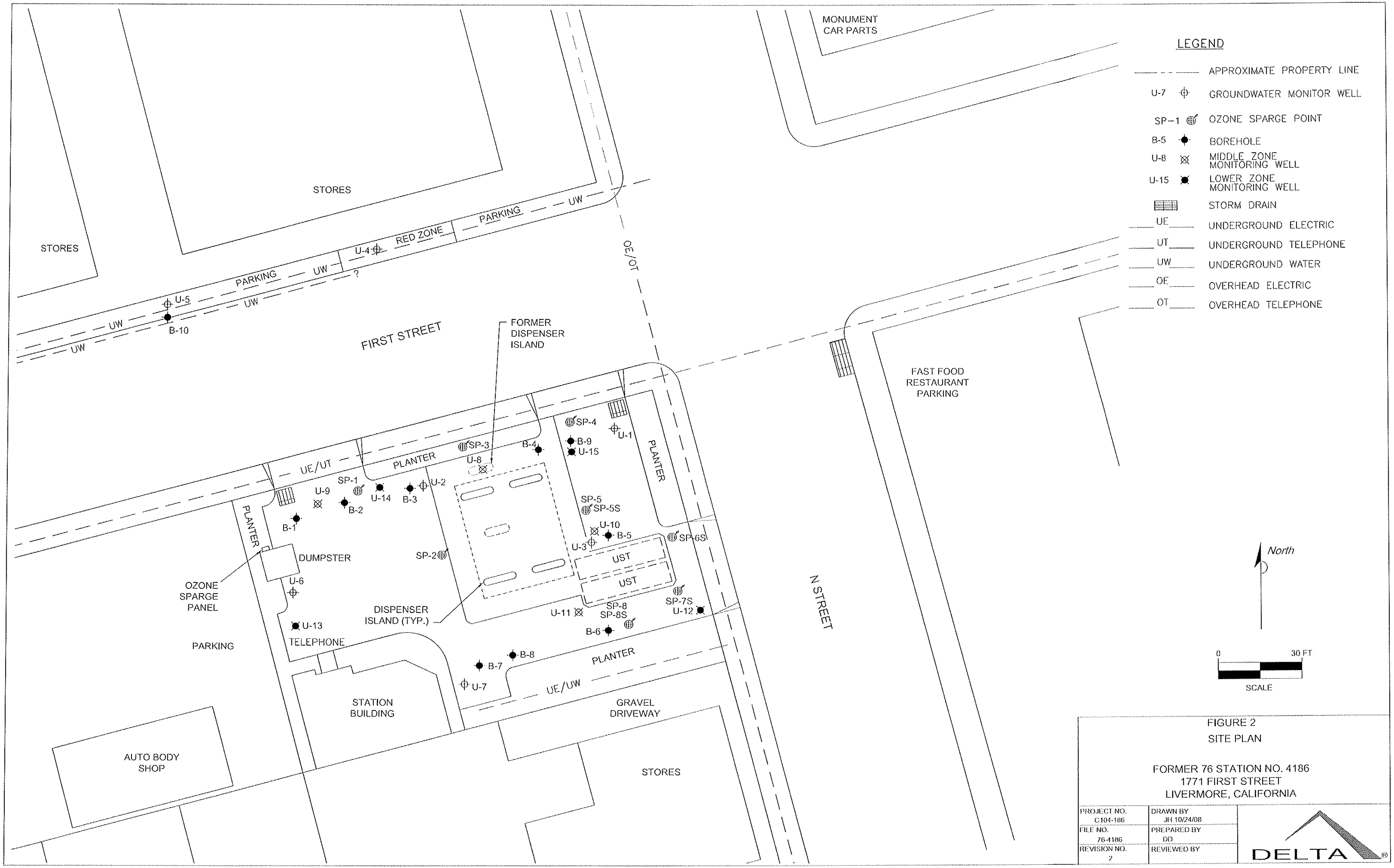

FIGURE 2

SITE PLAN

FORMER 76 STATION NO. 4186
1771 FIRST STREET
LIVERMORE, CALIFORNIA

PROJECT NO. C104-186
FILE NO. 76-4186
REVISION NO. 2
DRAWN BY JH 10/24/08
PREPARED BY DD
REVIEWED BY

# APPENDIX A

ACHCSA Letter, December 15, 2009

ALAMEDA COUNTY
**HEALTH CARE SERVICES**
AGENCY
ALEX BRISCOE, Acting Director

ENVIRONMENTAL HEALTH SERVICES
ENVIRONMENTAL PROTECTION
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577
(510) 567-6700
FAX (510) 337-9335

December 15, 2009

Terry Grayson (*Sent via E-mail to:* Terry.L.Grayson@contractor.conocophillips.com)
ConocoPhillips
76 Broadway
Sacramento, CA 95818

Thomas and Celine Vadakkekunnel
4481 Peacock Court
Dublin, CA 94568

Subject: Fuel Leak Case No. RO0000436 and Geotracker Global ID T0600101777, Unocal #4186, 1771 First Street, Livermore, CA 94550

Dear Mr. Grayson and Mr. and Ms. Vadakkekunnel:

Alameda County Environmental Health (ACEH) staff has reviewed the fuel leak case file for the above-referenced site including the recently submitted document entitled, "*Quarterly Summary Report – Second Quarter 2009*," dated July 21, 2009. The Quarterly Report presents the results from groundwater sampling conducted in June 2009 and includes summaries of the remediation status and characterization status. The Quarterly Report indicates that installation of additional ozone injection wells as well as upgrade of the existing ozone injection system is on hold pending the results of quarterly groundwater monitoring. This same has conclusion has been included in the past three quarterly groundwater monitoring reports. In previous correspondence dated December 12, 2008 regarding this issue, ACEH requested that a Work Plan for Ozone System Sparging Upgrade be submitted no later than May 11, 2009. A Work Plan for Ozone System Sparging has not been submitted to date.

We request that the evaluation of the ozone sparging system upgrade be completed and the Work Plan for Ozone System Sparging be submitted no later than February 24, 2010. For ease of reference, we have repeated the technical comments in our December 12, 2008 correspondence below. We request that you address the following technical comments, perform the proposed work, and send us the technical reports requested below.

## TECHNICAL COMMENTS

1. **Ozone Sparging System.** Following review of groundwater monitoring data from new and existing wells during the First Quarter 2009, we request that you submit plans for improvement and upgrade of the ozone sparging system. The plans must include abandonment of sparge wells as previously proposed and installation of additional or replacement of existing sparge wells. In addition, we request that you review historical groundwater monitoring data, system operation data, and results from the oxygen injection testing conducted in 2007 and incorporate these results as necessary in the Work Plan for Ozone Sparging System Upgrade requested below.

2. **Remediation of TBA.** In the Work Plan for Ozone Sparging System Upgrade requested below, please include a discussion of the effectiveness of proposed improvements to the ozone sparging system on remediation of TBA. A review of historical groundwater monitoring data indicates that although some decreases in concentrations have been observed for TPHg, BTEX, and MTBE during the operation of the ozone sparging system, TBA concentrations have remained elevated. Please evaluate recalcitrance of the TBA to ozone sparging and discuss whether the proposed improved sparing system will be effective in treating dissolved TBA.

3. **Well Construction Details and Cross Sections.** The Work Plan for Ozone Sparging System Upgrade must include a table of well construction details for all new and existing wells that lists the depth, diameter, filter pack and screen intervals, and date of installation. We also request that you include one downgradient and one cross gradient cross section in the Work Plan for Ozone Sparging System Upgrade. Please update cross section A-A' which was previously presented in the "*Additional Subsurface Assessment and Oxygen Injection Test Report*," dated April 26, 2007 for use as the cross gradient cross section. Please construct a downgradient cross section similar to A-A' that extends approximately through SP-8, U-3, U-8, and U-4. Proposed sparge wells are to be included on the cross sections.

4. **Remediation Status.** The most recent groundwater monitoring report for the site entitled, "*Quarterly Summary Report – Third Quarter 2008 and Sensitive Receptor Survey*," dated October 20, 2008 discusses shutdown of the ozone sparging system in the Second Quarter 2007 to evaluate whether dissolved phase concentrations would rebound. It is not clear whether this evaluation of rebound occurred. Please include this evaluation in the Work Plan for Ozone Sparging System Upgrade requested below. The Remediation Status section of future groundwater monitoring reports must be clearer about current operational status of the system. More specifically, the Remediation Status section must state whether the system is currently active, the dates of operation, and reasons for the system being not active.

## TECHNICAL REPORT REQUEST

Please submit technical reports to Alameda County Environmental Health (Attention: Jerry Wickham), according to the following schedule:

- **February 10, 2010** – Semi-Annual Monitoring Report – Fourth Quarter 2009 (To include summary report, remedial performance summary, and quarterly monitoring report in one document

- **February 24, 2010** – Work Plan for Ozone Sparging System Upgrade

These reports are being requested pursuant to California Health and Safety Code Section 25296.10. 23 CCR Sections 2652 through 2654, and 2721 through 2728 outline the responsibilities of a responsible party in response to an unauthorized release from a petroleum UST system, and require your compliance with this request.

## ELECTRONIC SUBMITTAL OF REPORTS

ACEH's Environmental Cleanup Oversight Programs (LOP and SLIC) require submission of reports in electronic form. The electronic copy replaces paper copies and is expected to be used for all public information requests, regulatory review, and compliance/enforcement activities. Instructions for submission of electronic documents to the Alameda County Environmental Cleanup Oversight Program FTP site are provided on the attached "Electronic Report Upload Instructions." Submission of reports to the Alameda County FTP site is an addition to existing requirements for electronic submittal of information to the State Water Resources Control Board (SWRCB) Geotracker website. In September 2004, the SWRCB adopted regulations that require electronic submittal of information for all groundwater cleanup programs. For several years, responsible parties for cleanup of leaks from underground storage tanks (USTs) have been required to submit groundwater analytical data, surveyed locations of monitoring wells, and other data to the Geotracker database over the Internet. Beginning July 1, 2005, these same reporting requirements were added to Spills, Leaks, Investigations, and Cleanup (SLIC) sites. Beginning July 1, 2005, electronic submittal of a complete copy of all reports for all sites is required in Geotracker (in PDF format). Please visit the SWRCB website for more information on these requirements (http://www.swrcb.ca.gov/ust/cleanup/electronic_reporting).

## PERJURY STATEMENT

All work plans, technical reports, or technical documents submitted to ACEH must be accompanied by a cover letter from the responsible party that states, at a minimum, the following: "I declare, under penalty of perjury, that the information and/or recommendations contained in the attached document or report is true and correct to the best of my knowledge." This letter must be signed by an officer or legally authorized representative of your company. Please include a cover letter satisfying these requirements with all future reports and technical documents submitted for this fuel leak case.

## PROFESSIONAL CERTIFICATION & CONCLUSIONS/RECOMMENDATIONS

The California Business and Professions Code (Sections 6735, 6835, and 7835.1) requires that work plans and technical or implementation reports containing geologic or engineering evaluations and/or judgments be performed under the direction of an appropriately registered or certified professional. For your submittal to be considered a valid technical report, you are to present site specific data, data interpretations, and recommendations prepared by an appropriately licensed professional and include the professional registration stamp, signature, and statement of professional certification. Please ensure all that all technical reports submitted for this fuel leak case meet this requirement.

## **UNDERGROUND STORAGE TANK CLEANUP FUND**

Please note that delays in investigation, later reports, or enforcement actions may result in your becoming ineligible to receive grant money from the state's Underground Storage Tank Cleanup Fund (Senate Bill 2004) to reimburse you for the cost of cleanup.

## AGENCY OVERSIGHT

If it appears as though significant delays are occurring or reports are not submitted as requested, we will consider referring your case to the Regional Board or other appropriate agency, including the County District Attorney, for possible enforcement actions. California Health and Safety Code, Section 25299.76 authorizes enforcement including administrative action or monetary penalties of up to $10,000 per day for each day of violation.

If you have any questions, please call me at 510-567-6791 or send me an electronic mail message at jerry.wickham@acgov.org.

Sincerely,

Jerry Wickham

Digitally signed by Jerry Wickham
DN: cn=Jerry Wickham, o, ou,
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Enclosure: ACEH Electronic Report Upload (ftp) Instructions

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Geotracker, File

| **Alameda County Environmental Cleanup Oversight Programs (LOP and SLIC)** | **ISSUE DATE:** July 5, 2005<br>**REVISION DATE:** March 27, 2009<br>**PREVIOUS REVISIONS:** December 16, 2005, October 31, 2005 |
|---|---|
| **SECTION:** Miscellaneous Administrative Topics & Procedures | **SUBJECT:** Electronic Report Upload (ftp) Instructions |

The Alameda County Environmental Cleanup Oversight Programs (LOP and SLIC) require submission of all reports in electronic form to the county's ftp site. Paper copies of reports will no longer be accepted. The electronic copy replaces the paper copy and will be used for all public information requests, regulatory review, and compliance/enforcement activities.

**REQUIREMENTS**

- Entire report including cover letter must be submitted to the ftp site as **a single portable document format (PDF) with no password protection**. (Please do not submit reports as attachments to electronic mail.)
- It is **preferable** that reports be converted to PDF format from their original format, (e.g., Microsoft Word) rather than scanned.
- Signature pages and perjury statements **must** be included and have either original or electronic signature.
- **Do not password protect the document**. Once indexed and inserted into the correct electronic case file, the document will be secured in compliance with the County's current security standards and a password. **Documents with password protection will not be accepted**.
- Each page in the PDF document should be rotated in the direction that will make it easiest to read on a computer monitor.
- Reports must be named and saved using the following naming convention:
  RO#_Report Name_Year-Month-Date (e.g., RO#5555_WorkPlan_2005-06-14)

**Additional Recommendations**

- A separate copy of the tables in the document should be submitted by e-mail to your Caseworker in **Excel** format. These are for use by assigned Caseworker only.

**Submission Instructions**

1) Obtain User Name and Password:
   a) Contact the Alameda County Environmental Health Department to obtain a User Name and Password to upload files to the ftp site.
      i) Send an e-mail to dehloptoxic@acgov.org
         Or
      ii) Send a fax on company letterhead to (510) 337-9335, to the attention of My Le Huynh.
   b) In the subject line of your request, be sure to include **"ftp PASSWORD REQUEST"** and in the body of your request, include the **Contact Information, Site Addresses**, and the **Case Numbers (RO# available in Geotracker) you will be posting for**.

2) Upload Files to the ftp Site
   a) Using Internet Explorer (IE4+), go to ftp://alcoftp1.acgov.org
      (i) Note: Netscape and Firefox browsers will not open the FTP site.
   b) Click on File, then on Login As.
   c) Enter your User Name and Password. (Note: Both are Case Sensitive.)
   d) Open "My Computer" on your computer and navigate to the file(s) you wish to upload to the ftp site.
   e) With both "My Computer" and the ftp site open in separate windows, drag and drop the file(s) from "My Computer" to the ftp window.

3) Send E-mail Notifications to the Environmental Cleanup Oversight Programs
   a) Send email to dehloptoxic@acgov.org notify us that you have placed a report on our ftp site.
   b) Copy your Caseworker on the e-mail. Your Caseworker's e-mail address is the entire first name then a period and entire last name @acgov.org. (e.g., firstname.lastname@acgov.org)
   c) The subject line of the e-mail must start with the RO# followed by **Report Upload**. (e.g., Subject: RO1234 Report Upload) If site is a new case without an RO# use the street address instead.
   d) If your document meets the above requirements and you follow the submission instructions, you will receive a notification by email indicating that your document was successfully uploaded to the ftp site.

# APPENDIX B

Magnesium Sulfate Case Studies

## Anaerobic Degradation of Benzene was Enhanced through Sulfate Addition Substantially Increasing the HC Degradation Rate at a Central Indiana Site.

Lyle Bruce, Jim Cuthbertson, Arati Kolhatkar, J. Scott Ziegler, and Brent Graves

At this Central Indiana site, dissolved BTEX levels were relatively high fifteen years after the service station closed. Despite the facts that the UST source area had been over excavated at the time the facility closed and a pump and treat system had operated for a period of time, concentrations were still too high to qualify for MNA. In 2004, dissolved benzene levels near the source area hovered at 1000 ppb. The dissolved plume was neither growing nor shrinking. If the source area could be addressed, the plume should shrink. Excavation was not an option because the site had already been redeveloped. Inorganic analyses showed that dissolved sulfate was present naturally in the aquifer outside the hydrocarbon plume with a mean concentration of 78 mg/l. In the dissolved phase BTEX plume area, however, sulfate concentrations were substantially reduced to concentrations less than 10 mg/l. Additionally, a shadow of reduced sulfate concentration extended downgradient of the plume area. This was a very strong indicator that the hydrocarbon plume had gone anaerobic and was undergoing sulfate reducing conditions. In 2004, high concentration sulfate solutions were added to the source area through an infiltration trench three times over a five month period. Within 841 days from the last application, dissolved benzene concentrations had decreased an order of magnitude and the site met criteria for MNA. Wells in the source area progressed from stable benzene concentrations (no apparent trend) to attenuation rates between -0.0022 to -0.0064 per day (half lives between 315 and 108 days). This site demonstrates that if a plume is already undergoing natural sulfate reduction, the addition of concentrated sulfate solution to the source area will increase the attenuation rate. Ethylbenzene did not decrease in concentration in some wells that had substantial benzene declines. This is evidence of selective degradation by the microorganisms and that dilution was not a factor in the attenuation rates.

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## INTRODUCTION

Petroleum contamination was discovered at this site on the south side of Indianapolis, Indiana, one year before it closed in 1990. It had been a service station for 26 years. The response to the contamination was to take out the underground storage tanks and over-excavate the tank basin to remove contaminated soil.

Dissolved phase contamination persisted. Therefore, a pump and treat system with air strippers was installed in 1996. It was deactivated a year later because poor groundwater recharge caused the system to run inefficiently. The system had treated approximately 124,000 gallons of groundwater, or about one pore volume from the contaminated area.

It was thought that the contamination would attenuate naturally. But 15 years after discovery (as of 2004), the plume was stable but not shrinking, and hydrocarbon concentrations were more or less constant. Concentrations were too high for closure using monitored natural attenuation (MNA).

The limiting factor for site closure was the benzene concentration which hovered near 1000 ppb in the heart of the plume just downgradient of the former tank basin. Based on the location of highest dissolved phase hydrocarbon contamination, a backward "L" shaped smear zone source area appeared to extend roughly north-south and east west from the west side of the former tank basin.

The stable plume indicated that attenuation was occurring, but that a source was adding contamination at about the same rate as it was degrading. The remediation team decided to try to increase the rate of hydrocarbon degradation and thereby lower concentrations and shrink the plume. This could be done by adding oxygen releasing compounds (ORC) to the plume and source area. However, recent experience indicated that adding ORC would be costly and would probably require adding much more oxygen than simple calculations specified.

Additionally, there were geochemical indications that the plume was degrading anaerobically. For oxygen to work it would require changing the natural system that had developed, which would take time and probably require even more ORC treatment material.

Based on recent experience, and a solid body of published research (Anderson and Lovely, 2000; Chapelle, 2001; Cunningham, et al., 2001; Kolhatkar, et al., 2000; Wiedemeir, et al., 1999; and Wilson, et al., 2002) the team decided to try to enhance the natural processes already at work on the site. The chosen solution was to add concentrated Epsom salt solution (hydrated magnesium sulfate) to the source area and plume. This method utilized a nontoxic household chemical to provide a needed electron acceptor for preexisting sulfate-reducing-bacteria (SRB) to flourish and increase their rate of hydrocarbon degradation.

## GEOLOGY AND HYDROGEOLOGY

The location is in the Central Lowlands physiographic province. The geology beneath the site consists of unconsolidated glacial drift deposits. The primary water bearing formation is sand and clayey sand with an average hydraulic conductivity of about one foot per day. The excavation at the former UST basin was backfilled with gravel which has a much higher hydraulic conductivity than the sand. Only the base of the gravel intersects the water table. The sandy zone is overlain by silt and silty clay to the surface. The contact between sand and silty clay plunges toward the north-northwest and intersects the water table in the northwest quarter of the site. Figure 1 is a base map of the site. Figures 2 and 3 are geologic cross sections from west to east and north to south respectively.

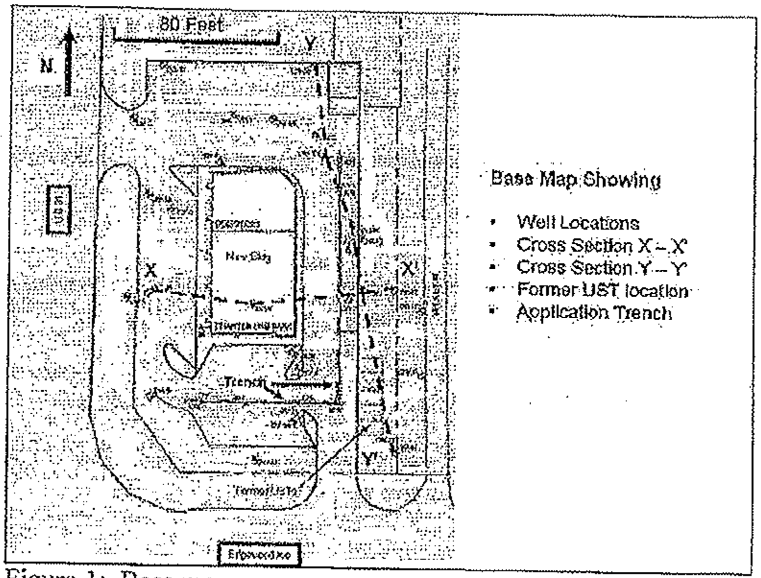


Figure 1: Base map.

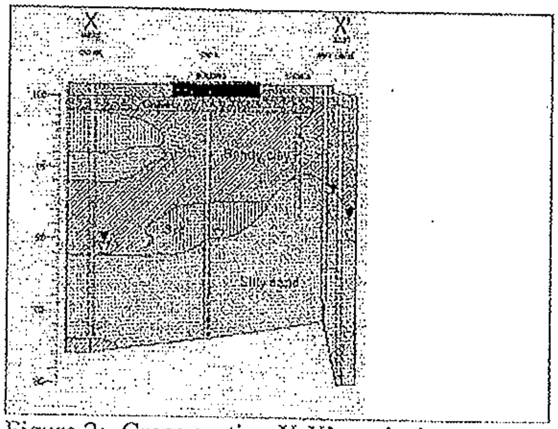


Figure 2: Cross section X-X' vertical exaggeration 7.5X

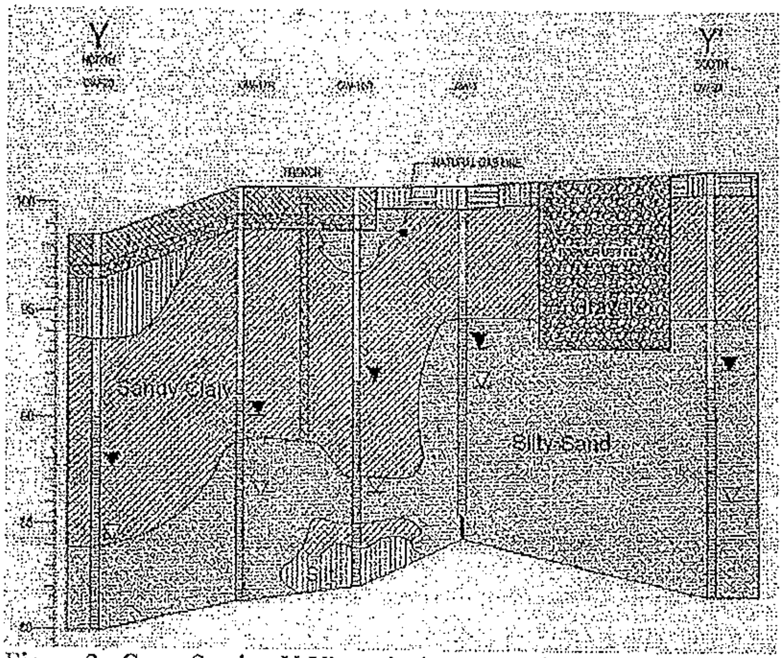


Figure 3: Cross Section Y-Y' vertical exaggeration 7.5X

Figure 4 is a water table map as of January, 2007. Gradient is predominantly toward the northwest at 0.035 ft/ft. Groundwater seepage velocity is approximately 37 feet per year.

