Environmental Security Technology Certification Program (ESTCP)

Final Report
Fiber Optic Biosensors for Contaminant Monitoring
ESTCP Project Number ER-0115

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Table of Contents

Appendices

List of Figures

List of Tables

Acronyms

µg/L	microgram per liter
1,1,2-TCA	1,1,2-trichloroethane
1,2-DCA	1,2-dichloroethane
bgs	below ground surface
CDM	Camp Dresser & McKee Inc.
CSU	Colorado State University
DCM	dichloromethane
DoD	Department of Defense
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
LNAPL	light non-aqueous phase liquid
M	molar
mL	milliliter
mm	millimeter
mM	micromolar
nm	nanomolar
OU 8	Operable Unit 8
PWIA	Public Works Industrial Area
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
Qva	Vashon Advance Outwash
Qvt	Vashon Till
RPD	relative percent difference
SUBASE Bangor	Bangor Naval Submarine Base, Washington
TCE	trichloroethene
UST	underground storage tank
VOA	volatile organic analyte
VOC	volatile organic compound

Preface

This report describes the demonstration of a novel analytical technology: fiber optic-based biosensors for detecting groundwater contaminants in the field in near-real time. The report describes the demonstration of biosensors at a Department of Defense (DoD) site as well as supplemental development of additional biosensors.

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Fiber Optic Biosensor Demonstration
(ESTCP Project Number CU-0115)

Executive Summary

Significant costs are associated with laboratory analyses of groundwater samples collected at Department of Defense (DoD) sites. The majority of these samples are needed to characterize the nature and extent of contamination at a site, evaluate remedial system performance and track contaminant plume migration via regularly scheduled monitoring events. A need exists to replace laboratory analyses with reliable, easy-to-use field methods that produce real time results. Colorado State University (CSU) has developed fiber optic biosensors that are ideally suited for field monitoring of groundwater contaminants. Generally, a biosensor is a device that utilizes a biological recognition element (typically enzymes or antibodies) to sense the presence of an analyte and create a response that is converted by a transducer to an electrical or optical signal.

The primary issue regarding the use of biosensors is reliability (i.e., are biosensor results comparable to laboratory analyses?). The end-user also needs to know whether there are conditions that affect the reliability of biosensor performance. Lastly, biosensors need to be easy to use and calibrate so that reproducible results can be obtained from different users. The demonstration described in this document was designed to address these issues. The overall objective of the biosensor demonstration was to provide a basis to justify the use of biosensors to augment or replace conventional analytical methods for measuring selected compounds in groundwater. Specific objectives included:

- Demonstrate the accuracy, reliability and cost of biosensors
- Demonstrate the effectiveness of on-site field measurements using biosensors
- Determine operational limits associated with using the biosensors
- Transfer the biosensor technology to end-users

Biosensors were used to analyze groundwater sampled from several monitoring wells at Operable Unit 8 (OU 8) of the Naval Submarine Base in Kipsap County, Washington (SUBASE Bangor) to evaluate biosensor performance under a range of conditions. The target analyte was 1, 2-dichloroethane (1,2-DCA). Groundwater samples were collected from monitoring wells spaced throughout the plume to analyze a wide range of 1,2-DCA and co-contaminant concentrations. Groundwater samples were analyzed by biosensors and gas chromatography/ mass spectroscopy (GC/MS). A flow-through cell was also set up to allow biosensor readings in flowing water similar to the setup typically used to collect pH, conductivity and turbidity readings prior to monitoring well sampling. Lastly, biosensors were lowered into monitoring wells to record down hole *in situ* readings.

Performance of the biosensors was evaluated based on the following criteria:

- **Accuracy** as demonstrated by a one-to-one correlation between the two analytical techniques (conventional GC/MS and biosensors).
- **Range** as demonstrated by a response from less than 5 µg/L to greater than 500 µg /L 1,2-DCA.
- **Precision** as demonstrated by a low relative percent difference (RPD) between duplicate analyses.
- **Sample throughput** as demonstrated by short analysis time in the field
- **Mechanical reliability** as demonstrated by a low incidence of failure.
- **Versatility** as demonstrated by acceptable performance under a variety of conditions.

Two performance levels were established with regard to the data that the biosensors might be used to collect:

Level 1: Semi-quantitative screening concentration data
Moderate accuracy
Moderate quantitation limit
Moderate specificity and selectivity

Level 2: Quantitative concentration data
High accuracy
Low quantitation limit
High specificity and selectivity

The interference of parameters affecting the pH of the groundwater being measured impacted how the biosensor performed against several performance criteria, including accuracy, precision, sensitivity, and range. This is because the biosensor measures small pH changes produced by the reaction of an enzyme with 1,2-DCA and techniques are required to distinguish these pH changes from pH changes due to other processes. For vial measurements, this interference can be significantly reduced by proper calibration. However, for flow-through cell and down-hole measurements, calibration procedures have not been developed to reduce the pH interference. At the present level of development, the biosensors would most appropriately be used to provide semi-quantitative data regarding 1,2-DCA concentrations in groundwater.

The biosensors can be used to collect Level 2, quantitative data when used in the vial measurement mode; however, further investigation into development and testing of the biosensors is required for them to be reliable field instruments for all of the applications originally intended.

1.0 Introduction

1.1 Background

Significant costs are associated with laboratory analyses of groundwater samples collected at Department of Defense (DoD) sites. The majority of these samples are needed to characterize the nature and extent of contamination at a site, evaluate remedial system performance and track contaminant plume migration via regularly scheduled monitoring events. A need exists to replace laboratory analyses with reliable, easy-to-use field methods that produce real time results. Colorado State University (CSU) has developed fiber optic biosensors that are ideally suited for field monitoring of groundwater contaminants. Generally, a biosensor is a device that utilizes a biological recognition element (typically enzymes or antibodies) to sense the presence of an analyte and create a response that is converted by a transducer to an electrical or optical signal.

Use of biosensors at DoD sites would provide a cost effective user-friendly approach for providing accurate contaminant analyses at low microgram per liter (μg/L) levels. In addition, biosensors would allow for *in situ* vertical profiling of contaminant concentrations within a monitoring well. This information would be valuable for identifying depth intervals that are primary migration pathways for contaminants.

1.2 Objectives of the Demonstration

The overall objective of the demonstration was to provide a basis to justify the use of biosensors to augment, or in some cases replace, the use of conventional analytical methods for measuring some compounds in groundwater.

Specific objectives of the field demonstration included:

- Demonstrate the accuracy, reliability and cost of biosensor
- Demonstrate the effectiveness of on-site field measurements using biosensors
- Determine operational limits associated with using the biosensors
- Transfer the biosensor technology to end-users

1.3 Regulatory Drivers

At most DoD sites a regulatory requirement exists to monitor groundwater quality before, during and after implementation of a remedial system. This requirement coupled with the number and average size of DoD sites results in a significant number of groundwater samples that are collected for laboratory analyses. A significant cost savings could be realized if a field method of analysis that provides real time results could be used in place of some of these analyses.

1.4 Stakeholder/End-User Issues

The primary issue regarding the use of biosensors is reliability (i.e., are biosensor results comparable to laboratory analyses?) The end-user also needs to know whether there are

conditions that affect the reliability of biosensor performance. Lastly, biosensors need to be easy to use and calibrate so that reproducible results can be obtained from different users. The demonstration discussed in this document was designed to address these issues.

2.0 Technology Description

2.1 Technology Development and Application

2.1.1 Description of Biosensor

The CSU biosensor is a two-layer detection element immobilized on the tip of an optical fiber (Figures 2-1 and 2-2). The outer layer of the detection element contains bacteria with an enzyme that catalyzes a reaction with the analyte resulting in protons being released. The inner detection layer contains a pH-sensitive fluorescent dye (fluoresceinamine). Thus, the presence of the contaminant leads to a pH change on the fiber tip, which can be measured as a change in fluorescence intensity (Figure 2-3). Since the change in fluorescence depends on the contaminant concentration, these optical, enzymatic biosensors provide quantitative output.

Many enzymes catalyze reactions that result in a pH change. CSU researchers have worked primarily with the class of enzymes known as hydrolytic dehalogenases, which catalyze the introduction of water into a halogenated organic compound with the production of a hydrohalide (e.g., hydrochloric acid) (Figure 2-4). However, a biosensor based on organophosphorous hydrolase has also been developed to detect members of the organophosphorous family (which includes many nerve agents).

One of the advantages of fiber optic sensors is their small size, typically about 1 millimeter (mm) in diameter (Figure 2-5). These optical sensors can be used at much longer distances than electronic sensors because signal loss in optical fibers is extremely low. In the field, the fiber optic biosensors can be lowered into a small well (e.g., Geoprobe well) for measurement.

Research on this biosensor concept began at CSU in 1995 and the viability of the sensor concept was first demonstrated in 1996 with development of a biosensor for 1,2-DCA. Research from 1996 to 1998 focused on a biosensor for EDB and characterization of the detection limits, stability, and effects of interfering chemicals for that biosensor. From 1998-2000, research was directed at the development of a biosensor for atrazine and the extension of the usable lifetime of the biosensor. During this period, the first soil column tests were also performed. Since 2000, a focus of the development work has been the refinement of the optical hardware and improving aspects of the system that will lead to increased sensitivity and robustness of the biosensor technology.

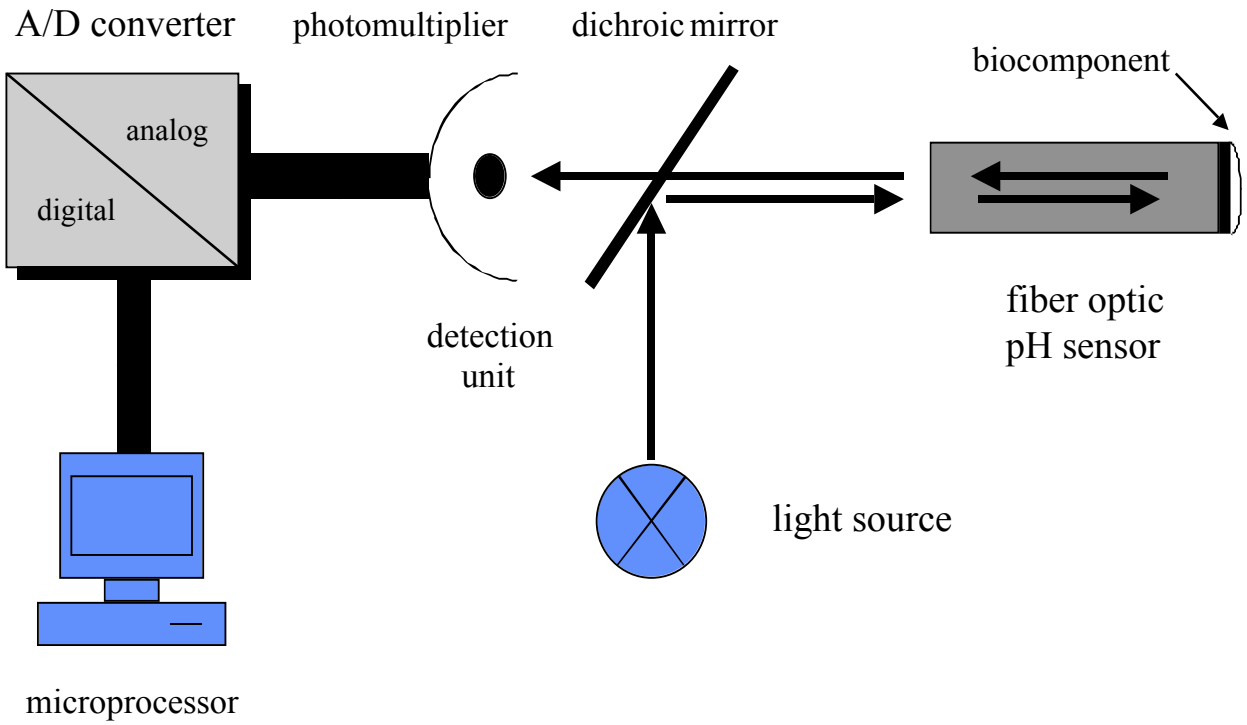


Figure 2-1. Schematic of the fiber optic biosensor system.

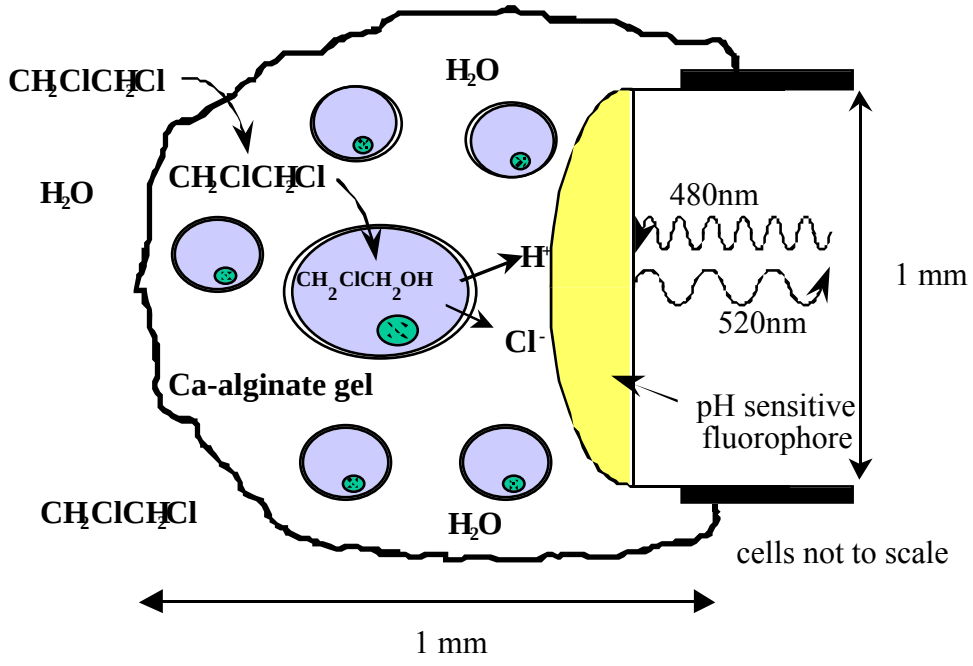


Figure 2-2. Schematic of the 2-layer detection element of the CSU biosensor, illustrated for the ethylene dibromide biosensor. The pH-sensitive fluorophore is excited with 480-nm light and emits fluorescence at 520 nm, which is transmitted along the optical fiber to a photomultiplier.

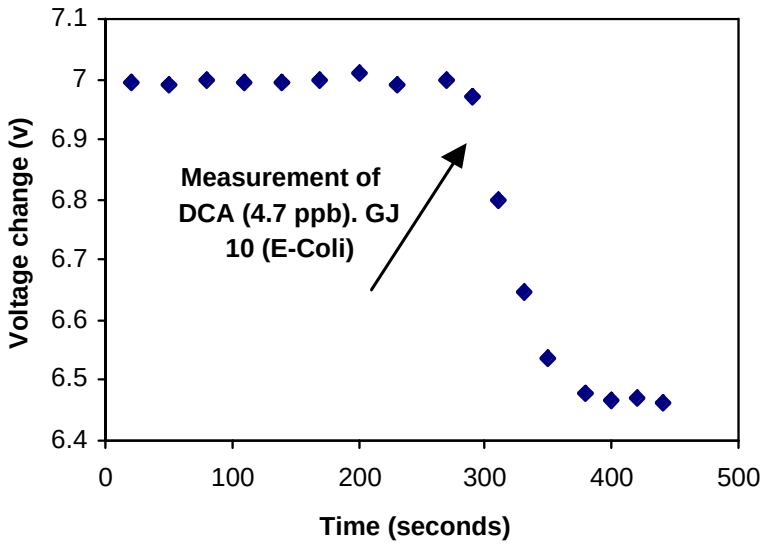


Figure 2-3. Biosensor response (as photomultiplier voltage change) following a change in analyte concentration.

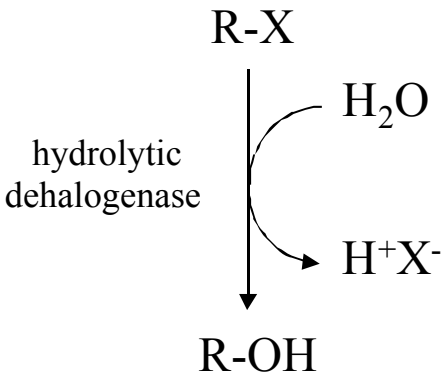


Figure 2-4. Reactions catalyzed by hydrolytic dehalogenases produce protons which change the pH of the environment near the enzyme.

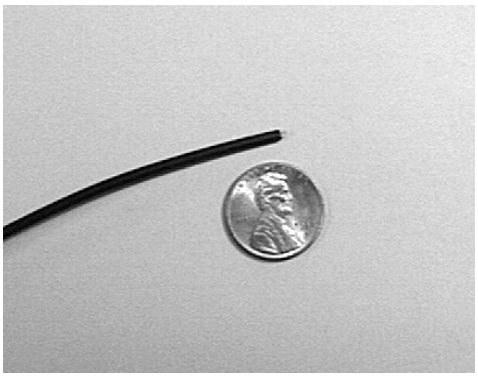


Figure 2-5. Photograph of a fiber optic biosensor; the functional tip with immobilized pH indicator and cells is directly over the coin.

2.1.2 Technology Development

2.1.2.1 Biosensor Construction Protocols

Standard method

Biosensors consist of a layer of calcium-alginate-entrapped cells or purified enzymes, in direct contact with a layer of a pH-sensitive fluorophore immobilized on one end of an optical fiber (Figure 2-6). Optical fibers coated only with fluorophore are termed pH optodes. To prepare these pH optodes, the cladding of fibers was removed from 1 mm of the distal end of the optical fiber, and then polished with very fine grit paper. A pH-sensitive fluorophore was affixed to the distal end of the fiber optic cable. The fluorophore, fluoresceinamine, was first coupled to polyvinyl alcohol (PVA) using cyanuric chloride, and the resulting product was cross-linked with glutaraldehyde in presence of HCl to form a hydrogel that was applied subsequently to the polished optical fiber tip by using a micropipette. After polymerization, the resulting pH optode was stored in 0.1 M Na_2HPO_4 at room temperature.

Figure 2-6. Fiber optic biosensor. One end of the optical fiber is coated by a pH-sensitive fluorophore which in turn is covered by cells or enzymes entrapped in Ca-alginate.

Two types of biosensors were developed and tested. The large majority of tests, including all field tests, were performed with biosensors in which the dehalogenase enzymes (the biocomponent) were immobilized within intact cells, taken directly from a cultivation. To prepare the second type of biosensor, these cells were disrupted and the dehalogenase enzyme removed and purified; only pure enzyme was immobilized on the tip of the biosensor. This

purified enzyme biosensor was constructed to determine whether it would have advantages in terms of sensitivity, response time, and specificity.

Whole cell biosensors were created by entrapping a small amount of concentrated cells in a calcium alginate hydrogel on the fluorophore end of a pH optode. Previously cultured cells were combined with a 4% sodium alginate solution to give a mixture at a desired ratio. Five microliters of this gel mixture were deposited on the end of a pH optode. The resulting biosensor was immediately immersed in ice-cold 0.47 M $CaCl_2$ for 30 minutes, placed into a buffered measurement solution (BMS) [1mM beta-morpholino-ethansulfonic acid monohydrate (MES) + 25 Mm $CaCl_2$ + 150 mM NaCl] and stored at 4°C.

Enzyme biosensors were created by entrapping pure enzymes in a calcium alginate hydrogel on the fluorophore end of a pH optode. Enzymes were previously isolated from cells by a special procedure consisting of disrupting fresh cells by sonication to get a cell-free extract that is purified on a Ni-nitrilotriacetic acid Sepharose column HR 16/10. The pure enzymes were combined with 4% sodium alginate solution to give a mixture at a desired ratio. The subsequent steps to create an enzyme biosensor are similar to those for preparation of whole cell biosensors.

Glutaraldehyde cross-linking

Biosensors were treated with the cross-linking agent glutaraldehyde to improve their physical stability. Biosensors were suspended in 6 M glutaraldehyde for 30 min at room temperature with stirring. The treated biosensors were washed with deionized water and stored at 4^oC in measurement solution until used.

The treatment improved the stability of biosensors, but lowered the diffusion of analyte and product in and out of the gel matrix, resulting in a slight decrease in the sensitivity of the biosensors.

Fluorophore performance

The performance of the pH-sensitive fluorophore was studied by depositing different amounts of cross-linked fluorophore on the tip of optical fibers (Figure 2-7). The response of the pH optode ($\Delta V/\Delta pH$) increased linearly with amounts of PVA-immobilized fluorophore less than 37.5 mg but was constant at higher amounts (Figure 2-7). Depositing large amounts of fluorophore (and polymer) on pH optode tips was found to decrease the sensor response time. Therefore, pH optodes with 37.5 mg of fluorophore were used subsequently for optimal biosensor response. The sensitivity of pH optodes was expressed per pH unit change as determined by testing in 1 mM MES solutions at pH values of 6.8 and pH 6.7 ($\Delta pH = 0.1$).

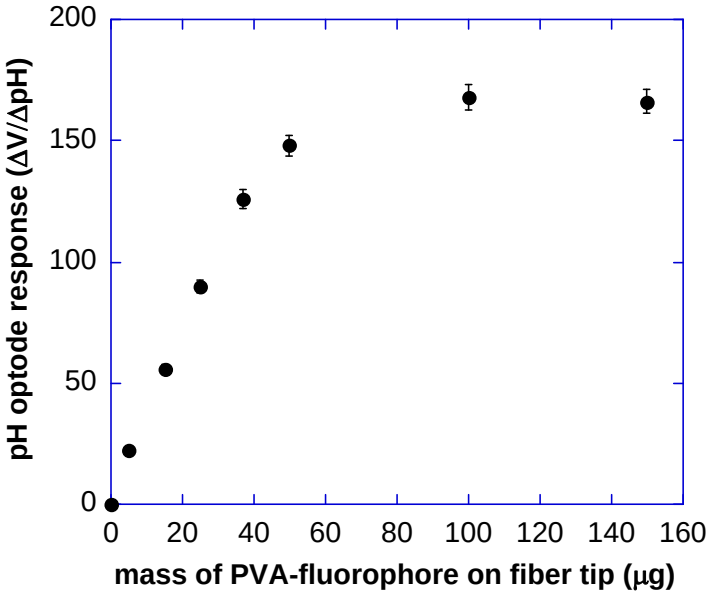


Figure 2-7. Response of pH optodes with different masses of immobilized polymer-fluorophore preparation. Each point is the average of three measurements; error bars represent one standard deviation.

Cells on the biosensor

The effect of the cell concentration in the Ca-alginate layer of the biosensors was also investigated. As a test case, *E. coli* cells expressing atrazine chlorohydrolase (AtzA) were combined with Ca-alginate hydrogel in different ratios. Figure 2-8 shows the biosensor response to atrazine (15.5 μg/L) as a function of the percent of cells in the Ca-alginate layer at the optical fiber tip. As the biocomponent concentration was increased from 10 to 85% – decreasing the Ca-alginate concentration from 90 to 15%, respectively – the biosensor response (DV) increased proportionally. Cells at 90% in Ca-alginate or at higher percent did not remain affixed to the fiber tip. Cells at 67% in Ca-alginate were used subsequently to ensure a good attachment of cells to the tip of the pH optode as well as high sensitivities.

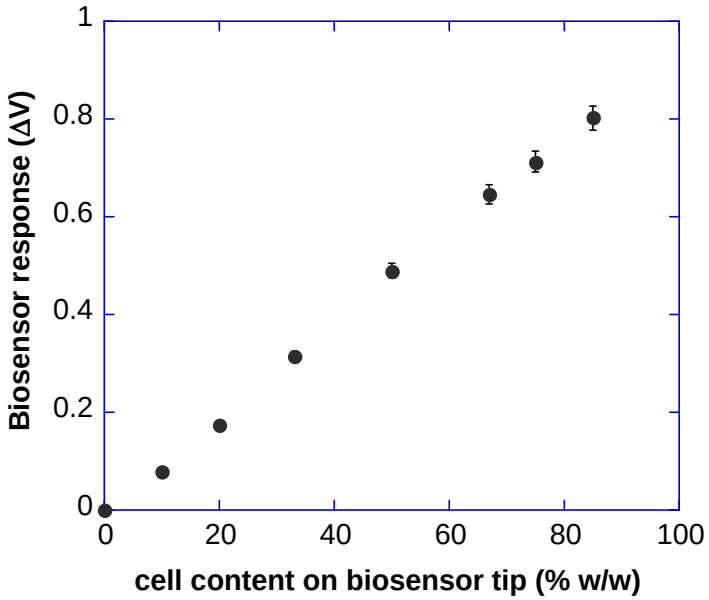


Figure 2-8. Biosensor response to atrazine (15.5 ppb) at different levels of *E. coli* DH5a pMD4 cells immobilized in Ca-alginate. Cells prepared at different percents in Ca-alginate were affixed to the tip of a pH optode that had a sensitivity of 25 V/pH. Each point is the average of three measurements; error bars represent one standard deviation.

2.1.2.2. Biosensor measurement protocols

Standard vial measurements

Biosensor experiments were performed in a 4.85-mL vial containing BMS at pH 7. The vial was covered with black tape to prevent interference by external light. To obtain a desired concentration of analyte in the vial, a known volume of analyte standard solution prepared in BMS at pH 7 was added to the vial using a syringe. The increase in analyte concentration resulted in a pH decrease at the biosensor tip and therefore a decrease in fluorescence intensity, recorded as a voltage decrease from the instrument photomultiplier tube (PMT). This response (voltage change, DV) could be related to the analyte concentration change in the vial. Continuous stirring in the vial ensured complete mixing. Control tests were conducted using a biosensor containing only Ca-alginate (no cells), using biosensors made with *E. coli* TG1 cells that cannot transform the tested analytes, and injecting analyte-free BMS into the vial.

pH correction

Since the biosensor measurements are based on pH changes, it is necessary to make sure that the measurement is based on the interaction of enzymes with the analyte and not by other effects (such as pH variation between the pH of the matrix and that of the analyte standard or the sample injected in the vial).

For a biosensor measurement in an aqueous matrix of unknown pH, an observed response (fluorescence intensity change recorded as PMT voltage change) can be expressed as:

$$R_{EB,obs} = R_{EB}^{*} + R_{EB,pH}$$

where $R_{EB,obs}$ is the observed response of the biosensor; R_{EB}^{*} is the response of a biosensor that is directly due to the dehalogenation of the analyte; and $R_{EB,pH}$ is the response of the biosensor that is due to a pH change in the measurement solution caused by the addition of a standard or analyte at a different pH.

$R_{EB,pH}$ was determined using information from a pH optode measurement in the same matrix. Since the pH optode does not measure analyte concentrations, the observed signal is:

$$R_{opt,obs} = R_{opt,pH}$$

Where $R_{opt,obs}$ is the observed response of the pH optode and $R_{opt,pH}$ is the response due to any solution pH change. The sensitivities of pH optodes and biosensors are not the same and must be calibrated by measuring their responses to identical pH changes (e.g., HCl in BMS). From this, the pH response ratio K_{pH} is determined as:

$$K_{pH} = R_{opt,pH} / R_{EB,pH}$$

Thus, the procedure for making pH corrections using a biosensor/pH optode pair for which K_{pH} is known is to use the biosensor to measure a set of standards and unknowns, then to use the pH optode to measure the identical set of samples. The corrected biosensor response for each measurement is calculated as:

$$R_{EB}^{*} = R_{EB,obs} - R_{opt,obs}/K_{pH}$$

Mass correction

For biosensor measurements of volatile analytes, the measurement vial was kept full to eliminate volatilization to the headspace. Before any injection in the vial, the same volume that was to be injected was first removed. This meant that some analyte mass was removed, and a simple mass balance calculation was performed to correct for this removal.

2.1.2.3. Development of biosensors for different analytes

Biosensors based on different strains of bacteria were developed to measure a wide range of analytes (Table 2-1, Figures 2-9 through 2-16).

Table 2-1. Biosensors developed in this project. Limit of detection (LOD) was estimated from the response curve for that biosensor

Analyte	Bacterial strain	Enzyme	Estimated LOD	Concentration range tested
1,2-dichloroethane (DCA)	*E. coli* BL21 (DE3) pGELAF	DhlA dehalogenase LinB dehalogenase	< 4 ppt (ng/L)	(0.1 - 1000) ppt
	E. coli HB101 pAQN		< 1 ppb (µg/L)	(0.035 – 35) ppb
1,2- dibromoethane (ethylene dibromide, EDB)	*E. coli* HB101 pAQN	LinB dehalogenase	< 5 ppt	(0.1– 1000) ppt
trichloroethene (TCE)	*E. coli* HB101 pAQN	LinB dehalogenase	< 0.5 ppb	(0.25 – 35) ppb
Tetrachloroethene (perchloroethene, PCE)	*E. coli* HB101 pAQN	LinB dehalogenase	< 0.5 ppb	(0.1 – 1000) ppt
cis-1,2-dichloroethene (DCE)	*E. coli* HB101 pAQN	LinB dehalogenase	< 0.5 ppb	(0.1 – 1000) ppt
1-chlorohexane	*E. coli* HB101 pAQN	LinB dehalogenase	< 1 ppb	(0.025 – 75) ppb
lindane	*E. coli* HB101 pAQN	LinB dehalogenase	< 1 ppb	(0.025 – 75) ppb
dichloromethane (DCM)	*E. coli* BL21 (DE3) pAQN	DhlA dehalogenase	< 25 ppb	(1 – 1000) ppb
	E. coli DH5a pME1983	DcmA dehalogenase	< 10 ppb	(1 – 750) ppb
paraoxon	*E. coli* XL1-Blue pPNCO33	Oph Organophosphorous hydrolase	< 1 ppt	(0.015 – 500) ppt

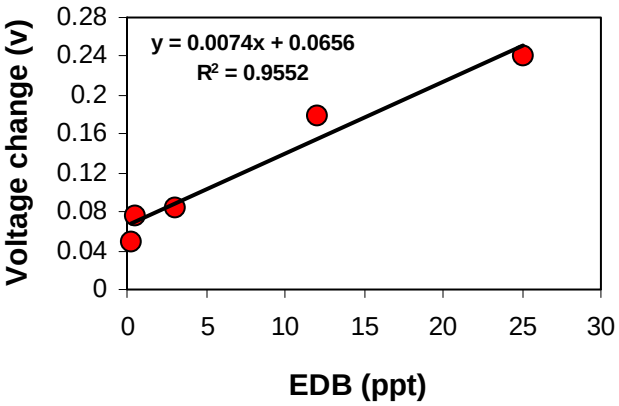


Figure 2-9. Calibration curve for an EDB biosensor [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase]

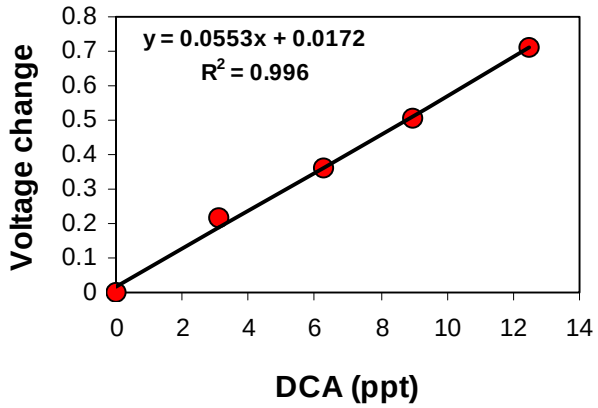


Figure 2-10a. Calibration curve for a DCA biosensor [*E. coli* strain BL21 (DE3) pGELAF

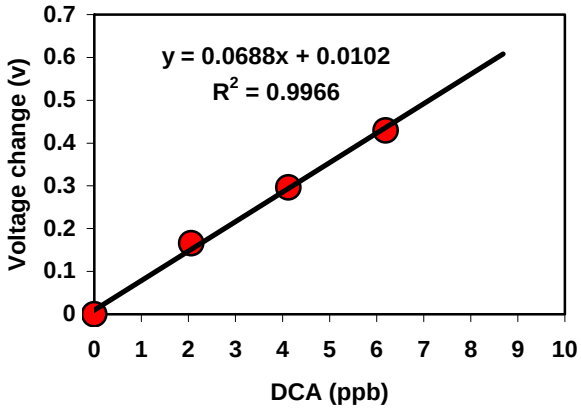


Figure 2-10b. Calibration curve for a DCA biosensor [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase].

