FINAL
Phase 1 Treatability Study Report
Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

Prepared for

Baldwin Park Operable Unit Steering Committee

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CONTENTS

TABLES

PLATES

APPENDICES

DISTRIBUTION

LIST OF ABBREVIATIONS AND ACRONYMS

BOD	Biological Oxygen Demand
BPOU	Baldwin Park Operable Unit
BPOUSC	Baldwin Park Operable Unit Steering Committee
cfm	cubic feet per minute
COD	Chemical Oxygen Demand
1,2-DCA	1,2-dichloroethane
DHS	California Department of Health Services
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
GAC/FB	Granular Activated Carbon/Fluidized Bed
gpm	gallon per minute
IPA	isopropyl alcohol
MIBK	methyl isobutyl ketone
mg/L	milligrams per liter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSGBWM	Main San Gabriel Basin Watermaster
MPN	Most Probable Number
MWD	Metropolitan Water District of Southern California
NDMA	N-nitorsodimethylamine
ORP	Oxidation-Reduction Potential
RfD	Reference Dose
RPD	Relative Percent Difference
TCE	Trichloroethylene
TVMWD	Three Valleys Municipal Water District
µg/L	micrograms per liter
UV	Ultraviolet
VOC	Volatile Organic Compound
WQA	Water Quality Authority

EXECUTIVE SUMMARY

The purpose of this Phase 1 Treatability Study was to develop a biological treatment technology for perchlorate that could become part of the Baldwin Park Operable Unit Steering Committee Project for remediating various plumes in groundwater in the cities of Azusa and Baldwin Park. The study utilized a biological reduction process consisting of a fixed-film bioreactor. The fixed film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB).

The following study objectives were accomplished:

- The GAC/FB technology successfully treated groundwater with perchlorate concentrations representative of that anticipated in the San Gabriel Basin to an effluent concentration of less than the laboratory detection limit of 4 micrograms per liter (μg/L), which is less than the California Department of Health Services action level of 18 μg/L.

- The GAC/FB technology successfully treated groundwater with nitrate concentrations representative of that anticipated in the San Gabriel Basin to less than the laboratory detection limit of 0.1 milligram per liter (mg/L).

- This treatability study demonstrated the effectiveness of a food industry source of microorganisms as opposed to the wastewater treatment plant sludge source previously evaluated.

- Effluent from the GAC/FB bioreactor was analyzed for parameters used to regulate the quality of drinking water. Additional work is needed to establish disinfection and filtration requirements and demonstrate that the treatment processes will reliably produce potable water. This objective will be fully addressed in a Phase 2 Treatability Study.

The study also determined and supported development of a number of operational parameters that will be useful in designing a larger system such as the organic substrate addition rate, nutrient addition rate, system monitoring parameters, residence time requirements, and a theoretical operating model. Degradation of volatile organic compounds was evaluated and determined to have minimal impact on the design of a Phase 2 system. This study has provided sufficient data to allow a Phase 2 study to proceed. A Phase 2 Treatability Study Work Plan has been developed, comments by concerned agencies addressed, and a final Work Plan issued.

1.0 INTRODUCTION

1.1 BPOU Project Overview

For the past several years the Baldwin Park Operable Unit Steering Committee (BPOUSC), U.S. EPA Region IX (EPA), the Main San Gabriel Basin Watermaster (MSGBWM), Three Valleys Municipal Water District (TVMWD), San Gabriel Basin Water Quality Authority (WQA), and the Metropolitan Water District of Southern California (MWD) have been planning a combined groundwater remediation and water supply project in the San Gabriel Basin, California. Project planning was initiated in response to a requirement of EPA to remediate various plumes of volatile organic compounds (VOCs) in groundwater in the cities of Azusa and Baldwin Park. These plumes extend from north of Interstate 210 in the city of Azusa southwest to the vicinity of Interstate 10 in the city of Baldwin Park. This area is called the Baldwin Park Operable Unit (BPOU).

The BPOUSC was in the process of negotiating agreements for the project when in June 1997, concentrations of perchlorate ion above the State of California Department of Health Services (DHS) action level of 18 micrograms per liter (µg/L) were found in BPOU groundwater. Before the project can move forward, the potential impact that perchlorate has on the overall conceptual project design must be evaluated. Work in three specific areas is underway to assess this potential impact so that the conceptual design of the BPOU Project can be modified and project implementation can begin.

First, the BPOUSC has assessed the distribution of perchlorate in BPOU groundwater through installation and sampling of monitoring wells. The BPOU Project extraction plan is being modified to address VOCs, N-nitrosodimethylamine (NDMA), 1.4 dioxane, and perchlorate.

Second, in February 1997, the DHS published an action level for perchlorate in drinking water of 18 µg/L. This action level was based on several case reports of perchlorate used to treat patients with Grave's disease, an autoimmune disorder; two short-term studies of perchlorate in healthy volunteers; and several studies in animals, ranging in duration from 4 days to 2 years. These studies did not examine organs other than thyroid or used doses too high to determine a "no effect" level. Thus a conservative approach and consultation with EPA was used to set the action level.

In order to develop a scientifically defensible reference dose, independent laboratories conducted several new studies on ammonium perchlorate (the most common form of perchlorate). Based on these studies, the National Center for Environmental Assessment, a division of EPA, has recommended a reference dose of 32 µg/L. This value is currently under external peer review. It is not known at this time whether California will revise the action level based on the new studies. In addition, the demands of water users may affect the decision whether to treat for perchlorate. Once California's action level is finalized and the demands of water users have been evaluated, a determination regarding whether BPOU groundwater must be treated for perchlorate can be made.

Third, at the time perchlorate was discovered in BPOU groundwater, no proven treatment technology existed that could reduce low levels of perchlorate in water to a concentration below the DHS action level. The Phase 1 Treatability Study was implemented to address this concern. Data from this study is being used to design a Phase 2 Treatability Study system.

1.2 Purpose of Study

The purpose of this Phase 1 Treatability Study and the future Phase 2 Treatability Study is to develop a biological treatment technology that can become part of the treatment train for the BPOU Project.

1.3 Biological Reduction of Perchlorate

At the time low concentrations of perchlorate were found in BPOU groundwater, considerable work regarding perchlorate treatment had already been conducted by Aerojet-General Corporation (Aerojet) in Rancho Cordova, California. This work consisted of technology screening, bench-scale and pilot-scale studies of several technologies, and design of a full-scale (4,000 gallon per minute [gpm]) system. The bench- and pilot-scale treatability testing of a biological reduction technology successfully reduced perchlorate concentrations from approximately 8,000 µg/L to less than the 400 µg/L laboratory reporting limit.

The technology is a biological reduction process using a fixed-film bioreactor. A fixed film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB). Groundwater, amended with an organic substrate (e.g., ethanol), and nutrients (nitrogen and phosphorus) are introduced into the influent stream. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously destroying the perchlorate, reducing it to chloride and oxygen. The bench- and pilot-scale testing demonstrated that the technology was effective in treating perchlorate in groundwater. Design and construction of the first phase (approximately 2,000 gpm) full-scale system is complete and the system is operating.

There are, however, several important differences between the objectives of the previous pilot-scale work performed in Rancho Cordova and current objectives for the BPOU Project. First, the flow rate was 0.1 percent of that needed in the San Gabriel Basin. Second, the influent perchlorate concentration was over 100 times that expected in the San Gabriel Basin. Third, the pilot system was not designed to achieve, nor did it achieve, effluent perchlorate concentrations less than the 18 µg/L provisional action level. Finally, the previous testing was not designed to deliver potable water.

To address these issues, further pilot-scale treatability testing was necessary. The pilot-scale testing was planned in two phases. In this first phase, the objective was to assess if the biological reduction technology could achieve the target effluent goal with influent concentrations similar to that found in BPOU groundwater. A work plan outlining the Phase 1 Treatability Study was prepared, and a copy is included as Appendix A. The work plan was then implemented using a pilot-scale unit operated at the Aerojet facility in Rancho Cordova. Deviations from the original work plan are detailed in Appendix B. The results of the Phase 1 Treatability Study are provided in this report.

In the second phase, scientific and engineering data needed to design and construct a full-scale treatment system will be collected. This testing will be performed at a site in the BPOU. A work plan outlining the scope of the Phase 2 Treatability Study has been issued in final form (HLA, 1999).

1.4 Analytical Detection Limits for Perchlorate and Nitrate

The current perchlorate reporting limit is 4 µg/L. This is achievable using a method developed by the DHS. To date, this method has not been peer reviewed. Since perchlorate is not a regulated substance, DHS does not issue laboratory certification for method analysis. However, DHS will issue informal approval to perform perchlorate analysis once a laboratory meets DHS requirements.

The lowest obtainable reporting limit for nitrate analyses is 0.1 milligram per liter (mg/L) (as nitrogen). Nitrate analytical results are reported "as nitrogen." In the text, however, the term "nitrates" will be used to describe the nitrate-nitrogen results. Ammonia results are also reported as ammonia-nitrogen in the analytical laboratory reports.

For the purposes of this report, complete or 100 percent destruction is defined as occurring when the influent concentration of the compound (i.e., perchlorate, nitrate) has been reduced in the effluent to a concentration that is not detectable. Therefore, if an influent perchlorate concentration of 50 µg/L is reduced to nondetect (<4 µg/L) in the effluent, the destruction is considered to be 100 percent; however, for data presentation purposes, nondetect values were plotted at half the reporting limit.

2.0 TREATABILITY STUDY OBJECTIVES

The objectives of this Phase 1 Treatability Study were to evaluate the performance of the biological reduction treatment technology previously tested at Aerojet's Sacramento facility with modifications described in the following sections. During the course of treatability testing, issues or questions not directly related to attainment of these objectives arose. These issues were addressed to the extent possible. These issues and related results are discussed in Section 5.0.

2.1 Evaluate Lower Perchlorate Influent Concentration

Based on the perchlorate distribution, proposed extraction well configuration and flow rate, and extraction plan modifications for the BPOU Project, it was estimated that the BPOU extraction system would produce groundwater containing concentrations of perchlorate between 50 and 100 µg/L. The previous pilot-scale testing used groundwater with influent perchlorate concentrations ranging from 7,000 to 8,000 mg/L. One objective of this treatability study was to treat water containing a perchlorate concentration representative of that anticipated in the San Gabriel Basin and determine to what degree the perchlorate could be destroyed.

2.2 Evaluate Higher Nitrate Influent Concentration

Previous pilot-scale testing conducted at Aerojet treated groundwater characterized by low (1.5 mg/L) nitrate concentrations. For the BPOU Project, influent nitrate concentrations have been estimated between 5 and 6 mg/L (as nitrogen). A second objective of this treatability study was to treat water containing a nitrate concentration representative of that anticipated in the San Gabriel Basin and determine to what degree the nitrate could be destroyed.

2.3 Demonstrate Technology Can Achieve 18 µg/L Perchlorate Limit or Lower

At the time the previous pilot-scale study was performed at Aerojet's Sacramento facility, the goal was to produce effluent that contained perchlorate at a concentration lower than the 400 µg/L laboratory reporting limit current at that time. With a lower perchlorate reporting limit of 4 µg/L, the third objective of this treatability study was to evaluate whether the technology could achieve an effluent perchlorate concentration at or below than the DHS provisional action level of 18 µg/L.

2.4 Evaluate Different Source of Microorganisms

The source of microorganisms in the previous pilot-scale study was municipal wastewater treatment plant sludge. DHS expressed concern about this source of microorganisms because the effluent is to be part of a public water supply. Pilot-scale work performed at Aerojet's Sacramento facility included testing of the pilot plant effluent for coliform, fecal coliform, and *E. coli*. This testing indicated these pathogens were not present in the pilot plant effluent; however, the potential presence of pathogens is a primary concern. The fourth objective of this treatability study was to test the effectiveness of sludge from the food processing industry, which will likely lack the pathogens that may be of concern.

2.5 Evaluate Potability of Treated Water

For the BPOU Project to be viable it must deliver potable water to water purveyors. Therefore, the selected treatment train must produce water that meets all federal and state requirements for a potable water supply. Embodied in the objectives described above is the need to produce water that contains acceptable concentrations of perchlorate and nitrate and lacks pathogens. In addition, this pilot-scale testing was designed to collect information on all other applicable water quality parameters to ensure treatment plant effluent can achieve other potable water quality goals.

Although this pilot-scale study included the analysis of bioreactor effluent for the range of water quality parameters used to regulate potable water, it was not an objective of this testing to produce potable water. To produce potable water and to fully evaluate the effectiveness of filtration and disinfection technologies, these unit processes must be part of the treatment train. Testing of filtration and disinfection technologies will be performed during the Phase 2 Treatability Study.

3.0 TREATMENT SYSTEM EQUIPMENT DESCRIPTION

During Phase 1 Treatability Study testing, three equipment configurations were used in four portions of the study. The only difference between the first two configurations was whether or not an air stripper placed in the treatment train before the bioreactor was operational. These two variations were tested to determine whether the bioreactor would function most effectively with the air stripper placed before or after the bioreactor. The third configuration placed the air stripper on the effluent side of the bioreactor. Since the conclusion of this study, the proposed treatment train for the BPOU Project has been modified, and removal of VOCs will be accomplished using ultraviolet (UV)/oxidation technology.

During the first portion of the study, the air stripper was operated on the influent side of the bioreactor. During the second portion of the study, the air stripper was not operational. During the third portion of the study, the air stripper was again operational. During the fourth portion of the study, the air stripper was operated on the effluent side of the bioreactor.

The configuration as used during the initial and third portions of the study is described below; for the second portion the description remains the same except that the air stripper was shutdown and bypassed. For the fourth portion of the study, the overall system operation remains the same except the air stripper is moved to the effluent side of the bioreactor. A system general arrangement drawing is attached as Plate 1.

First, extracted groundwater was pumped directly to an air stripper for removal of VOCs. Air stripper effluent was then pumped to a point where alcohol addition occurred. After alcohol addition, the groundwater influent water was mixed with recirculation water from the bioreactor (if any). The pilot plant is designed to constantly run at a flow rate of 30 gpm through the bioreactor. System design allows the operators to vary the proportion of groundwater and recirculated water entering the bioreactor. With no input from the well, the system runs with 100 percent recirculated water. Groundwater flow can be increased on a continuum until no recirculated water passes through the reactor.

The stream of mixed groundwater influent and recirculation water was then pumped to the bioreactor with nutrient feed addition occurring just before the bioreactor inlet. The granular carbon used in the bioreactor was virgin, coal-based carbon in a 10 x 30 mesh. A biological growth control system installed at the top of the bioreactor removed excess biomass from the GAC. Biomass exited the bioreactor in the effluent, and "cleaned" GAC particles were returned to the carbon bed. The effluent then exited the bioreactor and flowed through a carbon separator system that captured and returned any carbon that flowed out of the bioreactor. Once through the separator, the effluent flowed to a 500-gallon polyethylene equalization tank equipped with level controls. From the equalization tank, the effluent was discharged directly to an Aerojet groundwater extraction and treatment (GET-B) system. Carbon and fines that escaped the carbon separator system were discharged in the effluent to the GET-B facility.

Eight sample ports at key locations throughout the treatment system provided for the collection of water quality samples and measurement of field parameters. These eight sample ports were located as follows:

1. Air stripper inlet line (Port A)

2. Air stripper effluent line (Port B)
3. Air stripper effluent line, post-ethanol injection, pre-dilution (Port BS-C)
4. GAC/FB diluted bioreactor inlet influent line (Port C)
5. 25 percent of bioreactor height (Port D)
6. 50 percent of bioreactor height (Port E)
7. 75 percent of bioreactor height (Port F)
8. Effluent line from the bioreactor (Port G)

The bioreactor unit contained inline bioreactor influent and effluent dissolved oxygen (DO) sensors, flowmeters, and effluent temperature and pH probes. All other parameters evaluated during the study were measured using handheld instruments.

4.0 TREATMENT SYSTEM OPERATIONS AND SAMPLING

Pilot plant operations can be divided into four distinct timeframes corresponding to the different equipment configurations described above. When the air stripper was operating on the influent side of the bioreactor, a high concentration of DO was introduced into the bioreactor. In this equipment configuration the air stripper raised the natural DO concentration in the groundwater from 1 to 2 mg/L to 6 to 8 mg/L through aeration. When the air stripper was not operational or the air stripper was operated on the effluent side of the bioreactor, groundwater with lower DO, representative of untreated groundwater, was introduced directly into the bioreactor.

A description of the overall operational plan is provided in the original work plan, which is attached as Appendix A. Because of unplanned events (such as storms) and as a result of interpretation of treatability study data, certain deviations from procedures described in the work plan were made. These deviations or modifications to operational procedures as described in the work plan are discussed in Appendix B.

The first portion of pilot plant operations occurred from November 7, 1997, through January 23, 1998. The air stripper provided influent water with high DO concentrations to the bioreactor. Test runs were conducted at recirculated water percentages of 100, 83, 67, 50, 33, 17, and 0 percent (5 gpm increments). Water quality samples were collected and analyzed using EPA-approved methods for VOCs, ammonia (as nitrogen), alkalinity, chloride, phosphorus, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids, total dissolved solids, turbidity, perchlorate, chlorate, chlorite, chloride, nitrate (as nitrogen), nitrite (as nitrogen), sulfate, sulfide, alcohols, metals, and bacteriology. Field parameters, water and ethanol flow rates, pH, temperature, oxidation-reduction potential (ORP), DO, and ethanol flow rates were also collected. A detailed chronology of operations is included as Appendix C. Tables containing analytical laboratory results and results of the measurement of field parameters are included in Appendices D and E, respectively. A table combining representative laboratory analytical and field parameter data collected during both operational timeframes is attached as Table 1.

With high influent DO, complete destruction of perchlorate and nitrate was achieved but could not be maintained with low recirculation rates. Complete destruction of perchlorate and nitrate was observed at recirculated water percentages of 83, 67, 50, and 33 percent. As operating conditions were changed, intermittent destruction of perchlorate and nitrate was observed. Initial conclusions were that the DO loading was too high for the biomass to be able to consume the DO and destroy all of the perchlorate and nitrate. To test this hypothesis and gather performance data for an equipment configuration where air stripping would occur following biological treatment, the air stripper was shutdown.

The second portion of operations took place from January 24 through March 13, 1998, after the air stripper was shutdown. Test runs were conducted at recirculated water percentages of 33 and 17 percent. Samples and field parameters as described above and contained in Appendix C were collected. As above, sample analytical and field parameters results are summarized in Appendices D and E. With the influent DO concentration representative of that found in groundwater, complete destruction of perchlorate and nitrate was consistently achieved. Destruction was achieved at recirculation rates lower than those when the air stripper was operational.

The third portion of operations took place from March 14 to May 19, with the air stripper operational. Test runs were conducted at recirculated water percentages of 67, 50, and 33 percent. Samples and field parameters were collected as described above and detailed in Appendices C, D, and E. As operating conditions changed, inconsistent destruction of perchlorate and nitrate was observed at lower recycle rates. During the later part of this period, only intermittent destruction of perchlorate and nitrate was observed. To increase the efficacy of the bioreactor, the air stripper was moved to effluent side of the bioreactor.

The fourth portion of operations took place from May 20 to June 23, 1998, with the air stripper operational on the effluent side of the bioreactor. Test runs were conducted at recirculated water percentages of 50 and 17 percent. Samples and field parameters were collected as described above and detailed in Appendices C, D, and E. This phase of the study was specifically designed to evaluate degradation of VOCs across the bioreactor. The carbon was loaded with trichloroethene (TCE) in an attempt to eliminate the effect of carbon adsorption. Unfortunately, the air stripper malfunctioned on May 22 and the bioreactor was shutdown. The air stripper could not be repaired for two weeks. The unit was restarted on June 8. Samples and field parameters were collected as described above and detailed in Appendices C, D, and E starting on June 9. Stable and consistent perchlorate and nitrate degradation was observed. Significant degradation of VOCs across the bioreactor was not observed.

5.0 TECHNOLOGY PERFORMANCE ANALYSIS

Knowledge of biological reduction kinetics and fluidized-bed behavior are essential when analyzing the technology performance.

5.1 Perchlorate Reduction Theory

Perchlorate consists of one chlorine atom (Cl) and four oxygen atoms (O). Thermodynamically, perchlorate ion is a powerful oxidant; however, the majority of common inorganic reductants react with perchlorate ion at rates so slow as to be negligible under usual aqueous conditions. It is well documented that aqueous perchlorate ion is remarkably stable at ordinary temperatures even in the presence of strong reductants such as sodium amalgum, zinc, and iron(II). The sluggishness of perchlorate ion reduction is attributed to low charge density and substitution inertia.

Examples of perchlorate ion reactions that have favorable thermodynamic energies but do not occur spontaneously include:

$$ClO_4^- + 8 \cdot H^+ + 8 \cdot e^- \rightarrow Cl^- + 4 \cdot H_2O \qquad \Delta G^o = -1066kJ \qquad E^o = 1.38V$$

$$ClO_4^- + 2 \cdot H^+ + 2 \cdot e^- \rightarrow ClO_3^- + H_2O \qquad \Delta G^o = -232kJ \qquad E^o = 1.20V$$

Low aqueous perchlorate concentrations are reported in the literature as typically not being significantly retarded by soil adsorption or reduced by naturally occurring microbial activity during groundwater transport. As a result of these molecular properties, perchlorate is stable, persistent, and capable of being transported extended distances in groundwater.

Perchlorate reduction is expected to be similar to nitrate reduction. The energy-generating portion of the denitrification reaction with ethanol as the organic substrate (neglecting cell synthesis) is:

$$5 \cdot C_2H_5OH + 12 \cdot NO_3^- + 12H^+ \rightarrow 10 \cdot CO_2 + 6 \cdot N_2 + 21 \cdot H_2O$$

A similar reaction for perchlorate is:

$$2 \cdot C_2H_5OH + 4 \cdot ClO_4^- + 8 \cdot H^+ \rightarrow 4 \cdot CO_2 + 4 \cdot Cl^- + 10 \cdot H_2O$$

Note that nitrate and perchlorate are completely destroyed, and the carbon substrate (ethanol) is oxidized by bacteria. The end products for the process are biomass, carbon dioxide, water, chloride, and nitrogen. During energy generation in the cell protons are used, thus pH tends to increase during denitrification. We expect a similar pH increase for perchlorate reduction.

5.2 Fluidized-Bed Behavior

In a fluidized-bed bioreactor, flocculated organisms are suspended by drag forces exerted by the rising liquid. By carefully balancing operating conditions and organism characteristics, the flocs are retained in the bioreactor while the medium flows through it continuously.

To calculate residence time for a recycle bioreactor we use:

$$\tau_r' = \tau_r * (1 + R)$$

where:

τ_r' = Effective residence time for a recycle bioreactor (minutes)
τ_r = Residence time for a plug flow bioreactor (minutes)
R = Recycle rate (volume recycled to bioreactor/groundwater entering the bioreactor)

and:

$$\tau_r = V_r/F_T$$

where:

V_r = Bioreactor volume (cubic feet)
F_T = Total flow rate (cubic feet per minute [4 cfm])

For a fluidized bed:

$$V_r = H_c*\varepsilon*A_r + (H_t - H_c)* A_r$$

where:

H_t = Total fluidized bed height (feet [10 feet])
H_c = Carbon bed height (feet [5.7 feet])
A_r = Cross-sectional bioreactor area (square feet [2.2 feet])
ε = Carbon void fraction (0.40)

For this study, residence time is thus:

$$\tau_r' = 3.6 * (1 + R)$$

A table summarizing residence time for various recycle ratios is shown in Table 2.

5.3 Results

The results of the Phase 1 Treatability Study are presented in multiple appendices. These include:

- **Deviations from Work Plan (Appendix B).** As the treatability study progressed, deviations from the approved "Revised Final Phase 1 Treatability Study Work Plan," dated November 7, 1997, were made. These changes to pilot plant operation and analytical testing are provided in Appendix B.

- **Detailed Treatment System Operations Chronology (Appendix C).** This appendix includes a detailed chronology of treatment system operations. The text describes the various periods of testing, results of this testing, and operational changes made to achieve treatability study objectives or mitigate situations where bioreactor performance was initially less than required.

- **Laboratory Analytical Data Summary (Appendix D).** This appendix contains all results of laboratory analyses. Analytical results include those for routine operating parameters (alcohols, phosphorus, COD), parameters that are direct measurements of system performance (perchlorate, chlorate, nitrate, nitrite), and parameters of interest for effluent quality (coliform, bacteria, turbidity, metals, VOCs). Results are organized by date and sample port.

- **Field Data, DO Profile Summary (Appendix E).** This appendix contains the data collected or measured in the field during treatment system operation. Data include flow rate, pH, temperature, ORP, and DO.

5.3.1 Analytical Error Analysis

Potential analytical errors were evaluated two ways to provide a range of expected error and a "typical" error. First, the Matrix Spike (MS) and Matrix Spike Duplicate (MSD) were compared. The Relative Percent Difference (RPD) of the MS/MSD then gives an estimate of error. The RPD is then compared over a statistically valid number of samples to give an average error, range, and standard deviation.

The second method of error analysis was to send split samples to two analytical laboratories. The samples are then compared and the RPD gives an estimate of error. The RPD is then compared over a number of samples to give an average error, range, and a standard deviation.

For perchlorate, 47 MS/MSD comparisons were made. The average RPD was 8.4 percent, and the range was 0 to 27 percent. Seven split samples were compared. The average RPD was 16 percent, and the range was 2 to 49 percent. If the 49 percent RPD sample is discounted, the average RPD becomes 10 percent and the range 2 to 23 percent. For perchlorate, a typical error of 10 percent will be assumed based on these calculations (see Plate 2).

For nitrate, 66 MS/MSD comparisons were made. The average RPD was 2.6 percent, and the range was 0 to 7 percent (see Plate 3). The typical error for nitrate is assumed at 3 percent.

For ethanol, 62 MS/MSD comparisons were made. The average RPD was 9.3 percent, and the range was 0 to 38 percent (see Plate 4). The typical error for ethanol is assumed at 9 percent.

Appendix F provides a summary of estimated error calculations for perchlorate, nitrate, and ethanol laboratory data.

5.4 Data Evaluation and Discussion

The GAC/FB biochemical reduction system was successful in destroying perchlorate and nitrate in the concentration ranges representative of those found in the BPOU under certain conditions. Complete destruction of perchlorate was achieved when (1) dissolved oxygen was depleted (< 0.1 mg/L) in the first part of the bioreactor, (2) the bioreactor was under reducing conditions, (3) ethanol concentrations exceeded a critical minimum threshold, and (4) adequate phosphate was available for use by the microbial population (nitrates were present in the influent groundwater). Nitrate destruction was much easier to accomplish than perchlorate destruction. A summary of performance over various periods of time is included as Table 3. Specific performance parameters are discussed below.

(Note: when data were plotted for various figures, the raw data were filtered to ensure that all data being shown were gathered on a given day. For example, if perchlorate and DO were gathered for a given day but ORP was not, that day would not be included in a plot of perchlorate destruction versus DO and ORP. This filter ensures that data plots representing various timeframes are representative of the actual data available.)

5.4.1 Perchlorate Reduction

Perchlorate destruction is generally complete when influent DO is low (near 1 mg/L), the bioreactor is under reducing conditions (effluent ORP is negative), there is adequate food supply available (influent ethanol is greater than 40 mg/L), and there is an adequate supply of nutrients (phosphate). Each of these parameters is examined separately below.

DO is a critical operating parameter both to set up reducing condtions in the bioreactor and to stimulate facultative organisms to metabolize perchlorate and nitrate. During periods of low influent DO (near 1 mg/L) where bioreactor operating parameters were appropriate, perchlorate reduction was generally greater than 90 percent. This observation is depicted on Plate 5, which is a plot of perchlorate reduction across the bioreactor for various DO conditions during the time period January 7 to 27, 1998. Because DO is such a critical operating parameter, this has significant ramifications for inclusion of a bioreactor in a treatment system with other unit operations. Unit operations that increase DO (such as air stripping) either would have to be placed downstream of the bioreactor, would require a larger bioreactor to accommodate a longer effective residence time, or would require the addition of an oxygen scavenger, such as sodium bisulfite.

Reducing conditions in the bioreactor are essential to complete and consistent perchlorate destruction. When bioreactor effluent ORP was less than –200 mV and influent DO was low (near 1 mg/L), perchlorate destruction was generally complete. This observation is depicted on Plate 6, which is a plot of perchlorate effluent concentration, influent DO, and effluent ORP during the time period of December 17, 1997 to May 20, 1998. Reducing conditions in the bioreactor are generally controlled by the amount of DO and ethanol present in the bioreactor influent. Excess DO and/or ethanol will increase ORP in the bioreactor, and perchlorate and nitrate reduction will cease.

A critical question for scale-up design is the minimum effective residence time at which perchlorate destruction is complete. Residence time was controlled by varying the rate of recycled water. The minimum overall effective residence time with complete perchlorate destruction was approximately 4 minutes. Plate 7 shows effluent perchlorate concentration versus effective residence time for the period of November 21, 1997, to June 19, 1998. Note that residence time varied considerably but that complete perchlorate destruction occurred at a variety of residence times. As observed on Plate 7, stable perchlorate destruction was achieved over a significant time duration at an effective residence time of about 4 minutes.

The required residence time is dependent on the amount of DO, ethanol, nitrate, and perchlorate. In general, this technology is designed to treat water streams with perchlorate concentrations in the parts-per-billion range. Therefore, the concentration of perchlorate will typically not be critical to the operation of the bioreactor.

Under operating conditions conducive to perchlorate destruction, perchlorate was destroyed within approximately 7.5 feet along the bioreactor flow path. This corresponds to a bioreactor residence time of 3.2 minutes. (Note: this is not equivalent to the effective overall residence time

but merely the elapsed time in the bioreactor.) This observation is depicted on Plate 8, which is a plot of perchlorate bioreactor profiles taken during the time period from February 1 through 20, 1998. Perchlorate destruction was complete during this timeframe. Perchlorate bioreactor profiles were examined during a period of partial perchlorate destruction in December 1997 but were unremarkable.

Products of perchlorate breakdown, such as chlorate, chlorite, and hypochlorite, were difficult to quantify. Chlorate and chlorite analyses of bioreactor profile samples were conducted. For chlorate, measurable concentrations were present in most of the undiluted groundwater samples and bioreactor influent samples. However, by the time the flow had reached 25 percent of the bioreactor flow path, no measurable chlorate remained. During times of incomplete perchlorate and nitrate performance, measurable concentrations of chlorate remained in the effluent. No EPA method exists for hypochlorite analysis; therefore, no analyses were conducted. No detectable concentrations of chlorite were present in any sample collected. The evaluation of the mechanism and rate of perchlorate breakdown was limited by analytical detection limits. Detection limits for both chlorate and chlorite were 20 µg/L. With an influent perchlorate concentration of 30 to 40 µg/L, this allows little room for measurement of probable kinetic degradation products.

Subsequent sections of this portion of the report explain the controls that affect bioreactor performance.

5.4.2 Nitrate Reduction

Nitrate destruction was generally much easier to accomplish than perchlorate destruction. It is difficult to quantify with certainty with the data whether this is due to preferential reduction of nitrate over perchlorate or whether nitrate, present at much higher concentrations, was simply more bioavailable than perchlorate. However, in general, it appears nitrate reduction occurred more completely and rapidly than perchlorate reduction and the microorganisms present in the bioreactor prefer nitrate over perchlorate as an electron acceptor. This supports our previous theory (HLA, 1997b).

Under conditions of low influent DO and reducing conditions in the bioreactor, average nitrate destruction was generally greater than 99 percent (see Plates 9 and 10). Within the bioreactor, most of the nitrate was destroyed within a distance of approximately 4 feet along the bioreactor flow path (see Plate 11). This corresponds to a bioreactor residence time of 1.7 minutes. As with perchlorate, the minimum overall effective residence time with complete nitrate destruction was approximately 4 minutes (see Plate 12).

Effluent concentrations of the nitrate breakdown product nitrite were monitored during the study and were used as an indicator of the overall "health" of the bed. If detectable concentrations of nitrite were present in the bioreactor effluent, it was a sign that the biomass was not "healthy" since nitrate was not being completely broken down to basic nitrogen and oxygen. During periods when perchlorate and nitrate were being reduced at rates of greater than 99 percent, nitrite was not detected above the 0.03 mg/L detection limit. During periods when reduction was incomplete, nitrite was present.

5.4.3 Dissolved Oxygen

DO is a crucial parameter in evaluating bioreactor performance. It was generally found that at low DO concentrations (0.5 to 1 mg/L), the system operated in a stable manner and achieved

removal of nitrate and perchlorate to their relative detection limits. At higher DO concentrations (4 to 8 mg/L) and low recycle rates (low residence time), complete reduction of perchlorate and nitrate was not achieved reliably (higher DO concentrations result from use of the air stripper; see Plate 13).

This phenomenon is best understood in the context of variations in the biomass population and competing reactions. No speciation of the biomass organisms was complete, but the population of organisms is likely heterogeneous. We expect that facultative organisms are responsible for perchlorate and nitrate destruction. At low and high DO levels, different organisms compete for dominance. In a high DO environment, the microorganisms utilized oxygen as their preferred electron acceptor, and nitrate and perchlorate destruction do not proceed to completion. In a low DO environment, facultative microorganisms utilize oxygen, nitrate, and perchlorate as electron acceptors. This can be represented as competing electron acceptor reactions (neglecting cell synthesis and electron balances):

$$1 \cdot C_2H_5OH + 4 \cdot O_2 + 4 \cdot e^- + 4 \cdot H^+ \xrightarrow{k_1} 2 \cdot CO_2 + 5 \cdot H_2O \qquad [Oxygen]$$

$$5 \cdot C_2H_5OH + 12 \cdot NO_3^- + 12 \cdot H^+ \xrightarrow{k_2} 10 \cdot CO_2 + 6 \cdot N_2 + 21 \cdot H_2O \qquad [Nitrate]$$

$$2 \cdot C_2H_5OH + 4 \cdot ClO_4^- + 8 \cdot H^+ \xrightarrow{k_3} 4 \cdot CO_2 + 10 \cdot H_2O + 4 \cdot Cl^- \qquad [Perchlorate]$$

As expected, the field data suggest that the reaction rate for oxygen consumption was much faster than for perchlorate or nitrate. Plates 6, 10, and 13 show DO versus perchlorate and nitrate destruction. These figures demonstrate excellent correlation between influent DO and perchlorate/nitrate removal efficiency. In general, once influent DO drops from a range of 6 to 10 mg/L to near 1 mg/L, perchlorate destruction becomes complete. (Note: fluctuations in perchlorate destruction efficiency after February 1998 are due to optimization studies, experiments, and unplanned shutdowns.)

A more detailed examination of the profile of DO across the bioreactor confirms the above conclusion. Plate 14 presents the DO profile across the bioreactor on two days: one representative of conditions with high influent DO, which resulted in partial perchlorate destruction, and one with low influent DO, which resulted in complete perchlorate destruction. Under high DO conditions, perchlorate destruction was typically 25 percent. Under low DO conditions, perchlorate destruction was typically complete.

With sufficient bioreactor residence time and high DO, DO was depleted and perchlorate and nitrate destruction proceeds. With the air stripper online and complete perchlorate destruction, a maximum well water flow rate of 15 gpm was possible (7.2 minutes of effective residence time). With the air stripper offline and complete perchlorate destruction, a maximum well water flow rate of 25 gpm was possible (4.3 minutes of effective residence time).

If a unit operation that increases DO is used in the Phase 2 Treatability Study system, placing the unit after the bioreactor in the final design may result in the lowest total project cost, based on the reaction rate kinetics. However, placement of any unit operation that increases DO will ultimately depend on a variety of factors. If it is not feasible to place the unit downstream of the bioreactor, an oxygen-scavenging agent, such as sodium bisulfite, can be added.

5.4.4 Oxidation-Reduction Potential

Biological reduction of perchlorate and nitrate occurs in a low DO, reducing environment. The reducing environment is quantified by measuring ORP. Plate 15 shows effluent ORP as it related to percent reduction of perchlorate and nitrate. (Note: ORP was measured for bioreactor influent and effluent from system startup in early November 1997. The ORP electrodes were determined to be faulty and were replaced in December 1997. The electrodes were replaced again in April 1998.)

Comparison of ORP data for periods where the bioreactor was completely reducing perchlorate and periods where only partial destruction of perchlorate was occurring suggests that the optimal operating range for ORP in bioreactor effluent was -250 to -350 mV. Although monitoring of ORP at various positions along the bioreactor flow path was not performed during the Phase 1 Treatability Study, such monitoring will be done during the Phase 2 Treatability Study.

5.4.5 Ethanol Requirements and Consumption

This study utilized ethanol as a substrate and evaluated optimal ethanol addition rates. The goal was to provide sufficient influent concentrations such that most of the substrate is consumed in the bioreactor with no excess discharged into the effluent. Ethanol was added upstream of the bioreactor influent and showed excellent linearity with respect to effluent concentration (see Plate 16).

Ethanol in the bioreactor influent versus effluent perchlorate is shown on Plate 17. This graph demonstrates the ethanol working range was large. Perchlorate destruction generally decreased at high ethanol concentrations; however, at high ethanol concentrations, ORP was less negative or DO was also high. Thus, the data are not available to isolate ethanol dosage as a single variable in perchlorate destruction. At a minimum, visual observation suggests that high ethanol dosage inhibits fluidized bed performance by limiting mass transfer.

Ethanol consumption varied with bioreactor conditions and residence time. During low residence times (4 minutes), minimum influent ethanol concentrations were roughly 70 mg/L (see Plate 18). With higher residence time (11 minutes), influent ethanol was roughly 25 mg/L (see Plate 19).

Ethanol bioreactor profiles for low residence time (4 minutes) under conditions of both low and high influent DO are shown on Plates 20 and 21, respectively. Most of the ethanol was utilized by the 50 percent point in both cases. It should be noted that although the bioreactor was consuming ethanol at roughly the same rates in both figures, perchlorate reduction varied due to other conditions (e.g., DO, ORP).

Optimal bioreactor performance economics and effluent economics and characteristics occurred at the lower end of the working range shown on Plate 17. With influent ethanol concentrations of 40 to 75 mg/L, ethanol in the effluent was generally low (<10 mg/L) or not detectable. Furthermore, with low DO and reducing conditions, concentrations of methanol, an impurity in the denatured ethanol, were not detected at or above the laboratory reporting level of 5 mg/L.

5.4.6 Bioreactor Response and Biomass Stability

Stability of the biomass is an important consideration for the design and operation of a full-scale system. Items such as system redundancy and storage capacity are directly affected by biomass stability. There were no upsets of the biomass that were not correlated with operational or input

changes. While the timeframe of the study did not allow for a long-term biomass stability study, there are three general sets of conditions that allowed evaluation of the stability of the biomass and response of the bioreactor to operational changes. These included planned shutdowns, unplanned shutdowns, and flow ramp-up.

- **Planned shutdowns.** In two instances after power outages, the bioreactor experienced a planned shutdown in anticipation of repair to power lines damaged in a storm or to perform routine maintenance. In both cases, bioreactor performance was reestablished within approximately 24 hours. In both instances the biomass was healthy, demonstrating complete nitrate and perchlorate destruction. Recovery could have been more rapid than 24 hours, but more frequent samples were not collected.

  On several other occasions, planned shutdowns of the system occurred. In May 1998, during a period of time where operational problems were experienced, the system did not operate consistently for 2 weeks. To maintain biomass health, the GAC/biomass was recirculated one to two times daily. Both nutrients and organic substrate were added. Under such conditions system recovery was rapid, but analyses at less than 24-hour increments were not performed.

  Planned shutdowns would be the most common type during normal operation of a full-scale system. Auxiliary power could either be used to keep the system running at capacity or at a minimum provide regular recirculation should power outages occur. Should pumps or pipelines fail, the bioreactor would be automatically shifted into recirculation mode and the health of the biomass preserved.

- **Unplanned shutdowns.** Several times over the course of the Phase 1 Treatability Study the bioreactor experienced unplanned shutdowns. In one instance, due to weather, power to the entire section of the Aerojet facility was lost for 4 days. Once power was reestablished, the bioreactor returned to completely destroying perchlorate and nitrate within two days (this unplanned shutdown occurred on a weekend). When power was completely out for 4 days, no recirculation of the GAC/biomass was possible and no nutrients were added. Although the system recovered completely within 2 days, samples were not collected at a high enough frequency to monitor biomass recovery. The system could have recovered significantly faster than 2 days. Unplanned shutdowns could occur during full-scale operations due to power outages or failure of pumps or pipelines.

- **Changes in flow rate.** When influent DO was low and the biomass was healthy, the bioreactor responded relatively quickly to changes in flow rate. Typically within 24 hours after an increase in flow rate or startup of the system, complete perchlorate and nitrate destruction was established. When influent DO levels were high and the biomass was healthy, it generally took 2 days or longer to reestablish complete destruction at the next higher flow rate. Several times when flow rate was increased, complete perchlorate and nitrate destruction was not achieved. In general at least 5 days was allowed to determine if optimum performance would be achieved. Often by this time, the health of the biomass had significantly deteriorated either due to washout or because the biomass populations substantially decreased. Visual observations confirmed this fact. To reestablish the biomass, the recycle flow rate must be substantially increased and several days' time was required.

  The objectives of the Phase 1 Treatability Study required that the effect of variations in flow rate on destruction performance be tested. The resulting conclusion is that when increasing flow, bioreactor response is rapid as long as the maximum design rate is not exceeded. Once this rate is exceeded, and if the bioreactor is allowed to operate at this level for a prolonged

time, biomass wash out occurs, and bioreactor recovery is slow. Under normal operating conditions this type of bioreactor upset would not occur except in rare circumstances where the biomass is poisoned by a toxin, an unlikely event when using a groundwater supply.

5.4.7 VOC Degradation across the Bioreactor

When the decision was made to test the performance of the bioreactor without first removing VOCs, a concern arose regarding whether unwanted byproducts such as vinyl chloride would be formed in the bioreactor. The initial testing for VOC degradation products showed that while most consituents, such as TCE, decreased across the bioreactor (see Plate 22), no corresponding increase in daughter products, such as vinyl chloride, were observed (a single detection of vinyl chloride was deemed an anomaly). It was thus concluded that VOC removal was likely due to the adsorption by GAC and that the slightly reducing, anoxic conditions present in the bioreactor are not sufficiently reducing to cause VOC degradation.

To test this hypothesis, the GAC was saturated with VOCs, thus eliminating adsorption as a removal mechanism. The capacity of the GAC to adsorb TCE was estimated and TCE solvent was metered into the carbon bed with the system in full recirculation. TCE metering was discontinued once bioreactor effluent exceeded 200 mg/L of TCE. The system was then transitioned to normal operation at a 50 percent recirculation rate. Unfortunately, almost immediately the air stripper malfunctioned and the system was shutdown. The system remained shutdown for 2 weeks. The system almost certainly turned anaerobic during that period, but ORP was not measured during this shutdown.

After the air stripper was repaired, the system was restarted. The system stabilized rapidly and samples were gathered within 24 hours. Small, decreasing amounts of vinyl chloride were observed in the initial and subsequent sample; all other samples collected over the next 5 days did not contain detectable vinyl chloride (see Plate 23). Variations in other compounds such as TCE were either consistent with earlier results or were within expected error in spite of the TCE loading of the GAC (see Plate 24). It was concluded that carbon adsorption was the likely mechanism for the decrease and that initially observed daughter products were probably the result of anaerobic activity while the reactor was shutdown.

An important consideration is what effect will this have on a full-scale system. The preliminary conceptual design specified an air stripper for VOC removal. (The current conceptual design utilizes UV/oxidation for VOC removal and not an air stripper.) The chemical driving air stripper design here is 1,2-dichloroethane (1,2-DCA) which was essentially unchanged across the bioreactor during stable operation (see Plate 25). Thus, VOC degradation across the bioreactor should not affect the design of an air stripper, if it is included in the treatment train.

Acetone increased across the bioreactor while methyl isobutyl ketone (MIBK) decreased (see Plates 26 and 27). We hypothesize most of the increase in acetone is due to breakdown of MIBK. Alternative mechanisms, such as the oxidation of the alcohols, could have a role in the acetone increase; however, with the bioreactor in reducing conditions this is not a favored mechanism. Note that methanol, MIBK, and isopropyl alcohol were detected as impurities in the ethanol. Although acetone was not detected as an impurity in the ethanol, the limit of detection was 0.5 percent (5,000,000 µg/L). Therefore, concentrations of acetone consistent with bioreactor influent concentrations would not have been detected. A higher purity of ethanol will be used during the Phase 2 Treatability Study.