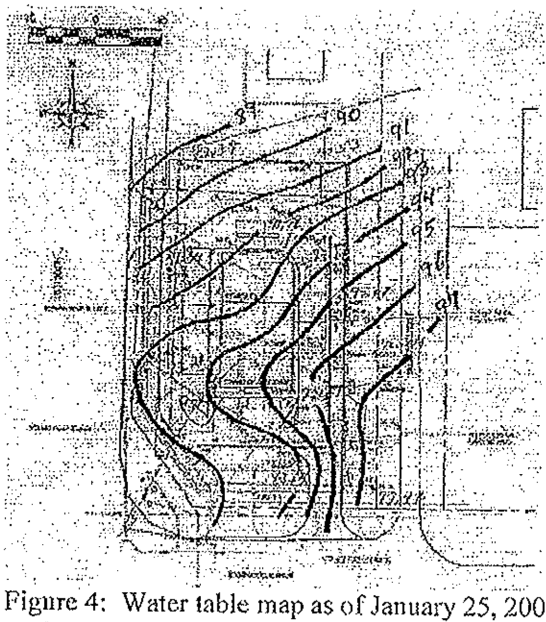
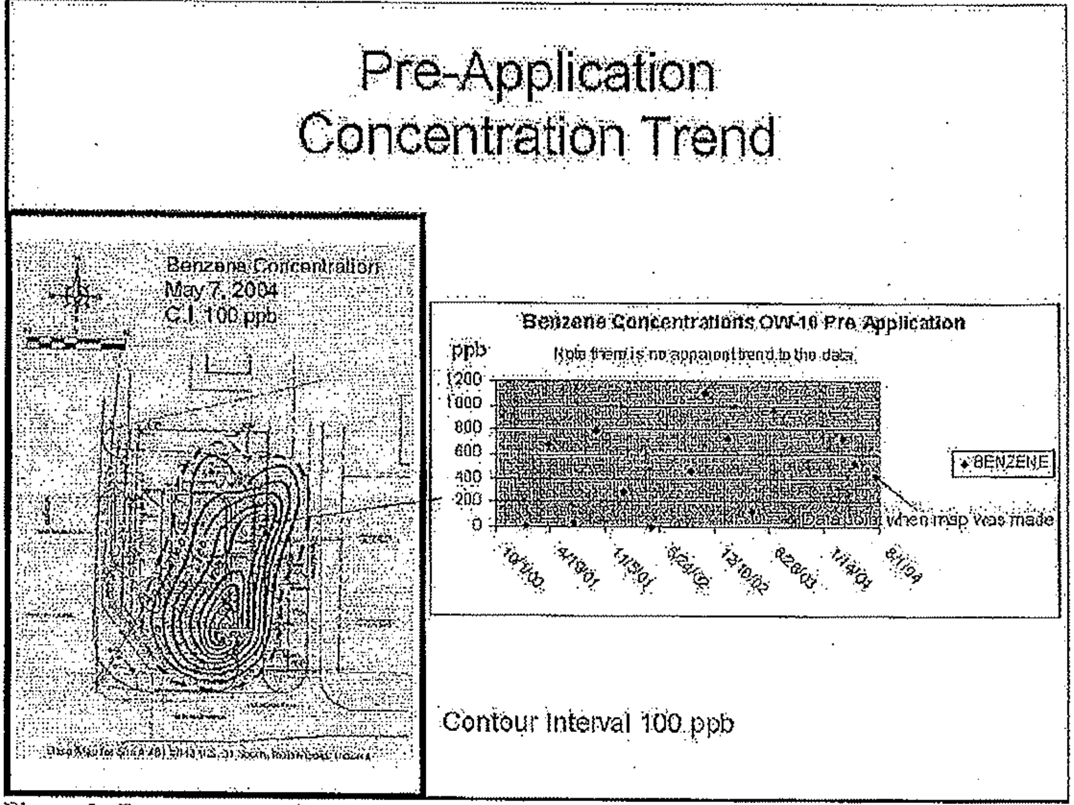


Figure 4: Water table map as of January 25, 2007. Cl 1 ft. Artificial datum with a surface point set at 100.

Figure 5 shows contours of the benzene concentrations in May, 2004 before any sulfate addition. The contaminant source zone was projected to lie beneath the area of highest dissolved benzene concentration. It coincides with the downgradient side of the former tank basin and where product lines ran from the USTs to dispensers (aka "the gas pumps").



Pre-Application
Concentration Trend

Contour Interval 100 ppb

Figure 5: Benzene concentration map at the Indianapolis site as of May, 2004, and a graph showing a benzene concentration over time on the upgradient side of the source zone. The source area is projected to be a backward "L" shaped smear zone located on the west side of the former tank basin.

## EVIDENCE OF ANAEROBIC DEGRADATION

Lateral changes in the concentration of some inorganic ions in groundwater across a hydrocarbon plume may provide indicators that microbial degradation is occurring and whether it is aerobic or anaerobic (Chapelle, 2001).

For example, if oxygen is abundant in background-groundwater and it is essentially depleted in the dissolved phase plume area, then we can assume that aerobic degradation has occurred. Similarly, if sulfate is present in the background and depleted in the plume area, we can assume that sulfate reduction has occurred, which is anaerobic. Both systems may be active, but in different zones or areas of the plume. In most cases where groundwater is contaminated with petroleum hydrocarbons, oxygen is consumed on the upgradient side of the contaminant source area. The plume then undergoes anaerobic degradation in a hierarchy of successive zones depending on the availability of electron acceptors. Table 1 shows this hierarchy.

| **TEAP Zone Processes and Parameters** | | | | |
|---|---|---|---|---|
| Electron Acceptor | Reaction | Metabolic Byproduct | Utilization Factor for BTEX | Thermodynamic Reaction Preference |
| Oxygen | Aerobic | $CO_2$ | 3..14 | Most Preferred |
| Nitrate | Anaerobic | $N_2$, $CO_2$ | 4.9 | ↓ |
| Fe III (solid) | Anaerobic | Fe II* | 21.8* | ↓ |
| Sulfate | Anaerobic | $H_2S$ | 4.7 | ↓ |
| $CO_2$ | Anaerobic | Methane* | .78* | Least Preferred |

Table 1: Hierarchy of terminal electron acceptor process (TEAP) zones and their associated processes and parameters. Utilization factors indicate how many grams of an electron acceptor are required to degrade one gram of BTEX (those with an asterisk use the metabolite rather than the electron acceptor). They are from Wiedemeier, et al., 1999.

The typical distribution of these TEAP zones in a petroleum contaminated aquifer is shown in Figure 6. The relative size or area of a given process is usually dependent on the availability of a given terminal electron acceptor. Oxygen is usually only available in near surface groundwater in concentrations up to 7 or 8 mg/l. Nitrate is seldom available in quantity, and iron III (ferric iron) is nearly insoluble in water and is taken up by iron reducing bacteria from bio-available iron in soil minerals. In the iron reduction process, iron III is reduced to soluble iron II (ferrous iron) which is the primary cause for increased dissolved iron in the contaminated zone. This iron stays in solution until it either mineralizes with available sulfide from the sulfate reducing zone, or precipitates when redox conditions change in the aquifer downgradient of the plume.

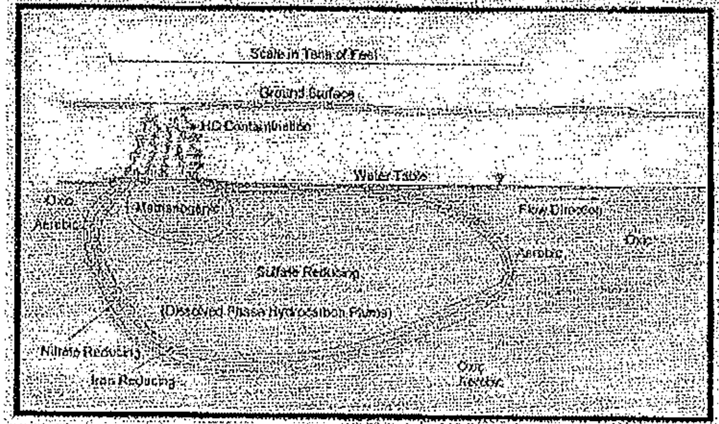


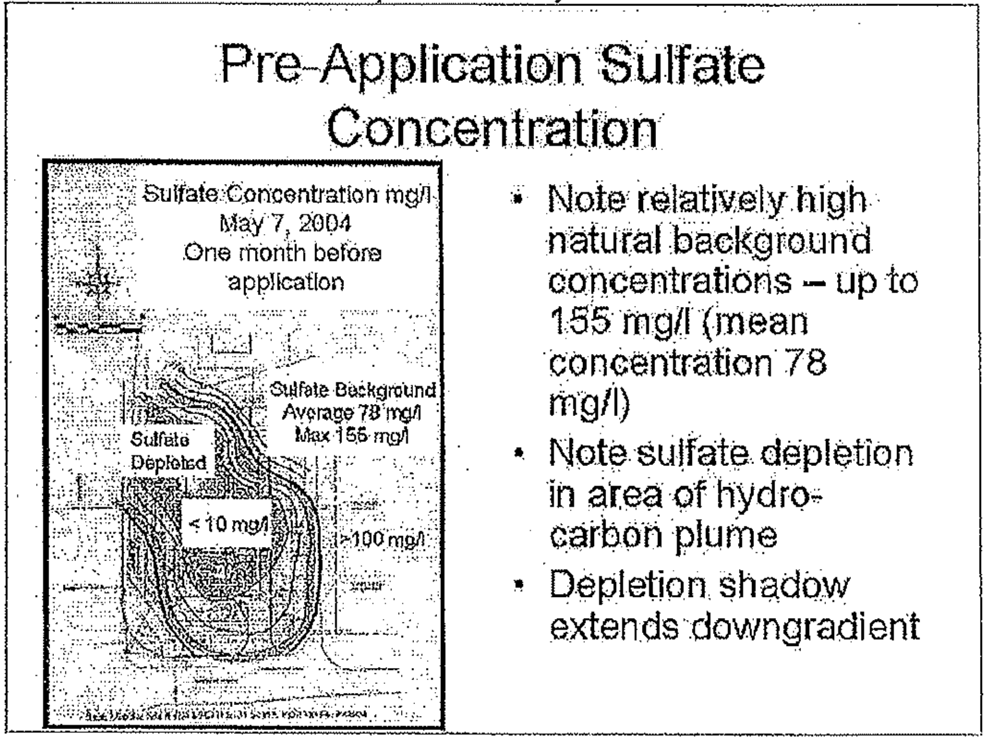
Figure 6: Typical profile of TEAP zones at a petroleum contaminated aquifer with a contaminant source area.

Sulfate is a very common and abundant natural groundwater ion. Sulfate concentrations average 25 to 100 mg/l in many areas of the United States, and it is not uncommon to have concentrations in the several hundred mg/l range. Because of this natural abundance, sulfate reduction is a major process in natural attenuation of hydrocarbon contamination.

At the Indianapolis site, in addition to BTEX compounds, nitrate and sulfate were analyzed in groundwater from background and plume observation wells. There was little or no nitrate in the background or the plume, and therefore no contrast to compare.

Background sulfate concentrations, however, were as high as 155 mg/l and averaged 78 mg/l. Sulfate depleted rapidly to less than 10 mg/l as groundwater migrated through the contaminant source area. There is also a shadow of low sulfate concentration immediately downgradient of the plume. Figure 7 shows the distribution of sulfate in groundwater in the area of interest before any treatments were applied.

The inverse relationship between the presence of BTEX contamination and the depletion of natural sulfate in the plume area is direct evidence that hydrocarbon degradation through sulfate reduction is occurring at the site. Figure 8 is a graph of sulfate versus benzene concentration across the plume before any sulfate treatment.



## Pre-Application Sulfate Concentration

- Note relatively high natural background concentrations – up to 155 mg/l (mean concentration 78 mg/l)
- Note sulfate depletion in area of hydrocarbon plume
- Depletion shadow extends downgradient

Figure 7: Sulfate distribution at the Indianapolis site prior to any treatment to enhance degradation.

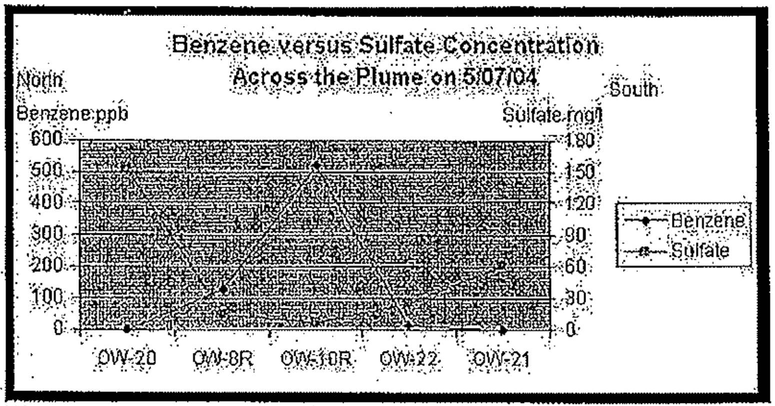


Figure 8: Benzene versus sulfate concentration across the plume prior to any sulfate addition.

## TREATMENT STRATEGY

The remediation team decided to enhance the preexisting sulfate reduction process by providing sulfate as an electron acceptor to the part of the plume where it was most needed – the smear zone source area. Sulfate requirements were estimated based on the stoichiometric mass of sulfate required to biodegrade the mass in the source zone.

We determined the most effective means to address the source area at this site was with an "L" shaped trench through the most contaminated region. The trench was about 160 feet north-south by 80 feet east-west (Figure 1) with eight sump-access-points evenly spaced along the length. Depth to groundwater was about eight feet, so the trench was installed to a depth of 10 feet and backfilled with coarse gravel.

### Concentration, Mass, and Volume

Note that because the plume is stable, we have already demonstrated that the amount of dissolved phase contamination being contributed by the source is being degraded by and in balance with the available natural electron acceptors. Because the contaminant concentrations in the plume were still too high, we needed to reduce the source. To estimate the mass of sulfate required, we estimated the mass of contaminants in the source area to be addressed.

There is considerable uncertainty involved in estimating the mass of dissolvable contaminants in the source zone. Nevertheless, in order to estimate treatment volumes an estimate of the source must be made. Fortunately, there was no free phase contamination to deal with.

Gallagher (1995) proposed that the source area be divided into three zones: 1) the vadose zone, 2) the smear zone which is the residual in the area of groundwater fluctuation and 3) the dissolved phase in the phreatic zone. We considered the vadose zone to be already in balance. The phreatic zone source was addressed by over excavation when the USTs were removed. Therefore we focused on the smear zone.

In most cases, detailed soil analyses are not available to calculate contaminant mass accurately. Gallagher suggested that the contaminant mass in the smear zone can be estimated using a map of dissolved phase concentration, the average contaminant concentration in the soil of the smear zone, and the smear zone thickness. He used the following equations:

$M = p * V$

Where: $p$ = soil density in $kg/ft^3$ (approximately 65 $kg/ft^3$)
And $V$ = calculated volume as given below

$V = (Tx * Cx * Ax)$

Where:
Tx = thickness of smear zone in feet
Cx = Average contaminant concentration in smear zone soil (mg/kg)
Ax = Area of smear zone (using the area within a designated contaminant contour)*

*Ax may be estimated by contouring the dissolved phase contamination and measuring the area inside a selected contour. Gallagher suggested using the 3000 ppb total BTEX contour.

The following table shows the estimate for the Indianapolis site.

| | | | |
|---|---|---|---|
| Tx | 10 | ft | Input |
| Cx | 200 | mg/kg | Input |
| Ax | 4,000 | $ft^2$ | Input |
| V | 8,000,000 | mg/kg-ft3 | calculated |
| p | 65 | $kg/ft^3$ | given |
| Mass | 520,000,000 | mg | calculated |

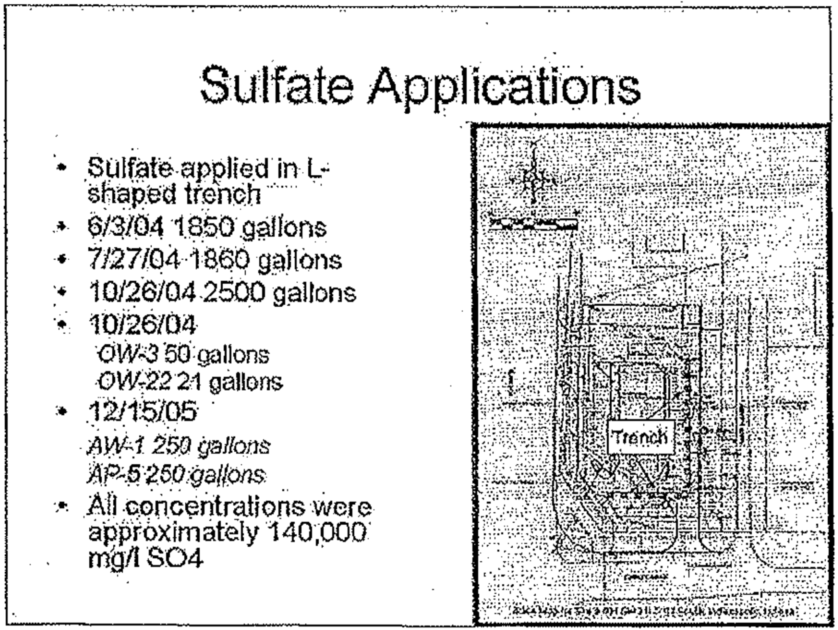
Table 2: Estimated mass of BTEX contamination in the source zone

The calculated mass of the source was about 520 kilograms, or almost 1150 pounds (equivalent to about 175 gallons of gasoline). Based on a utilization factor of 4.7 grams of sulfate to one gram of benzene, it was estimated that 2,444 kilograms (5,388 pounds) of sulfate would be needed. Based on experience, demand is usually somewhat higher because of the presence of other organic chemicals or contaminants. Therefore a safety factor is frequently applied which ranges approximately between 2 and 4 times the estimated amount. At this site we used 1.75 to minimize initial sulfate mass.

In addition to being a household chemical, Epsom salts solution is also sprayed on fields as an agricultural soil amendment. The standard agricultural concentration is 3 pounds per gallon which yields a sulfate solution of approximately 140,000 mg/l. Because this is readily available, we decided to base the volume of solution to be applied using this concentration.

## TREATMENTS

Sulfate solution was applied to the trench through the application sumps according to the schedule shown in Figure 9. There were three major applications on June 3, July 27 and October 26, 2004 and one minor application December 15, 2005. Total volume applied from all treatments was 6,781 gallons (30,800 liters), which provided 4,312 kilograms (9,500 pounds) of sulfate which was a safety factor of 1.75 over the calculated volume.



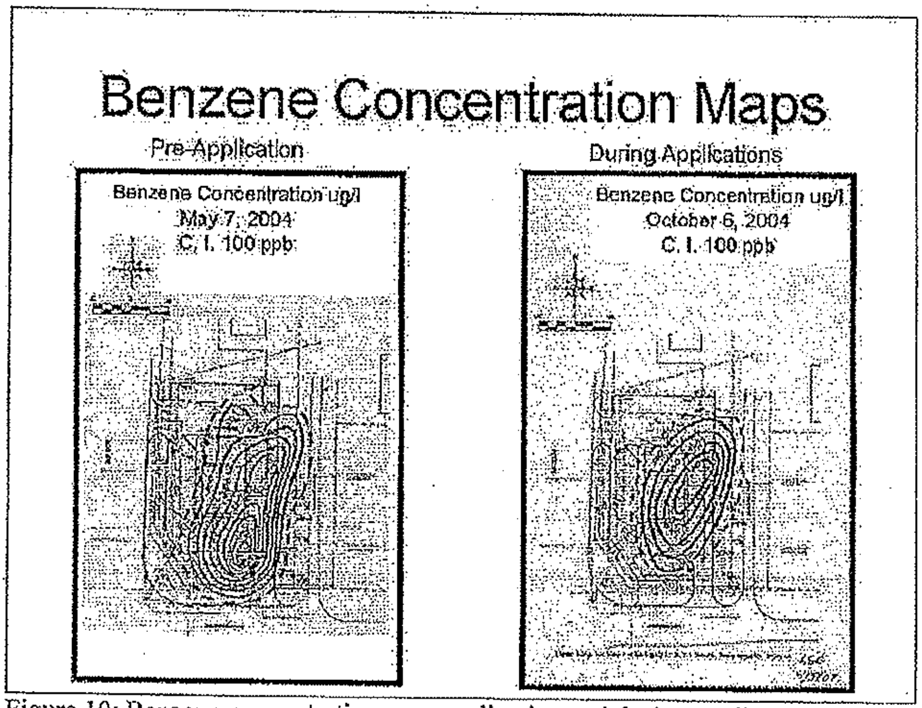
Sulfate Applications

- Sulfate applied in L-shaped trench
- 6/3/04 1850 gallons
- 7/27/04 1860 gallons
- 10/26/04 2500 gallons
- 10/26/04
  - *OW-3 50 gallons*
  - *OW-22 21 gallons*
- 12/15/05
  - *AW-1 250 gallons*
  - *AP-5 250 gallons*
- All concentrations were approximately 140,000 mg/l SO4

Figure 9: Schedule of sulfate applications

## RESULTS

Within 841 days from the last application, dissolved benzene concentrations had decreased an order of magnitude and the site met criteria for MNA. Wells downgradient of the application trench progressed from stable benzene concentrations (no apparent downward trend) to attenuation rates between -0.0022 to -0.0064 per day (half lives between 315 and 108 days). The plume visibly shrank (Figures 10 and 11). A contaminated control well upgradient of the trench showed no decreasing trend in benzene concentration.

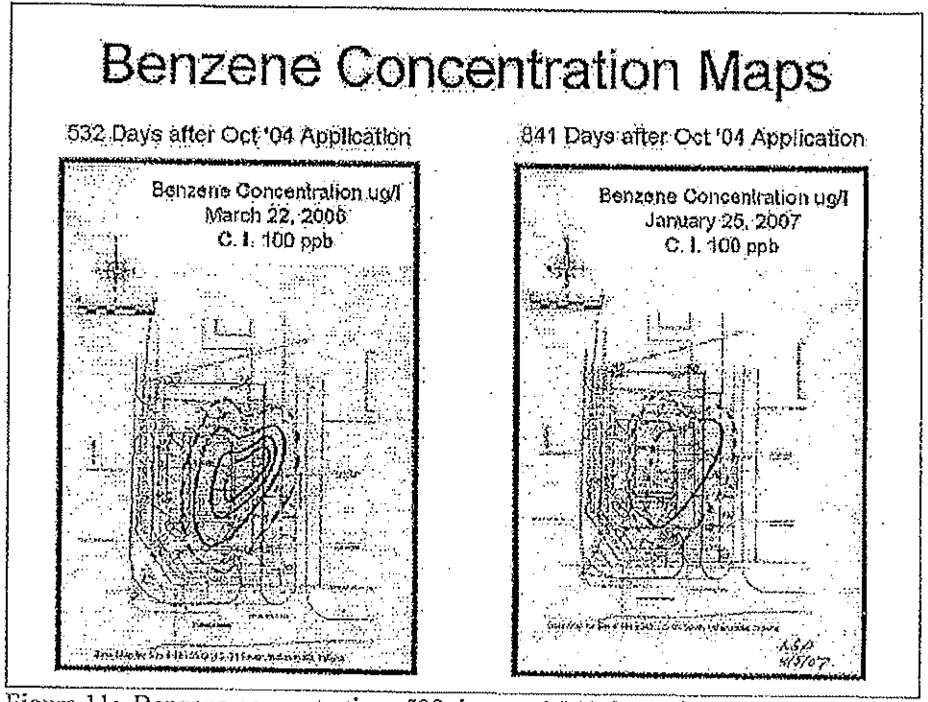


## Benzene Concentration Maps

Pre-Application

During Applications

Figure 10: Benzene concentrations pre-application and during applications.



## Benzene Concentration Maps

532 Days after Oct '04 Application

841 Days after Oct '04 Application

Figure 11: Benzene concentrations 532 days and 841 days after October 4 application.

Water Table Elevation Maps

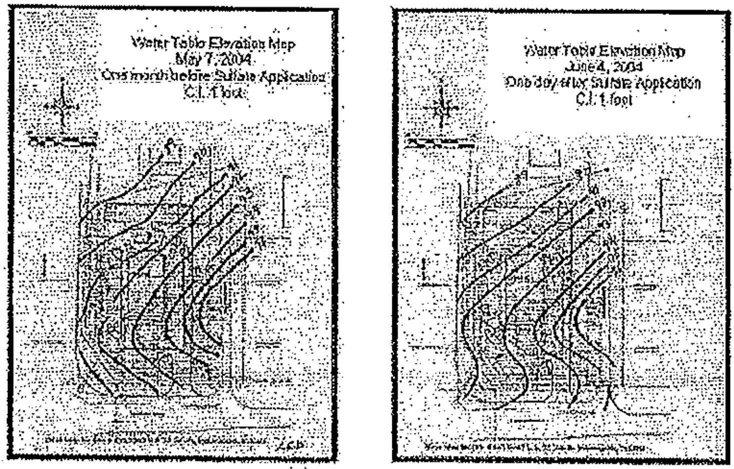


Figure 12: Water table maps before, and one day after the first application

Decreased concentrations were not due to dilution. The applied volumes were insignificant (maximum 2500 gallons in an application) compared to the plume pore volume of approximately 124,000 gallons. Figure 12 shows groundwater contour maps from before, and one day after the initial treatment. There is no appreciable change.