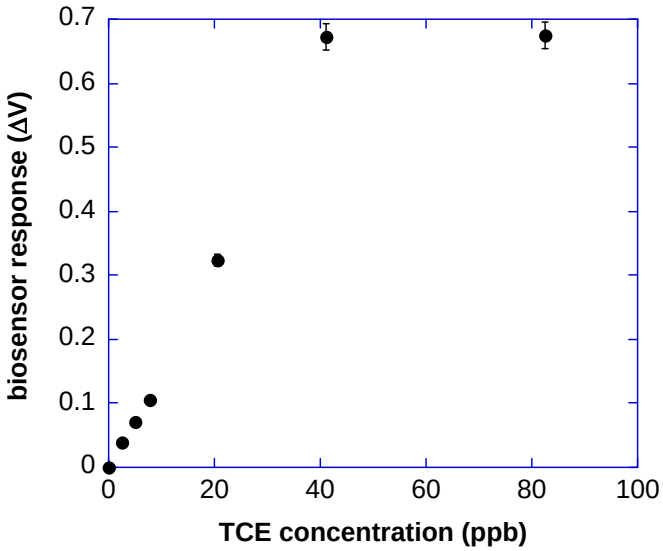


Figure 2-11. Calibration curve for a TCE biosensor [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase]. Error bars represent one standard deviation of triplicate measurements.

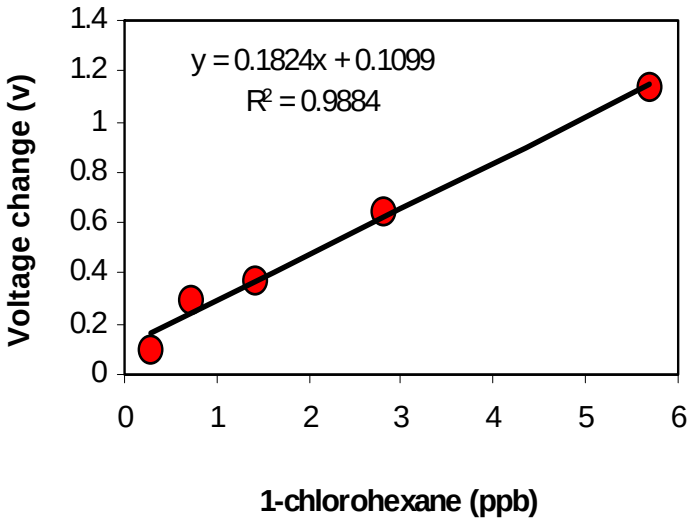


Figure 2-12. Calibration curve for a 1-chlorohexane biosensor [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase]

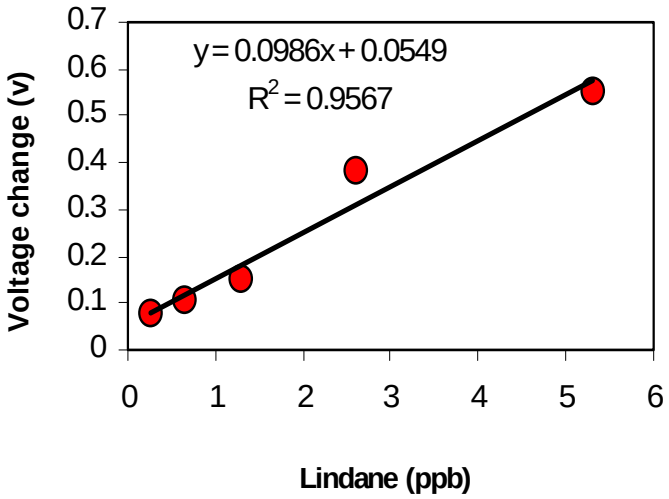


Figure 2-13. Calibration curve for a Lindane biosensor [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase]

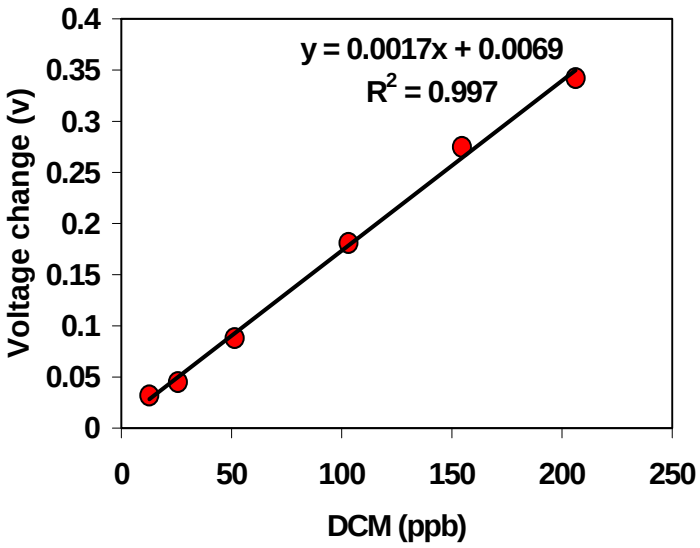


Figure 2-14. Calibration curve for a DCM (dichloromethane) biosensor [*E. coli* strain DH5a (pME1983) expressing DcmA dehalogenase]

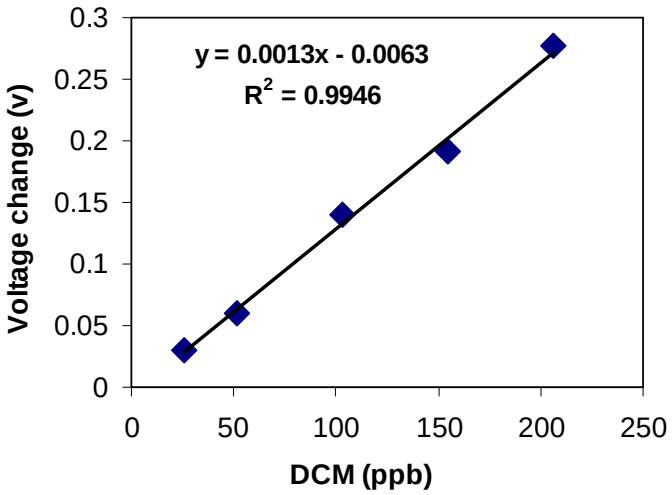


Figure 2-15. Calibration curve for a DCM biosensor [*E. coli* strain BL21 (DE3) expressing DhlA dehalogenase]

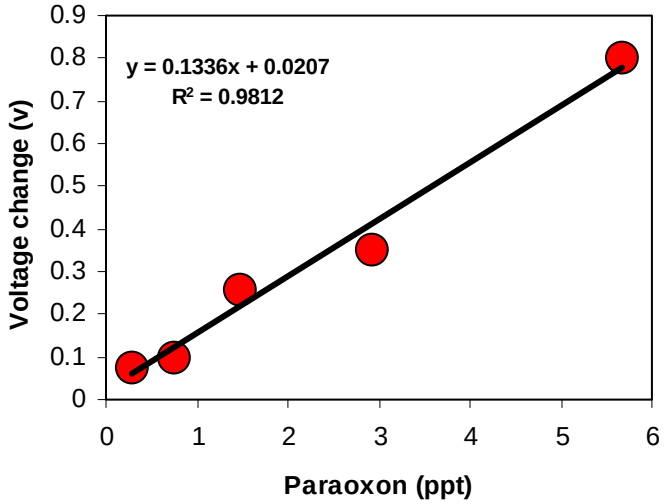


Figure 2-16. Calibration curve for Paraoxon biosensor [*E. coli* strain XL1-Blue (pPNCO33) expressing organophosphorous hydrolase (OPH)]

2.1.2.4. Influence of Environmental Parameters

pH

The effect of pH on the biosensor response is shown in Figure 2-17. The biosensor response increased up to pH 7 and then decreased as the sample became more basic. The maximum response was in the range of pH values 6.5-7.5. Since dehalogenases have maximum activity at pH 8 - 8.5, the cause of the decrease in sensitivity is the fluorophore. In fact, the pH optimum range of 3.5 - 7 was reported for the fluoresceinamine fluorescence response. Fort this reason, laboratory tests were performed at a pH value of 7.0 unless otherwise noted. Higher pH ranges could readily be achieved by using a different fluorophore.

Temperature

The biosensor response was temperature sensitive (Figure 2-18) increasing from 15 to 35^{o}C but declining rapidly with further temperature increase. This temperature effect on biosensor response could be attributed to the increase of both the enzyme reaction and mass transfer rates. At higher temperatures (> 45^{o}C), enzyme denaturation occurs. Standard laboratory biosensor experiments were done at room temperature.

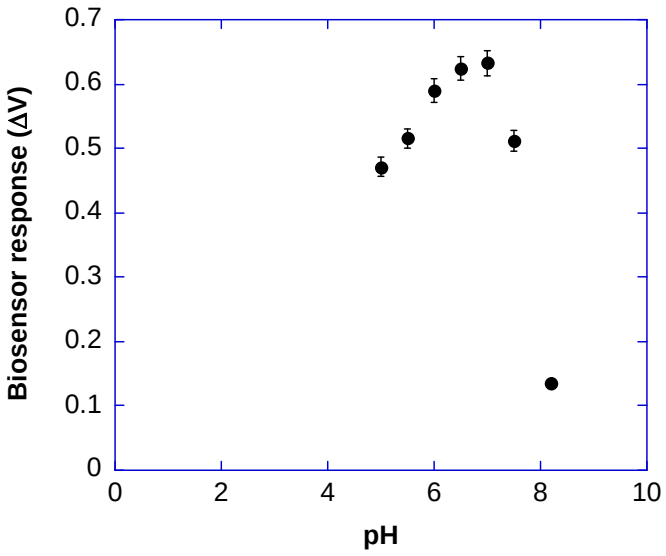


Figure 2-17. Effect of pH on biosensor response to 20.6 ppb DCA (in 1mM HEPES + 25 mM NaCl + 150mM $CaCl_2$). Error bars represent one standard deviation from triplicate measurements.

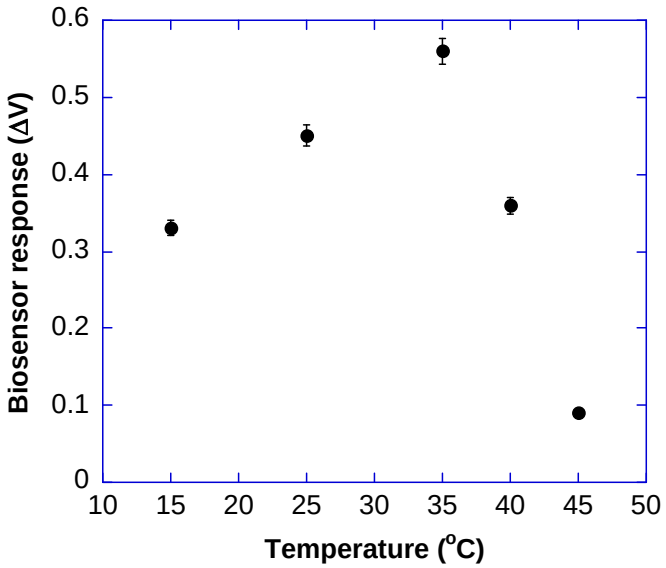


Figure 2-18. Effect of temperature on biosensor response to 3 ppb atrazine [*E. coli* strain DH5a (pMD4) expressing AtzA chlorohydrolase]. Error bars represent one standard deviation from triplicate measurements.

Ionic strength
The effect of the sample's ionic strength on biosensor response was studied at both high (brine) and low (groundwater) ranges.

Low ionic strength
The response of biosensors to DCA in different dilutions of the standard BMS was studied to provide information on the effect of low ionic strength, which is important for determining whether the biosensors can be effective in typical ground waters. Figure 2-19 shows the biosensor measurements of DCA in the different solutions. The response of the DhlA-based biosensors to DCA was not affected by ionic strength over the range evaluated. The measurement solution used had a TDS concentration of 11.6 g/L and thus the 1% solution contained 116 mg/L. Groundwater TDS generally ranges from 100 to 1,000 mg/L.

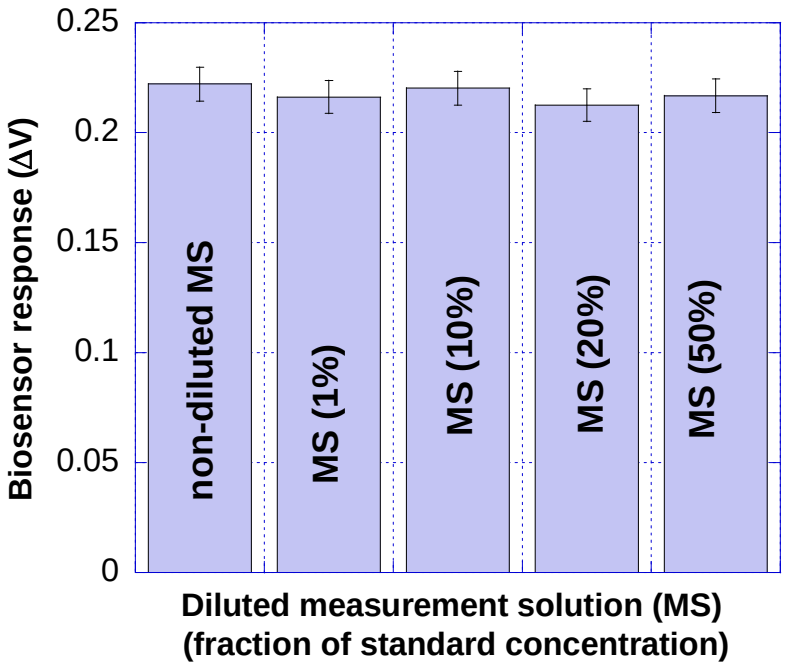


Figure 2-19. Effect of dilution measurement solution (MS) (9 g/L NaCl + 2.7 g/L $CaCl_2$) on biosensor response to DCA at 20.6 ppb [*E. coli* strain BL21 (DE3) expressing DhlA dehalogenase]. All the MS dilutions were prepared with deionized water. The BMS was prepared by combining each of the diluted MS with 1 mM MES buffer. Error bars represent one standard deviation of triplicate measurements.

High salt (NaCl) content
The response of biosensors in different measurement solutions containing high concentrations of NaCl was also studied (Figure 2-20). No effect was noted up to 20 g/L (for comparison, sea water has total dissolved solids of approximately 30 g/L).

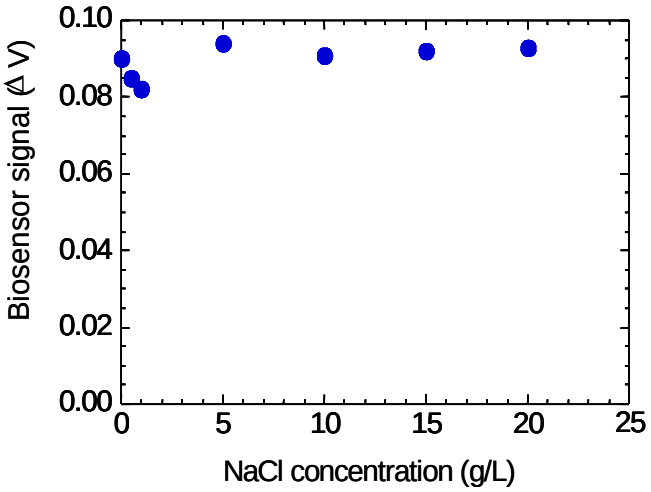


Figure 2-20. Effect of NaCl on biosensor response to atrazine at 13 ppb. [*E. coli* strain DH5a (pMD4) expressing AtzA chlorohydrolase]

Oxygen

To determine the effect of oxygen on biosensor measurements, oxygen levels in the measurement solution were changed by sparging with air or N_2. Figure 2-21 shows the biosensor responses to DCA in unsparged BMS, BMS sparged with air, and BMS sparged with N_2. The pH was constant after sparging the measurement solutions with air or N_2. The response of DhlA-based biosensors to DCA was not affected by the concentration of dissolved oxygen.

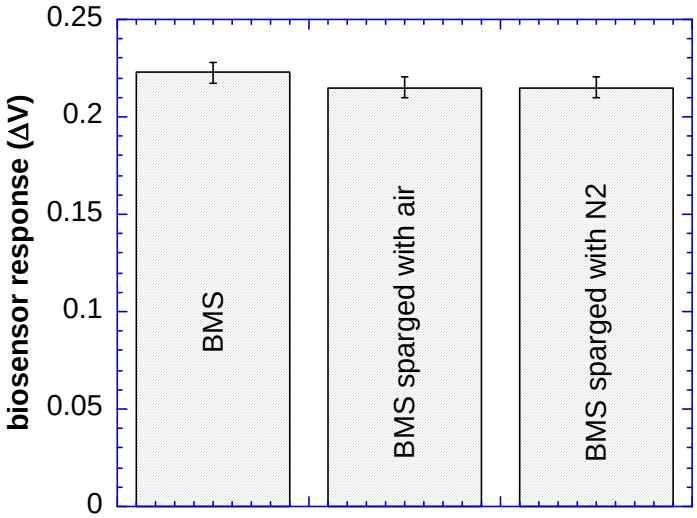


Figure 2-21. Effect of sparging the measurement solution with air or N_2 (1 mM MES+25 mM $CaCl_2$ + 150 mM NaCl) on biosensor response to DCA at 20.6 ppb [*E. coli* strain BL21 (DE3) expressing DhlA dehalogenase]. Error bars represent one standard deviation from triplicate measurement.

Buffer capacity

The biosensor response was studied in buffered measurement solutions representing different buffer capacities. When a buffering agent is present, the basic buffer ions neutralize part of the enzymatically-generated protons. Thus, little free acid is produced resulting in a smaller biosensor response. However, biosensors retained good sensitivity even at the buffer capacities normally present in ground water.

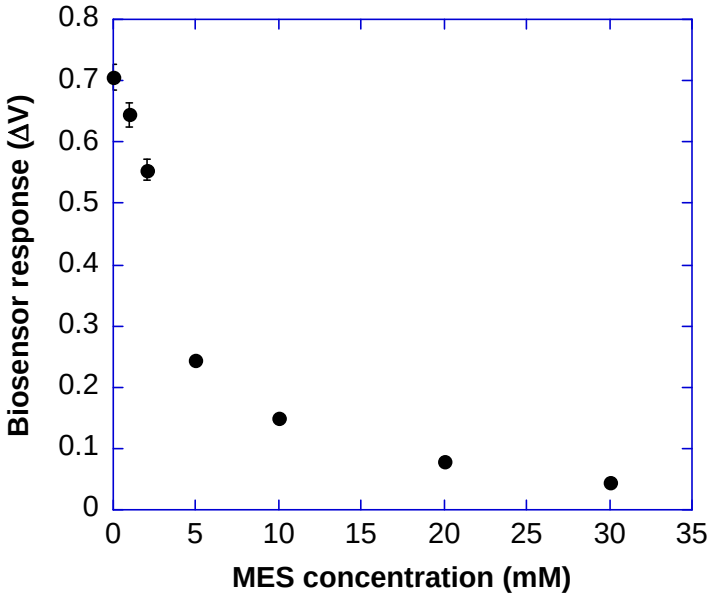


Figure 2-22. Effect of buffer capacity on biosensor response to atrazine at 15.5 ppb [*E. coli* strain DH5a (pMD4) expressing AtzA chlorohydrolase]. Tests were done in measurement solution with the indicated concentration of MES buffer at pH 7 and room temperature. Error bars represent one standard deviation from triplicate measurements.

2.1.2.5. Selectivity and Specificity

The goal of these studies was to determine whether certain co-contaminants would affect the measurement of the target analyte. Co-contaminants of two types were tested: those that are chemically dissimilar and not expected to be transformed by the dehalogenase enzyme (but which might alter the enzyme activity) and those that were potential or known dehalogenase substrates.

Results for dissimilar co-contaminants are shown in Figures 2-23 and 2-24. No effect of metals (Cd and Cr), aromatic hydrocarbons (benzene and toluene), or naturally occurring organic compounds (acetate and amino acids) was observed.

Some biosensors responded to several analytes. The LinB dehalogenase was found to be relatively nonspecific, producing biosensors for DCA (Figure 2-10b), EDB (Figure 2-9), Lindane

(Figure 2-13), 1-chlorohexane (Figure 2-12), and TCE,/PCE/*cis*-1,2-DCE (Figure 2-25). In the latter case, the response to PCE was about 50% greater than to TCE or *cis*-1,2-DCE.

DhlA dehalogenase-based biosensors responded to both DCM (Figure 2-15) and DCA (Figure 2-26), but they showed no response to the structurally similar EDB (Figure 2-27).

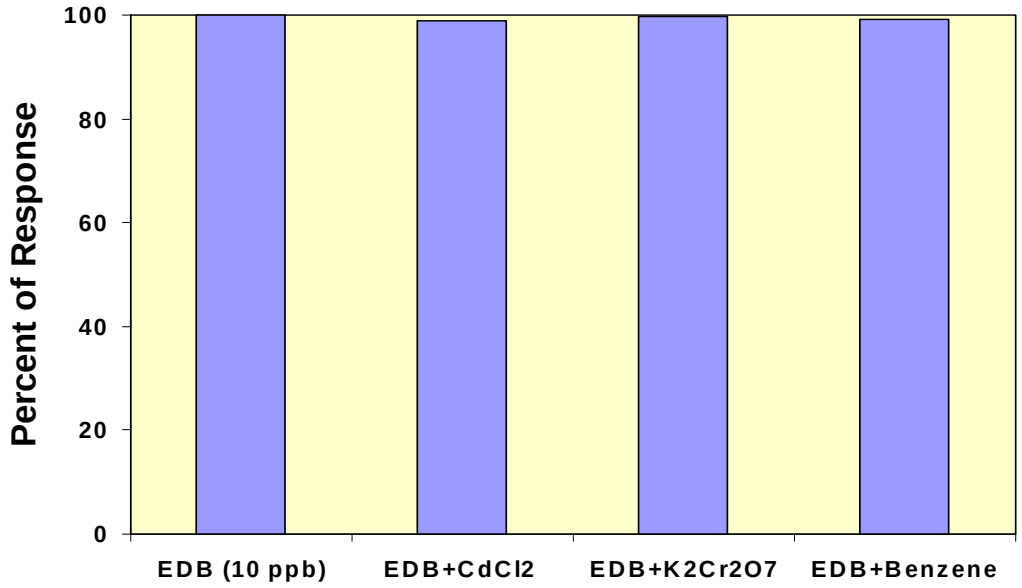


Figure 2-23. Selectivity of biosensor response to EDB at 10 ppb in measurement solutions containing different metals (1 ppm) and benzene (100 ppm) [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase].

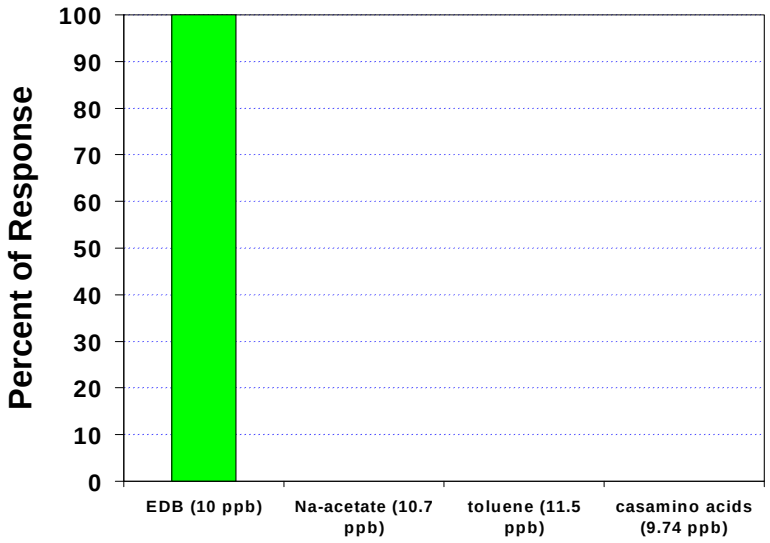


Figure 2-24. Specificity of biosensor response to EDB at 10 ppb in measurement solutions containing different contaminants [*E. coli* strain HB101 (pAQN) expressing LinB dehalogenase].

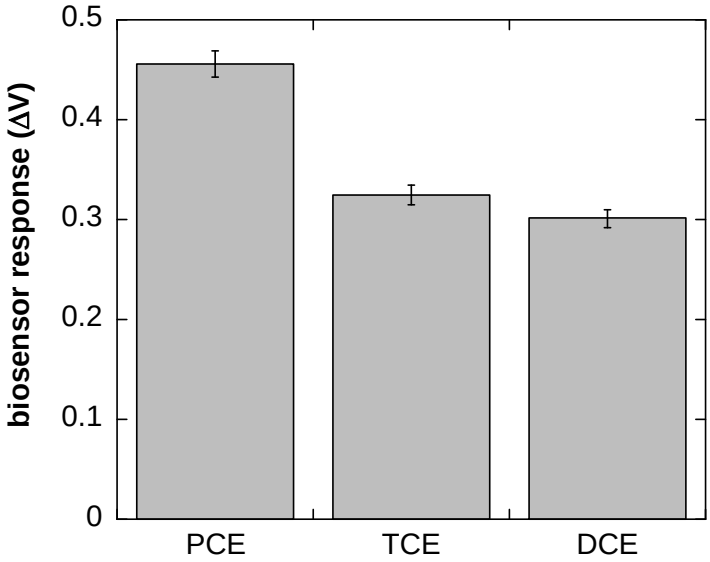


Figure 2-25. Relative biosensor response to different chlorinated compounds each at 20.6 ppb. Biosensors were based on *E. coli* strain HB101 (pAQN) expressing LinB dehalogenase. Error bars represent one standard deviation of triplicate measurements.

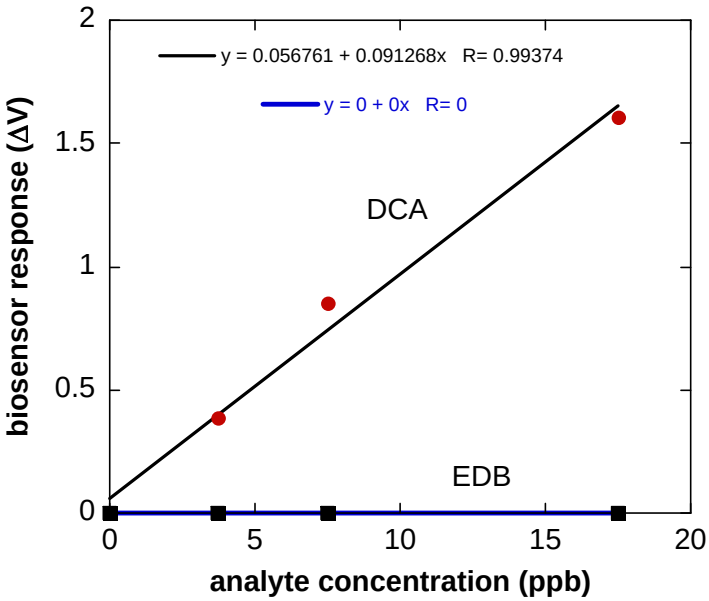


Figure 2-26. Calibration curve for a biosensor toward DCA [*E. coli* strain BL21 (DE3) expressing DhlA dehalogenase]. The same DhlA biosensor showed no response to EDB.

2.1.2.6. Purified Enzyme Biosensors

Biosensors based on purified enzymes were developed by immobilizing the enzymes in Ca-alginate hydrogel. The mass ratio of enzyme to Ca-alginate was 1 to 10. Although the detection limits achieved with this biosensor were not as low as for the whole-cell case, this result is significant because further development of purified enzyme biosensors could reduce certain non-specific responses and allow for further miniaturization of the sensors.

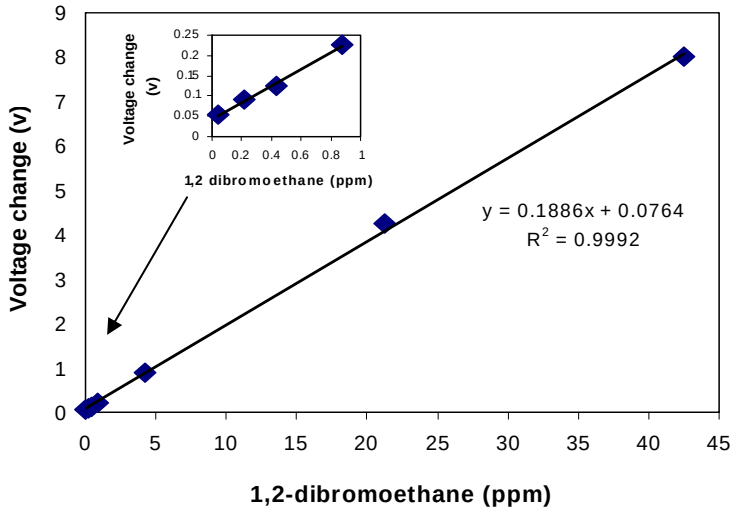


Figure 2-27. Response of biosensors based on purified LinB dehalogenase to 1,2-dibromoethane.

2.1.2.7. Stability

Since the biosensor technology is based on biological activity, the stability of the sensor output (activity retention of the enzyme) is a valid concern. However, since this biosensor concept does not require the cells to be alive (no cofactor such as NADH is required for the detection reaction), practical biosensor lifetimes should be achievable. Furthermore, for some applications (e.g., sentry wells), accurate concentration determination is less important than the capability to provide a yes/no response. Several laboratory tests indicate that multi-month lifetimes are possible (Figures 2-28 and 2-29).