5.4.8 Visual Inspection of Biomass/Bioreactor

Visual inspection of the biomass and bioreactor correlated well with bioreactor performance or lack thereof. Therefore, visual observation of the biomass and bioreactor can serve as a valuable indicator and predictor of biomass effectiveness and stability. The biomass displayed three distinct appearances under various conditions. This may be due to selective competition (i.e. Voltera's Principle) or from metabolic changes by established microorganisms in response to substrate and/or redox changes. While no laboratory differentiation of these populations was conducted, the biomass was likely a continuum of organisms that perform different functions. The following observations were made:

- Low Dissolved Oxygen. The biomass was a light translucent tan, formed a spherical configuration around the carbon particles, and was well attached. The biomass/carbon spheres resembled fish eggs with diameters ranging from 2 to 4 millimeters. Diameters appeared to be two to three times the diameter of the carbon particle. Gas bubbles were observed rising to the surface during nitrate reduction; however, it was not possible to correlate the degree of bubbling to nitrate destruction efficiency.

- High Dissolved Oxygen. The biomass varied from a light translucent tan during higher rates of recycle and perchlorate destruction to an opaque white/gray when recycle rates were low and perchlorate was not being reduced. The biomass was gelatinous, filamentous, and poorly attached to the carbon. Gas bubbles were observed rising to the surface during nitrate reduction; however, it was not possible to correlate the degree of bubbling to nitrate destruction efficiency.

- Excess Ethanol. If ethanol addition was too great, a white mucus began to accumulate in the system piping and around the biomass. The high cell mass concentrations caused carbon grains to clump together, slowing bed mixing and fluidization, causing channeling, and resulting in a decreased bioreactor working volume. This nonuniformity adversely affected perchlorate reduction. In addition, long, filamentous, string-like white/gray biomass was also formed. When the ethanol addition rate was decreased to an appropriate level, these biomass conditions ceased.

5.4.9 Phosphorus Requirements and Consumption

Results from a wide variety of biological treatability studies, including those using both suspended-growth and fixed-film technologies, confirm phosphorus is a key nutrient required for biomass growth and stability. Phosphorus must be present at a minimum concentration regardless of whether it is fully consumed or not.

Phosphorus consumption varied widely over the study as shown on Plate 28. Overall consumption varied from none to 1.5 mg/L. In general, as shown by the graph, more phosphorus was consumed when perchlorate and nitrate destruction was most successful, as would be expected.

When complete destruction of nitrate and perchlorate was realized, residual effluent phosphorus concentrations were typically 1 mg/L or less. Effluent phosphorus concentrations were often lower than 0.2 mg/L. Observations from the Phase 1 Treatability Study suggest the residual phosphorus concentration in the bioreactor effluent should be greater than 0.2 mg/L to ensure that enough phosphorus exists to support biomass activity. However, no detailed evaluation or

optimization of phosphorus loading was performed. Therefore, it may be possible to decrease influent concentrations of phosphorus but still maintain biomass stability. This component of perchlorate and nitrate treatability can be evaluated further during the Phase 2 Treatability Study.

5.4.10 pH As an Indicator of Performance

Biological reduction processes remove acidity (protons), and therefore alkalinity increases. This was confirmed by field observations across the bioreactor (see Plates 29 and 30). An increase in pH was expected. A greater reduction "load" results in a greater pH increase across the bioreactor. The maximum pH increase observed during high DO operations was approximatley 0.5 unit. The maximum pH increase during low DO operations was approximately 1 unit. Thus, pH increase can be used as a general indicator of bioreactor performance but it is not strictly correlated.

When the air stripper was online, the average influent pH was approximately 8.1 units. With the air stripper removed or on the effluent side of the bioreactor, the average influent pH decreased to approximately 7.3 units. Air stripping raises pH because carbon dioxide dissolved in groundwater is usually stripped out or removed in the process.

5.4.11 Bioreactor Temperature

Little to no sensitivity to temperature was observed during the study (see Plate 31). Bioreactor temperatures ranged from 13° to 23°C. Biological systems typically follow Arrenhius behavior with respect to temperature sensitivity. For a 10°C temperature difference, we would expect to see an observable increase in biological activity; however, operating conditions were not consistent over the entire timeframe and no difference was observed. Therefore, other variables masked our ability to evaluate the effect of temperature on perchlorate destruction.

Little to no temperature difference was observed across the bioreactor. Because of the small concentrations involved, the short reactor residence time, and the large heat capacity of water, no temperature change was expected.

An important design consideration is whether heating will be required to sustain biological activity during cold months. The average temperature of the San Gabriel Valley is higher than that of the Sacramento area during the cold months. Extracted groundwater temperatures were sufficient to support biological growth in this study. Therefore, we anticipate no heating will be required in the San Gabriel Valley.

5.5 Effluent Characteristics/Water Quality

One of the primary objectives of the Phase 1 Treatability Study was to evaluate effluent from the GAC/FB bioreactor for parameters used to regulate the quality of drinking water. Additional work is needed to establish disinfection and filtration requirements and demonstrate that the treatment processes will reliably produce potable water. This objective will be fully addressed in a Phase 2 Treatability Study. The specific activities undertaken during the Phase 1 Treatability Study and planned for the Phase 2 Treatability Study were identified as a result of discussions with DHS, MSGBWM, WQA, TVMWD, and MWD.

One concern expressed by DHS was with regard to the characteristics of the source of microorganisms used to inoculate the bioreactor. The microorganisms used in this study were taken from a baby food processing plant and proved to be acceptable for building needed

populations of microorganisms. Over the life of the study, 97 percent of the results for analysis of fecal coliform showed that no fecal coliform was present. Only two measurable results of 1 Most Probable Number (MPN)/100 mL were obtained. These results are extremely close to the method detection limit of 0 MPN/100 mL. General coliform was present, however, to some degree in nearly every effluent sample. From January 28 to March 1, 1998, coliform was present in the bioreactor effluent 78 percent of the time at an amount greater than 200.5 MPN/100 mL (the upper quantifiable limit of the method [no quantification was made of MPNs greater than 200]). These levels of bacteria are common for surface waters, and conventional disinfection and filtration are expected to bring the water to potable standards.

Since ethanol is added to the bioreactor as an organic substrate to support microorganism growth, the presence of ethanol and its impurities in bioreactor effluent was addressed. The ethanol used in the Phase 1 Treatability Study was denatured and contained low concentrations of methanol, MIBK, and isopropyl alcohol (IPA). The goal was to ensure that the influent ethanol concentration was sufficiently high to ensure perchlorate and nitrate destruction but also to optimize influent ethanol so that the microorganisms consume all the ethanol by the time water flows from the bioreactor. As discussed above, an ethanol optimization study was performed in late February 1998. Analytical results shown in Appendix D demonstrate that with an influent ethanol concentration of 40 to 70 mg/L, ethanol in bioreactor effluent was less than or near the 5 mg/L laboratory reporting limit. For the Phase 2 Treatability Study a higher grade of ethanol will be used. This grade of ethanol will be denatured only with ethyl acetate, and specifications confirm nondetectable levels of other alcohols and ketones.

Groundwater selected for this treatability study contained concentrations of NDMA ranging from about 70 to 80 µg/L. It should be noted that analyses of bioreactor influent and effluent for NDMA was performed on five dates in February 1998, and results indicate that the bioreactor had no effect on NDMA concentrations.

On two occasions, analysis of bioreactor influent and effluent for the full range of Primary and Secondary water quality parameters required by DHS was performed (see Table 4). These results demonstrate that with disinfection and filtration, the water produced from the intended treatment train will meet potable standards.

6.0 CONCLUSIONS

The conclusions of this Phase 1 Treatability Study with respect to the study objectives are:

- **Evaluate Lower Perchlorate Influent Concentration.** The biological reduction process successfully treated groundwater with perchlorate concentrations representative of that anticipated in the San Gabriel Basin.

- **Evaluate Higher Nitrate Influent Concentration.** The biological reduction process successfully treated groundwater with nitrate concentrations representative of that anticipated in San Gabriel Basin to less than the laboratory detection limit of 0.1 mg/L.

- **Demonstrate Technology Can Achieve 18 µg/L Perchlorate Limit or Lower.** The biological reduction process produced an effluent concentration of less than the laboratory detection limit of 4 µg/L and less than the DHS provisional action level of 18 µg/L.

- **Evaluate Different Source of Microorganisms.** This treatability study demonstrated the effectiveness of a different source of microorganisms. This study utilized sludge from the food processing industry. Laboratory analysis indicated a general lack of fecal coliform in the treatment system effluent; however, further evaluation of filtration and disinfection of the effluent will be necessary to ensure that potable water quality standards are reliably met. It is likely that a variety of sources of microorganisms contain microbes capable of reducing perchlorate; the key concern will be locating a source that does not contain human pathogens.

- **Evaluate Potability of Treated Water.** Effluent from the GAC/FB bioreactor was analyzed for parameters used to regulate the quality of drinking water and other chemicals mentioned by DHS to be of concern. Additional work is needed to establish disinfection and filtration requirements and demonstrate that the treatment processes will reliably produce potable water. This objective will be fully addressed in a Phase 2 Treatability Study.

Additional conclusions that can be drawn from the study are:

- The conceptual model of perchlorate reduction based on published literature agrees well with the actual results. A sound conceptual model will assist with the Phase 2 Treatability Study and full-scale design. The mechanism of degradation and reaction kinetics were not investigated.

- Bioreactor retention time can be adjusted to achieve complete perchlorate reduction with varying influent conditions. The recycle rate can be optimized to produce a maximum treatment rate meeting effluent parameters of concern. An increased recycle rate provides a greater average bioreactor residence time and generally allows the reduction reaction to proceed to completion.

- ORP, DO, and pH subjectively indicate perchlorate reduction. This will minimize laboratory costs in the future and aid in the development of automated controls and safety mechanisms.

- An optimal ethanol addition rate is approximately 40 to 70 mg/L. The optimal ethanol addition rate is a concentration such that there is sufficient ethanol to sustain biomass that will completely degrade perchlorate but there is little to no ethanol in the effluent.

- A minimum biomass phosphorus requirement is 0.4 to 0.5 mg/L. The phosphorus requirement is the minimum addition of phosphorus that sustains biomass growth. The biomass phosphorus requirement is dependent on influent mineral concentrations and may change in the San Gabriel Basin.

- There was an apparent selectivity for nitrate over perchlorate; however, the concentration ranges of nitrate and perchlorate were vastly different. Therefore, it is not clear whether the selectivity was reaction-rate driven or concentration driven.

- Little to no VOC reduction occurred across the bioreactor. Some VOC reduction products are more toxic and more difficult to remove than their parent compound. If VOC reduction occurred, the VOC removal system design could be significantly impacted. The lack of VOC reduction products allows more flexibility in designing the treatment system.

- The reaction proceeds well at nominal groundwater temperatures. Anticipated temperature fluctuations in San Gabriel Basin groundwater are moderate and should be compensated for through other bioreactor performance parameters.

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TABLES

Table 1
Phase 1 Perchlorate Treatability Study
Representative Laboratory Analytical/Field Parameter Summary

	DATE SAMPLED / MEASURED	12/11/97	12/12/97	12/13/97	12/14/97	12/15/97	12/16/97	12/17/97	12/18/97	12/19/97	12/20/97	1/29/98	1/30/98	2/1/98	2/2/98	2/3/98	2/4/98	2/6/98
	PERCENT INFLUENT WELL WATER	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	83%	83%	83%	83%	83%	83%	83%
	PERCENT RECIRCULATED WATER	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	17%	17%	17%	17%	17%	17%
	AIR STRIPPER OPERATIONAL?	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO
SAMPLING PORT	ANALYTE/PROPERTY																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	110.0	83.0	-	99.0	120.0	110.0	92.0
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	87	84	48	50	78	82.0	84.0	65.0	<5	110.0	98.0	71.0	100.0	95.0	97.0	76.0	40.0
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	37	50	<10	<10	12	-	7.2	<5	30.0	73.0	53.0	30.0	20.0	18.0	23.0	14.0	<5
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	36.0	25.0	-	57.0	35.0	28.0	38.0
Bioreactor Influent (C)	Perchlorate (ug/l)	41	39	40	40	36	42.0	34.0	35.0	34.0	34.0	<4	18.0	20.0	29.0	35.0	27.0	41.0
Bioreactor Effluent (G)	Perchlorate (ug/l)	27	34	40	29	24	25.0	26.0	28.0	30.0	30.0	<4	<4	<4	<4	<4	<4	<4
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	0.11	0.09	-	0.09	0.10	0.12	0.10
Bioreactor Influent (C)	Total Phosphorus (mg/l)	<0.05	0.46	0.28	0.27	0.26	0.25	0.25	0.41	0.47	0.43	0.62	0.84	0.75	0.53	0.57	0.79	0.52
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	<0.05	0.37	0.15	0.17	0.15	0.13	0.15	0.27	0.27	0.31	0.43	0.60	0.53	0.34	0.35	0.55	0.34
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	0.16	<0.1
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	0.14	<0.1	<0.1	<0.1	<0.1	0.20	<0.1	<0.1	<0.1	<0.1	0.59	0.78	0.66	0.51	0.59	0.72	0.62
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.82	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.57	0.55	0.54	0.29	0.44	0.73	0.75
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	17.00	22.00	-	18.00	17.00	18.00	19.00
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	11	14	0.21	13	13	11.00	10.00	11.00	8.90	10.00	14.00	14.00	16.00	15.00	14.00	13.00	14.00
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	7.9	9.5	2	<0.1	0.64	0.55	<0.1	2.40	<0.1	3.90	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	0.04	<0.03	0.051	<0.03	<0.03	<0.03	0.12	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	0.53	0.33	1.6	0.034	0.18	0.17	<0.03	0.26	<0.03	0.28	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	270.0	-	-	-	-	160.0	160.0
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	100	120	110	91	100	-	87.0	110.0	<10	200.0	300.0	200.0	240.0	280.0	350.0	130.0	140.0
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	98	98	69	52	52	52.0	56.0	74.0	56.0	120.0	240.0	170.0	190.0	160.0	300.0	230.0	65.0
Bioreactor Influent (C)	pH	7.96	7.67	7.49	7.60	8.22	7.91	7.75	7.28	7.82	-	7.17	7.13	-	7.35	7.27	7.20	7.08
Bioreactor Effluent (G)	pH	7.64	7.87	7.56	8.17	8.58	8.36	8.19	7.72	7.99	-	7.76	-	7.87	7.80	7.81	7.70	7.67
Bioreactor Influent (C)	Temperature °C	18.3	17.5	17.8	18.3	18.5	18.6	18.7	17.2	19.0	17.2	19.2	18.9	-	19.1	19.0	19.0	18.9#
Bioreactor Effluent (G)	Temperature °C	18.6	16.3	16.7	17.3	18.5	18.7	18.8	17.7	19.1	17.4	18.7	-	17.9	18.0	17.8	19.2#	19#
Bioreactor Influent (C)	Oxidation-Reduction Potential (mV)	118.5	153.3	228.6	108.6	104.6	90.8	76.0	-	65.5	105.6	-208.8	-202.7	-226.0	-243.8	-253.9	-249.5	-241.0
Bioreactor Effluent (G)	Oxidation-Reduction Potential (mV)	35.0	180.5	172.7	71.4	96.0	42.5	40.8	-	65.0	37.8	-274.0	-281.0	-304.2	-310.0	-323.0	-318.0	-314.1
Bioreactor Influent-Inline Meter (C)	Dissolved Oxygen	8.3	8.1	-	8.2	8.4	8.0	8.5	8.3	9.2	9.3	0.8	0.9	1.2	0.7	0.5	0.8	1.0
Bioreactor Effluent-Inline Meter (G)	Dissolved Oxygen	0.3	2.0	0.5	0.2	0.2	0.2	0.2	0.3	0.3	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.4
Inside Bioreactor Influent	Dissolved Oxygen	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	0.50	-	0.35
Inside Bioreactor Effluent	Dissolved Oxygen	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.08	-	0.11

Notes:
ug/l = microgram per liter, mg/l = milligram per liter
mV = millivolt
GW = groundwater
Dissolved Oxygen measured inside the reactor was measured by lowering DO probe directly inside reactor.
= temperature measured directly inside reactor with DO probe, all other temps measured at sample ports with hand-held meter.
pH and ORP measured at sample ports with hand-held meter.

Table 2

Phase I Perchlorate Treatability Study
Flowrate vs Percent Flow and Effective Retention Time

Influent Well Water Flowrate (gpm)	Recycle Water Flowrate (gpm)	Percent Influent Well Water	Percent Recirculated Water	Estimated Effective Retention Time (min)
0	30	0%	100%	---
5	25	17%	83%	21.6
10	20	33%	67%	10.8
15	15	50%	50%	7.2
20	10	67%	33%	5.4
25	5	83%	17%	4.3
30	0	100%	0%	3.6

Notes:

To calculate effective retention time several assumptions were made:

1) The time calculated is the retention time that the water is in contact with fluidized carbon.

2) With an average settled carbon bed height it was assumed that the carbon void space was 40%.

Table 3
Phase I Perchlorate Treatability Study
Performance Summary

Date	Air Stripper Operational?	System Flow		Average Perchlorate Destruction	Average Nitrate Destruction	Average Ethanol Consumption (mg/L)	Average Phosphorus Consumption (mg/L)	Average Effluent ORP (mV)	Average DO		Average pH Increase Across Bioreactor
		Influent Well Water	Recirculated Water						Influent (mg/L)	Effluent (mg/L)	
11/20/97 - 11/25/97	Yes	33%	67%	90%	42%	9	0.05	---	0.5	0.10	0.06
11/26/97	Yes	50%	50%	100%	100%	42	0.12	---	0.4	0.10	0.16
11/28/97 - 12/6/97	Yes	67%	33%	74%	56%	34	0.00	---	4.4	1.10	0.04
12/11/97 - 12/22/97	Yes	100%	0%	30%	75%	44	0.13	+74	8.8	0.50	0.25
12/24/97 - 12/26/97	Yes	83%	17%	32%	60%	30	0.10	+28	9	0.50	0.11
12/29/97 - 1/23/98	Yes	67%	33%	34%	79%	21	0.01	-103	5.6	0.30	0.23
1/25/98 - 1/27/98	No	67%	33%	100%	100%	14	0.10	-228	0.7	0.10	0.56
1/29/98 - 2/7/98	No	83%	17%	100%	100%	59	0.22	-298	0.45	0.09	0.58
2/10/98 - 3/1/98	No	83%	17%	99%	100%	75	0.14	-280	0.43	0.14	0.44
3/3/98 - 3/13/98*	No	83%	17%	85%	99.7%	64	0.17	-185	0.4	0.09	0.86
3/16/98 - 3/24/98	Yes	34%	66%	93%	100%	11.3	-0.02	-240	2.6	0.06	0.12
3/25/98 - 4/3/98	Yes	51%	49%	70%	99.5%	17.4	0.20	-88	3.6	0.10	0.23
4/4/98 - 4/10/98	Yes	66%	34%	82%	100%	41	0.18***	-179	3.1	0.09	0.41
4/11/98 - 4/24/98	Yes	52%	48%	76%	100%	28	0.10***	-153	1.4	0.07	0.29
4/25/98 - 4/30/98	Yes	34%	66%	78%	100%	23	0.11***	-209	0.4	0.06	0.12
5/6/98 - 5/18/98	Yes	32%	68%	100%	100%	1.3	-0.06	20	1.1	0.26	0.06
6/10/98 - 6/17/98	Yes	67%	33%	100%	100%	44	No Data	-272	0.6	0.11	0.38

Notes:
* = Decrease in perchlorate and nitrate destruction is due to ethanol reduction testing taking place over time period.
*** = Based on one data point.
system effluent.
ORP = Oxidation Reduction Potential
mV = millivolt
DO = Dissolved Oxygen
DO is measured at Port C (bioreactor influent and after internal cycle) and at Port G (bioreactor effluent).

Table 4
Phase I Perchlorate Treatability Study
Title 22 Laboratory Analytical Summary

PRIMARY STANDARDS - Mandatory health-related standards established by the State of California Department of Health Services

Parameter	Units	Maximum Contaminant Level	Sampling Port	Sampled 5/18/98	Sampled 6/15/98
MICROBIOLOGICAL					
Fecal Coliform (MPN/100ml)	% Samples	5.00	Air Strip. Infl. (A)	*	*
Fecal Coliform	Positive	5.00	Air Strip. Effl. (B)	*	*
Fecal Coliform		5.00	Bioreactor Effluent (G)	*	*
Coliform (MPN/100ml)	% Samples	5.00	Air Strip. Infl. (A)	*	*
Coliform	Positive	5.00	Air Strip. Effl. (B)	*	*
Coliform		5.00	Bioreactor Effluent (G)	*	*
Bacteria (CFU/ml)	% Samples	5.00	Air Strip. Infl. (A)	*	*
Bacteria	Positive	5.00	Air Strip. Effl. (B)	*	*
Bacteria		5.00	Bioreactor Effluent (G)	*	*
ORGANIC CHEMICALS					
Total Trihalomethanes (THM'S / TTHM)	ug/L	0.10	Air Strip. Infl. (A)	<0.1	<0.10
Total Trihalomethanes	ug/L	0.10	Air Strip. Eff. (B)	-	<0.10
Total Trihalomethanes	ug/L	0.10	Bioreactor Effluent (G)	-	<0.10
Endrin EPA 508	ug/L	2.00	Air Strip. Infl. (A)	<0.10	<0.10
Endrin	ug/L	2.00	Air Strip. Eff. (B)	-	<0.10
Endrin	ug/L	2.00	Bioreactor Effluent (G)	-	<0.10
Lindane EPA 3580	ug/L	0.20	Air Strip. Infl. (A)	<0.20	<0.20
Lindane	ug/L	0.20	Air Strip. Eff. (B)	-	<0.20
.indane	ug/L	0.20	Bioreactor Effluent (G)	-	<0.20
lethoxychlor EPA 3580	ug/L	40.00	Air Strip. Infl. (A)	<10.0	<10
Methoxychlor	ug/L	40.00	Air Strip. Eff. (B)	-	<10
Methoxychlor	ug/L	40.00	Bioreactor Effluent (G)	-	<10
Toxaphene EPA 508	ug/L	3.00	Air Strip. Infl. (A)	<1.0	<1.0
Toxaphene	ug/L	3.00	Air Strip. Eff. (B)	-	<1.0
Toxaphene	ug/L	3.00	Bioreactor Effluent (G)	-	<1.0
2,4-D EPA 515.1/3510	ug/L	70.00	Air Strip. Infl. (A)	<10.0	<10
2,4-D	ug/L	70.00	Air Strip. Eff. (B)	-	<10
2,4-D	ug/L	70.00	Bioreactor Effluent (G)	-	<10
2,4,5-TP (Silvex) EPA 515.1/3510	ug/L	50.00	Air Strip. Infl. (A)	<1.0	<1.0
2,4,5-TP (Silvex)	ug/L	50.00	Air Strip. Eff. (B)	-	<1.0
2,4,5-TP (Silvex)	ug/L	50.00	Bioreactor Effluent (G)	-	<1.0
Atrazine EPA 3510	ug/L	3.00	Air Strip. Infl. (A)	<1.0	<1.0
Atrazine	ug/L	3.00	Air Strip. Eff. (B)	-	<1.0
Atrazine	ug/L	3.00	Bioreactor Effluent (G)	-	<1.0
Bentazon EPA 515.1/3510	ug/L	1.80	Air Strip. Infl. (A)	<2.0	<2.0
Bentazon	ug/L	1.80	Air Strip. Eff. (B)	-	<2.0
Bentazon	ug/L	1.80	Bioreactor Effluent (G)	-	<2.0
Benzene	ug/L	1.00	Air Strip. Infl. (A)	<0.1	<0.10
Benzene	ug/L	1.00	Air Strip. Eff. (B)	-	<0.10
Benzene	ug/L	1.00	Bioreactor Effluent (G)	-	<0.10
Carbon tetrachloride EPA 502.2	ug/L	0.50	Air Strip. Infl. (A)	2.3	2.10
Carbon tetrachloride	ug/L	0.50	Air Strip. Eff. (B)	-	<0.10
Carbon tetrachloride	ug/L	0.50	Bioreactor Effluent (G)	-	0.38

Table 4
Phase I Perchlorate Treatability Study
Title 22 Laboratory Analytical Summary

arameter	Units	Maximum Contaminant Level	Sampling Port	Sampled 5/18/98	Sampled 6/15/98
1,2-Dibromo-3-chloropropane EPA 504	ug/L	0.20	Air Strip. Infl. (A)	<0.010	<0.01
1,2-Dibromo-3-chloropropane	ug/L	0.20	Air Strip. Eff. (B)	-	<0.01
1,2-Dibromo-3-chloropropane	ug/L	0.20	Bioreactor Effluent (G)	-	<0.01
1,4-Dichlorobenzene	ug/L	5.00	Air Strip. Infl. (A)	<0.1	<0.10
1,4-Dichlorobenzene	ug/L	5.00	Air Strip. Eff. (B)	-	<0.10
1,4-Dichlorobenzene	ug/L	5.00	Bioreactor Effluent (G)		<0.10
1,2-Dichloroethane EPA 502.2	ug/L	0.50	Air Strip. Infl. (A)	1.7	1.60
1,2-Dichloroethane	ug/L	0.50	Air Strip. Eff. (B)	-	0.18
1,2-Dichloroethane	ug/L	0.50	Bioreactor Effluent (G)	-	1.40
1,1-Dichloroethylene	ug/L	6.00	Air Strip. Infl. (A)	6.00	6.70
1,1-Dichloroethylene	ug/L	6.00	Air Strip. Eff. (B)	-	<0.10
1,1-Dichloroethylene	ug/L	6.00	Bioreactor Effluent (G)	-	6.20
Total 1,3-Dichloropropene	ug/L	0.50	Air Strip. Infl. (A)	<0.1	<0.10
Total 1,3-Dichloropropene	ug/L	0.50	Air Strip. Eff. (B)	-	<0.10
Total 1,3-Dichloropropene	ug/L	0.50	Bioreactor Effluent (G)	-	<0.10
Ethylbenzene	ug/L	700.00	Air Strip. Infl. (A)	<0.1	<0.10
Ethylbenzene	ug/L	700.00	Air Strip. Eff. (B)	-	<0.10
Ethylbenzene	ug/L	700.00	Bioreactor Effluent (G)	-	<0.10
Ethylene dibromide EPA 504	ug/L	0.05	Air Strip. Infl. (A)	<0.020	<0.02
Ethylene dibromide	ug/L	0.05	Air Strip. Eff. (B)	-	<0.02
Ethylene dibromide	ug/L	0.05	Bioreactor Effluent (G)	-	<0.02
Molinate EPA 3510	ug/L	20.00	Air Strip. Infl. (A)	<2.0	<2.0
Molinate	ug/L	20.00	Air Strip. Eff. (B)	-	<2.0
olinate	ug/L	20.00	Bioreactor Effluent (G)	-	<2.0
Monochlorobenzene	ug/L	70.00	Air Strip. Infl. (A)	<0.1	<0.10
Monochlorobenzene	ug/L	70.00	Air Strip. Eff. (B)	-	<0.10
Monochlorobenzene	ug/L	70.00	Bioreactor Effluent (G)	-	<0.10
Simazine EPA 3510	ug/L	4.00	Air Strip. Infl. (A)	<1.0	<1.0
Simazine	ug/L	4.00	Air Strip. Eff. (B)	-	<1.0
Simazine	ug/L	4.00	Bioreactor Effluent (G)	-	<1.0
1,1,2,2-Tetrachloroethane	ug/L	1.00	Air Strip. Infl. (A)	<0.1	<0.10
1,1,2,2-Tetrachloroethane	ug/L	1.00	Air Strip. Eff. (B)	-	<0.10
1,1,2,2-Tetrachloroethane	ug/L	1.00	Bioreactor Effluent (G)	-	<0.10
Tetrachloroethylene EPA 502.2	ug/L	5.00	Air Strip. Infl. (A)	0.18	0.19
Tetrachloroethylene	ug/L	5.00	Air Strip. Eff. (B)	-	<0.10
Tetrachloroethylene	ug/L	5.00	Bioreactor Effluent (G)	-	<0.10
Thiobencarb EPA 3510	ug/L	70.00	Air Strip. Infl. (A)	<1.0	<1.0
Thiobencarb	ug/L	70.00	Air Strip. Eff. (B)	-	<1.0
Thiobencarb	ug/L	70.00	Bioreactor Effluent (G)	-	<1.0
1,1,1-Trichloroethane EPA 502.2	ug/L	200.00	Air Strip. Infl. (A)	<0.1	<0.10
1,1,1-Trichloroethane	ug/L	200.00	Air Strip. Eff. (B)	-	<0.10
1,1,1-Trichloroethane	ug/L	200.00	Bioreactor Effluent (G)	-	0.11
1,1,2-Trichloroethane	ug/L	5.00	Air Strip. Infl. (A)	<0.1	<0.10
1,1,2-Trichloroethane	ug/L	5.00	Air Strip. Eff. (B)	-	<0.10
1,1,2-Trichloroethane	ug/L	5.00	Bioreactor Effluent (G)	-	<0.10
Tetrachloroethylene EPA 502.2	ug/L	5.00	Air Strip. Infl. (A)	0.18	0.19
Tetrachloroethylene	ug/L	5.00	Air Strip. Eff. (B)	-	<0.10
etrachloroethylene	ug/L	5.00	Bioreactor Effluent (G)	-	<0.10

Table 4
Phase I Perchlorate Treatability Study
Title 22 Laboratory Analytical Summary

arameter	Units	Maximum Contaminant Level	Sampling Port	Sampled 5/18/98	Sampled 6/15/98
Vinyl chloride EPA 502.2	ug/L	0.50	Air Strip. Infl. (A)	<0.1	<0.10
Vinyl chloride	ug/L	0.50	Air Strip. Eff. (B)	-	<0.10
Vinyl chloride	ug/L	0.50	Bioreactor Effluent (G)	-	<0.10
Xylenes, total	ug/L	1,750.00	Air Strip. Infl. (A)	<0.1	<0.10
Xylenes	ug/L	1,750.00	Air Strip. Eff. (B)	-	<0.10
Xylenes	ug/L	1,750.00	Bioreactor Effluent (G)	-	<0.10
cis-1,2-Dichloroethylene EPA 502.2	ug/L	6.00	Air Strip. Infl. (A)	3.3	3.10
cis-1,2-Dichloroethylene	ug/L	6.00	Air Strip. Eff. (B)	-	<0.10
cis-1,2-Dichloroethylene	ug/L	6.00	Bioreactor Effluent (G)	-	6.80
Trans-1,2- Dichloroethylene	ug/L	10.00	Air Strip. Infl. (A)	<0.10	<0.10
Trans-1,2- Dichloroethylene	ug/L	10.00	Air Strip. Eff. (B)	-	<0.10
Trans-1,2- Dichloroethylene	ug/L	10.00	Bioreactor Effluent (G)	-	<0.10
1,1-Dichloroethane EPA 502.2	ug/L	5.00	Air Strip. Infl. (A)	1.6	1.50
1,1-Dichloroethane	ug/L	5.00	Air Strip. Eff. (B)	-	<0.10
1,1-Dichloroethane	ug/L	5.00	Bioreactor Effluent (G)	-	1.40
1,2-Dichloropropane	ug/L	5.00	Air Strip. Infl. (A)	<0.1	<0.10
1,2-Dichloropropane	ug/L	5.00	Air Strip. Eff. (B)	-	<0.10
1,2-Dichloropropane	ug/L	5.00	Bioreactor Effluent (G)	-	<0.10
Trichlorofluoromethane (Freon 11)	ug/L	15.00	Air Strip. Infl. (A)	0.16	<0.10
Trichlorofluoromethane	ug/L	15.00	Air Strip. Eff. (B)	-	<0.10
Trichlorofluoromethane	ug/L	15.00	Bioreactor Effluent (G)	-	<0.10
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	ug/L	1,200.00	Air Strip. Infl. (A)	<0.1	<0.10
',1,2-Trichloro-1,2,2-Trifluoroethane	ug/L	1,200.00	Air Strip. Eff. (B)	-	<0.10
.,1,2-Trichloro-1,2,2-Trifluoroethane	ug/L	1,200.00	Bioreactor Effluent (G)	-	<0.10
Carbofuran EPA 531.1	ug/L	1.80	Air Strip. Infl. (A)	<5.0	<5
Carbofuran	ug/L	1.80	Air Strip. Eff. (B)	-	<5
Carbofuran	ug/L	1.80	Bioreactor Effluent (G)	-	<5
Glyphosate EPA 547	ug/L	700.00	Air Strip. Infl. (A)	<25.0	<25.0
Glyphosate	ug/L	700.00	Air Strip. Eff. (B)	-	<25.0
Glyphosate	ug/L	700.00	Bioreactor Effluent (G)	-	<25.0
Chlordane EPA 3580	ug/L	0.10	Air Strip. Infl. (A)	<0.10	<0.10
Chlordane	ug/L	0.10	Air Strip. Eff. (B)	-	<0.10
Chlordane	ug/L	0.10	Bioreactor Effluent (G)	-	<0.10
Heptachlor EPA 508	ug/L	0.01	Air Strip. Infl. (A)	<0.01	<0.01
Heptachlor	ug/L	0.01	Air Strip. Eff. (B)	-	<0.01
Heptachlor	ug/L	0.01	Bioreactor Effluent (G)	-	<0.01
Heptachlor epoxide EPA 508	ug/L	0.01	Air Strip. Infl. (A)	<0.01	<0.01
Heptachlor epoxide	ug/L	0.01	Air Strip. Eff. (B)	-	<0.01
Heptachlor epoxide	ug/L	0.01	Bioreactor Effluent (G)	-	<0.01
Di (2-ethylhexyl) phthalate EPA 3510	ug/L	4.00	Air Strip. Infl. (A)	<3.0	<3
Di (2-ethylhexyl) phthalate	ug/L	4.00	Air Strip. Eff. (B)	-	<3
Di (2-ethylhexyl) phthalate	ug/L	4.00	Bioreactor Effluent (G)	-	<3

Table 4
Phase I Perchlorate Treatability Study
Title 22 Laboratory Analytical Summary

Parameter	Units	Maximum Contaminant Level	Sampling Port	Sampled 5/18/98	Sampled 6/15/98
INORGANIC CHEMICALS					
Aluminum (Al) EPA Series 200	ug/L	1,000.00	Air Strip. Infl. (A)	<50.0	<50
Aluminum (Al)	ug/L	1,000.00	Air Strip. Eff. (B)	-	<50
Aluminum (Al)	ug/L	1,000.00	Bioreactor Effluent (G)	-	<50
Antimony (Sb) EPA Series 200	ug/L	6.00	Air Strip. Infl. (A)	<6.0	<6
Antimony (Sb)	ug/L	6.00	Air Strip. Eff. (B)	-	<6
Antimony (Sb)	ug/L	6.00	Bioreactor Effluent (G)	-	<6
Arsenic (As) EPA Series 200	ug/L	50.00	Air Strip. Infl. (A)	<2.0	2.3
Arsenic (As)	ug/L	50.00	Air Strip. Eff. (B)	-	2.5
Arsenic (As)	ug/L	50.00	Bioreactor Effluent (G)	-	<2.0
Asbestos (fibers)>10um	MFL	7.00	Air Strip. Infl. (A)	ND	ND
Asbestos	MFL	7.00	Air Strip. Eff. (B)	-	ND
Asbestos	MFL	7.00	Bioreactor Effluent (G)	-	ND
Barium (Ba) EPA Series 200	ug/L	1,000.00	Air Strip. Infl. (A)	<100.0	<100
Barium (Ba)	ug/L	1,000.00	Air Strip. Eff. (B)		<100
Barium (Ba)	ug/L	1,000.00	Bioreactor Effluent (G)		<100
Beryllium (Be) EPA Series 200	ug/L	4.00	Air Strip. Infl. (A)	<1.0	<1.0
Beryllium (Be)	ug/L	4.00	Air Strip. Eff. (B)		<1.0
Beryllium (Be)	ug/L	4.00	Bioreactor Effluent (G)		<1.0
Cadmium (Cd) EPA Series 200	ug/L	5.00	Air Strip. Infl. (A)	<1.0	<1.0
Cadmium (Cd)	ug/L	5.00	Air Strip. Eff. (B)		<1.0
Cadmium (Cd)	ug/L	5.00	Bioreactor Effluent (G)		<1.0
Chromium (Cr) EPA Series 200	ug/L	50.00	Air Strip. Infl. (A)	<10.0	<10
Chromium (Cr)	ug/L	50.00	Air Strip. Eff. (B)	-	<10
Chromium (Cr)	ug/L	50.00	Bioreactor Effluent (G)	-	<10
Cyanide (CN) Method 4500-CN F	ug/L	200.00	Air Strip. Infl. (A)	<10.0	<10
Cyanide (CN)	ug/L	200.00	Air Strip. Eff. (B)	-	<10
Cyanide (CN)	ug/L	200.00	Bioreactor Effluent (G)	-	<10
Flouride (F)	ug/L	1400-2400	Air Strip. Infl. (A)	0.27	0.25
Flouride (F)	ug/L	1400-2400	Air Strip. Eff. (B)	-	0.27
Flouride (F)	ug/L	1400-2400	Bioreactor Effluent (G)	-	0.22
Lead (Pb) EPA Series 200	ug/L	50.00	Air Strip. Infl. (A)	<5.0	<5
Lead (Pb)	ug/L	50.00	Air Strip. Eff. (B)	-	<5
Lead (Pb)	ug/L	50.00	Bioreactor Effluent (G)	-	<5
Mercury (Hg) EPA Series 200	ug/L	2.00	Air Strip. Infl. (A)	<1.0	<1
Mercury (Hg)	ug/L	2.00	Air Strip. Eff. (B)	-	<1.0
Mercury (Hg)	ug/L	2.00	Bioreactor Effluent (G)	-	<1.0
Nickel (Ni) EPA Series 200	ug/L	100.00	Air Strip. Infl. (A)	<10.0	<10
Nickel (Ni)	ug/L	100.00	Air Strip. Eff. (B)	-	<10
Nickel (Ni)	ug/L	100.00	Bioreactor Effluent (G)	-	<10
Nitrate (as NO3)	ug/L	45,000.00	Air Strip. Infl. (A)	57.0	60.0
Nitrate (as NO3)	ug/L	45,000.00	Air Strip. Eff. (B)	-	<2.0
Nitrate (as NO3)	ug/L	45,000.00	Bioreactor Effluent (G)	-	<2.0
Nitrite (as nitrogen)	ug/L	1,000.00	Air Strip. Infl. (A)	<400	<400
Nitrite (as nitrogen)	ug/L	1,000.00	Air Strip. Eff. (B)	-	<400
Nitrite (as nitrogen)	ug/L	1,000.00	Bioreactor Effluent (G)	-	<400
Selenium (Se) EPA Series 200	ug/L	50.00	Air Strip. Infl. (A)	<5.0	<5
Selenium (Se)	ug/L	50.00	Air Strip. Eff. (B)	-	<5
Selenium (Se)	ug/L	50.00	Bioreactor Effluent (G)	-	<5

Table 4
Phase I Perchlorate Treatability Study
Title 22 Laboratory Analytical Summary

arameter	Units	Maximum Contaminant Level	Sampling Port	Sampled 5/18/98	Sampled 6/15/98
Thallium (Tl) EPA Series 200	ug/L	2.00	Air Strip. Infl. (A)	<1.0	<1
Thallium (Tl)	ug/L	2.00	Air Strip. Eff. (B)	-	<1
Thallium (Tl)	ug/L	2.00	Bioreactor Effluent (G)	-	<1
RADIOACTIVITY					
Gross Alpha	pCi/L	15.00	Air Strip. Infl. (A)	<1	<1
Gross Alpha	pCi/L	15.00	Air Strip. Eff. (B)	-	<1
Gross Alpha	pCi/L	15.00	Bioreactor Effluent (G)	-	<1.0
Gross Beta	pCi/L	50.00	Air Strip. Infl. (A)	<4	<4
Gross Beta	pCi/L	50.00	Air Strip. Eff. (B)	-	<4
Gross Beta	pCi/L	50.00	Bioreactor Effluent (G)	-	<4
Tritium	pCi/L	20,000.00	Air Strip. Infl. (A)	<182	<176
Tritium	pCi/L	20,000.00	Air Strip. Eff. (B)	-	<183
Tritium	pCi/L	20,000.00	Bioreactor Effluent (G)	-	<178
Strontium-90	pCi/L	8.00	Air Strip. Infl. (A)	<0.302	<0.256
Strontium-90	pCi/L	8.00	Air Strip. Eff. (B)	-	<0.256
Strontium-90	pCi/L	8.00	Bioreactor Effluent (G)	-	<0.232
Radium 226	pCi/L	5.00	Air Strip. Infl. (A)	-0.120 +/- 0.41	-0.109 +/- 0.24
Radium 226	pCi/L	5.00	Air Strip. Eff. (B)	-	0.193 +/- 0.19
Radium 226	pCi/L	5.00	Bioreactor Effluent (G)	0.448 +/- 0.36	0.022 +/- 0.17
Radium 228	pCi/L	5.00	Air Strip. Infl. (A)	-0.323 +/- 0.30	0.057 +/- 0.61
Radium 228	pCi/L	5.00	Air Strip. Eff. (B)	-	-0.070 +/- 0.61
Radium 228	pCi/L	5.00	Bioreactor Effluent (G)	-0.146 +/- 0.33	-0.237 +/- 0.49
ranium	pCi/L	20.00	Air Strip. Infl. (A)	<2	<2
Uranium	pCi/L	20.00	Air Strip. Eff. (B)	-	<2
Uranium	pCi/L	20.00	Bioreactor Effluent (G)	-	<2
SECONDARY STANDARDS - Aesthetic standards established by the State of California Department of Health Services					
Turbidity	NTU	5.00	Air Strip. Infl. (A)	<1	<0.1
Turbidity	NTU	5.00	Air Strip. Eff. (B)	-	7.8
Turbidity	NTU	5.00	Bioreactor Effluent (G)	-	7.9
Color	Units	15.00	Air Strip. Infl. (A)	0.00	0.0
Color	Units	15.00	Air Strip. Eff. (B)	-	10.0
Color	Units	15.00	Bioreactor Effluent (G)	-	40.0
Odor-Threshold	TON Units	3.00	Air Strip. Infl. (A)	0.00	0.0
Odor-Threshold	TON Units	3.00	Air Strip. Eff. (B)	-	1.0
Odor-Threshold	TON Units	3.00	Bioreactor Effluent (G)	-	30.0
Silver (Ag) EPA Series 200	ug/L	100.00	Air Strip. Infl. (A)	<10.0	<10
Silver (Ag)	ug/L	100.00	Air Strip. Eff. (B)	-	<10
Silver (Ag)	ug/L		Bioreactor Effluent (G)	-	<10
Chloride	ug/L	500,000.00	Air Strip. Infl. (A)	8.10	8.2
Chloride	ug/L	500,000.00	Air Strip. Eff. (B)	-	8.5
Chloride	ug/L	500,000.00	Bioreactor Effluent (G)	-	8.6
Copper (Cu) EPA Series 200	ug/L	1,000.00	Air Strip. Infl. (A)	<50.0	<50
Copper (Cu)	ug/L	1,000.00	Air Strip. Eff. (B)	-	<50
Copper (Cu)	ug/L	1,000.00	Bioreactor Effluent (G)	-	<50

Table 4
Phase I Perchlorate Treatability Study
Title 22 Laboratory Analytical Summary

arameter	Units	Maximum Contaminant Level	Sampling Port	Sampled 5/18/98	Sampled 6/15/98
Foaming Agents (MBAS)	ug/L	500.00	Air Strip. Infl. (A)	<0.50	<0.50
Foaming Agents	ug/L	500.00	Air Strip. Eff. (B)	-	<0.50
Foaming Agents	ug/L	500.00	Bioreactor Effluent (G)	-	<0.50
Iron (Fe) EPA Series 200	ug/L	300.00	Air Strip. Infl. (A)	<100.0	<100
Iron (Fe)	ug/L	300.00	Air Strip. Eff. (B)	-	<100
Iron (Fe)	ug/L	300.00	Bioreactor Effluent (G)	-	<100
Manganese (Mn) EPA Series 200	ug/L	50.00	Air Strip. Infl. (A)	<10.0	<10
Manganese (Mn) EPA Series 200	ug/L	50.00	Air Strip. Eff. (B)	-	<10
Manganese (Mn) EPA Series 200	ug/L	50.00	Bioreactor Effluent (G)	-	<10
Sulfate	ug/L	500,000.00	Air Strip. Infl. (A)	15.0	15.0
Sulfate	ug/L	500,000.00	Air Strip. Eff. (B)	-	9.3
Sulfate	ug/L	500,000.00	Bioreactor Effluent (G)	-	7.4
Zinc (Zn) EPA Series 200	ug/L	5,000.00	Air Strip. Infl. (A)	<50.0	<50
Zinc (Zn) EPA Series 200	ug/L	5,000.00	Air Strip. Eff. (B)	-	<50
Zinc (Zn) EPA Series 200	ug/L	5,000.00	Bioreactor Effluent (G)	-	<50
Total Dissolved Solids	mg/L	1,000.00	Air Strip. Infl. (A)	280.0	250.0
Total Dissolved Solids	mg/L	1,000.00	Air Strip. Eff. (B)	-	230.0
Total Dissolved Solids	mg/L	1,000.00	Bioreactor Effluent (G)	-	250.0
ADDITIONAL CONSTITUENTS ANALYZED					
pH	Units	6.5-8.5	Air Strip. Infl. (A)	7.2	7.3
pH	Units	6.5-8.5	Air Strip. Eff. (B)	-	8.2
pH	Units	6.5-8.5	Bioreactor Effluent (G)	-	8.0
iardness as CaCO3	mg/L	No Standard	Air Strip. Infl. (A)	100.0	120.0
Hardness as CaCO3	mg/L	No Standard	Air Strip. Eff. (B)	-	120.0
Hardness as CaCO3	mg/L	No Standard	Bioreactor Effluent (G)	-	120.0
Sodium (Na)	mg/L	No Standard	Air Strip. Infl. (A)	37.0	36.0
Sodium (Na)	mg/L	No Standard	Air Strip. Eff. (B)	-	35.0
Sodium (Na)	mg/L	No Standard	Bioreactor Effluent (G)	-	35.0
Calcium (Ca)	mg/L	No Standard	Air Strip. Infl. (A)	24.0	24.0
Calcium (Ca)	mg/L	No Standard	Air Strip. Eff. (B)	-	24.0
Calcium (Ca)	mg/L	No Standard	Bioreactor Effluent (G)	-	24.0
Potassium (K)	mg/L	No Standard	Air Strip. Infl. (A)	1.4	1.5
Potassium (K)	mg/L	No Standard	Air Strip. Eff. (B)	-	1.2
Potassium (K)	mg/L	No Standard	Bioreactor Effluent (G)	-	1.2
Magnesium (Mg)	mg/L	No Standard	Air Strip. Infl. (A)	13.0	14.0
Magnesium (Mg)	mg/L	No Standard	Air Strip. Eff. (B)	-	14.0
Magnesium (Mg)	mg/L	No Standard	Bioreactor Effluent (G)	-	14.0

*Fecal Coliform, Coliform, and Bacteria were not tested on 5/18/98 and 6/15/98. Laboratory analyses for these parameters were performed previously and are presented in Appendix D (Laboratory Analytical Data Summary).