Based on groundwater flow calculations, the applied volume of sulfate resulted in a dilution of less than 4 to 8% per month and less than 2% per year during the application period. This was within the analytical variability.

Additionally, benzene and toluene concentrations declined at a substantially greater rate than xylenes or ethylbenzene. In fact ethylbenzene hardly declined at all, indicating a preferred sequence of degradation. If dilution were significant the concentrations would have decreased proportionately.

Figures 13 and 14 are example BTEX graphs. Well OW-10R is seven feet from the trench and within the sulfate treatment zone. Benzene and toluene degraded before ethylbenzene and xylenes.

Well OW-22 is 28 feet upgradient of the trench and was used as a control well. This well did have one 21 gallon sulfate treatment, but overall it was not in the treatment zone, and did not show decreases in concentrations of benzene, ethylbenzene or xylenes.

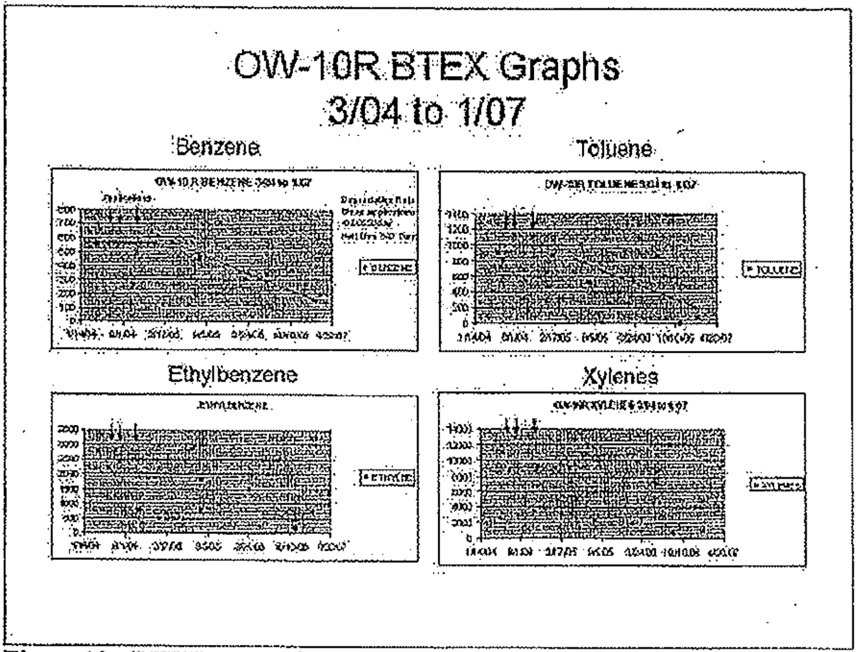


Figure 13: BTEX graphs from well OW-10R from March 2004 to January 2007. The well is seven feet from the application trench. Arrows indicate dates of sulfate application to the trench. Concentrations are in ppb. Note decreases in benzene and toluene.

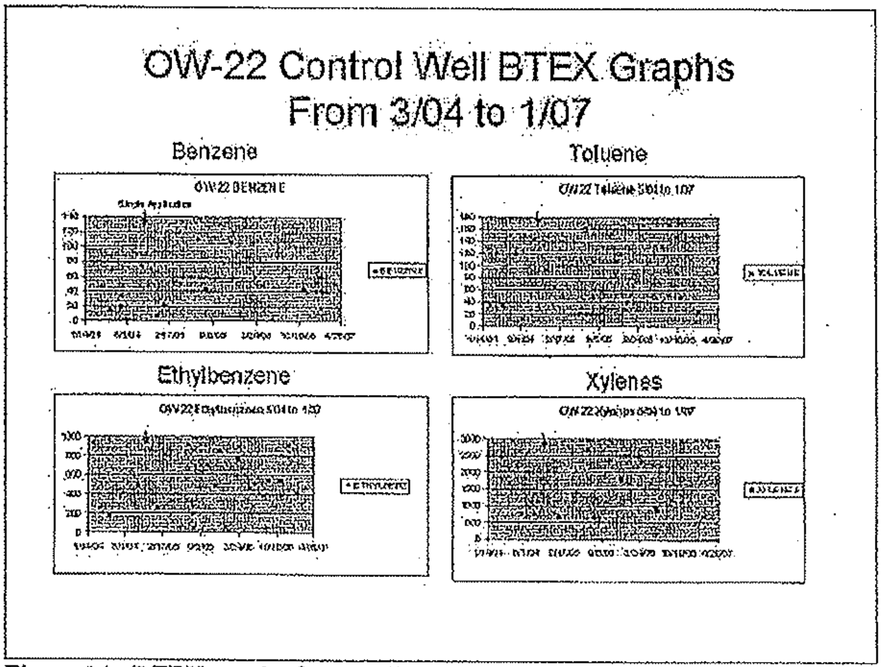
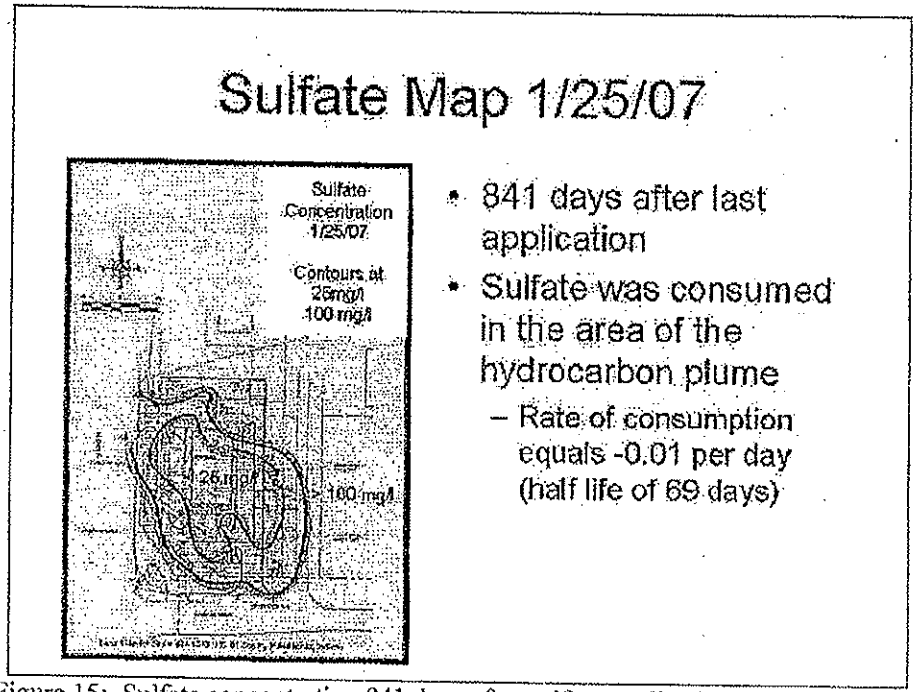


Figure 14: BTEX graphs from well OW-22. This well is a control well 28 feet upgradient of the trench. It had one 21 gallon treatment (arrow) on 10/26/04.

Regulators asked if a significant volume of dissolved oxygen, inadvertently added with the treatment fluid, would have affected degradation. The answer is no. Assuming the treatment water carried dissolved oxygen at a concentration of approximately 8 mg/l, and there were no sinks other than BTEX, with the utilization factor for oxygen equal to 3.14 grams of oxygen per gram of BTEX, the amount of introduced oxygen would have degraded less than 80 grams of BTEX versus an estimated 520,000 grams degraded by sulfate addition.

Another concern was the concentration of sulfate at the compliance point which should meet the secondary MCL of 250 mg/l sulfate. Figure 15 is a contour map of sulfate concentration 841 days after the last application. It appears that nearly the entire amount of added sulfate was consumed. The calculated rate of sulfate consumption was -0.01 per day yielding a half life for sulfate in the plume of approximately 69 days.



Sulfate Map 1/25/07

- 841 days after last application
- Sulfate was consumed in the area of the hydrocarbon plume
  - Rate of consumption equals -0.01 per day (half life of 69 days)

Figure 15: Sulfate concentration 841 days after sulfate applications – there was still reduced sulfate concentration in the plume area with no appreciable increase downgradient.

CONCLUSION

The addition of sulfate enhanced the natural anaerobic process, increasing the rate of sulfate reduction and hydrocarbon degradation. Within 841 days of the last sulfate treatment, the plume had shrunk and benzene concentrations were within regulatory levels to apply for MNA closure.

This site demonstrates that if a plume has already entered the sulfate reduction phase, the addition of sulfate to the source area will stimulate the existing processes and increase the hydrocarbon biodegradation rate.

Sampling results also suggest that, through proper planning, the sulfate concentrations in the aquifer can be controlled during the application process in order to prevent sulfate concentrations above the secondary drinking water standard from leaving the site location if receptors downgradient are a concern. Finally, sulfate enhanced biodegradation appears to be a viable alternative remediation approach for developed properties that are sensitive to disruptions associated with more invasive remedial actions such as excavation or large pump and treat systems.

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Ground Water Monitoring&Remediation

# Seasonal Recharge and Replenishment of Sulfate Associated with Biodegradation of a Hydrocarbon Plume

by *Dale R. Van Stempvoort, James Armstrong, and Bernhard Mayer*

## Abstract

The downward flux of sulfate in a weathered clayey aquitard to a hydrocarbon plume in ground water was investigated at a gas well site in Alberta, Canada. The dissolved hydrocarbon plume includes monoaromatic BTEX compounds and extends less than 20 m downgradient from a natural gas condensate source in silt- and clay-rich deposits. The vadose zone at the site has high concentrations of water soluble sulfate, which is apparently derived from pyrite oxidation. Seasonal infiltration of snowmelt water, most notably during the "wet" spring of 2003 and also in 2004, was focused in an excavation and recharged the water table. This recharge replenished the contaminated zone with sulfate that was flushed downward from the vadose zone. Recharge in 2003 resulted in episodic increases in sulfate concentrations in the ground water condensate plume of up to 1000 mg/L. After episodic increases in sulfate concentrations within the core of the contaminant plume associated with recharge, concentrations then decreased to less than 1 mg/L, accompanied by isotopic enrichment of the residual sulfate in $^{34}$S. The monitoring data provide strong field evidence that bacterial sulfate reduction is a dominant terminal electron-accepting process in the natural attenuation of the hydrocarbon plume in the ground water. This result suggests that engineered infiltration and replenishment of sulfate to petroleum hydrocarbon plumes in ground water might enhance biodegradation of these plumes.

## Introduction

The microbial degradation of dissolved petroleum hydrocarbons in ground water is often dominated by anaerobic processes. The realization of the importance of anaerobic biodegradation processes (Lovley 1997; Wiedemeier et al. 1999) has displaced an earlier view that petroleum hydrocarbons are recalcitrant in the absence of oxygen. Under anaerobic conditions in ground water, methanogenesis and/or the reduction of sulfate, nitrate, iron, or manganese may be important terminal electron-accepting processes (TEAPs) linked to the degradation of hydrocarbons such as the monoaromatic "BTEX" compounds (benzene, toluene, ethylbenzene, and xylenes). In ground water, sulfate is typically more abundant than more energy-favored electron acceptors such as oxygen or nitrate. As a result, bacterial (dissimilatory) sulfate reduction is often a dominant TEAP in the natural attenuation (intrinsic bioremediation) of hydrocarbons in ground water (e.g., Chapelle et al. 1996; Schmitt et al. 1996; Davis et al. 1999; Gieg et al. 1999; Wiedemeier et al. 1999). Recent pilot-scale field tests have demonstrated that the biodegradation of hydrocarbons in ground water can be enhanced by adding sulfate (Reinhard et al. 1997; Anderson and Lovley 2000; Cunningham et al. 2001; Sublette et al. 2006).

Little is known about the potential for natural downward migration of sulfate and other dissolved electron acceptors from the vadose zone to the saturated zone during seasonal infiltration. Recently, Scholl et al. (2006) reported the downward transport of sulfate to a shallow alluvial aquifer in Oklahoma during seasonal recharge, which appeared to cause enhanced bacterial sulfate reduction in a landfill leachate plume. At sites contaminated by petroleum hydrocarbons, such a vertical transport process could potentially increase the rate of biodegradation of hydrocarbons in the core zones of the contaminant plumes by providing an ongoing replenishment of the required electron acceptors. This process might be particularly effective at sites where soluble sulfate concentrations are high in the vadose zone due to weathering of sulfur-containing minerals. Such is the case in the Western Canada Sedimentary Basin of the Canadian Prairies (Van Stempvoort et al. 1994), where sulfate concentrations in shallow ground water are often higher than 1000 mg/L (Hendry et al. 1986; Fennell and Bentley 1998), largely due to oxidative weathering of pyrite in tills in the vadose zone (Van Stempvoort et al. 1994). This is an important area of oil and gas production, where numerous unintended releases of hydrocarbons to ground water have occurred. This study has following two objectives:

- To investigate hydraulic and chemical evidence for seasonal recharge and replenishment of sulfate from the vadose zone to the water table at a hydrocarbon-contaminated oil and gas site in the Prairie region of western Canada.
- To investigate evidence for the role of bacterial sulfate reduction as an electron acceptor in a hydrocarbon plume in ground water at the study site.

## Study Site

The study site (Figure 1; Van Stempvoort et al. 2002, 2007) is a small area of farmland in southern Alberta, Canada, that is leased for natural gas production. There has been a gas well on the site since 1972. On request by the well owner, the site location is not included in this article.

The landscape at the site is hummocky glaciated terrain. Test holes indicate that the surficial glacial/periglacial deposits are dominated by silt and clay (Van Stempvoort et al. 2007; Figure 2) to a depth of 17 m (base of testing). Cretaceous and Tertiary bedrock in this area, which consists of sandstone, siltstone, shale, and minor coal, is generally encountered within 30 m below ground surface.

Between the early 1970s and the mid-1990s, natural gas condensate was occasionally discharged to an unlined, earthen pit at the study site (Figure 1). In 1997, this pit was replaced by a tank, and approximately 250 m$^3$ of contaminated soil was excavated from beneath the pit area. Monitoring wells installed in 1999 delineated a plume of hydrocarbons in the ground water near the water table south of the pit excavation. This plume is derived from natural gas condensate that had been discharged to the pit. Condensate in the form of light nonaqueous phase liquid (LNAPL) has been detected at the water table in two monitoring wells, well 2 and well 13, near the south margin of the excavated pit (Figure 1). Based on borehole and monitoring well data, the overall spatial extent of LNAPL in the subsurface is estimated to be approximately 100 to 200 m$^2$. An analysis of the LNAPL indicated that the hydrocarbons are predominately in the range $C_6$ to $C_{10}$ (85% as mole fraction), with the remainder almost exclusively in the ranges $C_3$ to $C_5$ (7%) and $C_{11}$ to $C_{16}$ (7%). Given the overall fine texture and low permeability of this glacial sediment aquitard, the localized accumulation of LNAPL cannot be efficiently recovered by pumping (cf. Sale 2003); intermittent bailing of product has had limited success. Therefore, the potential for bioremediation of the plume is of particular relevance. The temperature of ground water at the study site is between 5°C and 6°C, with little seasonal variation (Van Stempvoort et al. 2007). The unsaturated zone of the site has high water soluble sulfate concentrations (Figure 2).

## Methods of Investigation

Prior to this study, a consultant firm had installed 14 wells at the site for ground water monitoring (Figure 1; Table 1). Two new wells were installed in 2002 (Figure 1; Table 1) for this study, one of which was used for an experimental injection of sulfate as reported by Van Stempvoort et al. (2007). Water levels and apparent thickness of LNAPL (two wells) were measured in the monitoring wells using a manual water level meter and interface probe. Compact transducer-datalogger systems (LeveLoggers, Solinst Canada Ltd., Ontario, Canada) were placed in two monitoring wells (well 3 and well 15) to record water levels at 1-h intervals over a 9-month period in 2004, and barometric pressure was also recorded (BaroLogger, Solinst).

Dedicated Teflon$^{TM}$ bailers or Waterra inertial pumps were used to sample ground water from all wells, typically within 0.5 to 1 m below the water table. Purging was excluded because of low permeability of the sediment. Ground water samples were collected in polyethylene bottles (inorganics), amber glass, or stoppered glass vials (hydrocarbons). These were then stored in coolers on ice and transported to laboratories as soon as possible (typically on the same or the next day) for analyses. Samples for dissolved iron and manganese analyses were field filtered (0.45 µm) and preserved with nitric acid. Samples for hydrocarbon analyses were preserved in the field by adding either sulfuric acid or $NaHSO_4$. The majority of the analyses (major ions, alkalinity, iron, manganese, benzene, toluene, ethylbenzene, xylenes, total $C_3$ to $C_{10}$ hydrocarbons, total extractable $C_{11}$ to $C_{60}$ hydrocarbons) were conducted by Maxxam Analytics (Calgary, Alberta, Canada) using standard methods. A suite of samples collected in June 2004 was analyzed for both inorganic species and hydrocarbons at the National Water Research Institute in Burlington, Ontario, Canada.

Field measurements of dissolved oxygen, pH, and conductivity of the ground water were conducted using portable probes. In June 2002, samples of ground water were collected using airtight samplers and analyzed for methane using the methods described by Van Stempvoort et al. (2005).

On three occasions (June and September 2002 and March 2004), samples for analyses of the sulfur isotope ratios of dissolved sulfate were collected in bottles that contained cadmium acetate solution to precipitate and stabilize dissolved sulfide. The June 2002 samples were collected by dedicated bailers, whereas subsequent samples were collected with dedicated Waterra pumps and filtered in-line during collection, prior to precipitation of sulfide as cadmium sulfide (CdS). In the laboratory, after refiltering to remove CdS, the samples were passed through cation exchange columns to remove dissolved iron, and sulfate in the remaining solution was precipitated as $BaSO_4$ with $BaCl_2$. Sulfur isotope ratios of the $BaSO_4$ were determined on $SO_2$ generated by thermal decomposition in an elemental analyzer, coupled to an isotope ratio mass spectrometer. Results are reported in the usual delta (δ) notation in parts per thousand (‰).

Analyses of short-chain fatty acids in ground water were conducted by ion chromatography to obtain additional evidence for biodegradation of hydrocarbons.

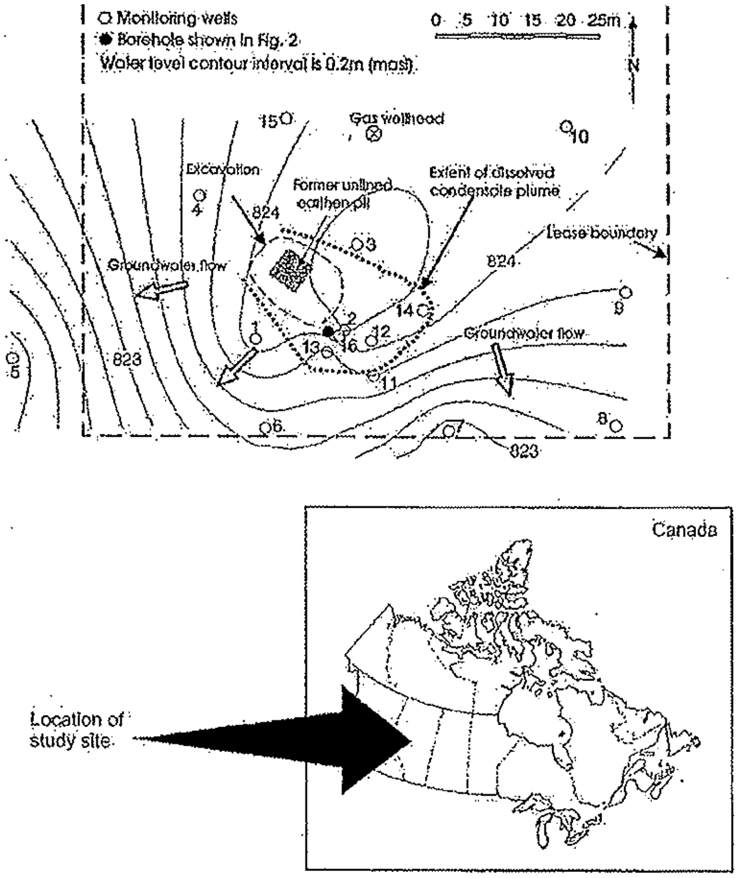

**Figure 1.** Plan of the study site showing locations of the gas wellhead, the fluid disposal pit, the current excavated pit, and the extent of dissolved condensate in ground water. Also shown are monitor wells 1 to 16 and the inferred piezometric surface of the ground water near the water table (June 5, 2002). Monitoring well 16 is referred to as D-IW by Van Stempvoort et al. (2007).

Sediment samples were obtained from the weathered vadose zone above the plume (Figure 1) using a hollow-stem auger rig equipped with a split spoon sampler. Water soluble sulfate was extracted from three samples that had been collected in separate boreholes at depths of 4.6 m below ground surface. The sulfate was extracted using the following procedures. Fifty grams of soil was added to 125 mL of Milli-Q water and shaken for 2 h. The following

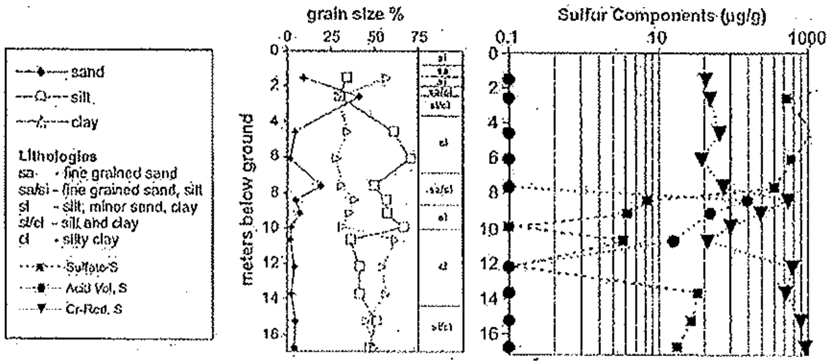

**Figure 2.** Profile of grain size distribution, lithologies, and sulfur components concentrations (per dry weight) in samples of the aquitard sediments at the study site (borehole location indicated in Figure 1), as described by Van Stempvoort et al. (in preparation). Nondetectable concentrations are plotted as 0.1 µg/g. Highest sulfate concentrations are in the unsaturated zone, which extends downward to approximately 9 m below ground surface.

**Table 1**
**Selected Monitor Well Construction Specifications**

| Monitoring Well No. | Year Constructed | Ground Elevation (m above sea level) | Stick-Up PVC Pipe (m) | Depth Interval of Well Screen (below ground) (m) | Depth Interval of Sand Pack (below ground) (m) |
|---|---|---|---|---|---|
| 1 | 1999 | 833.668 | 0.25 | 3.1–12.0 | 2.40–12.19 |
| 2 | 1999 | 833.899 | 0.29 | 1.5–13.8 | 1.20–15.51 |
| 3 | 1999 | 833.769 | 0.351 | 3.1–12.0 | 2.60–12.19 |
| 3 | 1999 | 833.769 | 0.351 | 3.1–12.0 | 2.60–12.19 |
| 4 | 1999 | 833.916 | 0.564 | 3.1–12.0 | 2.70–12.23 |
| 5 | 1999 | 833.791 | 0.559 | 6.1–12.0 | 5.60–12.24 |
| 6 | 1999 | 833.67 | 0.18 | 6.1–15.0 | 4.30–13.27 |
| 7 | 1999 | 833.902 | 0.248 | 4.5–13.6 | 4.30–13.73 |
| 8 | 1999 | 833.738 | 0.172 | 6.1–15.0 | 5.50–14.29 |
| 9 | 1999 | 833.613 | 0.257 | 6.1–15.0 | 4.30–12.93 |
| 10 | 1999 | 833.762 | 0.25 | 7.6–13.6 | 7.00–13.45 |
| 11 | 1999 | 833.816 | 0.17 | 6.1–18.1 | 5.20–15.58 |
| 12 | 1999 | 833.749 | 0.3 | 6.1–18.1 | 15.20–15.11 |
| 13 | 1999 | 833.819 | 0.81 | 6.1–18.1 | 5.20–13.77 |
| 14 | 1999 | 833.635 | 0.215 | 9.2–15.0 | 8.30–11.76 |
| 15 | 2002 | 833.67 | 0.5 | 8.5–11.6 | 8.50–11.6 |
| 16[1] | 2002 | 833.853 | 0.3 | 10.1–11.0 | 8.40–11.04 |

Note. PVC = polyvinyl chloride.
[1] Referred to as D-IW1 by Van Stempvoort et al. (2007).

day, the decant water was filtered (0.45 m), heated, and acidified to pH 4 to remove dissolved $CO_2$. The dissolved sulfate was then precipitated as $BaSO_4$ by adding $BaCl_2$, and analyzed for $\delta^{34}S_{sulfate}$, as described previously. The concentration of water soluble sulfate was determined by ion chromatography.