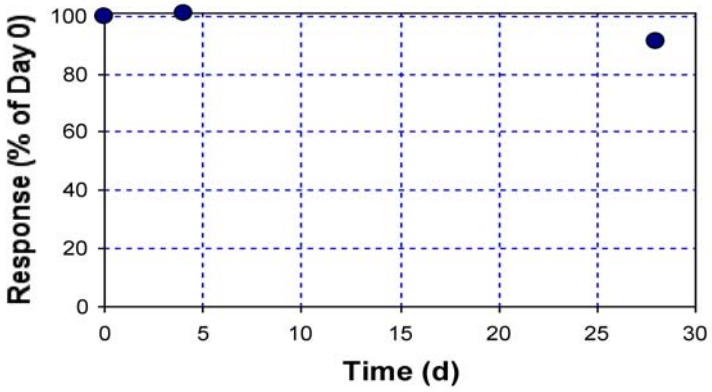


Figure 2-28. Activity retention by a Paraoxon biosensor in a laboratory test (response to 0.8 ppt Paraoxon). The biosensor was stored at 4°C between measurements.

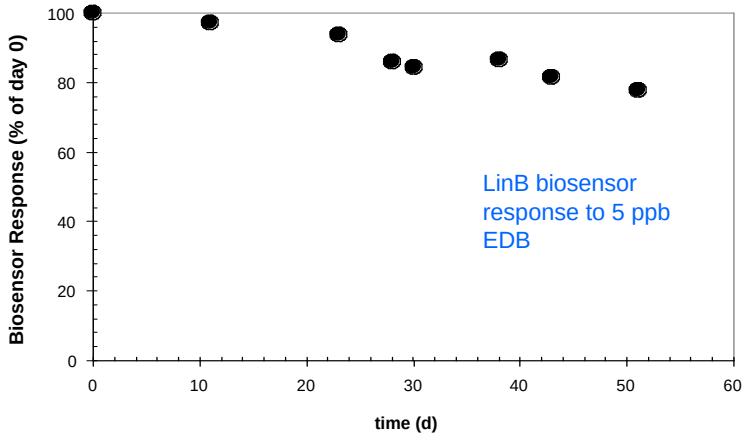


Figure 2-29. Activity retention by an EDB biosensor in a laboratory test. The biosensor was stored at 4°C between measurements.

2.1.2.8 Laboratory Samples Analyzed by Biosensors and Gas Chromatography

Samples for biosensor and GC analysis were prepared by dilution of pure chemical. GC samples were sent to Pace Analytical (Lenexa, KS) and analyzed for VOCs by EPA Method 8260b. Biosensor samples were analyzed as described above after preparation of a calibration curve using separate standards. Table 2-2 presents the results of the analysis of these samples for both methods.

Table 2-2. Results of Analysis of Laboratory Samples Using Biosensors and Gas Chromatography

Compound	GC Result (µg/L)	Biosensor Result (µg/L)
1,2-DCA	1.6	1.2
1,2-DCA	11	10.4
1,chlorohexane	<0.36	0.83
cis-1,2-dichlorethene	<0.36	0.86
trichloroethene	11	10.5
tetrachloroethene	3.2	2.3
ethylene dibromide	18	16.7

2.2 Previous Testing of the Technology

No significant field testing of the biosensors was performed prior to the ESTCP demonstrations.

2.3 Factors Affecting Cost and Performance

Issues that may arise when this technology is transferred to the field include sensor stability, and sensor durability. Strategies to address each of these problems are described below:

- Sensor Stability: Laboratory test results suggest that active lifetimes of the biosensors can exceed one month. This period could be extended by overcoming the causes of activity loss, and might include strategies such as heat treatment and expression of enzymes on the cell surface (to minimize protease attack), engineering or selecting more stable enzymes and loading the tip with a higher cell concentration. Ultimately, the most promising approach is to express the enzyme on the surface of the cells. However, the biosensor tips can easily be replaced with new tips which cost approximately $0.25 to produce.

- Sensor Durability: To date calcium alginate gel has been used to coat the biosensors. One strategy for increasing biosensor durability is to coat the outside of the alginate with a second, more durable polymer such as polyethyleneimine. This coating may lengthen the response time slightly but may also increase activity retention in addition to making the sensor more suitable for field use.

The primary performance issues that were validated in these field demonstrations were the ability of the biosensors to: function accurately as a repeat analytical device (to replace or supplement traditional field sampling and offsite lab analysis), and provide discrete-depth measurements instead of the well-averaged values obtained with traditional methods.

2.4 Advantages and Limitations of the Technology

In situ measurements by fiber optic biosensors could be used to reduce costs at DoD sites in at least three scenarios. First, biosensors could be used to monitor groundwater contaminant concentrations in existing plumes, either by permanent installation of wells for monitoring over

time or by analyses of wells at discrete time points. Second, biosensors could be placed in sentinel wells between a plume and a receptor to detect offsite contaminant migration. Finally, they could be used for site characterization -- as soon as a Geoprobe or well is placed, a biosensor could be used to determine the contaminant concentration and the results used to direct the placement of subsequent wells.

Relative to traditional, discrete sampling approaches, biosensors have the following advantages:

- The capability of providing low cost, simultaneous measurements at different depths in a well (i.e., spatial resolution); currently, average values over a screened interval are obtained because discrete interval monitoring, although more informative, is too expensive and complicated.

- The capability of providing low cost, continuous monitoring (i.e., temporal resolution); current methods rely on single periodic measurements that may not be representative

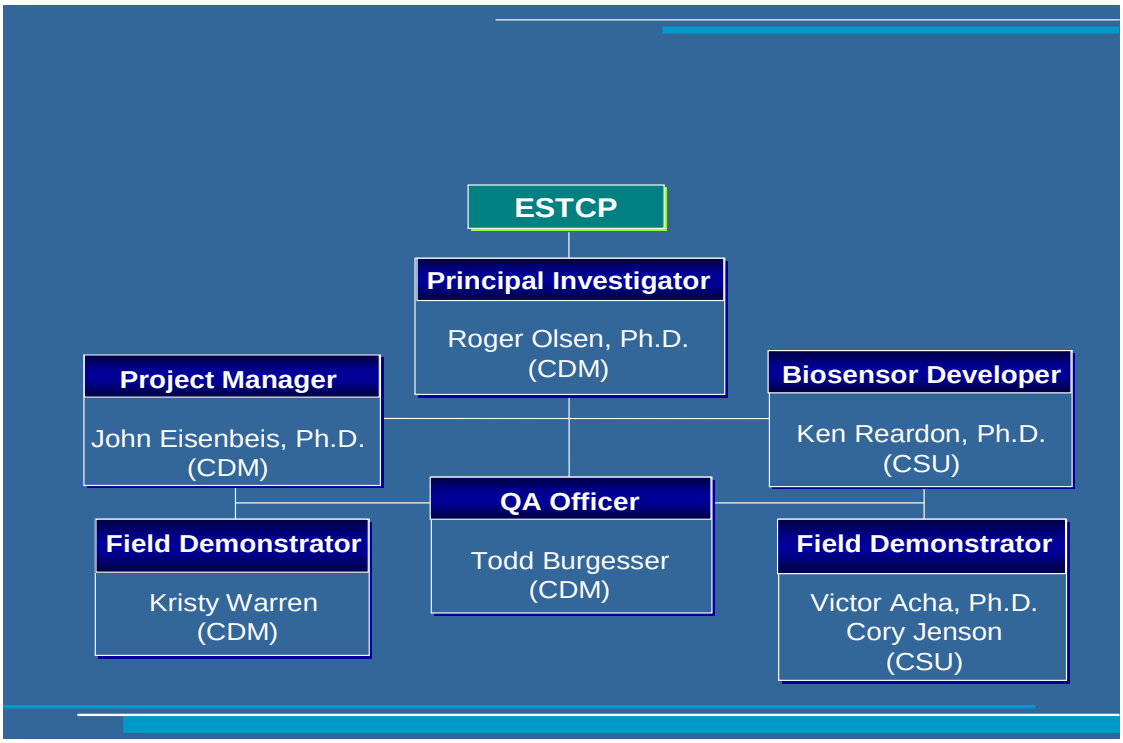
To achieve the full potential of this biosensor technology, it will be necessary to develop biosensors that are stable over long (> 2 months) periods. For many applications, such as on-site vial sampling, the requirement is that the rate of sensitivity loss be low enough to allow recalibration to occur only once per day, as would be typical of any sensor. For down-hole monitoring, the rate of sensitivity loss should be lower; if this cannot be achieved, then the down-hole monitoring mode will be limited to qualitative rather than quantitative measurements.

3.0 Demonstration Design

The demonstration described in this section was performed by CDM and CSU in accordance with the *Technology Demonstration Plan* (CDM and CSU, 2001) with the exceptions noted in Section 3.1.1. Points of contact involved in the demonstration are listed in Section 8. A project organization chart is shown in Figure 3-1.

This section describes the performance objectives, gives a summary of site conditions for the demonstration site, and describes the experimental design and methods that were used to implement this design.

Figure 3-1. Organizational chart for biosensor demonstration.



3.1 Performance Objectives

3.1.1 Deviations from Demonstration Plan

This section describes deviations from the methods and approach described in the Demonstration Plan.

It was originally intended to demonstrate the use of biosensors at three sites, the first of which was to be Operable Unit 8 (OU 8) of the Naval Submarine Base in Kipsap County, Washington (SUBASE Bangor). The Demonstration Plan stated that:

> "It is anticipated that at Sites 2 and 3 we will demonstrate multi-analyte measurement capability using bundled fiber optic sensors. These sites will be selected using the above criteria and other criteria that may be appropriate as the demonstration proceeds. Site 2 will be selected following completion of the field measurements at Site 1. Site 3 will be selected during the second set of field measurements at Site 2."

Due to difficulties encountered in calibrating the biosensors to compensate for pH changes in groundwater samples (see Section 4), the demonstration was instead limited to two events at SUBASE Bangor. The multi-analyte measurement capability using bundled biosensors was not developed or demonstrated as part of this project.

Over the course of the demonstration, the biosensor calibration procedures were modified and improved. As described in Section 3.5.7, the calibration procedures used were different from those described in the Demonstration Plan.

The schedule and period of performance were different from what was anticipated in the Demonstration Plan. The actual periods of biosensor field measurements were as follows:

- SUBASE Bangor (first demonstration): February 25 to March 2, 2002
- SUBASE Bangor (second demonstration): September 20 to September 24, 2004

3.1.2 Meeting Performance Objectives

Performance of the biosensors was compared to the conventional GC/MS method for groundwater analysis. Performance was evaluated based on the following objectives identified in the Demonstration Plan:

- **Accuracy** as demonstrated by a one-to-one correlation between the two analytical techniques (biosensor and GC/MS).
- **Rang**e as demonstrated by a response from less than 5 µg/L to greater than 500 µg/L 1,2-DCA
- **Precision** as demonstrated by a low relative percent difference (RPD) between duplicate analyses
- **Sample throughput** as demonstrated by short analysis time in the field
- **Mechanical reliability** as demonstrated by a low incidence of failure
- **Versatility** as demonstrated by acceptable performance under variety of conditions

A summary of the performance objectives is presented in Table 3-1 along with whether each objective was met during the demonstration.

Table 3-1. Performance Objectives

Type of Performance Objective	Primary Performance Criteria	Expected Performance (Metric)	Actual Performance Objective Met?
Qualitative	1. Sample Processing Rate	> 6 samples/day	Yes
	2. Mechanical Reliability	Low breakdown incidence	Yes
	3. Versatility	Applicability to all conditions	No
	4. Ease of use	Typical operator training and labor required	No
Quantitative	1. Accuracy	Relative Percent Difference (RPD) < 25 percent (RPD for GC/MS method); correlation coefficient (r^2) > 0.9	No (r^2) > 0.9, but RPD > 25%
	2. Precision	RPD for biosensor equal to or less than 25% (RPD for GC/MS method)	No
	3. Sensitivity	< 5 µg/L	Yes (if no interference)
	4. Range	> 500 µg/L	Yes (if no interference)

3.2 Selection of Test Site(s)

This section describes the criteria used to select demonstration site. These criteria included:

- Presence of a contaminant detectable by biosensors
- Existence of an ongoing groundwater monitoring program with which data can be coordinate and shared
- Preference for many monitoring points and monitoring wells with long screen intervals to facilitate discrete depth measurements
- Preference for non-homogeneous aquifer concentrations to demonstrate the importance of discrete depth monitoring

The demonstration site selected was SUBASE Bangor since it met all of the above criteria, including having a groundwater plume with 1,2-DCA as a major component. 1,2-DCA is one of the compounds for which a biosensor had already been developed and lab-tested.

3.3 Test Site Description

This section provides a brief summary of the history and site characteristics of SUBASE Bangor that are pertinent to the field demonstration of the biosensors. This information has been taken from the Final Technical Memoranda titled *Preliminary Evaluation of the Natural Attenuation Process Phase II* (EA Engineering, Science and Technology, 2000) and *First Quarter 2000 Sampling* (Foster Wheeler, 2000). Site characterization details are presented in Appendix A.

Two demonstrations were performed at Operable Unit 8 (OU8), which is located in the Public Works Industrial Area (PWIA) of Bangor. Bangor is located near the town of Silverdale, Washington. An onsite underground storage tank (UST) is believed to be the source of a release of unleaded gasoline into the surrounding media between 1982 and 1986. Chlorinated volatile organic compounds (VOC) and LNAPLs are also present in site groundwater (EA 2000).

OU8 geological conditions have been highly characterized by drilling and monitoring well installation. The area consists of four stratigraphic units: construction fill, Vashon till (Qvt), Vashon Advance Outwash (Qva), and Lawton Clay. The construction fill can be found 2 to 3 feet below ground surface (bgs) and consists of a sandy material. Underlying the construction fill and ranging to a depth of about 45 feet bgs is the Vashon till, which consists of silt, sand, gravel, and cobbles. This unit is 20 to 40 feet thick. The Vashon Advance Outwash (location of the shallow aquifer) is beneath the Vashon till and consists of sand, silt, and gravel. The thickness of the Vashon Advance Outwash is about 100 to 130 feet. Beneath the Vashon Advance Outwash is the Lawton Clay aquitard. A silty transition zone in the bottom of the Vashon Advance Outwash separates the shallow aquifer from the lower aquitard.

There are about 100 monitoring wells at OU8. The wells were installed at three different depth intervals: shallow, intermediate, and deep. The depth to groundwater is about 20 feet bgs and the general flow direction is southeast. The Vashon Advance Outwash lies beneath the Vashon till at OU8 and is the location of the shallow unconfined aquifer. The shallow aquifer contained in the Vashon Advance Outwash is about 125 feet thick. The shallow wells are screened within 30 feet of the water table, intermediate wells are screened within the middle 40 feet of the aquifer thickness, and the deeper wells are screened within 30 feet of the Lawton Clay aquitard. The plume contains dissolved petroleum contaminants (including benzene) and DCA. Some wells also contain LNAPLs. The majority of the contaminants are located in the shallow and intermediate zones of the Vashon Advance Outwash.

3.4 Pre-Demonstration Testing and Analysis

Prior to the first demonstration, the CDM/CSU team visited SUBASE Bangor and began to coordinate with the site's quarterly monitoring crew. Arrangements were made with site staff to work with the monitoring crew during their fall monitoring event (October 2001) to obtain co-located samples and to use the biosensors in wells that were to be sampled for this event. However, delays in laboratory preparation of the biosensors and associated hardware occurred prior to mobilizing to the field, and the first demonstration was postponed until February 2002.

Laboratory development and testing of the biosensors prior to the demonstrations is described in Section 2.1.2.

3.5 Testing and Evaluation Plans

3.5.1 Demonstration Installation and Start-Up

All equipment and supplies necessary for measurements were mobilized to and around the demonstration site in a van. No site utilities were required. Power was obtained either from a vehicle battery or from a portable generator. Biosensors were transported to the site from CSU on ice. The tips were stored in a 0.01 molar (M) buffer solution at pH 7.0 with no contaminant present, and were maintained in that solution on ice until shortly before their use.

3.5.2 Period of Operation

The periods of biosensor field measurements were as follows:

- SUBASE Bangor (first demonstration): February 25 to March 2, 2002
- SUBASE Bangor (second demonstration): September 20 to September 24, 2004

3.5.3 Amount/Treatment Rate of Material to Be Treated

Since this demonstration involved a site characterization method, this subsection is not applicable.

3.5.4 Residuals Handling

Use of the biosensors did not generate residuals that required special handling. Groundwater used in calibration of the sensors along with decontamination and rinse water was added to the waste generated during the quarterly monitoring sampling.

3.5.5 Operating Parameters for the Technology

Several modes of sampling were used during the demonstrations to evaluate the performance of the biosensors under different conditions. These sample modes are described in detail in the next subsection.

3.5.6 Experimental Design

The fiber optic biosensor demonstrations used a variety of sampling methods.

1. **Vial Measurements:** A biosensor was inserted into a vial containing a sample of the groundwater from a monitoring well. A split sample was sent to an off-site laboratory for analysis by GC/MS.

2. **Flow-Through Cell Measurements:** A biosensor was inserted into an aboveground, flow-through cell (with continuous flow of groundwater from the monitoring well) in conjunction with recording routine measurements of the field parameters pH, DO, ORP temperature, and specific conductance.

3. **Down Well Measurements:** A biosensor was lowered down hole in an un-pumped monitoring well. Measurements were taken at several depth intervals to define contaminant gradients.

4. **Sampling of "Sentinel" Wells:** A biosensor was installed down hole in a selected monitoring well. The fiber optic cable and analyte probe were left in the hole and monitored on a routine basis over a period of a day. Results from this type of sampling provided a basis to determine if the biosensors could be left in a well for longer periods and what calibration needs are necessary for such sampling.

The above procedures allowed for comparison of biosensor readings with analytical results from GC/MS laboratory analysis. The results were also used to compare sampling methods and concentration profiles with depth. The results and details concerning measurement methods used at each monitoring well are provided in Section 4.

Field QC Samples

The following types of QC samples were collected and analyzed.

Duplicate Samples – Three vials were filled with groundwater minimizing volatilization**.** Two of the vials filled with groundwater were analyzed onsite using the biosensor. The second sample was analyzed immediately after the first sample and was identified as a duplicate sample. A third sample was retained for potential later analysis.

Co-Located Samples - As previously described, concentrations of 1,2-DCA were measured downhole in selected wells. At one of these locations, the biosensor was removed and cleaned. The downhole analyses were then repeated at the same depths in the same well.

Additional QC Samples - Additional quality assurance/quality control (QA/QC) samples are discussed in the following paragraphs that would typically be used only in an offsite laboratory. However, because the biosensor is being evaluating for use as a replacement for offsite analyses, additional samples were analyzed.

Calibration Standards

Calibration procedures are described in Section 3.5.7.2 and will not be repeated in this section. The biosensors were calibrated once per day. As part of the calibration procedure, a laboratory control standard was analyzed after completion of the calibration.

Evaluation Methods

Onsite Duplicate Samples Precision of the onsite biosensor can be assessed by comparing the analytical results of the onsite duplicate samples. Precision is most often expressed in terms of relative percent difference (RPD). The RPD can be calculated for each pair of duplicate analyses using the following equation:

$$RPD\ (\%) = [S-D]/[(S+D)/2] \times 100$$

Where:

S = first sample value
D = second sample value

Comparison of Onsite and Offsite Samples Comparison of the onsite and offsite (GC/MS) analytical results was performed by calculating the RPD between samples. A RPD was calculated for each of the onsite duplicate samples described previously (i.e., an average value of the two onsite samples was not used).

Evaluation Criteria

The performance of the biosensor was assessed at two levels: Level 1 is the ability to provide qualitative, screening data with definitive compound identification. Level 2 is the ability to provide definitive compound identification and quantitative concentrations.

Level 1: Semi-quantitative screening concentration data
Moderate accuracy
Moderate quantitation limit
Moderate specificity and selectivity

Level 2: Quantitative concentration data
High accuracy (RPD $\leq$ 25%)
Low quantitation limit
High specificity and selectivity

The two corresponding sets of data quality objectives and evaluation criteria are provided in Table 4-2. Level 2 evaluation criteria for 1,2-DCA were selected to be consistent with those standard procedures used by the offsite laboratory (GC/MS methods equivalent to EPA method 8260B).

3.5.7 Sampling Plan

Section 3.5.7.1 provides the sampling plan description for the first demonstration and Section 3.5.7.2 provides the description of the sampling plan for the second demonstration.

3.5.7.1 First Demonstration

The biosensor demonstration largely depended on comparing results from the offsite laboratory with the biosensor results collected onsite. Samples for laboratory analysis were collected using methods described in the SUBASE Bangor long-term monitoring Quality Assurance Project Plan (QAPP) (EA 2000). Sampling and analysis procedures not associated with the site monitoring activities are described in this section.

Biosensor Calibration Procedure.

Individual biosensors vary in their response characteristics. Furthermore, biosensor measurements are influenced by groundwater characteristics such as pH and buffer capacity (alkalinity). Thus, calibration was performed using water from the well or representative water with similar characteristics from a nearby well. The following calibration procedure was used during the first demonstration. Measurements were only recorded when the instrument signal was steady (+/- 0.02 V) for three minutes. Measurements were made in standard 40 milliliter (mL) VOA vials with zero headspace, and the biosensor was fitted with a special VOA vial-compatible cap. Additions of standard solutions were made rapidly to avoid volatilization losses. The calibration steps used were:

- Obtain a steady reading of the biosensor in the standard buffer solution used for storage (2 mM Tris HCl). Adjust the output of the system using the offset control until a steady reading of 10.0 is obtained.
- Submerge the biosensor in the groundwater sample. Obtain a steady reading (R1).
- Rinse the biosensor with the standard buffer solution. Spike the groundwater sample with 10 µL of a concentrated solution (known value) of the analyte to bring the concentration in the groundwater sample to a value of C0 + x, where C0 is the unknown concentration of the analyte in the original groundwater sample and x is the concentration added by spiking. Mix the spiked solution using a magnetic stirrer (inert, clean stir bar previously inserted into vial) or by shaking (with inert solids previously added to the vial to facilitate mixing). Submerge the biosensor in the groundwater sample. Obtain a steady reading (R2).
- Rinse the biosensor with the standard buffer solution. Again spike the groundwater sample with 10 µL of the concentrated solution of the analyte to bring the concentration in the groundwater sample to a value of C0 + 2x. Submerge the biosensor in the groundwater sample. Obtain a steady reading (R3).
- Rinse the biosensor with the standard buffer solution and replace it in a vial of storage solution until use.

To obtain the calibration parameters, compute the change in readings from the baseline as $\Delta R = 10 - R_i$. Since the calibration curve ΔR versus concentration (C) is known to be linear, the equation of this curve is

$\Delta R = mC + b$ (m is slope and b is intercept)

Thus, for each of the three measurements, the following equations can be written:

$\Delta R_1 = mC_0 + b$
$\Delta R_2 = m(C_0 + x) + b$
$\Delta R_3 = m(C_0 + 2x) + b$

Since the values of ΔR_1, ΔR_2, ΔR_3, and x are known, this provides three equations that can be solved for the three unknowns: m, C_0, and b. Once m and b are obtained, the equation of the calibration curve ($\Delta R = mC + b$) can be rearranged as

$C = (\Delta R - b)/m$

This equation can be used to convert instrument readings to concentrations.

These calibration procedures were used for two types of analysis that were performed with the biosensors during the first demonstration, as described below.

Split VOA Analysis
The objective of this type of analysis was to compare the biosensor readings to offsite laboratory results (GS/MS) for 1,2-DCA. After field parameters indicated that stable groundwater conditions had been reached during pumping, two VOA vials were filled. Three additional VOA vials were filled for analysis by the biosensors. Filling alternated between vials for biosensor and offsite analyses. The cap of one of the biosensor vials was removed briefly and was immediately replaced with a cap fitted with a biosensor. A biosensor reading was recorded after sufficient time had elapsed to obtain a stable reading. This procedure was then repeated for the second vial (duplicate).

Flow-Through Cell Analysis
While groundwater from the sample pump was being measured for field parameters (pH, DO, etc) in a flow-through cell, a second flow-through cell (connected in series and attached to the effluent port of the first cell) was utilized to take biosensor readings of the groundwater flowing from the well. Before placement in the cell, a biosensor was inserted into a field standard of 1,2-DCA at a concentration that was similar to the anticipated concentration from the well being sampled (based on the last lab results for that well). This helped to minimize the time needed for a stable reading when the biosensor was put into the flow-through cell. Readings were recorded from the biosensor at regular intervals until field parameter readings stabilized. In addition to individual biosensor readings, notes were taken as to the range in fluctuation of readings and the approximate average reading.

Analysis Locations Table 3-2 presents the monitoring wells that were used for each analysis type described above during the first demonstration. The wells were selected based on the latest

1,2-DCA concentration measured, as well as the diameter and construction (e.g., depth) of the well.

Table 3-2. Monitoring Wells Used in the First Demonstration

Analysis Type	Monitoring Well ID	1,2-DCA (µg/L)	Screened Interval (feet bgs)
Split VOA/Flow-Through Cell	8MW06	1,200	37.8 - 47.8
	8MW03	56	72 - 82
	8MW33	16	68.3 - 78.3
	8MW35	3.0	72.6 - 82.6
Vertical Profiling	8MW48	320*	23 - 38
	MW05	340*	20 - 40
	25MW05	62*	12.8 - 22.8
Multi-Day	8MW03	56	72 - 82

* Collected June 2000

3.5.7.2 Second Demonstration

Based on lessons learned from the first demonstration, some of the methods used in the second demonstration were modified from those used during the first. Prior to beginning the second demonstration, calibration tests were performed at CSU using SUBASE Bangor groundwater to reduce the chance that unforeseen problems would occur during the second field demonstration. The 1,2-DCA biosensors were refined based on results of these calibration efforts, and then biosensors were produced in sufficient quantity for field use.

Calibration Methods This section describes the steps that were used during the second demonstration to calibrate and take sample measurements with the biosensors for three types of measurements: 1) Measurements in vials; 2) Measurements in a flow-through cell; and 3) *in situ* measurements in a monitoring well.

Vial Measurements

The vial method calibration procedures used during the second demonstration were based on those described in Section 2.1.2.2. Specifically, a pH optode was used to separate the response of the biosensor to the analyte (R_{EB}^{*}) from the biosensor's response to bulk solution pH changes ($R_{EB,pH}$), since both contribute to the observed response of the biosensor ($R_{EB,obs}$). A set of measurements is performed first with a biosensor and then with a pH optode, and the two sets of data used to calculate R_{EB}^{*}.

Measurements

1. Collect a groundwater sample from the well (about 50 mL) and record the pH. Completely fill several small vials (e.g., 4.85 mL) with this sample and close with septum caps.

2. In a separate 4.85-mL vial, place a small magnetic stir bar. Fill the vial completely with buffered measurement solution (BMS; 150 mM NaCl, 25 mM CaCl2, and 10 mM MES at pH 7.0). Close the vial with a septum cap through which a biosensor tip has been inserted.

3. Connect the biosensor tip to the fiber optic lead (and the optoelectronic instrument) and place the vial in a darkened measurement chamber on top of a magnetic stirring plate.

4. When a steady signal (PMT voltage) has been obtained, remove 100 µL of solution using a syringe inserted through the vial septum. Then add 100 µL of groundwater sample.

5. When a new steady signal has been obtained, calculate the voltage change (ΔV) between the initial and the final values. This is REB,obs.

6. Perform at least three additions of a standard solution of the analyte, each time removing the same volume that will subsequently be added. Record the ΔV resulting from each addition. The volume of standard added should be varied to obtain ΔV values that are both larger and smaller than REB,obs. In the case of the second demonstration, the standard solution was 100 µg/L of 1,2-DCA, and the volumes added were typically 25, 50, and 100 µL.

7. Perform a series of injections of a 1 mM HCl solution in water, adding 25, 50, and then 75 µL of solution, withdrawing the same amount before each addition, and measuring the resulting ΔV. These values will be used to calculate the relative pH response of the biosensor vs. the pH optode.

8. Fill a new 4.85-mL vial with BMS and close the vial with a septum cap through which a pH optode tip has been inserted.

9. Connect the pH optode tip to the fiber optic lead (and the optoelectronic instrument) and place the vial in a darkened measurement chamber on top of a magnetic stirring plate.

10. Repeat exactly the measurements described in steps 4-7 above.

Calculations

1. Calculate the pH response ratio KpH, defined by

$$K_{pH} = R_{opt,pH} / R_{EB,pH}$$

from the sets of ΔV values obtained from the HCl additions as measured by the pH optode and the biosensor.

2. Use this value of KpH to convert the ΔV values measured by the pH optode (Ropt,obs) to equivalent biosensor values, and from this obtain the pH-corrected biosensor response for each measurement according to:

$$R_{EB}^{*} = R_{EB,obs} - R_{opt,obs}/K_{pH}$$

3. For biosensor measurements of volatile analytes such as 1,2-DCA, the same volume that was to be injected was first removed. This meant that some analyte mass was removed, and a simple mass balance calculation must be performed to correct for this removal.

A sample spreadsheet is provided in Appendix D to illustrate these calculations.

Flow-Through Cell Measurements

The calibration procedure for the flow cell was similar to that in the vials except that the volumes involved were larger and that the primary solution was the groundwater.

1. Collect a groundwater sample from the well (about 50 mL). Completely fill several small vials (e.g., 4.85 mL) with this sample and close with septum caps.

2. In a separate 4.85-mL vial, place a small magnetic stir bar. Fill completely with buffered measurement solution (BMS; 150 mM NaCl, 25 mM CaCl2, and 10 mM MES at pH 7.0). Close the vial with a septum cap through which a biosensor tip has been inserted.

3. Collect a sample from the well (about 50 mL). Record the pH.

4. Create a closed-loop flow system with the flow cell by connecting the outlet and inlet tubing and having the peristaltic pump in-line. Fill this closed-loop system with the groundwater sample, minimizing the headspace. Insert a biosensor in the flow cell and get a steady voltage signal.

5. Spike the flow cell with known volumes of a standard 100 µg/L DCA solution.

6. When each new steady signal has been obtained, calculate the voltage change (ΔV) between the initial and the final values.

7. Remove the biosensor from the flow cell and insert a pH optode in its place. Fill the closed-loop flow-cell system with fresh groundwater sample.

8. Repeat steps 3 and 4 using the same volumes of standard 1,2-DCA solution.

9. Correct the biosensor ΔV readings with their corresponding ΔV values obtained using the pH optode sensor and the KpH (determined separately).

10. Plot the corrected ΔV values against the 1,2-DCA concentrations after each additions to obtain the calibration equation.

11. Convert the flow cell back to the open (flow-through) configuration and begin pumping groundwater through the flow cell.

12. Determine ΔV when a new steady response has been obtained.
13. Determine the concentration of 1,2-DCA in the groundwater from the calibration equation.

Down-Hole Direct Measurement

The strategy for calibrating the biosensors for downhole measurement was slightly different than for the other two methods because standards could not be added directly to the measurement environment (the well). Instead, biosensors to be used in a well were first calibrated in a groundwater-filled vial and then used down-hole.

1. Collect a groundwater sample from the well (about 50 mL) and record the pH. Completely fill several small vials (e.g., 4.85 mL) with this sample and close with septum caps.