CHEMICAL SYNONYMS

1,1- Dichloroethene	=	1,1- Dichloroethylene
Tetrachloroethene	=	Tetrachloroethylene
Trichloroethene	=	Trichloroethylene
Cis-1,2- Dichloroethene	=	Cis-1,2- Dichloroethylene
Trans-1,2- Dichloroethene	=	Trans-1,2- Dichloroethylene
is(2-ethylhexyl)phthalate	=	Di(2-ethylhexyl)phthalate

PLATES

R14 PLOT 1 = 1 TO 4MV H:\DT\39860\355\PHS1-2

CONFIDENTIAL
BUSINESS
INFORMATION

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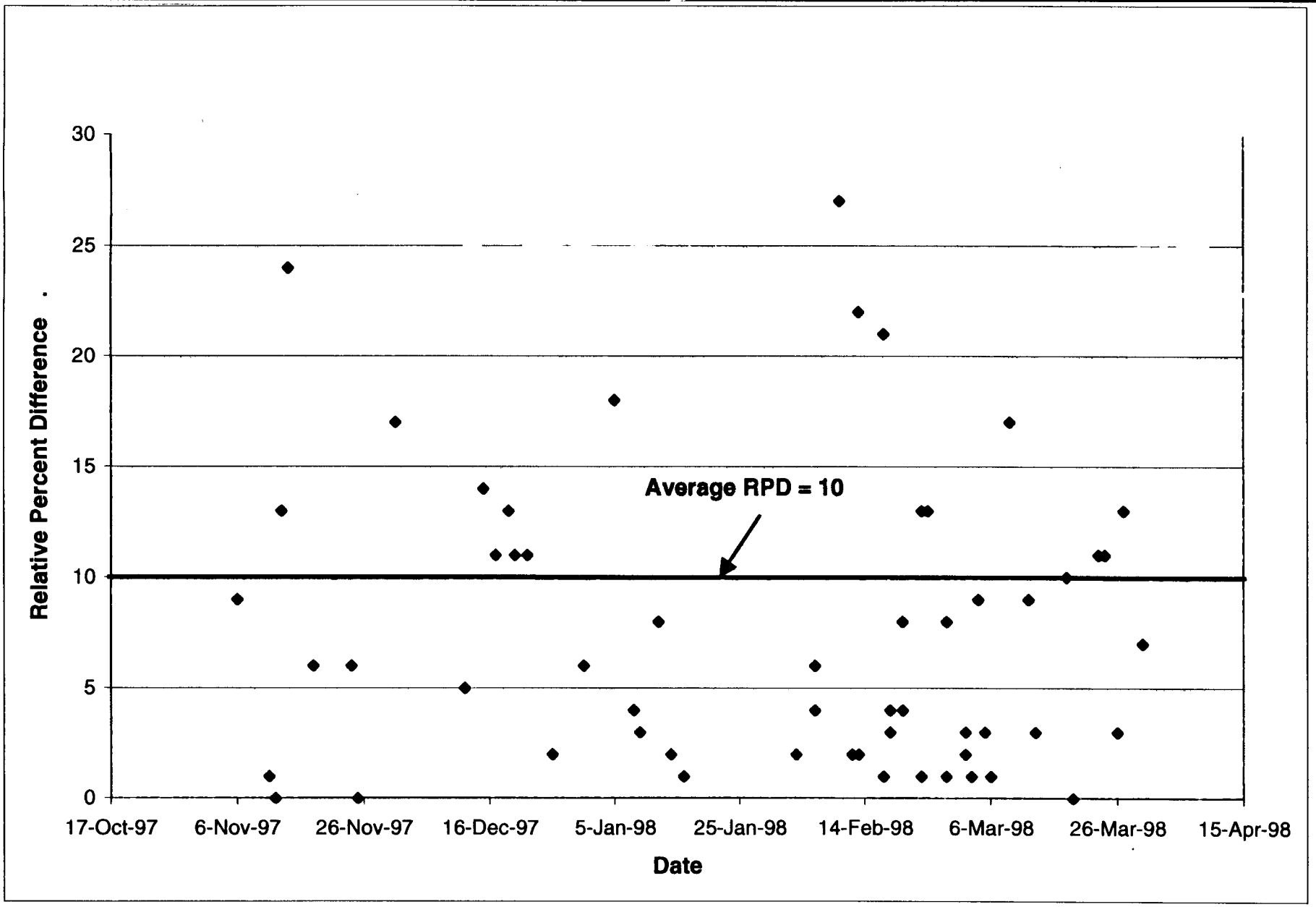
GAC/FB SYSTEM GENERAL ARRANGEMENT
Phase I Perchlorate Treatability Study

PLATE
1

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
KJT/JTL	39860-355		5/98	



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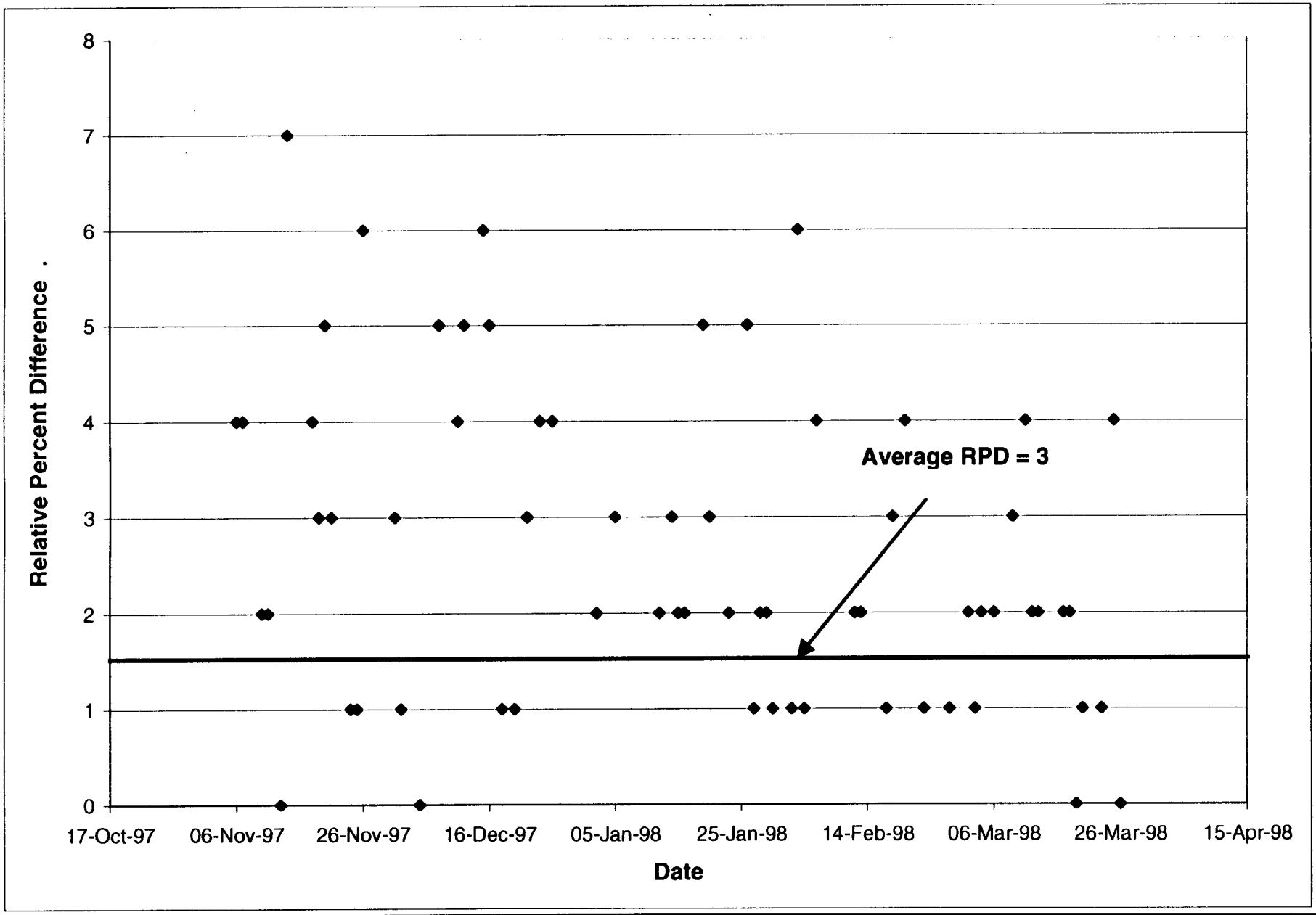
ANALYTICAL ERROR SUMMARY
PERCHLORATE
Phase I Perchlorate Treatability Study

PLATE
2

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



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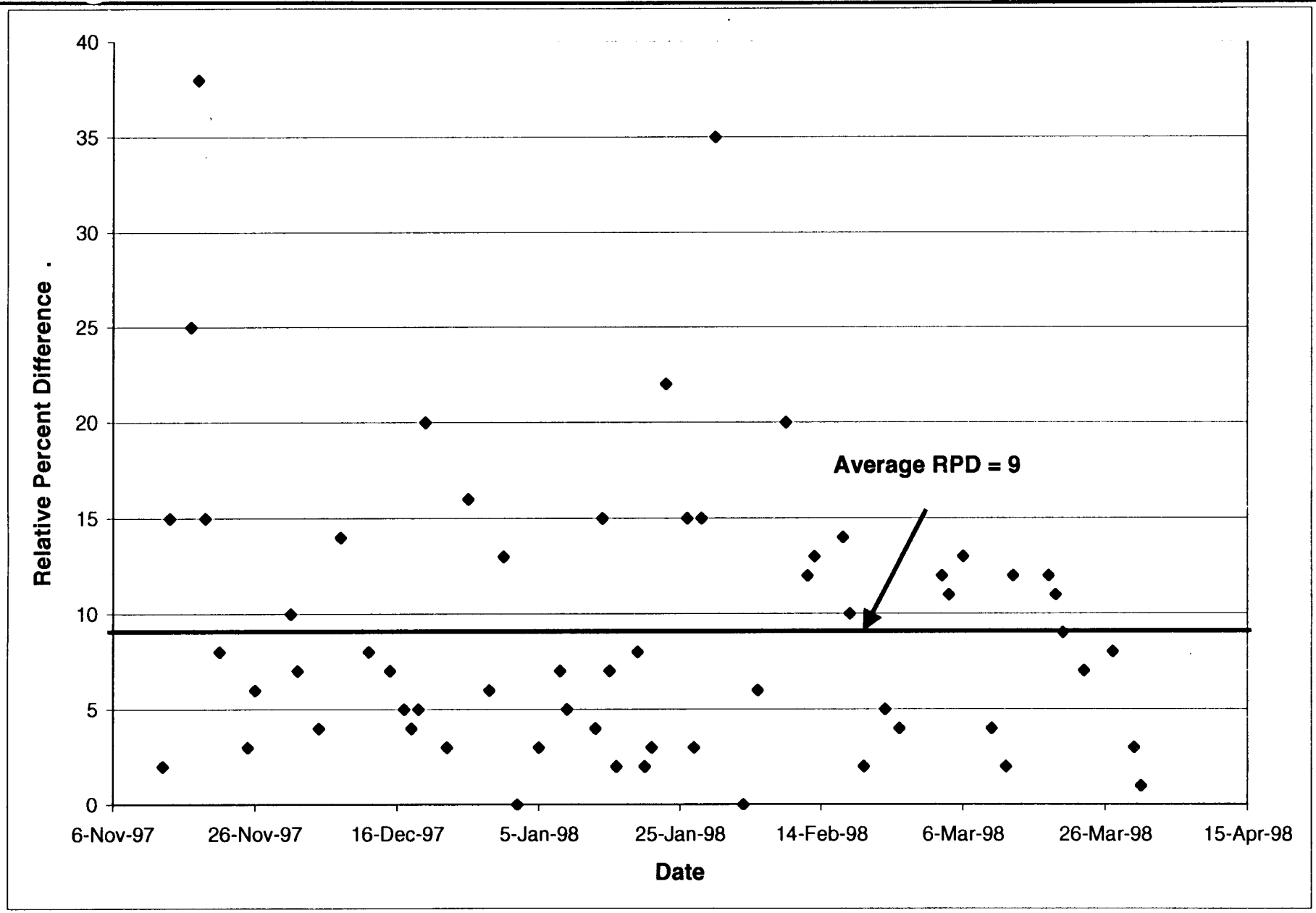
ANALYTICAL ERROR SUMMARY
NITRATE
Phase I Perchlorate Treatability Study

PLATE
3

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



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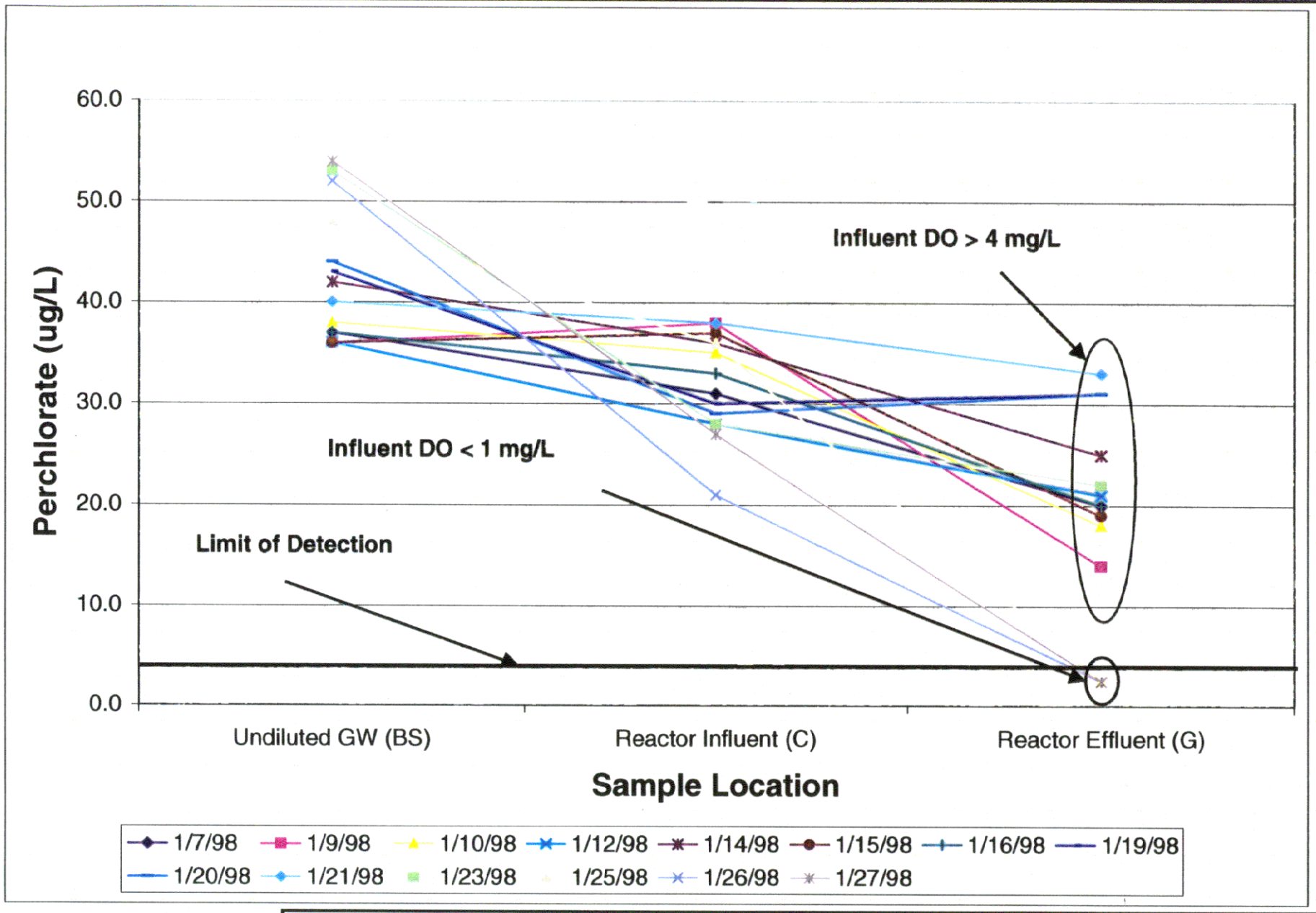
ANALYTICAL ERROR SUMMARY
ETHANOL
Phase I Perchlorate Treatability Study

PLATE
4

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



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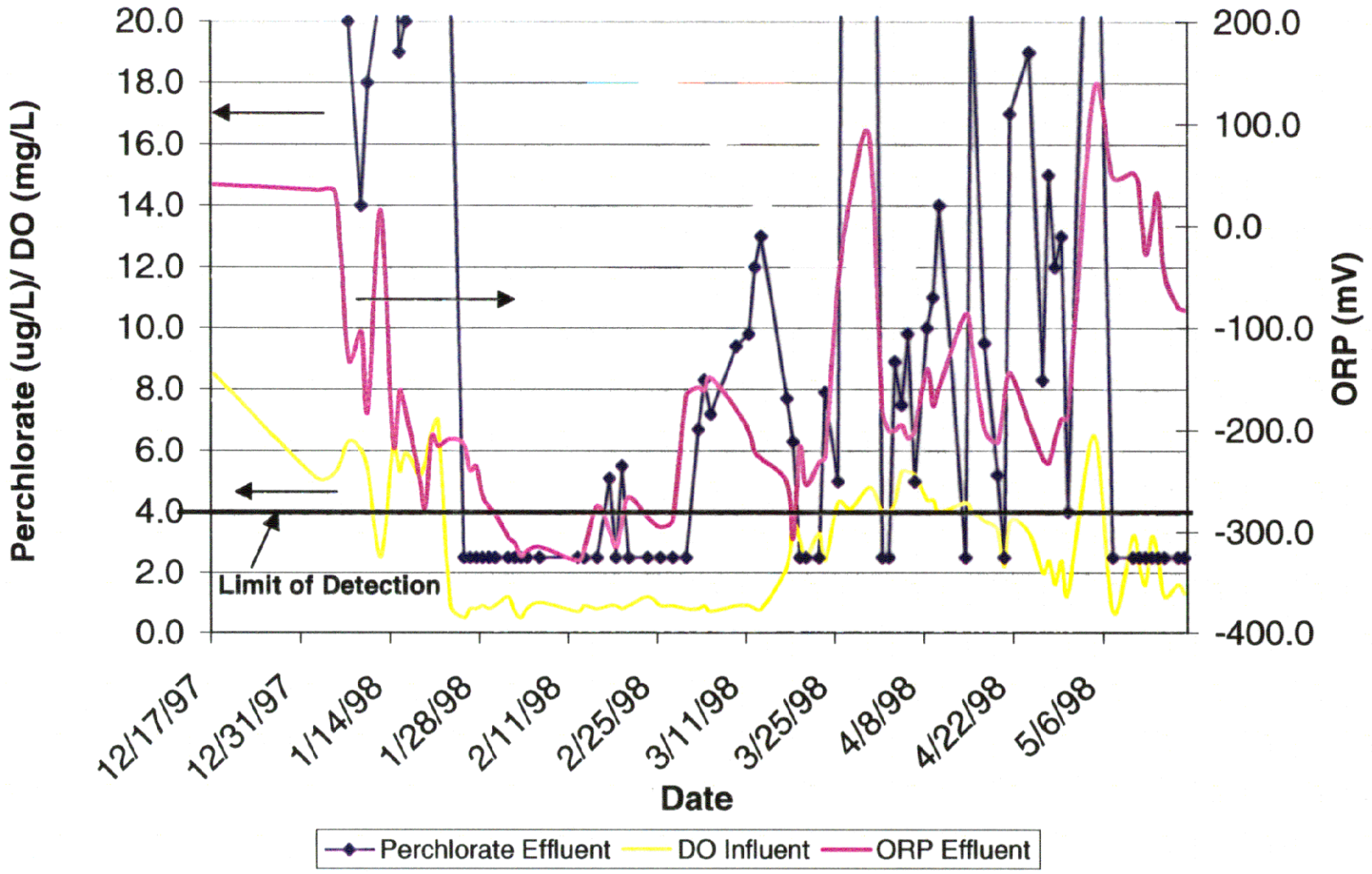
PERCHLORATE REDUCTION ACROSS THE BIOREACTOR
INFLUENCE OF DO 5.4 MINUTE EFFECTIVE RESIDENCE TIME
INCOMPLETE DESTRUCTION WITH DO > 4 mg/L
Phase I Perchlorate Treatability Study

PLATE **5**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



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PERCHLORATE REDUCTION
EFFECT OF DO AND ORP
Phase I Perchlorate Treatability Study

PLATE
6

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	

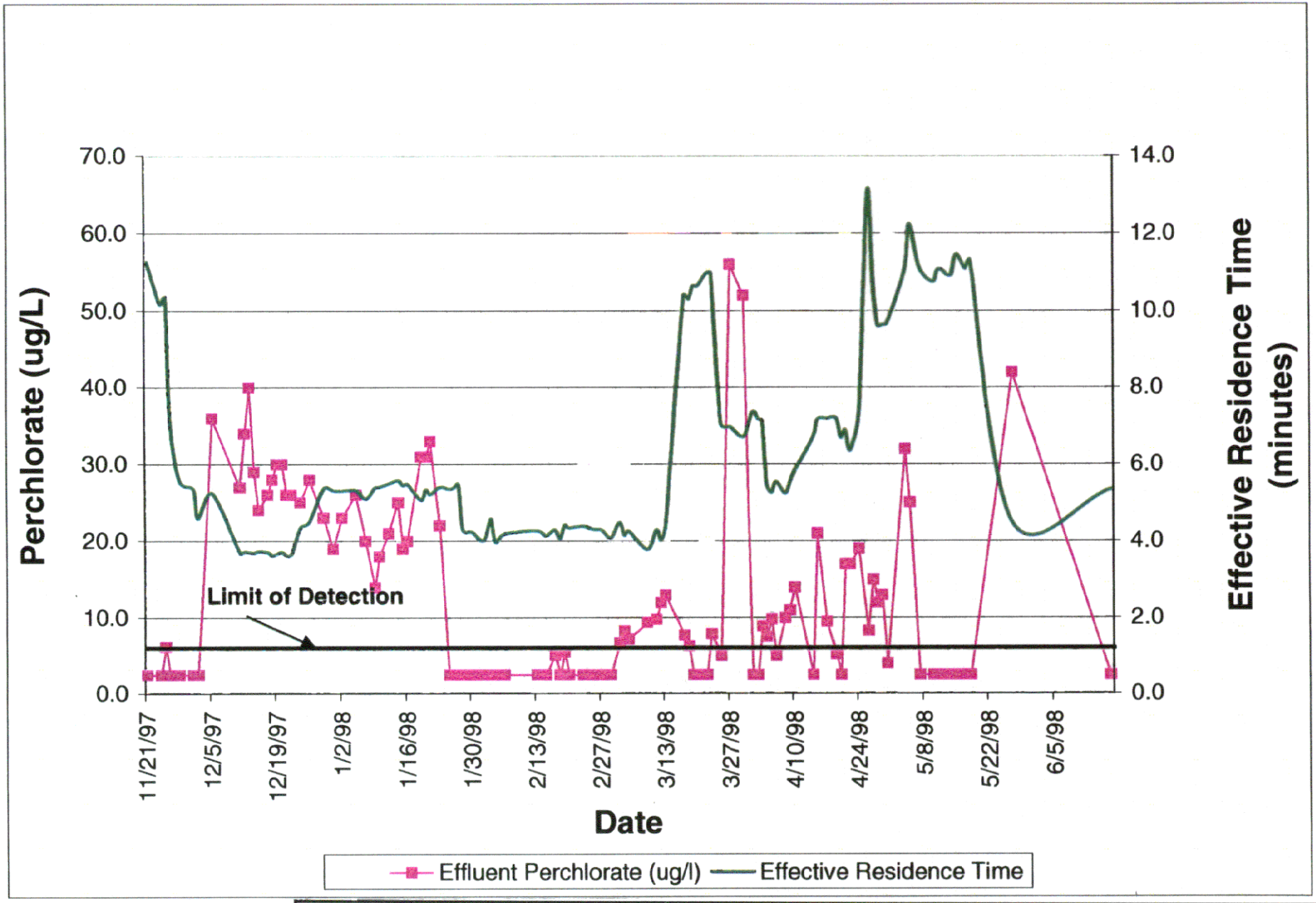

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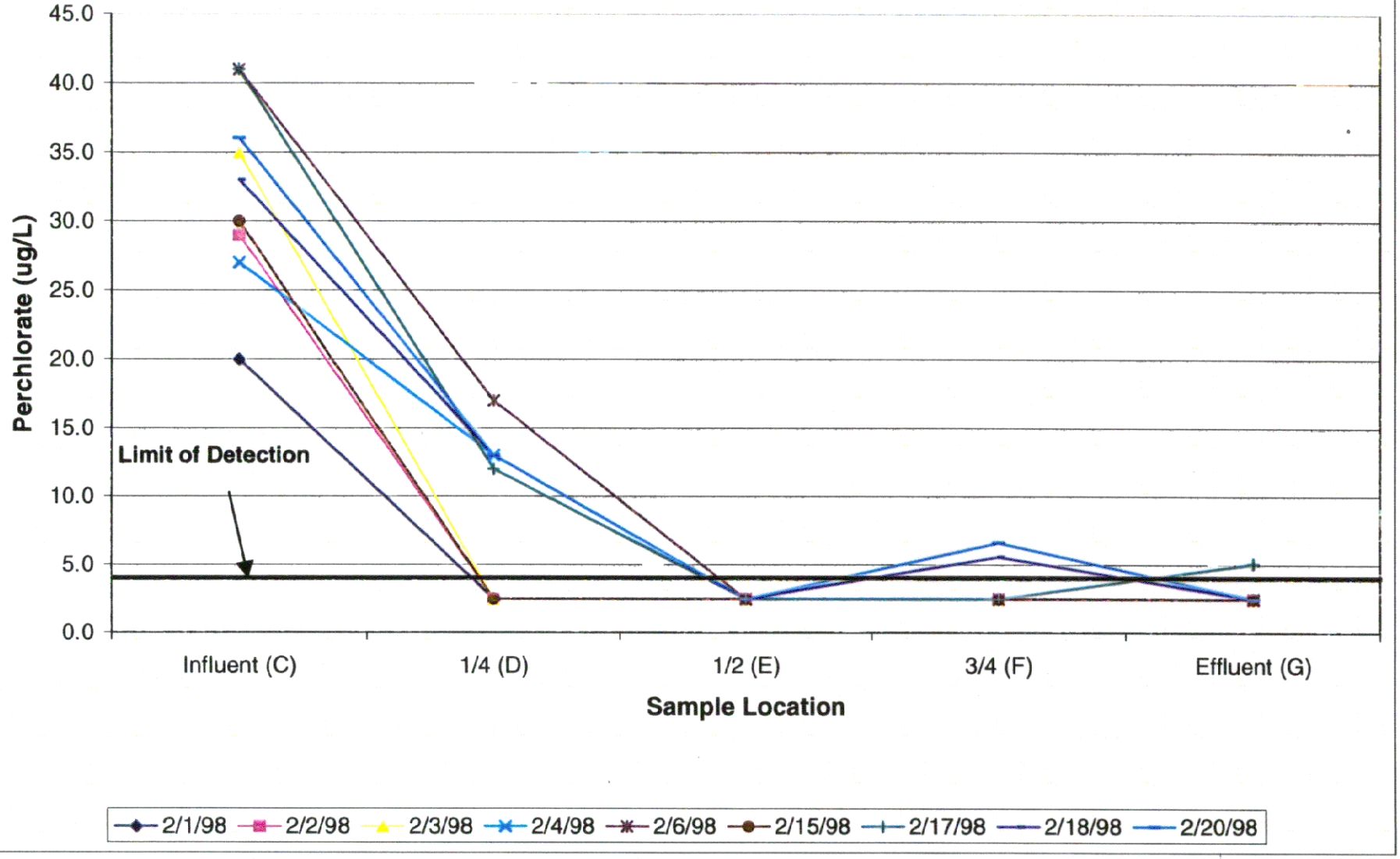
PLATE **7**

PERCHLORATE REDUCTION vs. EFFECTIVE RESIDENCE TIME VARIOUS BIOREACTOR CONDITONS
Phase I Perchlorate Treatability Study

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



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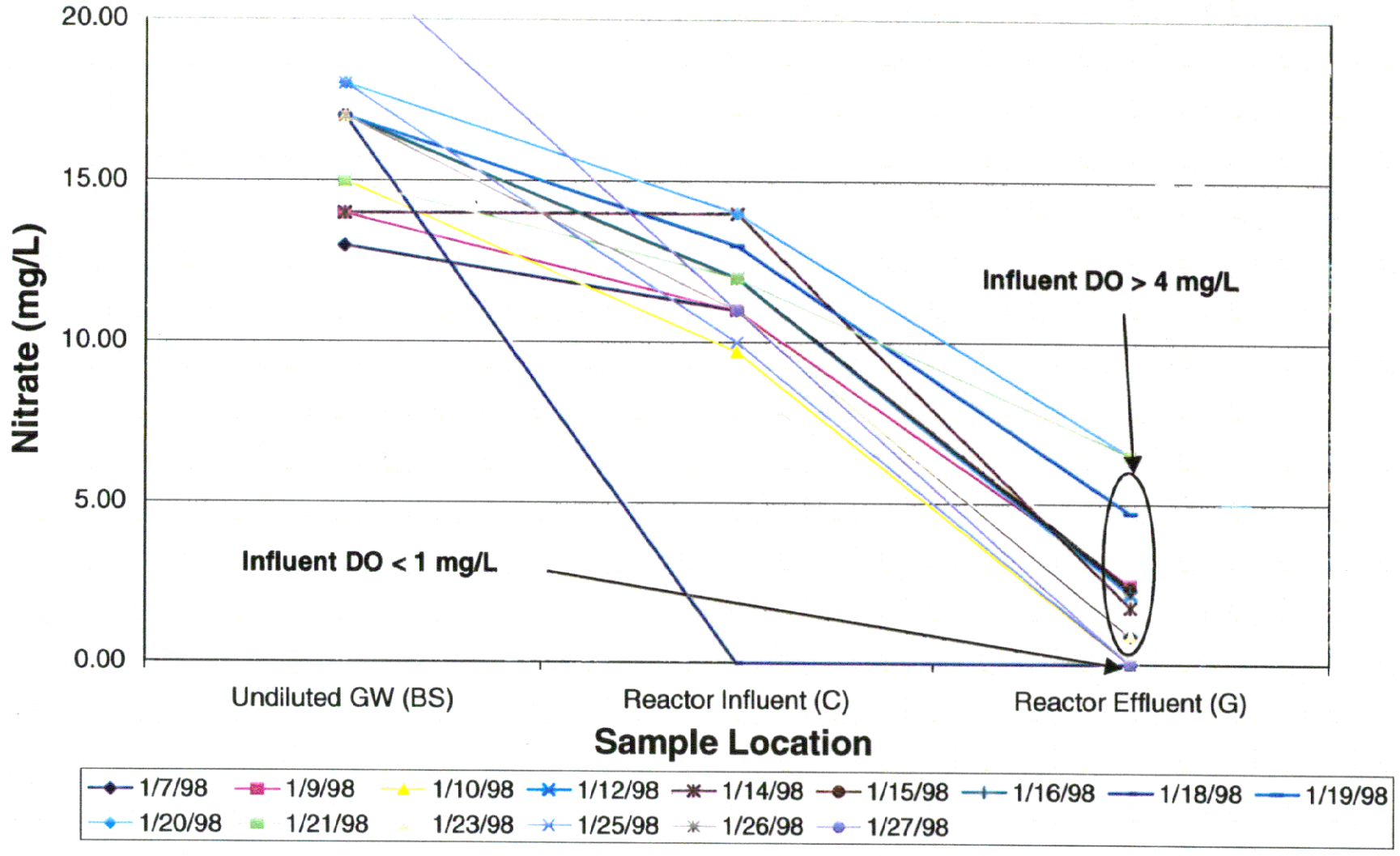
PERCHLORATE BIOREACTOR PROFILES
INFLUENT DO < 1 mg/L
5.4 MINUTE EFFECTIVE RESIDENCE TIME
Phase I Perchlorate Treatability Study

PLATE **8**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



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NITRATE REDUCTION ACROSS THE BIOREACTOR
INFLUENCE OF DO & 4 MINUTE EFFECTIVE RESIDENCE TIME
PARTIAL DESTRUCTION WITH DO > 4 mg/L
Phase I Perchlorate Treatability Study

PLATE **9**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
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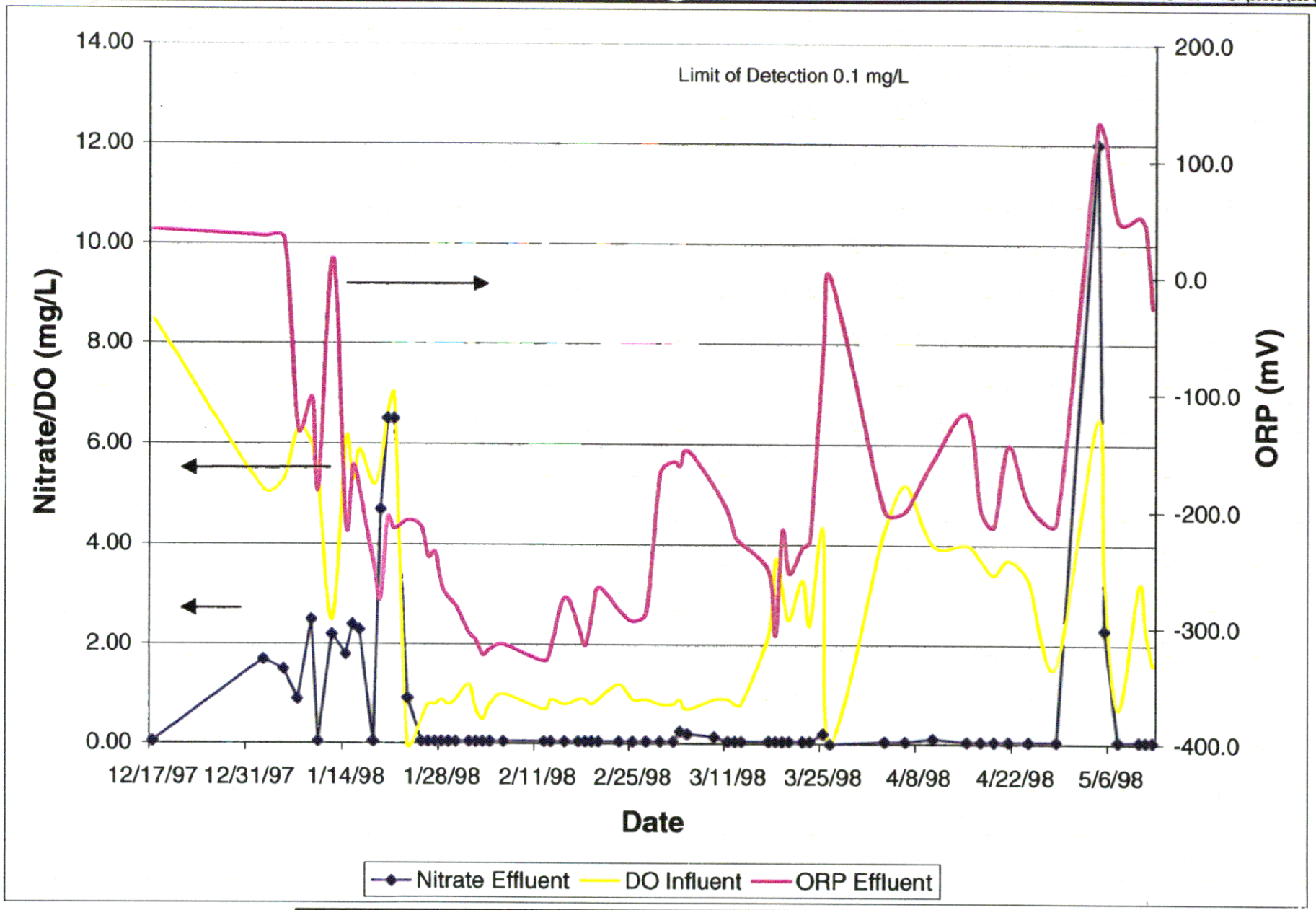

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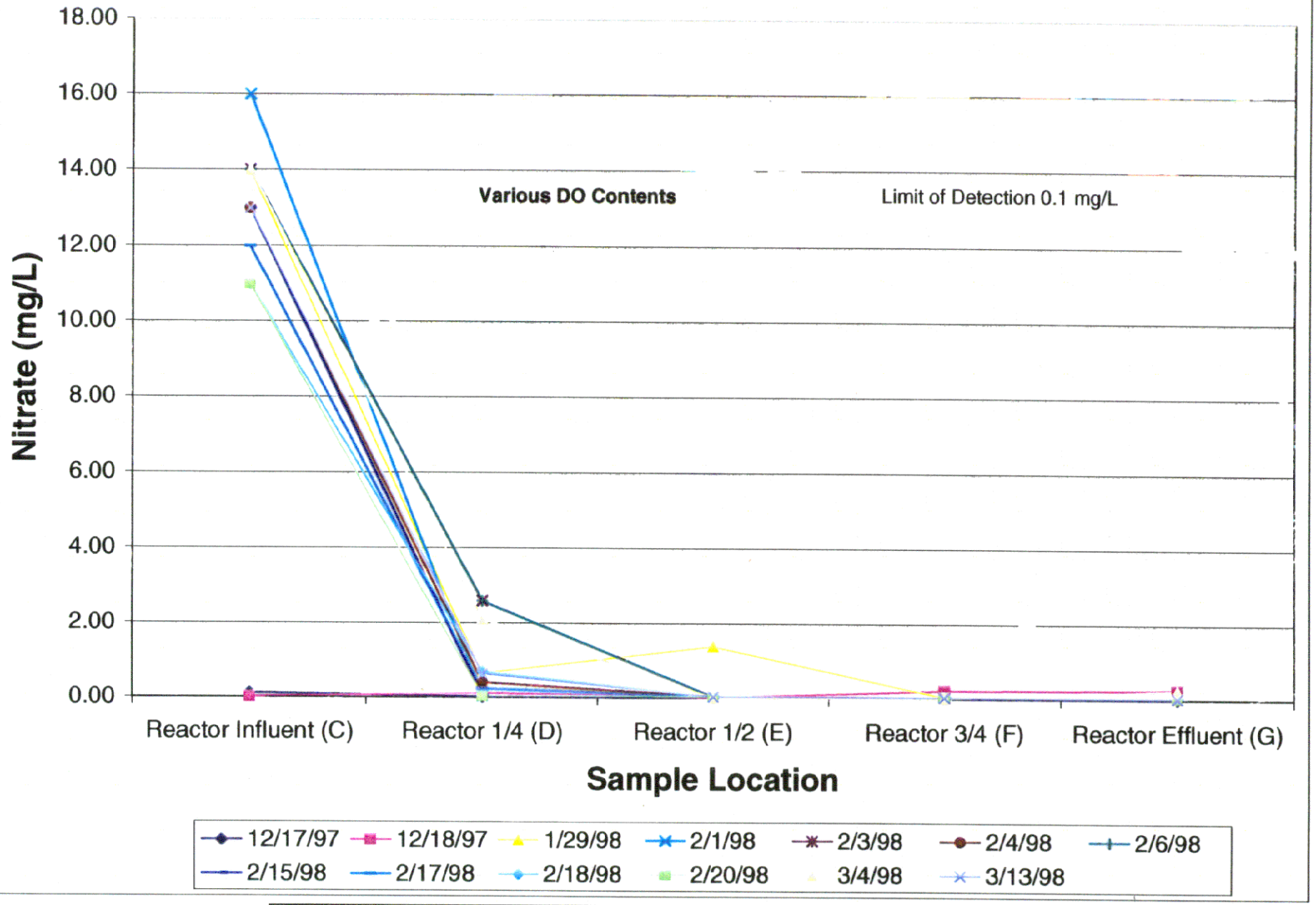
NITRATE REDUCTION
EFFECT OF DO AND ORP
Phase I Perchlorate Treatability Study