## Results and Discussion

### Evidence for Rapid Infiltration and Recharge of Spring Snowmelt/Runoff

A large amount (estimated 200 $m^3$) of spring runoff/snowmelt water accumulated temporarily in the excavation in the spring 2003, nearly filling the excavation (personal communication with site manager). Monitoring indicated sharp rises in water levels (by 0.79 to 1.31 m) in monitoring wells in the vicinity of the excavation between September 2002 and October 2003 (wells 1, 2, 3, and 12), whereas other wells upgradient (well 4) and downgradient (well 7) had only small rises (0.08 and 0.23 m, respectively) in water levels (Figure 3). This indicates that infiltration of the meltwater that had pooled in the excavation was associated with an excavation- or depression-focused recharge event.

Taken collectively, the hydrologic information for 2000 to 2003 indicates that in wet springs such as 2003, this excavation can receive a large quantity of runoff from adjacent upland areas due to melting of snow and precipitation events, coupled with the presence of a relatively impermeable frost layer in the soil (Hayashi et al. 2003) and that this seasonal ponding results in depression-focused recharge.

Given the sparse observations on seasonal recharge in 2003, more detailed information was obtained in 2004. Pooled snowmelt water was observed in the excavation in March and June 2004 (Figure 4). The volume of meltwater observed in the excavation in 2004 is estimated to have been approximately 50 $m^3$. A recharge event associated with this pooling and infiltration of snowmelt and spring runoff was monitored using water level data by Solinst LeveLoggers (Figure 5), in addition to periodic manual measurements. There was a seasonal 20 cm increase in the water level at well 3 in April through June 2004, apparently in response to spring snowmelt and infiltration. Note the lack of a similar response in the water level at well 15, which is farther away from the excavation (Figure 1). Figure 3 indicates that the seasonal increase in the water level at well 3 associated with recharge in 2004 (~0.2 m) was not nearly as pronounced as in 2003 (~1 m, or more given that water levels were not measured during the summer 2003), apparently related to differences in amounts of spring precipitation (data not shown) and/or snowmelt. Nevertheless, the more detailed data collected in 2004 by LeveLoggers do constrain the rate of infiltration through the clayey aquitard below the excavation to the water table, associated with the observed recharge. The seasonal recharge of the ground water in 2004 was largest in April and May (Figure 5), estimated to have occurred approximately 60 ± 30 d after spring snowmelt/runoff and the associated infiltration period. These water level data indicate an estimated vertical flow rate of water from the excavation through the unsaturated zone to the water table of 6 ± 2 m (vertical distance from bottom of excavation to water table) in 60 ± 30 d, or approximately 0.04 to 0.3 m/d. This finding is consistent with reports of other researchers, who

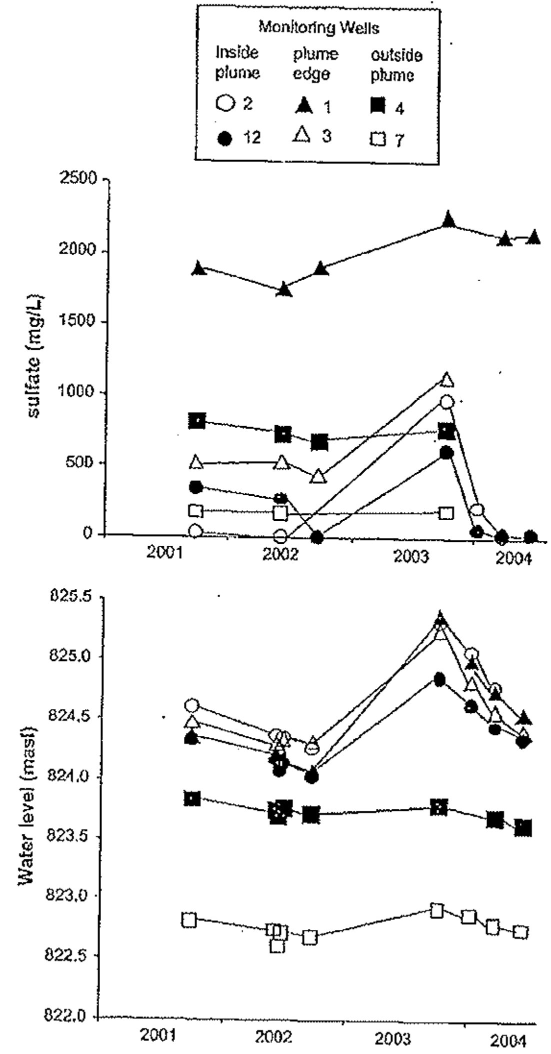

**Figure 3. Top: Manually measured changes in water levels. Bottom: Changes in sulfate concentrations in same wells over time.**

found rapid downward flow through fracture "macropores" in clayey sediments (Hinsby et al. 1996; Helmke et al. 2005). Moreover, the 2003 to 2004 water level data indicate that water table mounding decayed slowly, likely due to low permeability of the clay- and silt-rich sediments (consistent with unpublished slug test data).

### Evidence for Episodic Replenishment of Sulfate

Associated with the large water table rise near the excavated pit between September 2002 and October 2003, the sulfate concentration in ground water sampled from wells inside the contaminant plume near the excavation increased by 600 to 1000 mg/L (wells 2 and 12: Figure 3). In other wells in the vicinity of the excavation, there were also large increases in sulfate concentrations (wells 3 and 14) or smaller but significant increases of sulfate (wells 1, 11, and 13: Figure 3). Farther away from the excavation, changes in sulfate concentrations were small or negligible (wells 4 and 7: Figure 3). Overall, the 2002 to 2003 trends indicate that the large seasonal recharge "event" in 2003 produced large increases in the sulfate concentrations in the mounded ground water sampled near the excavation.

Given the evidence for concurrent water table rise and increasing sulfate concentrations in ground water near the water table, the sulfate is inferred to have been flushed down to the saturated zone from the weathered vadose

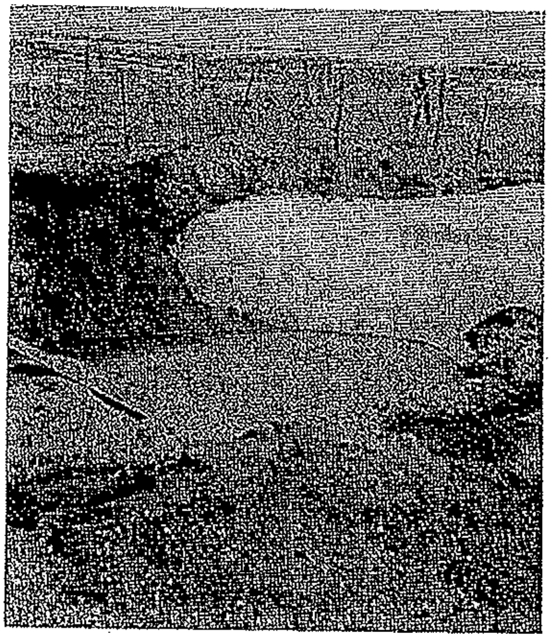

**Figure 4. Photograph taken on March 22, 2004, showing snowmelt water pooled in the excavation at the site. Monitoring well 3 is in the upper left between the excavation and the fence.**

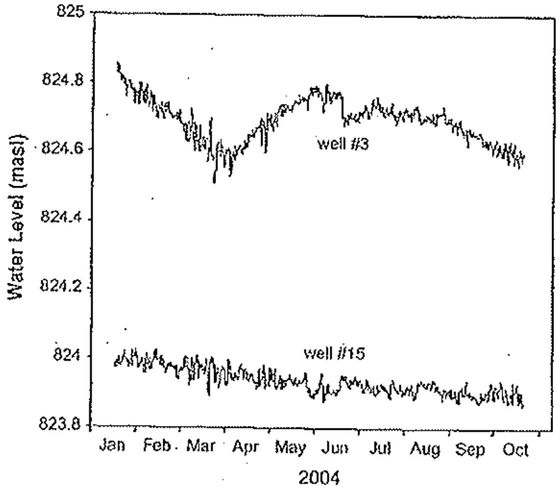

**Figure 5. Water levels monitored in wells by LeveLoggers in 2004.**

zone, where it is abundant (Figure 2: 350 to 3800 μg water soluble sulfate per gram dry sediment). It appears that the infiltrating water mobilized the sulfate as it moved downward through the vadose zone.

In contrast to the older wells (wells 1 to 14), which have long screens that cross the water table, one of the new wells that were installed near the excavation, well 16 (Figure 1), has a relatively short screen (Table 1), which was installed approximately 1 to 2 m below the water table. The sulfate concentration in well 16 increased slightly from February to October 2003 (45.9 to 59.6 mg/L). This indicates that seasonal increases in sulfate concentrations in 2003 occurred mainly near the water table and not at depths 1 to 2 m below the water table.

### Evidence for Bioattenuation of Hydrocarbons in Ground Water

Water samples from five of the monitoring wells at the site (wells 2, 12, 13, 14, and 16) have had elevated concentrations of hydrocarbons, mainly dissolved monoaromatic species (BTEX) (Figure 6; Table 2). The hydrocarbon-impacted wells are located within 5 to 10 m and downgradient of the excavation (Figure 1). Over 5 years of monitoring (1999 to 2004), the total BTEX concentrations have fluctuated up and down in the two wells nearest the core of the hydrocarbon plume (wells 2 and 16). The concentrations have been relatively constant in well 12 and increased significantly over the past few years in wells 13 and 14 (Figure 6). We suspect that the fluctuations in total BTEX concentrations may be largely related to seasonal recharge events, particularly in 2003, which may have caused some episodic dilution of ground water near the water table by mixing with the infiltrated seepage water from the vadose zone. Localized movement of LNAPL phase may also have occurred in response to water table fluctuations (e.g., Steffy et al. 1998) and may have affected the dissolved phase hydrocarbon concentrations.

Based on the monitoring data for 1999 to 2004, there are several lines of evidence that the plume of dissolved monoaromatic hydrocarbons (BTEX) is undergoing natural attenuation, which are as follows:

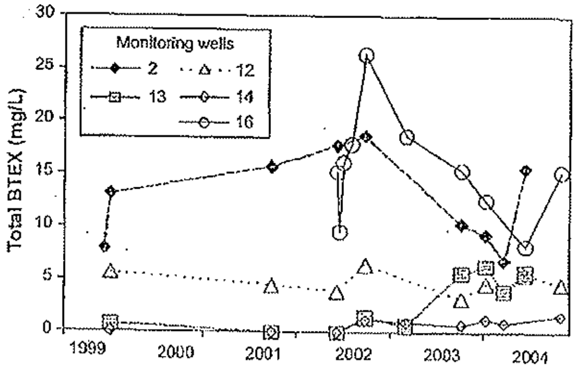

**Figure 6.** Trends in total BTEX concentrations in the hydrocarbon plume from 1999 through 2004.

1. The hydrocarbon plume is associated with a chloride plume that is apparently derived from produced water/brine that was also disposed of in the unlined pit. Along an approximated 4 m ground water flow line from monitoring well 2 in the core of the hydrocarbon plume (with LNAPL present) to well 12 (Figure 1), concentrations of chloride in ground water were nearly identical in both wells, whereas total concentrations of $C_3$ to $C_{10}$ hydrocarbons were nearly an order of magnitude lower in well 12. At other wells near the fringe of the hydrocarbon plume (wells 1, 3, 11, and 14), chloride was elevated above background concentrations, whereas hydrocarbons were generally nondetectable (Table 2). These observations indicate that the lateral transport of BTEX has been retarded relative to chloride.
2. The relative dissolved concentrations of benzene, toluene, and xylenes were similar in samples taken from the core of the plume in wells 2 and 16 and from well 13, where LNAPL is also present as a separate phase (Figure 7). In contrast, benzene was the dominant monoaromatic compound downgradient at wells 12 and 14 (Figure 7), while the concentrations of toluene, ethylbenzene, and xylenes were much lower or nondetectable. Simple one-dimensional (1D) modeling (Appendix) indicated that the inferred differences in attenuation of these dissolved aromatic hydrocarbons during transport from the core to the fringe of the plume (e.g., from vicinity of well 2 toward well 12) cannot be explained by sorption. Similar to other studies (e.g., Davis et al. 1999; Cunningham et al. 2001), this pattern indicates preferential biodegradation of the alkylbenzenes and benzene recalcitrance.
3. In ground water samples collected in June 2004, short-chain fatty acids (formate, acetate, propionate, butyrate) were found within the dissolved hydrocarbon plume in wells 2, 12, and 16 but not in samples collected from wells 1, 11, and 13 near the edge of the plume (Table 3). These appear to be key indirect indicators of hydrocarbon biodegradation, which possibly involves degradation by fermentative bacteria (Meckenstock 1999).
4. Elevated alkalinity concentrations are another indirect but key indicator that biodegradation of hydrocarbons is occurring in the ground water at the site. Alkalinity concentrations in ground water inside the hydrocarbon-contaminant plume (810 to 4797 mg/L as bicarbonate in wells 2, 12, and 16) were higher than those near the edge of the hydrocarbon plume (346 to 616 mg/L in wells 1, 3, 11, 13, and 14), which in turn were higher than concentrations at wells more than 5 m from the margin of the plume (199 to 310 mg/L). The elevated levels of alkalinity in the contaminant plume are inferred to be mainly due to the generation of dissolved inorganic carbon (DIC) (mainly bicarbonate) as a by-product of reactions associated with the biodegradation of hydrocarbons. However, organic acids (cf. point 3) may also contribute to the elevated alkalinity in the plume (Rounds and Wilde 2001).
5. Near the edge of the hydrocarbon plume, at monitoring wells 1, 3, and 11 (Figure 1), elevated levels of both chloride and alkalinity have consistently appeared from

**Table 2**

**Selected Chemical Analyses of Samples in Milligrams per Liter Based on Samples Collected on June 5 to 7, 2002, Except for Field Analyses of Dissolved $O_2$ (June 14, 2002)**

| Well No. | 1 | 2 | 3 | 4 | 6 | 7 | 11 | 12 | 13 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.42 | 6.59 | 7.18 | 7.4 | 7.82 | 7.45 | 7.49 | 7.07 | 7.28 | 7.43 | 6.17 |
| Ca | 783 | 2200 | 288 | 364 | 245 | 58 | 696 | 644 | 653 | 530 | 2350 |
| Mg | 212 | 578 | 74.7 | 90.7 | 56.2 | 7.6 | 149 | 121 | 142 | 135 | 781 |
| K | 26 | 18.8 | 9.1 | 9.2 | 9.5 | 6.6 | 14 | 13.8 | 19.8 | 13.8 | 35.9 |
| Na | 370 | 637 | 52.2 | 49.8 | 47.3 | 44.3 | 68.1 | 157 | 184 | 155 | 644 |
| Cl | 861 | 2060 | 101 | 39.3 | 13.4 | 5 | 114 | 430 | 83.3 | 80 | 2170 |
| $SO_4^{2-}$ | 1760 | 2.7 | 535 | 732 | 440 | 159 | 1110 | 267 | 1170 | 1060 | 95.1 |
| $NO_2^- + NO_3^-$ | <0.003 | 0.009 | 0.016 | 5.99 | 11.2 | 0.031 | 17.6 | 0.029 | 0.925 | 2.79 | 0.007 |
| Alkalinity as $HCO_3^-$ | 1240 | 7100 | 702 | 617 | 521 | 542 | 697 | 1770 | 1290 | 1190 | 6580 |
| $O_2$ | 6.5 | NA | 0.8 | 4.2 | 4.0 | 2.5 | 0.3 | 0.6 | 0.5 | 1.0 | 0.4 |
| Fe | 2.09 | 445 | 0.9 | 0.22 | 0.15 | 0.17 | 0.04 | 15.5 | 0.09 | 0.03 | 351 |
| Mn | 0.039 | 30.2 | 2.71 | 0.021 | 0.012 | 0.528 | 0.047 | 4.55 | 3.46 | 0.205 | 16.6 |
| Methane | NA | NA | 0.004 | <0.002 | 0.002 | <0.002 | <0.002 | 3.0 | 0.02 | <0.002 | NA |
| Benzene | <0.0004 | 6.71 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | 3.93 | <0.0004 | <0.0004 | 6.53 |
| Toluene | <0.0004 | 5.71 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.04 | <0.0004 | <0.0004 | 0.54 |
| Ethylbenzene | <0.0004 | 0.76 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.04 | <0.0004 | <0.0004 | 4.86 |
| Xylenes | <0.0012 | 4.55 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.13 | <0.0012 | <0.0012 | 3.24 |
| $C_3$–$C_{10}$ hydrocarbons | <0.1 | 20.4 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 4 | 0.8 | <0.1 | 15.6 |
| $C_{11}$–$C_{60}$ hydrocarbons | <2 | 8.8 | <0.5 | <0.5 | <0.7 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |

2001 to 2003, whereas BTEX have not been detected (Table 2). These data suggest that in the zone immediately peripheral to the dissolved hydrocarbon plume, dissolved BTEX were absent because they had been degraded to bicarbonate and/or organic acids (and possibly with other intermediate metabolites) along the ground water flowpath. Perhaps, the benzene recalcitrance observed between wells 2 and 12 (point 2 mentioned previously) was due to the presence of other preferred substrates (alkyl-benzenes) rather than an inability of resident microorganisms to degrade benzene (cf. Edwards and Grbic-Galic 1992).

6. As discussed by Van Stempvoort et al. (2002), the $\delta^{13}C$ values of DIC in the ground water at the site were generally more negative with increasing alkalinity concentrations due to conversion of $^{13}C$-depleted hydrocarbons to DIC. In contrast, highest alkalinity concentrations in or near the core of the condensate plume (wells 2, 12, and 16) were observed coincident with DIC enriched in $^{13}C$, suggesting that methanogenesis was important in the plume core (Van Stempvoort et al. 2002).
7. Analyses of sulfate, nitrite plus nitrate, oxygen, iron, manganese, and methane in ground water (Table 2) provided strong evidence that various TEAPs occur in the plume, likely linked to hydrocarbon degradation. Of particular relevance to this study, the hydrocarbon plume generally had lower concentrations of sulfate compared to the surrounding ground water (see subsequent section).

Though the focus of this article is on bacterial sulfate reduction related to biodegradation of a dissolved hydrocarbon plume in the saturated zone, it is likely that biodegradation processes are also important in the vadose zone, where LNAPL phase is present.

### Evidence for Bacterial Sulfate Reduction as a Key TEAP in the Plume

In addition to sulfate reduction by microorganisms, sorption, dilution, and uptake by plant roots could potentially result in lower dissolved sulfate concentrations in ground water. However, sorption, dilution, and root uptake are not likely the cause of the 2003 to 2004 decline in sulfate concentrations observed in the wells within the condensate plume (Figure 3) at the study site for the following reasons:

- Dissolved sulfate is an anion, and thus, under near-neutral pH soil/ground water conditions such as observed at the study site (Table 2), sulfate sorption is typically negligible (e.g., Guadalix and Pardo 1991).
- Dilution due to input of additional water would be expected to be associated with a water level rise rather than

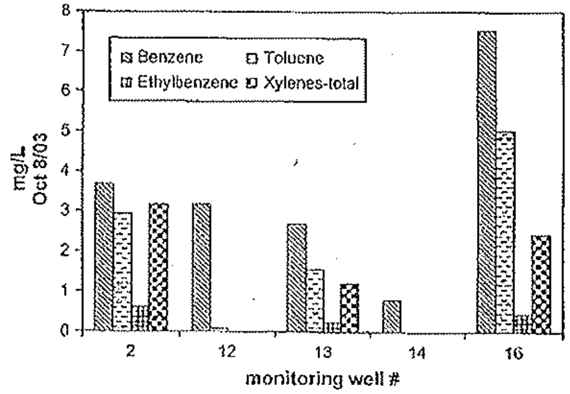

Figure 7. Concentrations of BTEX within the dissolved condensate plume in ground water. Note the dominance of benzene in wells 12 and 14 (see text for discussion).

### Table 3
### Analyses of Short-Chain Fatty Acids in Ground Water Sampled on June 15, 2004

| Well No. | Acetate (mg/L) | Propionate (mg/L) | Formate (mg/L) | Iso-butyrate (mg/L) | n-Butyrate (mg/L) |
|---|---|---|---|---|---|
| 1 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| 2 | 3917 | 39 | 7.68 | 44.74 | 2529 |
| 11 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| 12 | 891 | 18.1 | <0.005 | 9.27 | 57.2 |
| 13 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 16 | 10,951 | 54.8 | 15.8 | 55.5 | 1908 |

the concurrent declines in both water levels and sulfate concentrations that were observed (Figure 3).

- Plant root uptake of sulfate is unlikely to be an important process at 9 m below ground at the study site. Though alfalfa roots have been reported to depths of 6 to 7 m in Montana (U.S. Department of Agriculture 1983), typically plant roots extend 2 m or less below ground surface in agricultural soils (Ley et al. 1994).

Typically, sulfate concentrations were lowest in the dissolved hydrocarbon plume (wells 2, 12, and 16: Figure 8), whereas sulfate levels tended to be highest in other nearby wells (wells 1, 11, 13, and 14), south and west of the excavation (cf. Figures 1, 3, and 8). Of all TEAP indicators measured (Table 2: $SO_4^{2-}$, $NO_2^-$ + $NO_3^-$, $O_2$, Fe, Mn, and methane), sulfate concentrations had the largest spatial concentration gradients from plume edge to plume core (up to ~1500 mg/L) and the largest temporal changes within the plume (Figure 3). Based on relative concentrations of three alternative electron acceptors in the ground water, sulfate, nitrate, and oxygen (Table 2), the microbial utilization of sulfate reduction as a TEAP could remove more than 100 times more dissolved condensate from the ground water than utilization of either of the other two alternative and more energy-favorable electron acceptors (Table 4). This calculation suggests that bacterial (dissimilatory) sulfate reduction may be the dominant TEAP associated with the biodegradation of hydrocarbons in the ground water at this site.

### Table 4
### Relative Potential for Sulfate, Nitrate, and Oxygen as Electron Acceptors in Ground Water at the Site for the Biodegradation of Hydrocarbons

| Electron Acceptor | Average Concentration in Ground Water (cf. Table 2) | | Potential for Degradation of[1] Hydrocarbons (mmol/L as benzene) |
|---|---|---|---|
| | mg/L | mmol/L | |
| Sulfate | 666 | 6.9 | 1.9 |
| Nitrate[2] | 4 | 0.06 | 0.009 |
| Oxygen | 2 | 0.13 | 0.017 |

Note. This simplified calculation is based on average concentrations of electron acceptors in ground water in June 2002 (Table 2) and does not take into consideration replenishment of electron acceptors during seasonal recharge.

[1] Based on the following stoichiochemetry for consumption of electron acceptors in the biodegradation of 1 mmol of benzene: 3.75 mmol of sulfate, 6 mmol of nitrate, or 7.5 mmol of oxygen (Wiedemeier et al. 1999).

[2] Assuming nitrite plus nitrate (Table 2) = nitrate.

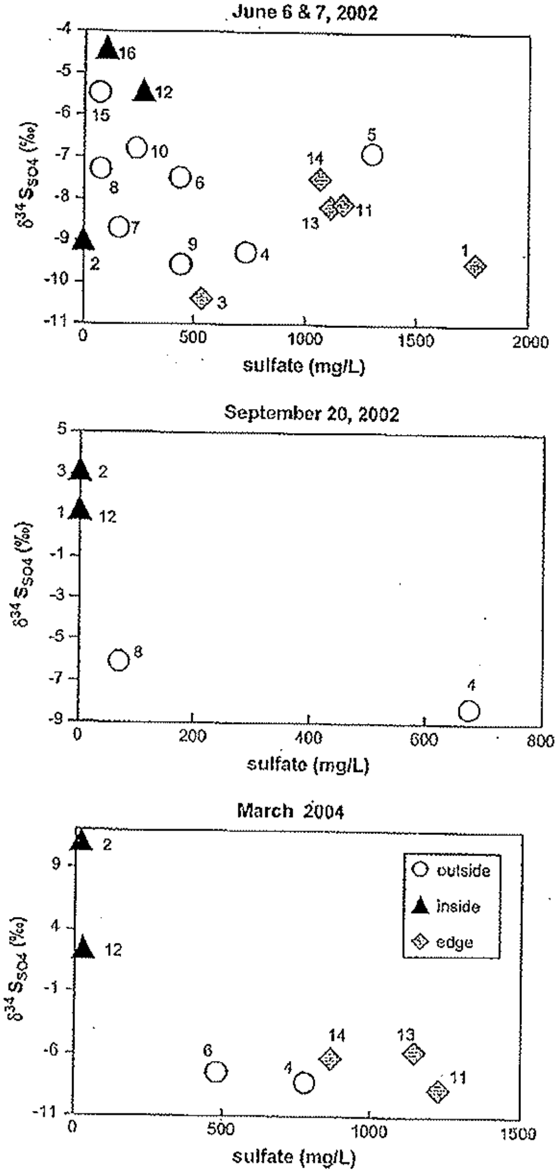

**Figure 8. Plots of sulfate concentrations vs. $\delta^{34}S_{sulfate}$ for wells located outside, inside, and along the edge, with respect to the hydrocarbon plume. The three graphs are for different dates. Well numbers are plotted next to the symbols.**

As indicated in Figures 3 and 8 (cf. Figure 1), the spatial and temporal trends of dissolved sulfate concentrations in the monitoring wells at the site are complex. These trends appear to be controlled by interactive hydrological and biogeochemical processes in the vicinity of the excavation:

- Enhanced infiltration and recharge in the vicinity of the excavation flushes sulfate down to the water table, resulting in a zone of high concentrations of sulfate that persists in some monitoring wells near the excavation year-round (e.g., well 1).