2. Open one of these vials, place a small magnetic stir bar inside, and close the vial with a septum cap through which a biosensor tip has been inserted.

3. Connect the biosensor tip to the fiber optic lead (and the optoelectronic instrument) and place the vial in a darkened measurement chamber on top of a magnetic stirring plate.

4. Follow steps 4-7 of the vial measurement calibration procedure.

5. Open a second vial, place a small magnetic stir bar inside, and close the vial with a septum cap through which a pH optode has been inserted.

6. Follow steps 9-10 of the vial measurement calibration procedure.

7. Use the calculations described for the vial measurement calibration procedure to determine REB* for each addition of 1,2-DCA, and make a calibration curve that relates this REB* to the 1,2-DCA concentration.

8. To start the down-hole measurement procedure, place the calibrated biosensor in a new groundwater-filled vial and record the steady signal from the optoelectronic instrument.

9. Remove the biosensor from the vial and lower it into the well. Record the signal at each depth of interest.

10. Changes in signal (ΔV) are calculated between the signal obtained with the biosensor in the vial and those signals measured down-hole. Using the calibration curve produced in step 7, these signal changes can be converted to changes in 1,2-DCA concentration relative to the concentration in the vial. To obtain actual concentration data, the concentration of 1,2-DCA in the vial can be measured in a separate vial test.

Measurement Locations
For the second demonstration of the biosensors, specific monitoring wells were selected based primarily upon:

- The latest 1,2-DCA concentration
- The depth of the screened interval
- The accessibility of the well

Table 3-3 shows the wells that were sampled, the 1,2-DCA concentration detected in samples collected in July 2004 (offsite analyses by GC/MS), and the groundwater zone in which the well is screened.

Table 3-3. Second Demonstration Monitoring Wells for Biosensor Measurements

Monitoring Well	July 2004 1,2-DCA (µg/L)	Groundwater Zone
8MW-06	1,100	Shallow
MW-5	500[1]	Shallow
8MW-33	35	Intermediate
8MW-47	25	Shallow
8MW-35	20	Intermediate
8MW-03	11	Intermediate
8MW-28	<0.12	Intermediate
8MW-25	<0.12	Deep

[1] Sample collected 6/15/04

3.5.8 Demobilization
No major demobilization activities were needed for demonstration of the biosensors. At each monitoring well where the biosensors were used the following was done:

- Monitoring wells were recapped and locked
- The biosensor and optical cable were rinsed with clean water
- All waste solutions were placed in containers and
- Instrument electronics turned off
- Equipment packed and moved to next well

3.6 Selection of Analytical/Testing Methods
Groundwater samples collected from monitoring wells for analytical laboratory analysis were analyzed for VOCs using U.S. Environmental Protection Agency (EPA) Method 8260B, a GC/MS method.

3.7 Selection of Analytical/Testing Laboratory

Laboratory analysis was done by Columbia Analytical (Kelso, Washington) for the first demonstration and by Pace Analytical (Lenexa, Kansas) for the second demonstration.

4.0 Performance Assessment

4.1 Performance Criteria

Performance criteria that were used to evaluate the performance of the biosensors are given in Table 4-1. The performance criteria have been categorized as primary criteria (the project's performance objectives), or secondary criteria.

Table 4-1. Performance Criteria

Performance Criteria	Description	Primary or Secondary
Sample Throughput	Short analysis time in the field	Primary
Mechanical Reliability	Low incidence of mechanical failure	Primary
Versatility	Acceptable performance under various conditions	Primary
Ease of Use	Minimal user training required	Primary
Accuracy	Correlation between biosensor results and GC/MS results	Primary
Precision	Low relative percent deviation between duplicate analyses	Primary
Sensitivity	Detection limit for 1,2-DCA < 5 µg/L	Primary
Range	Accurate results between <5 and 500 µg/L 1,2-DCA	Primary
Hazardous Materials	Little or no hazardous material generated during use of biosensors	Secondary
Process Waste	Little of no process waste generator during biosensor use	Secondary
Factors Affecting Technology Performance	Few interferences and accurate operation possible over a wide range of groundwater quality and field conditions	Secondary
Maintenance	Easily kept in operating order with infrequent part replacement	Secondary
Scale-Up Constraints	Can biosensors be easily produced commercially	Secondary

4.2 Performance Confirmation Methods

The primary method of evaluating the biosensors' performance was to determine the correlation between the biosensor results and the laboratory GC/MS method results for duplicate samples that were collected from the same well. However, other methods, metrics, and criteria were also used to evaluate performance of the biosensors. Table 4-2 presents a summary of these and lists them as either primary criteria (performance objectives) or secondary criteria. Within these two categories, the criteria are further divided as being qualitative or quantitative.

Table 4-2. Expected Performance and Performance Confirmation Methods

Performance Criteria	Expected Performance Metric (pre-demonstration)	Performance Confirmation Method	Actual (post-demonstration)
PRIMARY CRITERIA (Performance Objectives) (Qualitative)			
Sample Throughput	> 6 samples per day	Experience from demonstration operation	For vial measurements, > 6 samples per day
Mechanical Reliability	Low breakdown incidence	Experience from demonstration operation	Further development needed to improve mechanical reliability of biosensor tips. Hardware reliability was high.
Versatility	Applicability to all conditions tested	Comparison of results from different wells and laboratory testing	Further development needed for the biosensors to address interference of pH on measurements.
Ease of Use	Operator training and labor required similar to other field equipment	Comparison to operator requirements for other commonly used field instruments	Ease of operation similar to other field instruments, although calibration could be simplified.
PRIMARY CRITERIA (Performance Objectives) (Quantitative)			
Accuracy	Relative Percent Difference (RPD) < 25 percent (the RPD for EPA Method 8060B) $r^2 > 0.9$	Correlation with GC/MS reference method.	Accuracy was dependent on ability to correct for non-analyte related pH changes. For vial measurements: $r^2 = 0.934$
Precision	RPD for biosensor equal to or less than RPD for reference method	RPD between replicates taking into account best RPD attained with the GC/MS reference method.	Average RPD for vial measurements: 45.6% Overall, RPDs higher than reference method.
Sensitivity	Detection limit for 1,2-DCA < 5 µg/L	Detection of 1,2-DCA concentrations less than 5 µg/L as determined by GC/MS reference method.	Detection limit for 1,2-DCA < 5 µg/L.

Table 4-2. Expected Performance and Performance Confirmation Methods

Performance Criteria	Expected Performance Metric (pre-demonstration)	Performance Confirmation Method	Actual (post-demonstration)
Range	> 500 µg/L 1,2-DCA	Ability to quantify 1,2-DCA concentrations greater than 500 µg/L as determined by GC/MS reference method.	> 500 µg/L 1,2-DCA.
SECONDARY PERFORMANCE CRITERIA (Qualitative)			
Hazardous Materials	No hazardous materials produced	Evaluate materials needed for operation	No hazardous materials produced
Process Waste	No process waste produced	Observation	No process waste produced.
Factors Affecting Performance ▪ throughput ▪ groundwater quality	▪ analysis rate $\geq$ 6 samples/day ▪ no interferences under typical groundwater conditions	▪ time/sample analysis ▪ performance not affected by groundwater characteristics	▪ analysis rate $\geq$ 6 samples/day ▪ in some cases, pH changes interfered with biosensor analysis
Maintenance	Maintenance requirements similar to other field instruments	Comparison of field records to operator requirements for other commonly used field instruments	Biosensor tips need refrigeration and have a finite shelf life. Durability of tip could be improved. Hardware maintenance not dissimilar to other field instruments.
Scale up Constraints	No commercialization constraints	Investigate ability to easily produce commercially	Likely no commercialization constraints; however, depends on further development results.

4.3 Data Analysis, Interpretation, and Evaluation

This section presents the results for the various types of biosensor measurements taken during the second demonstration at SUBASE Bangor. The first demonstration was ineffective due to damage to the biosensor hardware during shipping to the site. The hardware was repaired on-site; however, few useable measurements were collected. As previously discussed, valuable experience was obtained during the first demonstration (logistics, sampling methods, field calibration, etc.) The following sections describe results from the second demonstration.

4.3.1 Vial Measurements

Results of the biosensor and the offsite laboratory measurements (GC/MS) are summarized in Table 4-3. Daily field report forms for the biosensor measurements are provided in Appendix B. Laboratory reports for the vial measurements are provided in Appendix C. The biosensor results for these measurements are plotted against results of the laboratory method (GC/MS) in Figures 4-1a and b. The correlation coefficient (r^2 value) for the two methods was 0.934. This indicates good agreement between biosensor readings and the laboratory results under the conditions of the vial measurements.

Figure 4-1b shows the biosensor results for vial measurements plotted against the laboratory GC/MS results. The one-to-one correlation line is shown as the dashed line. The 50% and 100% error lines represent the areas of the graph where points must fall to be within 50 and 100% of the one-to-one correlation.

Table 4-3 also presents the RPD values for the biosensor and laboratory analyses. The average RPD for nine vial samples was 45.6 %, with a range of 16.2 to 80.0%. This is greater than the RPD for the reference method (EPA Method 8260B for GC/MS) of 25%.

Table 4-3 data show that samples with high 1,2-DCA concentrations had high concentrations of aromatic VOCs (e.g., benzene). No correlation between aromatic VOC concentrations or chlorinated VOC concentrations and the RPD of laboratory and biosensor measurements were observed. This indicates that the biosensors were not affected by the presence of relatively high concentrations of these co-contaminants.

The vial measurement results indicate that at their current state of development, the biosensors would be appropriately used as a Level 1 instrument, providing semi-quantitative screening concentration data.

4.3.2 Flow-Through Cell Measurements

Flow-through cell measurements were taken with the biosensors at two monitoring wells – 8MW47 and 8MW33. Figure 4-2 shows the setup for taking biosensor readings in a flow-through cell. As biosensor readings were taken in the flow-through cell, measurements of pH, specific conductivity, temperature, ORP, and DO were also recorded.

8MW47

Figure 4-3 shows the flow-through cell setup at 8MW47. Figures 4-4, 4-5, and 4-6 show the flow-through cell biosensor readings plotted along with pH, ORP, and DO readings, respectively. Since flow-through cell measurements are frequently used to indicate when a well has been pumped sufficiently to allow for sampling of groundwater, it is of interest to note that the biosensor measurements were steady before ORP and at about the same time as DO and pH. The data in these three figures do not indicate a strong correlation between ORP or DO with the biosensor response (and none is expected). Since the biosensor signal is composed of a response to the analyte concentration as well as a response to the environmental pH (see Section 3.5.7.2), some correlation of the biosensor response with pH signal might be expected. This was not the case in the first 15 minutes of the test, suggesting that changes in analyte concentration were dominant during this period (recall that lower biosensor signal indicates increased analyte concentration). These two effects could be resolved by including a second optical fiber on the instrument for measurement of pH.

8MW33

Figures 4-7 and 4-8 show the flow-through cell setup at 8MW33. Figures 4-9, 4-10, and 4-11 show the flow-through cell biosensor readings plotted along with pH, ORP, and DO readings, respectively.

The results were similar to those obtained from 8MW47 in that the biosensor measurements did not correlate with ORP or DO. The influence of pH on the biosensor measurements can be noted when the two data sets are parallel (after approximately 15 minutes of pumping). However, in the initial phase of the experiment, the biosensor and pH measurements change at different rates, indicating that the biosensor measurements reached a steady value earlier. Inclusion of an optical pH measurement as a second channel on the biosensor instrument would allow analyte measurements to be separated from these environmental pH changes (not related directly to the analyte).

Overall, the results indicate that the biosensors can be used to determine when water quality during pumping and sampling has reached stable conditions. At these wells (at least 8MW33), the water could have been sampled earlier based on the stable biosensor readings. The results are classified as Level 1.

4.3.3 Down-Hole Profiling

A biosensor was placed in a protective sheath (Figure 4-12) to take measurements down-hole for the purpose of defining the 1,2-DCA vertical profile within a monitoring well. This setup was lowered into well 8MW47 and readings were recorded at 2-foot intervals from the water table to the bottom of the screened zone. The results are shown in Figure 4-13. This figure shows measurements in millivolts because calibration procedures for a flow-through setup have not yet been developed to effectively translate millivolts readings to 1,2-DCA concentrations. Although a firm assessment of 1,2-DCA concentrations can not be made without having an optical pH measurement at the same location as the biosensor, a preliminary evaluation of the data in Figure 4-13 suggests that the concentration of 1,2-DCA was highest at the surface, decreased over the next 5 feet until a layer of higher concentration was reached, then decreased again (recall from Figure 2-3 that higher 1,2-DCA concentrations lead to lower fluorescence measurements). Small

amounts of LNAPL were encountered in this well, and thus it is possible that the high surface concentrations were caused by 1,2-DCA that was partitioned into the LNAPL.

These biosensor readings may be among the first near real time readings to allow detection of varying 1,2-DCA concentrations with varying hydraulic conductivity in a vertical profile. The results clearly show that stratification within the screened interval occurs. Therefore, the typical pumped samples will depend on placement of the pump and the mixing of stratification that occurs. Development of a tool to measure stratification in situ is a significant advancement. The results are classified as Level 1 (no quantitative data were obtained). However, estimates of the changes in concentrations between the depths were made and the changes were significant.

4.3.4 Sentinel Well Measurements

A biosensor was placed down-hole in the protective sheath used for down-hole profiling in monitoring well 8MW-47 and was left in place for 24 hours. Periodically, readings were recorded by connecting the hardware to the biosensor. The results are shown in Figure 4-14. The biosensor signal decreased about 20% over the first 18 hours and the signal was essentially constant from 15 to 18 hours. However, the biosensor output then dropped another 65% in the next 6 hours. Since the biosensors were shown to have significantly longer lifetimes in laboratory studies (Figures 2-28 and 2-29), the observed decline was expected to be caused by a factor other than loss of enzyme activity. Visual inspection of the tip of the biosensor after 24 hours down-hole indicated the alginate layer containing the bacteria (and enzyme) had become detached from the tip. If the biosensors are to be used in a down-hole mode, then the biosensor tips need to be stabilized to allow for long-term immersion in groundwater. This can be accomplished by cross-linking the alginate polymer or by choosing a different immobilization matrix.

4.3.5 Conclusions

In general, the biosensors functioned as Level 1 measurement devices and provided measurements that were not impacted by the presence of other groundwater contaminants. When used in flow-through cells and for vertical profiling, the biosensors produced significant data that were not readily available by other means. Three factors that limit the performance and utility of this measurement technology must be addressed:

1. The influence of pH on the biosensor measurement -- Because the biosensor measures small pH changes produced by the reaction of an enzyme with 1,2-DCA, methods are required to distinguish these pH changes from pH changes due to other processes. This can readily be accomplished by adding an optical fiber (bundled with the biosensor) and a second measurement channel to the hardware, thus providing optical pH measurement for correction of the pH changes.

2. Calibration Procedures –An adequate calibration procedure has been developed for vial measurements; however, calibration procedures must still be developed for flow-through cell and down-hole measurements

3. Robustness – The biosensor tips should be designed to be more durable. Methods to do this (e.g., cross-linking the alginate layer) have been tested in the laboratory and appear to be feasible.

The biosensors can be used to collect Level 2 data when used in the vial measurement mode; however, further investigation into development and testing of the biosensors is required for them to be reliable field instruments for all of the applications originally intended.

4.4 Publication of Results

The following is a list of publications and presentations regarding biosensor development and testing:

Acha, V. and K.F. Reardon. Measurement of 1,2-Dichloroethane at pM Levels using a Dehalogenase-Based Fiber-Optic Biosensor. In preparation.

Acha, V. and K.F. Reardon. Fiber-Optic Biosensor Measurement of Trichloroethene. In preparation.

Acha, V., C. Jensen, J.J. Eisenbeis, R.L. Olsen, and K.F. Reardon. Field Measurements of 1,2-Dichloroethane in Groundwater using Fiber-Optic Biosensors. In preparation.

Acha, V. and K.F. Reardon. Fiber-Optic Biosensor Development for the Detection of Paraoxon at pM Levels. In preparation.

Acha, V. and K.F. Reardon. Fiber-Optic Biosensor Development for the Detection of Atrazine at Parts-per-Trillion Levels. In preparation.

Acha, V. and K.F. Reardon. Comparison of Dehalogenases for Detection of Halogenated Methanes using Fiber-Optic Biosensors. In preparation.

Acha, V. and K.F. Reardon. Sensitive Detection of Halogenated Pesticides using Fiber-Optic Biosensors based on LinB Haloalkane Dehalogenase. In preparation.

Acha, V., W.B. Willis, N. Das, and K.F. Reardon. 2003. Fiber Optic Biosensors for Halogenated Organics in Ground Water. Proceedings of the 225th American Chemical Society National Meeting.

Presentations (reverse chronological order))

Reardon, K.F., V. Acha, C.D. Jensen, D.S. Dandy, K.L. Lear, J.J. Eisenbeis, and R.L Olsen. 2004. Field Measurements of Groundwater Contaminants using Fiber Optic Enzymatic Biosensors. Annual Meeting of the American Institute of Chemical Engineers, Austin, TX, 7-12 November.

Acha, V. and K.F. Reardon. 2003. Laboratory and Field Measurements of Groundwater Contaminants with Fiber Optic Biosensors. Annual Meeting of the American Institute of Chemical Engineers, San Francisco, CA, November 16-21.

Acha, V., W.B. Willis, N. Das, and K.F. Reardon. 2003. Fiber Optic Biosensors for Halogenated Organics in Ground Water. 225th American Chemical Society National Meeting, New Orleans, LA, March 23-27.

Reardon, K.F., W.B. Willis, M.O. Herigstad, J.J. Eisenbeis, and R.L. Olsen. 2002. Use of Fiber Optic Biosensors to Monitor Dichloroethane in Groundwater. 3rd International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 20-23.

Willis, W.B. and K.F. Reardon. 2001. Environmental Effects on Biosensor Quantification of Ethylene Dibromide in Groundwater. Annual Meeting of the American Institute of Chemical Engineers, Reno, NV, November 4-9.

Table 4-3. Comparison Of Biosensor And Laboratory (GC/MS) Measurements Of 1,2-DCA Concentrations From Second Demonstration Sampling, Along With Laboratory Data On Co-Contaminants In Each Well.

Well	Lab DCA (µg/L)	Biosensor DCA (µg/L)	RPD (%)	Aromatic VOCs (µg/L)	Chlorinated VOCs (µg/L)
8MW35	17	10	51.8	ND	18.4
8MW33	18	38	71.4	ND	55
8MW33	19	15	23.5	78	51
8MW33	18	36	66.7	77	52
MW-05	900	475	61.8	14,090	1,520
8MW49	730	610	17.9	40,460	730
8MW06	990	842	16.2	4,548	1,031
8MW25	< 1	< 27*	-	ND	ND
8MW03	6	14	80.0	ND	6
8MW47	600	483	21.6	38,100	600
8MW08	<20	<107*	-	9,780	58
Average			45.6		

* Unreliable delta V/pH (pho)

Table 4-4. Comparison Of Biosensor And Laboratory (GC/MS) Measurements Of 1,2-DCA Concentrations From Second Demonstration Sampling, Along With Field Parameter Results For Sampled Groundwater.

Well	Laboratory DCA (µg/L)	Biosensor DCA (µg/L)	pH (S.U.)	ORP (mV)	DO (mg/L)	Spec. Cond. (µS/cm)
8MW35	17	10	6.7	132	0.07	128
8MW33	18,19, 18	38, 15, 36	7.1	92	0.11	346
MW-05	900	475	6.5	-46	0.13	457
8MW25	<1	<27	6.6	22	1.11	131
8MW03	6	14	6.7	46	1.63	140
8MW47	600	483	6.7	-59	0.09	704
8MW08	<20	13	6.6	6	1.18	764

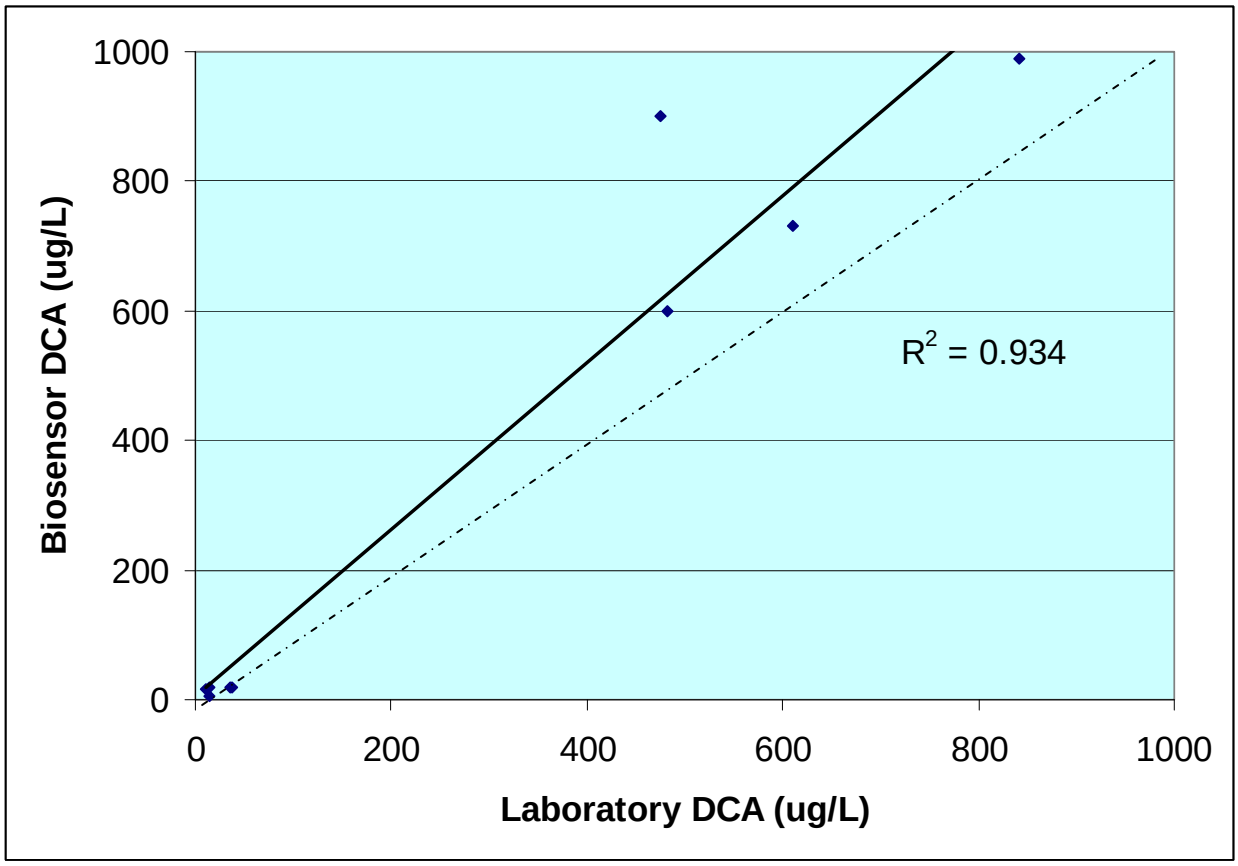


Figure 4-1a. Correlation between biosensor and laboratory results
(dashed line is the one-to-one correlation line)

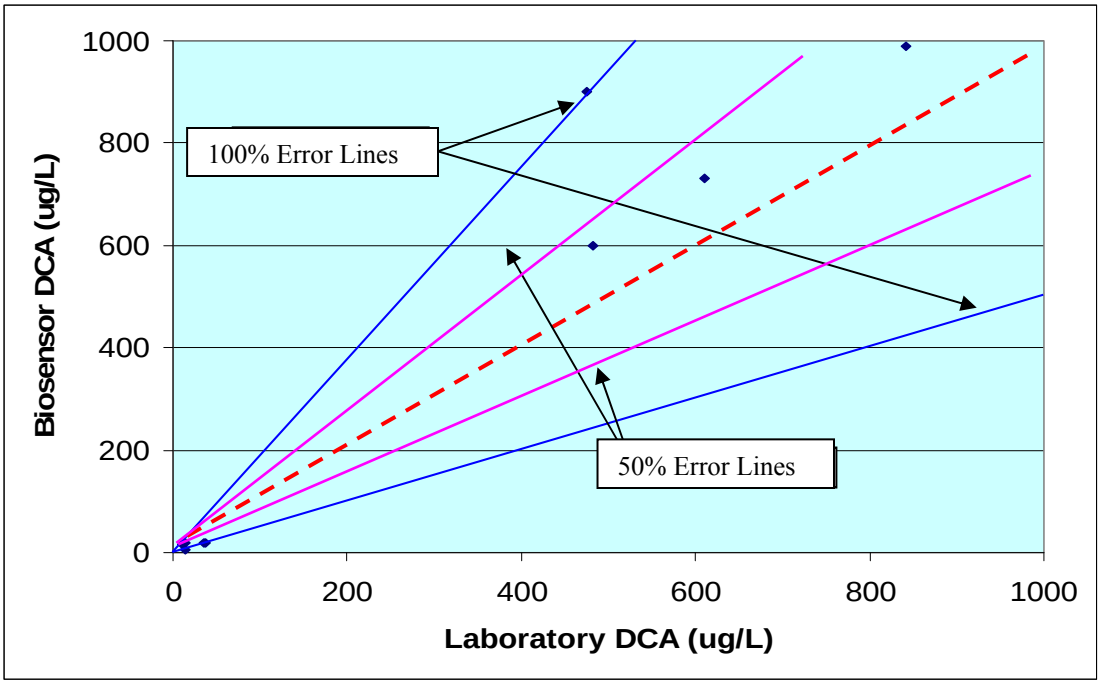


Figure 4-1b. Biosensor and laboratory results for vial samples shown with percent error lines.

Figure 4-2. Flow-through cell set up

Figure 4-3. Flow-through cell set up at 8MW47

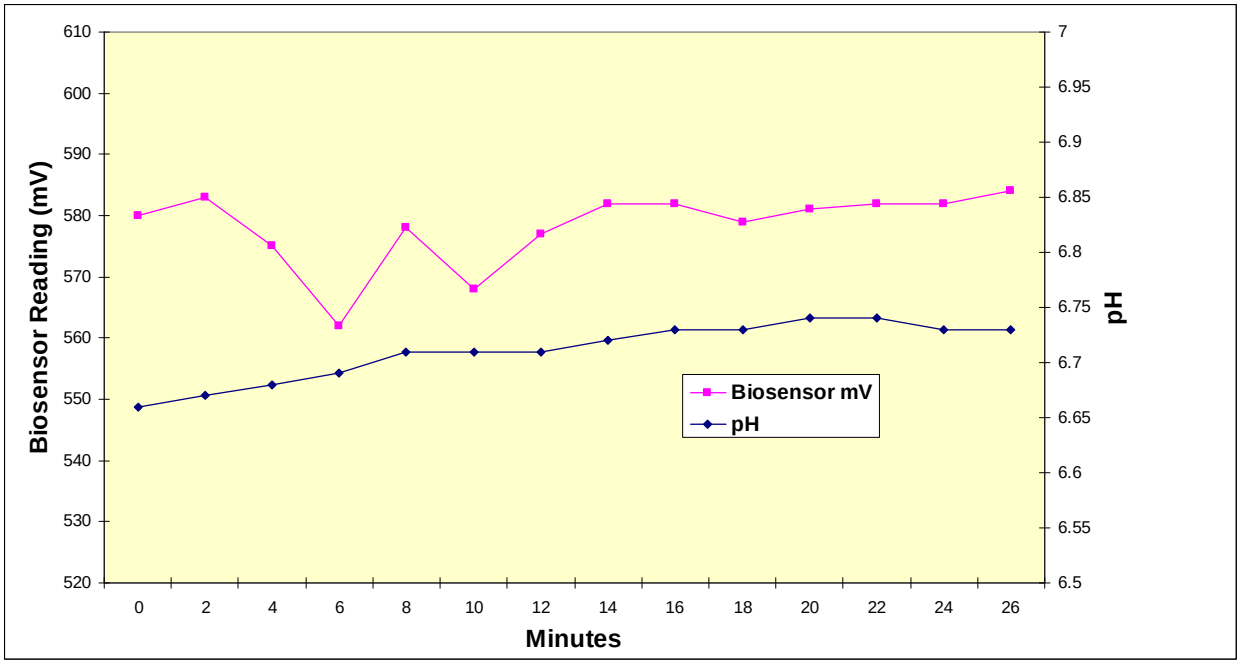


Figure 4-4. Flow-through cell results at 8MW47 – pH vs. biosensor readings

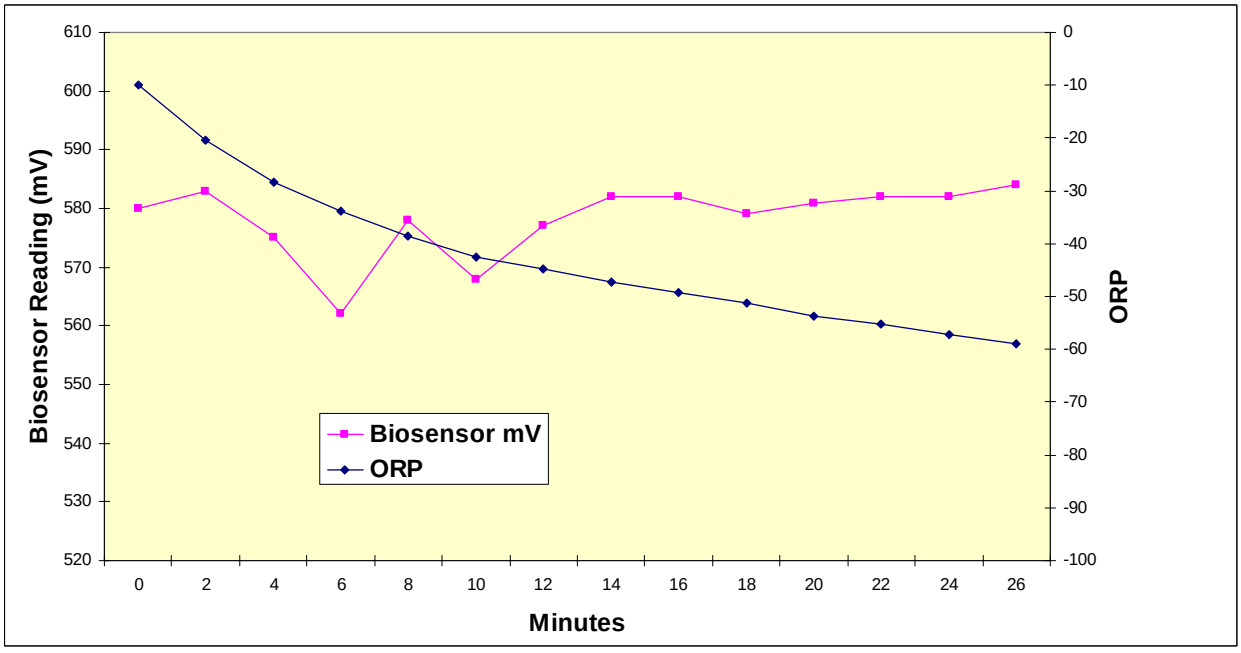


Figure 4-5. Flow-through cell results at 8MW47 – ORP vs. biosensor reading

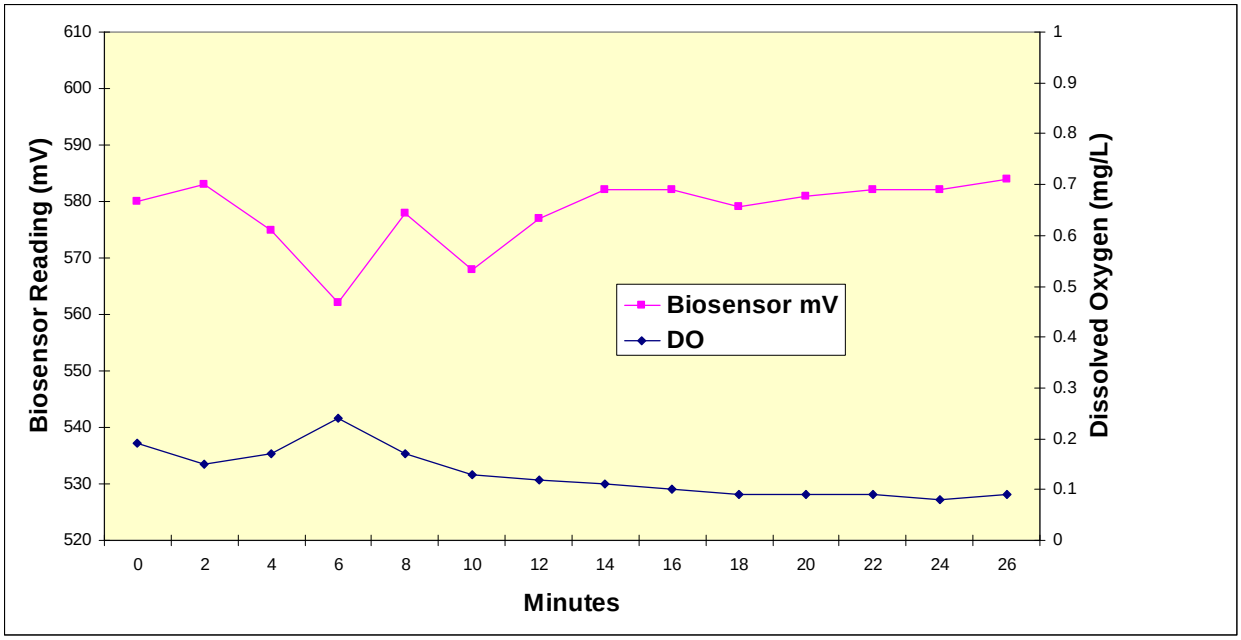


Figure 4-6. Flow-through cell results at 8MW47 – DO vs. biosensor reading

Figure 4-7. Flow-through setup at 8MW33.