PLATE **10**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



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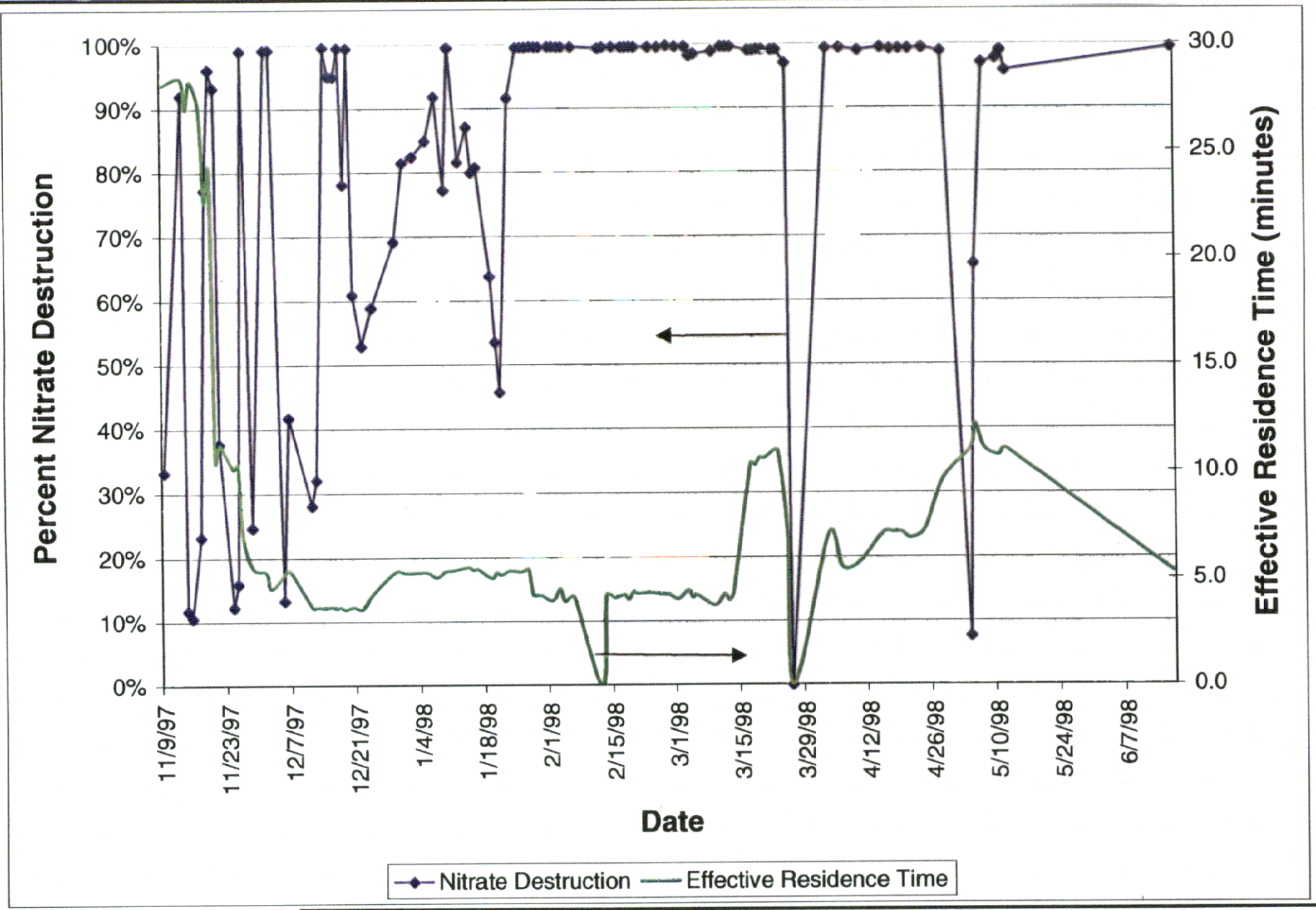
NITRATE BIOREACTOR PROFILES
VARIOUS BIOREACTOR CONDITIONS
Phase I Perchlorate Treatability Study

PLATE **11**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



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NITRATE DESTRUCTION
EFFECT OF RESIDENCE TIME
Phase I Perchlorate Treatability Study

PLATE **12**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
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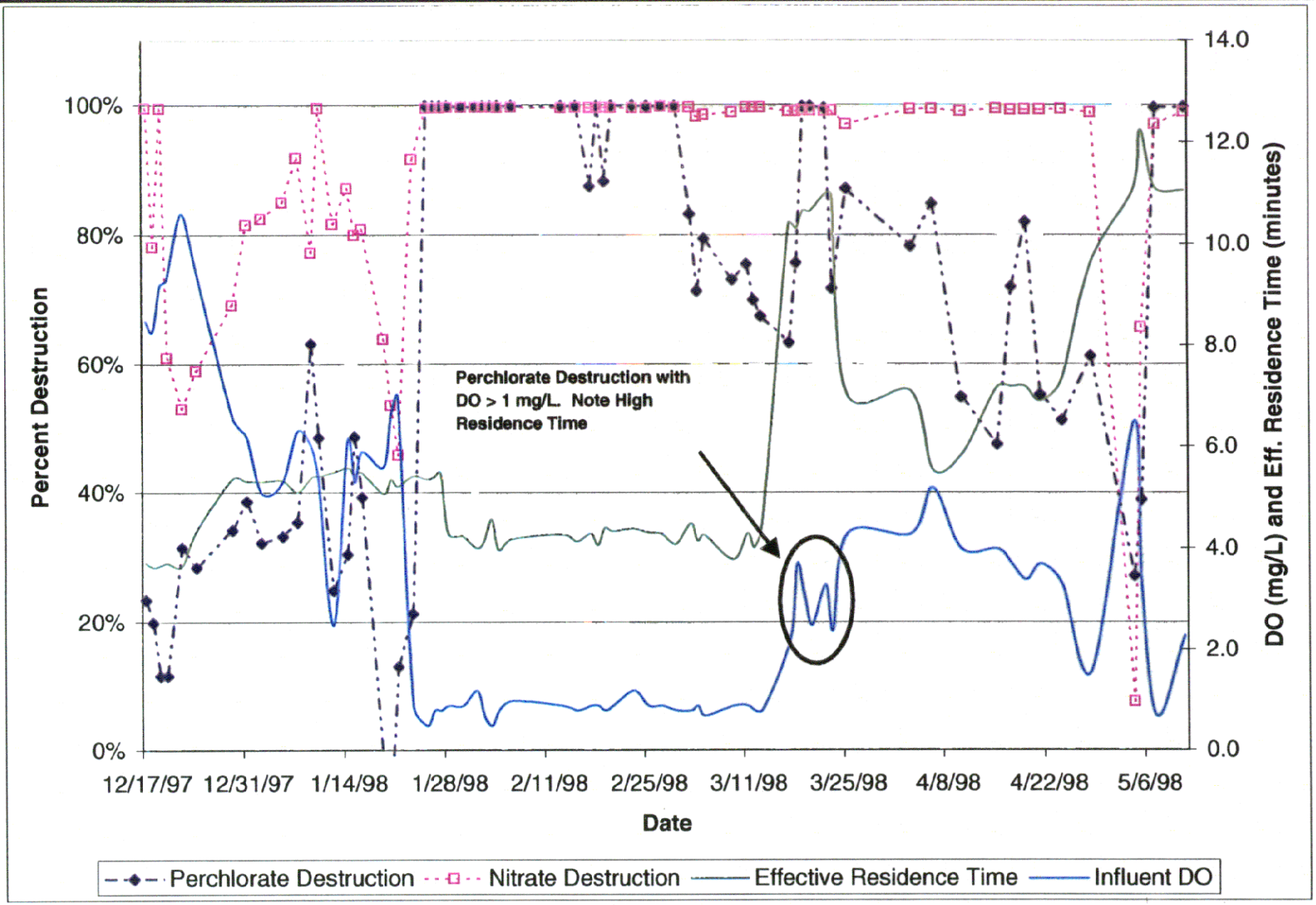

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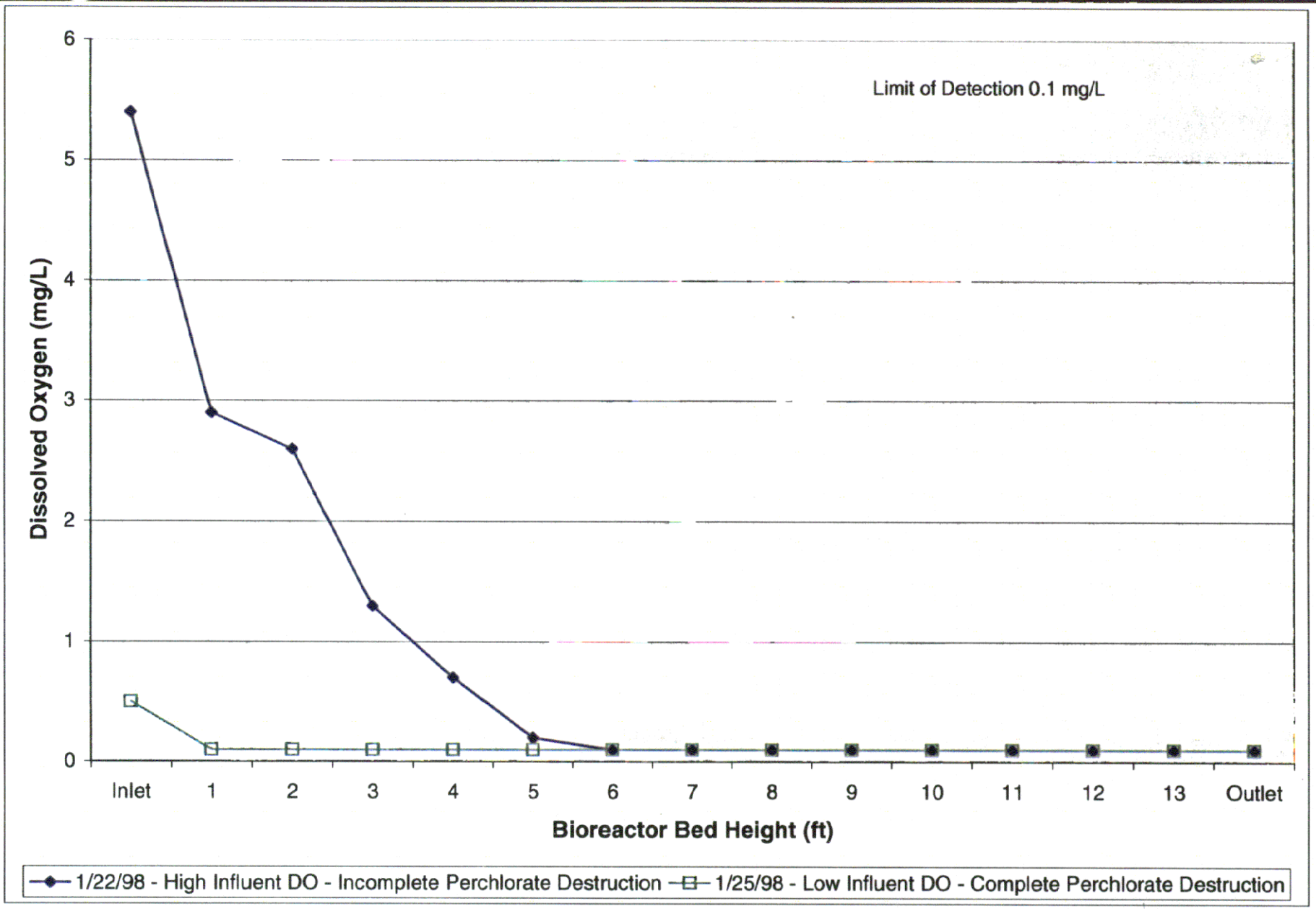
PERCHLORATE AND NITRATE DESTRUCTION EFFECT OF DO AND RESIDENCE TIME
Phase I Perchlorate Treatability Study

PLATE **13**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



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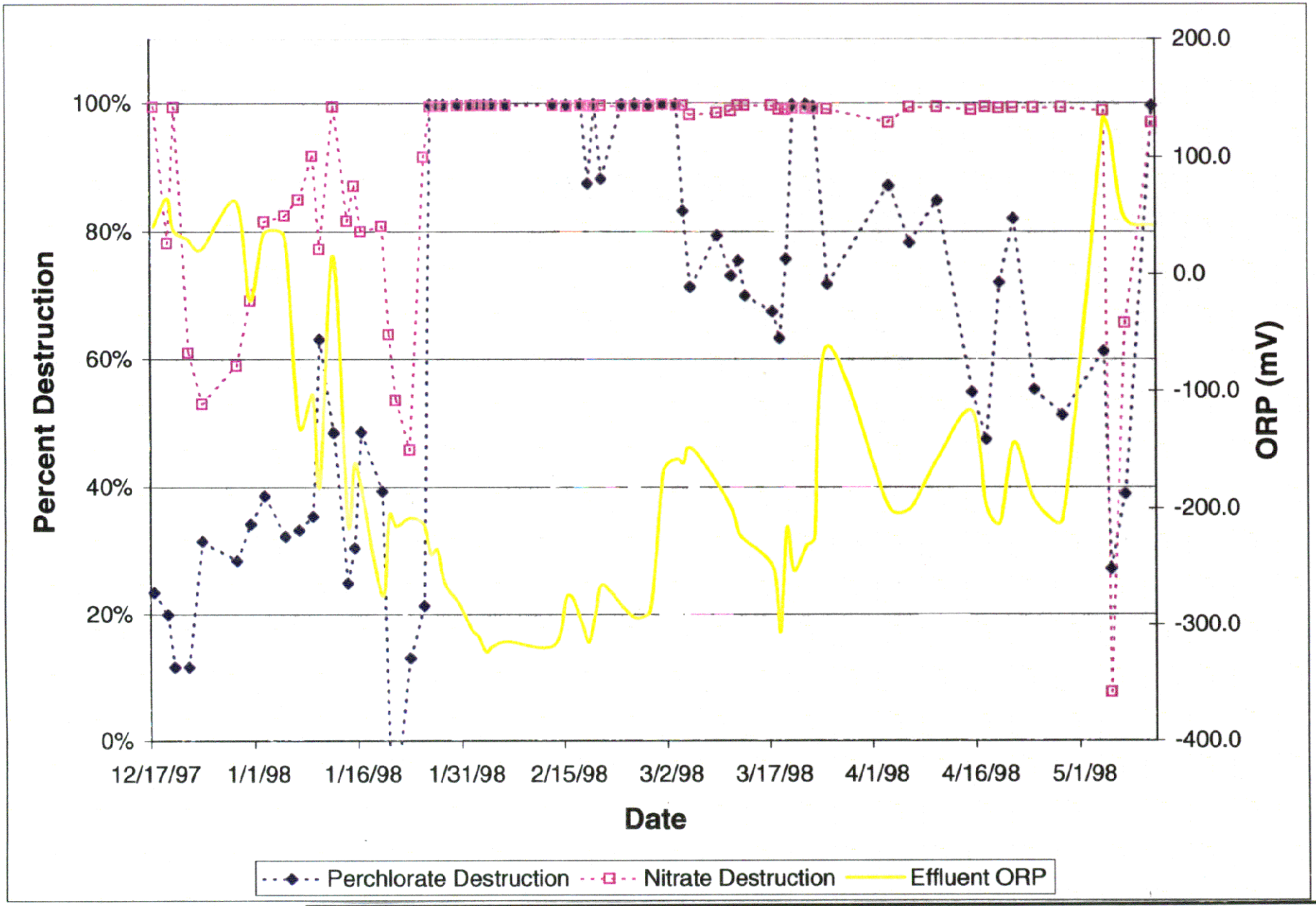
DISSOLVED OXYGEN BIOREACTOR PROFILES
INCOMPLETE/COMPLETE PERCHLORATE DESTRUCTION
Phase I Perchlorate Treatability Study

PLATE **14**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



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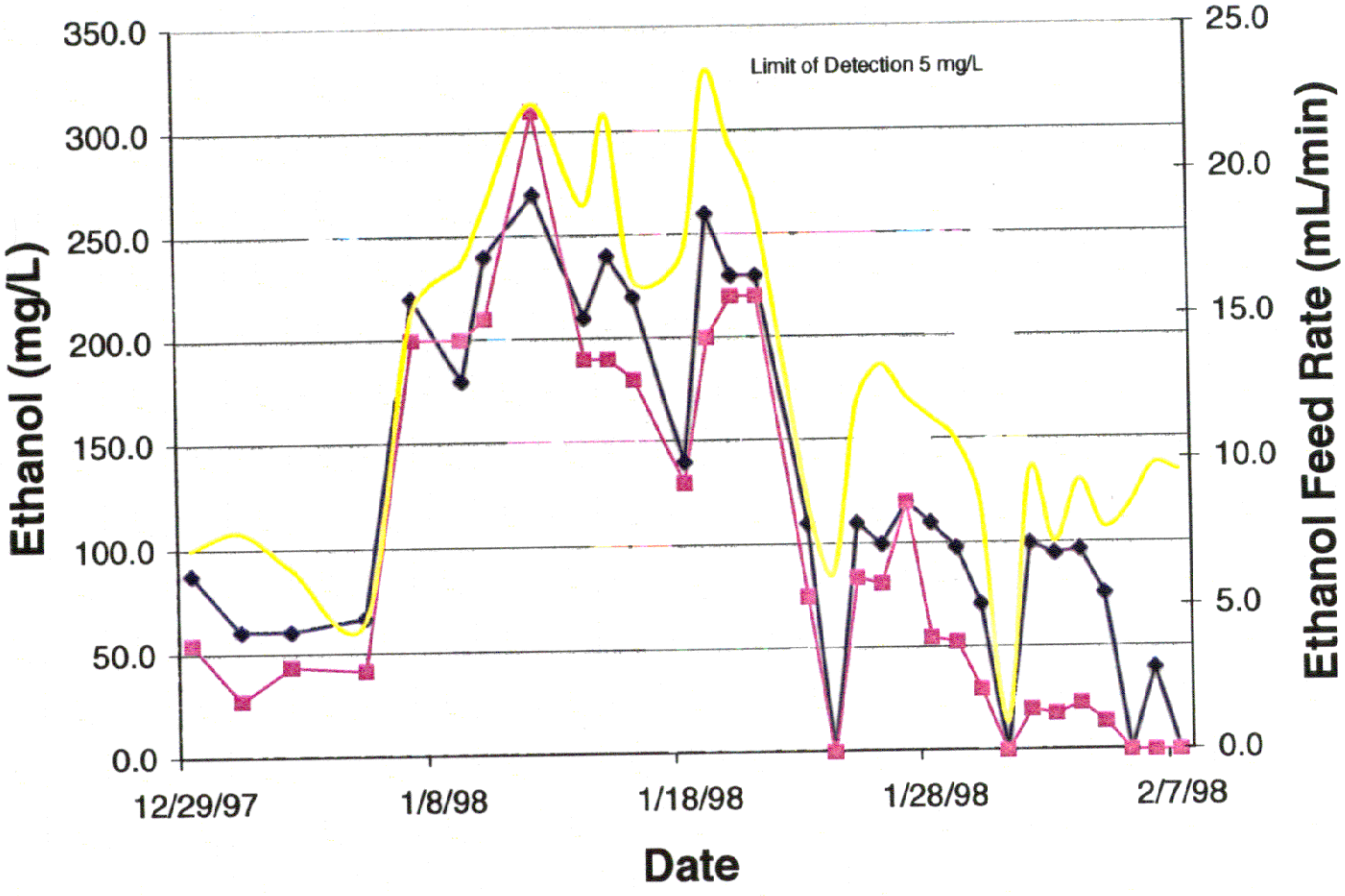
PERCHLORATE AND NITRATE DESTRUCTION EFFECT OF ORP
Phase I Perchlorate Treatability Study

PLATE **15**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



PLATE

16

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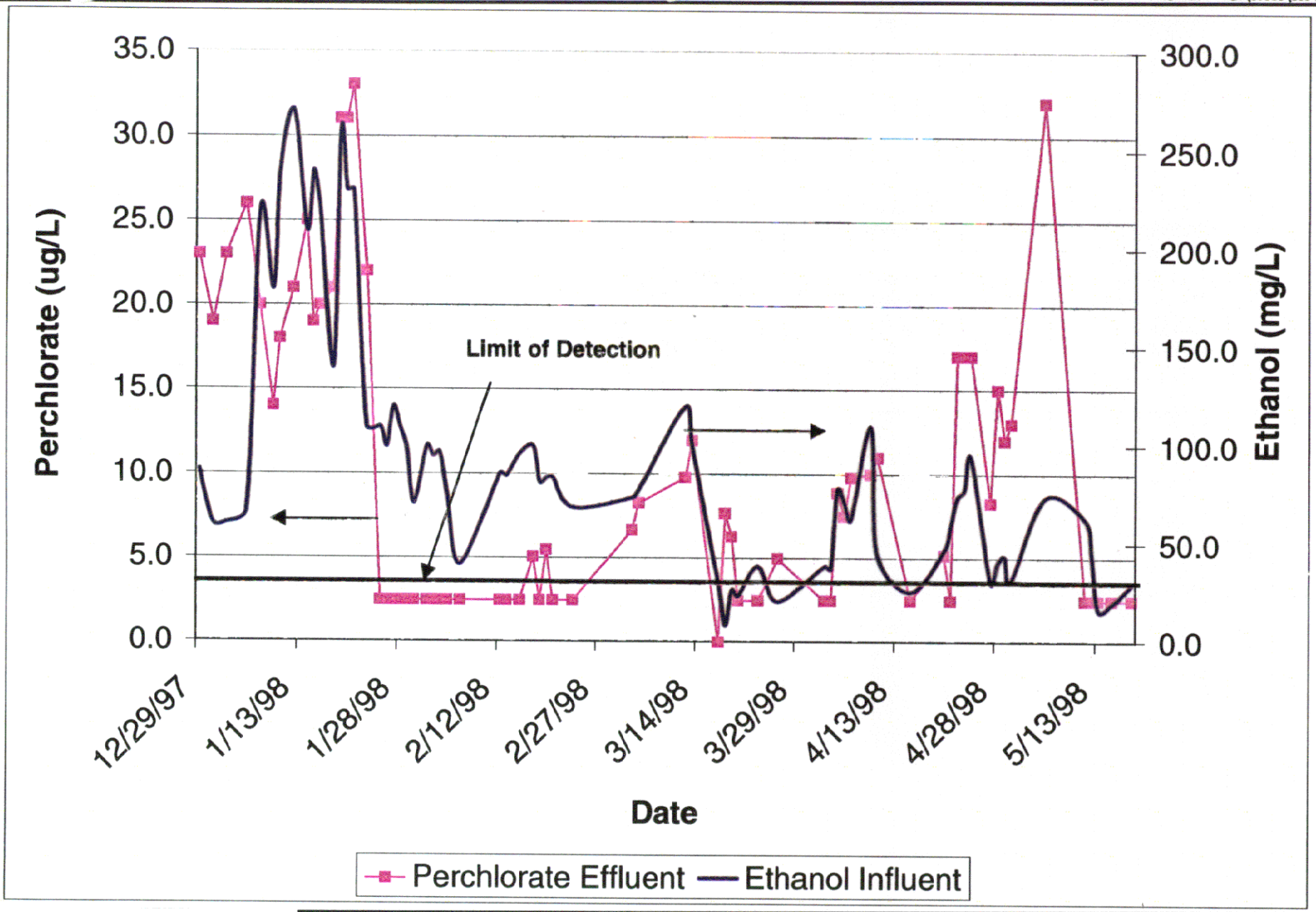
LINEARITY OF ETHONAL ADDITION
Phase I Perchlorate Treatability Study

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	

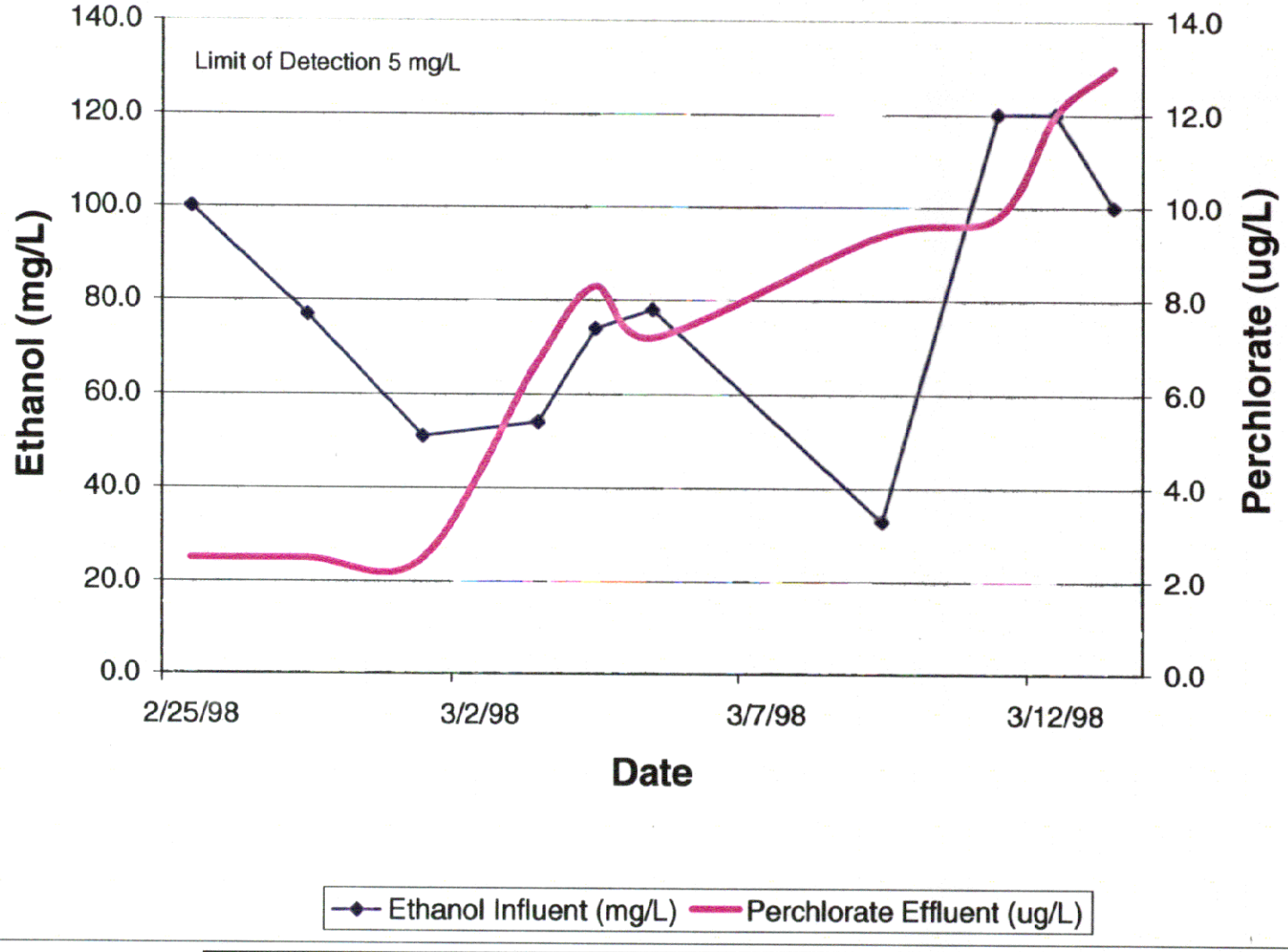


Harding Lawson Associates
Engineering and Environmental Services

PERCHLORATE EFFLUENT vs. ETHANOL INFLUENT
Phase I Perchlorate Treatability Study

PLATE **17**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	

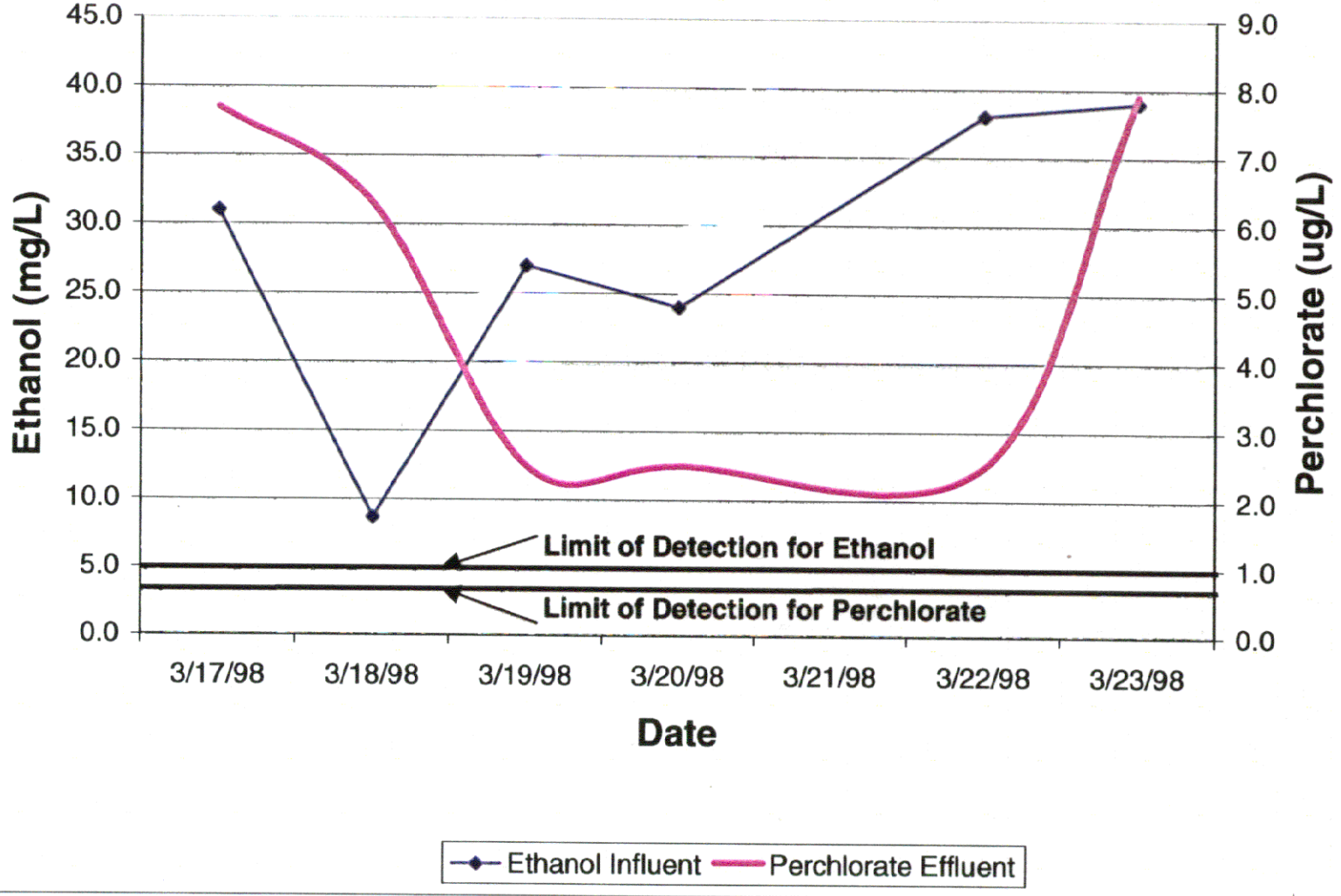


Harding Lawson Associates
Engineering and Environmental Services

ETHANOL INFLUENT
4.3 MINUTE EFFECTIVE RESIDENCE TIME
Phase I Perchlorate Treatability Study

PLATE **18**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	

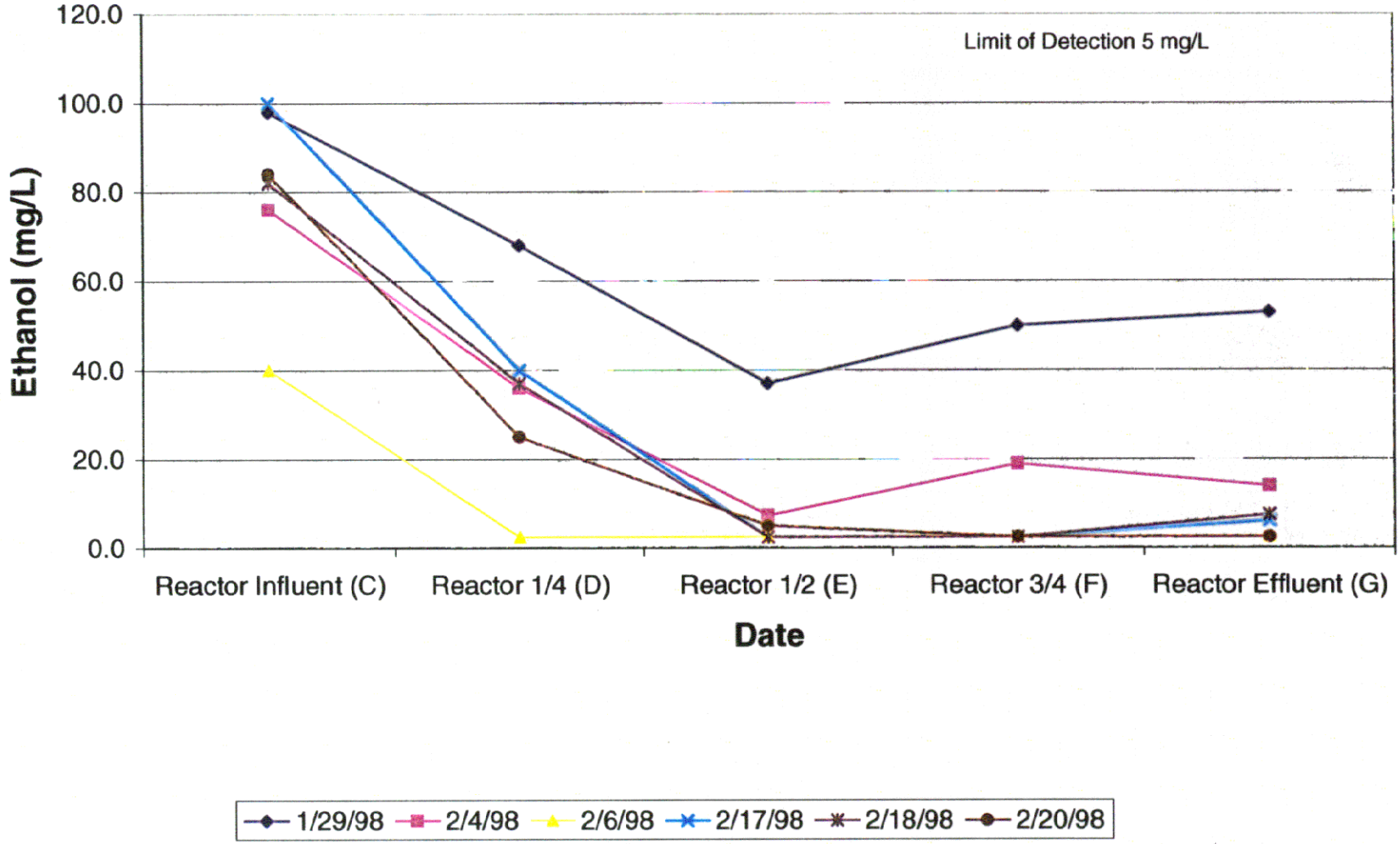


Harding Lawson Associates
Engineering and Environmental Services

ETHANOL INFLUENT
10.8 MINUTE EFFECTIVE RESIDENCE TIME
Phase I Perchlorate Treatability Study

PLATE **19**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	

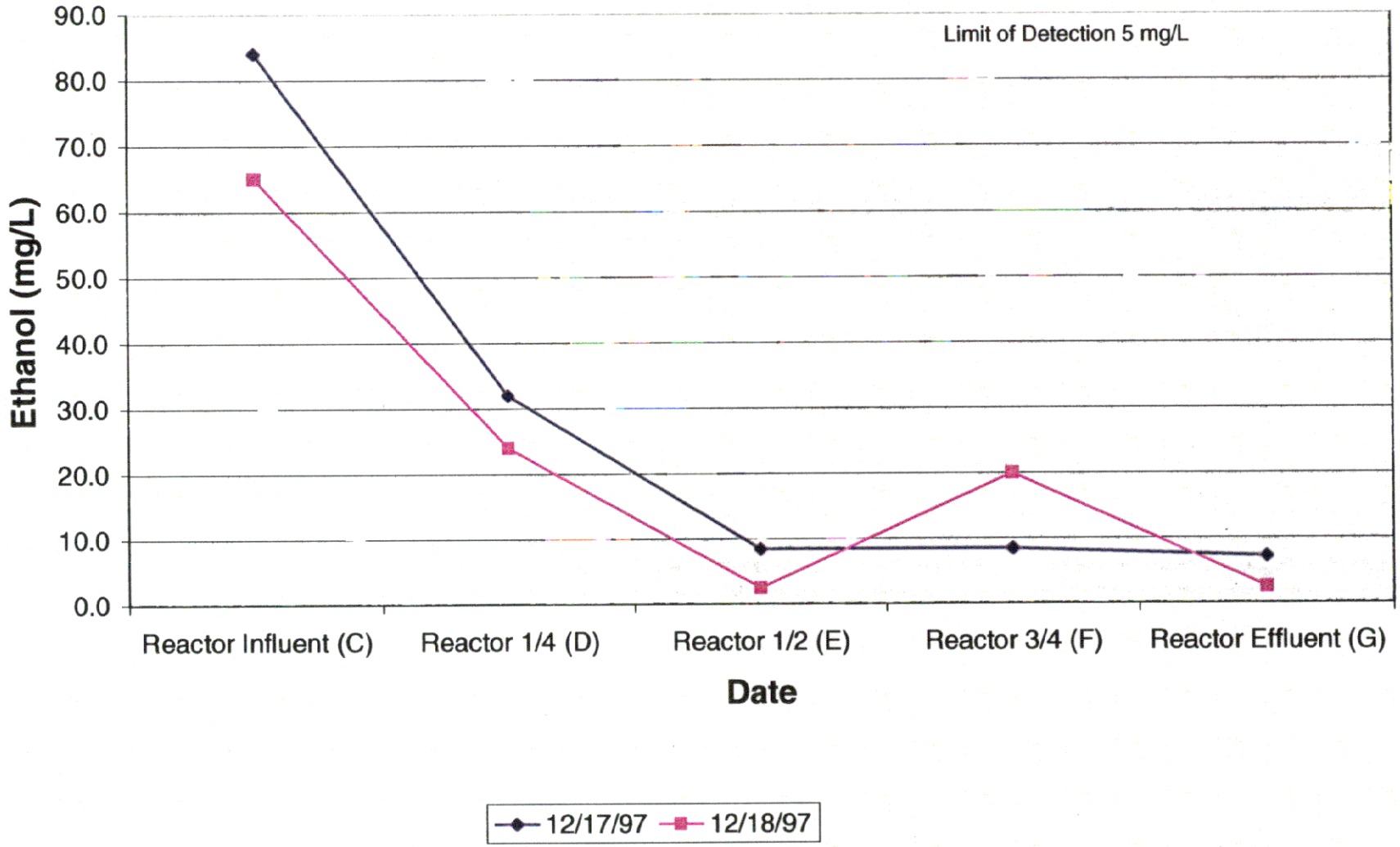


Harding Lawson Associates
Engineering and Environmental Services

ETHANOL BIOREACTOR PROFILES
DO < 1 mg/L
Phase I Perchlorate Treatability Study

PLATE **20**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



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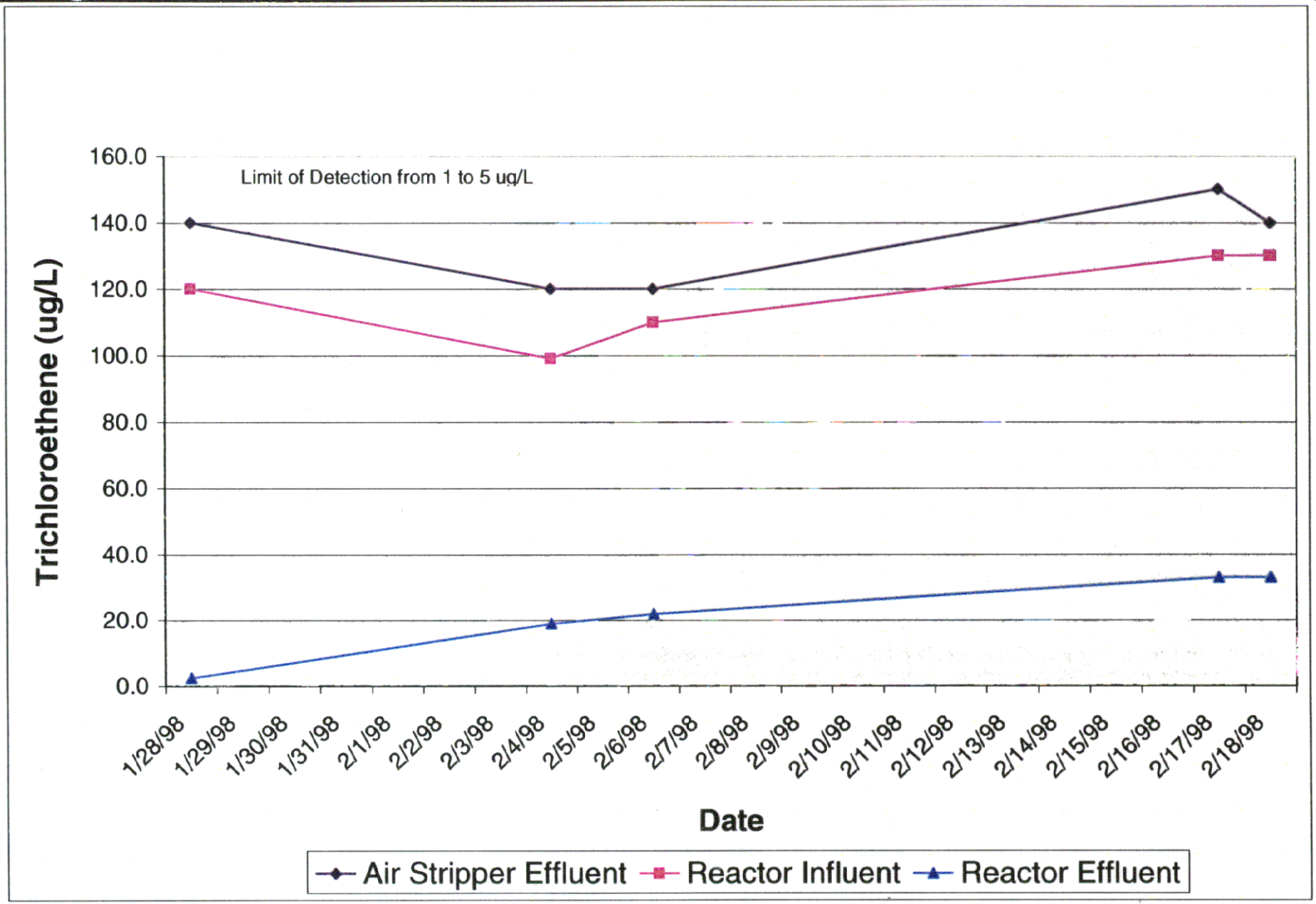
Engineering and Environmental Services