- In the zone of hydrocarbon contamination near the excavation (e.g., well 2), bacterial sulfate reduction results periodically in a decrease in sulfate concentrations to levels less than 10 mg/L (Figure 3).
- These low concentrations in the core of the plume periodically rebound due to episodic influx of sulfate with recharge water from the vadose zone (Figure 3).

Of special note is the precipitous decrease of sulfate concentrations noted in samples collected near the water table in monitoring well 2 from December 1999 (1570 mg/L) to September 2001 (30.3 mg/L) and June 2002 (2.7 mg/L). This trend shows that sulfate was rapidly depleted in the plume core. Assuming that the ground water in the vicinity of this well behaved according to closed system conditions during the monitoring period, which is considered to be a conservative assumption (i.e., there was no additional input of sulfate), the well 2 data indicate an overall bacterial sulfate reduction rate of approximately 1540 mg/L over 21 months (1999 to 2001), equivalent to 2.4 mg/L/d. It is likely that the rate of sulfate reduction at well 2 became diffusion limited once the sulfate was depleted to low levels (Figure 3) (Nielsen 1987).

A more recent trend at monitoring well 12, near the edge of the hydrocarbon plume, also provides an indication of the rate of bacterial sulfate reduction. Over a period of 106 d, from June 8 to September 20, 2002, the sulfate concentration at well 12 decreased from 267 to 0.3 mg/L. This was an average decline of 2.5 mg/L/d.

As a simplified, conservative approach, the decline in sulfate concentrations in ground water at monitoring wells 2, 12, 13, and 14 following the 2003 recharge event (from October 2003 to January 2004) was modeled as closed system behavior (i.e., no additional sulfate input). Based on this assumption, average in situ sulfate reduction rates of 2.7 to 8.1 mg/L/d were estimated (Table 5).

Van Stempvoort et al. (2007) reported a sulfate injection test in the summer 2002 at monitoring well 16 (which they denoted as D-IW). This test provided additional information on the occurrence and rate of microbial sulfate reduction within the hydrocarbon plume at the study site. Using a bromide tracer, Van Stempvoort et al. (2007) could account for mixing with adjacent ground water, and they calculated an overall zero-order sulfate reduction rate of 4 to 6 mg/L/d. However, they found isotopic evidence that the ground water behaved as an open system with respect to sulfate, suggesting that the actual rate of sulfate reduction was higher than their estimate, which should thus be viewed as conservative.

**Table 5**
**Inferred Average in situ Sulfate Reduction Rates at Monitoring Wells Impacted by Gas Condensate, Assuming Closed System Behavior**

| Well No. | 2 | 12 | 13 | 14 |
|---|---|---|---|---|
| A. Sulfate concentration, October 8, 2003 (mg/L) | 975 | 611 | 1540 | 1300 |
| B. Sulfate concentration, January 10, 2004 (mg/L) | 211 | 58.9 | 1030 | 1050 |
| C. Decrease over 94 d (A and B) (mg/L) | 764 | 552 | 510 | 250 |
| D. Inferred average sulfate reduction rate (C/94) (mg/L/d) | 8.1 | 5.9 | 5.4 | 2.7 |

The aforementioned conservative estimates for different locations and time periods and for different initial sulfate concentrations resulted in similar overall declines in sulfate concentrations of 5 ± 3 mg/L/d. This consistency allows us to have confidence in inferring a conservative overall zero-order sulfate reduction rate in the hydrocarbon plume at the study site of 5 ± 3 mg/L/d during periods when sulfate is not limiting. This inferred sulfate reduction rate falls in the middle of the overall range of the rates of microbially mediated sulfate reduction reported for ground water and for marine sediment porewaters (McGuire et al. 2002; Van Stempvoort et al. 2007).

## Stable Isotope Evidence for Sulfate Sources and Bacterial Sulfate Reduction

Three extracts of water soluble sulfate from sediment samples collected in the vadose zone above the condensate plume had the following $\delta^{34}S$ values: −10.8‰, −9.1‰, and −8.5‰. Van Stempvoort et al. (1994) reported that pyrite in a till in southern Alberta had $\delta^{34}S$ values ranging from −11.5‰ to −8.8‰. This indicates that water soluble sulfate sampled at the site is apparently derived from oxidation of pyrite present in the surficial glacial/periglacial deposits above the water table.

Sulfate in ground water outside the contaminant plume, and along the edge of the plume, had similar $\delta^{34}S$ values in 2002 to 2004, ranging from −9.6‰ to −5.5‰ (average −7.6‰) and −10.4‰ to −5.7‰ (average −8.0‰), respectively (Figure 8). The similarity of these ground water $\delta^{34}S_{sulfate}$ values to those of the water soluble sulfate in the vadose zone (aforementioned) suggests that the ground water sulfate is also largely derived from pyrite oxidation, presumably in the vadose zone, followed by mobilization to the saturated zone during seasonal recharge events.

In contrast, the sulfate within the plume of condensate-contaminated ground water, which typically had the lowest concentrations (Figure 8), was found to be enriched in $^{34}S$, with the majority of the $\delta^{34}S_{sulfate}$ values ranging from 1.2‰ to 11.1‰ (Figure 8). This $^{34}S$-enrichment of sulfate in the plume is clear evidence for dissimilatory sulfate reduction by microorganisms, a process that tends to enrich residual sulfate in $^{34}S$ (e.g., Chambers and Trudinger 1979). There was a notable shift in the $\delta^{34}S_{sulfate}$ values of sulfate in the plume from June 2002 (−9.0‰ to −4.4‰) to September 2002 (1.3‰ and 3.2‰) and March 2004 (2.4‰ to 11.1‰) (Figure 8).

The temporal fluctuations in $\delta^{34}S_{sulfate}$ values in the plume can be explained as the result of a combination of two processes:

1. Episodic recharge and replenishment of sulfate from the vadose zone, with $\delta^{34}S$ values of −9.7‰ ± 1.2‰. The high concentrations of sulfate in the vicinity of the excavation (above 1000 mg/L), including those from along the edge of the plume (Figures 3 and 8), are inferred to derive from the downward migration of recharge water with high sulfate concentrations from the weathered zone to the water table associated with excavation-focused infiltration and recharge.
2. Bacterial (dissimilatory) sulfate reduction by microorganisms, associated with biodegradation of the condensate plume, lowered the sulfate concentrations in the plume while enriching the residual sulfate in $^{34}S$, resulting in more positive $\delta^{34}S$ sulfate values.

Based on the aforementioned stable isotope evidence, it appears that the process of bacterial sulfate reduction occurs in the hydrocarbon plume at the study site in a ground water system that is periodically open with respect to sulfate. This finding is supported by the interpretation of results from a sulfate injection test at the site as reported by Van Stempvoort et al. (2007).

## Implications

The excavation at the site has apparently played an unintended role in enhancing sulfate replenishment and subsequently bacterial sulfate reduction in the core of the contaminant plume. The excavation traps snowmelt water and runoff, which infiltrates through the unsaturated zone, where it obtains sulfate derived from pyrite oxidation and then recharges the water table, forming a ground water mound beneath the excavation. Perhaps, it would be feasible to exploit this relatively permeable vertical pathway of water flow to enhance bioremediation of ground water at this and similar sites. For example, irrigation (with ground water if feasible) or use of an infiltration gallery could perhaps be used to flush sulfate downward to the hydrocarbon plume at the water table and subsequently enhance bacterial sulfate reduction.

In this study, there was clearly sufficient available water soluble sulfate (350 to 3800 μg/g dry sediment) in the vadose zone (5 to 6 m thick beneath the excavation) for infiltration to provide a significant replenishment of this electron acceptor to the saturated zone. By extension, these results suggest that hydrocarbon biodegradation could be enhanced in zones with depleted electron acceptors, simply by using appropriate backfill material in an infiltration gallery.

The evidence that bacterial sulfate reduction is an important TEAP in the hydrocarbon plume does not imply that sulfate-reducing bacteria (SRB) are directly attacking the hydrocarbons. Though a number of researchers have observed degradation of petroleum hydrocarbons by SRB (Spormann and Widdel 2000; Van Hamme et al. 2003), other SRB that are present in hydrocarbon plumes appear to be members of complex syntrophic consortia, with fermentative bacteria, for example (Meckenstock 1999; Franzmann et al. 2002), in which the SRB may consume $H_2$ or intermediate metabolites, including short-chain fatty acids (Franzmann et al. 2002; Kleikemper et al. 2002).

## Conclusions

Mounding of ground water beneath the excavation at the study site indicates depression-focused infiltration and recharge.

Evidence for natural attenuation, including intrinsic bioremediation, of the hydrocarbon plume includes (1) attenuation of hydrocarbons relative to chloride; (2) recalcitrance of benzene relative to alkyl-benzenes; (3) elevated alkalinity in the hydrocarbon plume; (4) presence of short-chain fatty acids in the plume; and (5) dissolved inorganic TEAP indicators, including sulfate, iron, manganese, oxygen, nitrate/nitrite, and methane.

Sulfate appears to be a dominant TEAP in the plume based on spatial and temporal sulfate concentration trends. $\delta^{34}S$ values indicate that sulfate is derived from pyrite oxidation and that the sulfate is subject to dissimilatory sulfate reduction by bacteria in ground water contaminated by condensate hydrocarbons.

Conservative estimates for the rates of bacterial sulfate reduction in the hydrocarbon plume were obtained for periods immediately following recharge, which had resulted in maximum concentrations of sulfate, exceeding 500 mg/L. The inferred rates, 2 to 8 mg/L, are mid-range for bacterial sulfate reduction in ground water reported elsewhere and are similar to the rate based on a sulfate injection test at the same site, as reported in a previous article (Van Stempvoort et al. 2007).

Together with the evidence for excavation-focused recharge of sulfate-rich water, the observed spatial patterns of sulfate in the ground water indicate that (1) replenishment of sulfate from the vadose zone and (2) bacterial sulfate reduction are key complementary processes within the core of the contaminated plume at this site. Hence, engineering techniques to replenish sulfate in petroleum hydrocarbon plumes in ground water may be viable approaches to enhance in situ bioremediation.

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## Appendix

### Modeling Indicates Limited Role of Sorption in Natural Attenuation of BTEX

The role that sorption may be playing in the attenuation of the various BTEX contaminants along the flowpath from monitoring wells 2/16 toward wells 12/13 (Figure 1) was assessed using a 1D contaminant transport model (Groundwater Contaminant 1D Model 1.01: Daniel Gallagher, Virginia Tech., 1998). For this modeling, assumptions were hydrophobic sorption to the organic carbon (OC) fraction of the sediment, based on measured OC content from the saturated zone of an uncontaminated profile (0.004 as dry weight fraction at well 15), $K_{oc}$ values ranging from 55 L/kg OC for benzene to 407 L/kg OC for m-xylene, a ground water flow rate of 1 m/year, a 5 m flowpath, a steady-state nonaqueous phase liquid source of dissolved BTEX at wells 2/16, no biodegradation, and negligible dispersion. The modeling indicated that sorption of hydrocarbons to sediment along the 5 m flowpath would have very little effect on the dissolved concentrations of benzene. Benzene concentrations at monitoring wells 12 and 13 would be reduced by approximately 5% by sorption after 2 years, an effect that would not be detectable, given analytical uncertainty. Even for the most hydrophobic compound, m-xylene, sorption would reduce the concentrations observed at monitoring wells 12 and 13 by only approximately 20% after 2 years and by only approximately 8% after 10 years.

## Biographical Sketches

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# APPENDIX C

Historical Groundwater Monitoring and Sampling Analytical Results

# Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-1 | | | (Screen Interval in feet: 14.0-34.0) | | | | | | | | | | | |
| 7/13/98 | 478.27 | 23.28 | 0.00 | 454.99 | -- | ND | -- | ND | ND | ND | ND | ND | -- | |
| 10/7/98 | 478.27 | 26.43 | 0.00 | 451.84 | -3.15 | ND | -- | ND | ND | ND | ND | ND | -- | |
| 1/15/99 | 478.27 | 30.42 | 0.00 | 447.85 | -3.99 | ND | -- | ND | ND | ND | 1.1 | 7.3 | -- | |
| 4/14/99 | 478.27 | 24.21 | 0.00 | 454.06 | 6.21 | ND | -- | ND | ND | ND | ND | 160 | -- | |
| 7/19/99 | 478.27 | 27.10 | 0.00 | 451.17 | -2.89 | ND | -- | ND | ND | ND | ND | 92 | -- | |
| 10/12/99 | 478.27 | 29.40 | 0.00 | 448.87 | -2.30 | ND | -- | ND | ND | ND | ND | 37 | -- | |
| 1/24/00 | 478.27 | 27.90 | 0.00 | 450.37 | 1.50 | ND | -- | ND | ND | ND | ND | 28 | -- | |
| 4/10/00 | 478.27 | 26.16 | 0.00 | 452.11 | 1.74 | ND | -- | ND | 0.930 | ND | ND | ND | -- | |
| 7/17/00 | 478.27 | 28.04 | 0.00 | 450.23 | -1.88 | ND | -- | ND | ND | ND | ND | 160 | -- | |
| 10/2/00 | 478.27 | 28.41 | 0.00 | 449.86 | -0.37 | ND | -- | ND | ND | ND | ND | 120 | -- | |
| 1/8/01 | 478.27 | 28.68 | 0.00 | 449.59 | -0.27 | ND | -- | ND | ND | ND | ND | 103 | -- | |
| 4/3/01 | 478.27 | 25.74 | 0.00 | 452.53 | 2.94 | ND | -- | ND | ND | ND | ND | 55.1 | -- | |
| 7/2/01 | 478.27 | 30.67 | 0.00 | 447.60 | -4.93 | ND | -- | ND | ND | ND | ND | ND | -- | |
| 10/8/01 | 478.27 | 33.13 | 0.00 | 445.14 | -2.46 | ND<50 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<5.0 | -- | |
| 1/3/02 | 478.27 | 27.67 | 0.00 | 450.60 | 5.46 | 160 | -- | ND<0.50 | 0.51 | ND<0.50 | 0.69 | 31 | -- | |
| 4/5/02 | 478.27 | 29.40 | 0.00 | 448.87 | -1.73 | ND<50 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 60 | -- | |
| 7/2/02 | 478.27 | 31.17 | 0.00 | 447.10 | -1.77 | -- | 1100 | ND<0.50 | 1.7 | 0.73 | 130 | -- | 35 | |
| 10/1/02 | 478.27 | 33.00 | 0.00 | 445.27 | -1.83 | -- | 120 | ND<0.50 | ND<0.50 | ND<0.50 | 8.8 | -- | 28 | |
| 12/30/02 | 478.27 | 22.03 | 0.00 | 456.24 | 10.97 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.2 | -- | 90 | |
| 5/2/03 | 478.27 | 24.13 | 0.00 | 454.14 | -2.10 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 50 | |
| 7/1/03 | 478.27 | 25.35 | 0.00 | 452.92 | -1.22 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |
| 10/3/03 | 478.27 | 27.24 | 0.00 | 451.03 | -1.89 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |

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| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-1 continued | | | | | | | | | | | | | | |
| 1/8/04 | 478.27 | 22.67 | 0.00 | 455.60 | 4.57 | -- | 54 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 5.5 | |
| 4/15/04 | 478.27 | 25.33 | 0.00 | 452.94 | -2.66 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 7/15/04 | 478.27 | 26.47 | 0.00 | 451.80 | -1.14 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 12/8/04 | 478.27 | 31.17 | 0.00 | 447.10 | -4.70 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 3/23/05 | 478.27 | 22.47 | 0.00 | 455.80 | 8.70 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 6/28/05 | 478.27 | 25.37 | 0.00 | 452.90 | -2.90 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 9/23/05 | 478.27 | 29.15 | 0.00 | 449.12 | -3.78 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 12/30/05 | 478.27 | 23.69 | 0.00 | 454.58 | 5.46 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 3/24/06 | 478.27 | 22.54 | 0.00 | 455.73 | 1.15 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 1.6 | |
| 6/26/06 | 478.27 | 24.99 | 0.00 | 453.28 | -2.45 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 9/26/06 | 478.27 | 30.19 | 0.00 | 448.08 | -5.20 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 11/21/06 | 478.27 | 28.27 | 0.00 | 450.00 | 1.92 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 3/26/07 | 478.27 | 26.92 | 0.00 | 451.35 | 1.35 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 6/27/07 | 478.27 | 30.78 | 0.00 | 447.49 | -3.86 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 9/23/07 | 478.27 | 33.17 | 0.00 | 445.10 | -2.39 | -- | -- | -- | -- | -- | -- | -- | -- | Not enough water to sample |
| 12/20/07 | 478.27 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 478.27 | 31.20 | 0.00 | 447.07 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 6/12/08 | 478.27 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 9/3/08 | 478.27 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 480.29 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.29 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.29 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 480.29 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |

# Table 2
# HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
## July 1998 Through December 2009
## 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-2 | | | (Screen Interval in feet: 13.0-34.0) | | | | | | | | | | | |
| 7/13/98 | 477.44 | 23.52 | 0.00 | 453.92 | -- | 1200 | -- | 130 | 12 | 62 | 180 | 1100 | -- | |
| 10/7/98 | 477.44 | 25.31 | 0.00 | 452.13 | -1.79 | ND | -- | ND | ND | ND | ND | 160 | -- | |
| 1/15/99 | 477.44 | 30.22 | 0.00 | 447.22 | -4.91 | ND | -- | ND | ND | ND | ND | 280 | -- | |
| 4/14/99 | 477.44 | 24.50 | 0.00 | 452.94 | 5.72 | ND | -- | ND | ND | ND | ND | 460 | -- | |
| 7/19/99 | 477.44 | 28.54 | 0.00 | 448.90 | -4.04 | ND | -- | ND | ND | ND | ND | 220 | -- | |
| 10/12/99 | 477.44 | 30.48 | 0.00 | 446.96 | -1.94 | ND | -- | ND | ND | ND | ND | 160 | -- | |
| 1/24/00 | 477.44 | 24.52 | 0.00 | 452.92 | 5.96 | ND | -- | ND | ND | ND | ND | 150 | -- | |
| 4/10/00 | 477.44 | 23.68 | 0.00 | 453.76 | 0.84 | ND | -- | ND | ND | ND | ND | 177 | -- | |
| 7/17/00 | 477.44 | 28.35 | 0.00 | 449.09 | -4.67 | ND | -- | ND | ND | ND | ND | 62.7 | -- | |
| 10/2/00 | 477.44 | 28.72 | 0.00 | 448.72 | -0.37 | ND | -- | ND | ND | ND | ND | 52 | -- | |
| 1/8/01 | 477.44 | 29.11 | 0.00 | 448.33 | -0.39 | ND | -- | ND | ND | ND | ND | 57.3 | -- | |
| 4/3/01 | 477.44 | 25.95 | 0.00 | 451.49 | 3.16 | ND | -- | ND | ND | ND | ND | 30.2 | -- | |
| 7/2/01 | 477.44 | 29.01 | 0.00 | 448.43 | -3.06 | ND | -- | ND | ND | ND | ND | 16 | -- | |
| 10/8/01 | 477.44 | 30.94 | 0.00 | 446.50 | -1.93 | ND<50 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 82 | -- | |
| 1/3/02 | 477.44 | 27.33 | 0.00 | 450.11 | 3.61 | 260 | -- | 7.7 | 11 | 1.7 | 15 | 42 | -- | |
| 4/5/02 | 477.44 | 30.02 | 0.00 | 447.42 | -2.69 | ND<50 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 25 | -- | |
| 7/2/02 | 477.44 | 31.23 | 0.00 | 446.21 | -1.21 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 10/1/02 | 477.44 | 32.00 | 0.00 | 445.44 | -0.77 | -- | ND<50 | ND<0.50 | 0.62 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |
| 12/30/02 | 477.44 | 22.32 | 0.00 | 455.12 | 9.68 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |
| 5/2/03 | 477.44 | 25.92 | 0.00 | 451.52 | -3.60 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |
| 7/1/03 | 477.44 | 24.99 | 0.00 | 452.45 | 0.93 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |
| 10/3/03 | 477.44 | 25.31 | 0.00 | 452.13 | -0.32 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<2.0 | |
| 1/8/04 | 477.44 | 21.94 | 0.00 | 455.50 | 3.37 | -- | ND<50 | ND<0.50 | ND<0.50 | 0.51 | ND<1.0 | -- | ND<2.0 | |

# Table 2
# HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
## July 1998 Through December 2009
## 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-2 continued | | | | | | | | | | | | | | |
| 4/15/04 | 477.44 | 25.20 | 0.00 | 452.24 | -3.26 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 7/15/04 | 477.44 | 24.45 | 0.00 | 452.99 | 0.75 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 12/8/04 | 477.44 | 29.89 | 0.00 | 447.55 | -5.44 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 3/23/05 | 477.44 | 22.00 | 0.00 | 455.44 | 7.89 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | 1.1 | -- | ND<0.50 | |
| 6/28/05 | 477.44 | 25.30 | 0.00 | 452.14 | -3.30 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 9/23/05 | 477.44 | 28.25 | 0.00 | 449.19 | -2.95 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 12/30/05 | 477.44 | 24.33 | 0.00 | 453.11 | 3.92 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 3/24/06 | 477.44 | 22.34 | 0.00 | 455.10 | 1.99 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 6/26/06 | 477.44 | 23.15 | 0.00 | 454.29 | -0.81 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 9/26/06 | 477.44 | 28.52 | 0.00 | 448.92 | -5.37 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 11/21/06 | 477.44 | 25.85 | 0.00 | 451.59 | 2.67 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 3/26/07 | 477.44 | 25.62 | 0.00 | 451.82 | 0.23 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 6/27/07 | 477.44 | 28.37 | 0.00 | 449.07 | -2.75 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 9/23/07 | 477.44 | 31.40 | 0.00 | 446.04 | -3.03 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 12/20/07 | 477.44 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 477.44 | 30.45 | 0.00 | 446.99 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 6/12/08 | 477.44 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 9/3/08 | 477.44 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 479.45 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 479.45 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 479.45 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 479.45 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |

U-3 **(Screen Interval in feet: 14.0-34.0)**

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-3 continued | | | | | | | | | | | | | | |
| 7/13/98 | 478.46 | 23.82 | 0.00 | 454.64 | -- | 70000 | -- | 3100 | 5500 | 2700 | 16000 | 7500 | -- | |
| 10/7/98 | 478.46 | 25.64 | 0.00 | 452.82 | -1.82 | 54000 | -- | 5000 | 1100 | 3100 | 14000 | 6100 | -- | |
| 1/15/99 | 478.46 | 30.92 | 0.00 | 447.54 | -5.28 | 41000 | -- | 3100 | ND | 1800 | 3800 | 15000 | -- | |
| 4/14/99 | 478.46 | 24.48 | 0.00 | 453.98 | 6.44 | 33000 | -- | 86 | 290 | 2200 | 7800 | 39000 | -- | |
| 7/19/99 | 478.46 | 28.46 | 0.00 | 450.00 | -3.98 | 48000 | -- | 3900 | 2500 | 3600 | 14000 | 12000 | 16000 | |
| 10/12/99 | 478.46 | 30.39 | 0.00 | 448.07 | -1.93 | 35000 | -- | 4200 | ND | 2300 | 1800 | 22000 | 8300 | |
| 1/24/00 | 478.46 | 23.43 | 0.00 | 455.03 | 6.96 | 13000 | -- | 260 | ND | 770 | 3200 | 53000 | 42000 | |
| 4/10/00 | 478.46 | 23.31 | 0.00 | 455.15 | 0.12 | 35200 | -- | 1070 | 241 | 2820 | 8850 | 35600 | 40900 | |
| 7/17/00 | 478.46 | 27.53 | 0.00 | 450.93 | -4.22 | 29000 | -- | 3570 | 525 | 3180 | 5660 | 22500 | 21000 | |
| 10/2/00 | 478.46 | 28.19 | 0.00 | 450.27 | -0.66 | 11000 | -- | 2100 | 31 | 2000 | 780 | 25000 | 28000 | |
| 1/8/01 | 478.46 | 29.85 | 0.00 | 448.61 | -1.66 | 33600 | -- | 3060 | 427 | 3040 | 4190 | 24700 | 30900 | |
| 4/3/01 | 478.46 | 24.98 | 0.00 | 453.48 | 4.87 | 5390 | -- | 660 | 10.8 | 304 | 356 | 15200 | 19300 | |
| 7/2/01 | 478.46 | 31.35 | 0.00 | 447.11 | -6.37 | 13000 | -- | 1200 | 58 | 1300 | 930 | 25000 | 26000 | |
| 10/8/01 | 478.46 | 32.69 | 0.00 | 445.77 | -1.34 | 6100 | -- | 500 | ND<10 | 570 | 130 | 23000 | 22000 | |
| 1/3/02 | 478.46 | 23.73 | 0.00 | 454.73 | 8.96 | 9900 | -- | 700 | 130 | 24 | 1000 | 14000 | 12000 | |
| 4/5/02 | 477.44 | 28.27 | 0.00 | 449.17 | -5.56 | 9800 | -- | 1100 | 180 | 220 | 1400 | 16000 | 30000 | |
| 7/2/02 | 478.46 | 29.71 | 0.00 | 448.75 | -0.42 | -- | ND<25000 | ND<250 | ND<250 | ND<250 | ND<500 | 12000 | 12000 | |
| 10/1/02 | 478.46 | 31.18 | 0.00 | 447.28 | -1.47 | -- | ND<25000 | ND<250 | ND<250 | ND<250 | ND<500 | 12000 | 12000 | |
| 12/30/02 | 478.46 | 21.62 | 0.00 | 456.84 | 9.56 | -- | 23000 | 330 | 170 | 870 | 4900 | 18000 | 18000 | |
| 5/2/03 | 478.46 | 23.11 | 0.00 | 455.35 | -1.49 | -- | 19000 | 280 | ND<50 | 880 | 1500 | 15000 | 15000 | |
| 7/1/03 | 478.46 | 24.89 | 0.00 | 453.57 | -1.78 | -- | 19000 | 120 | ND<100 | 180 | 880 | 22000 | 22000 | |
| 10/3/03 | 478.46 | 26.59 | 0.00 | 451.87 | -1.70 | -- | 20000 | 170 | ND<50 | 250 | 730 | -- | 16000 | |
| 1/8/04 | 478.46 | 21.92 | 0.00 | 456.54 | 4.67 | -- | 17000 | 250 | ND<100 | 770 | 1500 | -- | 9700 | |

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-3 continued | | | | | | | | | | | | | | |
| 4/15/04 | 478.46 | 23.59 | 0.00 | 454.87 | -1.67 | -- | 4600 | ND<25 | ND<25 | 36 | 100 | -- | 3700 | |
| 7/15/04 | 478.46 | 24.80 | 0.00 | 453.66 | -1.21 | -- | 2700 | ND<25 | ND<25 | ND<25 | ND<50 | -- | 3400 | |
| 12/8/04 | 478.46 | 29.13 | 0.00 | 449.33 | -4.33 | -- | 12000 | ND<50 | ND<50 | 250 | 140 | -- | 13000 | |
| 3/23/05 | 478.46 | 21.64 | 0.00 | 456.82 | 7.49 | -- | 21000 | 94 | ND<50 | 630 | 1200 | -- | 6200 | |
| 6/28/05 | 478.46 | 24.57 | 0.00 | 453.89 | -2.93 | -- | 6600 | 24 | 0.64 | 150 | 70 | -- | 4700 | |
| 9/23/05 | 478.46 | 27.64 | 0.00 | 450.82 | -3.07 | -- | 6000 | 31 | ND<25 | 150 | ND<50 | -- | 8900 | |
| 12/30/05 | 478.46 | 23.96 | 0.00 | 454.50 | 3.68 | -- | 390 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 840 | |
| 3/24/06 | 478.46 | 22.52 | 0.00 | 455.94 | 1.44 | -- | 2700 | 28 | ND<5.0 | 57 | 120 | -- | 690 | |
| 6/26/06 | 478.46 | 23.89 | 0.00 | 454.57 | -1.37 | -- | 2000 | 51 | 0.77 | 84 | 45 | -- | 560 | |
| 9/26/06 | 478.46 | 28.08 | 0.00 | 450.38 | -4.19 | -- | 1200 | 20 | ND<2.5 | 5.2 | 2.8 | -- | 170 | |
| 11/21/06 | 478.46 | 27.23 | 0.00 | 451.23 | 0.85 | -- | 1500 | 22 | ND<5.0 | 5.8 | ND<5.0 | -- | 180 | |
| 3/26/07 | 478.46 | 25.27 | 0.00 | 453.19 | 1.96 | -- | 3900 | 65 | 0.61 | 50 | 160 | -- | 95 | |
| 6/27/07 | 478.46 | 27.51 | 0.00 | 450.95 | -2.24 | -- | 1400 | 29 | ND<0.50 | 5.6 | 2.3 | -- | 170 | |
| 9/23/07 | 478.46 | 31.70 | 0.00 | 446.76 | -4.19 | -- | 1600 | 16 | 0.61 | 2.7 | 3.7 | -- | 88 | |
| 12/20/07 | 478.46 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 478.46 | 28.84 | 0.00 | 449.62 | -- | -- | 1400 | 17 | ND<1.0 | 2.3 | ND<2.0 | -- | 150 | |
| 6/12/08 | 478.46 | 31.23 | 0.00 | 447.23 | -2.39 | -- | 770 | 4.1 | ND<1.0 | ND<1.0 | ND<2.0 | -- | 27 | |
| 9/3/08 | 478.46 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 480.48 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.48 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.48 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 480.48 | 31.73 | 0.00 | 448.75 | -- | -- | 1100 | 4.2 | ND<0.50 | 2.1 | 2.9 | -- | 62 | |
| U-4 | | | | (Screen Interval in feet: 35.0-45.0) | | | | | | | | | | |

# Table 2
# HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
## July 1998 Through December 2009
## 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-4 continued | | | | | | | | | | | | | | |
| 4/3/01 | 476.93 | 31.63 | 0.00 | 445.30 | -- | ND | -- | ND | ND | ND | ND | 37.8 | 38.2 | |
| 7/2/01 | 476.93 | 37.96 | 0.00 | 438.97 | -6.33 | ND | -- | ND | ND | ND | ND | ND | 5.3 | |
| 10/8/01 | 476.93 | 44.24 | 0.00 | 432.69 | -6.28 | -- | -- | -- | -- | -- | -- | -- | -- | Not enough water to sample |
| 1/3/02 | 476.93 | 36.15 | 0.00 | 440.78 | 8.09 | 100 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 10 | 8.5 | |
| 4/5/02 | 476.93 | 37.64 | 0.00 | 439.29 | -1.49 | ND<50 | -- | 0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 4.1 | -- | |
| 7/2/02 | 476.93 | 36.85 | 0.00 | 440.08 | 0.79 | -- | 67 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 12 | |
| 10/1/02 | 476.93 | 38.54 | 0.00 | 438.39 | -1.69 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 9.8 | |
| 12/30/02 | 476.93 | 32.64 | 0.00 | 444.29 | 5.90 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 25 | |
| 5/2/03 | 476.93 | 31.40 | 0.00 | 445.53 | 1.24 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 4.1 | |
| 7/1/03 | 476.93 | 33.60 | 0.00 | 443.33 | -2.20 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 2.1 | |
| 10/3/03 | 476.93 | 37.63 | 0.00 | 439.30 | -4.03 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 9.1 | |
| 1/8/04 | 476.93 | 29.23 | 0.00 | 447.70 | 8.40 | -- | ND<50 | 0.55 | ND<0.50 | 1.6 | 3.7 | -- | 2.5 | |
| 4/15/04 | 476.93 | 29.80 | 0.00 | 447.13 | -0.57 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 5.2 | |
| 7/15/04 | 476.93 | 35.05 | 0.00 | 441.88 | -5.25 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 5.1 | |
| 12/8/04 | 476.93 | 35.10 | 0.00 | 441.83 | -0.05 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 3.0 | |
| 3/23/05 | 476.93 | 25.38 | 0.00 | 451.55 | 9.72 | -- | ND<50 | ND<0.50 | ND<0.50 | 1.3 | 1.2 | -- | 0.65 | |
| 6/28/05 | 476.93 | 28.67 | 0.00 | 448.26 | -3.29 | -- | 34J | ND<0.50 | 0.15J | ND<0.50 | ND<1.0 | -- | 0.23J | |
| 9/23/05 | 476.93 | 32.25 | 0.00 | 444.68 | -3.58 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 11 | |
| 12/30/05 | 476.93 | 31.02 | 0.00 | 445.91 | 1.23 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 17 | |
| 3/24/06 | 476.93 | 26.51 | 0.00 | 450.42 | 4.51 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | 4.4 | -- | 21 | |
| 6/26/06 | 476.93 | 27.98 | 0.00 | 448.95 | -1.47 | -- | 63 | ND<0.50 | ND<0.50 | 0.56 | ND<1.0 | -- | 11 | |
| 9/26/06 | 476.93 | 33.72 | 0.00 | 443.21 | -5.74 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 13 | |
| 11/21/06 | 476.93 | 33.43 | 0.00 | 443.50 | 0.29 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |

# Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-4 continued | | | | | | | | | | | | | | |
| 3/26/07 | 476.93 | 30.52 | 0.00 | 446.41 | 2.91 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<0.50 | |
| 6/27/07 | 476.93 | 38.20 | 0.00 | 438.73 | -7.68 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 0.78 | |
| 9/23/07 | 476.93 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Car parked over well |
| 12/20/07 | 476.93 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 476.93 | 34.18 | 0.00 | 442.75 | -- | -- | 71 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 4.9 | |
| 6/12/08 | 476.93 | 39.50 | 0.00 | 437.43 | -5.32 | -- | 71 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 7.5 | |
| 9/3/08 | 476.93 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 478.95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 478.95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 478.95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 478.95 | 40.98 | 0.00 | 437.97 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 3.3 | |
| U-5 | | | (Screen Interval in feet: 37.0-47.0) | | | | | | | | | | | |
| 4/3/01 | 476.51 | 31.75 | 0.00 | 444.76 | -- | ND | -- | ND | 0.728 | ND | 0.993 | 54.8 | 55.4 | |
| 7/2/01 | 476.51 | 38.68 | 0.00 | 437.83 | -6.93 | ND | -- | ND | ND | ND | ND | 88 | 94 | |
| 10/8/01 | 476.51 | 46.31 | 0.00 | 430.20 | -7.63 | ND<50 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 37 | 54 | |
| 1/3/02 | 476.51 | 36.55 | 0.00 | 439.96 | 9.76 | ND<50 | -- | ND<0.50 | 0.59 | ND<0.50 | 0.91 | 51 | 53 | |
| 4/5/02 | 476.51 | 37.83 | 0.00 | 438.68 | -1.28 | ND<50 | -- | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 37 | -- | |
| 7/2/02 | 476.51 | 36.92 | 0.00 | 439.59 | 0.91 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 43 | |
| 10/1/02 | 476.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Truck parked over well |
| 12/30/02 | 476.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Car parked over well |
| 5/2/03 | 476.51 | 31.55 | 0.00 | 444.96 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 18 | |
| 7/1/03 | 476.51 | 33.83 | 0.00 | 442.68 | -2.28 | -- | 73 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 46 | |
| 10/3/03 | 476.51 | 37.72 | 0.00 | 438.79 | -3.89 | -- | 58 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 44 | |

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-5 continued | | | | | | | | | | | | | | |
| 1/8/04 | 476.51 | 29.21 | 0.00 | 447.30 | 8.51 | -- | ND<50 | ND<0.50 | ND<0.50 | 1.1 | 2.7 | -- | 17 | |
| 4/15/04 | 476.51 | 30.05 | 0.00 | 446.46 | -0.84 | -- | 57 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 37 | |
| 7/15/04 | 476.51 | 35.15 | 0.00 | 441.36 | -5.10 | -- | 60 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 27 | |
| 12/8/04 | 476.51 | 35.33 | 0.00 | 441.18 | -0.18 | -- | 62 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 39 | |
| 3/23/05 | 476.51 | 25.45 | 0.00 | 451.06 | 9.88 | -- | ND<50 | ND<0.50 | ND<0.50 | 0.51 | ND<1.0 | -- | 4.5 | |
| 6/28/05 | 476.51 | 28.90 | 0.00 | 447.61 | -3.45 | -- | 73 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 40 | |
| 9/23/05 | 476.51 | 33.01 | 0.00 | 443.50 | -4.11 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 53 | |
| 12/30/05 | 476.51 | 30.96 | 0.00 | 445.55 | 2.05 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 72 | |
| 3/24/06 | 476.51 | 22.42 | 0.00 | 454.09 | 8.54 | -- | 2400 | 13 | ND<5.0 | 48 | 58 | -- | 54 | |
| 6/26/06 | 476.51 | 29.31 | 0.00 | 447.20 | -6.89 | -- | 72 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 82 | |
| 9/26/06 | 476.51 | 34.35 | 0.00 | 442.16 | -5.04 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 51 | |
| 11/21/06 | 476.51 | 32.43 | 0.00 | 444.08 | 1.92 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 25 | |
| 3/26/07 | 476.51 | 31.20 | 0.00 | 445.31 | 1.23 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 29 | |
| 6/27/07 | 476.51 | 38.62 | 0.00 | 437.89 | -7.42 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 30 | |
| 9/23/07 | 476.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Car parked over well |
| 12/20/07 | 476.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 476.51 | 34.28 | 0.00 | 442.23 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 25 | |
| 6/12/08 | 476.51 | 39.90 | 0.00 | 436.61 | -5.62 | -- | 55 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 28 | |
| 9/3/08 | 476.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 478.52 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 478.52 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 478.52 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 478.52 | 41.35 | 0.00 | 437.17 | -- | -- | 83 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 41 | |

# Table 2
# HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
## July 1998 Through December 2009
## 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-6 | | | (Screen Interval in feet: 35-45) | | | | | | | | | | | |
| 1/3/02 | 478.38 | 33.99 | 0.00 | 444.39 | -- | 5000 | -- | 36 | ND<25 | 260 | 450 | ND<250 | ND<10 | |
| 4/5/02 | 478.38 | 36.18 | 0.00 | 442.20 | -2.19 | 1300 | -- | 16 | ND<5.0 | 54 | ND<5.0 | ND<25 | -- | |
| 7/2/02 | 478.38 | 36.33 | 0.00 | 442.05 | -0.15 | -- | 1100 | 1.4 | ND<0.50 | 16 | ND<1.0 | -- | 0.94 | |
| 10/1/02 | 478.38 | 37.70 | 0.00 | 440.68 | -1.37 | -- | 2000 | 5.4 | ND<0.50 | 62 | ND<1.0 | -- | 2.6 | |
| 12/30/02 | 478.38 | 31.63 | 0.00 | 446.75 | 6.07 | -- | 130 | ND<0.50 | ND<0.50 | 2.3 | ND<1.0 | -- | ND<2.0 | |
| 5/2/03 | 478.38 | 31.49 | 0.00 | 446.89 | 0.14 | -- | 150 | ND<0.50 | ND<0.50 | 1.8 | 1.7 | -- | 82 | |
| 7/1/03 | 478.38 | 32.88 | 0.00 | 445.50 | -1.39 | -- | 190 | 1.8 | ND<0.50 | 9.4 | 8.7 | -- | 36 | |
| 10/3/03 | 478.38 | 36.54 | 0.00 | 441.84 | -3.66 | -- | ND<10000 | 140 | ND<100 | 940 | 560 | -- | ND<400 | |
| 1/8/04 | 478.38 | 30.45 | 0.00 | 447.93 | 6.09 | -- | 3500 | 29 | 32 | 90 | 89 | -- | 27 | |
| 4/15/04 | 478.38 | 29.48 | 0.00 | 448.90 | 0.97 | -- | 2400 | 19 | ND<2.5 | 91 | 53 | -- | 16 | |
| 7/15/04 | 478.38 | 34.30 | 0.00 | 444.08 | -4.82 | -- | 8500 | 150 | 5.7 | 970 | 560 | -- | 24 | |
| 12/8/04 | 478.38 | 34.80 | 0.00 | 443.58 | -0.50 | -- | 2700 | 16 | ND<2.5 | 28 | ND<5.0 | -- | 10 | |
| 3/23/05 | 478.38 | 25.08 | 0.00 | 453.30 | 9.72 | -- | 960 | 2.7 | ND<0.50 | 9.6 | 4.8 | -- | 2.5 | |
| 6/28/05 | 478.38 | 28.75 | 0.00 | 449.63 | -3.67 | -- | 12000 | 120 | 4.9 | 930 | 780 | -- | 21 | |
| 9/23/05 | 478.38 | 32.38 | 0.00 | 446.00 | -3.63 | -- | 5200 | 78 | ND<25 | 540 | 230 | -- | 34 | |
| 12/30/05 | 478.38 | 30.43 | 0.00 | 447.95 | 1.95 | -- | 2400 | 15 | 0.67 | 99 | 12 | -- | 3.5 | |
| 3/24/06 | 478.38 | 25.94 | 0.00 | 452.44 | 4.49 | -- | 4300 | 52 | ND<5.0 | 440 | 160 | -- | 11 | |
| 6/26/06 | 478.38 | 28.07 | 0.00 | 450.31 | -2.13 | -- | 5300 | 59 | ND<5.0 | 520 | 300 | -- | ND<5.0 | |
| 9/26/06 | 478.38 | 33.31 | 0.00 | 445.07 | -5.24 | -- | 7400 | 78 | ND<5.0 | 490 | 160 | -- | 6.4 | |
| 11/21/06 | 478.38 | 31.65 | 0.00 | 446.73 | 1.66 | -- | 1500 | 5.5 | ND<0.50 | 37 | 2.4 | -- | 1.4 | |
| 3/26/07 | 478.38 | 29.25 | 0.00 | 449.13 | 2.40 | -- | 480 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 0.50 | |
| 6/27/07 | 478.38 | 35.09 | 0.00 | 443.29 | -5.84 | -- | 110 | 1.2 | ND<0.50 | 1.3 | ND<0.50 | -- | 0.86 | |
| 9/23/07 | 478.38 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-6 continued | | | | | | | | | | | | | | |
| 12/20/07 | 478.38 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 478.38 | 33.82 | 0.00 | 444.56 | -- | -- | 580 | 1.5 | ND<0.50 | 3.2 | ND<1.0 | -- | ND<0.50 | |
| 6/12/08 | 478.38 | 38.16 | 0.00 | 440.22 | -4.34 | -- | 2100 | 11 | 0.79 | 27 | 2.3 | -- | 1.1 | |
| 9/3/08 | 478.38 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 480.40 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.40 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.40 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 480.40 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| U-7 | | | (Screen Interval in feet: 35-45) | | | | | | | | | | | |
| 1/3/02 | 478.74 | 32.43 | 0.00 | 446.31 | -- | 3100 | -- | 93 | ND<10 | 35 | 73 | 140 | 130 | |
| 4/5/02 | 478.74 | 34.06 | 0.00 | 444.68 | -1.63 | 630 | -- | 22 | 0.53 | 2.6 | ND<0.50 | 45 | -- | |
| 7/2/02 | 478.74 | 35.28 | 0.00 | 443.46 | -1.22 | -- | 1100 | 21 | ND<0.50 | 6.9 | ND<1.0 | -- | 60 | |
| 10/1/02 | 478.74 | 37.70 | 0.00 | 441.04 | -2.42 | -- | 1700 | 11 | ND<0.50 | 3.1 | ND<1.0 | -- | 25 | |
| 12/30/02 | 478.74 | 31.93 | 0.00 | 446.81 | 5.77 | -- | 4600 | 41 | 5.3 | 32 | 13 | -- | 34 | |
| 5/2/03 | 478.74 | 31.81 | 0.00 | 446.93 | 0.12 | -- | 3000 | 17 | 2.7 | 14 | 5.1 | -- | 42 | |
| 7/1/03 | 478.74 | 33.47 | 0.00 | 445.27 | -1.66 | -- | 2300 | 11 | 0.53 | 8.0 | 1.5 | -- | 35 | |
| 10/3/03 | 478.74 | 35.84 | 0.00 | 442.90 | -2.37 | -- | 6500 | 30 | ND<5.0 | 41 | ND<10 | -- | 53 | |
| 1/8/04 | 478.74 | 30.35 | 0.00 | 448.39 | 5.49 | -- | 1600 | 4.0 | ND<1.0 | 4.2 | 8.7 | -- | 56 | |
| 4/15/04 | 478.74 | 29.03 | 0.00 | 449.71 | 1.32 | -- | 3600 | 22 | 1.3 | 64 | 40 | -- | 57 | |
| 7/15/04 | 478.74 | 33.52 | 0.00 | 445.22 | -4.49 | -- | 4700 | 15 | 1.2 | 59 | 57 | -- | 50 | |
| 12/8/04 | 478.74 | 34.68 | 0.00 | 444.06 | -1.16 | -- | 5800 | 26 | 1.9 | 63 | 27 | -- | 52 | |
| 3/23/05 | 478.74 | 24.49 | 0.00 | 454.25 | 10.19 | -- | 5600 | 18 | 1.3 | 42 | 14 | -- | 39 | |
| 6/28/05 | 478.74 | 28.83 | 0.00 | 449.91 | -4.34 | -- | 5400 | 16 | 1.1 | 35 | 10 | -- | 45 | |

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-7 continued | | | | | | | | | | | | | | |
| 9/23/05 | 478.74 | 32.35 | 0.00 | 446.39 | -3.52 | -- | 2400 | 13 | 1.3 | 31 | 6.9 | -- | 46 | |
| 12/30/05 | 478.74 | 30.18 | 0.00 | 448.56 | 2.17 | -- | 2500 | 11 | 1.1 | 28 | 4.3 | -- | 35 | |
| 3/24/06 | 478.74 | 25.06 | 0.00 | 453.68 | 5.12 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 32 | |
| 6/26/06 | 478.74 | 28.30 | 0.00 | 450.44 | -3.24 | -- | 2500 | 11 | 1.1 | 45 | 15 | -- | 55 | |
| 9/26/06 | 478.74 | 33.47 | 0.00 | 445.27 | -5.17 | -- | 2300 | 7.8 | 0.84 | 17 | 2.1 | -- | 61 | |
| 11/21/06 | 478.74 | 31.66 | 0.00 | 447.08 | 1.81 | -- | 3000 | 15 | 1.1 | 26 | 2.2 | -- | 69 | |
| 3/26/07 | 478.74 | 29.82 | 0.00 | 448.92 | 1.84 | -- | 2200 | 1.2 | ND<0.50 | ND<0.50 | ND<0.50 | -- | 70 | |
| 6/27/07 | 478.74 | 36.59 | 0.00 | 442.15 | -6.77 | -- | 590 | 5.8 | ND<0.50 | 3.3 | 0.94 | -- | 100 | |
| 9/23/07 | 478.74 | 44.05 | 0.00 | 434.69 | -7.46 | -- | -- | -- | -- | -- | -- | -- | -- | Not enough water to sample |
| 12/20/07 | 478.74 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry well |
| 3/17/08 | 478.74 | 33.83 | 0.00 | 444.91 | -- | -- | 1200 | 1.9 | ND<0.50 | 0.82 | ND<1.0 | -- | 27 | |
| 6/12/08 | 478.74 | 38.56 | 0.00 | 440.18 | -4.73 | -- | 1200 | 1.9 | ND<0.50 | 1.1 | ND<1.0 | -- | 40 | |
| 9/3/08 | 478.74 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/3/08 | 480.78 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.78 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.78 | 38.80 | 0.00 | 441.98 | -- | -- | 1100 | 2.4 | 0.80 | 3.2 | ND<1.0 | -- | 8.2 | |
| 12/9/09 | 480.78 | 37.08 | 0.00 | 443.70 | 1.72 | -- | 1200 | 2.8 | 0.72 | 5.3 | 1.5 | -- | 8.1 | |
| U-8 | | | (Screen Interval in feet: 35-45) | | | | | | | | | | | |
| 12/3/08 | 480.43 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.43 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.43 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 480.43 | 38.22 | 0.00 | 442.21 | -- | -- | 7200 | 42 | ND<2.5 | 50 | 250 | -- | ND<2.5 | |
| U-9 | | | (Screen Interval in feet: 35-45) | | | | | | | | | | | |