Figure 4-8. Flow-through cell readout setup.

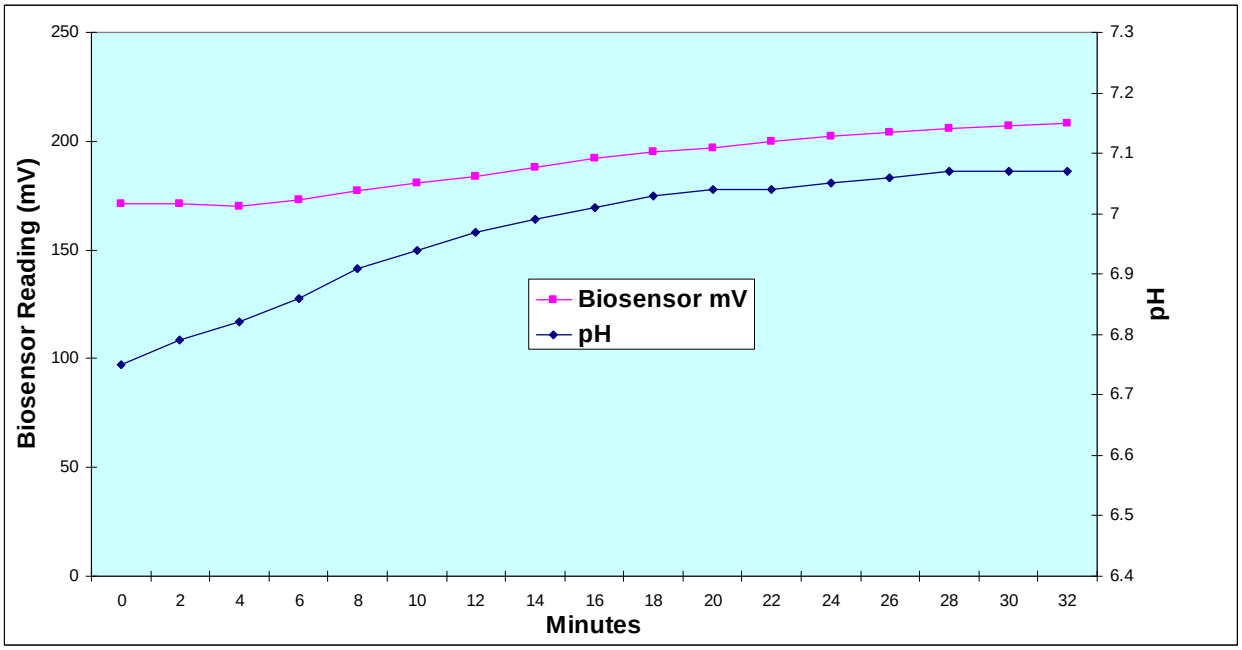


Figure 4-9. Flow-through cell results at 8MW33 – pH vs. biosensor reading

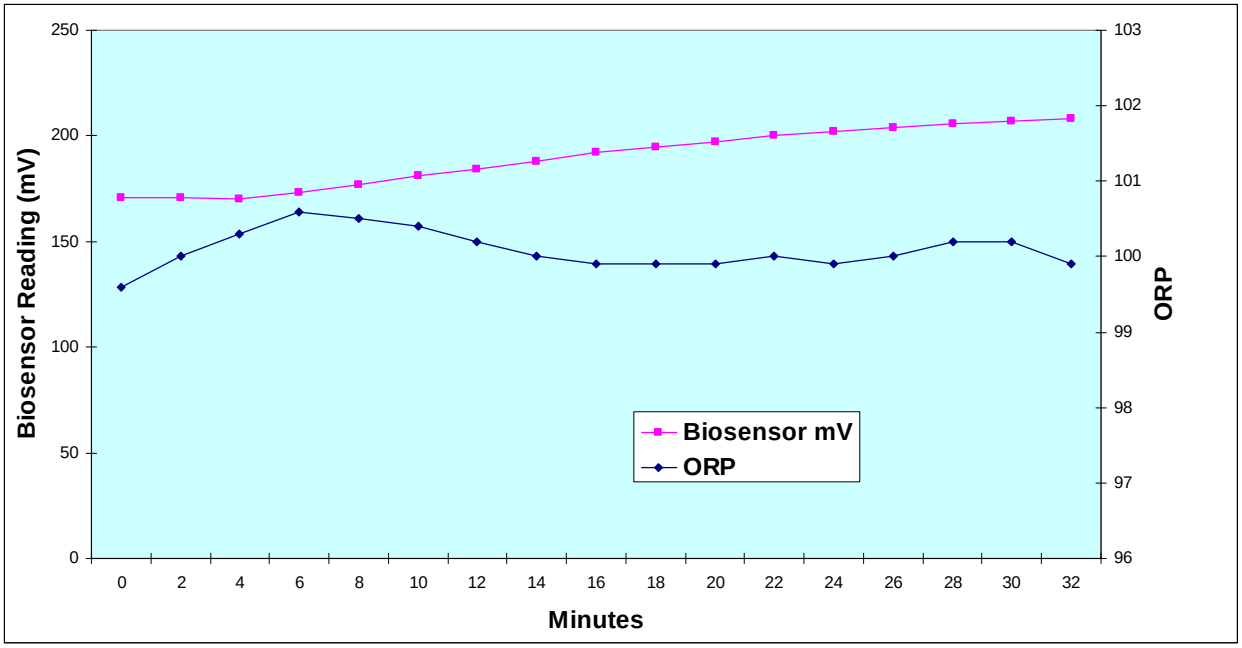


Figure 4-10. Flow-through cell results at 8MW33 – ORP vs. biosensor reading

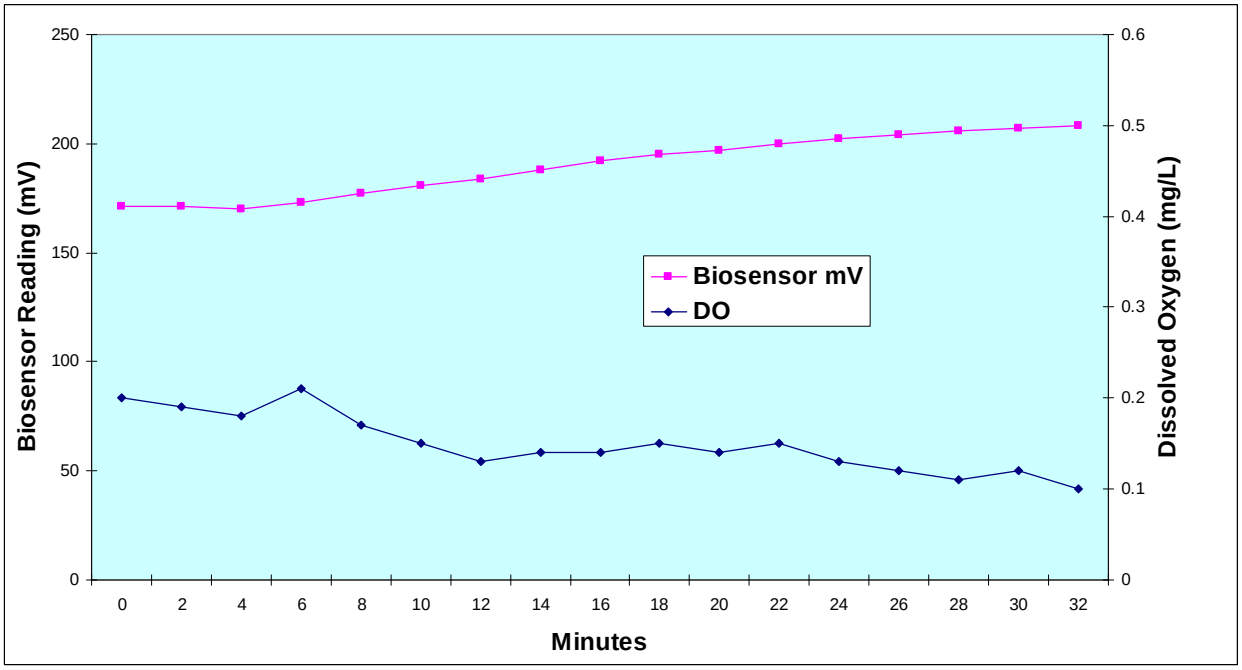


Figure 4-11. Flow-through cell results at 8MW33 – DO vs. biosensor reading

Figure 4-12. Down-hole profiling setup.

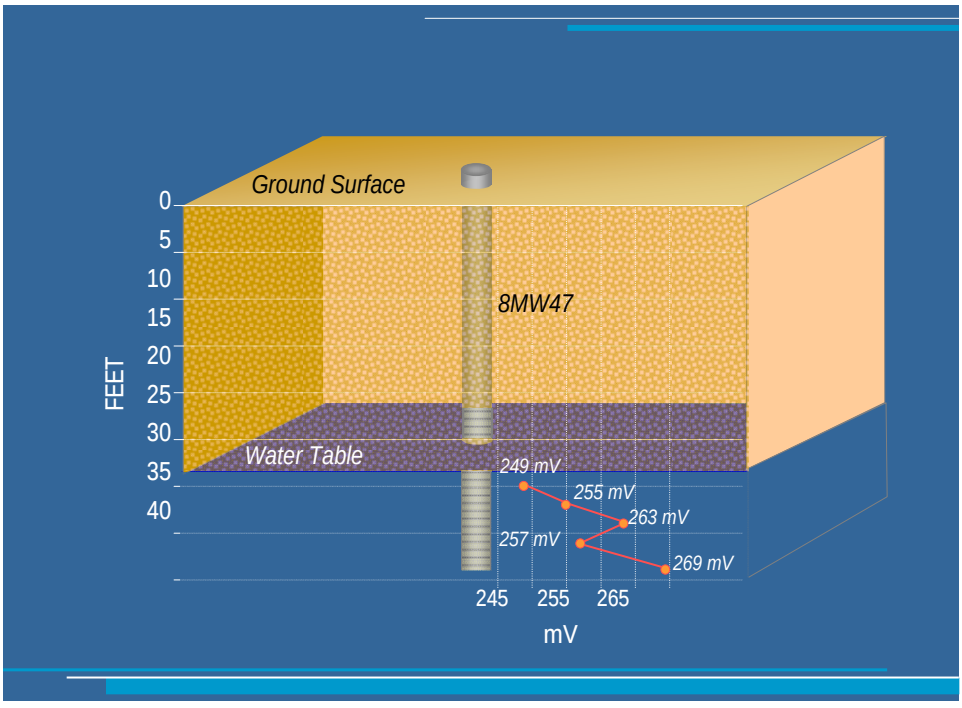


Figure 4-13. Down-hole profiling results (biosensor readings vs. depth)

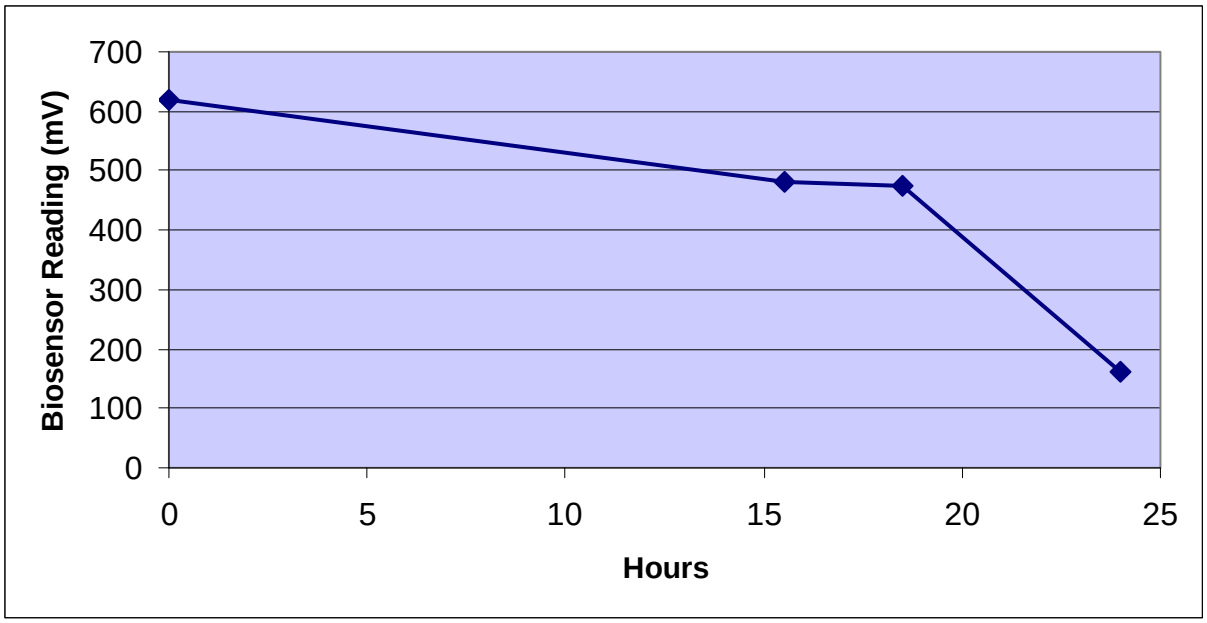


Figure 4-14. Sentinel well results for 8MW47

5.0 Cost Assessment

5.1 Cost Reporting/Analysis

Given the developmental requirements of the biosensors before they can be commercialized and at ESTCP's direction (telephone communication from Dr. Andrea Leeson, December 2005), no costs for their use have been developed at this time.

After further development, the potential benefits of using biosensors in groundwater monitoring can be assessed by comparing the costs associated with biosensor use with conventional monitoring methods (i.e., laboratory using methods similar to EPA Method 8260) on a per well basis as well as on a sampling event basis.

The primary cost driver for the biosensor technology is the capital cost of the optical-electronic system that includes the light source and detection units. Although the cost of this unit is currently approximately $5,000, the figure is for custom construction. If manufactured commercially, the price would be substantially lower.

One cost issue with biosensors is the length of time a biosensor tip will last during regular use. To date, biosensor tips have been prepared with very good activity retention over 10 days and further improvements are anticipated. However, the biosensor tips themselves are inexpensive to prepare and thus should not be costly to purchase. Installation of new tips and disposal of old ones is not labor intensive. Recalibration must be done periodically, regardless of whether a new tip has been installed or an old tip is being used in a new location.

6.0 Implementation Issues

6.1 Environmental Checklist

No permits would be needed to operate the biosensors.

6.2 Other Regulatory Issues

Comparison of the biosensor results to conventional results will be necessary to obtain regulatory approval of biosensor use. With respect to execution of the demonstration, minimal regulatory involvement was needed since this was a demonstration of analytical technology and not of a remediation technology.

6.3 End-User Issues

Potential end-user issues that exist for the use of biosensors for groundwater monitoring include:

- Is the instrument easy to use?
- Is calibration an easy process?
- Are the results accurate and repeatable for conditions at the site?
- What is the detection limit and does it change with changing conditions?
- Can biosensors detect other and/or multiple compounds?

The demonstration was designed to address each of these issues. Ease of use and calibration procedures were documented. The evaluation criteria that have been presented for comparing biosensor and convention laboratory method results address accuracy, interference, and detection limit issues.

After the required additional development, procurement of the biosensor technology is expected to be straightforward. Although CSU is pursuing patent protection for this technology (a provisional patent application, Reardon, K.F. and N. Das, *Optical Biosensor with Enhanced Activity Retention for Detection of Halogenated Organic Compounds* has been filed), this is being done with the purpose of providing incentive for an equipment manufacturer that would require intellectual property protection to commercialize the device. The goal is to license the patent to such a company, which would then manufacture the biosensors commercially with no restrictions; i.e., the biosensors would be available to DoD and remediation professionals similar to oxygen and pH sensors.

6.3.1 Future Development Needs

This demonstration showed that while the biosensors are not yet ready for commercialization, with further development they can be a valuable tool for providing accurate field analyses of several groundwater contaminants. This further development needs to focus on:

- Improving calibration methods to increase accuracy and precision

- Improving field usability
- Adding multi-channel capability to hardware to facilitate calibration and analyze multiple compounds

Also, the long-term performance of this sensor technology is an important factor for its commercialization. Although this performance characteristic was not within the scope of this demonstration, we have evidence from laboratory tests that storage lifetimes of at least 50 days are possible with less than 10% loss in sensitivity. If sensitivity loss is limited to the same, low rate when the biosensors are in frequent or continual use, this would mean that recalibration would need to occur only weekly in the vial or depth profiling measurement modes. For down-hole monitoring, that rate of sensitivity loss would mean that the biosensors would need to be recalibrated every 50 days to retain accuracy within 10%. However, if only semi-quantitative or presence/absence signals are required, recalibration could occur much less frequently. Future research could target this aspect of the biosensor performance. Once the cause(s) of sensitivity loss (e.g., enzyme leakage from the biosensor tip, enzyme degradation, fluorophore bleaching) are evaluated, the appropriate re-design could take place.

7.0 References

CDM and CSU, 2001. *Demonstration Plan – Fiber Optic Biosensors for Contaminant Monitoring – ESTCP Project Number CU-0115* September

The Environmental Company. 2001. Environmental Services Monitoring - Long-Term Monitoring. Draft Round 3 Monitoring Report - Monitored Natural Attenuation OU8 Naval Submarine Base Bangor, Bangor, Washington. June.

The Environmental Company. 2000. *Final Site Specific Health and Safety Plan Monitoring Natural Attenuation Operable Unit 8 Submarine Base Bangor Washington.* October 30.

ESTCP (Environmental Security Technology Certification Program). 2000. *Demonstration Plan Guidance for Cleanup, Site Characterization, and UXO Projects.* June.

Reardon, K.F. and N. Das. 2001. *Optical Biosensor with Enhanced Activity Retention for Detection of Halogenated Organic Compounds*. Provisional Patent Application.

Reardon, K.F., D.W. Campbell, and C. Müller. 1998. *Biosensor for Halogenated Hydrocarbons*. Provisional Patent Application 60/099,890.

8.0 Points of Contact

Point of Contact	Organization Address	Phone/Fax/e-mail	Role in Project
Roger Olsen	CDM 1331 17th St. Ste 1200 Denver, CO 80202	p) 303-298-1311 f) 303-293-8236 olsenrl@cdm.com	PI
Ken Reardon	CSU Dept. Chem. Eng. 200 West Lake Fort Collins, Co 80523-1370	p) 970-491-6505 f) 970-491-7369	Technical Lead
Herbert Fredrickson	U.S. Army Engineer Research & Development Center Environmental Laboratory at Waterways Experiment Station CEERD-EP 3909 Halls Ferry Road Vicksburg, Mississippi 39180-6199	p) 601-634-3716 f) 601-634-3410 fredrih@wes.army.mil	Contract Office Rep.
Andrea Leeson	SERDP/ESTCP Cleanup Program Mgr. 901 Stuart St., Suite 303 Arlington, VA 22203	p) 703-696-2118 f) 703-696-2114	Reviewer

Roger L. Olsen, Ph. D. Date
Principal Investigator
Camp Dresser & McKee, Inc.

Appendix A
SUBASE Bangor
Site Information

Table F-1 Site Selection Information for SUBASE Bangor			
(Source: EA, January 2000)			
Well Information			
Number of wells	76		
Well depth	Shallow Wells: are screened within 30 ft below the water table		
	Intermediate Wells are screened within the middle 40 ft of the Vashon aquifer thickness		
	Deep Wells are screened within 30 ft of Lawton Clay		
Well development	Yes		
Extraction flow rate	500 mL /minute		
Groundwater Information			
Depth to GW	19 – 22 ft bgs (EFA NW comments 10/25/00)		
Groundwater sampling	Low-flow purge sampling techniques w/ peristaltic pump		
Aquifer thickness	(approximately 125 ft thick in public works area)		
GW flow direction	Southeast		
Hydraulic conductivity	67 ft/day		
Soil Information			
Soil Types	**Thickness**	**Depth (ft)**	
Construction Fill		2 to 3 ft bgs	
Vashon Till	20 to 40 ft	15 to 45 ft bgs	
Vashon Advanced Outwash	100 to 130 ft	30 to 160 ft bgs	
Silty Transition zone	20 to 50 ft	110 to 160 ft bgs	
Lawton Clay		100 to 160 ft bgs	

Contaminant Information (Based on wells in Appendix A, EA, January, 2000)				
Contaminants	**Depth to Contaminants**	**Max. (µg/L)**	**Min. (µg/L)**	**Average (µg/L)**
1,2-DCA	Shallow	1500	0	214
Benzene	Shallow	7800	0	1330
1,1,2-TCA	Shallow	2.1	0	0.16

Contaminants	**Depth to contaminants**	**Max. (µg/L)**	**Min. µg/L)**	**Average (µg/L)**
1,2-DCA	Intermediate	48	0	8.9
Benzene	Intermediate	2.3	0	0.30
1,1,2-TCA	Intermediate	29	0	3.5

	Shallow			**Intermediate**		
Groundwater Chemistry	**Max.**	**Min.**	**Average**	**Max.**	**Min.**	**Average**
Turbidity (NTU)	644	0	220	280	0	53
Temperature (C)	27.4	10.22	14.6	24.9	10.1	14.1
Sulfide (mg/L)	1.2	0	0.16	0	0	0
Sulfate (mg/L)	27	0	6.7	12	5	6.6
pH	7.24	6	6.54	7.42	6.25	6.91
BOD(mg/L)	34.5	0	11.7	0	0	0
Nitrite (mg-N/L)	0.57	0	0.04	0	0	0
Nitrate (mg-N/L)	4	0	0.52	1.0	0	0.31
N as Ammonia (mg/L)	0.47	0	0.21	0.26	0.11	0.16
Methane (mg/L)	1.48	0	0.14	0.02	0	0
Manganese (µg/L)	6730	0	3410	2700	0	400
Iron-II (mg/L)	1.35	0.04	1.35	1.4	0	0.34
Iron (µg/L)	15200	0	2460	734	0	116
Hydrogen (nM)	36.72	0	4.0	10.84	0	1.82
Eh (mV)	187	-217	-9.2	149	-26	63.9
DO (mg/L)	7.7	0	1.6	4.63	0.08	1.22
Conductivity (mS/cm)	0.86	.095	0.42	0.28	0.1	0.17
Chloride (mg/L)	61	2.8	11.3	7.7	1.4	3.8
TIC (mg/L)	128	13.2	79.3	55	14.4	26.6
TOC (mg/L)	114	0	16.1	2.1	0	0.52
Carbon dioxide (mg/L)	400	47.8	190	118	20	51.8
Bromide (mg/L)	1.1	0	0.23	0	0	0
Total Alkalinity	447	61.2	242	276	58.4	123

Appendix B
Daily Field Reports

Biosensor Measurement Datasheet
Second Bangor Demonstration, September 2004

40 mL Vial Number: MOW-1-1 (B)	**Analyst:** NICOLA ACHA	**Checked By:**
Biosensor ID: 422	**Date:** 09/20/04	**Date Checked:**
pH Optode ID: 105	**Time:**	
pH Optode Sensitivity: 32 **PMT:** 600V		

Subsample Number (4.85 mL Vial)	Biosensor or Optode Reading?	Step Number	Step Description	Solution Removed and Volume (uL)	Solution Added and Volume (uL)	Start Time	Start Volts	End Time	End Volts	Delta T	Delta V
	BIO	1	MOW-1-1	100	100	8:23	6.66	8:30	6.355	7	0.306
	BIO	2	dca (100ppb)	50	50	8:33	6.363	8:42	6.115	9	0.248
	BIO	3	dca (100ppb)	25	25	8:49	5.97	8:07	5.369	18	0.601
	BIO	4	dca (100ppb	75	75	9:16	4.305	9:34	3.258	18	1.047
	BIO	5	HCl (1mM)	50	50	9:36	3.31	9:40	3.02	4	0.29
	BIO	6	HCl (1mM)	25	25	9:43	3.01	9:47	2.77	4	0.24
	BIO	7	HCl (1mM)	75	75	9:50	2.75	9:58	2.37	8	0.378
	pHopt	8	MOW-1-1	100	100	10:01	9.732	10:04	9.37	3	0.362
	pHopt	9	DCA (100ppb)	50	50	10:05	9.37	10:12	8.62	5	0.75
	pHopt	10	DCA (100ppb)	25	25	10:14	8.64	10:20	8.06	6	0.58
	pHopt	11	DCA (100ppb)	75	75	10:21	8.00	10:28	6.98	6	1.02
	pHopt	12	HCl (1mM)	50	50	10:30	7.54	10:37	7.38	7	0.16
	pHopt	13	HCl (1mM)	25	25	10:38	7.37	10:49	6.86	11	0.51
	pHopt	14	HCl (1mM)	75	75	10:50	6.86	10:57	6.18	7	0.68

Comments:

Uncorrected DCA Concentration of Unknown (ug/L) =

Corrected DCA Concentration of Unknown (ug/L) =

Biosensor Measurement Datasheet
Second Bangor Demonstration, September 2004

40 mL Vial Number: mow-1-1	Analyst: Doctor ACHA	Checked By:
Biosensor ID: 422	Date: 09/20/04	Date Checked:
pH Optode ID: 105	Time: 2:11 PM	
pH Optode Sensitivity: 32 PMT: 600		

Subsample Number (4.85 mL Vial)	Biosensor or Optode Reading?	Step Number	Step Description	Solution Removed and Volume (uL)	Solution Added and Volume (uL)	Start Time	Start Volts	End Time	End Volts	Delta T	Delta V
	Bio	1	mow-1-1	100	100	2:11	8.232	2:15	8.159	4	0.073
	Bio	2	DCA (100 ppb)	50	50	2:21	8.351	2:24	8.278	3	0.073
	Bio	3	DCA (100 ppb)	25	25	2:31	8.393	2:35	8.243	4	0.150
	Bio	4	DCA (100 ppb)	75	75	2:45	8.393	2:49	8.244	4	0.149
	Bio	5	HCl (1mM)	50	50	3:50	9.576	3:53	9.507	3	0.069
	Bio	6	HCl (1mM)	25	25	4:01	9.436	4:03	9.391	2	0.045
	Bio	7	HCl (1mM)	75	75	4:08	9.482	4:11	9.383	3	0.1
	pHop	8	mow-1-1	100	100	4:41	11.313	4:44	11.261	3	0.052
	pHop	9	DCA (100 ppb)	50	50	4:45	11.26	4:47	11.078	2	0.182
	pHop	10	DCA (100 ppb)	25	25	4:50	11.057	4:52	10.909	2	0.149
	pHop	11	DCA (100 ppb)	75	75	4:59	10.47	5:06	9.863	7	0.615
	pHop	12	HCl (1mM)	50	50	5:15	10.884	5:17	10.829	2	0.055
	pHop	13	HCl (1mM)	25	25	5:19	10.808	5:20	10.779	1	0.029
	pHop	14	HCl (1mM)	75	75	5:22	10.714	5:25	10.635	3	0.105

Comments:

Uncorrected DCA Concentration of Unknown (ug/L) =

Corrected DCA Concentration of Unknown (ug/L) =

Biosensor Measurement Datasheet
Second Bangor Demonstration, September 2004

40 mL Vial Number: mow-2-1	**Analyst:** VICTOR ACHA	**Checked By:**	
Biosensor ID: 422	**Date:** 9/20/04	**Date Checked:**	
pH Optode ID: 105	**Time:** 11:13 PM		
pH Optode Sensitivity: 32 **PMT:** 600 V			

Subsample Number (4.85 mL Vial)	Biosensor or Optode Reading?	Step Number	Step Description	Solution Removed and Volume (uL)	Solution Added and Volume (uL)	PM Start Time	Start Volts	End Time	End Volts	min Delta T	Delta V
	BIO	1	mow-2-1	100	100	11:13	10.456	11:26	10.173	13	0.283 (0.283)
	BIO	2	DCA (100ppb)	50	50	11:26	10.173	11:34	10.01	8	0.163
	BIO	3	DCA (100ppb)	25	25	11:36	10.004	11:43	9.82	7	0.184
	BIO	4	DCA (100ppb)	75	75	11:45	9.782	11:59	9.39	14	0.392
	BIO	5	HCl (1mM)	50	50 9/21/04 AM	00:21	8.554	00:26	8.31	5	0.243
	BIO	6	HCl (1mM)	25	25 AM	00:28	8.205	00:32	7.965	4	0.24 (0.24)
	BIO	7	HCl (1mM)	75	75 AM	00:35	7.97	00:42	7.586	7	0.384
	pHopt	8	mow-2-1	100	100	00:54	8.632	00:56	8.38	2	0.252
	pHopt	9	DCA (100ppb)	50	50	00:57	8.386	01:07	7.593	4	0.793
	pHopt	10	DCA (100ppb)	25	25	01:03	7.5185	1:10	6.947	7	0.5715
	pHopt	11	DCA (100ppb)	75	75	1:11	6.923	1:18	5.84	7	1.083
	pHopt	12	HCl (1mM)	50	50	1:29	7.919	1:35	7.76	6	0.159
	pHopt	13	HCl (1mM)	25	25	1:37	7.746	1:49	7.314	12	0.432
	pHopt	14	HCl (1mM)	75	75	1:50	7.322	1:58	6.616	8	0.706

Comments:

Uncorrected DCA Concentration of Unknown (ug/L) =

Corrected DCA Concentration of Unknown (ug/L) =

Biosensor Measurement Datasheet
Second Bangor Demonstration, September 2004

40 mL Vial Number: MOW-3-2 16H30 9/24/04	Analyst: Victor Acha	Checked By:
Biosensor ID: 422	Date: 9/21/04	Date Checked:
pH Optode ID: 105	Time:	
pH Optode Sensitivity: 32 PMT: 600V		

Subsample Number (4.85 mL Vial)	Biosensor or Optode Reading?	Step Number	Step Description	Solution Removed and Volume (uL)	Solution Added and Volume (uL)	Start Time	Start Volts	End Time	End Volts	Delta T	Delta V	
	Bio	1	MOW-3-2	100	100	8:32	11.255	8:33	11.224	1	0.031	
	Bio	2	DCA (100ppb)	50	50	8:38	11.2365	8:41	11.21	3	0.0265	
	Bio	3	DCA (100ppb)	25	25	8:45	11.2465	8:47	11.202	2	0.0445	
	Bio	4	DCA (100ppb)	75	75	8:49	11.2015	8:53	11.1225	4	0.079	✓
	Bio	5	HCl (1mM)	50	50	9:08	10.97	9:09	10.932	1	0.038	0.025
	Bio	6	HCl (1mM)	25	25	9:09	10.947	9:11	10.9115	2	0.0335	0.013
	Bio	7	HCl (1mM)	75	75	9:21	10.96	9:24	10.924	3	0.036	0.051
	pHopt	8	MOW-3-2	100	100	9:47	11.383	9:52	10.788	5	0.595	(0.595
	pHopt	9	DCA (100ppb)	50	50	9:57	10.784	10:01	10.554	4	0.23	
	pHopt	10	DCA (100ppb)	25	25	10:03	10.37	10.13	10.37	10	0.2	
	pHopt	11	DCA (100ppb)	75	75	10:14	10.35	10:18	10.022	4	0.328	
	pHopt	12	HCl (1mM)	50	50	11:49	11.234	12.01	11.125	12	0.109	
			HCl (1mM)	25	25	12:01	11.124	12:05	11.08	4	0.044	
			HCl (1mM)	75	75	12:08	11.04	12:14	10.965	6	0.1405	

Comments:

75uL HCl additions
1) - 0.01
2) - 0.02

Uncorrected DCA Concentration of Unknown (ug/L) =

Corrected DCA Concentration of Unknown (ug/L) =

Appendix C
Analytical Laboratory Result Reports

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
Phone: 913.599.5665
Fax: 913.599.1759

September 24, 2004

Dr. John Eisenbeis
Camp Dresser & McKee Inc.
1331 17th Street
Suite 1200
Denver, CO 80202

RE: Lab Project Number: 6087072
Client Project ID: Bangor

Dear Dr. Eisenbeis:

Enclosed are the analytical results for sample(s) received by the laboratory on September 22, 2004. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

If you have any questions concerning this report please feel free to contact me.