ETHANOL BIOREACTOR PROFILES
DO > 1 mg/L
Phase I Perchlorate Treatability Study

PLATE **21**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



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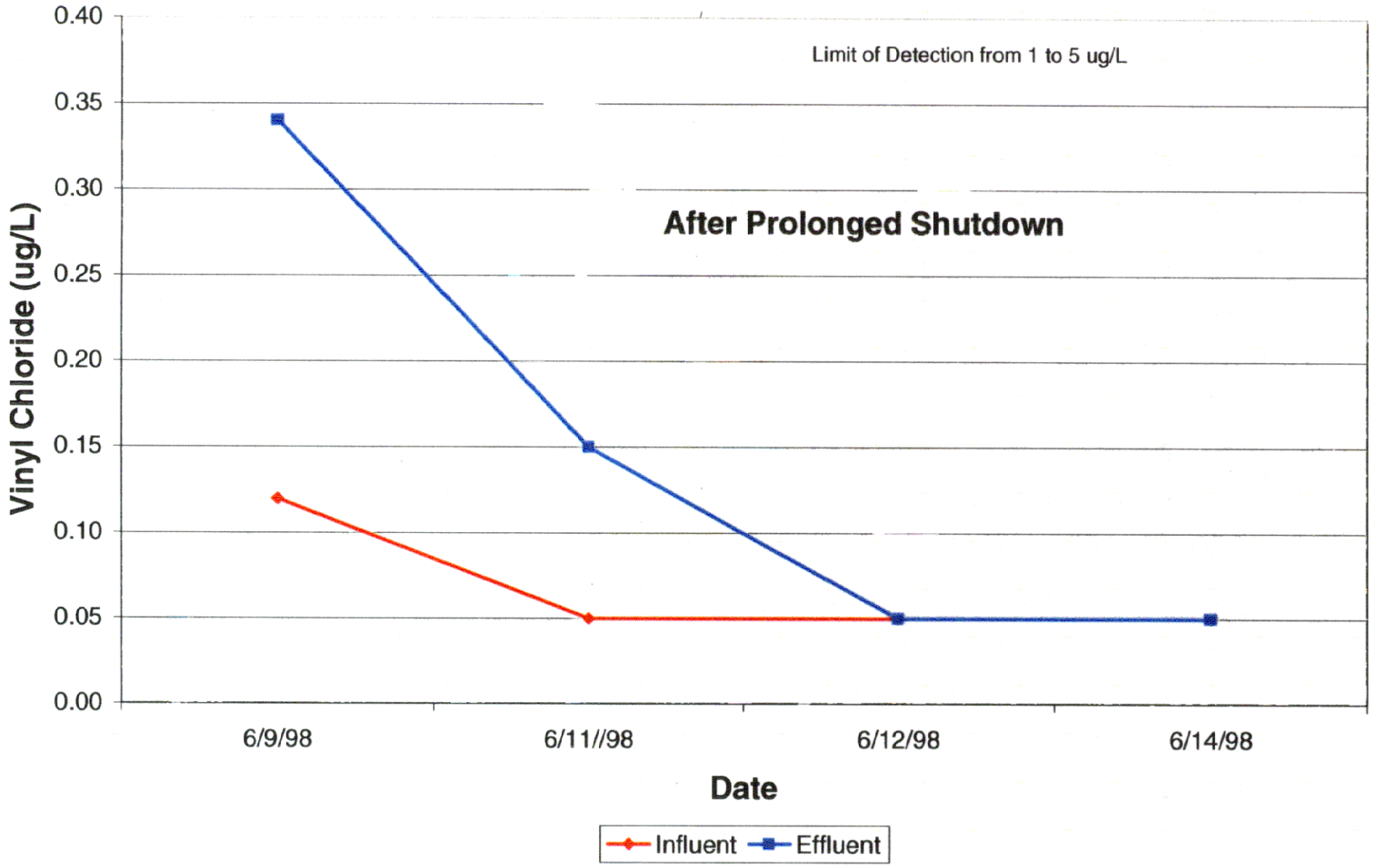
Engineering and Environmental Services

TRICHLOROETHENE ACROSS THE BIOREACTOR
Phase I Perchlorate Treatability Study

PLATE
22

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	

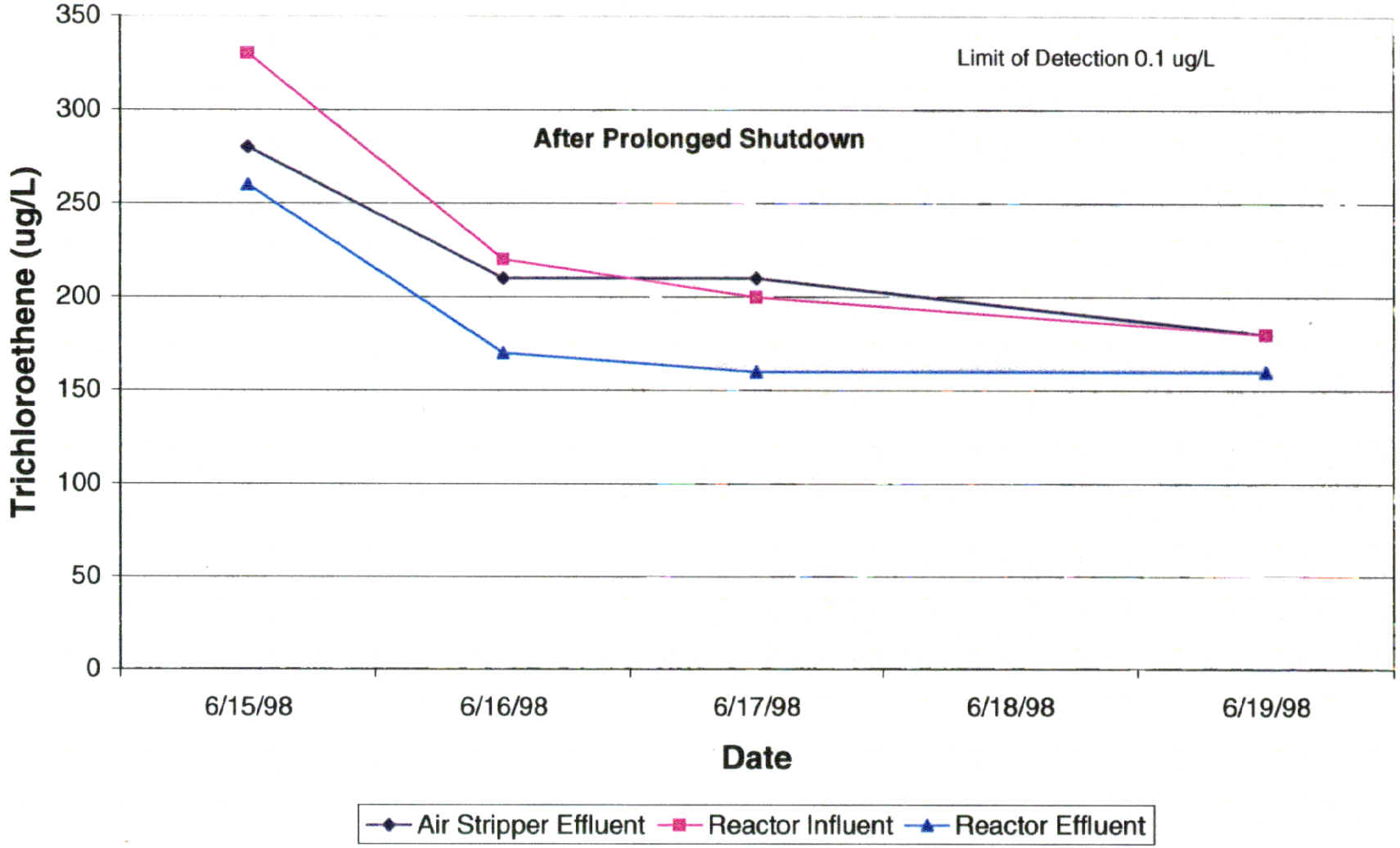


Harding Lawson Associates
Engineering and Environmental Services

PLATE **23**

VINYL CHLORIDE ACROSS THE BIOREACTOR AFTER PROLONGED SHUTDOWN
Phase I Perchlorate Treatability Study

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



HLA

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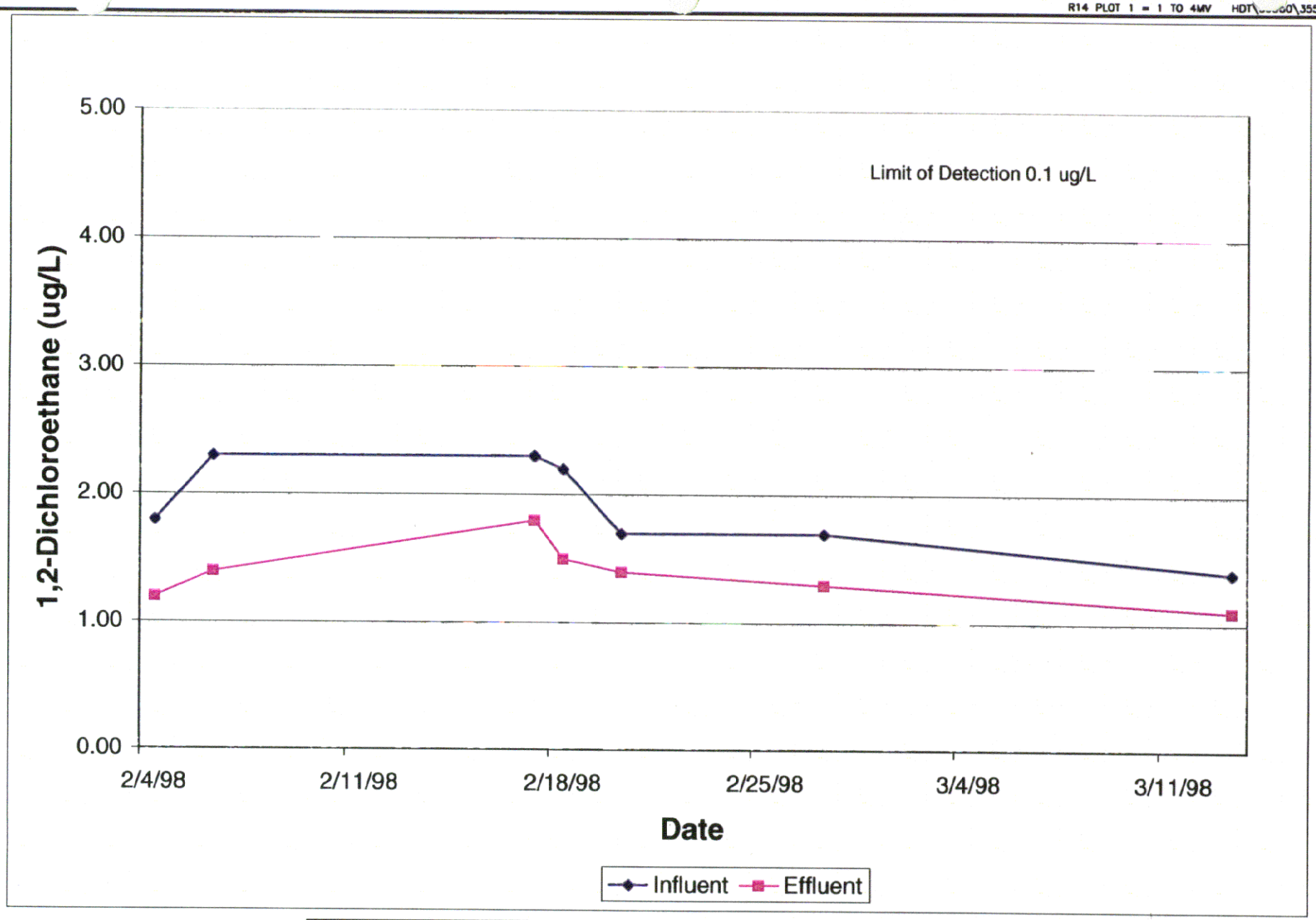
Environmental Services

TRICHLOROETHENE ACROSS THE BIOREACTOR AFTER PROLONGED SHUTDOWN
Phase I Perchlorate Treatability Study

PLATE **24**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	

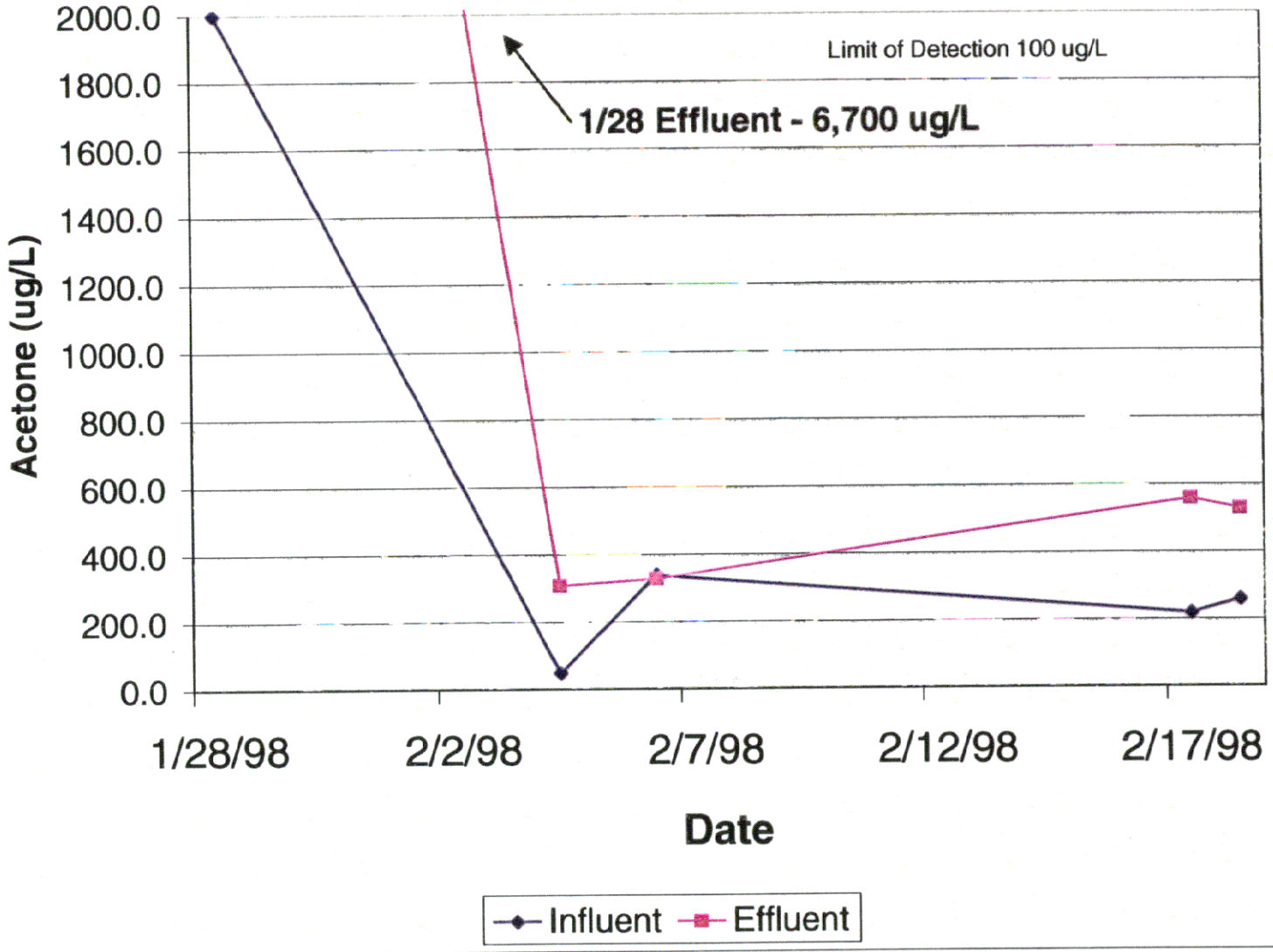


Harding Lawson Associates
Engineering and Environmental Services

1,2-DICHLOROETHANE ACROSS THE BIOREACTOR
Phase I Perchlorate Treatability Study

PLATE **25**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



PLATE

26

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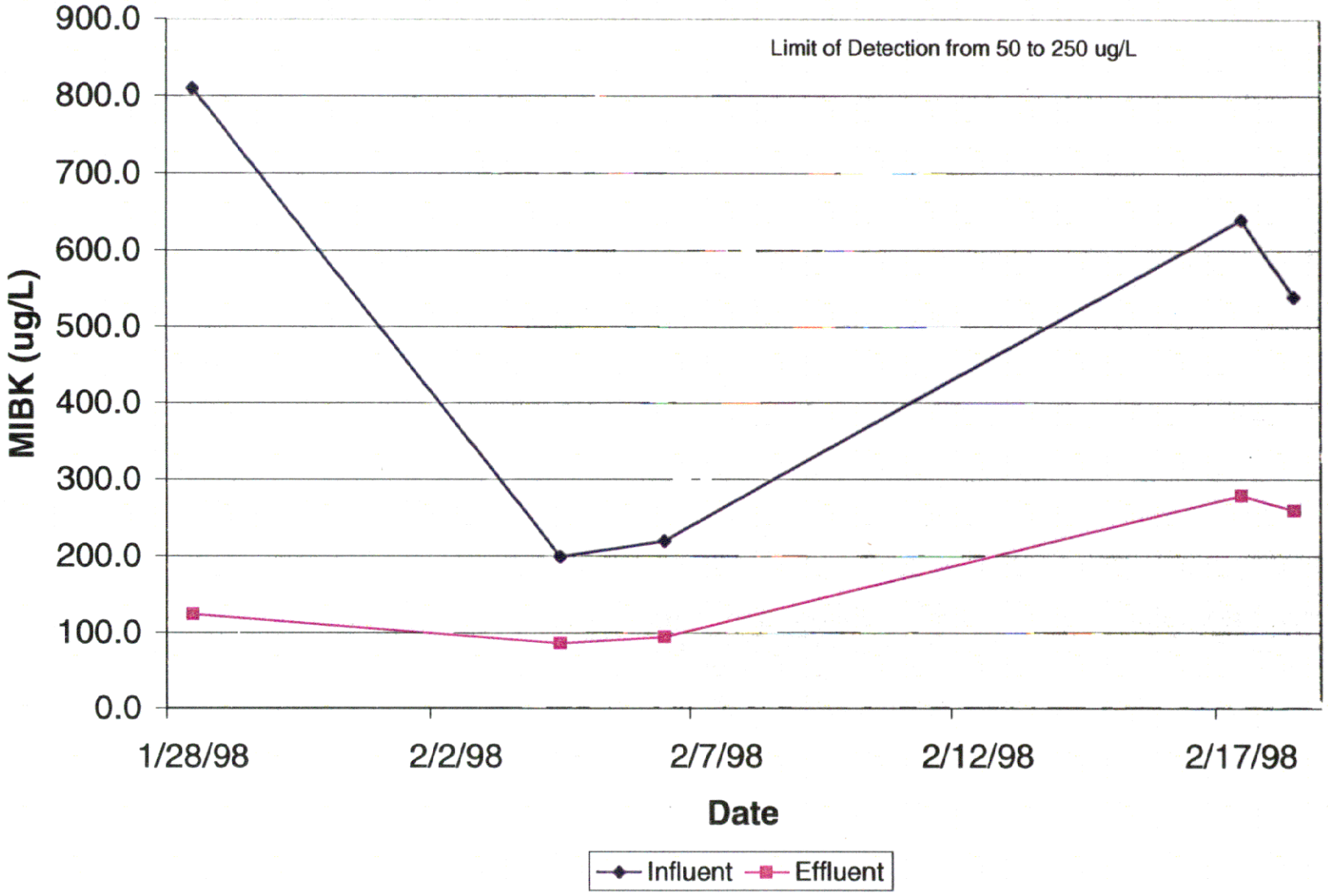
ACETONE INCREASE ACROSS THE BIOREACTOR
Phase I Perchlorate Treatability Study

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	

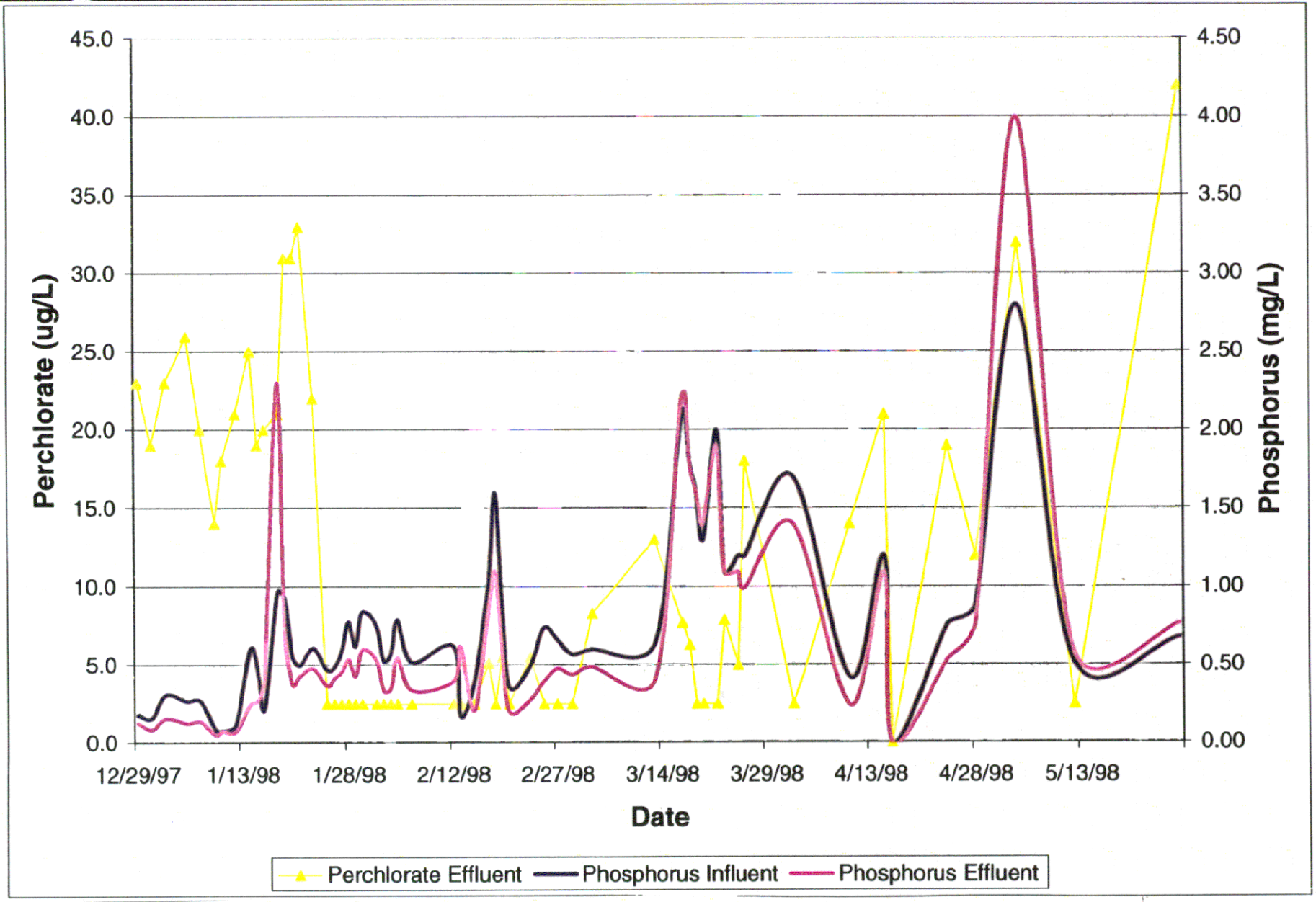


Harding Lawson Associates
Engineering and Environmental Services

MIBK DECREASE ACROSS THE BIOREACTOR
Phase I Perchlorate Treatability Study

PLATE **27**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	



HLA

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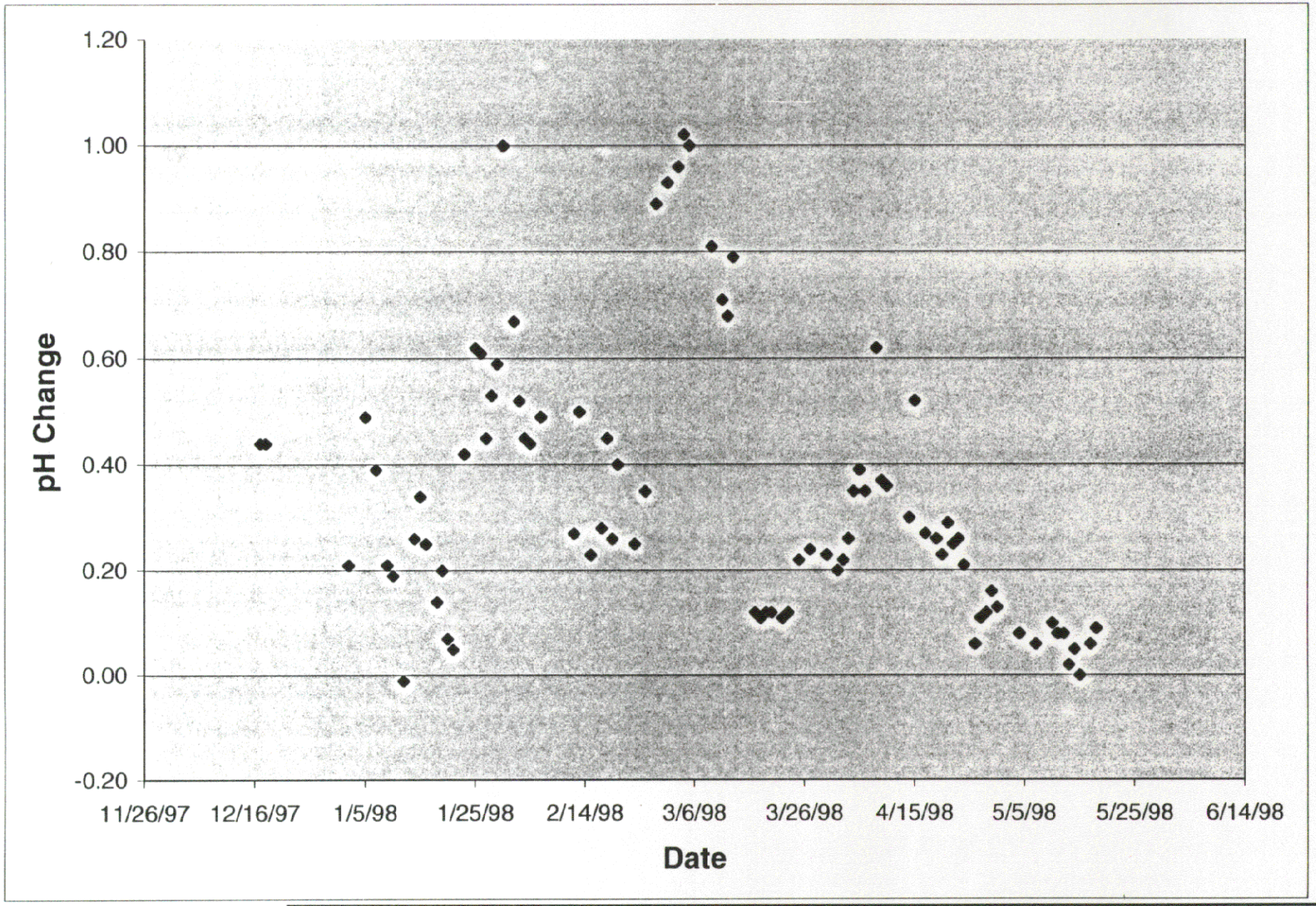
Environmental Services

PHOSPHORUS CONSUMPTION vs. PERCHLORATE EFFLUENT
Phase I Perchlorate Treatability Study

PLATE
28

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	

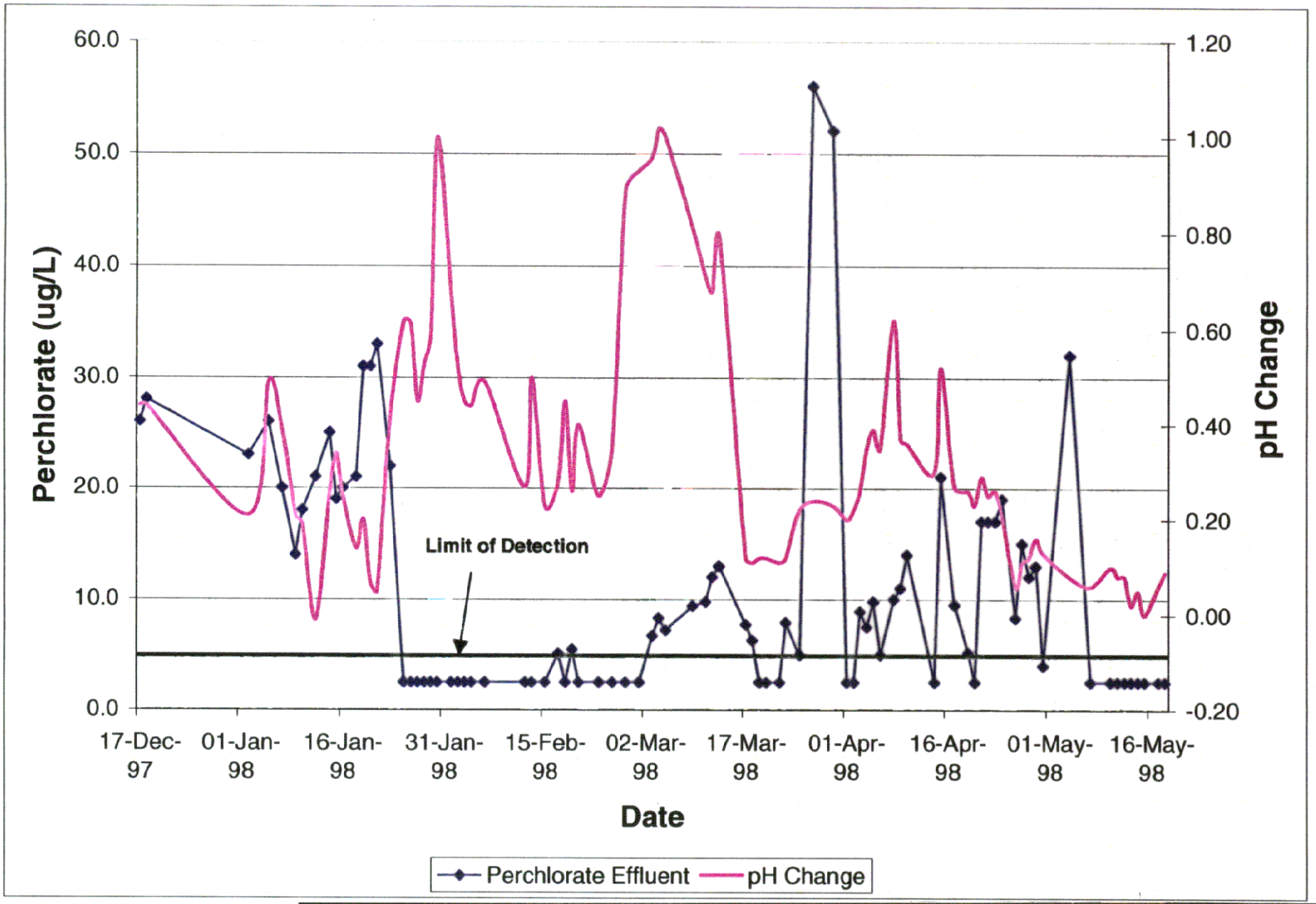


Harding Lawson Associates
Engineering and
Environmental Services

pH CHANGE ACROSS THE BIOREACTOR
Phase I Perchlorate Treatability Study

PLATE
29

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	

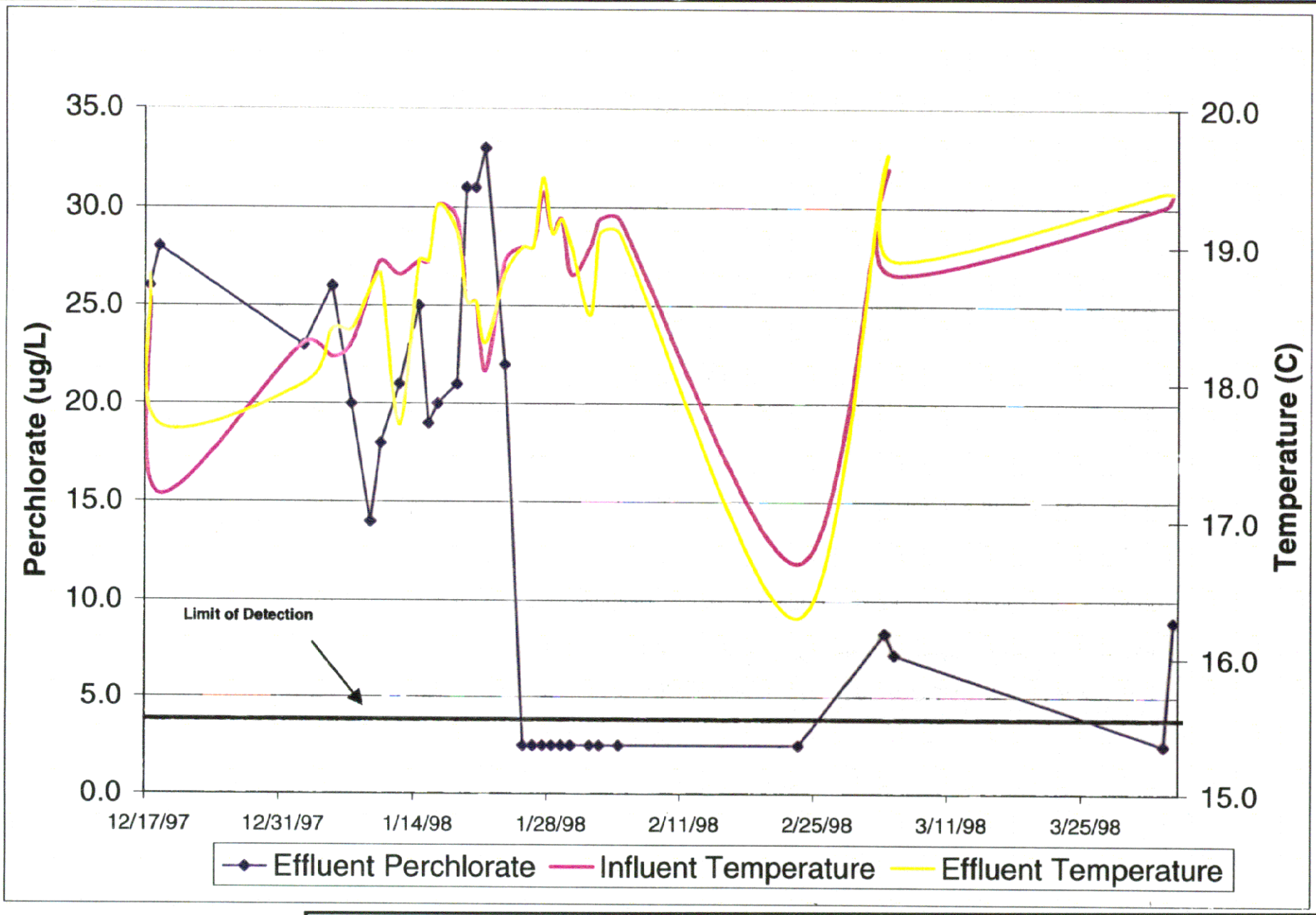


Harding Lawson Associates
Engineering and Environmental Services

PERCHLORATE EFFLUENT vs. pH CHANGE
Phase I Perchlorate Treatability Study

PLATE **30**

DRAWN	PROJECT–TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860–355		3/99	



HLA

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Environmental Services

PERCHLORATE EFFLUENT AND BIOREACTOR TEMPERTURE
Phase I Perchlorate Treatability Study

PLATE **31**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		3/99	

APPENDIX A

REVISED FINAL PHASE I TREATABILITY STUDY WORK PLAN

FILE COPY

REVISED FINAL
Phase I Treatability Study Work Plan
Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

Prepared for

Baldwin Park Operable Unit Steering Committee

HLA Project No. 37933 003

John G. Catts, Ph.D.
Vice President
Chief Technical Officer

Matthew L. McCullough, P.E.
Vice President

November 7, 1997

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Harding Lawson Associates

November 7, 1997

37393 003

Mr. Wayne Praskins
United States Environmental Protection Agency
Project Manager
75 Hawthorne Street
San Francisco, California 94105-3901

Revised Final Phase I Treatability Study Work Plan, Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

Dear Mr. Praskins:

On behalf of the Baldwin Park Operable Unit Steering Committee (BPOUSC), Harding Lawson Associates (HLA) is submitting the attached "Revised Final Phase 1 Treatability Study Work Plan, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin". We have revised the Final Phase 1 Treatability Work Plan dated October 6, 1997 to address EPA comments provided in letters dated September 12, 1997 and October 16, 1997. We have also revised the Work Plan to reflect changes to the treatment plant configuration that were made during the design and construction stage of the project, and refined the description of startup, sampling, and analysis procedures.

The following are responses to your comments on the Work Plan. Each U.S. EPA comment is repeated below with citation to the page/column/section (e.g. 3/2/2.3) to which you referred. This comment is followed by the BPOUSC response.

Comment: 3/2/2.3 — *Please identify the "higher than normal level of quality control precautions" that will be taken.*

Response: Since the date that the Draft Work Plan was first issued, additional commercial laboratories have received approval for analysis of perchlorate in water. In addition the BPOUSC, in sampling BPOU monitoring wells, sent split samples to multiple laboratories. Results indicate precision in line with other analytical methods. Therefore the language present in the Draft Work Plan has been removed. Details on laboratory and field quality control procedures are now contained in the text of the Work Plan, Table 7.5, and Table 7.6.

Comment: 7/2/4.2 — *Please specify the perchlorate concentration or concentration range that is "representative of that anticipated in San Gabriel Basin."*

Response: Based on available water quality data, modeling performed to support extraction system design, and assumptions regarding the location, construction, and production of future extraction wells, the concentration of perchlorate in groundwater extracted by the BPOU project, is expected to range between 50 and 100 ug/L. The well at Aerojet's Sacramento facility which will provide treatment plant influent will contain approximately 50 ug/L perchlorate. This is stated in the text.

Comment: 7/2/4.3 *We understand that biological denitrification has been used directly on a drinking water system in France in a 5 MGD system, and indirectly on a drinking water supply in El Paso, Texas.*

Response: The workplan text has been modified to include reference to this information.

Comment: 8/1/4.3 *Please specify the nitrate concentration or concentration range that is "similar to that expected in San Gabriel Basin."*

Response: Based on available water quality data, modeling performed to support extraction system design, and assumptions regarding the location, construction, and production of future extraction wells, the nitrate concentration in groundwater extracted by the BPOU project is expected to range between 20 and 25 ug/L. The well selected to provide treatment plant influent will contain between 50 and 70 mg/L nitrate. This is stated in the text.

Comment: 8/1/4.5 *We expect that phase 2 testing can begin earlier than April 1998. As explained in the EPA letter dated 8/28/97, we expect that the Steering Committee will submit the following documents within 75 calendar days of EPA approval of the workplan: a written phase 1 progress report for treatability testing of the biological process that includes a description of and schedule for the remaining phase 1 testing and either: (I) a supplemental workplan for phase 2 treatability studies; or (ii) a detailed explanation why additional phase 1 testing is necessary before preparation of a phase 2 workplan and planned submittal date for the phase 2 workplan.*

We agree with the narrative on page 8 (Section 4.5) and page 13 (Section 10.0), but believe that tasks planned for completion after 11/27/97 can be finished and submitted earlier. Specifically, we believe that in the absence of unforseen difficulties during pilot-scale testing, "Phase 1 testing" can be completed before 12/27/97. We also believe that "Draft Phase 1 Report" can be submitted well before 2/25/98. The proposed schedule allows an unnecessarily lengthy 6 1/2 weeks after the end of testing for report preparation.

We assume that the last two dates provided in Section 10.0 are in 1998, not 1997.

Response: The BPOUSC will comply with the project reporting requirement presented in EPA's letter dated August 28, 1997. The text of Section 10.0 has been modified accordingly.

Although U.S. EPA has communicated in writing (October 16, 1997) and orally (October 22,1997) the belief that Phase 1 testing can be completed before 12/27/97, and that a draft Phase 1 report can be prepared before 2/25/97, the U.S. EPA and the BPOUSC agreed in a meeting on October 22, 1997 that following receipt of the November 27, 1997 written progress report both parties would review progress made and revise the schedule accordingly. The BPOUSC will certainly work diligently to accomplish tasks as rapidly as possible, and look for ways to reduce the schedule for report preparation.

The last two dates in Section 10.0 were incorrectly reported as 1997 and have been revised to 1998.

Comment: 8/2/4.5

One of the objectives listed for phase 2 is to evaluate the relative bacterial preference for perchlorate and nitrate. The treatability study should examine other parameters relevant to microbially-catalyzed oxidation-reduction reactions, including the presence and depletion of competing electron acceptors. Measurement of these parameters may provide information that can be used to optimize removal rates, reduce operating costs, and diagnose the cause of lower than expected perchlorate removal rates. These processes are commonly examined during evaluations of biological degradation and natural attenuation in groundwater (e.g., see Technical Protocol for Natural Attenuation of Chlorinated Solvents in Groundwater, by T.H. Wiedemeier et. Al.).

Parameters commonly measured during studies of biological degradation and natural attenuation include:

- *iron II (Fe^{+2}) - reaction product for competing redox reaction (iron reduction)*
- *sulfate and sulfide - competing electron acceptor and reaction product (sulfate reduction)*
- *methane - reaction product for competing redox reaction (methanogenesis)*
- *oxidation-reduction potential - indicator of type of redox reactions that may occur.*

Consideration should also be given to measurement of additional chlorine compounds, and preparation of a mass balance of all chlorine species, in order to determine whether the perchlorate is fully reduced to chloride. Other possible chlorinated products include chlorate, chlorite, and hypochlorite.

Text and Tables in revised workplan include measurement or analysis of sulfate, redox potential, chlorate, chlorite, and hypochlorite. Sulfide is not mentioned in the text, but included in Tables 7.1 and 7.3. Fe+2 and methane are not mentioned in the text or Tables.

Response:

The BPOUSC will examine the presence and effect of competing electron acceptors in Phase 2 treatability testing. To the extent possible data to support this evaluation will be collected and interpreted during Phase 1 treatability testing. Specifically redox potential and dissolved oxygen will be measured in the field and on select samples perchlorate/chlorate/chlorite/hypochlorite/chloride, sulfate/sulfide, and nitrate/nitrite will be measured. These parameters will be measured during the initial start up period and the performance monitoring period in accordance with Tables 7.1, 7.2, and 7.3.

Iron (II) and methane will not be measured during Phase 1 testing. Concentrations of iron in groundwater in both Sacramento and San Gabriel Basin are expected to be low. Analysis for iron (II) is most commonly performed using a colorimetric field technique with a high reporting limit. Therefore iron (II) concentrations will likely be less than this

reporting limit. Should metals analysis performed during the initial source water analysis result in total iron concentrations that suggest iron (II) would be measurable, analysis for iron (II) will be reconsidered.

Samples for the analysis of methane will not be collected because based on the slightly reducing (anoxic) conditions observed during past pilot-scale testing measurable concentrations of methane are not expected. In addition it will not be possible to collect a meaningful and representative sample from the GAC/FB bioreactor which is not a pressurized system and is open to the atmosphere.

Throughout the treatability study, analytical test results will be evaluated to determine whether they are providing meaningful information. Tests that are providing meaningful information will be continued; however, some analytical testing may be discontinued if these tests are not providing meaningful data.

Comment: Figure 5-1 *The photograph of the pilot unit shows an air compressor, oxygen generator, bubble contactor, and dissolved oxygen control meter. Presumably, these will not be used during the treatability study.*

Response: The photograph of the pilot unit was provided by the vendor. This photograph includes system components that may or may not be used in this pilot study. Specifically the GAC/FB bioreactor will not contain an air compressor, oxygen generator, or bubble contactor. In line meters, placed in the bioreactor influent and effluent lines will measure dissolved oxygen, pH, redox potential, and temperature.

Comment: Figure 5-2 *The Process and Instrumentation Diagram also shows an Oxygen Generation System and recycling line. Please correct the diagram or explain the need for this equipment. Also, please add other system components described elsewhere in the workplan (e.g., air stripper, filters, effluent pumps, recycle line, backwash line, backwash pumps, effluent equalization tank, 20,000 gallon storage tank, sample ports).*

Please provide a schematic showing the relationship between major system components. Describe the purpose of any components not discussed in the text. If preferred, provide as separate document.

Response: The Process and Instrumentation Diagram (P&ID) for the pilot unit is a general P&ID and was provided by the vendor. This P&ID includes system components that may or may not be used in this pilot study.

A schematic showing major system components is not provided in the Work Plan. This request will be addressed by Aerojet in a separate letter.

Comments: 8/2/5.0 *Should tests also be conducted in reverse order: through the biological unit first, followed by air stripping? Isn't the biological process likely to remove some of the VOCs, offering the potential to reduce air stripping and/or offgas control costs?*

Response: Under our current schedule, we do not anticipate any time will be available to reverse the order of unit operations. The current system configuration was selected because we wished to focus solely on perchlorate and nitrate treatment and because of a concern that flow of water containing VOCs through the bioreactor would remove some VOCs but that others would be recalcitrant, and that vinyl chloride, a VOC that is not captured effectively by vapor phase carbon, may formed. At the conclusion of our planned testing, we will evaluate and prioritize what further testing is necessary. This has been addressed in the Work Plan in Sections 5.0 and 10.0.

Comment: 9/2/5.0 *Will the methanol in denatured alcohol limit the end use of the water? Should methanol be analyzed for in the effluent?*

Water temperature should be measured, given the potential temperature dependence of reaction rate. If the water temperature in the reactor may be cooler than San Gabriel basin groundwater (as implied by need for heat tracing on the filtration line), should water temperature be adjusted?

The text describes the effluent being discharged into a 550 gallon equalization tank. Is this tank for solids removal?