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-9 continued | | | | | | | | | | | | | | |
| 12/3/08 | 479.39 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 479.39 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 479.39 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 12/9/09 | 479.39 | 40.70 | 0.00 | 438.69 | -- | -- | 8800 | 51 | ND<0.50 | 300 | 74 | -- | 23 | |
| U-10 | | | (Screen Interval in feet: 37-47) | | | | | | | | | | | |
| 12/3/08 | 480.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.51 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.51 | 44.30 | 0.00 | 436.21 | -- | -- | 1400 | 15 | 1.1 | 12 | 12 | -- | 88 | |
| 12/9/09 | 480.51 | 41.45 | 0.00 | 439.06 | 2.85 | -- | 4300 | 280 | 71 | 180 | 900 | -- | 320 | |
| U-11 | | | (Screen Interval in feet: 35-45) | | | | | | | | | | | |
| 12/3/08 | 480.34 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 2/18/09 | 480.34 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Dry |
| 6/11/09 | 480.34 | 43.18 | 0.00 | 437.16 | -- | -- | 1200 | 0.93 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 2500 | |
| 12/9/09 | 480.34 | 39.62 | 0.00 | 440.72 | 3.56 | -- | 1300 | ND<2.5 | ND<2.5 | ND<2.5 | ND<5.0 | -- | 2100 | |
| U-12 | | | (Screen Interval in feet: 63-73) | | | | | | | | | | | |
| 12/3/08 | 480.75 | 50.08 | 0.00 | 430.67 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 2/18/09 | 480.75 | 46.10 | 0.00 | 434.65 | 3.98 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 6/11/09 | 480.75 | 45.85 | 0.00 | 434.90 | 0.25 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 12/9/09 | 480.75 | 40.74 | 0.00 | 440.01 | 5.11 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| U-13 | | | (Screen Interval in feet: 62-72) | | | | | | | | | | | |
| 12/3/08 | 480.31 | 50.74 | 0.00 | 429.57 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 0.85 | |
| 2/18/09 | 480.31 | 45.87 | 0.00 | 434.44 | 4.87 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 0.87 | |

## Table 2
## HISTORIC FLUID LEVELS AND SELECTED ANALYTICAL RESULTS
### July 1998 Through December 2009
### 76 Station 4186

| Date Sampled | TOC Elevation (feet) | Depth to Water (feet) | LPH Thickness (feet) | Ground-water Elevation (feet) | Change in Elevation (feet) | TPH-G 8015 (µg/l) | TPH-G (GC/MS) (µg/l) | Benzene (µg/l) | Toluene (µg/l) | Ethyl-benzene (µg/l) | Total Xylenes (µg/l) | MTBE (8021B) (µg/l) | MTBE (8260B) (µg/l) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-13 continued | | | | | | | | | | | | | | |
| 6/11/09 | 480.31 | 46.60 | 0.00 | 433.71 | -0.73 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 0.81 | |
| 12/9/09 | 480.31 | 41.28 | 0.00 | 439.03 | 5.32 | -- | ND<50 | ND<0.50 | 1.1 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| U-14 | | | (Screen Interval in feet: 65-75) | | | | | | | | | | | |
| 12/3/08 | 479.38 | 49.90 | 0.00 | 429.48 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 1.4 | |
| 2/18/09 | 479.38 | 46.65 | 0.00 | 432.73 | 3.25 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 6/11/09 | 479.38 | 45.75 | 0.00 | 433.63 | 0.90 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 12/9/09 | 479.38 | 40.60 | 0.00 | 438.78 | 5.15 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| U-15 | | | (Screen Interval in feet: 61-71) | | | | | | | | | | | |
| 12/3/08 | 479.99 | 49.58 | 0.00 | 430.41 | -- | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |
| 2/18/09 | 479.99 | 45.58 | 0.00 | 434.41 | 4.00 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 1.2 | |
| 6/11/09 | 479.99 | 45.45 | 0.00 | 434.54 | 0.13 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | 1.6 | |
| 12/9/09 | 479.99 | 40.38 | 0.00 | 439.61 | 5.07 | -- | ND<50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<1.0 | -- | ND<0.50 | |

# Table 2 a
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1.2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-1 | | | | | | | | | | | | |
| 10/2/00 | ND | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/1/03 | -- | ND<500000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 10/3/03 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1/8/04 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/8/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/23/05 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/26/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| U-2 | | | | | | | | | | | | |
| 10/2/00 | ND | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/1/03 | -- | ND<500000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 10/3/03 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1/8/04 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

## Table 2 a
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-2 continued | | | | | | | | | | | | |
| 12/8/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/23/05 | -- | 730 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/26/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 9/23/07 | 69 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | -- | 58 | -- | 2000 |
| U-3 | | | | | | | | | | | | |
| 10/2/00 | 63000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1/8/01 | 49300 | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 4/3/01 | 22200 | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 7/2/01 | 27000 | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 10/8/01 | 33000 | ND<140000000 | ND<290 | ND<290 | ND<290 | ND<290 | ND<290 | -- | -- | -- | -- | -- |
| 1/3/02 | 17000 | ND<50000000 | ND<100 | ND<100 | ND<100 | ND<100 | ND<100 | -- | -- | -- | -- | -- |
| 4/5/02 | 66000 | ND<25000000 | ND<100 | ND<100 | ND<100 | ND<100 | ND<100 | -- | -- | -- | -- | -- |
| 7/2/02 | 47000 | ND<13000000 | ND<250 | ND<250 | ND<500 | ND<250 | ND<250 | -- | -- | -- | -- | -- |
| 10/1/02 | ND<50000 | ND<250000000 | ND<1000 | ND<1000 | ND<1000 | ND<1000 | ND<1000 | -- | -- | -- | -- | -- |
| 12/30/02 | 23000 | ND<100000000 | ND<400 | ND<400 | ND<400 | ND<400 | ND<400 | -- | -- | -- | -- | -- |
| 5/2/03 | 25000 | ND<50000000 | ND<200 | ND<200 | ND<200 | ND<200 | ND<200 | -- | -- | -- | -- | -- |

# Table 2 a
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-3 continued | | | | | | | | | | | | |
| 7/1/03 | 32000 | ND<100000000 | ND<400 | ND<400 | ND<400 | ND<400 | ND<400 | -- | -- | -- | -- | -- |
| 10/3/03 | 39000 | ND<50000 | ND<200 | ND<200 | ND<2.0 | ND<200 | ND<200 | -- | -- | -- | -- | -- |
| 1/8/04 | ND<20000 | ND<100000 | ND<400 | ND<400 | ND<400 | ND<400 | ND<400 | -- | -- | -- | -- | -- |
| 4/15/04 | 18000 | ND<2500 | ND<0.5 | ND<0.5 | ND<1.0 | ND<0.5 | ND<0.5 | -- | -- | -- | -- | -- |
| 7/15/04 | 15000 | ND<2500 | ND<25 | ND<25 | ND<50 | ND<25 | ND<25 | -- | -- | -- | -- | -- |
| 12/8/04 | 34000 | ND<5000 | ND<50 | ND<50 | ND<100 | ND<50 | ND<50 | -- | -- | -- | -- | -- |
| 3/23/05 | -- | ND<5000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<50000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | 2000 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | 0.58 | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<2500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/26/06 | 18000 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<1200 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | 33000 | ND<2500 | ND<5.0 | ND<5.0 | ND<5.0 | ND<5.0 | ND<5.0 | -- | -- | -- | -- | -- |
| 3/26/07 | 13000 | ND<250 | ND<0.50 | 0.95 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | 20000 | ND<250 | ND<0.50 | 0.79 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 9/23/07 | 19000 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | 15000 | ND<500 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<100 | ND<100 | 95 | ND<50 | 1700 |
| 6/12/08 | 21000 | ND<500 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<100 | -- | 210 | -- | 2800 |
| 12/9/09 | 8800 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| U-4 | | | | | | | | | | | | |
| 4/3/01 | ND | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 7/2/01 | ND | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 1/3/02 | ND<20 | ND<500000 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | -- | -- | -- | -- | -- |
| 7/1/03 | -- | ND<500000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

## Table 2 a
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-4 continued | | | | | | | | | | | | |
| 10/3/03 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1/8/04 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/8/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/23/05 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/26/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 2000 |
| 6/12/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 2500 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 2200 |
| U-5 | | | | | | | | | | | | |
| 4/3/01 | ND | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 7/2/01 | ND | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- |
| 10/8/01 | ND<100 | ND<1000000 | ND<2.0 | ND<2.0 | ND<2.0 | ND<2.0 | ND<2.0 | -- | -- | -- | -- | -- |
| 1/3/02 | ND<20 | ND<500000 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | -- | -- | -- | -- | -- |
| 7/1/03 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 10/3/03 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

# Table 2 a
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-5 continued | | | | | | | | | | | | |
| 1/8/04 | -- | ND<500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/15/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/8/04 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/23/05 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<2500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/26/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 1300 |
| 6/12/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 830 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 1300 |
| U-6 | | | | | | | | | | | | |
| 1/3/02 | ND<200 | ND<5000000 | ND<10 | ND<10 | ND<10 | ND<10 | ND<10 | -- | -- | -- | -- | -- |
| 7/1/03 | -- | ND<500000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 10/3/03 | -- | ND<100000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1/8/04 | -- | ND<5000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/15/04 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/15/04 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/8/04 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

## Table 2 a
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-6 continued | | | | | | | | | | | | |
| 3/23/05 | -- | ND<50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<50000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<2500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/26/06 | -- | ND<2500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<2500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/26/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 520 |
| 6/12/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 910 |
| U-7 | | | | | | | | | | | | |
| 1/3/02 | 30 | ND<500000 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | ND<1.0 | -- | -- | -- | -- | -- |
| 7/1/03 | -- | ND<500000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 10/3/03 | -- | ND<5000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1/8/04 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/15/04 | -- | ND<100 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 7/15/04 | -- | ND<100 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/8/04 | -- | ND<100 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/23/05 | -- | ND<100 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6/28/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/23/05 | -- | ND<1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12/30/05 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/24/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

# Table 2 a
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-7 continued | | | | | | | | | | | | |
| 6/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 9/26/06 | -- | ND<250 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 11/21/06 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/26/07 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/27/07 | 14 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 3/17/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 6/12/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 670 |
| 6/11/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 520 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 380 |
| | | | | | | | | ND<100 | ND<100 | ND<50 | ND<50 | 390 |
| U-8 | | | | | | | | | | | | |
| 12/9/09 | ND<50 | ND<1200 | ND<2.5 | ND<2.5 | ND<2.5 | ND<2.5 | ND<2.5 | ND<100 | ND<100 | ND<50 | ND<50 | 650 |
| U-9 | | | | | | | | | | | | |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 96 |
| U-10 | | | | | | | | | | | | |
| 6/11/09 | 98 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | -- | ND<100 | -- | ND<50 | -- |
| 12/9/09 | 1100 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 150 |
| U-11 | | | | | | | | | | | | |
| 6/11/09 | 6800 | ND<250 | ND<0.50 | 1.8 | ND<0.50 | ND<0.50 | ND<0.50 | -- | -- | -- | -- | -- |
| 12/9/09 | 10000 | ND<1200 | ND<2.5 | ND<2.5 | ND<2.5 | ND<2.5 | ND<2.5 | ND<100 | ND<100 | ND<50 | ND<50 | 170 |
| U-12 | | | | | | | | | | | | |
| 12/3/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 330 |
| 2/18/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 370 |
| 6/11/09 | 15 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 400 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 360 |

# Table 2 a
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | TBA (µg/l) | Ethanol (8260B) (µg/l) | Ethylene-dibromide (EDB) (µg/l) | 1,2-DCA (EDC) (µg/l) | DIPE (µg/l) | ETBE (µg/l) | TAME (µg/l) | Antimony (total) (µg/l) | Antimony (dissolved) (µg/l) | Arsenic (total) (µg/l) | Arsenic (dissolved) (µg/l) | Barium (total) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-13 | | | | | | | | | | | | |
| 12/3/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 140 |
| 2/18/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 120 |
| 6/11/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 120 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 15 |
| U-14 | | | | | | | | | | | | |
| 12/3/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 340 |
| 2/18/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 350 |
| 6/11/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 340 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 310 |
| U-15 | | | | | | | | | | | | |
| 12/3/08 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 320 |
| 2/18/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 140 |
| 6/11/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 52 |
| 12/9/09 | ND<10 | ND<250 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<0.50 | ND<100 | ND<100 | ND<50 | ND<50 | 96 |

# Table 2 b
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Barium (dissolved) (µg/l) | Beryllium (total) (µg/l) | Beryllium (dissolved) (µg/l) | Cadmium (total) (µg/l) | Cadmium (dissolved) (mg/l) | Calcium (mg/l) | Chromium VI (µg/l) | Chromium (total) (µg/l) | Chromium (dissolved) (µg/l) | Cobalt (total) (µg/l) | Cobalt (dissolved) (µg/l) | Copper (dissolved) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-1 | | | | | | | | | | | | |
| 3/17/08 | -- | -- | -- | -- | -- | -- | ND<2.0 | -- | -- | -- | -- | -- |
| U-2 | | | | | | | | | | | | |
| 3/17/08 | -- | ND<10 | -- | ND<10 | -- | -- | ND<2.0 | 540 | -- | 150 | -- | -- |
| U-3 | | | | | | | | | | | | |
| 3/17/08 | 410 | ND<10 | ND<10 | ND<10 | ND<0.01 | 59 | ND<2.0 | 450 | ND<10 | 140 | ND<50 | ND<10 |
| 6/12/08 | -- | ND<10 | -- | ND<10 | -- | -- | -- | 980 | -- | 350 | -- | -- |
| U-4 | | | | | | | | | | | | |
| 3/17/08 | 470 | ND<10 | ND<10 | ND<10 | ND<0.01 | 68 | ND<2.0 | 410 | ND<10 | 140 | ND<50 | ND<10 |
| 6/12/08 | 52 | ND<10 | ND<10 | ND<10 | ND<10 | 2.4 | ND<2.0 | 610 | ND<10 | 180 | ND<50 | ND<10 |
| 12/9/09 | 500 | ND<10 | ND<10 | ND<10 | ND<10 | 62 | ND<2.0 | 610 | ND<10 | 200 | ND<50 | ND<10 |
| U-5 | | | | | | | | | | | | |
| 3/17/08 | 390 | ND<10 | ND<10 | ND<10 | ND<0.01 | 67 | ND<2.0 | 110 | -- | ND<50 | ND<50 | ND<10 |
| 6/12/08 | 370 | ND<10 | ND<10 | ND<10 | ND<10 | 66 | ND<2.0 | 86 | ND<10 | ND<50 | ND<50 | ND<10 |
| 12/9/09 | 410 | ND<10 | ND<10 | ND<10 | ND<10 | 62 | ND<2.0 | 180 | ND<10 | 50 | ND<50 | ND<10 |
| U-6 | | | | | | | | | | | | |
| 3/17/08 | 330 | ND<10 | ND<10 | ND<10 | ND<0.01 | 73 | ND<2.0 | 34 | ND<10 | ND<50 | ND<50 | ND<10 |
| 6/12/08 | 600 | ND<10 | ND<10 | ND<10 | ND<10 | 69 | ND<2.0 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| U-7 | | | | | | | | | | | | |
| 3/17/08 | 510 | ND<10 | ND<10 | ND<10 | ND<0.01 | 68 | ND<2.0 | 28 | ND<10 | ND<50 | ND<50 | ND<10 |
| 6/12/08 | 490 | ND<10 | ND<10 | ND<10 | ND<10 | 60 | ND<2.0 | 10 | ND<10 | ND<50 | ND<50 | ND<10 |
| 6/11/09 | 340 | ND<10 | ND<10 | ND<10 | ND<0.01 | 31 | ND<2.0 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| 12/9/09 | 280 | ND<10 | ND<10 | ND<10 | ND<10 | 37 | ND<2.0 | 27 | ND<10 | ND<50 | ND<50 | ND<10 |
| U-8 | | | | | | | | | | | | |

# Table 2 b
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
### 76 Station 4186

| Date Sampled | Barium (dissolved) (µg/l) | Beryllium (total) (µg/l) | Beryllium (dissolved) (µg/l) | Cadmium (total) (µg/l) | Cadmium (dissolved) (mg/l) | Calcium (mg/l) | Chromium VI (µg/l) | Chromium (total) (µg/l) | Chromium (dissolved) (µg/l) | Cobalt (total) (µg/l) | Cobalt (dissolved) (µg/l) | Copper (dissolved) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-8 continued | | | | | | | | | | | | |
| 12/9/09 | 200 | ND<10 | ND<10 | ND<10 | ND<10 | 53 | ND<2.0 | ND<10 | ND<10 | 78 | ND<50 | ND<10 |
| U-9 | | | | | | | | | | | | |
| 12/9/09 | 64 | ND<10 | ND<10 | ND<10 | ND<10 | 69 | ND<2.0 | 18 | ND<10 | ND<50 | ND<50 | ND<10 |
| U-10 | | | | | | | | | | | | |
| 6/11/09 | 50 | -- | ND<10 | -- | ND<0.01 | 40 | ND<2.0 | -- | ND<10 | -- | ND<50 | ND<10 |
| 12/9/09 | 59 | ND<10 | ND<10 | ND<10 | ND<10 | 47 | ND<2.0 | 34 | ND<10 | ND<50 | ND<50 | ND<10 |
| U-11 | | | | | | | | | | | | |
| 12/9/09 | 89 | ND<10 | ND<10 | ND<10 | ND<10 | 61 | ND<2.0 | 31 | ND<10 | ND<50 | ND<50 | ND<10 |
| U-12 | | | | | | | | | | | | |
| 12/3/08 | 330 | ND<10 | ND<10 | ND<10 | ND<10 | 51 | 2.7 | 11 | ND<10 | ND<50 | ND<50 | ND<10 |
| 2/18/09 | 330 | ND<10 | ND<10 | ND<10 | ND<10 | 50 | 2.7 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| 6/11/09 | 320 | ND<10 | ND<10 | ND<10 | ND<0.01 | 47 | ND<2.0 | 21 | ND<10 | ND<50 | ND<50 | ND<10 |
| 12/9/09 | 330 | ND<10 | ND<10 | ND<10 | ND<10 | 47 | 2.3 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| U-13 | | | | | | | | | | | | |
| 12/3/08 | 110 | ND<10 | ND<10 | ND<10 | ND<10 | 24 | 85 | 93 | 86 | ND<50 | ND<50 | ND<10 |
| 2/18/09 | 98 | ND<10 | ND<10 | ND<10 | ND<10 | 22 | 88 | 88 | 88 | ND<50 | ND<50 | ND<10 |
| 6/11/09 | 110 | ND<10 | ND<10 | ND<10 | ND<0.01 | 24 | 82 | 84 | 78 | ND<50 | ND<50 | ND<10 |
| 12/9/09 | 10 | ND<10 | ND<10 | ND<10 | ND<10 | 3.9 | 67 | 74 | 70 | ND<50 | ND<50 | ND<10 |
| U-14 | | | | | | | | | | | | |
| 12/3/08 | 320 | ND<10 | ND<10 | ND<10 | ND<10 | 47 | 3.0 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| 2/18/09 | 320 | ND<10 | ND<10 | ND<10 | ND<10 | 46 | 3.4 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| 6/11/09 | 310 | ND<10 | ND<10 | ND<10 | ND<0.01 | 45 | 2.9 | 16 | ND<10 | ND<50 | ND<50 | ND<10 |
| 12/9/09 | 270 | ND<10 | ND<10 | ND<10 | ND<10 | 42 | 2.9 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |

## Table 2 b
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
### 76 Station 4186

| Date Sampled | Barium (dissolved) (µg/l) | Beryllium (total) (µg/l) | Beryllium (dissolved) (µg/l) | Cadmium (total) (µg/l) | Cadmium (dissolved) (mg/l) | Calcium (mg/l) | Chromium VI (µg/l) | Chromium (total) (µg/l) | Chromium (dissolved) (µg/l) | Cobalt (total) (µg/l) | Cobalt (dissolved) (µg/l) | Copper (dissolved) (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **U-15** | | | | | | | | | | | | |
| 12/3/08 | 300 | ND<10 | ND<10 | ND<10 | ND<10 | 47 | 3.7 | ND<10 | ND<10 | ND<50 | ND<50 | ND<10 |
| 2/18/09 | 91 | ND<10 | ND<10 | ND<10 | ND<10 | 14 | 10 | 11 | ND<10 | ND<50 | ND<50 | ND<10 |
| 6/11/09 | 30 | ND<10 | ND<10 | ND<10 | ND<0.01 | 4.6 | 9.0 | 12 | ND<10 | ND<50 | ND<50 | ND<10 |
| 12/9/09 | 64 | ND<10 | ND<10 | ND<10 | ND<10 | 13 | 17 | 20 | 17 | ND<50 | ND<50 | ND<10 |

# Table 2 c
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Copper (total) (µg/l) | Lead (dissolved) (mg/l) | Lead (total) (µg/l) | Magnesium (dissolved) (mg/l) | Manganese (dissolved) (µg/l) | Mercury (total) (µg/l) | Mercury (dissolved) (µg/l) | Molyb-denum (total) (µg/l) | Molyb-denum (dissolved) (µg/l) | Nickel (total) (µg/l) | Nickel (dissolved) (µg/l) | Potassium (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-2 | | | | | | | | | | | | |
| 3/17/08 | 330 | -- | 71 | -- | -- | 1.7 | -- | ND<50 | -- | 1500 | -- | -- |
| U-3 | | | | | | | | | | | | |
| 3/17/08 | 240 | ND<50 | 65 | 94 | 2600 | 0.84 | ND<0.20 | ND<50 | ND<50 | 1200 | ND<10 | 1.6 |
| 6/12/08 | 590 | -- | 160 | -- | -- | 2.4 | -- | 81 | -- | 2800 | -- | -- |
| U-4 | | | | | | | | | | | | |
| 3/17/08 | 250 | ND<50 | ND<50 | 88 | 2000 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 1300 | ND<10 | 2.3 |
| 6/12/08 | 360 | ND<50 | 53 | 7.7 | 720 | 2.5 | ND<0.20 | ND<50 | ND<50 | 2100 | ND<10 | ND<1.0 |
| 12/9/09 | 300 | ND<50 | 59 | 91 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 2000 | ND<10 | 2.7 |
| U-5 | | | | | | | | | | | | |
| 3/17/08 | 72 | ND<50 | ND<50 | 89 | 76 | 0.55 | ND<0.20 | ND<50 | ND<50 | 360 | ND<10 | 2.4 |
| 6/12/08 | 53 | ND<50 | ND<50 | 73 | 36 | 0.26 | ND<0.20 | ND<50 | ND<50 | 290 | ND<10 | 1.9 |
| 12/9/09 | 110 | ND<50 | ND<50 | 79 | 1000 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 540 | ND<10 | 2.4 |
| U-6 | | | | | | | | | | | | |
| 3/17/08 | 17 | ND<50 | ND<50 | 120 | 4300 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 91 | ND<10 | 1.0 |
| 6/12/08 | ND<10 | ND<50 | ND<50 | 110 | 3800 | 0.60 | ND<0.20 | ND<50 | ND<50 | 47 | ND<10 | 1.3 |
| U-7 | | | | | | | | | | | | |
| 3/17/08 | 16 | ND<50 | ND<50 | 110 | 2300 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 79 | ND<10 | 2.4 |
| 6/12/08 | ND<10 | ND<50 | ND<50 | 92 | 2400 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 38 | ND<10 | 2.4 |
| 6/11/09 | ND<10 | ND<0.05 | ND<50 | 50 | 1100 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 25 | ND<10 | 2.6 |
| 12/9/09 | 14 | ND<50 | ND<50 | 64 | 1800 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 74 | ND<10 | 2.1 |
| U-8 | | | | | | | | | | | | |
| 12/9/09 | 130 | ND<50 | ND<50 | 91 | 4000 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 690 | ND<10 | 2.8 |
| U-9 | | | | | | | | | | | | |

## Table 2 c
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Copper (total) (µg/l) | Lead (dissolved) (mg/l) | Lead (total) (µg/l) | Magnesium (dissolved) (mg/l) | Manganese (dissolved) (µg/l) | Mercury (total) (µg/l) | Mercury (dissolved) (µg/l) | Molyb-denum (total) (µg/l) | Molyb-denum (dissolved) (µg/l) | Nickel (total) (µg/l) | Nickel (dissolved) (µg/l) | Potassium (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-9 continued | | | | | | | | | | | | |
| 12/9/09 | 15 | ND<50 | ND<50 | 120 | 3800 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 35 | ND<10 | 8.5 |
| U-10 | | | | | | | | | | | | |
| 6/11/09 | -- | ND<0.05 | -- | 87 | 780 | -- | ND<0.20 | -- | ND<50 | -- | ND<10 | 30 |
| 12/9/09 | 17 | ND<50 | ND<50 | 110 | 1400 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 110 | ND<10 | 29 |
| U-11 | | | | | | | | | | | | |
| 12/9/09 | 22 | ND<50 | ND<50 | 110 | 2500 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 83 | ND<10 | 4.3 |
| U-12 | | | | | | | | | | | | |
| 12/3/08 | 12 | ND<50 | ND<50 | 73 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 24 | ND<10 | 2.6 |
| 2/18/09 | ND<10 | ND<50 | ND<50 | 71 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 12 | ND<10 | 2.3 |
| 6/11/09 | ND<10 | ND<0.05 | ND<50 | 70 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 62 | ND<10 | 2.2 |
| 12/9/09 | ND<10 | ND<50 | ND<50 | 70 | 26 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 10 | ND<10 | 2.7 |
| U-13 | | | | | | | | | | | | |
| 12/3/08 | 21 | ND<50 | ND<50 | 53 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 8.3 |
| 2/18/09 | ND<10 | ND<50 | ND<50 | 52 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 14 |
| 6/11/09 | ND<10 | ND<0.05 | ND<50 | 53 | 12 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 13 |
| 12/9/09 | ND<10 | ND<50 | ND<50 | 45 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 88 |
| U-14 | | | | | | | | | | | | |
| 12/3/08 | 26 | ND<50 | ND<50 | 67 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 15 | ND<10 | 2.6 |
| 2/18/09 | ND<10 | ND<50 | ND<50 | 66 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 2.5 |
| 6/11/09 | ND<10 | ND<0.05 | ND<50 | 64 | 17 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 40 | ND<10 | 2.5 |
| 12/9/09 | ND<10 | ND<50 | ND<50 | 53 | 27 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 10 | ND<10 | 3.1 |
| U-15 | | | | | | | | | | | | |
| 12/3/08 | 12 | ND<50 | ND<50 | 69 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 3.7 |
| 2/18/09 | ND<10 | ND<50 | ND<50 | 62 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 39 |