Sincerely,

Adam Taylor
adam.taylor@pacelabs.com
Project Manager

Kansas/NELAP Certification Number E-10116

Enclosures

REPORT OF LABORATORY ANALYSIS

Pace Analytical®
www.pacelabs.com

SAMPLE SUMMARY

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
Phone: 913.599.5665
Fax: 913.599.1759

Lab Project Number: 6087072
Client Project ID: Bangor

Project Sample Number	Sample Number	Client Sample ID	Matrix	Date Collected	Date Received
6087072-001	607500071	MON 1-1	Water	09/20/04 12:10	09/22/04 08:50
6087072-002	607500089	MON 2-1	Water	09/20/04 15:30	09/22/04 08:50
6087072-003	607500097	MON 3-1	Water	09/20/04 16:30	09/22/04 08:50
6087072-004	607500105	TUES 6-1	Water	09/21/04 10:00	09/22/04 08:50
6087072-005	607500113	TUES 7-1	Water	09/21/04 13:30	09/22/04 08:50
6087072-006	607500121	TUES 8-1	Water	09/21/04 14:00	09/22/04 08:50

REPORT OF LABORATORY ANALYSIS

ACCREDITED IN ACCORDANCE WITH nelac

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SAMPLE ANALYTE COUNT

Lab Project Number: 6087072
Client Project ID: Bangor

Project Sample Number	Sample No	Client Sample ID	Analysis Code	Analysis Description	Analytes Reported
6087072-001	607500071	MON 1-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	**72**
6087072-002	607500089	MON 2-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087072-003	607500097	MON 3-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087072-004	607500105	TUES 6-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087072-005	607500113	TUES 7-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087072-006	607500121	TUES 8-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500071 Project Sample Number: **6087072-001** Date Collected: 09/20/04 12:10
Client Sample ID: MON 1-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/23/04 14:12	KBL1	67-64-1		
Benzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/23/04 14:12	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/23/04 14:12	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/23/04 14:12	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-34-3		
1,2-Dichloroethane	17.	ug/l	1.0	1.0	09/23/04 14:12	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	540-59-0		
1,1-Dichloroethene	1.4	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	563-58-6		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500071 Project Sample Number: 6087072-001 Date Collected: 09/20/04 12:10
Client Sample ID: MON 1-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	10061-02-6		
Ethylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/23/04 14:12	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/23/04 14:12	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/23/04 14:12	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	127-18-4		
Toluene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/23/04 14:12	KBL1	96-18-4		
1,2,4-Trimethylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	95-63-6		
1,3,5-Trimethylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	75-01-4		
Xylene (Total)	ND	ug/l	3.0	1.0	09/23/04 14:12	KBL1	1330-20-7		
m&p-Xylene	ND	ug/l	2.0	1.0	09/23/04 14:12	KBL1			
o-Xylene	ND	ug/l	1.0	1.0	09/23/04 14:12	KBL1	95-47-6		
pH	1.0			1.0	09/23/04 14:12	KBL1			
Toluene-d8 (S)	106	%		1.0	09/23/04 14:12	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	91	%		1.0	09/23/04 14:12	KBL1	460-00-4		
Dibromofluoromethane (S)	102	%		1.0	09/23/04 14:12	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	108	%		1.0	09/23/04 14:12	KBL1	17060-07-0		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500089 Project Sample Number: 6087072-002 Date Collected: 09/20/04 15:30
Client Sample ID: MON 2-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/23/04 14:29	KBL1	67-64-1		
Benzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/23/04 14:29	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/23/04 14:29	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/23/04 14:29	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-34-3		
1,2-Dichloroethane	18.	ug/l	1.0	1.0	09/23/04 14:29	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	540-59-0		
1,1-Dichloroethene	12.	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	156-60-5		
1,2-Dichloropropane	5.2	ug/l	1.0	1.0	09/23/04 14:29	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	563-58-6		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500089 Project Sample **Number: 6087072-002** Date Collected: 09/20/04 15:30
Client Sample ID: MON 2-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	10061-02-6		
Ethylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/23/04 14:29	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/23/04 14:29	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/23/04 14:29	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	127-18-4		
Toluene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	71-55-6		
1,1,2-Trichloroethane	20.	ug/l	1.0	1.0	09/23/04 14:29	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/23/04 14:29	KBL1	96-18-4		
1,2,4-Trimethylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	95-63-6		
1,3,5-Trimethylbenzene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	75-01-4		
Xylene (Total)	ND	ug/l	3.0	1.0	09/23/04 14:29	KBL1	1330-20-7		
m&p-Xylene	ND	ug/l	2.0	1.0	09/23/04 14:29	KBL1			
o-Xylene	ND	ug/l	1.0	1.0	09/23/04 14:29	KBL1	95-47-6		
pH	1.0			1.0	09/23/04 14:29	KBL1			
Toluene-d8 (S)	103	%		1.0	09/23/04 14:29	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	108	%		1.0	09/23/04 14:29	KBL1	460-00-4		
Dibromofluoromethane (S)	103	%		1.0	09/23/04 14:29	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	104	%		1.0	09/23/04 14:29	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500097 Project Sample **Number: 6087072-003** Date Collected: 09/20/04 16:30
Client Sample ID: MON 3-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	1000	100	09/24/04 14:42	KBL1	67-64-1		
Benzene	7100	ug/l	100	100	09/24/04 14:42	KBL1	71-43-2		
Bromobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-27-4		
Bromoform	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-25-2		
Bromomethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	1000	100	09/24/04 14:42	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	500	100	09/24/04 14:42	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	100	100	09/24/04 14:42	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	108-90-7		
Chloroethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-00-3		
Chloroform	ND	ug/l	100	100	09/24/04 14:42	KBL1	67-66-3		
Chloromethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	100	100	09/24/04 14:42	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	100	100	09/24/04 14:42	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	250	100	09/24/04 14:42	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	100	100	09/24/04 14:42	KBL1	106-93-4		
Dibromomethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-34-3		
1,2-Dichloroethane	900	ug/l	100	100	09/24/04 14:42	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	100	100	09/24/04 14:42	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	100	100	09/24/04 14:42	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	100	100	09/24/04 14:42	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	100	100	09/24/04 14:42	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	100	100	09/24/04 14:42	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	100	100	09/24/04 14:42	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	100	100	09/24/04 14:42	KBL1	563-58-6		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500097 Project Sample Number: 6087072-003 Date Collected: 09/20/04 16:30
Client Sample ID: MON 3-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	100	100	09/24/04 14:42	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	100	100	09/24/04 14:42	KBL1	10061-02-6		
Ethylbenzene	230	ug/l	100	100	09/24/04 14:42	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	100	100	09/24/04 14:42	KBL1	87-68-3		
2-Hexanone	ND	ug/l	1000	100	09/24/04 14:42	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	100	100	09/24/04 14:42	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	100	100	09/24/04 14:42	KBL1	99-87-6		
Methylene chloride	210	ug/l	100	100	09/24/04 14:42	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	1000	100	09/24/04 14:42	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	100	100	09/24/04 14:42	KBL1	1634-04-4		
Naphthalene	ND	ug/l	1000	100	09/24/04 14:42	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	103-65-1		
Styrene	ND	ug/l	100	100	09/24/04 14:42	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	100	100	09/24/04 14:42	KBL1	127-18-4		
Toluene	2200	ug/l	100	100	09/24/04 14:42	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	100	100	09/24/04 14:42	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	79-00-5		
Trichloroethene	410	ug/l	100	100	09/24/04 14:42	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	250	100	09/24/04 14:42	KBL1	96-18-4		
1,2,4-Trimethylbenzene	520	ug/l	100	100	09/24/04 14:42	KBL1	95-63-6		
1,3,5-Trimethylbenzene	440	ug/l	100	100	09/24/04 14:42	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	100	100	09/24/04 14:42	KBL1	75-01-4		
Xylene (Total)	3600	ug/l	300	100	09/24/04 14:42	KBL1	1330-20-7		
m&p-Xylene	2200	ug/l	200	100	09/24/04 14:42	KBL1			
o-Xylene	1500	ug/l	100	100	09/24/04 14:42	KBL1	95-47-6		
pH	1.0			1.0	09/24/04 14:42	KBL1			
Toluene-d8 (S)	103	%		1.0	09/24/04 14:42	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	99	%		1.0	09/24/04 14:42	KBL1	460-00-4		
Dibromofluoromethane (S)	98	%		1.0	09/24/04 14:42	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	107	%		1.0	09/24/04 14:42	KBL1	17060-07-0		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500105 Project Sample Number: 6087072-004 Date Collected: 09/21/04 10:00
Client Sample ID: TUES 6-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	200	20.0	09/24/04 15:15	KBL1	67-64-1		
Benzene	3500	ug/l	20.	20.0	09/24/04 15:15	KBL1	71-43-2		
Bromobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-27-4		
Bromoform	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-25-2		
Bromomethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	200	20.0	09/24/04 15:15	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	100	20.0	09/24/04 15:15	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	108-90-7		
Chloroethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-00-3		
Chloroform	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	67-66-3		
Chloromethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	50.	20.0	09/24/04 15:15	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	106-93-4		
Dibromomethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-34-3		
1,2-Dichloroethane	990	ug/l	20.	20.0	09/24/04 15:15	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	563-58-6		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500105 Project Sample Number: 6087072-004 Date Collected: 09/21/04 10:00
Client Sample ID: TUES 6-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	10061-02-6		
Ethylbenzene	280	ug/l	20.	20.0	09/24/04 15:15	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	87-68-3		
2-Hexanone	ND	ug/l	200	20.0	09/24/04 15:15	KBL1	591-78-6		
Isopropylbenzene (Cumene)	34.	ug/l	20.	20.0	09/24/04 15:15	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	99-87-6		
Methylene chloride	41.	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	200	20.0	09/24/04 15:15	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	1634-04-4		
Naphthalene	ND	ug/l	200	20.0	09/24/04 15:15	KBL1	91-20-3		
n-Propylbenzene	92.	ug/l	20.	20.0	09/24/04 15:15	KBL1	103-65-1		
Styrene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	127-18-4		
Toluene	170	ug/l	20.	20.0	09/24/04 15:15	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	79-00-5		
Trichloroethene	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	50.	20.0	09/24/04 15:15	KBL1	96-18-4		
1,2,4-Trimethylbenzene	140	ug/l	20.	20.0	09/24/04 15:15	KBL1	95-63-6		
1,3,5-Trimethylbenzene	82.	ug/l	20.	20.0	09/24/04 15:15	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	20.	20.0	09/24/04 15:15	KBL1	75-01-4		
Xylene (Total)	250	ug/l	60.	20.0	09/24/04 15:15	KBL1	1330-20-7		
m&p-Xylene	170	ug/l	40.	20.0	09/24/04 15:15	KBL1			
o-Xylene	80.	ug/l	20.	20.0	09/24/04 15:15	KBL1	95-47-6		
pH	1.0			1.0	09/24/04 15:15	KBL1			
Toluene-d8 (S)	105	%		1.0	09/24/04 15:15	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	89	%		1.0	09/24/04 15:15	KBL1	460-00-4		
Dibromofluoromethane (S)	98	%		1.0	09/24/04 15:15	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	103	%		1.0	09/24/04 15:15	KBL1	17060-07-0		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500113 Project Sample **Number: 6087072-005** Date Collected: 09/21/04 13:30
Client Sample ID: TUES 7-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/24/04 14:25	KBL1	67-64-1		
Benzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/24/04 14:25	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/24/04 14:25	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/24/04 14:25	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-34-3		
1,2-Dichloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	563-58-6		

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500113 Project Sample Number: **6087072-005** Date Collected: 09/21/04 13:30
Client Sample ID: TUES 7-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	10061-02-6		
Ethylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/24/04 14:25	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/24/04 14:25	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/24/04 14:25	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	127-18-4		
Toluene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/24/04 14:25	KBL1	96-18-4		
1,2,4-Trimethylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	95-63-6		
1,3,5-Trimethylbenzene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	75-01-4		
Xylene (Total)	ND	ug/l	3.0	1.0	09/24/04 14:25	KBL1	1330-20-7		
m&p-Xylene	ND	ug/l	2.0	1.0	09/24/04 14:25	KBL1			
o-Xylene	ND	ug/l	1.0	1.0	09/24/04 14:25	KBL1	95-47-6		
pH	1.0			1.0	09/24/04 14:25	KBL1			
Toluene-d8 (S)	103	%		1.0	09/24/04 14:25	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	105	%		1.0	09/24/04 14:25	KBL1	460-00-4		
Dibromofluoromethane (S)	102	%		1.0	09/24/04 14:25	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	102	%		1.0	09/24/04 14:25	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500121 Project Sample Number: 6087072-006 Date Collected: 09/21/04 14:00
Client Sample ID: TUES 8-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/23/04 15:35	KBL1	67-64-1		
Benzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/23/04 15:35	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/23/04 15:35	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/23/04 15:35	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-34-3		
1,2-Dichloroethane	6.0	ug/l	1.0	1.0	09/23/04 15:35	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	563-58-6		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No: 607500121 Project Sample Number: 6087072-006 Date Collected: 09/21/04 14:00
Client Sample ID: TUES 8-1 Matrix: Water Date Received: 09/22/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	10061-02-6		
Ethylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/23/04 15:35	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/23/04 15:35	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/23/04 15:35	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	127-18-4		
Toluene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/23/04 15:35	KBL1	96-18-4		
1,2,4-Trimethylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	95-63-6		
1,3,5-Trimethylbenzene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	75-01-4		
Xylene (Total)	ND	ug/l	3.0	1.0	09/23/04 15:35	KBL1	1330-20-7		
m&p-Xylene	ND	ug/l	2.0	1.0	09/23/04 15:35	KBL1			
o-Xylene	ND	ug/l	1.0	1.0	09/23/04 15:35	KBL1	95-47-6		
pH	1.0			1.0	09/23/04 15:35	KBL1			
Toluene-d8 (S)	105	%		1.0	09/23/04 15:35	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	105	%		1.0	09/23/04 15:35	KBL1	460-00-4		
Dibromofluoromethane (S)	101	%		1.0	09/23/04 15:35	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	99	%		1.0	09/23/04 15:35	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087072
Client Project ID: Bangor

PARAMETER FOOTNOTES

Dilution factor shown represents the factor applied to the reported result and reporting limit due to changes in sample preparation, dilution of the extract, or moisture content

ND	Not detected at or above adjusted reporting limit
NC	Not Calculable
J	Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit
MDL	Adjusted Method Detection Limit
(S)	Surrogate

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

QC Batch: 178434 Analysis Method: EPA 8260
QC Batch Method: EPA 8260 Analysis Description: GC/MS VOCs by 8260 (Low Level)
Associated Lab Samples: 607500071 607500089 607500121

METHOD BLANK: 607503059
Associated Lab Samples: 607500071 607500089 607500121

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Acetone	ug/l	ND	10.	
Benzene	ug/l	ND	1.0	
Bromobenzene	ug/l	ND	1.0	
Bromochloromethane	ug/l	ND	1.0	
Bromodichloromethane	ug/l	ND	1.0	
Bromoform	ug/l	ND	1.0	
Bromomethane	ug/l	ND	1.0	
2-Butanone (MEK)	ug/l	ND	10.	
n-Butylbenzene	ug/l	ND	1.0	
sec-Butylbenzene	ug/l	ND	1.0	
tert-Butylbenzene	ug/l	ND	1.0	
Carbon disulfide	ug/l	ND	5.0	
Carbon tetrachloride	ug/l	ND	1.0	
Chlorobenzene	ug/l	ND	1.0	
Chloroethane	ug/l	ND	1.0	
Chloroform	ug/l	ND	1.0	
Chloromethane	ug/l	ND	1.0	
2-Chlorotoluene	ug/l	ND	1.0	
4-Chlorotoluene	ug/l	ND	1.0	
1,2-Dibromo-3-chloropropane	ug/l	ND	2.5	
Dibromochloromethane	ug/l	ND	1.0	
1,2-Dibromoethane (EDB)	ug/l	ND	1.0	
Dibromomethane	ug/l	ND	1.0	
1,2-Dichlorobenzene	ug/l	ND	1.0	
1,3-Dichlorobenzene	ug/l	ND	1.0	
1,4-Dichlorobenzene	ug/l	ND	1.0	
Dichlorodifluoromethane	ug/l	ND	1.0	
1,1-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethene (Total)	ug/l	ND	1.0	
1,1-Dichloroethene	ug/l	ND	1.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

METHOD BLANK: 607503059
Associated Lab Samples: 607500071 607500089 607500121

Parameter	Units	Blank Result	Reporting Limit	Footnotes
cis-1,2-Dichloroethene	ug/l	ND	1.0	
trans-1,2-Dichloroethene	ug/l	ND	1.0	
1,2-Dichloropropane	ug/l	ND	1.0	
1,3-Dichloropropane	ug/l	ND	1.0	
2,2-Dichloropropane	ug/l	ND	1.0	
1,1-Dichloropropene	ug/l	ND	1.0	
cis-1,3-Dichloropropene	ug/l	ND	1.0	
trans-1,3-Dichloropropene	ug/l	ND	1.0	
Ethylbenzene	ug/l	ND	1.0	
Hexachloro-1,3-butadiene	ug/l	ND	1.0	
2-Hexanone	ug/l	ND	10.	
Isopropylbenzene (Cumene)	ug/l	ND	1.0	
p-Isopropyltoluene	ug/l	ND	1.0	
Methylene chloride	ug/l	ND	1.0	
4-Methyl-2-pentanone (MIBK)	ug/l	ND	10.	
Methyl-tert-butyl ether	ug/l	ND	1.0	
Naphthalene	ug/l	ND	10.	
n-Propylbenzene	ug/l	ND	1.0	
Styrene	ug/l	ND	1.0	
1,1,1,2-Tetrachloroethane	ug/l	ND	1.0	
1,1,2,2-Tetrachloroethane	ug/l	ND	1.0	
Tetrachloroethene	ug/l	ND	1.0	
Toluene	ug/l	ND	1.0	
1,2,3-Trichlorobenzene	ug/l	ND	1.0	
1,2,4-Trichlorobenzene	ug/l	ND	1.0	
1,1,1-Trichloroethane	ug/l	ND	1.0	
1,1,2-Trichloroethane	ug/l	ND	1.0	
Trichloroethene	ug/l	ND	1.0	
Trichlorofluoromethane	ug/l	ND	1.0	
1,2,3-Trichloropropane	ug/l	ND	2.5	
1,2,4-Trimethylbenzene	ug/l	ND	1.0	
1,3,5-Trimethylbenzene	ug/l	ND	1.0	
Vinyl chloride	ug/l	ND	1.0	
Xylene (Total)	ug/l	ND	3.0	
m&p-Xylene	ug/l	ND	2.0	
o-Xylene	ug/l	ND	1.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

METHOD BLANK: 607503059
Associated Lab Samples: 607500071 607500089 607500121

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Toluene-d8 (S)	%	107		
4-Bromofluorobenzene (S)	%	101		
Dibromofluoromethane (S)	%	97		
1,2-Dichloroethane-d4 (S)	%	100		

LABORATORY CONTROL SAMPLE: 607503067

Parameter	Units	Spike Conc.	LCS Result	LCS	% Rec Limits	Footnotes
Acetone	ug/l	20.00	17.52	88	18-147	
Benzene	ug/l	10.00	8.990	90	74-118	
Bromobenzene	ug/l	10.00	8.610	86	79-115	
Bromochloromethane	ug/l	10.00	10.13	101	67-122	
Bromodichloromethane	ug/l	10.00	8.080	81	81-124	
Bromoform	ug/l	10.00	8.460	85	65-125	
Bromomethane	ug/l	10.00	13.26	133	10-150	
2-Butanone (MEK)	ug/l	20.00	15.42	77	35-132	
n-Butylbenzene	ug/l	10.00	9.520	95	67-124	
sec-Butylbenzene	ug/l	10.00	9.520	95	75-121	
tert-Butylbenzene	ug/l	10.00	9.650	96	76-118	
Carbon disulfide	ug/l	20.00	17.09	86	12-132	
Carbon tetrachloride	ug/l	10.00	11.74	117	69-131	
Chlorobenzene	ug/l	10.00	9.290	93	77-115	
Chloroethane	ug/l	10.00	10.51	105	23-140	
Chloroform	ug/l	10.00	8.880	89	74-123	
Chloromethane	ug/l	10.00	12.44	124	25-150	
2-Chlorotoluene	ug/l	10.00	9.440	94	76-118	
4-Chlorotoluene	ug/l	10.00	8.760	88	75-119	
1,2-Dibromo-3-chloropropane	ug/l	10.00	8.740	87	59-124	
Dibromochloromethane	ug/l	10.00	8.780	88	73-125	
1,2-Dibromoethane (EDB)	ug/l	10.00	9.760	98	78-120	
Dibromomethane	ug/l	10.00	9.310	93	71-124	
1,2-Dichlorobenzene	ug/l	10.00	9.430	94	77-117	
1,3-Dichlorobenzene	ug/l	10.00	9.440	94	75-116	
1,4-Dichlorobenzene	ug/l	10.00	8.530	85	72-117	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607503067

Parameter	Units	Spike Conc.	LCS Result	LCS	% Rec Limits	Footnotes
Dichlorodifluoromethane	ug/l	10.00	7.360	74	10-142	
1,1-Dichloroethane	ug/l	10.00	10.02	100	65-126	
1,2-Dichloroethane	ug/l	10.00	10.95	110	71-126	
1,2-Dichloroethene (Total)	ug/l	20.00	19.88	99	73-124	
1,1-Dichloroethene	ug/l	10.00	10.60	106	63-135	
cis-1,2-Dichloroethene	ug/l	10.00	9.060	91	74-120	
trans-1,2-Dichloroethene	ug/l	10.00	10.82	108	68-131	
1,2-Dichloropropane	ug/l	10.00	9.430	94	74-117	
1,3-Dichloropropane	ug/l	10.00	9.360	94	78-118	
2,2-Dichloropropane	ug/l	10.00	11.57	116	47-145	
1,1-Dichloropropene	ug/l	10.00	11.61	116	73-130	
cis-1,3-Dichloropropene	ug/l	10.00	9.500	95	73-124	
trans-1,3-Dichloropropene	ug/l	10.00	10.28	103	72-124	
Ethylbenzene	ug/l	10.00	9.310	93	76-119	
Hexachloro-1,3-butadiene	ug/l	10.00	9.680	97	63-122	
2-Hexanone	ug/l	20.00	18.49	92	43-117	
Isopropylbenzene (Cumene)	ug/l	10.00	8.750	88	73-113	
p-Isopropyltoluene	ug/l	10.00	9.270	93	71-117	
Methylene chloride	ug/l	10.00	10.04	100	65-133	
4-Methyl-2-pentanone (MIBK)	ug/l	20.00	17.73	89	44-113	
Methyl-tert-butyl ether	ug/l	10.00	10.11	101	54-129	
Naphthalene	ug/l	10.00	10.43	104	46-127	
n-Propylbenzene	ug/l	10.00	10.98	110	74-119	
Styrene	ug/l	10.00	9.070	91	78-121	
1,1,1,2-Tetrachloroethane	ug/l	10.00	9.810	98	78-122	
1,1,2,2-Tetrachloroethane	ug/l	10.00	9.200	92	69-121	
Tetrachloroethene	ug/l	10.00	9.710	97	72-121	
Toluene	ug/l	10.00	9.360	94	76-116	
1,2,3-Trichlorobenzene	ug/l	10.00	9.710	97	59-122	
1,2,4-Trichlorobenzene	ug/l	10.00	9.590	96	59-121	
1,1,1-Trichloroethane	ug/l	10.00	11.54	115	71-125	
1,1,2-Trichloroethane	ug/l	10.00	9.710	97	78-121	
Trichloroethene	ug/l	10.00	9.750	98	75-120	
Trichlorofluoromethane	ug/l	10.00	10.87	109	55-141	
1,2,3-Trichloropropane	ug/l	10.00	9.010	90	74-126	
1,2,4-Trimethylbenzene	ug/l	10.00	9.710	97	77-116	
1,3,5-Trimethylbenzene	ug/l	10.00	9.900	99	76-117	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607503067

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Footnotes
Vinyl chloride	ug/l	10.00	10.99	110	50-131	
Xylene (Total)	ug/l	30.00	28.20	94	78-120	
m&p-Xylene	ug/l	20.00	18.40	92	74-120	
o-Xylene	ug/l	10.00	9.800	98	77-120	
Toluene-d8 (S)				104	88-110	
4-Bromofluorobenzene (S)				102	86-115	
Dibromofluoromethane (S)				99	86-118	
1,2-Dichloroethane-d4 (S)				105	80-120	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

QC Batch: 178584 Analysis Method: EPA 8260
QC Batch Method: EPA 8260 Analysis Description: GC/MS VOCs by 8260 (Low Level)
Associated Lab Samples: 607500097 607500105 607500113

METHOD BLANK: 607510583
Associated Lab Samples: 607500097 607500105 607500113

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Acetone	ug/l	ND	10.	
Benzene	ug/l	ND	1.0	
Bromobenzene	ug/l	ND	1.0	
Bromochloromethane	ug/l	ND	1.0	
Bromodichloromethane	ug/l	ND	1.0	
Bromoform	ug/l	ND	1.0	
Bromomethane	ug/l	ND	1.0	
2-Butanone (MEK)	ug/l	ND	10.	
n-Butylbenzene	ug/l	ND	1.0	
sec-Butylbenzene	ug/l	ND	1.0	
tert-Butylbenzene	ug/l	ND	1.0	
Carbon disulfide	ug/l	ND	5.0	
Carbon tetrachloride	ug/l	ND	1.0	
Chlorobenzene	ug/l	ND	1.0	
Chloroethane	ug/l	ND	1.0	
Chloroform	ug/l	ND	1.0	
Chloromethane	ug/l	ND	1.0	
2-Chlorotoluene	ug/l	ND	1.0	
4-Chlorotoluene	ug/l	ND	1.0	
1,2-Dibromo-3-chloropropane	ug/l	ND	2.5	
Dibromochloromethane	ug/l	ND	1.0	
1,2-Dibromoethane (EDB)	ug/l	ND	1.0	
Dibromomethane	ug/l	ND	1.0	
1,2-Dichlorobenzene	ug/l	ND	1.0	
1,3-Dichlorobenzene	ug/l	ND	1.0	
1,4-Dichlorobenzene	ug/l	ND	1.0	
Dichlorodifluoromethane	ug/l	ND	1.0	
1,1-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethene (Total)	ug/l	ND	1.0	
1,1-Dichloroethene	ug/l	ND	1.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