Figure 5-2 shows an equalization separation tank on the influent line. What is the purpose of this tank?

"Alcohol" specified as carbon source/electron donor in revised workplan. Possible impact of methanol not discussed.

Need for water temperature adjustment not discussed.

Purpose of equalization tanks (2) not discussed.

Response: Treated water will ultimately have to be acceptable for potable use. Based on past treatability studies neither methanol or ethanol are expected in the effluent. This is in fact a goal of the treatability study, to minimize alcohol addition so that perchlorate reduction is maximized but residual substrate (alcohol) and nutrients are minimized. To ensure this goal is achieved water quality analysis for ethanol and methanol will be performed as described in Section 7.0. Analytical reporting limits for these chemicals and all other chemicals of concern, as shown in Table 7.4, are below available health based standards for water intended for potable use.

As described in Section 7.1 water temperature will be measured during treatability testing; however, no adjustment in water temperature is planned. We anticipate that

extracted groundwater temperature will be fairly constant based upon previous test data. Some precautions will be taken to ensure that cold weather does not affect system operations. These precautions are described in Section 5.0. During previous treatability testing of this technology, performed from April through December, water temperature varied less than 2 degrees centrigrade. With respect to comparison between Sacramento and San Gabriel Basin, groundwater temperature in Sacramento generally varies between 18 to 22 degrees centigrade averaging approximately 20 degrees, while the temperature of groundwater in San Gabriel Basin generally varies from 10 to 28 degrees centigrade averaging approximately 22 degrees.

Based on changes made to system configuration during design and construction activities the equalization tank on the influent line has been eliminated. There is a 70 gallon reservoir in the base of the air stripper that with appropriate sensors will serve to assure a constant flow rate to the fluidized bed.

The 500 gallon effluent equalization tank will be used to assure a constant flow through the pump which sends treated water back to the GET-B system. Contrary to previous discussions, the GAC/FB bioreactor has an internal recycle system and the equalization tank is therefore not needed for this purpose. The text of Section 5.0 has been revised to reflect these changes and provide additional clarification.

Comment: 10/2/6.1 *Should the expected organic loading rate reflect the difference in perchlorate concentration between Sacramento and Baldwin Park?*

The workplan states that "targeted analytical parameters will be measured after each change of operating conditions." How long is needed for stabilization - minutes or hours? Perhaps a parameter vs. Time curve should be generated to determine the optimal time for sample collection after a change in operational conditions.

Response: The extraction well selected as the source water will yield water with perchlorate and nitrate concentrations similar to that expected in San Gabriel Basin (Sections 4.2 and 4.3). The organic substrate will be initially added to the influent at a rate that was recommended as a result of previous treatability testing. This was a recommendation for addition of alcohol to perchlorate at a molar ratio of 4:1. The expected perchlorate concentrations will be significantly lower than encountered during previous testing and nitrate concentrations are expected to be significantly higher than encountered during previous testing. Therefore the initial alcohol loading rate will be set at a ratio of 4:1 based molar concentrations of perchlorate plus nitrate.

Reactor stability will be investigated as part of the treatability study. Although it is expected that the reactor will respond relatively rapidly to changes in operating conditions, approximately 24 hours will be allowed for stabilization after an influent change. At this time samples will be collected and analyzed and data interpreted before

additional operating parameters are changed. This approach is described in the workplan in Sections 6.1 and 7.2. These data will allow plots of parameter vs. time.

Comment: 11/1/7.1 *The workplan states that DO concentrations in the influent and effluent of the GAC/FB system will be monitored daily. We assume that these measurements will be made at sample ports located on the influent and effluent lines immediately adjacent to the reactor vessel. Please show the locations of the recycle line and sample ports on Figure 5-2.*

Project-specific schematic not provided

Response: The Process and Instrumentation Diagram (P&ID) for the pilot unit, as shown in Figure 5-2, was provided by the vendor. This P&ID includes system components that may or may not be used in this pilot study and does not detail sample port locations. During bioreactor construction sampling valves that withdraw water from the influent and effluent lines will be added and sampling devices that withdraw water from positions that are approximately 25 %, 50 %, and 75 % through the reactor flow path will be added.

A project specific schematic is not provided in the Work Plan. This request will be addressed by Aerojet in a separate letter.

Comment: 11/2/7.2 *The source water for the treatability testing should be sampled for anions, metals, general water chemistry, and other parameters that might affect system performance.*

Why collect the effluent ethanol samples as composites rather than grab samples?

Analysis of source water not specifically addressed. Will "GAC/FB influent" be identical to source water ?

Comments requesting explanation for collection of composite samples not addressed.

Response: The influent and effluent will be tested for a wide range of water quality parameters including appropriate parameters from the California Code of Regulations (CCR), Title 22, common cations, common anions, and metals. At least one sample of influent (source water) will be collected and analyzed during the initial system startup. In addition weekly samples of influent and effluent will be collected and tested for the duration of the performance monitoring period.

All samples will be gathered as grab samples. In the Draft Work Plan the only composite samples to be collected were from the effluent equalization tank, with all other samples collected as grabs. The rationale for collecting composite samples from this tank was to obtain an integrated composition of this water prior to discharge to the ground surface. Now that treated water is to be discharged directly to the GET-B treatment system these composite samples will not be needed. The text of Section 7.2 has been revised accordingly.

Comment: 12/1/7.3 *The list of analytes should include parameters mentioned in the comment on page 8, column 2, section 4.5.*

See earlier comment.

Response: Section 7.0 and associated tables have been modified in accordance with this comment.

Comment: 12/2/10.0 *The schedule should be modified as explained in the comment on page 8, column 1, section 4.5.*

See earlier comment.

Response: The schedule as described in Section 10.0 has been modified in accordance with this comment.

Comment: 8/2/5.0 *How likely is it that an additional treatment step will be needed to remove residual alcohol ?*

Response: Past treatability testing using this technology produced effluent that did not contain detectable concentrations of alcohol. It is the objective of this testing to optimize reactor performance such that effluent does not contain measurable alcohol. The detection limits for these and other parameters as shown on Table 7.3 are below health based concentrations suitable for unrestricted consumption (potable).

Comment: 9/2/5.0 *Why is filtration no longer believed to be needed ?*

Why does the workplan no longer specify a 20,000 gallon backup tank for discharge of effluent, or a recycle line ?

Response: Filtration is no longer needed as effluent from the treatment system will be discharged to the GET-B treatment system. Testing and selection of a suitable filtration system will be performed during Phase 2 treatability testing.

The 20,000 gallon tank is no longer needed. Effluent was to be retained in this tank and tested prior to discharge to the ground surface. Now effluent will be pumped directly to the GET-B treatment system, and therefore storage capacity is not needed.

Comment: 10/2/6.3 *The text states that approximately 5 % of all samples will be collected as splits. How will these samples be chosen ? Will these analyses be in addition to the duplicates listed in Table 7.2 ?*

The text also states that field blanks, equipment blanks, and trip blanks will be submitted daily or weekly. Is this correct?

Response: The duplicate samples previously shown on Table 7.2 are the split samples that will be collected at a minimum frequency of 5 %. To clarify this issue field quality control samples are now shown separately in Table 7.5.

The text has been revised to state that field quality control samples that will be collected will include sample splits (duplicates), and trip blanks. Field blanks and equipment blanks are not appropriate for this treatability test and have therefore been deleted.

Comment: 12/1/8.0 *Please describe the process for obtaining Regional Water Quality Control Board approval for discharge of treated water.*

Response: Effluent from this treatability test will be pumped to the GET-B. Therefore additional discharge approval specifically for this treatability test is unnecessary. Earlier drafts of the Work Plan planned for discharge to the ground surface, but this protocol was modified with the knowledge of the Regional Water Quality Control Board.

Comment: 13/1/10.0 *Did DHS or MWD review the workplan, as described in the schedule ?*

Response: Both DHS and MWD were sent a copy of the Work Plan , but to date no comments have been received.

Comment: Table 7.3 *The MDL for perchlorate appears to be incorrectly reported as 28 ug/L.*

Response: Both the Method Detection Limit and the Reporting Limit for perchlorate were incorrectly reported in Table 7.4. This table has been revised.

Should you have questions regarding this Work Plan or the treatability testing that is in progress, please do not hesitate to call Don Vanderkar at (916) 355-4282, John Catts at (415) 899-8825, or Matt McCullough at (714) 260-1800.

Sincerely,

HARDING LAWSON ASSOCIATES

John G.Catts, Ph.D.
Chief Technical Officer

Matthew McCullough P.E.
Vice President

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CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

For the past several years the Baldwin Park Operable Unit Steering Committee (BPOUSC), the U.S. EPA Region IX (U.S. EPA), Three Valleys Municipal Water District (TVMWD), and the Metropolitan Water District of Southern California (MWD) have been planning a combined groundwater remediation and water supply project in the San Gabriel Basin, California. Project planning was initiated in response to a requirement of U.S. EPA to remediate a plume of volatile organic compounds (VOCs) in groundwater in the Cities of Azusa and Baldwin Park. This plume is distributed from locations north of Interstate 210 in the City of Azusa southwest to locations in the vicinity of Interstate 10 in the City of Baldwin Park. This area is called the Baldwin Park Operable Unit (BPOU).

The BPOUSC was in the process of negotiating agreements for the project with the U.S. EPA, MWD, and TVMWD when in June 1997 concentrations of perchlorate ion, above the State of California Department of Health Services (DHS) provisional action level of 18 μg/L, were found in BPOU groundwater. Before the project can move forward, the potential impact that perchlorate has on the conceptual project design must be evaluated. Perchlorate in BPOU groundwater is particularly troublesome since there is no treatment technology that has been demonstrated to be effective in reducing concentrations of perchlorate to the provisional action level.

Treatability testing at a pilot-scale has been successfully performed at the Aerojet General Corporation (Aerojet) facility near Sacramento, California. The technology can be described as a biochemical reduction process using a fixed film bioreactor. The fixed film is attached to granular activated carbon operated as a fluidized bed (GAC/FB). This pilot-scale test demonstrated that the technology was effective in treating perchlorate in groundwater.

There are however several important differences between objectives of this previous pilot-scale work and current objectives for the BPOU project. First, the flow rate was 0.1% of that needed in San Gabriel Basin. Second, the influent perchlorate concentration was over 100 times that expected in San Gabriel Basin. Third, the pilot system was not designed to achieve nor did it achieve effluent perchlorate concentrations less than 18 μg/L provisional action level. Finally, the previous testing was not designed to deliver potable water.

The purpose of this Work Plan is to describe the approach and methods that will be used in performing pilot-scale treatability testing of the GAC/FB biochemical reduction technology specifically for application in San Gabriel Basin. The pilot-scale testing will be performed in two phases. In the first phase the objective is to assess if the chosen technology can achieve the target effluent goal. In the second phase, scientific and engineering data needed to design and construct a full-scale treatment system will be collected.

Although this GAC/FB treatment technology has shown the potential to treat perchlorate at concentrations present in San Gabriel groundwater, other treatment technologies may also be applicable. The BPOUSC is in the process of completing a technology screening to assess the viability of other treatment technologies and make recommendations regarding bench-scale and pilot-scale testing if appropriate.

2.0 HISTORY OF PERCHLORATE ISSUES

In February 1997 perchlorate was discovered in five drinking water supply wells in Sacramento, California. This discovery was a result of the recent improvement in the method of perchlorate analysis which has only allowed detection of perchlorate in water at concentrations below the level which EPA and DHS considers acceptable for use by the public (18 μg/L) since early 1997. The detection of perchlorate in Sacramento water supply wells led DHS to perform sampling and analysis of groundwater for perchlorate in other portions of the state including San Gabriel Basin.

2.1 Distribution of Perchlorate in the BPOU

Perchlorate was first detected in San Gabriel Basin groundwater in June 1997 by DHS. This prompted the Main San Gabriel Basin Watermaster (MSGBWM) and the BPOUSC to perform additional groundwater sampling and

analysis to better understand the distribution of perchlorate in groundwater.

To date, the BPOUSC has compiled perchlorate data for over 50 monitoring wells, production wells, and sampling points in the vicinity of the BPOU. Perchlorate analysis for production wells was performed on samples obtained by the DHS and MSGBWM and provided by the San Gabriel Basin Water Quality Authority (SGBWQA). Groundwater samples from monitoring wells in the BPOU were collected by Camp Dresser McKee, Harding Lawson Associates, and Geosyntec on behalf of the BPOUSC.

The lateral and vertical distribution of perchlorate in groundwater has been previously described (see "The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin" [HLA, 1997a], "Final Addendum to Sampling and Analysis Plan, Pre-remedial Design Groundwater Monitoring Program, Baldwin Park Operable Unit, San Gabriel Basin" [HLA, 1997b]). In general, the area which contains concentrations greater than the DHS provisional action level of 18 μg/L is 5 to 6 miles in length, oriented from northeast to southwest, approximately 1 mile in width, and up to 800 feet in depth. This approximate perchlorate distribution is based on maximum concentrations detected in any sample or at any depth within a given well.

It should be noted that for the majority of these wells, only a single sample has been collected. In addition, there is uncertainty regarding the concentrations above the 18 μg/L provisional action level in both the northernmost and southernmost portions of the plume. Therefore, the known distribution may change as wells are resampled or new wells constructed and sampled.

2.2 Toxicity/Provisional Action Level

A significant source of uncertainty associated with the potential effect that concentrations of perchlorate ion in groundwater may have on the selection of a remedy for the BPOU is the limited data available on the toxicity of low concentrations of perchlorate to humans. Limited animal studies have been performed and no studies documenting human effects at low concentrations are available. Therefore, the provisional Reference Dose (RfD) and provisional action level established by DHS have an inherently high level of uncertainty. These may be subject to significant change once appropriate studies have been conducted.

The primary human health concern related to perchlorate is that it interferes with the thyroid gland's ability to utilize iodine to produce thyroid hormones. While high doses of perchlorate (mg/kg per day levels) have been used therapeutically in medicine, no studies have examined the health effects at the lower dosages potentially received from the ingestion of groundwater at concentrations present in the San Gabriel Basin groundwater. Examples of therapeutic perchlorate use are as a medicine to treat Grave's disease, a condition in which excessive amounts of thyroid hormone are produced, and in Europe to counteract the side effects of the heart drug amiodarone.

In December of 1992, the U.S. EPA National Center for Environmental Assessment (NCEA) responded to a request by U.S. EPA Region IX to evaluate the toxicity of perchlorate in soil and groundwater. Based on limited data on the toxicity of this ion, NCEA recommended a provisional RfD for soil and groundwater that included a conservative safety factor and correlated with acceptable levels of 70 mg/L and 3.5 μg/L, for these media, respectively. NCEA later stated in a letter dated February 25, 1997, that these provisional RfDs were merely opinions provided to EPA regional officials and were not to be considered formal EPA policy.

In April of 1993, the Perchlorate Study Group (PSG) was formed by the U.S. Air Force, various aerospace companies, and the two primary manufacturers of perchlorate compounds. The mission of the PSG was to review and evaluate information on the toxicity of perchlorate and develop better information on what constitutes an acceptable level of perchlorate in soil and groundwater.

In June 1995, the PSG submitted a position paper to the U.S. EPA presenting the groups' findings. The U.S. EPA again reviewed available toxicological data on perchlorate and concluded that although information was available on the effects of high concentrations of perchlorate on the thyroid, there was not enough information on the effects of long-term exposure to low

concentrations. In October 1995, the U.S. EPA responded to the PSG paper by recommending a provisional reference dose correlating to an acceptable level in groundwater that ranged between 3.5 and 17.5 μg/L. Because there was limited information available, the U.S. EPA recommendation includes a large margin of safety. In fact a 300-fold margin of safety above the level at which no health effects were observed was used to establish the 17.5 μg/L provisional standard. This value became the 18 μg/L value currently used as the DHS provisional action level.

In March 1997, the PSG assembled a technical Peer Review Panel of nationally recognized scientists to evaluate the health effect of perchlorate in drinking water. The conclusion of this panel was that there are insufficient toxicological data available to establish a technically defensible RfD or support the U.S. EPA provisional RfD.

In May 1997, the Air Force and the PSG brought the Peer Review Panel back together with California state and federal regulators in Cincinnati, Ohio. The purpose was to have the panel develop a protocol and the scope of studies that would lead to a recommendation to U.S. EPA for a new RfD which could serve as the basis for a groundwater MCL. The Air Force and the PSG have undertaken to commence the necessary studies in August 1997, interpret the data, peer-review the results, and submit recommendations to U.S. EPA by July 1998.

It should be noted that to date the U.S. EPA has not endorsed the Peer Review Panel but did have representatives participate on the panel. Further, U.S. EPA has not endorsed the evaluation process or committed to a schedule for review of the resultant recommendations or its effect on the U.S. EPA's former provisional RfD. As a result it is uncertain how long it will take for the provisional RfD to be revised and an MCL established.

In February 1997 the DHS set a provisional action level for perchlorate in groundwater at 4 μg/L, but at that time laboratory methods were not designed or approved to measure concentrations this low. In May of 1997 DHS, based on the results of U.S. EPA's recommendations, revised its provisional action level from 4 μg/L to 18 μg/L. DHS stated that it had reevaluated scientific studies in greater detail and had determined that 18 μg/L is consistent with the range of perchlorate exposures the U.S. EPA considers protective of human health. DHS requires that water suppliers promptly notify customers whenever perchlorate is present in concentrations greater than 18 μg/L.

2.3 Analytical Methodology and Detection Limits

At the time that the U.S. EPA set its provisional RfD and the DHS set its provisional action level for perchlorate in groundwater, no EPA laboratory method existed and few laboratories were set up to analyze for perchlorate. Some laboratories were using a modification of EPA Method 300 (Ion Chromatography), while others were using an Ion Selective Electrode (ISE). Reporting limits for analysis of perchlorate in water were generally in the range of 400 to 1,000 μg/L.

It was not until April 1997, that the DHS (Sanitation and Radiation Laboratories Branch) attained the current reporting limit of 4 μg/L after having performed its own method development. To date, this method has not be peer reviewed. Because perchlorate is not a regulated substance DHS does not issue laboratory certification for method analysis. DHS will however issue informal approval to perform perchlorate analysis once a laboratory meets DHS requirements.

To receive DHS approval the laboratory must hold a current certification for EPA Method 300, develop a Standard Operating Procedure (SOP), determine its Method Detection Limit (MDL), and prepare a data package demonstrating its ability to perform the analysis. The laboratory must then contact the DHS who will send out a field auditor. The laboratory must perform analysis on the samples with acceptable results (±10%) in the presence of the auditor. To date, at least six laboratories in California have received approval.

3.0 PREVIOUS PERCHLORATE TREATABILITY REVIEW

In response to the presence of perchlorate in groundwater at Aerojet's Sacramento facility, a considerable amount of work has been performed to address perchlorate treatability. This work, consisting of technology screening, bench-scale studies, pilot-scale studies, and the design of a

full-scale (1,500 gpm) system, was performed by Aerojet and a consultant starting in 1994.

3.1 Literature Review

In 1994, Aerojet completed an initial screening of technologies available for treatment of perchlorate. An on-line data search was first performed. The following databases were searched:

- Energy SciTech (1974-1994)
- Ei Compendex Plus (TM) (1970-1994)
- National Technical Information Service (1964-1994)
- Aerospace Database (1962-1994)
- Chemical Engineering Abstracts (1970-1994)
- Biotechnology Abstracts (1970-1994)
- PTS Aerospace/Defense Markets (1986-1994)
- Pollution Abstracts (1970-1994)
- Analytical Abstracts (1980-1994)

Only limited information on the treatment of water for perchlorate was found, and the available data addressed the treatment of high concentration wastewaters, not low concentrations in groundwater. The technologies for which information was found include both biological and physical/chemical treatment methods.

Biological Methods

Biochemical reduction of oxygen-containing compounds, like perchlorate, with the simultaneous biochemical oxidation of organic matter contained in sludge from municipal wastewater treatment plants was the subject of three patents with dates from 1973 to 1994. The patents varied in bioreactor configuration and the source and type of the microorganisms used. Concentrations in wastewater in excess of 7,000 mg/L were the subject of treatment.

A 1973 patent (Yakevlev et al., 1973) describes biochemical oxidation of activated sludge in an unaerated tank. A 1976 patent (Korenkov et al., 1976) is a modification of this approach but a specific microorganism is identified. The source of the microorganism is settled municipal sewage. A 1994 patent (Attaway et al., 1994) held by the U.S. Air Force uses an anaerobic bioreactor and a specific microorganism. Brewer's yeast, cottonseed protein, and whey powder were all added to the bioreactor.

Physical/Chemical Methods

The physical/chemical processes which were reviewed by Aerojet in 1994 included ion exchange, reverse osmosis, an electrochemical process which reduces inorganic oxyhalides, and a process where perchlorate wastewater was treated with an oxidant in supercritical (high temperature, high pressure) water.

The electrochemical method, patented in 1992 (Kaczur et al., 1992), uses an anode and cathode separated by a cation exchange membrane. A 1993 paper (Harradine et al., 1993) describes treatment of perchlorate in wastewater with an oxidant (O_2, air, H_2O_2) under conditions of high pressure (200 atm) and temperature (370°C).

In addition to these two techniques, Aerojet's staff reviewed the applicability of ion exchange and reverse osmosis treatment technologies. Although both ion exchange and reverse osmosis are considered technically proven methods for reducing concentrations of dissolved solids in waters, there are significant technical challenges presented by both methods for treatment of water containing perchlorate.

With respect to ion exchange, common groundwater ions will interfere with perchlorate adsorption. The ion exchange resin is regenerated with brine (usually sodium chloride). Perchlorate concentrations in regeneration brine present a unique disposal or treatment problem.

There are significant operational difficulties associated with the use of reverse osmosis. Like ion exchange, perchlorate is not treated but merely conveyed to a waste concentrate that would be a waste disposal challenge. The resultant brine would contain perchlorate and would be significant in volume. In addition, pretreatment of influent, use of anti-fouling

chemicals, and membrane cleaning are time-consuming and costly.

Based on the literature review described above, Aerojet decided to pursue laboratory-scale testing of chemical reduction and biochemical methods.

The BPOUSC is in the process of completing an updated technology screening, building upon past work performed by Aerojet. This effort will include a literature review, a review of recent patents and technical articles, and a review of additional technical performance data which may have been generated by various parties interested in perchlorate treatability but not present in the literature.

3.2 Bench-Scale Laboratory Testing

Bench-scale treatability studies for several biochemical and chemical reduction treatment methods were performed by an Aerojet consultant in 1995. The tested water came from Aerojet's Sacramento facility and contained between 7,000 and 8,000 μg/L perchlorate.

Relatively high dosages of several reducing agents (sodium sulfite, sodium bisulfite, and sodium thiosulfate) up to 1,000 mg/L were added under ambient conditions to water containing 7,000 μg/L perchlorate. As perchlorate concentrations did not significantly decrease over time, these reducing agents were concluded to be ineffective, and the process was not taken to pilot-scale.

In addition to chemical reduction, Aerojet staff evaluated the use of ion exchange technology in more detail. Time was devoted to resin selection, resin regeneration, and treatment of regeneration wastes. Efforts were also made to develop a method for biodegradation of perchlorate in these wastes.

Two biochemical reduction methods were tested on a bench-scale: a fixed film bioreactor using submerged plastic media, and a fluidized bed bioreactor using a granular activated carbon media (GAC/FB). For both processes the water to be treated was amended with an organic carbon source (acetate or alcohol) and nutrients (nitrogen and phosphorus) before entering the bioreactor.

Both biochemical reduction methods were shown to be effective in reducing perchlorate concentrations. The GAC/FB system was more resilient, recovering more quickly from system upsets such as feed water variations. The GAC/FB system also accommodated a higher (6-fold) perchlorate loading rate of 0.70 grams perchlorate/liter/day in comparison to the submerged plastic media loading rate of 0.11 grams perchlorate/liter/day. Effluents for both processes were below the 400 μg/L reporting limit for perchlorate.

Because of the success with the biochemical treatment methods, and due to the comparatively better performance of the GAC/FB method, this method was taken to pilot-scale.

3.3 Pilot-Scale Testing

In 1996, a 30 gpm skid-mounted pilot system, was set up at the Aerojet facility in Sacramento. The pilot-scale system operated between April and December of 1996. Operation of this pilot-scale system allowed optimization of feed rates for the organic carbon source (alcohol) and nutrients (nitrogen in the form of urea and phosphorus in the form of ammonium phosphate). Alcohol was added in molar ratio to perchlorate of approximately 4:1. Nitrogen and phosphorus levels were augmented to be similar to those described in the literature to assure microbial growth.

Effluent concentrations were consistently less than the 400 μg/L laboratory reporting limit for perchlorate. Effluent concentrations were 500 μg/L for phosphorus, 340 μg/L for ammonia-nitrogen, and less than 50 μg/L for nitrate-nitrogen.

The initial pilot-scale effluent contained very low or non-detectable levels of bacteria. After one month of operation, bacteria were at non-detectable levels.

3.4 Full-Scale Design

Aerojet is in the process of designing a full-scale perchlorate treatment system for one of the groundwater extraction and treatment systems at their Sacramento facility. The design and construction are currently scheduled to be complete in the fall of 1998. The hydraulic loading rate for the system is 1,500 gpm. The

full-scale system will be similar to that pilot-tested in 1996.

Aerojet is working with the design contractor to optimize certain design features which will result in lower effluent concentrations. The pilot-scale study was completed prior to the recent reduction in laboratory reporting limits by agency and commercial laboratories and, therefore, Aerojet and its contractor are hoping to modify either the design or operating parameters to produce effluent below the 18 μg/L provisional action level.

In addition, Aerojet and its contractor have located an alternative source of microorganisms Waste sludge from the food processing industry was determined to contain acceptable microorganisms.

3.5 Biological Treatment Technology Overview

Biological treatment, or biochemical reduction of perchlorate, involves a microbially induced reaction in which perchlorate is biochemically reduced to form chloride, oxygen, and biomass, simultaneous with the biochemical oxidation of an organic substrate. The substrate is typically selected based on its readily biodegradable chemical structure, non-hazardous nature from an environmental standpoint, relatively low cost, and availability.

Biological treatment technologies generally fall into two classes: suspended-growth and attached-growth (fixed-film). Attached-growth systems are expected to be better suited to the relatively low influent perchlorate concentrations and are therefore the focus of BPOUSC efforts. Attached-growth systems can typically attain higher concentrations of microorganisms per unit reactor volume, and because the microorganisms are attached to media within the biological reactor, there is no requirement for return of microorganisms to the treatment reactor.

The GAC/FB technology is an attached growth (fixed film) process which utilizes granular activated carbon as a support medium for biological attachment and growth in a fluidized bed reactor. The GAC/FB technology offers the additional advantage of greater surface area on which microorganisms can attach and grow, as well as the presence of activated carbon, which provides some buffer capacity to varying operating conditions. Groundwater, amended with an organic substrate (e.g., alcohol, acetate) and nutrients (nitrogen and phosphorus), is introduced into the treatment bed. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously bioreducing the perchlorate. Thus, the microorganisms multiply to a steady-state level, determined by the organic loading to the system.

Non-viable microorganisms eventually become detached from the media, and exit the system in the groundwater effluent, allowing new microorganisms to attach and reproduce. The reaction takes place under anoxic conditions, and therefore no air or oxygen (other than that contained in the influent water) is introduced to the system.

4.0 DATA REQUIREMENTS

The long-term goals of this treatability work are: 1) to demonstrate the technology can achieve effluent goals for perchlorate and nitrate concentrations, and 2) to collect the data necessary for the design and construction of a full-scale treatment unit that will be part of the BPOU treatment train, delivering potable water to local and regional water purveyors.

The objectives of this Phase 1 treatability study are to evaluate the performance of the GAC/FB treatment technology previously tested at Aerojet's Sacramento facility with the following modifications:

- Decrease the concentration of perchlorate in the influent to a concentration representative of that which will be present in San Gabriel Basin groundwater
- Increase the concentration of nitrate in the influent water to a concentration representative of San Gabriel Basin groundwater
- Achieve a lower perchlorate concentration in treatment plant effluent
- Test the effectiveness of an alternative source of microorganisms.

- Evaluate the characteristics of the effluent to ensure potability.

Phase 1 testing is planned at Aerojet's Sacramento facility because many of the pilot system components are onsite, staff familiar with prior pilot system construction and operation are available, and there are no complicating issues related to the discharge of treated water.

4.1 Demonstrate Technology Can Achieve 18 µg/L Limit or Lower

At the time the pilot-scale study was performed at Aerojet's Sacramento facility, the goal was to produce effluent that was less than the 400 µg/L laboratory reporting limit current at that time. When the pilot-scale study was completed, the effluent generally was characterized by perchlorate concentrations less than 100 µg/L. Measurement of concentrations at this level had a higher level of uncertainty as they were below the established reporting limit. At that time it was not possible to measure to the current reporting limit of 4 µg/L. Therefore, it was not possible to optimize system flow rate, organic carbon source, or nutrients to see if lower effluent concentrations were possible. Therefore, it is uncertain if the full-scale system to be constructed by Aerojet in Sacramento may reach treatment goals for the BPOU. Treatability studies will need to demonstrate that a sufficiently low perchlorate concentration in treatment plant effluent is possible.

4.2 Evaluate Lower Perchlorate Influent Concentration

Based on the distribution of perchlorate in San Gabriel Basin groundwater, the configuration of extraction wells and flow rates described in the December 1996 Pre-Remedial Design Report (CDM, 1996), and modifications to the extraction plan discussed with U.S. EPA, the BPOU extraction system, as conceived, would produce groundwater containing concentrations of perchlorate between 50 and 100 µg/L. This value was estimated by selecting surrogate wells for each extraction well location, assigning recently measured concentrations from each surrogate well to its corresponding extraction well, and flow-weighting these concentrations based on expected pumping rates to produce a flow-weighted average concentration for the BPOU extraction system. This method is a rough estimation of concentrations that will be initially extracted. The actual concentrations present in the extracted groundwater will be known after extraction wells are constructed and pumped at their designed flow rate.

Although concentrations of perchlorate in groundwater at Aerojet's Sacramento facility that were used as influent to the pilot test ranged from 7,000 to 8,000 mg/L, there are wells at the Sacramento facility that have lower perchlorate concentrations. This treatability test will extract water from a well containing a perchlorate concentration representative of that anticipated in San Gabriel Basin. The selected well (40-11) is currently part of one of Aerojet's groundwater extraction and treatment systems (GET-B). This well consistently produces water containing approximately 50 ug/L perchlorate and 50 to 70 mg/L nitrate.

4.3 Utilize Higher Nitrate Influent Concentration

Pilot testing at Aerojet's Sacramento facility treated groundwater characterized by low (1.5 mg/L) nitrate concentrations. The results of the pilot-scale study performed in Sacramento show effluent nitrate concentrations less than 0.05 mg/L. This suggests that along with consumption of alcohol and reduction of perchlorate, that reduction of nitrate is also occurring in the fixed film bioreactor.

Supporting evidence that the same anoxic conditions that contribute to the reduction of perchlorate may also reduce nitrate concentrations may be found in the literature where processes using bacterial denitrification of wastewater have been described. Although denitrification has not been widely applied to drinking water systems, such systems do exist in Colorado, Texas, and France. One such system was designed for the town of Wiggins, Colorado to denitrify their drinking water. The process equipment, designed and testing performed by Joann Silverstein of the University of Colorado, Boulder (Silverstein, 1997). The system consists of a packed tower fixed film bioreactor where denitrifying bacteria are supported on a high-porosity plastic media.

This observation could have a significant beneficial effect on the BPOU project as influent nitrate concentrations have been estimated between 20 and 25 mg/L, by the same method described above to estimate influent perchlorate concentrations. Although these concentrations are well below the 45 mg/L MCL, they are substantially higher than concentrations currently received by customers of MWD and TVMWD. Should the GAC/FB biochemical system prove to be an effective method of reducing nitrate concentrations in treatment plant effluent, it may be possible to reduce both perchlorate and nitrate concentrations.

Preliminary evaluation of candidate wells identified a well (40-11) at Aerojet's Sacramento facility that has historically produced water containing between 50 and 70 mg/L nitrate. In addition, this well is part of a current groundwater extraction system (GET-B) so that water quality is anticipated to remain relatively constant for the duration of the pilot test.

4.4 Evaluate Different Source of Microorganisms

The source of microorganisms in the previous study was municipal wastewater treatment plant sludge. This approach presents a concern related to the introduction of pathogens into potable water supply. Pilot-scale work performed at Aerojet's Sacramento facility demonstrated that pathogens are not present in pilot plant effluent; however, the potential presence of these pathogens remains a concern.

The Phase 1 treatability study will utilize waste sludge from the food processing industry. The waste sludge will likely contain microorganisms appropriate for perchlorate reduction, but lack the pathogens that may be of concern.

4.5 Potability of Treated Water

For the BPOU project to be viable it must deliver potable water to local and regional water purveyors. Therefore the selected treatment train must produce water that meets all federal and state requirements for a potable water supply. Embodied in the objectives described above are the need to produce water that contains acceptable concentrations of perchlorate and nitrate and lacks pathogens. In addition this pilot-scale testing will evaluate all other applicable water quality parameters to ensure treatment plant effluent can achieve other potable water quality goals.

The source water and the effluent will be tested for an appropriate range of water quality parameters including those specified in the Safe Drinking Water Act and the California Code of Regulations, Title 22.

4.6 Phase 2 Pilot-Scale Treatability Study

Assuming Phase 1 results demonstrate effluent goals can be met, Phase 2 testing would be performed. It is the intention of the BPOUSC to perform Phase 2 treatability testing at a site in the San Gabriel Basin. Details and logistics regarding this testing will be developed during the performance of Phase 1 testing. Details which will be resolved during Phase 1 testing will include the well site where treatability testing will be performed, the flow rate at which the testing will be performed, and the method and condition under which the effluent will be delivered.

Phase 2 testing could commence in early 1998, with testing complete and a draft report available for EPA review later in 1998. Adherance to this schedule is dependent upon several key assumptions. These include identification of a suitable site for testing, an agreement with the current well owner/operator, resolution regarding the flow rate to be tested, resolution regarding use of the water and disposal of wastewaters, and the ability to design and construct a Phase 2 system at the selected flow rate within this timeframe.

In late 1998 Aerojet's Sacramento perchlorate treatment unit should be on-line and several months of performance data should be available. Input from both phases of treatability testing and performance data from Aerojet's Sacramento treatment unit would allow the BPOUSC to proceed with design of the BPOU project.

Preliminary Phase 2 treatability testing objectives are to: 1) determine the efficiency of perchlorate reduction, 2) evaluate required nutrients, 3) assess factors affecting biomass stability, 4) assess the effect of various nitrate concentrations, 5) evaluate relative bacterial

preference for perchlorate and nitrate and the role that competing electron acceptors play in system performance and 6) establish filtration/ disinfection requirements for potable water use.

5.0 TREATMENT EQUIPMENT DESCRIPTION

The Phase 1 treatment system includes an extraction well, an air stripper with vapor phase carbon air emission control, a bioreactor with granular activated carbon, a fluidization pump, a nutrient feed system, an alcohol feed system, a biological growth control system, a 500 gallon equalization tank, and assorted pumps, valves, sensors, and piping.

The extraction well (40-11) is currently connected to the GET-B treatment system. This connection will remain, but a valve will be inserted in the line to allow flow to be diverted from the GET-B system to the Phase 1 treatment system as needed. This will allow well 40-11 to continue operating at a constant flow rate as the Phase 1 system is operated in recycle mode and as the treatment system flow rate is increased to the maximum design rate for this treatability test.

The conceptual design of the BPOU project central treatment plant includes air stripping technology to remove VOCs from San Gabriel Basin groundwater. For purposes of this Phase 1 treatability test it has been assumed that perchlorate removal will occur following VOC removal. Therefore for Phase 1 treatability testing VOCs will first be removed with the use of a portable air stripper. This portable air stripper contains a 70 gallon reservoir in its base which with appropriate sensors will be operated to ensure constant flow to the bioreactor. VOC-free groundwater will then flow into the GAC/FB bioreactor.

Following completion of planned Phase 1 treatability testing consideration will be given to reversing the order of the air stripper and bioreactor. This configuration was not initially selected for testing as the biological treatment of VOCs in groundwater may result in the formation of vinyl chloride, a compound not effectively removed by vapor phase carbon, or the presence of recalcitrant VOCs in the treatment stream which may complicate the interpretation of the effectiveness of perchlorate and nitrate treatment.

An alcohol metering line, constructed of stainless steel tubing, will be connected to the bioreactor influent line. The alcohol will be added to the influent to provide a readily-degradable carbon source for the microorganisms. The alcohol will be purchased in 55-gallon drums. Because the alcohol is flammable, the drums will be stored in a fire-rated outdoor storage cabinet which contains an integral sump for spill control. The alcohol will be metered from the 55-gallon drum using a hazardous duty diaphragm metering pump which is UL-listed for use in Class I, Group D, Division I hazardous locations. Containment around the metering pump will be provided for spill control. The flow rate of the alcohol will be measured with a graduated cylinder and stopwatch.

The central reactor for the GAC/FB pilot system will be leased from a contractor. The bioreactor is 20 inches in diameter and 15 feet high. Additional components for the pilot system are available at Aerojet's Sacramento facility. The pilot system, rated for a once through flow rate of 30 gpm (113.6 liters/minute), is skid mounted.

A photograph of a generalized GAC/FB bioreactor is presented as Figure 5-1. A generalized process and instrumentation diagram (P&ID) is presented as Figure 5-2. These figures are not specific to this Phase 1 Pilot-scale test. The specific components and configuration of the treatability testing equipment to be used for Phase 1 treatability testing will differ from these figures to suit treatability test objectives.

The GAC/FB pilot unit is enclosed in a weather resistant container for protection from freezing during cold weather operation. The piping located outside of the reactor column will be insulated as appropriate. The purpose is to maintain a relatively constant water temperature in the GAC/FB reactor and prevent icing if the ambient temperature drops significantly. Previous pilot-scale testing was performed from April through December of 1996 and only minor changes (1 to 2 degrees) in temperature were observed.

Seven sample ports will provide for the collection of water quality samples and measurement of field parameters at key locations throughout the treatment system. These seven sample ports will be located as follows:

1. Air stripper inlet line
2. Air stripper effluent line
3. GAC/FB influent line after strainer, alcohol feed, nutrient feed, and recycle line
4. 25 percent of flow path in GAC/FB bioreactor
5. 50 percent of flow path in GAC/FB bioreactor
6. 75 percent of flow path in GAC/FB bioreactor
7. Effluent line from GAC/FB bioreactor

Samples will be collected from the 25 %, 50 %, and 75 % positions along the bioreactor flow path using individual 1/2 inch PVC tubing with screened ends which extend from the top of the bioreactor down to the appropriate horizon in the bioreactor. All three tubes will be connected through a common manifold with a three-way valve for ease of sample collection.

After the effluent exits the bioreactor, it will flow by gravity to a 500-gallon, polyethylene equalization tank equipped with level controls. From the equalization tank, the effluent will be discharged directly to the GET-B treatment system. The purpose of this equalization tank is to assure the pump moving water to the GET-B system receives a constant flow.

The equalization tank pump will be a centrifugal end-suction pump. Operation of the effluent equalization tank pump will be controlled by high-high, high, and low-level switches in the equalization tank. When the high-high level switch is activated a signal will be sent to the solenoid valve to close the influent line. The closed valve will eliminate flow to the bioreactor which will then operate in recycle mode to prevent spills. In addition, the high-high level switch will act as a fail-safe shutdown and signal the alcohol metering pump to turn off so that it no longer supplies alcohol to the influent line. When the high-level switch activates, the equalization tank centrifugal pump will be sent a signal to turn on, discharging the contents of the tank to the GET-B Treatment Pond. When the low-level switch activates, the equalization tank pump will be signaled to turn off. A totalizer will be installed to measure the total water flow treated by the system.

Filtration of the treatment system effluent will not be necessary before discharge. Pilot-scale testing of filtration equipment may be necessary prior to full-scale system design, but this testing if needed will be performed as part of the Phase 2 Treatability Study.

6.0 PILOT SYSTEM OPERATION AND MAINTENANCE PLAN

6.1 System Start Up and Operation

Upon delivery of the GAC/FB bioreactor to the site, a general/mechanical contractor will perform the mechanical and electrical installation. During system construction, personnel from HLA and Aerojet will provide oversight. The system will be filled with water and hydraulically operated prior to adding carbon or microbial seed to the bioreactor to ensure proper, leak-free operation.

After leak and mechanical testing, the system will be drained and the GAC/FB reactor column will be filled with the recommended amount of granular activated carbon. The remaining free volume of the bioreactor will then be filled with process water and the microbial seed.

From this point forward system operation is separated into two periods. The first is the startup period where microorganism growth and attachment occurs and basic bioreactor operating conditions are established. The startup period is planned for 2 weeks. The second period is referred to as the performance monitoring period where system operating conditions are optimized and performance monitoring samples collected. The performance monitoring period is expected to last 6 weeks.

During the startup period the bioreactor will be operated in recycle mode for approximately one week to allow for growth and attachment of the microorganisms to the GAC. During recycle mode, groundwater will not be flowing through the system. Batch additions of alcohol, nutrients, and perchlorate will be added on a regular basis to support the microbial growth. As an option

the bioreactor may be started up in flow through mode.

After sufficient time is allowed for microorganism attachment (one week), groundwater containing perchlorate and nitrate will be introduced to the bioreactor. At this time, the alcohol and nutrient feed systems will be started. The flow of groundwater will be gradually increased to the design rate for the treatability test. Initial flow will be 5 to 10 gpm, but as measured parameters show the bioreactor has stabilized the flow rate will be incrementally increased to the 20 to 30 gpm range.

The flow rate and the dosage of alcohol will be adjusted during the startup period to establish a stable microbial population in the bioreactor. Nutrients will be dosed at a rate sufficient to satisfy microbial requirements.

To assist in establishing stable operating conditions during the second portion of the startup period a profile of reactor conditions will be obtained. Water samples will be collected from sample ports on the influent and effluent lines and at the 25, 50, and 75 percent points along the bioreactor flow path. The profile of selected parameters and concentrations of selected ions including perchlorate will be evaluated to examine perchlorate destruction. These data will also be used to vary the alcohol and hydraulic loading rates in a controlled, step-like manner until the target organic loading rate is established.

Targeted analytical parameters will be measured before and after each change in operating conditions. Although it is anticipated that the system will respond rapidly to changes in influent quality, nutrient feed, or alcohol feed, approximately 24 hours will be allowed to pass, samples collected and results interpreted before additional changes are made. Assuming one day turn-around for laboratory analysis this will mean that operating changes will be made no more frequently than every 48 hours. This will ensure reactor stabilization and allow a better understanding of how changes to reactor operation affect effluent quality. Should results from the initial startup period and measurement of field parameters suggest the reactor stabilized more rapidly, this protocol will be modified.

Once the microbial populations have been established and stable bioreactor operating conditions achieved (2 week startup period), the system will be operated in the performance monitoring mode (6 weeks). System operating conditions will be optimized to match the feed rate for alcohol with perchlorate and nitrate destruction. The goal is to maximize perchlorate and nitrate destruction and produce effluent free of detectable alcohol. Sample collection and analysis will be performed as described in Section 7.0.

Analytical reporting limits are below health based standards for potable water so production of effluent without detectable alcohol will satisfy water supply requirements.

HLA personnel will assume operation and maintenance responsibilities. Operation and maintenance activities and frequencies will be modified as necessary to ensure proper control and performance of the Phase 1 treatment system. A logbook will be maintained at the site for recording all operating activities and observations. The logbook will serve as a daily checklist to ensure that necessary maintenance, sampling, and observations are conducted.

6.2 Health and Safety Plan

A Site Health and Safety Plan, prepared by HLA, will govern the activities of all HLA workers at the site who are associated with this pilot-scale treatability study. This plan will be prepared after Work Plan approval but prior to system start up.

7.0 SAMPLING AND ANALYSIS PLAN

The sampling and analysis portion of the Phase 1 treatability study is divided into two phases: a system startup period and a performance monitoring period. - During the first week of the startup period the objective is to build and establish the necessary population of microorganisms. The monitoring of field parameters and sampling and analysis schedule for this period is designed to support this objective. Field parameters will be measured and reported at least once each day. Although water quality samples will be collected on a daily basis

these samples will be analyzed for the limited number of laboratory analytes necessary to ensure the microorganisms are receiving sufficient organic substrate and nutrients.