## Table 2 c
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Copper (total) (µg/l) | Lead (dissolved) (mg/l) | Lead (total) (µg/l) | Magnesium (dissolved) (mg/l) | Manganese (dissolved) (µg/l) | Mercury (total) (µg/l) | Mercury (dissolved) (µg/l) | Molyb-denum (total) (µg/l) | Molyb-denum (dissolved) (µg/l) | Nickel (total) (µg/l) | Nickel (dissolved) (µg/l) | Potassium (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-15 continued | | | | | | | | | | | | |
| 6/11/09 | ND<10 | ND<0.05 | ND<50 | 62 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | ND<10 | ND<10 | 36 |
| 12/9/09 | ND<10 | ND<50 | ND<50 | 70 | ND<10 | ND<0.20 | ND<0.20 | ND<50 | ND<50 | 11 | ND<10 | 41 |

# Table 2 d
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Selenium (total) (µg/l) | Selenium (dissolved) (µg/l) | Silver (total) (µg/l) | Silver (dissolved) (µg/l) | Sodium (mg/l) | Thallium (total) (µg/l) | Thallium (dissolved) (µg/l) | Vanadium (total) (µg/l) | Vanadium (dissolved) (µg/l) | Zinc (dissolved) (µg/l) | Zinc (total) (µg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-2 | | | | | | | | | | | | |
| 3/17/08 | ND<100 | -- | ND<10 | -- | -- | ND<100 | -- | 240 | -- | -- | 590 | -- |
| U-3 | | | | | | | | | | | | |
| 3/17/08 | ND<100 | ND<100 | ND<10 | ND<10 | 41 | ND<100 | ND<100 | 190 | ND<10 | ND<10 | 360 | 14 |
| 6/12/08 | ND<100 | -- | ND<10 | -- | -- | ND<100 | -- | 410 | -- | -- | 970 | -- |
| U-4 | | | | | | | | | | | | |
| 3/17/08 | ND<100 | ND<100 | ND<10 | ND<10 | 35 | ND<100 | ND<100 | 190 | ND<10 | ND<10 | 340 | 37 |
| 6/12/08 | ND<100 | ND<100 | ND<10 | ND<10 | 9.0 | ND<100 | ND<100 | 260 | ND<10 | ND<10 | 420 | 38 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 35 | ND<100 | ND<100 | 230 | ND<10 | ND<10 | 400 | 35 |
| U-5 | | | | | | | | | | | | |
| 3/17/08 | ND<100 | ND<100 | ND<10 | ND<10 | 49 | ND<100 | ND<100 | 60 | ND<100 | ND<10 | 120 | 32 |
| 6/12/08 | ND<100 | ND<100 | ND<10 | ND<10 | 26 | ND<100 | ND<100 | 44 | ND<10 | ND<10 | 87 | 31 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 32 | ND<100 | ND<100 | 93 | ND<10 | ND<10 | 180 | 43 |
| U-6 | | | | | | | | | | | | |
| 3/17/08 | ND<100 | ND<100 | ND<10 | ND<10 | 90 | ND<100 | ND<100 | 15 | ND<10 | ND<10 | 79 | 160 |
| 6/12/08 | ND<100 | ND<100 | ND<10 | ND<10 | 76 | ND<100 | ND<100 | ND<10 | ND<10 | 11 | ND<50 | 190 |
| U-7 | | | | | | | | | | | | |
| 3/17/08 | ND<100 | ND<100 | ND<10 | ND<10 | 68 | ND<100 | ND<100 | 12 | ND<10 | ND<10 | 51 | 91 |
| 6/12/08 | ND<100 | ND<100 | ND<10 | ND<10 | 59 | ND<100 | ND<100 | ND<10 | ND<10 | 11 | ND<50 | 120 |
| 6/11/09 | ND<100 | ND<100 | ND<10 | ND<10 | 62 | ND<100 | ND<100 | ND<10 | ND<10 | 26 | ND<50 | 110 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 64 | ND<100 | ND<100 | 13 | ND<10 | ND<10 | ND<50 | 110 |
| U-8 | | | | | | | | | | | | |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 58 | ND<100 | ND<100 | 96 | ND<10 | ND<10 | 180 | 59 |
| U-9 | | | | | | | | | | | | |

## Table 2 d
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Selenium (total) (µg/l) | Selenium (dissolved) (µg/l) | Silver (total) (µg/l) | Silver (dissolved) (µg/l) | Sodium (mg/l) | Thallium (total) (µg/l) | Thallium (dissolved) (µg/l) | Vanadium (total) (µg/l) | Vanadium (dissolved) (µg/l) | Zinc (dissolved) (µg/l) | Zinc (total) (µg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-9 continued | | | | | | | | | | | | |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 84 | ND<100 | ND<100 | ND<10 | ND<10 | ND<10 | 55 | 100 |
| U-10 | | | | | | | | | | | | |
| 6/11/09 | -- | ND<100 | -- | ND<10 | 170 | -- | ND<100 | -- | ND<10 | 24 | -- | 110 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 130 | ND<100 | ND<100 | 16 | ND<10 | ND<10 | ND<50 | 47 |
| U-11 | | | | | | | | | | | | |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 67 | ND<100 | ND<100 | 19 | ND<10 | ND<10 | ND<50 | 70 |
| U-12 | | | | | | | | | | | | |
| 12/3/08 | ND<100 | ND<100 | ND<10 | ND<10 | 49 | ND<100 | ND<100 | ND<10 | ND<10 | 26 | ND<50 | 85 |
| 2/18/09 | ND<100 | ND<100 | ND<10 | ND<10 | 48 | ND<100 | ND<100 | ND<10 | ND<10 | 13 | ND<50 | 86 |
| 6/11/09 | ND<100 | ND<100 | ND<10 | ND<10 | 50 | ND<100 | ND<100 | ND<10 | ND<10 | 30 | ND<50 | 91 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 51 | ND<100 | ND<100 | ND<10 | ND<10 | ND<10 | ND<50 | 83 |
| U-13 | | | | | | | | | | | | |
| 12/3/08 | ND<100 | ND<100 | ND<10 | ND<10 | 59 | ND<100 | ND<100 | ND<10 | ND<10 | ND<10 | ND<50 | 95 |
| 2/18/09 | ND<100 | ND<100 | ND<10 | ND<10 | 65 | ND<100 | ND<100 | ND<10 | ND<10 | ND<10 | ND<50 | 96 |
| 6/11/09 | ND<100 | ND<100 | ND<10 | ND<10 | 66 | ND<100 | ND<100 | ND<10 | ND<10 | 29 | ND<50 | 100 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 110 | ND<100 | ND<10 | ND<10 | ND<10 | ND<10 | ND<50 | 82 |
| U-14 | | | | | | | | | | | | |
| 12/3/08 | ND<100 | ND<100 | ND<10 | ND<10 | 48 | ND<100 | ND<100 | ND<10 | ND<10 | 43 | 69 | 85 |
| 2/18/09 | ND<100 | ND<100 | ND<10 | ND<10 | 47 | ND<100 | ND<100 | ND<10 | ND<10 | 24 | 53 | 84 |
| 6/11/09 | ND<100 | ND<100 | ND<10 | ND<10 | 47 | ND<100 | ND<100 | ND<10 | ND<10 | 34 | ND<50 | 86 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 41 | ND<100 | ND<100 | ND<10 | ND<10 | 21 | 64 | 66 |
| U-15 | | | | | | | | | | | | |
| 12/3/08 | ND<100 | ND<100 | ND<10 | ND<10 | 48 | ND<100 | ND<100 | ND<10 | ND<10 | 36 | 54 | 87 |
| 2/18/09 | ND<100 | ND<100 | ND<10 | ND<10 | 78 | ND<100 | ND<100 | ND<10 | ND<10 | ND<10 | ND<50 | 86 |

## Table 2 d
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Selenium (total) (µg/l) | Selenium (dissolved) (µg/l) | Silver (total) (µg/l) | Silver (dissolved) (µg/l) | Sodium (mg/l) | Thallium (total) (µg/l) | Thallium (dissolved) (µg/l) | Vanadium (total) (µg/l) | Vanadium (dissolved) (µg/l) | Zinc (dissolved) (µg/l) | Zinc (total) (µg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-15 continued | | | | | | | | | | | | |
| 6/11/09 | ND<100 | ND<100 | ND<10 | ND<10 | 76 | ND<100 | ND<100 | ND<10 | ND<10 | 24 | ND<50 | 92 |
| 12/9/09 | ND<100 | ND<100 | ND<10 | ND<10 | 80 | ND<100 | ND<100 | ND<10 | ND<10 | ND<10 | 52 | 85 |

## Table 2 e
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Conductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **U-1** | | | | | | | | | | | |
| 12/30/02 | -- | -- | -- | -- | -- | -- | -- | 0.60 | -- | -- | 91 |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 0.50 | -- | -- | 90 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 0.60 | -- | -- | 110 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 3.79 | -- | -- | 329 |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 12.36 | -- | -- | 184 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 10.56 | -- | -- | 213 |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 6.62 | -- | -- | 251 |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 2.66 | -- | -- | 68 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 3.12 | -- | -- | 091 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 8.84 | -- | -- | 153 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 2.26 | -- | -- | 187 |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 7.74 | -- | -- | 159 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 4.02 | 3.88 | 036 | 016 |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 7.05 | 5.50 | 008 | 007 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 4.24 | 4.66 | 203 | 200 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 4.24 | 4.56 | 1.97 | 2.00 |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 6.58 | 6.98 | 107 | 102 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 4.98 | 4.85 | 20 | 34 |
| 3/17/08 | -- | -- | -- | -- | -- | -- | -- | 3.12 | 2.43 | 151 | 153 |
| **U-2** | | | | | | | | | | | |
| 10/1/02 | -- | -- | -- | -- | -- | -- | -- | 1.40 | -- | -- | -- |
| 12/30/02 | -- | -- | -- | -- | -- | -- | -- | 2.80 | -- | -- | 120 |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 150.00 | -- | -- | 120 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 1.20 | -- | -- | 110 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 5.61 | -- | -- | 321 |

## Table 2 e
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Conductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-2 continued | | | | | | | | | | | |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 12.11 | -- | -- | - 6 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 11.39 | -- | -- | 259 |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 7.46 | -- | -- | 238 |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 3.57 | -- | -- | 132 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 4.57 | -- | -- | 024 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 8.08 | -- | -- | 230 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 5.47 | -- | -- | 188 |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 8.33 | -- | -- | 177 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 4.80 | 6.20 | -004 | 002 |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 6.20 | 4.51 | 040 | 046 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 3.70 | 3.49 | -31 | -17 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 3.70 | 3.45 | -29 | -20 |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 10.05 | 10.31 | 90 | 95 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 3.87 | 4.21 | -63 | -41 |
| 9/23/07 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -133 | -48 |
| 3/17/08 | -- | -- | -- | 600 | -- | -- | -- | 3.31 | 3.13 | 154 | 153 |
| 6/12/08 | -- | -- | -- | -- | -- | -- | -- | -- | 8.32 | 177 | -- |
| U-3 | | | | | | | | | | | |
| 10/1/02 | -- | -- | -- | -- | -- | -- | -- | 0.50 | -- | -- | - 47 |
| 12/30/02 | -- | -- | -- | -- | -- | -- | -- | 0.20 | -- | -- | 106 |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 0.50 | -- | -- | 85 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 0.50 | -- | -- | 90 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 3.80 | -- | -- | - 27 |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 12.82 | -- | -- | 133 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 3.11 | -- | -- | 24 |

# Table 2 e
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Con- ductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-3 continued | | | | | | | | | | | |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 1.90 | -- | -- | 53 |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 1.30 | -- | -- | -81 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 0.52 | -- | -- | -087 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 1.47 | -- | -- | -151 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 1.40 | -- | -- | -80 |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 1.45 | -- | -- | -068 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 1.53 | 0.79 | 003 | 009 |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 2.19 | 3.56 | 015 | 017 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 1.06 | 1.10 | -72 | -95 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 1.04 | 1.10 | -83 | -96 |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 7.08 | 6.99 | 78 | 68 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 4.89 | 4.79 | -79 | -82 |
| 9/23/07 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -114 | -88 |
| 3/17/08 | 0.073 | ND<0.44 | ND<1.0 | 530 | -- | -- | -- | 2.88 | 1.96 | -5 | -33 |
| 6/12/08 | -- | -- | -- | -- | -- | -- | -- | 0.11 | 1.30 | -17 | -40 |
| 12/9/09 | -- | -- | -- | -- | 781 | 6.95 | 16.7 | -- | -- | -- | -- |
| U-4 | | | | | | | | | | | |
| 10/1/02 | -- | -- | -- | -- | -- | -- | -- | 1.00 | -- | -- | 83 |
| 12/30/02 | -- | -- | -- | -- | -- | -- | -- | 0.40 | -- | -- | 126 |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 0.70 | -- | -- | 120 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 0.60 | -- | -- | 130 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 2.06 | -- | -- | 3.05 |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 11.90 | -- | -- | 76 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 3.30 | -- | -- | 116 |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 2.50 | -- | -- | 32 |

## Table 2 e
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Con-ductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-4 continued | | | | | | | | | | | |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 2.09 | -- | -- | 47 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 0.04 | -- | -- | 021 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 2.24 | -- | -- | 120 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 3.01 | -- | -- | 176 |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 1.96 | -- | -- | 175 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 1.17 | 1.48 | 015 | 014 |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 2.55 | 1.31 | 031 | 034 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 1.38 | 1.23 | -54 | -7 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 1.38 | 1.13 | -60 | -10 |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 7.09 | 7.28 | 14 | 25 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 2.82 | 2.62 | 82 | 73 |
| 3/17/08 | 0.12 | 0.61 | 29 | 540 | -- | -- | -- | 2.47 | 2.71 | 153 | 150 |
| 6/12/08 | 0.14 | ND<0.44 | 30 | 610 | -- | -- | -- | 1.26 | 4.00 | 185 | 188 |
| 12/9/09 | 0.096 | 0.59 | 37 | 590 | 927 | 7.55 | 15.5 | 1.82 | -- | -- | -84 |
| U-5 | | | | | | | | | | | |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 0.60 | -- | -- | 120 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 0.90 | -- | -- | 145 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 2.21 | -- | -- | 3.13 |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 11.27 | -- | -- | 104 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 3.35 | -- | -- | 65 |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 2.87 | -- | -- | 66 |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 1.67 | -- | -- | 102 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 0.75 | -- | -- | 131 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 2.29 | -- | -- | 103 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 2.05 | -- | -- | 172 |

## Table 2 e
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Con-ductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-5 continued | | | | | | | | | | | |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 1.39 | -- | -- | 171 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 0.97 | 0.97 | 011 | 013 |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 7.18 | 7.23 | 091 | 084 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 1.19 | 0.80 | 44 | 44 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 1.12 | 0.79 | 41 | 47 |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 3.20 | 3.60 | 31 | 52 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 2.01 | 1.67 | 66 | 58 |
| 3/17/08 | 0.086 | 3.8 | 31 | 530 | -- | -- | -- | 2.91 | 1.98 | 151 | 156 |
| 6/12/08 | 0.070 | 1.8 | 26 | 550 | -- | -- | -- | 1.89 | 1.22 | 172 | 171 |
| 12/9/09 | 0.17 | ND<0.44 | 30 | 530 | 792 | 7.40 | 18.2 | 1.12 | -- | -- | -101 |
| U-6 | | | | | | | | | | | |
| 10/1/02 | -- | -- | -- | -- | -- | -- | -- | 0.90 | -- | -- | -- |
| 12/30/02 | -- | -- | -- | -- | -- | -- | -- | 0.20 | -- | -- | 88 |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 0.90 | -- | -- | 145 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 0.70 | -- | -- | 120 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 2.26 | -- | -- | 12 |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 11.95 | -- | -- | - 37 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 3.47 | -- | -- | - 20 |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 3.25 | -- | -- | - 43 |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 0.94 | -- | -- | -91 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 0.55 | -- | -- | -077 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 0.86 | -- | -- | -129 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 1.97 | -- | -- | -82 |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 1.01 | -- | -- | -66 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 0.79 | 1.25 | 011 | 009 |

# Table 2 e
# ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Con-ductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-6 continued | | | | | | | | | | | |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 1.23 | 5.48 | 015 | 027 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 6.97 | 7.05 | -67 | -69 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 0.83 | 1.05 | -65 | -69 |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 6.40 | 6.26 | 15 | 9 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 3.51 | 3.20 | -64 | -54 |
| 3/17/08 | 0.066 | ND<0.44 | 51 | 860 | -- | -- | -- | 1.19 | 1.87 | 101 | 26 |
| 6/12/08 | 0.11 | 0.45 | 27 | 860 | -- | -- | -- | 1.10 | 2.08 | -20 | -26 |
| U-7 | | | | | | | | | | | |
| 10/1/02 | -- | -- | -- | -- | -- | -- | -- | 1.80 | -- | -- | - 60 |
| 12/30/02 | -- | -- | -- | -- | -- | -- | -- | 0.10 | -- | -- | 121 |
| 5/2/03 | -- | -- | -- | -- | -- | -- | -- | 0.40 | -- | -- | 105 |
| 7/1/03 | -- | -- | -- | -- | -- | -- | -- | 0.50 | -- | -- | 95 |
| 10/3/03 | -- | -- | -- | -- | -- | -- | -- | 2.91 | -- | -- | - 21 |
| 1/8/04 | -- | -- | -- | -- | -- | -- | -- | 11.85 | -- | -- | - 51 |
| 4/15/04 | -- | -- | -- | -- | -- | -- | -- | 4.68 | -- | -- | - 16 |
| 7/15/04 | -- | -- | -- | -- | -- | -- | -- | 2.55 | -- | -- | - 52 |
| 12/8/04 | -- | -- | -- | -- | -- | -- | -- | 1.20 | -- | -- | -88 |
| 3/23/05 | -- | -- | -- | -- | -- | -- | -- | 0.21 | -- | -- | -088 |
| 6/28/05 | -- | -- | -- | -- | -- | -- | -- | 1.32 | -- | -- | -160 |
| 9/23/05 | -- | -- | -- | -- | -- | -- | -- | 2.25 | -- | -- | 108 |
| 12/30/05 | -- | -- | -- | -- | -- | -- | -- | 1.12 | -- | -- | 105 |
| 3/24/06 | -- | -- | -- | -- | -- | -- | -- | 1.09 | 0.99 | 008 | 009 |
| 6/26/06 | -- | -- | -- | -- | -- | -- | -- | 1.46 | 1.27 | 025 | 032 |
| 9/26/06 | -- | -- | -- | -- | -- | -- | -- | 0.78 | 1.02 | -47 | -63 |
| 11/21/06 | -- | -- | -- | -- | -- | -- | -- | 0.88 | 0.98 | -43 | -59 |

## Table 2 e
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Conductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-7 continued | | | | | | | | | | | |
| 3/26/07 | -- | -- | -- | -- | -- | -- | -- | 5.85 | 6.00 | 14 | 8 |
| 6/27/07 | -- | -- | -- | -- | -- | -- | -- | 2.98 | 2.60 | -90 | -102 |
| 3/17/08 | 0.077 | ND<0.44 | 7.0 | 640 | -- | -- | -- | 3.06 | 2.86 | 137 | 120 |
| 6/12/08 | 0.15 | 19 | 13 | 700 | -- | -- | -- | 0.98 | 2.27 | 9 | -11 |
| 6/11/09 | ND<0.050 | ND<0.44 | 30 | 490 | -- | -- | -- | -- | -- | -- | -- |
| 12/9/09 | 0.12 | ND<0.44 | 13 | 510 | 772 | 7.27 | 17.0 | 0.94 | -- | -- | 23 |
| U-8 | | | | | | | | | | | |
| 12/9/09 | 0.19 | ND<0.44 | 4.1 | 630 | 972 | 7.87 | 16.6 | 2.06 | -- | -- | -78 |
| U-9 | | | | | | | | | | | |
| 12/9/09 | 0.30 | ND<0.44 | ND<1.0 | 860 | 1203 | 6.94 | 13.5 | 1.29 | -- | -- | -10 |
| U-10 | | | | | | | | | | | |
| 6/11/09 | 0.49 | ND<0.44 | 190 | 970 | -- | -- | -- | -- | -- | -- | -- |
| 12/9/09 | 0.33 | ND<0.44 | 76 | 880 | 1009 | 7.04 | 17.9 | 0.94 | -- | -- | -77 |
| U-11 | | | | | | | | | | | |
| 12/9/09 | 0.26 | ND<0.44 | 4.9 | 700 | 896 | 7.47 | 17.3 | 1.39 | -- | -- | 91 |
| U-12 | | | | | | | | | | | |
| 12/3/08 | 0.14 | 28 | 59 | 630 | -- | -- | -- | 2.85 | 2.71 | 66 | 26 |
| 2/18/09 | 0.086 | 29 | 61 | 610 | 1007 | 7.82 | 18.2 | 2.74 | 2.65 | 145 | 121 |
| 6/11/09 | 0.13 | 29 | 61 | 610 | -- | -- | -- | -- | -- | -- | -- |
| 12/9/09 | 0.20 | 26 | 57 | 550 | 813 | 7.75 | 17.1 | 2.51 | -- | -- | 62 |
| U-13 | | | | | | | | | | | |
| 12/3/08 | 0.16 | 26 | 65 | 610 | -- | -- | -- | 1.70 | 2.21 | 62 | 58 |
| 2/18/09 | 0.20 | 26 | 69 | 510 | 1022 | 7.75 | 18.0 | 1.49 | 1.52 | 171 | 110 |
| 6/11/09 | 0.14 | 25 | 71 | 550 | -- | -- | -- | -- | -- | -- | -- |

## Table 2 e
## ADDITIONAL HISTORIC ANALYTICAL RESULTS
## 76 Station 4186

| Date Sampled | Fluoride (mg/l) | Nitrogen as Nitrate (mg/l) | Sulfate (mg/l) | TDS (mg/l) | Field Conductivity (µS/cm) | Field pH (pH unit) | Field Temp. (deg. C) | Post-purge Dissolved Oxygen (mg/l) | Pre-purge Dissolved Oxygen (mg/l) | Pre-purge ORP (mV) | Post-purge ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| U-13 continued | | | | | | | | | | | |
| 12/9/09 | 0.15 | 22 | 59 | 600 | 820 | 7.61 | 16.6 | 1.65 | -- | -- | -52 |
| U-14 | | | | | | | | | | | |
| 12/3/08 | 0.14 | 25 | 55 | 660 | -- | -- | -- | 2.63 | 2.96 | 91 | 59 |
| 2/18/09 | 0.13 | 25 | 57 | 560 | 950.4 | 7.70 | 18.4 | 2.25 | 2.55 | 106 | 113 |
| 6/11/09 | 0.11 | 25 | 56 | 600 | -- | -- | -- | -- | -- | -- | -- |
| 12/9/09 | 0.084 | 26 | 44 | 460 | 776 | 7.90 | 17.9 | 1.66 | -- | -- | -22 |
| U-15 | | | | | | | | | | | |
| 12/3/08 | 0.13 | 21 | 52 | 670 | -- | -- | -- | 2.21 | 2.55 | 108 | 118 |
| 2/18/09 | 0.12 | 23 | 54 | 570 | 962.4 | 7.66 | 17.4 | 1.98 | 1.95 | 109 | 104 |
| 6/11/09 | 0.12 | 22 | 55 | 560 | -- | -- | -- | -- | -- | -- | -- |
| 12/9/09 | 0.17 | 18 | 52 | 560 | 831 | 7.85 | 15.1 | 1.98 | -- | -- | -84 |