METHOD BLANK: 607510583
Associated Lab Samples: 607500097 607500105 607500113

Parameter	Units	Blank Result	Reporting Limit	Footnotes
cis-1,2-Dichloroethene	ug/l	ND	1.0	
trans-1,2-Dichloroethene	ug/l	ND	1.0	
1,2-Dichloropropane	ug/l	ND	1.0	
1,3-Dichloropropane	ug/l	ND	1.0	
2,2-Dichloropropane	ug/l	ND	1.0	
1,1-Dichloropropene	ug/l	ND	1.0	
cis-1,3-Dichloropropene	ug/l	ND	1.0	
trans-1,3-Dichloropropene	ug/l	ND	1.0	
Ethylbenzene	ug/l	ND	1.0	
Hexachloro-1,3-butadiene	ug/l	1.3	1.0	1
2-Hexanone	ug/l	ND	10.	
Isopropylbenzene (Cumene)	ug/l	ND	1.0	
p-Isopropyltoluene	ug/l	ND	1.0	
Methylene chloride	ug/l	ND	1.0	
4-Methyl-2-pentanone (MIBK)	ug/l	ND	10.	
Methyl-tert-butyl ether	ug/l	ND	1.0	
Naphthalene	ug/l	ND	10.	
n-Propylbenzene	ug/l	ND	1.0	
Styrene	ug/l	ND	1.0	
1,1,1,2-Tetrachloroethane	ug/l	ND	1.0	
1,1,2,2-Tetrachloroethane	ug/l	ND	1.0	
Tetrachloroethene	ug/l	ND	1.0	
Toluene	ug/l	ND	1.0	
1,2,3-Trichlorobenzene	ug/l	ND	1.0	
1,2,4-Trichlorobenzene	ug/l	ND	1.0	
1,1,1-Trichloroethane	ug/l	ND	1.0	
1,1,2-Trichloroethane	ug/l	ND	1.0	
Trichloroethene	ug/l	ND	1.0	
Trichlorofluoromethane	ug/l	ND	1.0	
1,2,3-Trichloropropane	ug/l	ND	2.5	
1,2,4-Trimethylbenzene	ug/l	ND	1.0	
1,3,5-Trimethylbenzene	ug/l	ND	1.0	
Vinyl chloride	ug/l	ND	1.0	
Xylene (Total)	ug/l	ND	3.0	
m&p-Xylene	ug/l	ND	2.0	
o-Xylene	ug/l	ND	1.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

METHOD BLANK: 607510583
Associated Lab Samples: 607500097 607500105 607500113

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Toluene-d8 (S)	%	105		
4-Bromofluorobenzene (S)	%	103		
Dibromofluoromethane (S)	%	105		
1,2-Dichloroethane-d4 (S)	%	106		

LABORATORY CONTROL SAMPLE: 607510591

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Footnotes
Acetone	ug/l	20.00	18.25	91	18-147	
Benzene	ug/l	10.00	9.870	99	74-118	
Bromobenzene	ug/l	10.00	9.840	98	79-115	
Bromochloromethane	ug/l	10.00	9.430	94	67-122	
Bromodichloromethane	ug/l	10.00	8.540	85	81-124	
Bromoform	ug/l	10.00	8.980	90	65-125	
Bromomethane	ug/l	10.00	14.91	149	10-150	
2-Butanone (MEK)	ug/l	20.00	17.95	90	35-132	
n-Butylbenzene	ug/l	10.00	9.630	96	67-124	
sec-Butylbenzene	ug/l	10.00	9.830	98	75-121	
tert-Butylbenzene	ug/l	10.00	9.050	90	76-118	
Carbon disulfide	ug/l	20.00	17.45	87	12-132	
Carbon tetrachloride	ug/l	10.00	12.12	121	69-131	
Chlorobenzene	ug/l	10.00	9.740	97	77-115	
Chloroethane	ug/l	10.00	10.45	105	23-140	
Chloroform	ug/l	10.00	9.700	97	74-123	
Chloromethane	ug/l	10.00	14.15	142	25-150	
2-Chlorotoluene	ug/l	10.00	9.100	91	76-118	
4-Chlorotoluene	ug/l	10.00	9.360	94	75-119	
1,2-Dibromo-3-chloropropane	ug/l	10.00	8.400	84	59-124	
Dibromochloromethane	ug/l	10.00	9.640	96	73-125	
1,2-Dibromoethane (EDB)	ug/l	10.00	11.52	115	78-120	
Dibromomethane	ug/l	10.00	9.700	97	71-124	
1,2-Dichlorobenzene	ug/l	10.00	9.270	93	77-117	
1,3-Dichlorobenzene	ug/l	10.00	9.060	91	75-116	
1,4-Dichlorobenzene	ug/l	10.00	9.280	93	72-117	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607510591

Parameter	Units	Spike Conc.	LCS Result	LCS	% Rec Limits	Footnotes
Dichlorodifluoromethane	ug/l	10.00	8.380	84	10-142	
1,1-Dichloroethane	ug/l	10.00	10.72	107	65-126	
1,2-Dichloroethane	ug/l	10.00	11.37	114	71-126	
1,2-Dichloroethene (Total)	ug/l	20.00	20.01	100	73-124	
1,1-Dichloroethene	ug/l	10.00	10.84	108	63-135	
cis-1,2-Dichloroethene	ug/l	10.00	9.630	96	74-120	
trans-1,2-Dichloroethene	ug/l	10.00	10.38	104	68-131	
1,2-Dichloropropane	ug/l	10.00	10.02	100	74-117	
1,3-Dichloropropane	ug/l	10.00	9.880	99	78-118	
2,2-Dichloropropane	ug/l	10.00	11.73	117	47-145	
1,1-Dichloropropene	ug/l	10.00	12.41	124	73-130	
cis-1,3-Dichloropropene	ug/l	10.00	9.530	95	73-124	
trans-1,3-Dichloropropene	ug/l	10.00	11.16	112	72-124	
Ethylbenzene	ug/l	10.00	9.820	98	76-119	
Hexachloro-1,3-butadiene	ug/l	10.00	10.34	103	63-122	
2-Hexanone	ug/l	20.00	15.27	76	43-117	
Isopropylbenzene (Cumene)	ug/l	10.00	8.970	90	73-113	
p-Isopropyltoluene	ug/l	10.00	9.120	91	71-117	
Methylene chloride	ug/l	10.00	10.46	105	65-133	
4-Methyl-2-pentanone (MIBK)	ug/l	20.00	18.71	94	44-113	
Methyl-tert-butyl ether	ug/l	10.00	9.650	96	54-129	
Naphthalene	ug/l	10.00	9.330	93	46-127	
n-Propylbenzene	ug/l	10.00	11.00	110	74-119	
Styrene	ug/l	10.00	10.08	101	78-121	
1,1,1,2-Tetrachloroethane	ug/l	10.00	9.550	96	78-122	
1,1,2,2-Tetrachloroethane	ug/l	10.00	8.900	89	69-121	
Tetrachloroethene	ug/l	10.00	10.03	100	72-121	
Toluene	ug/l	10.00	10.42	104	76-116	
1,2,3-Trichlorobenzene	ug/l	10.00	9.410	94	59-122	
1,2,4-Trichlorobenzene	ug/l	10.00	8.880	89	59-121	
1,1,1-Trichloroethane	ug/l	10.00	12.06	121	71-125	
1,1,2-Trichloroethane	ug/l	10.00	9.910	99	78-121	
Trichloroethene	ug/l	10.00	9.700	97	75-120	
Trichlorofluoromethane	ug/l	10.00	10.54	105	55-141	
1,2,3-Trichloropropane	ug/l	10.00	10.96	110	74-126	
1,2,4-Trimethylbenzene	ug/l	10.00	9.230	92	77-116	
1,3,5-Trimethylbenzene	ug/l	10.00	9.490	95	76-117	

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QUALITY CONTROL DATA

Lab Project Number: 6087072
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607510591

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Footnotes
Vinyl chloride	ug/l	10.00	11.83	118	50-131	
Xylene (Total)	ug/l	30.00	30.01	100	78-120	
m&p-Xylene	ug/l	20.00	20.32	102	74-120	
o-Xylene	ug/l	10.00	9.690	97	77-120	
Toluene-d8 (S)				100	88-110	
4-Bromofluorobenzene (S)				97	86-115	
Dibromofluoromethane (S)				100	86-118	
1,2-Dichloroethane-d4 (S)				103	80-120	

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Lab Project Number: 6087072
Client Project ID: Bangor

QUALITY CONTROL DATA PARAMETER FOOTNOTES

Consistent with EPA guidelines, unrounded concentrations are displayed and have been used to calculate % Rec and RPD values.

LCS(D)	Laboratory Control Sample (Duplicate)
MS(D)	Matrix Spike (Duplicate)
DUP	Sample Duplicate
ND	Not detected at or above adjusted reporting limit
NC	Not Calculable
J	Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit
MDL	Adjusted Method Detection Limit
RPD	Relative Percent Difference
(S)	Surrogate
[1]	This compound was detected above the reporting limit in the blank. It was not detected above the reporting limit in the associated samples, therefore the amount detected in the **blank does not affect the usability** of the reported results

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QUALITY CONTROL DATA

CROSS REFERENCE TABLE

Lab Project Number: 6087072
Client Project ID: Bangor

Lab Sample No Identifier	Client Sample Identifier	QC Batch Method	QC Batch Identifier	Analytical Method	Analytical Batch Identifier
607500071	MON 1-1	EPA 8260	178434		
607500089	MON 2-1	EPA 8260	178434		
607500121	TUES 8-1	EPA 8260	178434		
607500097	MON 3-1	EPA 8260	178584		
607500105	TUES 6-1	EPA 8260	178584		
607500113	TUES 7-1	EPA 8260	178584		

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September 28, 2004

Dr. John Eisenbeis
Camp Dresser & McKee Inc.
1331 17th Street
Suite 1200
Denver, CO 80202

RE: Lab Project Number: 6087145
Client Project ID: Bangor

Dear Dr. Eisenbeis:

Enclosed are the analytical results for sample(s) received by the laboratory on September 23, 2004. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

If you have any questions concerning this report please feel free to contact me.

Sincerely,

Adam Taylor

Adam Taylor
adam.taylor@pacelabs.com
Project Manager

Kansas/NELAP Certification Number E-10116

Enclosures

REPORT OF LABORATORY ANALYSIS

ACCREDITED IN ACCORDANCE WITH nelac

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SAMPLE SUMMARY

Lab Project Number: 6087145
Client Project ID: Bangor

Project Sample Number	Sample Number	Client Sample ID	Matrix	Date Collected	Date Received
6087145-001	607504727	TUE-9-1	Water	09/21/04 18:15	09/23/04 08:50
6087145-002	607504735	WED-10-1	Water	09/22/04 11:00	09/23/04 08:50
6087145-003	607504750	WED-11-1	Water	09/22/04 11:05	09/23/04 08:50
6087145-004	607504776	TUES-5-1	Water	09/21/04 09:30	09/23/04 08:50
6087145-005	607504818	RINSATE 9-22-04	Water	09/22/04 11:45	09/23/04 08:50
6087145-006	607504834	TRIP BLANK	Water	09/22/04	09/23/04 08:50

REPORT OF LABORATORY ANALYSIS

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SAMPLE ANALYTE COUNT

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Lab Project Number: 6087145
Client Project ID: Bangor

Project Sample Number	Sample No	Client Sample ID	Analysis Code	Analysis Description	Analytes Reported
6087145-001	607504727	TUE-9-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087145-002	607504735	WED-10-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087145-003	607504750	WED-11-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087145-004	607504776	TUES-5-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087145-005	607504818	RINSATE 9-22-04	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72
6087145-006	607504834	TRIP BLANK	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504727 **Project Sample Number:** 6087145-001 Date Collected: 09/21/04 18:15
Client Sample ID: TUE-9-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	500	50.0	09/25/04 17:06	KBL1	67-64-1		
Benzene	11000	ug/l	200	200	09/27/04 18:17	KBL1	71-43-2		
Bromobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-27-4		
Bromoform	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-25-2		
Bromomethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	500	50.0	09/25/04 17:06	KBL1	78-93-3		
n-Butylbenzene	200	ug/l	50.	50.0	09/25/04 17:06	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	250	50.0	09/25/04 17:06	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	108-90-7		
Chloroethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-00-3		
Chloroform	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	67-66-3		
Chloromethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	120	50.0	09/25/04 17:06	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	106-93-4		
Dibromomethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-34-3		
1,2-Dichloroethane	600	ug/l	50.	50.0	09/25/04 17:06	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	563-58-6		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504727 Project Sample Number: 6087145-001 Date Collected: 09/21/04 18:15
Client Sample ID: TUE-9-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	10061-02-6		
Ethylbenzene	1200	ug/l	50.	50.0	09/25/04 17:06	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	87-68-3		
2-Hexanone	ND	ug/l	500	50.0	09/25/04 17:06	KBL1	591-78-6		
Isopropylbenzene (Cumene)	76.	ug/l	50.	50.0	09/25/04 17:06	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	99-87-6		
Methylene chloride	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	500	50.0	09/25/04 17:06	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	1634-04-4		
Naphthalene	2800	ug/l	500	50.0	09/25/04 17:06	KBL1	91-20-3		
n-Propylbenzene	330	ug/l	50.	50.0	09/25/04 17:06	KBL1	103-65-1		
Styrene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	127-18-4		
Toluene	15000	ug/l	200	200	09/27/04 18:17	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	79-00-5		
Trichloroethene	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	120	50.0	09/25/04 17:06	KBL1	96-18-4		
1,2,4-Trimethylbenzene	1300	ug/l	50.	50.0	09/25/04 17:06	KBL1	95-63-6		
1,3,5-Trimethylbenzene	390	ug/l	50.	50.0	09/25/04 17:06	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	50.	50.0	09/25/04 17:06	KBL1	75-01-4		
Xylene (Total)	5800	ug/l	150	50.0	09/25/04 17:06	KBL1	1330-20-7		
m&p-Xylene	3900	ug/l	100	50.0	09/25/04 17:06	KBL1			
o-Xylene	1900	ug/l	50.	50.0	09/25/04 17:06	KBL1	95-47-6		
pH	1.0			1.0	09/25/04 17:06	KBL1			
Toluene-d8 (S)	106	%		1.0	09/25/04 17:06	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	112	%		1.0	09/25/04 17:06	KBL1	460-00-4		
Dibromofluoromethane (S)	96	%		1.0	09/25/04 17:06	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	110	%		1.0	09/25/04 17:06	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504735 Project Sample Number: 6087145-002 Date Collected: 09/22/04 11:00
Client Sample ID: WED-10-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/25/04 14:03	KBL1	67-64-1		
Benzene	12.	ug/l	1.0	1.0	09/25/04 14:03	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/25/04 14:03	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/25/04 14:03	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/25/04 14:03	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-34-3		
1,2-Dichloroethane	19.	ug/l	1.0	1.0	09/25/04 14:03	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	540-59-0		
1,1-Dichloroethene	11.	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	156-60-5		
1,2-Dichloropropane	5.2	ug/l	1.0	1.0	09/25/04 14:03	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	563-58-6		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504735 Project Sample Number: 6087145-002 Date Collected: 09/22/04 11:00
Client Sample ID: WED-10-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	10061-02-6		
Ethylbenzene	2.5	ug/l	1.0	1.0	09/25/04 14:03	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/25/04 14:03	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/25/04 14:03	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/25/04 14:03	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	127-18-4		
Toluene	42.	ug/l	1.0	1.0	09/25/04 14:03	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	71-55-6		
1,1,2-Trichloroethane	16.	ug/l	1.0	1.0	09/25/04 14:03	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/25/04 14:03	KBL1	96-18-4		
1,2,4-Trimethylbenzene	1.9	ug/l	1.0	1.0	09/25/04 14:03	KBL1	95-63-6		
1,3,5-Trimethylbenzene	2.8	ug/l	1.0	1.0	09/25/04 14:03	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/25/04 14:03	KBL1	75-01-4		
Xylene (Total)	14.	ug/l	3.0	1.0	09/25/04 14:03	KBL1	1330-20-7		
m&p-Xylene	9.0	ug/l	2.0	1.0	09/25/04 14:03	KBL1			
o-Xylene	5.5	ug/l	1.0	1.0	09/25/04 14:03	KBL1	95-47-6		
pH	1.0			1.0	09/25/04 14:03	KBL1			
Toluene-d8 (S)	101	%		1.0	09/25/04 14:03	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	100	%		1.0	09/25/04 14:03	KBL1	460-00-4		
Dibromofluoromethane (S)	101	%		1.0	09/25/04 14:03	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	109	%		1.0	09/25/04 14:03	KBL1	17060-07-0		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504750 Project Sample Number: 6087145-003 Date Collected: 09/22/04 11:05
Client Sample ID: WED-11-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/25/04 14:20	KBL1	67-64-1		
Benzene	11.	ug/l	1.0	1.0	09/25/04 14:20	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/25/04 14:20	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/25/04 14:20	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/25/04 14:20	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-34-3		
1,2-Dichloroethane	18.	ug/l	1.0	1.0	09/25/04 14:20	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	540-59-0		
1,1-Dichloroethene	12.	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	156-60-5		
1,2-Dichloropropane	4.9	ug/l	1.0	1.0	09/25/04 14:20	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	563-58-6		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504750 Project Sample Number: 6087145-003 Date Collected: 09/22/04 11:05
Client Sample ID: WED-11-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	10061-02-6		
Ethylbenzene	2.7	ug/l	1.0	1.0	09/25/04 14:20	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/25/04 14:20	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/25/04 14:20	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/25/04 14:20	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	127-18-4		
Toluene	43.	ug/l	1.0	1.0	09/25/04 14:20	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	71-55-6		
1,1,2-Trichloroethane	17.	ug/l	1.0	1.0	09/25/04 14:20	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/25/04 14:20	KBL1	96-18-4		
1,2,4-Trimethylbenzene	2.0	ug/l	1.0	1.0	09/25/04 14:20	KBL1	95-63-6		
1,3,5-Trimethylbenzene	2.9	ug/l	1.0	1.0	09/25/04 14:20	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/25/04 14:20	KBL1	75-01-4		
Xylene (Total)	15.	ug/l	3.0	1.0	09/25/04 14:20	KBL1	1330-20-7		
m&p-Xylene	10.	ug/l	2.0	1.0	09/25/04 14:20	KBL1			
o-Xylene	5.2	ug/l	1.0	1.0	09/25/04 14:20	KBL1	95-47-6		
pH	1.0			1.0	09/25/04 14:20	KBL1			
Toluene-d8 (S)	108	%		1.0	09/25/04 14:20	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	101	%		1.0	09/25/04 14:20	KBL1	460-00-4		
Dibromofluoromethane (S)	102	%		1.0	09/25/04 14:20	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	96	%		1.0	09/25/04 14:20	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504776 Project Sample Number: 6087145-004 Date Collected: 09/21/04 09:30
Client Sample ID: TUES-5-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	500	50.0	09/25/04 17:22	KBL1	67-64-1		
Benzene	10000	ug/l	500	500	09/27/04 18:34	KBL1	71-43-2		
Bromobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-27-4		
Bromoform	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-25-2		
Bromomethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	500	50.0	09/25/04 17:22	KBL1	78-93-3		
n-Butylbenzene	190	ug/l	50.	50.0	09/25/04 17:22	KBL1	104-51-8		
sec-Butylbenzene	1800	ug/l	50.	50.0	09/25/04 17:22	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	250	50.0	09/25/04 17:22	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	108-90-7		
Chloroethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-00-3		
Chloroform	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	67-66-3		
Chloromethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	120	50.0	09/25/04 17:22	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	110	ug/l	50.	50.0	09/25/04 17:22	KBL1	106-93-4		
Dibromomethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-34-3		
1,2-Dichloroethane	730	ug/l	50.	50.0	09/25/04 17:22	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	563-58-6		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504776 Project Sample **Number: 6087145-004** Date Collected: 09/21/04 09:30
Client Sample ID: TUES-5-1 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	10061-02-6		
Ethylbenzene	1300	ug/l	50.	50.0	09/25/04 17:22	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	87-68-3		
2-Hexanone	ND	ug/l	500	50.0	09/25/04 17:22	KBL1	591-78-6		
Isopropylbenzene (Cumene)	51.	ug/l	50.	50.0	09/25/04 17:22	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	99-87-6		
Methylene chloride	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	500	50.0	09/25/04 17:22	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	1634-04-4		
Naphthalene	1100	ug/l	500	50.0	09/25/04 17:22	KBL1	91-20-3		
n-Propylbenzene	290	ug/l	50.	50.0	09/25/04 17:22	KBL1	103-65-1		
Styrene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	127-18-4		
Toluene	12000	ug/l	500	500	09/27/04 18:34	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	79-00-5		
Trichloroethene	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	**120**	**50.0**	**09/25/04 17:22**	**KBL1**	**96-18-4**		
1,2,4-Trimethylbenzene	2100	ug/l	50.	50.0	09/25/04 17:22	KBL1	95-63-6		
1,3,5-Trimethylbenzene	520	ug/l	50.	50.0	09/25/04 17:22	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	50.	50.0	09/25/04 17:22	KBL1	75-01-4		
Xylene (Total)	11000	ug/l	150	50.0	09/25/04 17:22	KBL1	1330-20-7		
m&p-Xylene	8300	ug/l	100	50.0	09/25/04 17:22	KBL1			
o-Xylene	3100	ug/l	50.	50.0	09/25/04 17:22	KBL1	95-47-6		
pH	1.0			1.0	09/25/04 17:22	KBL1			
Toluene-d8 (S)	105	%		1.0	09/25/04 17:22	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	109	%		1.0	09/25/04 17:22	KBL1	460-00-4		
Dibromofluoromethane (S)	93	%		1.0	09/25/04 17:22	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	106	%		1.0	09/25/04 17:22	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504818 Project Sample **Number: 6087145-005** Date Collected: 09/22/04 11:45
Client Sample ID: RINSATE 9-22-04 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/25/04 14:36	KBL1	67-64-1		
Benzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/25/04 14:36	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/25/04 14:36	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-00-3		
Chloroform	1.0	ug/l	1.0	1.0	09/25/04 14:36	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/25/04 14:36	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-34-3		
1,2-Dichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	563-58-6		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504818 Project Sample **Number: 6087145-005** Date Collected: 09/22/04 11:45
Client Sample ID: RINSATE 9-22-04 Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	10061-02-6		
Ethylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/25/04 14:36	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/25/04 14:36	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/25/04 14:36	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	127-18-4		
Toluene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/25/04 14:36	KBL1	96-18-4		
1,2,4-Trimethylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	95-63-6		
1,3,5-Trimethylbenzene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	75-01-4		
Xylene (Total)	ND	ug/l	3.0	1.0	09/25/04 14:36	KBL1	1330-20-7		
m&p-Xylene	ND	ug/l	2.0	1.0	09/25/04 14:36	KBL1			
o-Xylene	ND	ug/l	1.0	1.0	09/25/04 14:36	KBL1	95-47-6		
pH	1.0			1.0	09/25/04 14:36	KBL1			
Toluene-d8 (S)	101	%		1.0	09/25/04 14:36	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	99	%		1.0	09/25/04 14:36	KBL1	460-00-4		
Dibromofluoromethane (S)	98	%		1.0	09/25/04 14:36	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	106	%		1.0	09/25/04 14:36	KBL1	17060-07-0		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504834 Project Sample Number: **6087145-006** Date Collected: 09/22/04 00:00
Client Sample ID: TRIP BLANK Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	ND	ug/l	10.	1.0	09/25/04 13:47	KBL1	67-64-1		
Benzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	71-43-2		
Bromobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-27-4		
Bromoform	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-25-2		
Bromomethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	10.	1.0	09/25/04 13:47	KBL1	78-93-3		
n-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	104-51-8		
sec-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	5.0	1.0	09/25/04 13:47	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	108-90-7		
Chloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-00-3		
Chloroform	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	67-66-3		
Chloromethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	2.5	1.0	09/25/04 13:47	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	106-93-4		
Dibromomethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-34-3		
1,2-Dichloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	563-58-6		

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Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No: 607504834 Project Sample Number: 6087145-006 Date Collected: 09/22/04 00:00
Client Sample ID: TRIP BLANK Matrix: Water Date Received: 09/23/04 08:50

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	10061-02-6		
Ethylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	87-68-3		
2-Hexanone	ND	ug/l	10.	1.0	09/25/04 13:47	KBL1	591-78-6		
Isopropylbenzene (Cumene)	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	99-87-6		
Methylene chloride	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-09-2		
4-Methyl-2-pentanone (MIBK)	ND	ug/l	10.	1.0	09/25/04 13:47	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	1634-04-4		
Naphthalene	ND	ug/l	10.	1.0	09/25/04 13:47	KBL1	91-20-3		
n-Propylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	103-65-1		
Styrene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	127-18-4		
Toluene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	79-00-5		
Trichloroethene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	2.5	1.0	09/25/04 13:47	KBL1	96-18-4		
1,2,4-Trimethylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	95-63-6		
1,3,5-Trimethylbenzene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	75-01-4		
Xylene (Total)	ND	ug/l	3.0	1.0	09/25/04 13:47	KBL1	1330-20-7		
m&p-Xylene	ND	ug/l	2.0	1.0	09/25/04 13:47	KBL1			
o-Xylene	ND	ug/l	1.0	1.0	09/25/04 13:47	KBL1	95-47-6		
pH	1.0			1.0	09/25/04 13:47	KBL1			
Toluene-d8 (S)	106	%		1.0	09/25/04 13:47	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	95	%		1.0	09/25/04 13:47	KBL1	460-00-4		
Dibromofluoromethane (S)	97	%		1.0	09/25/04 13:47	KBL1	1868-53-7		
1,2-Dichloroethane-d4 (S)	104	%		1.0	09/25/04 13:47	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087145
Client Project ID: Bangor

PARAMETER FOOTNOTES

Dilution factor shown represents the factor applied to the reported result and reporting limit due to changes in sample preparation, dilution of the extract, or moisture content

ND	Not detected at or above adjusted reporting limit
NC	Not Calculable
J	**Estimated conc**entration above the adjusted method detection limit and below the adjusted reporting limit
MDL	Adjusted Method Detection Limit
(S)	Surrogate

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QUALITY CONTROL DATA

Lab Project Number: 6087145
Client Project ID: Bangor

QC Batch: 178587 Analysis Method: EPA 8260
QC Batch Method: EPA 8260 Analysis Description: GC/MS VOCs by 8260 (Low Level)
Associated Lab Samples: 607504727 607504735 607504750 607504776 607504818 607504834

METHOD BLANK: 607510732
Associated Lab Samples: 607504727 607504735 607504750 607504776 607504818 607504834

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Acetone	ug/l	ND	10.	
Benzene	ug/l	ND	1.0	
Bromobenzene	ug/l	ND	1.0	
Bromochloromethane	ug/l	ND	1.0	
Bromodichloromethane	ug/l	ND	1.0	
Bromoform	ug/l	ND	1.0	
Bromomethane	ug/l	ND	1.0	
2-Butanone (MEK)	ug/l	ND	10.	
n-Butylbenzene	ug/l	ND	1.0	
sec-Butylbenzene	ug/l	ND	1.0	
tert-Butylbenzene	ug/l	ND	1.0	
Carbon disulfide	ug/l	ND	5.0	
Carbon tetrachloride	ug/l	ND	1.0	
Chlorobenzene	ug/l	ND	1.0	
Chloroethane	ug/l	ND	1.0	
Chloroform	ug/l	ND	1.0	
Chloromethane	ug/l	ND	1.0	
2-Chlorotoluene	ug/l	ND	1.0	
4-Chlorotoluene	ug/l	ND	1.0	
1,2-Dibromo-3-chloropropane	ug/l	ND	2.5	
Dibromochloromethane	ug/l	ND	1.0	
1,2-Dibromoethane (EDB)	ug/l	ND	1.0	
Dibromomethane	ug/l	ND	1.0	
1,2-Dichlorobenzene	ug/l	ND	1.0	
1,3-Dichlorobenzene	ug/l	ND	1.0	
1,4-Dichlorobenzene	ug/l	ND	1.0	
Dichlorodifluoromethane	ug/l	ND	1.0	
1,1-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethene (Total)	ug/l	ND	1.0	

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Lab Project Number: 6087145
Client Project ID: Bangor

METHOD BLANK: 607510732
Associated Lab Samples: 607504727 607504735 607504750 607504776 607504818 607504834

Parameter	Units	Blank Result	Reporting Limit	Footnotes
1,1-Dichloroethene	ug/l	ND	1.0	
cis-1,2-Dichloroethene	ug/l	ND	1.0	
trans-1,2-Dichloroethene	ug/l	ND	1.0	
1,2-Dichloropropane	ug/l	ND	1.0	
1,3-Dichloropropane	ug/l	ND	1.0	
2,2-Dichloropropane	ug/l	ND	1.0	
1,1-Dichloropropene	ug/l	ND	1.0	
cis-1,3-Dichloropropene	ug/l	ND	1.0	
trans-1,3-Dichloropropene	ug/l	ND	1.0	
Ethylbenzene	ug/l	ND	1.0	
Hexachloro-1,3-butadiene	ug/l	ND	1.0	
2-Hexanone	ug/l	ND	10.	
Isopropylbenzene (Cumene)	ug/l	ND	1.0	
p-Isopropyltoluene	ug/l	ND	1.0	
Methylene chloride	ug/l	ND	1.0	
4-Methyl-2-pentanone (MIBK)	ug/l	ND	10.	
Methyl-tert-butyl ether	ug/l	ND	1.0	
Naphthalene	ug/l	ND	10.	
n-Propylbenzene	ug/l	ND	1.0	
Styrene	ug/l	ND	1.0	
1,1,1,2-Tetrachloroethane	ug/l	ND	1.0	
1,1,2,2-Tetrachloroethane	ug/l	ND	1.0	
Tetrachloroethene	ug/l	ND	1.0	
Toluene	ug/l	ND	1.0	
1,2,3-Trichlorobenzene	ug/l	ND	1.0	
1,2,4-Trichlorobenzene	ug/l	ND	1.0	
1,1,1-Trichloroethane	ug/l	ND	1.0	
1,1,2-Trichloroethane	ug/l	ND	1.0	
Trichloroethene	ug/l	ND	1.0	
Trichlorofluoromethane	ug/l	ND	1.0	
1,2,3-Trichloropropane	ug/l	ND	2.5	
1,2,4-Trimethylbenzene	ug/l	ND	1.0	
1,3,5-Trimethylbenzene	ug/l	ND	1.0	
Vinyl chloride	ug/l	ND	1.0	
Xylene (Total)	ug/l	ND	3.0	
m&p-Xylene	ug/l	ND	2.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087145
Client Project ID: Bangor

METHOD BLANK: 607510732
Associated Lab Samples: 607504727 607504735 607504750 607504776 607504818 607504834

Parameter	Units	Blank Result	Reporting Limit	Footnotes
o-Xylene	ug/l	ND	1.0	
Toluene-d8 (S)	%	106		
4-Bromofluorobenzene (S)	%	104		
Dibromofluoromethane (S)	%	100		
1,2-Dichloroethane-d4 (S)	%	106		