In addition, early in the first week one influent sample will be collected and analyzed to provide a complete characterization of the source water. This will allow for modification of the analytical schedule if appropriate. Samples of air stripper influent and effluent will be collected and analyzed for VOCs as the air stripper is brought on-line to ensure VOCs are removed from the influent to the bioreactor.

During the second week of the startup period, monitoring of field parameters and sampling will be sufficiently frequent to provide complete characterization of the process influent and effluent, collect data to allow for bioreactor profiling, and allow adjustments to operating conditions.

After steady-state operating conditions are reached, less frequent but regular performance monitoring will be conducted to monitor treatment process performance.

7.1 Field Data Collection

During the first week of system startup, frequent monitoring of field parameters will be performed to assure steady-state conditions while microorganism populations are increasing and stabilizing. The parameters to be measured in the field include flow rate, dissolved oxygen (DO), pH, oxidation-reduction potential (redox potential), and temperature.

Flow rates will be continuously monitored with in-line, correlated flow meters. Flow meter readings will be confirmed by monitoring the effluent volume that accumulates in the polyethylene tank. A reference line for tank volume versus fluid height is present on the outside of the tank. The flow from the alcohol metering pump will be measured using a graduated cylinder and a stopwatch.

The bioreactor influent and effluent DO will be monitored at least once each day with a field DO meter and field probe or equivalent in-line device. Each day the DO meter will be calibrated using the air calibration method. DO measurements will be corrected for temperature and pressure.

A hand held pH meter or equivalent device will used to measure and record pH at least once each day. The meter will be standardized to two reference buffer solutions prior to obtaining each pH measurements.

A hand held platinum electrode or equivalent device will used to measure and record redox potential at least once each day.

The temperature of bioreactor influent and effluent will be measured at least once each day with a hand held mercury thermometer or equivalent device.

During the second half of the startup period and the performance monitoring period field parameters will be measured and recorded on at least a daily basis. Field parameters will be measured and recorded whenever a water quality sample is collected.

7.2 Sample Collection

Seven sample ports will provide for the collection of water quality samples and measurement of field parameters at key locations throughout the treatment system. These seven sample ports will be located as follows:

1. Air stripper inlet line
2. Air stripper effluent line
3. GAC/FB influent line after strainer, alcohol feed, nutrient feed, and recycle line
4. 25 percent of flow path in GAC/FB bioreactor
5. 50 percent of flow path in GAC/FB bioreactor
6. 75 percent of flow path in GAC/FB bioreactor
7. Effluent line from GAC/FB bioreactor

The sampling and analytical schedules for the startup period are presented in Tables 7-1 (week

1) and 7.2 (week 2). The sampling and analytical schedule for the performance monitoring period can be found as Table 7-3. These tables illustrate the location and frequency of sample collection as well as the compounds, ions, and parameters to be monitored.

Sample tubing will be connected to the GAC/FB bioreactor influent and effluent lines using labcock ball valves to reduce the velocity of the sample as it enters the sample bottles and thereby reduce turbulence. Tubing and valves on sample port lines will be opened and extensively flushed prior to sample collection to ensure collection of representative samples.

Samples collected from the pilot treatment system will be in the form of discrete grab samples. Grab samples provide better control than composite samples for monitoring the effects that changes in influent quality and reactor operating conditions have on reactor performance.

After collection, VOC samples in zero-headspace vials will be inverted and inspected for the presence of bubbles. All samples will be placed into coolers for same-day transportation to the analytical laboratory. Influent and effluent samples will be stored and transported on ice to preserve the samples and to prevent cross contamination of samples. Upon arrival at the laboratory, the samples will be stored at 4°C in walk-in coolers. Samples collected on Sunday or holidays will be stored in a refrigerator onsite, as the laboratory is not open that day. Samples will be delivered to the laboratory as soon as possible.

Sample container selection and sample preservation techniques will comply with U.S. EPA guidelines detailed in SW-846. Sample tags indicating sample location, date and time of sampling, and the initials of the individual who collected the sample will be attached to each sample. Each sample will be logged onto a chain-of-custody form. Copies of all chain-of-custody forms generated during the pilot study will be kept on file and available for review.

7.3 Analytical Testing

The project laboratory will perform analyses for volatile organic compounds (VOCs), ammonia-nitrogen, alkalinity, chloride, phosphate, BOD, COD, total suspended solids, total dissolved solids, turbidity, perchlorate, chlorate, chlorite, hypochlorite, chloride, ammonia, nitrate, nitrite, sulfate, sulfide, alcohols, metals, and bacteriology. The purpose of this testing is to evaluate the effectiveness and mechanisms of perchlorate reduction. Analytical testing will be conducted using the U.S. EPA approved methods. Analytical method requirements are detailed in Table 7-4. Detection limits for all parameters are below health based water quality (drinking water) standards where such standards exist.

7.4 Quality Assurance Project Plan

HLA's Quality Assurance Management Plan (QAMP) assures that appropriate measures will be taken to assure project data quality objectives (DQOs) are achieved and data integrity is maintained. In addition to DQOs, HLA's QAMP addresses methods for sample collection and handling, sample custody, the type and frequency of quality control samples, laboratory quality control procedures, methods for data verification, reduction, management and interpretation, record keeping and corrective actions.

For field activities approximately five percent of all samples will be collected as splits (duplicates). Sample splits (duplicates) and blanks will be submitted to the project laboratory on a more frequent basis during the startup period when samples are collected more frequently. Trip blanks will be used where laboratory contamination is a concern. Field blanks will be used where field contamination is a concern. Quality control samples will be collected, but less frequently during the performance monitoring period. Sample splits (duplicates) will submitted more frequently for analyses that are performed more frequently. Table 7-5 describes the type and frequency of field quality control samples. All samples will be appropriately labeled, packaged, and will be shipped to the project laboratory under chain of custody.

Analysis of samples by the project laboratory will be performed in conformance with laboratory QC procedures and QC procedures specified by each of the certified or approved analytical methods. Table 7-6 details laboratory quality control procedures and statistical analysis guidelines.

8.0 WASTE STREAM MANAGEMENT

Under approval of the Central Valley Regional Water Quality Control Board, system effluent will be discharged directly to the GET-B treatment system. At the conclusion of the study, TCLP testing will be conducted to verify the GAC does not exhibit the hazardous characteristics. After reviewing test results, the GAC will be disposed of in accordance with applicable laws and regulations.

9.0 IMPLEMENTATION TEAM AND COMMUNICATION PLAN

9.1 Implementation Team

Activities described here will be implemented by the team shown on Figure 9-1. Individuals responsible for the implementation of the activities in this Work Plan are: 1) appropriately qualified and licensed, 2) have considerable knowledge of a range of treatment technologies and experience designing and performing bench-scale and pilot-scale treatability tests, and 3) are experienced with the methods and procedures including those related to Health and Safety and Quality Assurance required to perform the proposed work.

This treatability study will be performed by a team of personnel from HLA and Aerojet under the direction of BPOUSC Co-chairpersons, Don Vanderkar and Steve Richtel.

9.2 Communication Plan

Communication during the implementation of this treatability work will be conducted in a manner to facilitate timely decision making and communication of work progress. Lines of communication are shown on Figure 9-1.

John Catts will serve as technical director for the work and be responsible for communicating work progress to the BPOUSC and U.S. EPA.

It is anticipated that work progress and results will be communicated via telephone conversations, meetings, written correspondence, and reports as described in Section 10.0.

10.0 SCHEDULE

This Work Plan was prepared within the schedule proposed by the BPOUSC in the document entitled "The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin" dated July 15, 1997 (HLA, 1997a) This Work Plan was first issued in draft form on August 26, 1997. The U.S. EPA issued comments and approved the Work Plan in a letter dated September 12, 1997. The BPOUSC issued a "Final Phase 1 Treatability Study Work Plan" on October 6, 1997. The U.S. EPA issued comments on this document in a letter dated October 16, 1997.

This "Revised Final Phase 1 Treatability Study Work Plan" incorporates changes and additions resulting from design and construction of the Phase 1 treatment system and also addresses U.S. EPA comments from both September 12, 1997 and October 16, 1997 letters.

Planning and preparation for Phase 1 treatability testing commenced in mid September 1997. Assembly of the pilot-scale bioreactor is presently in progress.

The BPOUSC will provide U.S. EPA with progress reports in the form of conference calls approximately 30 and 60 days following approval of this Work Plan. Assuming an U.S. EPA Work Plan approval date of September 12, 1997, teleconference progress reports will be held in mid-October and mid-November, 1997.

The BPOU will submit to U.S. EPA a written Phase 1 treatability testing progress report within 75 days of Work Plan approval. This progress report will contain preliminary Phase 1 results if available. In addition this progress report will contain either a Supplemental Work Plan for Phase 2 Treatability Testing or an explanation as to why additional Phase 1 testing is necessary before a Phase 2 Work Plan can be prepared, and a planned submittal date for a Phase 2 Work Plan. These recommendations may include additional testing with reversal of the air stripper and bioreactor if appropriate.

Regardless, this written progress report will serve as the basis for establishing the schedule for the balance of Phase 1 treatability testing. A schedule for Phase 1 treatability testing is

provided below with tentative completion dates for activities that will occur following the submittal of the written progress report on November 27, 1997.

Task Description	Duration from approval	Task Completion Date
Draft Phase 1 Work Plan	---	8/26/97
EPA, DHS, MWD Review	0 days	9/12/97
Progress Report (telephone)	30 days	10/12/97
Phase 1 Mobilization	45 days	10/27/97
Progress Report (telephone)	60 days	11/12/97
Written Progress Report	75 days	11/27/97
Phase 1 Testing	105 days	12/27/97
Draft Phase 1 Report	150 days	2/25/98
EPA, DHS, MWD Review	165 days	3/12/98
Final Phase 1 Report	180 days	3/25/98

11.0 REFERENCES

Attaway et al., 1994. Propellant wastewater treatment process. U.S. Patent 5,302,285.

CDM, 1996. Draft Baldwin Park Operable Unit, pre-remedial design groundwater monitoring program, pre-remedial design report, December.

Harradine et al., 1993. Oxidation chemistry of energetic materials in supercritical water. *Hazardous Waste and Hazardous Materials* 10, pp. 233-246.

HLA, 1997a. The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin, July 15, 1997.

HLA, 1997b. Final Addendum to Sampling and Analysis Plan, Pre-Remedial Design Groundwater Monitoring Program, Baldwin Park Operable Unit, San Gabriel Basin, October 1, 1997.

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Korenkov et al., 1976. Process for purification of industrial waste waters from perchlorates and chlorates. U.S. Patent 3,943,055.

Silverstein, J. and University of Colorado. Biological denitrification of water. Patent awarded 1997.

Yakevlev et al., 1973. Method for biochemical treatment of industrial wastewater. U.S. Patent 3,755,156.

TABLES

Table 7-1
Sampling and Analysis Plan
System Startup Period (Week 1)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	2/week	1/week					1/week	4
Alcohols			7/week				7/week	14
Perchlorate			7/week				7/week	14
Chlorate, Chlorite, Hypochlorite			1/week					1
Alkalinity (carbonate, bicarbonate)			1/week					1
Chloride			1/week					1
Total Phosphorus			1/week					1
Nitrogen, Ammonia			7/week				7/week	14
Nitrogen, Nitrate, Nitrite			7/week				7/week	14
Sulfate, sulfide			1/week					1
Metals[1]			1/week					1
Bacteriology[2]			1/week				1/week	2
Total Dissolved Solids			1/week					1
Total Suspended Solids			1/week					1
Turbidity			1/week					1
Biochemical Oxygen Demand			1/week					1
Chemical Oxygen Demand			7/week				7/week	14

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

Table 7-2
Sampling and Analysis Plan
System Startup Period (Week 2)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	2/week	2/week					2/week	6
Alcohols			7/week	7/week	7/week	7/week	7/week	35
Perchlorate			7/week	7/week	7/week	7/week	7/week	35
Chlorate, Chlorite, Hypochlorite			7/week	7/week	7/week	7/week	7/week	35
Alkalinity (carbonate, bicarbonate)			2/week				2/week	4
Chloride			7/week	7/week	7/week	7/week	7/week	35
Total Phosphorus			7/week				7/week	14
Nitrogen, Ammonia			7/week	7/week	7/week	7/week	7/week	35
Nitrogen, Nitrate, Nitrite			7/week	7/week	7/week	7/week	7/week	35
Sulfate, sulfide			2/week				2/week	4
Metals[1]			2/week				2/week	4
Bacteriology[2]			2/week				7/week	9
Total Dissolved Solids			2/week				2/week	4
Total Suspended Solids			2/week				2/week	4
Turbidity			2/week				2/week	4
Biochemical Oxygen Demand			2/week				2/week	4
Chemical Oxygen Demand			7/week	7/week	7/week	7/week	7/week	35

1 Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
2 Total and fecal coliform and heterotrophic plate count

Table 7-3
Sampling and Analysis Plan
Performance Monitoring Period (Weeks 3 through 8)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	1/week	1/week					1/week	18
Alcohols			7/week	1/week	1/week	1/week	7/week	102
Perchlorate			7/week	1/week	1/week	1/week	7/week	102
Chlorate, Chlorite, Hypochlorite			1/week				1/week	12
Alkalinity (carbonate/bicarbonate)			1/week				1/week	12
Chloride			1/week				1/week	12
Total Phosphorus			1/week				1/week	12
Nitrogen, Ammonia			1/week				1/week	12
Nitrogen, Nitrate, Nitrite			7/week	1/week	1/week	1/week	7/week	102
Sulfate			1/week				1/week	12
Metals[1]			1/week				1/week	12
Bacteriology[2]			1/week				1/week	12
Total Dissolved Solids			1/week				1/week	12
Total Suspended Solids			1/week				1/week	12
Turbidity			1/week				1/week	12
Biochemical Oxygen Demand			1/week				1/week	12
Chemical Oxygen Demand			1/week				1/week	12

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

Table 7-4
Analytical Method Requirements

Analytes	U.S. EPA Method	Preservative	Holding Time	Sample Container	Sample Volume	Method Detection Limit	Reporting Limit
Volatile Organic Compounds	8260	HCL-pH<2	14 days	40 ml VOA	3 x 40 mL	Varied	5 - 100 µg/L
Alcohols	8015	4°C	14 days	40 ml VOA	1 x 40 mL	Varied	100 mg/L
Perchlorate	300 (modified)	Cool 4°C	14 days	Poly	125 mL	2 ppb	5 ppb
Chlorate, Chlorite, Hypochlorite	300	4°C	14 days	Poly	100 mL	Still being determined	200,20,50 ppb
Alkalinity (carbonate/bicarbonate)	310.1	4°C	14 days	Poly	500 mL	---	5 mg/L ppm
Chloride	325.2	4°C	28 days	Poly	50 mL	0.72 ppb	1.0 mg/L ppm
Total Phosphorus	365.5	H_2SO_4	28 days	Poly	100 mL	0.04 ppb	0.3 mg/L ppm
Nitrogen, Ammonia	350.1	H_2SO_4	28 days	Poly	100 mL	0.027 ppb	0.1 mg/L ppm
Nitrogen, Nitrate, Nitrite	353.1	4°C	28 days	Poly	100 mL	0.0044 ppb	0.1 mg/L ppm
Sulfate, Sulfide	375.4	Cool 4°C	Sulfate - 28 days Sulfide - 7 days	Poly	100 mL	---	1.0 mg/L ppm
Metals[1]	6000/7000	HNO_2 - pH<2	6 months	Poly	500 mL	Varied	Varied
Bacteriology[2]	9200	Sodium Thosulfate - 4°C	24 hours	Plastic	100 mL	Varied	Varied
Total Dissolved Solids	160.1	4°C	7 days	Poly	100 mL	---	10 mg/L ppm
Total Suspended Solids	160.2	4°C	7 days	Poly	500 mL	---	5 mg/L ppm
Turbidity	180.1	4°C	2 days	Poly	50 mL	---	1 NTU
Biochemical Oxygen Demand	405.1	4°C	2 days	1L Amber	1,000 mL	---	3.0 mg/L
Chemical Oxygen Demand	410.4	HNO_2 - pH<2	28 days	Poly	50 mL	8.9 ppb	10 mg/L

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

Table 7-5
Field Quality Control Sample Schedule
(Total Samples)

Analytes	U.S. EPA Method	Week 1		Week 2		Week 3		Total Samples
		Splits	Blanks	Splits	Blanks	Splits	Blanks	
Volatile Organic Compounds	8260		2 (T)	1	1 (T)	2	3 (T)	9
Alcohols	8015	1		2	1 (T)	6	3 (T)	13
Perchlorate	300 (modified)	1		2	1 (F)	6	3 (F)	13
Chlorate, Chlorite, Hypochlorite	300			2		1		3
Alkalinity (carbonate/bicarbonate)	310.1			1		1		2
Chloride	325.2			2		1		3
Total Phosphorus	365.5			2		1		3
Nitrogen, Ammonia	350.1	1		2		1		4
Nitrogen, Nitrate, Nitrite	353.1	1		2		6		9
Sulfate, Sulfide	375.4			1		1		2
Metals[1]	6000/7000			1		1		2
Bacteriology[2]	9200			2		3		5
Total Dissolved Solids	160.1			1		1		2
Total Suspended Solids	160.2			1		1		2
Turbidity	180.1			1		1		2
Biochemical Oxygen Demand	405.1			1		1		2
Chemical Oxygen Demand	410.4	1		2		1		3

T = Trip Blank F = Field Blank

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

Table 7-6
Laboratory Quality Control Procedures

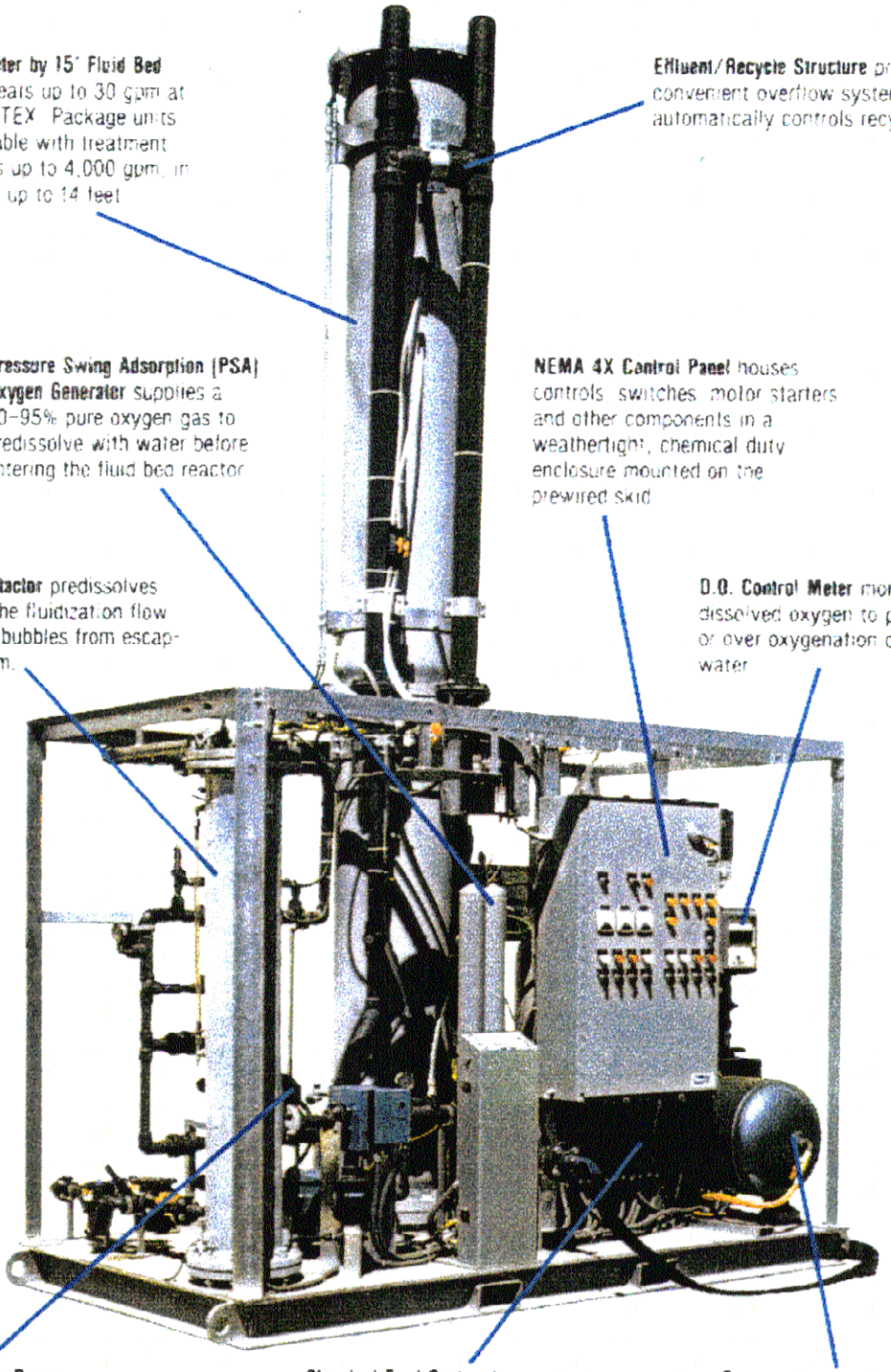
Analytes	U.S. EPA Method	Initial Calibration	Continuing Calibration	Standard	Method Blank		Matrix Spike		Matrix Spike Duplication		Laboratory Control Sample	
					Control Limit	Minimum Frequency	Control Limit (%R)	Minimum Frequency	Control Limit (RFD)	Minimum Frequency	Control Limit (%R)	Minimum Frequency
Volatile Organic Compounds	8260	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	60-140	1 per 20 samples	±30	1 per 20 samples	60-140	1 per 20 samples
Alcohols	8015	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	50-150	1 per 20 samples	±30	1 per 20 samples	50-150	1 per 20 samples
Perchlorate	300 (modified)	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	70-130	1 per 20 samples	±20	1 per 20 samples	85-115	1 per 20 samples
Chlorate, Chlorite, Hypochlorite	300	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±30	1 per 20 samples	50-150	1 per 20 samples
Alkalinity (carbonate/bicarbonate)	310.1	6 points	Every 10 samples	---	<R.L.	1 per batch	---	---	---	---	---	---
Chloride	325.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±30	1 per 20 samples	60-140	1 per 20 samples
Total Phosphorus	365.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	60-140	1 per 20 samples
Nitrogen, Ammonia	350.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples
Nitrogen, Nitrate, Nitrite	353.3	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples

Analytes	U.S. EPA Method	Initial Calibration	Continuing Calibration	Standard	Method Blank		Matrix Spike		Matrix Spike Duplication		Laboratory Control Sample	
					Control Limit	Minimum Frequency	Control Limit (%R)	Minimum Frequency	Control Limit (RFD)	Minimum Frequency	Control Limit (%R)	Minimum Frequency
Sulfate	375.4	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples
Metals[1]	6000/7000	3 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	50-150	1 per 20 samples
Bacteriology[2]	9221B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Dissolved Solids	160.1	---	---	---	<R.L.	1 per patch	---	---	---	---	---	---
Total Suspended Solids	160.2	---	---	---	<R.L.	1 per batch	---	---	---	---	---	---
Turbidity	180.1	---	---	---	---	---	---	---	---	---	---	---
Biochemical Oxygen Demand	405.1	N/A	N/A	N/A	<0.2	1 per batch	---	---	---	---	---	---
Chemical Oxygen Demand	410.4	6 points	Every 10 samples	Every 10 samples	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	---	1 per 20 samples

N/A = Not Applicable

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

FIGURES



20"-diameter by 15' Fluid Bed Reactor treats up to 30 gpm at 10 ppm BTEX. Package units are available with treatment capacities up to 4,000 gpm, in diameters up to 14 feet.

Effluent/Recycle Structure provides a convenient overflow system that automatically controls recycle.

Pressure Swing Adsorption (PSA) Oxygen Generator supplies a 90–95% pure oxygen gas to predissolve with water before entering the fluid bed reactor.

NEMA 4X Control Panel houses controls, switches, motor starters and other components in a weathertight, chemical duty enclosure mounted on the prewired skid.

O_2 Bubble Contactor predissolves oxygen into the fluidization flow and prevents bubbles from escaping the system.

D.O. Control Meter monitors system dissolved oxygen to prevent under or over oxygenation of the treated water.

Dual Fluidization Pumps ensure a steady fluidization flow to the reactor, eliminating sensitivity to fluctuations in inlet flow. The second pump provides the reliability of a prepiped spare.

Chemical Feed System for nutrient deficient groundwater includes storage tank and metering feed pump.

Compressor supplies pressurized air for feeding the PSA oxygen generator.

REFERENCE: CONTRACTOR EQUIPMENT BROCHURE

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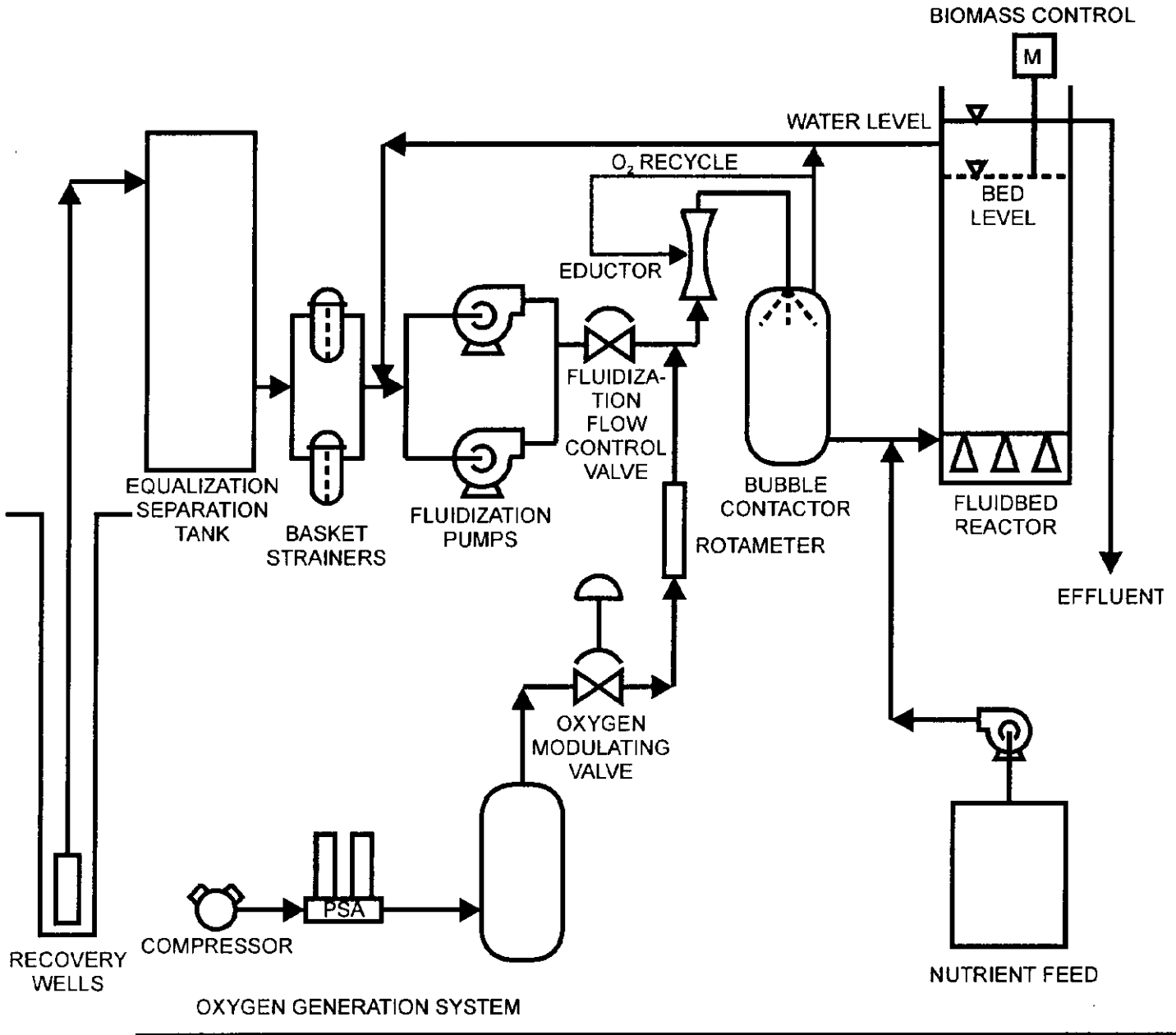
PHOTOGRAPH
Typical Contractor GAC/FB Pilot Unit

FIGURE
5-1

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	37933-003		8/97	



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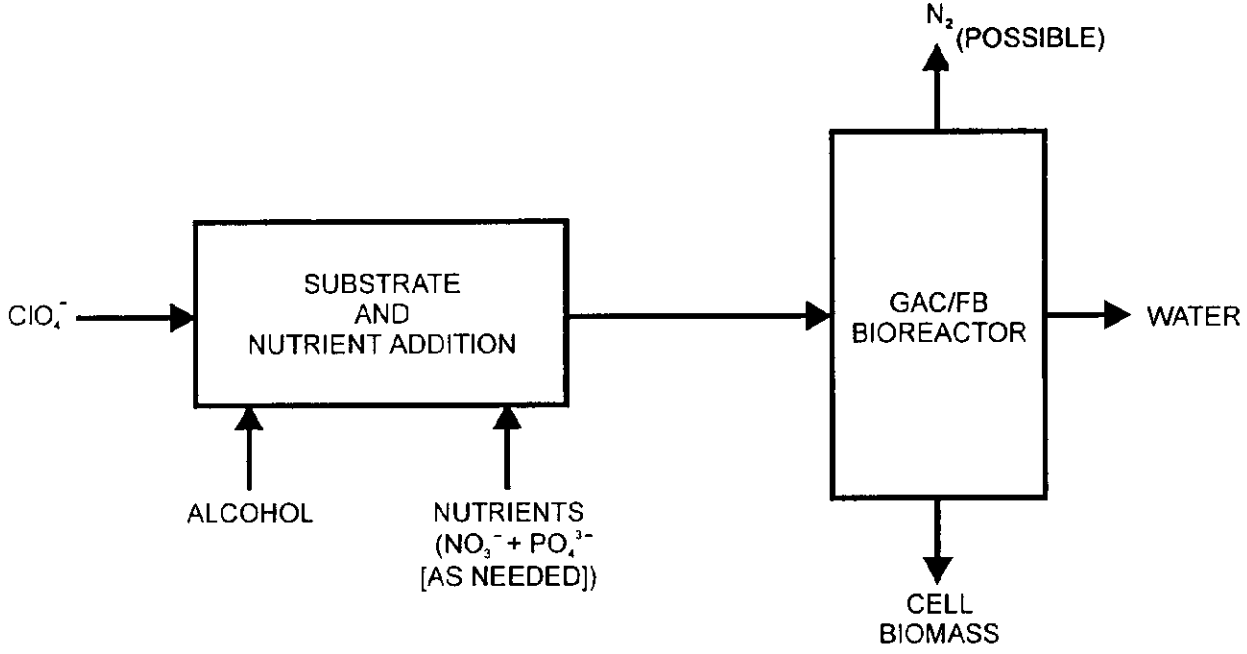
TYPICAL CONTRACTOR PROCESS AND INSTRUMENTATION DIAGRAM

FIGURE
5-2

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	37933-003		8/97	



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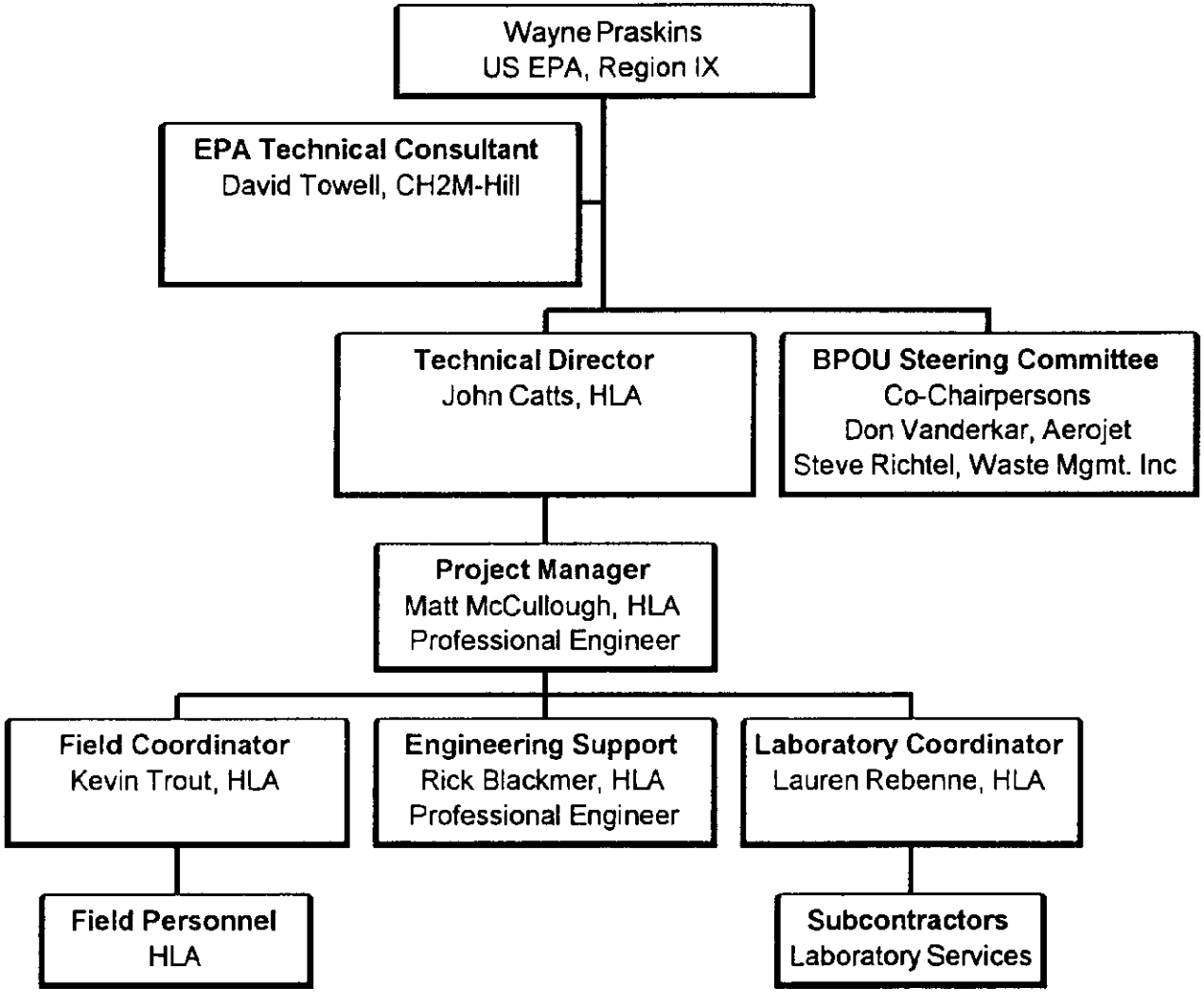
IDEALIZED MASS FLOW DIAGRAM - BIOCHEMICAL PERCHLORATE REDUCTION

FIGURE 5-3

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	37933-003		8/97	

Figure 9-1. Implementation Team



APPENDIX B

DEVIATIONS FROM FINAL PHASE 1 TREATABILITY STUDY WORK PLAN

DEVIATIONS FROM FINAL PHASE 1 TREATABILITY STUDY WORK PLAN

The following deviations/additions to the Phase I Work Plan relate to equipment used during the study:

- With the goal of providing a constant flow rate to the bioreactor, a method for controlling the water level in the reservoir at the bottom of the air stripper was developed and implemented. The influent flow rate to the air stripper was purposely set approximately 2 gallons per minute (gpm) higher than the effluent discharge from the air stipper reservoir. The water overflow drained out of the reservoir into a nearby overflow tank. When this overflow tank was full, the water was pumped back to the GET-B treatment system pond. This method for controlling the water level in the air stripper reservoir provided constant flow to the bioreactor.

- Although an ethanol dosing pump equipped with a graduated pipet was designed to measure ethanol influent, this system did not provide reliable data or dosing. The flow rate of ethanol was measured by monitoring changes in the ethanol supply drum level. This method proved to be more accurate than using the graduated pipet connected directly to the pump discharge.

- The GAC/FB bioreactor was provided as a turnkey unit and was modified to meet the needs of the study. Several of the components provided with the bioreactor were not used during the study. These components were shown in the work plan (Figures 5-1 and 5-2). The equalization tank shown in the drawing is not used, rather the air stripper reservoir serves the same purpose. The oxygen generation system, bubble contactor, and eductor will not be used during this study. However, the compressor, which is part of the oxygen generation system, was used to supply air to air-operated valves within the unit as well as the carbon separator and return system.

- The biological growth control system at the top of the reactor was automatically controlled by a timer.

- A carbon separator and return system was installed in the reactor effluent pipe.

- The sample ports were labeled in the following manner. A sample port (BS-C) was added to the undiluted groundwater supply line after the ethanol influent line. Sample collection from BS-C was performed in accordance with sampling and analysis procedures described in the Work Plan.

    1. Air stripper inlet line (Port A)

    2. Air stripper effluent line (Port B)

    3. Air stripper effluent line, post-ethanol injection, pre-mix with recirculation water (Port BS-C)

    4. GAC/FB diluted reactor inlet influent line (Port C)

    5. 25 percent of flow path in GAC/FB bioreactor (Port D)

    6. 50 percent of flow path in GAC/FB bioreactor (Port E)

7. 75 percent of flow path in GAC/FB bioreactor (Port F)

8. Effluent line from GAC/FB bioreactor (Port G)

The following deviations/additions to the Phase I Work Plan relate to treatability study operations:

- During the startup period the bioreactor was operated with 100 percent recirculated water for only 2 days, rather than 1 week as described in the work plan. It was decided that flow-through operation would provide the best environment to foster microorganism growth and attachment to the GAC. The groundwater well flow rate was increased slowly during this startup because of a concern that if the groundwater well flow rate was increased too quickly, the biomass might wash out of the system before it was completely attached to the GAC.

- The actual operational plan changed from that listed in the work plan. In the work plan there were two distinct operational periods. The startup period was to last approximately 2 weeks, and then the performance monitoring period was to last 6 weeks. The startup period actually lasted approximately 1 month. During this period influent groundwater flow was increased to 20 gpm, with stabilization between increases in flow rate. Trouble shooting of various system problems extended the startup period. The remainder of problems extended the startup period. The remainder of the testing program is considered the performance monitoring period.

- In general, a modified Week 1 sampling and analysis plan was used while attempting to establish complete destruction. It was decided that since it took longer than expected in the work plan to establish destruction, a modified sampling plan containing only the critical parameters needed to gauge performance (ethanol, perchlorate, nitrate, nitrite, phosphorus, ammonia, COD, and bacteriology) should be used. To collect additional samples for other, noncritical parameters (e.g., alkalinity, chloride, sulfate, sulfide, metals) while destruction was still being established was not efficient or economical. Typically, all of the critical parameter analyses were performed on bioreactor influent (C) and effluent (G) samples (except bacteriology, which was performed on G only). For the undiluted samples (BS-C), usually only ethanol, perchlorate, phosphorus, nitrate, and nitrite analyses were performed. Modified Week 1 sampling was performed daily, except when unforeseen circumstances, changes, or interruptions would not allow. Once complete destruction was established, detailed profile samples were collected per the work plan (Week 2) with the addition of sample collection at the BS-C port. The work plan listed 7 days of profile sampling, but 16 days' worth of profile samples were collected.

- No hypochlorite analyses were conducted because no EPA test method exists for that analysis.

- At the request of Aerojet, analyses for nitrosodimethylamine were performed on a limited basis.

- VOC analyses per EPA Method 502.2 were conducted because a lower detection limit than that obtainable from EPA Method 8260 was possible. At some points during the study, VOC analyses were conducted more frequently than listed in the work plan to specifically monitor for vinyl chloride.

APPENDIX C

DETAILED TREATMENT SYSTEM OPERATIONS CHRONOLOGY

DETAILED TREATMENT SYSTEM OPERATIONS CHRONOLOGY

This appendix provides a chronology of activities related to the startup and operation of the Phase 1 Perchlorate Treatability Study performed at the Aerojet facility in Rancho Cordova, California.

For this report, complete or 100 percent destruction is defined as occurring when the influent concentration of the compound (i.e., perchlorate, nitrate) has been reduced in the effluent to a concentration that is not detectable. Therefore, if an influent perchlorate concentration of 50 µg/L is reduced to nondetect (<4 µg/L) in the effluent, the destruction is considered to be 100 percent.

On November 5, 1997, granular activated carbon and microorganisms were added to the bioreactor and the system operated in 100 percent recirculated water mode at a flow rate of 30 gpm for 2 days. The pilot plant is designed to constantly run at a flow rate of 30 gpm through the bioreactor. System design allows the operators to vary the proportion of groundwater influent and recirculated water. With no input from the well, the system runs with 100 percent recirculated water. Groundwater flow can be increased on a continuum until the pilot plant is running a 0 percent recirculated water component.

Baseline groundwater samples were also collected and analyzed at that time. Forward flow operations began on November 7, 1997, with 83 percent recirculated water. The initial ethanol flow rate was calculated using data derived from the previous perchlorate study. The initial loading rate of the urea and diammonium phosphate nutrient mix was set according to known microbial requirements. The unit was operated at a 83 percent recirculated water for nearly 2 weeks to ensure microorganism attachment to the GAC.

The recirculating water percentage was slowly increased in 17 percent increments. Once complete perchlorate destruction was observed at a flow rate, the flow rate was increased. To assist microbial growth, batch additions of nitrate were made to the system during this time period. Three weeks after startup, the unit was operating with 33 percent recirculating water. During this time period, samples were collected per the modified Week 1 sampling schedule. Complete destruction of perchlorate to the detection limit was observed with 67, 50, and 33 percent recirculating water but was not consistent. With 83 percent recirculating water, detection of perchlorate destruction was not possible as the perchlorate concentration entering the bioreactor was diluted by recycle water to below its detection limit. On days of complete perchlorate destruction, at 67, 50, and 33 percent recirculating water, concentrations of perchlorate in the bioreactor influent averaged 8, 9, and 12 µg/L, respectively. The overall average destruction rates at 10, 15, and 20 gpm were 90 percent, 100 percent, and 74 percent, respectively. Note that only one sample set was collected with 50 percent recirculating water.

Complete nitrate destruction to its detection limit was observed with 83, 67, 50, and 33 percent recirculating water but was not consistent. Influent concentrations of nitrate varied widely because of batch nitrate addition. On days when complete nitrate destruction was obtained at 83, 67, 50, and 33 percent recirculating water, the influent nitrate concentrations averaged 0.78, 0.75, 5.3, and 6.3 mg/L, respectively. The overall average destruction rates at 10, 15, and 20 gpm were 42 percent, 100 percent, and 56 percent, respectively. Again note that only one sample set was collected with 50 percent recirculating water.

On days of complete nitrate destruction, effluent values for nitrite, the nitrate degradation product, were all nondetect. On days when nitrate destruction was less than 25 percent, detectable concentrations of nitrite ranging from 0.08 to 0.58 mg/L were observed. It was observed that significant amounts of nitrogen gas bubbles were being created at higher influent groundwater flow rates as a result of the nitrate reduction occurring in the bioreactor. Nitrogen bubbles would attach to granules of carbon/biomass, carrying the carbon/biomass out of the bioreactor. This in turn led to plugging of system piping.

During operations with 67, 50, and 33 percent recirculating water, residual effluent ethanol concentrations were high, ranging from 68 to 370 mg/L. Residual effluent phosphorus levels ranged from 0.1 to 1.3 mg/L. Bioreactor influent values of ethanol and phosphorus varied widely.

During this time period, typical effluent DO values were 0.0 or 0.1 mg/L. The pH both decreased and increased across the bioreactor. The denitrification process consumes protons, which should increase the pH across the bioreactor. Temperature increases or decreases across the reactor varied from no change to 0.9°C. The average reactor temperature was 18.2°C. ORP measurements were not taken during this time as the ORP meter obtained for the study was not functioning properly and a new meter was being ordered.