LABORATORY CONTROL SAMPLE: 607510740

Parameter	Units	Spike Conc.	LCS Result	LCS	% Rec Limits	Footnotes
Acetone	ug/l	20.00	13.55	68	18-147	
Benzene	ug/l	10.00	9.570	96	74-118	
Bromobenzene	ug/l	10.00	8.690	87	79-115	
Bromochloromethane	ug/l	10.00	11.60	116	67-122	
Bromodichloromethane	ug/l	10.00	9.630	96	81-124	
Bromoform	ug/l	10.00	6.970	70	65-125	
Bromomethane	ug/l	10.00	12.35	124	10-150	
2-Butanone (MEK)	ug/l	20.00	30.20	151	35-132	1
n-Butylbenzene	ug/l	10.00	9.740	97	67-124	
sec-Butylbenzene	ug/l	10.00	10.07	101	75-121	
tert-Butylbenzene	ug/l	10.00	9.240	92	76-118	
Carbon disulfide	ug/l	20.00	15.02	75	12-132	
Carbon tetrachloride	ug/l	10.00	12.31	123	69-131	
Chlorobenzene	ug/l	10.00	9.360	94	77-115	
Chloroethane	ug/l	10.00	9.220	92	23-140	
Chloroform	ug/l	10.00	9.890	99	74-123	
Chloromethane	ug/l	10.00	10.38	104	25-150	
2-Chlorotoluene	ug/l	10.00	8.440	84	76-118	
4-Chlorotoluene	ug/l	10.00	8.300	83	75-119	
1,2-Dibromo-3-chloropropane	ug/l	10.00	6.030	60	59-124	
Dibromochloromethane	ug/l	10.00	8.740	87	73-125	
1,2-Dibromoethane (EDB)	ug/l	10.00	9.400	94	78-120	
Dibromomethane	ug/l	10.00	9.570	96	71-124	
1,2-Dichlorobenzene	ug/l	10.00	9.040	90	77-117	
1,3-Dichlorobenzene	ug/l	10.00	8.860	89	75-116	

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Lab Project Number: 6087145
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607510740

Parameter	Units	Spike Conc.	LCS Result	LCS	% Rec Limits	Footnotes
1,4-Dichlorobenzene	ug/l	10.00	8.660	87	72-117	
Dichlorodifluoromethane	ug/l	10.00	3.500	35	10-142	
1,1-Dichloroethane	ug/l	10.00	10.75	108	65-126	
1,2-Dichloroethane	ug/l	10.00	11.86	119	71-126	
1,2-Dichloroethene (Total)	ug/l	20.00	26.97	135	73-124	2
1,1-Dichloroethene	ug/l	10.00	9.190	92	63-135	
cis-1,2-Dichloroethene	ug/l	10.00	16.19	162	74-120	3
trans-1,2-Dichloroethene	ug/l	10.00	10.78	108	68-131	
1,2-Dichloropropane	ug/l	10.00	10.04	100	74-117	
1,3-Dichloropropane	ug/l	10.00	10.47	105	78-118	
2,2-Dichloropropane	ug/l	10.00	15.99	160	47-145	1
1,1-Dichloropropene	ug/l	10.00	12.27	123	73-130	
cis-1,3-Dichloropropene	ug/l	10.00	9.160	92	73-124	
trans-1,3-Dichloropropene	ug/l	10.00	8.450	84	72-124	
Ethylbenzene	ug/l	10.00	9.270	93	76-119	
Hexachloro-1,3-butadiene	ug/l	10.00	10.51	105	63-122	
2-Hexanone	ug/l	20.00	17.49	88	43-117	
Isopropylbenzene (Cumene)	ug/l	10.00	7.960	80	73-113	
p-Isopropyltoluene	ug/l	10.00	8.700	87	71-117	
Methylene chloride	ug/l	10.00	9.590	96	65-133	
4-Methyl-2-pentanone (MIBK)	ug/l	20.00	18.09	90	44-113	
Methyl-tert-butyl ether	ug/l	10.00	9.290	93	54-129	
Naphthalene	ug/l	10.00	8.580	86	46-127	
n-Propylbenzene	ug/l	10.00	10.22	102	74-119	
Styrene	ug/l	10.00	9.360	94	78-121	
1,1,1,2-Tetrachloroethane	ug/l	10.00	10.47	105	78-122	
1,1,2,2-Tetrachloroethane	ug/l	10.00	7.880	79	69-121	
Tetrachloroethene	ug/l	10.00	9.870	99	72-121	
Toluene	ug/l	10.00	9.670	97	76-116	
1,2,3-Trichlorobenzene	ug/l	10.00	8.710	87	59-122	
1,2,4-Trichlorobenzene	ug/l	10.00	8.670	87	59-121	
1,1,1-Trichloroethane	ug/l	10.00	12.29	123	71-125	
1,1,2-Trichloroethane	ug/l	10.00	11.43	114	78-121	
Trichloroethene	ug/l	10.00	10.36	104	75-120	
Trichlorofluoromethane	ug/l	10.00	9.480	95	55-141	
1,2,3-Trichloropropane	ug/l	10.00	10.51	105	74-126	
1,2,4-Trimethylbenzene	ug/l	10.00	8.760	88	77-116	

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QUALITY CONTROL DATA

Lab Project Number: 6087145
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607510740

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Footnotes
1,3,5-Trimethylbenzene	ug/l	10.00	9.210	92	76-117	
Vinyl chloride	ug/l	10.00	9.200	92	50-131	
Xylene (Total)	ug/l	30.00	28.28	94	78-120	
m&p-Xylene	ug/l	20.00	18.83	94	74-120	
o-Xylene	ug/l	10.00	9.450	94	77-120	
Toluene-d8 (S)				103	88-110	
4-Bromofluorobenzene (S)				91	86-115	
Dibromofluoromethane (S)				104	86-118	
1,2-Dichloroethane-d4 (S)				107	80-120	

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Lab Project Number: 6087145
Client Project ID: Bangor

QUALITY CONTROL DATA PARAMETER FOOTNOTES

Consistent with EPA guidelines, unrounded concentrations are displayed and have been used to calculate % Rec and RPD values.

LCS(D)	Laboratory Control Sample (Duplicate)
MS(D)	Matrix Spike (Duplicate)
DUP	Sample Duplicate
ND	Not detected at or above adjusted reporting limit
NC	Not Calculable
J	Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit
MDL	Adjusted Method Detection Limit
RPD	Relative Percent Difference
(S)	Surrogate
[1]	The compound or surrogate recovery exceeds the laboratory generated acceptance limits. While the recovery was elevated, the compound was not detected above the reporting limit in the associated samples; therefore, the high bias does not affect the usability of the reported sample results.
[2]	Spike recovery was outside of QC limits high. Therefore samples with this compound detected may have a slightly high bias.
[3]	Spike recovery was outside of QC limits high. Therefore samples with this compound detected may have a slightly high bias.

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QUALITY CONTROL DATA

CROSS REFERENCE TABLE

Lab Project Number: 6087145
Client Project ID: Bangor

Lab Sample No Identifier	Client Sample Identifier	QC Batch Method	QC Batch Identifier	Analytical Method	Analytical Batch Identifier
607504727	TUE-9-1	EPA 8260	178587		
607504735	WED-10-1	EPA 8260	178587		
607504750	WED-11-1	EPA 8260	178587		
607504776	TUES-5-1	EPA 8260	178587		
607504818	RINSATE 9-22-04	EPA 8260	178587		
607504834	TRIP BLANK	EPA 8260	178587		

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September 29, 2004

Dr. John Eisenbeis
Camp Dresser & McKee Inc.
1331 17th Street
Suite 1200
Denver, CO 80202

RE: Lab Project Number: 6087199
Client Project ID: Bangor

Dear Dr. Eisenbeis:

Enclosed are the analytical results for sample(s) received by the laboratory on September 24, 2004. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

If you have any questions concerning this report please feel free to contact me.

Sincerely,

Adam Taylor
adam.taylor@pacelabs.com
Project Manager

Kansas/NELAP Certification Number E-10116

Enclosures

REPORT OF LABORATORY ANALYSIS

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SAMPLE SUMMARY

Lab Project Number: 6087199
Client Project ID: Bangor

Project Sample Number	Sample Number	Client Sample ID	Matrix	Date Collected	Date Received
6087199-001	607509056	THURS-13-1	Water	09/23/04 07:45	09/24/04 09:15

REPORT OF LABORATORY ANALYSIS

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SAMPLE ANALYTE COUNT

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Lab Project Number: 6087199
Client Project ID: Bangor

Project Sample Number	Sample No	Client Sample ID	Analysis Code	Analysis Description	Analytes Reported
6087199-001	607509056	THURS-13-1	826LL WEPA	GC/MS VOCs by 8260 (Low Level)	72

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087199
Client Project ID: Bangor

Lab Sample No: 607509056 Project Sample **Number: 6087199-001** Date Collected: 09/23/04 07:45
Client Sample ID: THURS-13-1 Matrix: Water Date Received: 09/24/04 09:15

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
GC/MS Volatiles									
GC/MS VOCs by 8260 (Low Level)	Method: EPA 8260								
Acetone	440	ug/l	200	20.0	09/29/04 14:22	KBL1	67-64-1		
Benzene	2300	ug/l	20.	20.0	09/29/04 14:22	KBL1	71-43-2		
Bromobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	108-86-1		
Bromochloromethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	74-97-5		
Bromodichloromethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-27-4		
Bromoform	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-25-2		
Bromomethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	74-83-9		
2-Butanone (MEK)	ND	ug/l	200	20.0	09/29/04 14:22	KBL1	78-93-3		
n-Butylbenzene	130	ug/l	20.	20.0	09/29/04 14:22	KBL1	104-51-8		
sec-Butylbenzene	22.	ug/l	20.	20.0	09/29/04 14:22	KBL1	135-98-8		
tert-Butylbenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	98-06-6		
Carbon disulfide	ND	ug/l	100	20.0	09/29/04 14:22	KBL1	75-15-0		
Carbon tetrachloride	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	56-23-5		
Chlorobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	108-90-7		
Chloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-00-3		
Chloroform	35.	ug/l	20.	20.0	09/29/04 14:22	KBL1	67-66-3		
Chloromethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	74-87-3		
2-Chlorotoluene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	95-49-8		
4-Chlorotoluene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	106-43-4		
1,2-Dibromo-3-chloropropane	ND	ug/l	50.	20.0	09/29/04 14:22	KBL1	96-12-8		
Dibromochloromethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	124-48-1		
1,2-Dibromoethane (EDB)	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	106-93-4		
Dibromomethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	74-95-3		
1,2-Dichlorobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	95-50-1		
1,3-Dichlorobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	541-73-1		
1,4-Dichlorobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	106-46-7		
Dichlorodifluoromethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-71-8		
1,1-Dichloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-34-3		
1,2-Dichloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	107-06-2		
1,2-Dichloroethene (Total)	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	540-59-0		
1,1-Dichloroethene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-35-4		
cis-1,2-Dichloroethene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	156-59-2		
trans-1,2-Dichloroethene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	156-60-5		
1,2-Dichloropropane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	78-87-5		
1,3-Dichloropropane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	142-28-9		
2,2-Dichloropropane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	594-20-7		
1,1-Dichloropropene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	563-58-6		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087199
Client Project ID: Bangor

Lab Sample No: 607509056 Project Sample Number: 6087199-001 Date Collected: 09/23/04 07:45
Client Sample ID: THURS-13-1 Matrix: Water Date Received: 09/24/04 09:15

Parameters	Results	Units	Report Limit	DF	Analyzed	By	CAS No.	Qual	RegLmt
cis-1,3-Dichloropropene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	10061-01-5		
trans-1,3-Dichloropropene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	10061-02-6		
Ethylbenzene	760	ug/l	20.	20.0	09/29/04 14:22	KBL1	100-41-4		
Hexachloro-1,3-butadiene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	87-68-3		
2-Hexanone	1200	ug/l	200	20.0	09/29/04 14:22	KBL1	591-78-6		
Isopropylbenzene (Cumene)	51.	ug/l	20.	20.0	09/29/04 14:22	KBL1	98-82-8		
p-Isopropyltoluene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	99-87-6		
Methylene chloride	23.	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-09-2	1,2	
4-Methyl-2-pentanone (MIBK)	ND	ug/l	200	20.0	09/29/04 14:22	KBL1	108-10-1		
Methyl-tert-butyl ether	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	1634-04-4		
Naphthalene	320	ug/l	200	20.0	09/29/04 14:22	KBL1	91-20-3		
n-Propylbenzene	180	ug/l	20.	20.0	09/29/04 14:22	KBL1	103-65-1		
Styrene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	100-42-5		
1,1,1,2-Tetrachloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	630-20-6		
1,1,2,2-Tetrachloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	79-34-5		
Tetrachloroethene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	127-18-4		
Toluene	97.	ug/l	20.	20.0	09/29/04 14:22	KBL1	108-88-3		
1,2,3-Trichlorobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	87-61-6		
1,2,4-Trichlorobenzene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	120-82-1		
1,1,1-Trichloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	71-55-6		
1,1,2-Trichloroethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	79-00-5		
Trichloroethene	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	79-01-6		
Trichlorofluoromethane	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-69-4		
1,2,3-Trichloropropane	ND	ug/l	50.	20.0	09/29/04 14:22	KBL1	96-18-4		
1,2,4-Trimethylbenzene	1500	ug/l	20.	20.0	09/29/04 14:22	KBL1	95-63-6		
1,3,5-Trimethylbenzene	280	ug/l	20.	20.0	09/29/04 14:22	KBL1	108-67-8		
Vinyl chloride	ND	ug/l	20.	20.0	09/29/04 14:22	KBL1	75-01-4		
Xylene (Total)	2500	ug/l	60.	20.0	09/29/04 14:22	KBL1	1330-20-7		
m&p-Xylene	2400	ug/l	40.	20.0	09/29/04 14:22	KBL1			
o-Xylene	88.	ug/l	20.	20.0	09/29/04 14:22	KBL1	95-47-6		
pH	1.0			1.0	09/29/04 14:22	KBL1			
Toluene-d8 (S)	98	%		1.0	09/29/04 14:22	KBL1	2037-26-5		
4-Bromofluorobenzene (S)	100	%		1.0	09/29/04 14:22	KBL1	460-00-4		
Dibromofluoromethane (S)	83	%		1.0	09/29/04 14:22	KBL1	1868-53-7	3	
1,2-Dichloroethane-d4 (S)	89	%		1.0	09/29/04 14:22	KBL1	17060-07-0		

REPORT OF LABORATORY ANALYSIS

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Lab Project Number: 6087199
Client Project ID: Bangor

PARAMETER FOOTNOTES

Dilution factor shown represents the factor applied to the reported result and reporting limit due to changes in sample preparation, dilution of the extract, or moisture content

ND	Not detected at or above adjusted reporting limit
NC	Not Calculable
J	Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit
MDL	Adjusted Method Detection Limit
(S)	Surrogate
[1]	Analyte is found in the associated blank as well as in the sample (CLP B-Flag).
[2]	Compound was detected in the method blank at approximately the same level on the instrument. Therefore it is expected that this concentration is laboratory contamination.
[3]	Low surrogate recovery was confirmed as a matrix effect by a second analysis.

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QUALITY CONTROL DATA

Lab Project Number: 6087199
Client Project ID: Bangor

QC Batch: 178887 Analysis Method: EPA 8260
QC Batch Method: EPA 8260 Analysis Description: GC/MS VOCs by 8260 (Low Level)
Associated Lab Samples: 607509056

METHOD BLANK: 607524014
Associated Lab Samples: 607509056

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Acetone	ug/l	ND	10.	
Benzene	ug/l	ND	1.0	
Bromobenzene	ug/l	ND	1.0	
Bromochloromethane	ug/l	ND	1.0	
Bromodichloromethane	ug/l	ND	1.0	
Bromoform	ug/l	ND	1.0	
Bromomethane	ug/l	ND	1.0	
2-Butanone (MEK)	ug/l	ND	10.	
n-Butylbenzene	ug/l	ND	1.0	
sec-Butylbenzene	ug/l	ND	1.0	
tert-Butylbenzene	ug/l	ND	1.0	
Carbon disulfide	ug/l	ND	5.0	
Carbon tetrachloride	ug/l	ND	1.0	
Chlorobenzene	ug/l	ND	1.0	
Chloroethane	ug/l	ND	1.0	
Chloroform	ug/l	ND	1.0	
Chloromethane	ug/l	ND	1.0	
2-Chlorotoluene	ug/l	ND	1.0	
4-Chlorotoluene	ug/l	ND	1.0	
1,2-Dibromo-3-chloropropane	ug/l	ND	2.5	
Dibromochloromethane	ug/l	ND	1.0	
1,2-Dibromoethane (EDB)	ug/l	ND	1.0	
Dibromomethane	ug/l	ND	1.0	
1,2-Dichlorobenzene	ug/l	ND	1.0	
1,3-Dichlorobenzene	ug/l	ND	1.0	
1,4-Dichlorobenzene	ug/l	ND	1.0	
Dichlorodifluoromethane	ug/l	ND	1.0	
1,1-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethane	ug/l	ND	1.0	
1,2-Dichloroethene (Total)	ug/l	ND	1.0	
1,1-Dichloroethene	ug/l	ND	1.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087199
Client Project ID: Bangor

METHOD BLANK: 607524014
Associated Lab Samples: 607509056

Parameter	Units	Blank Result	Reporting Limit	Footnotes
cis-1,2-Dichloroethene	ug/l	ND	1.0	
trans-1,2-Dichloroethene	ug/l	ND	1.0	
1,2-Dichloropropane	ug/l	ND	1.0	
1,3-Dichloropropane	ug/l	ND	1.0	
2,2-Dichloropropane	ug/l	ND	1.0	
1,1-Dichloropropene	ug/l	ND	1.0	
cis-1,3-Dichloropropene	ug/l	ND	1.0	
trans-1,3-Dichloropropene	ug/l	ND	1.0	
Ethylbenzene	ug/l	ND	1.0	
Hexachloro-1,3-butadiene	ug/l	ND	1.0	
2-Hexanone	ug/l	ND	10.	
Isopropylbenzene (Cumene)	ug/l	ND	1.0	
p-Isopropyltoluene	ug/l	ND	1.0	
Methylene chloride	ug/l	2.5	1.0	
4-Methyl-2-pentanone (MIBK)	ug/l	ND	10.	
Methyl-tert-butyl ether	ug/l	ND	1.0	
Naphthalene	ug/l	ND	10.	
n-Propylbenzene	ug/l	ND	1.0	
Styrene	ug/l	ND	1.0	
1,1,1,2-Tetrachloroethane	ug/l	ND	1.0	
1,1,2,2-Tetrachloroethane	ug/l	ND	1.0	
Tetrachloroethene	ug/l	ND	1.0	
Toluene	ug/l	ND	1.0	
1,2,3-Trichlorobenzene	ug/l	ND	1.0	
1,2,4-Trichlorobenzene	ug/l	ND	1.0	
1,1,1-Trichloroethane	ug/l	ND	1.0	
1,1,2-Trichloroethane	ug/l	ND	1.0	
Trichloroethene	ug/l	ND	1.0	
Trichlorofluoromethane	ug/l	ND	1.0	
1,2,3-Trichloropropane	ug/l	ND	2.5	
1,2,4-Trimethylbenzene	ug/l	ND	1.0	
1,3,5-Trimethylbenzene	ug/l	ND	1.0	
Vinyl chloride	ug/l	ND	1.0	
Xylene (Total)	ug/l	ND	3.0	
m&p-Xylene	ug/l	ND	2.0	
o-Xylene	ug/l	ND	1.0	

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QUALITY CONTROL DATA

Lab Project Number: 6087199
Client Project ID: Bangor

METHOD BLANK: 607524014
Associated Lab Samples: 607509056

Parameter	Units	Blank Result	Reporting Limit	Footnotes
Toluene-d8 (S)	%	106		
4-Bromofluorobenzene (S)	%	104		
Dibromofluoromethane (S)	%	103		
1,2-Dichloroethane-d4 (S)	%	119		

LABORATORY CONTROL SAMPLE: 607524022

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Footnotes
Acetone	ug/l	20.00	17.02	85	18-147	
Benzene	ug/l	10.00	9.470	95	74-118	
Bromobenzene	ug/l	10.00	8.420	84	79-115	
Bromochloromethane	ug/l	10.00	11.87	119	67-122	
Bromodichloromethane	ug/l	10.00	8.930	89	81-124	
Bromoform	ug/l	10.00	9.820	98	65-125	
Bromomethane	ug/l	10.00	12.91	129	10-150	
2-Butanone (MEK)	ug/l	20.00	18.84	94	35-132	
n-Butylbenzene	ug/l	10.00	9.490	95	67-124	
sec-Butylbenzene	ug/l	10.00	9.380	94	75-121	
tert-Butylbenzene	ug/l	10.00	8.850	88	76-118	
Carbon disulfide	ug/l	20.00	17.08	85	12-132	
Carbon tetrachloride	ug/l	10.00	11.81	118	69-131	
Chlorobenzene	ug/l	10.00	10.59	106	77-115	
Chloroethane	ug/l	10.00	10.33	103	23-140	
Chloroform	ug/l	10.00	9.760	98	74-123	
Chloromethane	ug/l	10.00	9.660	97	25-150	
2-Chlorotoluene	ug/l	10.00	9.210	92	76-118	
4-Chlorotoluene	ug/l	10.00	9.190	92	75-119	
1,2-Dibromo-3-chloropropane	ug/l	10.00	7.330	73	59-124	
Dibromochloromethane	ug/l	10.00	9.490	95	73-125	
1,2-Dibromoethane (EDB)	ug/l	10.00	10.45	105	78-120	
Dibromomethane	ug/l	10.00	9.250	92	71-124	
1,2-Dichlorobenzene	ug/l	10.00	9.700	97	77-117	
1,3-Dichlorobenzene	ug/l	10.00	9.060	91	75-116	
1,4-Dichlorobenzene	ug/l	10.00	8.770	88	72-117	

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QUALITY CONTROL DATA

Lab Project Number: 6087199
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607524022

Parameter	Units	Spike Conc.	LCS Result	LCS	% Rec Limits	Footnotes
Dichlorodifluoromethane	ug/l	10.00	7.240	72	10-142	
1,1-Dichloroethane	ug/l	10.00	11.18	112	65-126	
1,2-Dichloroethane	ug/l	10.00	11.68	117	71-126	
1,2-Dichloroethene (Total)	ug/l	20.00	20.83	104	73-124	
1,1-Dichloroethene	ug/l	10.00	9.350	94	63-135	
cis-1,2-Dichloroethene	ug/l	10.00	9.950	100	74-120	
trans-1,2-Dichloroethene	ug/l	10.00	10.87	109	68-131	
1,2-Dichloropropane	ug/l	10.00	9.720	97	74-117	
1,3-Dichloropropane	ug/l	10.00	9.960	100	78-118	
2,2-Dichloropropane	ug/l	10.00	12.76	128	47-145	
1,1-Dichloropropene	ug/l	10.00	12.16	122	73-130	
cis-1,3-Dichloropropene	ug/l	10.00	9.450	94	73-124	
trans-1,3-Dichloropropene	ug/l	10.00	11.50	115	72-124	
Ethylbenzene	ug/l	10.00	9.320	93	76-119	
Hexachloro-1,3-butadiene	ug/l	10.00	12.50	125	63-122	1
2-Hexanone	ug/l	20.00	18.61	93	43-117	
Isopropylbenzene (Cumene)	ug/l	10.00	8.190	82	73-113	
p-Isopropyltoluene	ug/l	10.00	8.640	86	71-117	
Methylene chloride	ug/l	10.00	11.32	113	65-133	
4-Methyl-2-pentanone (MIBK)	ug/l	20.00	18.38	92	44-113	
Methyl-tert-butyl ether	ug/l	10.00	9.130	91	54-129	
Naphthalene	ug/l	10.00	8.110	81	46-127	
n-Propylbenzene	ug/l	10.00	10.73	107	74-119	
Styrene	ug/l	10.00	9.850	98	78-121	
1,1,1,2-Tetrachloroethane	ug/l	10.00	10.47	105	78-122	
1,1,2,2-Tetrachloroethane	ug/l	10.00	8.710	87	69-121	
Tetrachloroethene	ug/l	10.00	10.66	107	72-121	
Toluene	ug/l	10.00	10.01	100	76-116	
1,2,3-Trichlorobenzene	ug/l	10.00	8.170	82	59-122	
1,2,4-Trichlorobenzene	ug/l	10.00	8.230	82	59-121	
1,1,1-Trichloroethane	ug/l	10.00	12.14	121	71-125	
1,1,2-Trichloroethane	ug/l	10.00	11.88	119	78-121	
Trichloroethene	ug/l	10.00	9.640	96	75-120	
Trichlorofluoromethane	ug/l	10.00	9.730	97	55-141	
1,2,3-Trichloropropane	ug/l	10.00	9.940	99	74-126	
1,2,4-Trimethylbenzene	ug/l	10.00	9.130	91	77-116	
1,3,5-Trimethylbenzene	ug/l	10.00	9.020	90	76-117	

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QUALITY CONTROL DATA

Lab Project Number: 6087199
Client Project ID: Bangor

LABORATORY CONTROL SAMPLE: 607524022

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Footnotes
Vinyl chloride	ug/l	10.00	10.92	109	50-131	
Xylene (Total)	ug/l	30.00	29.83	99	78-120	
m&p-Xylene	ug/l	20.00	19.88	99	74-120	
o-Xylene	ug/l	10.00	9.950	100	77-120	
Toluene-d8 (S)				107	88-110	
4-Bromofluorobenzene (S)				92	86-115	
Dibromofluoromethane (S)				102	86-118	
1,2-Dichloroethane-d4 (S)				106	80-120	

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QUALITY CONTROL DATA PARAMETER FOOTNOTES

Consistent with EPA guidelines, unrounded concentrations are displayed and have been used to calculate % Rec and RPD values.

LCS(D)	Laboratory Control Sample (Duplicate)
MS(D)	Matrix Spike (Duplicate)
DUP	Sample Duplicate
ND	Not detected at or above adjusted reporting limit
NC	Not Calculable
J	Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit
MDL	Adjusted Method Detection Limit
RPD	Relative Percent Difference
(S)	Surrogate
[1]	The compound or surrogate recovery exceeds the laboratory generated acceptance limits. While the recovery was elevated, the compound was not detected above the reporting limit in the associated samples; therefore, the high bias does not affect the usability of the reported sample results.

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

CROSS REFERENCE TABLE

Lab Project Number: 6087199
Client Project ID: Bangor

Lab Sample No Identifier	Client Sample Identifier	QC Batch Method	QC Batch Identifier	Analytical Method	Analytical Batch Identifier
607509056	THURS-13-1	EPA 8260	178887		

Appendix D
Sample Calibration Calculation

SAMPLE	**TUE-4-1**
baseline solution	BMS
	[10 mM MES pH 7.0 in 0.15 M (8.85 g/L) NaCl + 0.025 M (~2.5 g/L) CaCl2]
Date	20-Sep-04

Biosensor	30		
pH optode	77		
Hardware	Model 1	with PMT at	600 V

total volume 4850 uL
always removed same volume as was to be injected

Data from measurement of sample and stand s:

vol (uL)	soln	co ppb)	biosensor ΔV_{obs}	pH optode ΔV
100	GW	??	0.107	0.022
100	DCA standard	100	0.312	0.026
50	DCA standard	100	0.157	0.013
25	DCA standard	100	0.086	0.007

Data for correlation of pH response:
(performed in same baseline solution as above)

use correlation for biosensor 30 and pH optode 77 on separate worksheet

so ΔVpH (bio30) = ΔVpH (pH77) * 3.58

so ΔVpH experienced by biosensor is:

vol (uL)	soln	conc (ppb)	biosensor ΔV_{pH}
100	GW	??	0.079
100	DCA standard	100	0.093
50	DCA standard	100	0.047
25	DCA standard	100	0.025

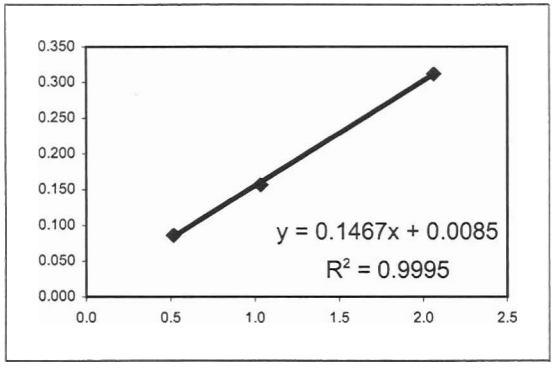
then, since:
$\Delta V_{obs} = \Delta V_{pH} + \Delta V_{DCA}$
can calculate ΔV_{DCA} (biosensor response due to DCA only):

vol (uL)	soln	conc (ppb)	biosensor ΔV_{DCA}
100	GW	??	0.028
100	DCA standard	100	0.219
50	DCA standard	100	0.110
25	DCA standard	100	0.061

Calculation with no corrections:

0

vol (uL)	soln	conc (ppb)	Δ conc (ppb)	biosensor ΔVobs
100	GW	??		0.107
100	DCA standard	100	2.1	0.312
50	DCA standard	100	1.0	0.157
25	DCA standard	100	0.5	0.086



GW ΔC = 0.7

GW DCA = 32.6

Calculation including mass removed effects only:

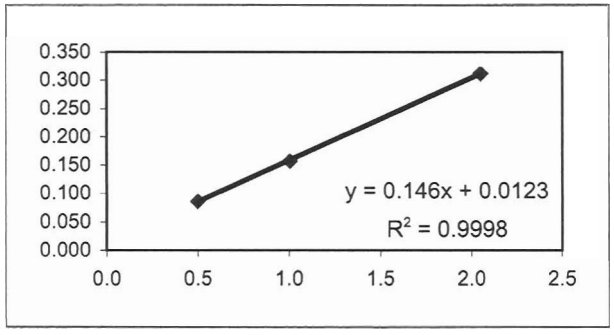
Initial concentration in baseline solution is:

0 ppb

Then starting conc in vial is: 0 ppb

Guess GW conc 32 ppb

vol (uL)	soln	conc (ppb)	conc after spike	Δ conc (ppb)	biosensor ΔVobs
100	GW	??	0.7	0.7	0.107
100	DCA standard	100	2.7	2.0	0.312
50	DCA standard	100	3.7	1.0	0.157
25	DCA standard	100	4.2	0.5	0.086



0.6

31.5

Calculation including volume & pH effects:

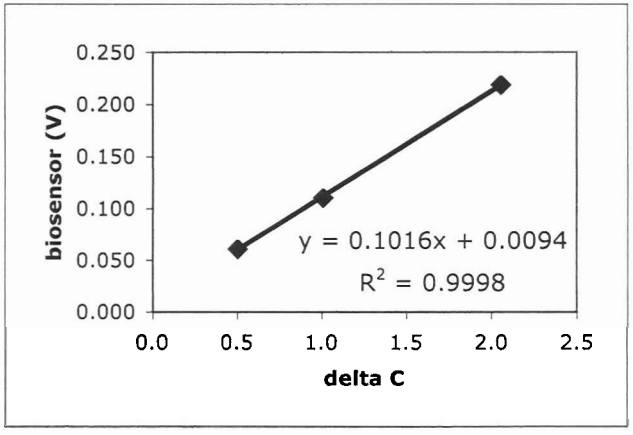
Initial concentration in baseline solution is:

0 ppb

Then starting conc in vial is: 0 ppb

Guess GW conc 9 ppb

vol (uL)	soln	conc (ppb)	conc after spike	Δ conc (ppb)	biosensor ΔV_{DCA}
100	GW	??	0.2	0.2	0.028
100	DCA standard	100	2.2	2.1	0.219
50	DCA standard	100	3.3	1.0	0.110
25	DCA standard	100	3.8	0.5	0.061



GW ΔC = 0.2

GW DCA = 9.0