From December 2 through 4, 1997, a carbon separator and return system was installed in the bioreactor effluent pipe to minimize carbon loss from the bioreactor. During the carbon separator installation, it was noted that an unknown white, mucus-like substance had caused carbon granules to clump together in the bioreactor. Such clumping decreases surface area within the bioreactor, thereby potentially decreasing perchlorate and nitrate destruction. This substance had also been encountered during the previous perchlorate study conducted at Aerojet. The extent to which this substance is present appears to be directly related to the amount of excess ethanol added to the system. The presence of the mucus also clogged several of the reactor sample ports, making sample collection from these ports impossible on some days. For future operations, the ethanol flow rate was decreased and optimized as much as possible to minimize the presence of the white mucus.

On December 11, 1997, the nutrient source was changed from urea and diammonium phosphate to hexametaphosphate. It was thought that the denitrification process would provide enough elemental nitrogen for use by the microorganisms so that a nutrient source that provided phosphorus only would be adequate.

After carbon separator installation, the unit was started up with 33 percent recirculating water to see if the biomass could respond immediately and reestablish previous destruction. This was not possible, and so the recirculating water was increased to 83 percent to rebuild the microbial population. Complete perchlorate and nitrate destruction had been obtained at 33 percent recirculating water, and so the recirculating water was decreased to 0 percent to see if complete destruction could be established at that flow rate as well.

While the system operated with 0 percent recirculation, 4 days of reactor profile samples (per Week 2 sampling schedule) were collected. All other samples were collected per the modified Week 1 sampling schedule. Complete perchlorate destruction was never obtained, and destruction averaged 30 percent. The average influent perchlorate concentration was 37 µg/L, and the average effluent concentration was 29 µg/L.

Complete destruction of nitrate was obtained three times, but it could not be established consistently. On the 3 days of complete destruction, the nitrate bioreactor influent concentration averaged 10.6 mg/L. The overall average nitrate destruction was 75 percent. The overall average influent nitrate concentration was 11 mg/L, and the overall average effluent nitrate concentration was 2.9 mg/L. At 30 gpm, only two sample sets had nondetect effluent concentrations of nitrite. The overall average effluent nitrite concentration was 0.32 mg/L.

Influent ethanol concentrations averaged 71 mg/L, while effluent residual concentrations averaged 27 mg/L. Bioreactor influent phosphorus concentrations averaged 0.34 mg/L, while effluent residual phosphorus concentrations averaged 0.21 mg/L.

Profile sampling was not performed for a continuous week, as originally outlined in the work plan, because complete destruction could not be obtained. Until complete destruction was reestablished, no further profile sampling would be performed.

The ORP value in the effluent averaged +74 mV. A value of -200 to -300 mV was expected for typical denitrification processes but would vary with influent groundwater flow rate. The influent and effluent DO, as measured by the inline DO probes, averaged 8.8 and 0.5 mg/L, respectively. The pH increase across the reactor averaged 0.25 pH units. The average temperature change across the reactor was 0.2°C.

Complete destruction of perchlorate and nitrate could not be obtained with 0 percent recirculating water; therefore, the percent of recirculation would be increased in 17 percent increments until complete destruction could be obtained consistently. Complete destruction had been achieved previously with 33 percent recirculating water. No testing had been conducted with 17 percent recirculation, and so on December 23, 1997, the recirculation was changed to 17 percent. Samples were collected per the modified Week 1 sampling schedule. The complete destruction of nitrate and perchlorate was not obtained. Perchlorate destruction was approximately 32 percent, with influent and effluent concentrations of 35 and 25 µg/L, respectively. Nitrate destruction was approximately 60 percent, with influent and effluent concentrations of 9.5 and 3.9, respectively. Effluent nitrite concentrations averaged 1.2 mg/L. The influent and effluent ethanol concentrations were 57 and 27 mg/L, respectively. The influent and effluent phosphorus concentrations were 0.4 and 0.3 mg/L, respectively. The ORP value in the effluent averaged +28 mV. Influent and effluent DO concentrations, as measured by the inline DO probes, averaged 9 and 0.5 mg/L, respectively. The average pH increase across the reactor was 0.11 pH unit. The average temperature increase across the reactor was negligible.

Since complete perchlorate and nitrate destruction was not obtainable with 17 percent recirculation, the recirculation was increased to 33 percent on December 28, 1997. Since complete destruction had been obtained before at this flow rate on December 1 and 2, 1997, it was anticipated that it would be obtained again. Samples were collected per the modified Week 1 sampling schedule.

From December 29, 1997, to January 23, 1998, complete perchlorate destruction was obtained only once, with the destruction averaging 34 percent. The overall average influent and effluent concentrations were 33 and 23 µg/L, respectively.

Complete nitrate destruction was never obtained. Nitrate destruction averaged 79 percent, with the average influent and effluent concentrations at 11 and 2.5 µg/L, respectively. The average

effluent nitrite concentration was 0.60 mg/L, with only one sample result below the standard detection limit.

At the time, it was thought that one potential reason that complete perchlorate and nitrate destruction could not be established was the loss of carbon from the bioreactor. Due to carbon carryover the settled bed height, which began at 7 feet, had decreased to 5 ½ feet. Carbon was added to the reactor to bring the settled bed height back to its original height. Samples collected soon after showed that this addition of carbon had no effect on destruction. For the remainder of the study, the settled bed height was checked routinely and carbon was added when needed.

Ethanol influent and effluent concentrations averaged 177 and 156 mg/L, respectively. The ethanol addition rate was increased to see if this would help achieve complete reduction of both nitrate and perchlorate since previous performance with 33 percent recirculation had been achieved at high ethanol loading rates. The increased ethanol led to the generation of additional mucous but did not improve destruction. The bioreactor had to be probed regularly to break apart coagulated mucus and carbon and to ensure that the bed fluidization properties were as good as possible.

At that time it was thought that a potential reason for not establishing complete destruction was that the hexametaphosphate nutrient mix did not provide enough elemental nitrogen to support the microorganisms as was originally anticipated. The hexametaphosphate source was removed and replaced with the original nutrient source of urea and diammonium phosphate on December 31, 1997. However, the change in nutrients did not improve destruction. After switching to the original nutrient source. influent and effluent phosphorus concentrations averaged 0.43 and 0.42 mg/L, respectively.

The ORP value in the effluent averaged -103 mV. From January 13 through 23, 1998, the ORP fell to an average of -209 mV; however, nitrate or perchlorate destruction did not improve. DO influent and effluent concentrations, as measured by inline DO probes, averaged 5.6 and 0.3 mg/L, respectively. When complete destruction was obtained previously with 33 percent recirculation, effluent DO concentrations averaged 0.05 mg/L. The average pH increase across the reactor was 0.23 pH unit. The average temperature increase across the reactor was negligible.

Near the end of the operation, it was decided that DO profiles within the reactor would be taken to see where most of the DO was being depleted. A DO profile was completed by directly lowering the DO probe inside the reactor and recording DO concentrations as the probe traversed from the bottom to the top of the reactor. While this was done temperature measurements were also taken with the DO probe as they would be more accurate than temperature measurements taken through the D, E, and F sampling ports.

After ruling out ethanol and nutrient addition and proper bed fluidization as potential reasons for the nonattainment of complete destruction with 33 percent recirculation, a fourth hypothesis for nonattainment was developed. This hypothesis was that the DO loading might be too high for the biomass to both consume available free oxygen and degrade perchlorate and nitrate. To test this theory, the air stripper was taken offline on January 24, 1998, effectively decreasing the undiluted influent DO from a range of 8 to 10 mg/L to about 1 mg/L.

With the air stripper removed, the recirculation was set at 33 percent on January 24, 1998. Samples were collected per the modified Week 1 sampling schedule. Complete nitrate and

perchlorate destruction was obtained within 2 days. For the next 3 days, perchlorate destruction averaged 100 percent. The average influent perchlorate concentration was 28 µg/L.

The nitrate destruction also averaged 100 percent. The average influent nitrate concentration was 10.7 mg/L. The average effluent nitrite concentration was 0.05 mg/L.

The influent ethanol concentrations averaged 110 mg/L, while effluent residual concentrations averaged 96 mg/L. Bioreactor influent phosphorus concentrations averaged 0.52 mg/L, while effluent residual phosphorus concentrations averaged 0.42 mg/L.

The ORP value in the effluent averaged -228 mV. The influent and effluent DO, as measured by inline DO probes, averaged 0.7 and 0.1 mg/L, respectively. The pH increase across the reactor averaged 0.56 pH unit. The average temperature change across the reactor was negligible.

With complete perchlorate and nitrate destruction achieved with 33 percent recirculating water, the recirculation was decreased to 17 percent on January 28, 1998. Samples were collected per the modified Week 1 and Week 2 profile sampling schedules. Six sets of profile samples were collected on different days from January 28 to February 6, 1998.

Complete nitrate and perchlorate destruction was obtained within 1 day after reducing the recirculating water. For the next 8 days, perchlorate destruction averaged 100 percent. The average influent perchlorate concentration was 28 µg/L.

The nitrate destruction also averaged 100 percent. The average influent nitrate concentration was 14.4 mg/L. Nitrite was nondetect, at the standard detection limit of 0.03 mg/L, in every bioreactor effluent sample collected over this time period.

The influent ethanol concentrations averaged 86 mg/L, while effluent residual concentrations averaged 27 mg/L. Bioreactor influent phosphorus concentrations averaged 0.68 mg/L, while effluent residual phosphorus concentrations averaged 0.46 mg/L.

The ORP value in the effluent averaged -298 mV. The influent and effluent DO, as measured with the handheld DO probe inside the bioreactor, averaged 0.45 and 0.09 mg/L, respectively. The pH increase across the reactor averaged 0.58 pH unit. The average temperature change across the reactor was negligible.

With complete perchlorate and nitrate destruction established regularly, particular attention was now paid to how the biomass would affect chlorinated VOCs (e.g., TCE, 1,1-DCE) traveling through the bioreactor. It was unsure how VOCs would be destroyed and whether or not highly toxic VOCs such as vinyl chloride would be generated as a result of interaction with the biomass. No detectable concentrations (at a detection limit of 0.1 µg/L) of vinyl chloride were present in any effluent sample collected over this time period. Chlorinated VOCs were regularly reduced to varying degrees by either adsorption to the carbon, biomass activity, or a combination of the two. At this point in time, the reason for reduced VOC concentrations across the bioreactor is unknown.

The successful run with 17 percent recirculating water was cut short when a storm caused a major power outage at the site on February 7, 1998. The unit remained completely shutdown until power was restored to site on February 10, 1998.

Once power was restored to the site, the system was started up again, and the recirculating water was gradually decreased from 50 to 17 percent. For the next month the system was operated with recirculating water at 17 percent. The majority of samples were collected per the modified Week 1 and Week 2 profile sample schedules (six sets of profiles were collected). During the last 2 weeks of operations, testing was conducted to find the point at which complete destruction was lost after continually reducing the ethanol addition rate. During this testing, the Weeks 3 through 8 sample schedule listed in the work plan was used.

Within 2 days after startup, complete destruction of perchlorate and nitrate was obtained with 33 percent recirculation. The recirculation was then decreased to 17 percent, where it remained. Within 1 day of the change in flow rate, complete destruction was achieved with 17 percent recirculation. The unit had to be shutdown again over another weekend on February 21 and 22, 1998, due to Aerojet construction. The unit was restarted on February 23, 1998, and samples were collected approximately 2 and 8 hours after startup. Complete nitrate destruction was observed in both samples; however, complete perchlorate destruction was observed only in the 2-hour sample. The 8-hour effluent sample perchlorate result rose slightly above the detection limit to 5 µg/L.

From February 13 through March 1, 1998, perchlorate destruction averaged 99 percent with 17 percent recirculation. Complete perchlorate destruction was not obtained on three occasions, when the effluent concentration rose slightly above the detection limit to 5.1 µg/L once and 5.5 µg/L twice. The average influent perchlorate concentration was 38 µg/L, and the average effluent concentration was 4.4 µg/L (assuming a concentration equal to that of the detection limit for nondetect results).

Nitrate destruction averaged 100 percent over this period of time. The average influent nitrate concentration was 12.8 mg/L. Nitrite was nondetect, at the standard detection limit of 0.03 mg/L, in every bioreactor effluent sample collected over this time period.

Influent ethanol concentrations averaged 83 mg/L, while effluent residual concentrations averaged 8 mg/L. Bioreactor influent phosphorus concentrations averaged 0.63 mg/L, while effluent residual phosphorus concentrations averaged 0.49 mg/L.

The ORP value in the effluent averaged -280 mV. The influent and effluent DO, as measured with the handheld DO probe inside the bioreactor, averaged 0.43 and 0.14 mg/L, respectively. The pH increase across the reactor averaged 0.44 pH unit. The average temperature change across the reactor was negligible.

On February 25, 1998, the ethanol loading rate began to be reduced to find the point at which complete perchlorate and nitrate destruction was incomplete. This was done in an attempt to maximize destruction while minimizing the ethanol usage and the concentration of ethanol in the system effluent. By March 3, 1998, perchlorate destruction was incomplete (92 percent). As the influent concentration of ethanol was decreased to approximately 50 mg/L, perchlorate (and soon after nitrate) destruction was observed to be incomplete. Therefore, the range of ethanol concentrations at which perchlorate and nitrate destruction is incomplete lies between 50 to 70 mg/L. The ethanol was then increased in an attempt to reestablish complete destruction. This attempt was aborted because the air stripper had to be brought back online to remove VOCs from the groundwater as Aerojet's groundwater treatment system at the treatment pond was shutdown. The overall average perchlorate destruction during the ethanol testing was 85 percent, with average influent and effluent concentrations of 39 and 9 µg/L, respectively.

With incomplete perchlorate destruction, the ORP value in the effluent increased to an average of -185 mV. The influent and effluent DO, as measured with the handheld DO probe inside the bioreactor, averaged 0.40 and 0.09 mg/L, respectively. The pH increase across the reactor averaged 0.86 pH unit. The average temperature change across the reactor was negligible.

By March 13, 1998, the effluent ORP was -228 mV with a decreasing trend toward the average ORP value of -280 mV, observed prior to the initiation of ethanol testing. On March 13, 1998, Aerojet determined that effluent from the bioreactor could no longer be discharged into the GET-B system since it was to be decommissioned. The system was shutdown and batch additions of ethanol and nutrients were added to maintain the microorganism population.

On March 16, 1998 the unit was restarted on well water with the air stripper on the front (influent) end of the bioreactor. By March 19, 1998, complete destruction of perchlorate and nitrate was obtained with 66 percent recirculation. This was achieved at a bioreactor influent ethanol concentration of approximately 30 mg/L.

These adjustments affected the influent and effluent pH by raising them by approximately 1.3 and 0.50 pH units, respectively. The temperatures at the influent and effluent ports increased by approximately 1.2 °C. The effluent ORP averaged -240 mV during this period. The influent DO concentration increased by approximately 2 mg/L and the effluent DO was not affected.

The recirculation was decreased to 50 percent on March 25, 1998, in an attempt to determine the maximum flow rate at which complete removal of perchlorate could be sustained with the air stripper on the front end of the bioreactor. By the next day the effluent perchlorate had increased to 56.0 µg/L and the effluent ORP increased to -61.5 mV. This was apparently due to a lack of ethanol. The ethanol flow problem was solved on March 30, 1998. Immediately the effluent perchlorate and nitrate concentrations were nondetect.

Bioreactor performance producing effluent free from detectable perchlorate and nitrate continued until the recirculation was decreased to 33 percent on April 4, 1998. After a week of running at 33 percent recirculation and not achieving perchlorate and nitrate removal, the recirculation was increased to 50 percent on April 11, 1998. The perchlorate concentration from April 4 through April 30, 1998, averaged 10.4 µg/L, and the ORP averaged approximately 150 mV, at which time almost no biomass was present on the granular activated carbon (GAC). It was decided to cease operations and attempt to reestablish the biomass population.

On May 1, 1998, the unit was set to 100 percent recycle and batch additions of ethanol and nutrients were made. This continued for 3 days. The unit was restarted on well water with the air stripper on the front (influent) end of the bioreactor on May 4, 1998, at a recirculation of 66 percent. By May 7, 1998, both perchlorate and nitrate concentrations were nondetect. The complete removal of perchlorate and nitrate continued through May 19, 1998.

The unit was set to 100 percent recycle on May 19, 1998, and TCE was added to the bioreactor by means of the ethanol metering pump. On May 22, 1998 the TCE addition was complete. The unit was restarted on May 23, 1998, with the air stripper on the back (effluent) end of the bioreactor. It ran intermittently through June 8, 1998, due to mechanical and electrical problems

Continuous operation of the unit restarted on June 8, 1998. By June 10 complete removal of perchlorate and nitrate was reestablished at 33 percent recirculation. This continued through June 17, 1998. On June 9, 1998, the TCE concentration was decreased from 430 µg/L to 220 µg/L

across the bioreactor, a removal of 51 percent. This was probably due to flushing of excess TCE from the system and not degradation. From June 10 to June 19, 1998, the average influent bioreactor TCE concentration was 216 µg/L. The average effluent bioreactor TCE concentration was 183 µg/L, yielding an average removal of TCE of 15 percent.

TCLP and Priority Pollutant sampling was performed on the carbon/biomass that was extracted from the bioreactor prior to shutdown on June 19, 1998. The TCLP was performed on the carbon/biomass combined for disposal purposes. The Priority Pollutants analyses were performed on the biomass only, which was leached from the carbon in the laboratory. These analyses were performed to characterize the biomass to establish disposal requirements for the Phase 2 Treatability Study. Based on Aerojet's analysis of the laboratory results, it was determined that the carbon/biomass could be disposed of as nonhazardous.

The Phase 1 Perchlorate Treatability Study was terminated on June 23, 1998, at which time demobilization began. First, the carbon/biomass was pumped from the bioreactor using the diaphram pump that had been used by the carbon seperator. This continued to the following morning. Following this, the remainder of the water from the equilization tank, air stripper sump, and carbon separator were pumped to the GET-B pond. Next, the air stripper and trays were disassembled and pressure washed. On June 25, 1998, demobilization continued with pressure washing of the bioreactor skid and the bioreactor. HLA subcontractors arrived onsite on June 26, 1998 to disassemble the electrical system and the plumbing. The plumbing and electrical was completely disassembled by mid-day on June 29, 1998.

On June 30, 1998 the bioreactor skid, the air stripper and the air scrubber were loaded onto trucks and removed from the site. Demobilization was completed on July 1, 1998, when an Aerojet electrician made the final wire disconnection from the company's panel. Aerojet disposed of the carbon/biomass was left onsite in two 55-gallon drums and placed in a secondary containment unit and the remainder of the ethanol that was in two 55-gallon drums.

APPENDIX D

LABORATORY ANALYTICAL DATA SUMMARY

Phase I Perchlor eatability Study
Laboratory Analy sults Summary

	DATE SAMPLED	11/5/97	11/6/97	11/7/97	11/8/97	11/9/97	11/10/97	11/11/97	11/12/97	11/13/97	11/14/97	11/15/97	11/15/97 Even.	11/16/97	11/16/97 Even.	11/17/97	11/17/97 Even.	11/18/97
	INFLUENT GW FLOWRATE (GPM)	-	-	5.1	-	3.8	3.6	3.5	4.1	3.8	4.0	3.8	-	3.9	-	4.0	-	4.3
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	94	-	32	17	21	30	33	<10	<10	-	<10	-	<10	-	33
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	61	-	24	20	24	22	23	<10	<10	-	<10	-	<10	-	21
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	<10	-	<10	<10	<10	<10	<10	<10	<10	-	-	-	<10	-	<10
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	<10	-	<10	<10	<10	<10	<10	<10	<10	-	-	-	<10	-	<10
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Perchlorate (ug/l)	-	-	<4	-	<4	<4	<4	<4	<4	<4	<4	-	<4	-	<4	-	<4
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	-	<4	-	<4	<4	<4	<4	<4	<4	<4	-	<4	-	<4	-	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	<2/<0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	-	1.60	-	1.10	1.30	1.30	0.91	14.00	2.30	2.40	-	8.40	-	3.60	-	0.94
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	-	1.60	-	1.20	1.30	1.20	0.88	13.00	2.30	2.70	-	6.70	-	3.50	-	1.1
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	2.70	-	0.15	0.48	0.26	0.41	0.46	9.60	4.10	-	15.00	-	2.50	-	<0.1
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	2.80	-	<0.1	0.17	0.29	0.19	0.21	8.90	3.60	-	2.20	-	3.70	-	<0.1
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	13.0	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	10	-	3.3	<0.1	<0.1	<0.1	0.63	11	8.4	1.8	<0.1	2.1	4.3	2.0	0.22
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	11	-	2.2	<0.1	<0.1	<0.1	<0.1	10	7.5	2.6	0.46	0.48	3.3	2.6	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	<0.03	-	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	0.19	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	0.21	-	0.13	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	0	absent	0	-	-	0	-	0	-	0
Air Strip. Infl. (A)	Coliform (MPN/100ml)	absent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	2.0	present	1.0	-	-	present	-	present	-	3.1
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	1027	2783	3630	-	-	8730	-	9970	-	2739
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	<1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	<3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	210	-	81	120	81	88	86	11	<10	-	29	-	<10	-	<10
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	210	-	70	72	72	79	97	11	<10	-	11	-	<10	-	<10
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	11/18/97 Even.	11/19/97	11/19/97 Even.	11/20/97	11/21/97	11/22/97	11/23/97	11/24/97	11/25/97	11/26/97	11/27/97	11/28/97	11/29/97	11/30/97	12/1/97	12/2/97	12/3/97
	INFLUENT GW FLOWRATE (GPM)	-	4.4	-	10.1	9.8	-	-	10.9	10.6	15.2	-	20.1	-	20.2	20.7	19.6	-
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	180	-	200	94	-	-	46	51	120	-	<10	-	440	220	140	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	120	-	130	23	-	-	34	59	110	-	<10	-	460	120	140	-
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	36	-	180	<10	-	-	<10	<10	68	-	<10	-	370	120	100	-
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	<10	-	<10	<10	-	-	<10	<10	<10	-	<10	-	<10	<10	<10	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	23	-	<10	<10	-	-	<10	<10	<10	-	<10	-	12	<10	<10	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	<10	-	<10	<10	-	-	<10	<10	<10	-	<10	-	17	<10	<10	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Perchlorate (ug/l)	-	<4	-	<4	7.6	-	-	8.1	11	9	-	<4	-	<4	9.9	14	-
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	<4	-	<4	<4	-	-	<4	6.2	<4	-	<4	-	<4	<4	<4	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	3.1	-	1.3	0.33	-	-	0.41	0.46	0.48	-	0.46	-	0.65	0.14	0.20	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	3.7	-	1.3	0.27	-	-	0.37	0.38	0.36	-	0.77	-	0.48	0.10	0.10	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	0.63	-	0.26	0.19	-	-	<0.1	<0.1	0.10	-	0.77	-	0.13	0.11	0.32	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	0.47	-	0.12	0.10	-	-	<0.1	<0.1	<0.1	-	1.00	-	0.15	<0.1	0.21	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	-	9.2	12	-	-	11	12	12	-	12	-	15	11	11	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	<0.1	1.3	0.97	0.75	4.5	-	-	8.9	9.4	5.30	-	8.90	-	<0.1	5.9	6.6	-
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	<0.1	<0.1	<0.1	<0.1	2.8	-	-	7.8	7.9	<0.1	-	6.70	-	<0.1	<0.1	<0.1	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	-	<0.03	<0.03	-	-	<0.03	<0.03	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	<0.03	0.13	-	-	0.10	0.25	0.07	-	0.33	-	<0.03	<0.03	0.08	-
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	0.08	0.34	<0.03	-	0.58	-	<0.03	<0.03	<0.03	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	absent	-	0	0	-	-	0	0	0	-	-	-	1	0	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	present	-	8.7	1.0	-	-	2.0	9.9	2.0	-	-	-	>200.5	1.0	2.0	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	7300	-	5382	2371	-	-	2373	1816	1375	-	-	-	5381	2372	2164	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	140	-	200	53	-	-	55	53	160	-	11	-	600	270	410	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	140	-	190	51	-	-	<10	<10	130	-	14	-	590	260	410	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	12/4/97	12/5/97	12/6/97	12/7/97	12/8/97	12/9/97	12/10/97	12/11/97	12/12/97	12/13/97	12/14/97	12/15/97	12/16/97	12/17/97	12/18/97	12/19/97	12/20/97
	INFLUENT GW FLOWRATE (GPM)	-	20.5	20.0	-	-	5.0	-	29.9	29.9	29.4	29.6	29.0	29.4	30.0	29.4	28.3	28.6
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	130	110	-	-	190	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	110	110	-	-	200	-	87	84	48	50	78	82.0	84.0	65.0	<5	110.0
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	44.0	32.0	24.0	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	8.5	<5	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<5	8.5	20.0	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	100	78	-	-	190	-	37	50	<10	<10	12	6.0	7.2	<5	30.0	73.0
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	<10	<10	-	-	<10	-	-	-	-	-	-	<5	<5	-	-	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	<10	<10	-	-	<10	-	-	-	-	-	-	<5	<5	<5	<5	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	<5	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<5	<5	<5	<5	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	50	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Perchlorate (ug/l)	-	55	44	-	-	-	-	41	39	40	40	36	42.0	34.0	35.0	34.0	34.0
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	29.0	31.0	31.0	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<4	<4	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	28.0	27.0	25.0	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	36.0	<20	-	-	-	-	27	34	40	29	24	25.0	26.0	28.0	30.0	30.0
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	0.074/<0.02	0.076/<0.02	<0.076/<0.02	0.074/<0.02	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	0.054/<0.02	0.046/<0.02	0.031/<0.02	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	0.041/<0.02	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	0.04/<0.02	<0.02/<0.02	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	0.043/<0.02	<0.02/<0.02	<0.02/<0.02	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-	100.0	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	150.0	-	-	140.0	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	5.6	5.9	6.8	6.9	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	6.1	5.7	6.8	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9	6.9	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	6.3	5.8	6.8	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	6.3	5.7	6.8	6.9	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	0.17	0.54	-	-	-	-	<0.05	0.46	0.28	0.27	0.26	0.25	0.25	0.41	0.47	0.43
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	0.10	0.69	-	-	-	-	<0.05	0.37	0.15	0.17	0.15	0.13	0.15	0.27	0.27	0.31
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	0.31	0.28	-	-	-	-	0.14	<0.1	<0.1	<0.1	<0.1	0.20	<0.1	<0.1	<0.1	<0.1
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	0.10	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	0.17	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	<0.1	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	0.45	0.28	-	-	-	-	0.82	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	11	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	8.2	9.8	-	-	-	-	11	14	0.21	13	13	11.00	10.00	11.00	8.90	10.00
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	8.40	<0.1	4.60	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	2.30	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	7.1	5.7	-	-	-	-	7.9	9.5	2	<0.1	0.64	0.55	<0.1	2.40	<0.1	3.90
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	<0.03	<0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	0.15	<0.03	-	-	-	-	0.04	<0.03	0.051	<0.03	<0.03	<0.03	0.12	<0.03	<0.03	<0.03
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	0.44	<0.03	0.12	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.03	<0.03	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<0.03	<0.03	0.23	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	0.5	<0.03	-	-	-	-	0.53	0.33	1.6	0.034	0.18	0.17	<0.03	0.26	<0.03	0.28
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	15.0	-	-	12/<1.0	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	17.0	-	-	16/<1.0	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	0	-	-	-	-	-	0	0	-	0	1	0	-	0	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	0.0	-	-	0.0	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	2.0	-	-	-	-	-	1.0	1.0	-	0.0	1.0	1.0	0.0	1.0	1.0	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	373	-	-	1862	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	1306	-	-	-	-	-	760	320	-	1237	1118	571	1012	2784	11440	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	260.0	-	-	300.0	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	260.0	-	-	260.0	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-	<5	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-	<5	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	-	2.0	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	-	2.3	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	67.0	-	-	4.3	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	8.0	-	-	4.8	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	130	110	-	-	-	-	100	120	110	91	100	110.0	87.0	110.0	<10	200.0
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	94.0	80.0	69.0	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	96.0	120.0	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	49.0	54.0	65.0	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	110	87	-	-	-	-	98	98	69	52	52	52.0	56.0	74.0	56.0	120.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	12/21/97	12/22/97	12/23/97	12/24/97	12/25/97	12/26/97	12/27/97	12/28/97	12/29/97	12/30/97	12/31/97	1/1/98	1/2/98	1/3/98	1/4/98	1/5/98	1/6/98
	INFLUENT GW FLOWRATE (GPM)	28.9	29.0	29.1	25.1	-	24.0	-	20.0	20.1	20.6	20.3	-	19.5	20.7	-	19.5	20.0
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	-	64.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	75.0	82.0	-	57.0	-	59.0	-	-	88.0	-	61.0	-	61.0	-	-	67.0	-
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	34.0	47.0	-	27.0	-	27.0	-	-	55.0	-	28.0	-	44.0	-	-	42.0	-
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	-	-	<5	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	11.0	12.0	-	<5	-	-	-	-	<5	-	<5	-	<5	-	-	<5	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	11.0	11.0	-	<5	-	-	-	-	<5	-	<5	-	<5	-	-	<5	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	-	34.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Perchlorate (ug/l)	35.0	38.0	-	35.0	-	-	-	-	35.0	-	31.0	-	34.0	-	-	39.0	-
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	26.0	26.0	-	25.0	-	28.0	-	-	23.0	-	19.0	-	23.0	-	-	26.0	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	0.051/<0.02	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	0.34	0.27	-	0.40	-	-	-	-	0.18	-	0.16	-	0.31	-	-	0.27	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	0.21	0.17	-	0.30	-	-	-	-	0.13	-	0.09	-	0.16	-	-	0.13	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	<0.1	<0.1	-	<0.1	-	-	-	-	<0.1	-	<0.1	-	0.27	-	-	0.19	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	<0.1	<0.1	-	<0.1	-	-	-	-	<0.1	-	<0.1	-	0.11	-	-	<0.1	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	-	13.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	8.80	10.00	-	9.50	-	-	-	-	12.00	-	13.00	-	9.70	-	-	10.00	-
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	2.00	4.70	-	3.90	-	3.30	-	-	3.70	-	2.40	-	1.70	-	-	1.50	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	-	<0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	0.033	-	-	0.12	-	-	-	-	0.27	-	0.35	-	0.27	-	-	0.12	-
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	0.39	-	-	0.76	-	1.60	-	-	0.76	-	1.00	-	0.87	-	-	0.29	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	0	-	0	-	-	-	-	0	-	-	-	-	-	-	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	3.1	0.0	-	3.1	-	-	-	-	5.3	-	0.0	-	0.0	-	-	109.1	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	981	1320	-	12480	-	-	-	-	1780	-	1280	-	1083	-	-	1532	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	140.0	150.0	-	100.0	-	-	-	-	130.0	-	-	-	170.0	-	-	130.0	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	110.0	120.0	-	63.0	-	-	-	-	110.0	-	98.0	-	110.0	-	-	110.0	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

Phase I Perchlor eatability Study
Laboratory Analy esults Summary

	DATE SAMPLED	1/7/98	1/8/98	1/9/98	1/10/98	1/11/98	1/12/98	1/13/98	1/14/98	1/15/98	1/16/98	1/17/98	1/18/98	1/19/98	1/20/98	1/21/98	1/22/98	1/23/98	1/24/98
	INFLUENT GW FLOWRATE (GPM)	20.8	20.1	20.0	20.0	19.0	19.2	19.5	19.2	19.8	20.0	-	20.1	19.5	19.5	20.0	-	20.6	20.2
SAMPLING PORT	ANALYTES																		
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	220.0	-	260.0	300.0	-	260.0	-	180.0	240.0	280.0	-	170.0	220.0	260.0	200.0	-	150.0	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	220.0	-	180.0	240.0	-	270.0	-	210.0	240.0	220.0	-	140.0	260.0	230.0	230.0	-	110.0	-
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	200.0	-	200.0	210.0	-	310.0	-	190.0	190.0	180.0	-	130.0	200.0	220.0	220.0	-	75.0	-
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	11.0	-	15.0	10.0	-	17.0	-	5.4	5.1	-	-	<5	-	5.8	<5	-	<5	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	11.0	-	12.0	12.0	-	13.0	-	5.9	5.8	-	-	5.8	-	5.3	5.7	-	<5	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	10.0	-	16.0	9.5	-	8.9	-	5.8	6.1	5.2	-	6.4	5.6	5.3	5.3	-	<5	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	37.0	-	36.0	38.0	-	36.0	-	42.0	36.0	37.0	-	40.0	43.0	44.0	40.0	-	53.0	-
Bioreactor Influent (C)	Perchlorate (ug/l)	31.0	-	38.0	35.0	-	28.0	-	36.0	37.0	33.0	-	<4	30.0	29.0	38.0	-	28.0	-
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	20.0	-	14.0	18.0	-	21.0	-	25.0	19.0	20.0	-	21.0	31.0	31.0	33.0	-	22.0	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	0.12	-	0.10	0.11	-	0.12	-	0.12	0.10	0.12	-	0.10	0.08	0.10	0.10	-	0.11	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	0.27	-	0.09	0.08	-	0.12	-	0.60	0.48	0.22	-	0.97	0.93	0.56	0.50	-	0.61	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	0.14	-	0.05	0.08	-	0.08	-	0.25	0.27	0.41	-	2.30	0.71	0.38	0.43	-	0.48	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	0.29	-	<0.1	0.12	-	0.21	-	0.99	0.56	0.56	-	0.72	0.82	0.58	0.60	-	0.53	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.12	-	<0.1	0.10	-	<0.1	-	0.13	0.19	0.13	-	0.73	0.96	0.77	0.79	-	0.51	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	13.00	-	14.00	15.00	-	15.00	-	14.00	17.00	17.00	-	17.00	17.00	18.00	15.00	-	17.00	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	11.00	-	11.00	9.70	-	12.00	-	14.00	12.00	12.00	-	<0.1	13.00	14.00	12.00	-	11.00	-
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	0.90	-	2.50	<0.1	-	2.20	-	1.80	2.40	2.30	-	<0.1	4.70	6.50	6.50	-	0.92	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	<0.03	-	<0.1	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	0.12	-	0.25	0.18	-	0.20	-	0.19	0.17	0.22	-	<0.03	0.23	0.41	0.39	-	0.14	-
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	0.28	-	0.66	0.52	-	0.52	-	0.56	0.51	0.59	-	<0.03	0.76	0.99	1.10	-	0.37	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	-		-	-	-	-	0	0	-	-	0	0	0	0	-	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	12.4	-	0.0	-	-	0.0	-	1.0	8.7	0.0	-	>200.5	1.0	1.0	49.2	-	2.0	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	1101	-	6500	-	-	353	-	2123	4319	5723	-	6786	6786	5100	60	-	5700	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	380.0	-	430.0	230.0	-	360.0	-	370.0	430.0	370.0	-	360.0	440.0	450.0	450.0	-	230.0	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	350.0	-	430.0	220.0	-	200.0	-	330.0	400.0	430.0	-	390.0	450.0	450.0	420.0	-	190.0	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	1/25/98	1/26/98	1/27/98	1/28/98	1/29/98	1/30/98	1/31/98	2/1/98	2/2/98	2/3/98	2/4/98	2/5/98	2/6/98	2/7/98	2/8/98	2/9/98	2/10/98
	INFLUENT GW FLOWRATE (GPM)	19.8	20.0	20.0	25.0	25.0	25.5	25.8	25.9	25.0	24.2	26.4	25.1	24.9	24.5	0.0	0.0	0.0
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	100.0	120.0	120.0	100.0	110.0	83.0	-	-	99.0	120.0	110.0	-	92.0	-	-	-	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	110.0	100.0	120.0	110.0	98.0	71.0	-	100.0	95.0	97.0	76.0	-	40.0	-	-	-	-
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	68.0	-	-	-	-	-	36.0	-	<5	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	37.0	-	-	-	-	-	7.4	-	<5	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	50.0	-	-	-	-	-	19.0	-	<5	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	84.0	81.0	120.0	55.0	53.0	30.0	-	20.0	18.0	23.0	14.0	-	<5	-	-	-	-
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	-	<5	-	-	-	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	-	<5	-	-	-	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	<5	-	<5	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	<5	-	<5	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	<5	-	<5	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	-	<5	-	-	-	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	48.0	52.0	54.0	51.0	36.0	25.0	-	-	57.0	35.0	28.0	-	38.0	-	-	-	-
Bioreactor Influent (C)	Perchlorate (ug/l)	36.0	21.0	27.0	33.0	<4	18.0	-	20.0	29.0	35.0	27.0	-	41.0	-	-	-	-
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	<4	-	-	<4	<4	<4	13.0	-	17.0	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	<4	-	-	<4	<4	<4	<4	-	<4	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	<4	-	-	<4	<4	<4	<4	-	<4	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	<4	<4	<4	<4	<4	<4	-	<4	<4	<4	<4	-	<4	-	-	-	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	-	0.067/<0.02	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	-	<0.02/<0.02	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	-	<0.02/<0.02	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	-	<0.02/<0.02	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	-	<0.02/<0.02	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	-	<0.02/<0.02	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	100.0	-	-	-	-	-	110.0	-	100.0	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	110.0	-	-	-	-	-	120.0	-	120.0	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	150.0	-	-	-	-	-	150.0	-	150.0	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	9.5	-	-	-	-	-	9.0	-	8.5	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	8.5	-	-	-	-	-	7.5	-	5.0	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	8.0	-	-	-	-	-	7.0	-	8.2	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	7.3	-	-	-	-	-	9.5	-	7.2	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	7.5	-	-	-	-	-	9.3	-	8.0	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	8.5	-	-	-	-	-	10.0	-	7.2	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	0.10	0.09	0.10	0.10	0.11	0.09	-	-	0.09	0.10	0.12	-	0.10	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	0.47	0.49	0.59	0.78	0.62	0.84	-	0.75	0.53	0.57	0.79	-	0.52	-	-	-	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	0.37	0.42	0.46	0.54	0.43	0.60	-	0.53	0.34	0.35	0.55	-	0.34	-	-	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	<0.1	-	-	-	-	-	0.16	-	<0.1	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	0.59	0.80	0.98	0.73	0.59	0.78	-	0.66	0.51	0.59	0.72	-	0.62	-	-	-	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	0.58	-	-	-	-	-	0.62	-	0.73	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	0.52	-	-	-	-	-	0.60	-	0.61	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	0.55	-	-	-	-	-	0.59	-	0.64	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.82	1.10	1.40	0.70	0.57	0.55	-	0.54	0.29	0.44	0.73	-	0.75	-	-	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	18.00	17.00	22.00	17.00	17.00	22.00	-	-	18.00	17.00	18.00	-	19.00	-	-	-	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	10.00	11.00	11.00	15.00	14.00	14.00	-	16.00	15.00	14.00	13.00	-	14.00	-	-	-	-
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	0.66	-	-	<0.1	<0.1	2.60	0.41	-	2.60	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	1.40	-	-	<0.1	-	<0.1	<0.1	-	<0.1	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	-	-	-	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	<0.03	<0.03	<0.03	-	<0.03	-	-	-	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	<0.03	0.05	0.12	0.04	<0.03	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	-	-	-	-
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	0.32	-	-	<0.03	<0.03	0.61	0.36	-	0.51	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	-	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	-	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	0.10	<0.03	<0.03	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	-	-	-	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	16 / <1	-	-	-	-	-	16/<1	-	17/<1	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	16 / <1	-	-	-	-	-	15/<1	-	15/<1	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	15 / <1	-	-	-	-	-	11/<1	-	11/<1	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	0	-	-	-	-	-	-	-	0	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	0	-	0	0	-	-	0	0	0	0	-	0	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	0.0	-	0.0	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	6.4	-	-	-	-	-	88.5	-	109.4	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	34.4	0.0	42.9	13.7	>200.5	-	>200.5	>200.5	>200.5	>200.5	-	25.4	-	-	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	373	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	674	-	590	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	6011	-	-	-	-	-	4721	-	509	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	6923	3713	3113	7321	952	-	637	5311	7321	3511	-	18	-	-	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	300.0	-	-	-	-	-	310.0	-	290.0	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	300.0	-	-	-	-	-	290.0	-	280.0	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	280.0	-	-	-	-	-	260.0	-	260.0	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	<5	-	-	-	-	-	<5	-	<5	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	9.0	-	-	-	-	-	<5	-	<5	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	12.0	-	-	-	-	-	11.0	-	6.0	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	10.0	-	-	-	-	-	2.0	-	<1	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	1.5	-	-	-	-	-	4.5	-	1.8	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	10.0	-	-	-	-	-	18.0	-	13.0	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	48.0	-	-	-	-	-	96.0	-	87.0	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	53.0	-	-	-	-	-	63.0	-	54.0	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	48.0	-	-	-	-	-	43.0	-	54.0	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	270.0	-	-	-	-	-	160.0	-	160.0	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	300.0	330.0	320.0	300.0	300.0	200.0	-	240.0	280.0	350.0	130.0	-	140.0	-	-	-	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	390.0	-	-	-	-	-	130.0	-	72.0	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	250.0	-	-	-	-	-	140.0	-	65.0	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	230.0	-	-	-	-	-	120.0	-	74.0	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	270.0	290.0	280.0	250.0	240.0	170.0	-	190.0	160.0	300.0	230.0	-	65.0	-	-	-	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	74	-	76	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	75	-	69	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	75	-	74	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	2/11/98	2/12/98	2/13/98	2/14/98	2/15/98	2/16/98	2/17/98	2/18/98	2/19/98	2/20/98	2/21/98	2/22/98	2/23/1998; 2 h after start up	2/23/1998; 6 h after start up	2/24/98	2/25/98
	INFLUENT GW FLOWRATE (GPM)	14.0	25.0	25.1	-	25.2	-	25.2	25.6	25.1	25.5	-	-	25.0	25.3	25.0	25.0
SAMPLING PORT	ANALYTES																
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	120.0	120.0	87.0	-	130.0	-	96.0	96.0	110.0	93.0	-	-	86.0	98.0	-	98.0
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	86.0	85.0	-	96.0	-	100.0	82.0	84.0	84.0	-	-	69.0	85.0	-	100.0
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	40.0	37.0	-	25.0	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	<5	<5	-	5.1	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	<5	<5	-	<5	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	24.0	19.0	-	13.0	-	6.2	7.6	10.0	<5	-	-	<5	6.2	-	<5
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	<5	<5	<5	-	<5	-	<5	<5	<5	<5	-	-	<5	<5	-	<5
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	<5	<5	-	<5	-	<5	<5	<5	<5	-	-	<5	<5	-	<5
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	<5	-	<5	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	<5	-	<5	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	<5	-	<5	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	<5	<5	-	<5	-	<5	<5	<5	<5	-	-	<5	<5	-	<5
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	39.0	27.0	-	36.0	-	41.0	38.0	48.0	43.0	-	-	62.0	60.0	-	31.0
Bioreactor Influent (C)	Perchlorate (ug/l)	-	30.0	29.0	-	30.0	-	41.0	33.0	47.0	36.0	-	-	62.0	49.0	-	30.0
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	<4	-	12.0	13.0	-	13.0	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	<4	-	<4	<4	-	<4	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	<4	-	<4	5.6	-	6.6	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	<4	<4	-	<4	-	5.1	<4	5.5	<4	-	-	<4	5.5	-	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	0.0611/<0.02	0.0625/<0.02		0.0611/<0.02	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	0.0523/<0.02	0.0545/<0.02		0.0534/<0.02	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	<0.02/<0.02		<0.02/<0.02	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	<0.02/<0.02		<0.02/<0.02	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	<0.02/<0.02		<0.02/<0.02	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	<0.02/<0.02		<0.02/<0.02	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	100.0	100.0	-	100.0	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	110.0	100.0	-	120.0	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	150.0	150.0	-	160.0	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	8.2	9.5	-	11.0	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	8.0	7.5	-	8.2	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	7.3	8.0	-	8.0	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	16.0	9.3	-	15.0	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	8.5	7.7	-	7 0	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	10.0	7.3	-	9.0	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	0.10	0.11	-	0.09	-	0.10	0.11	0.42	0.14	-	-	0.11	0.17	-	0.11
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	0.62	0.17	-	0.39	-	1.00	1.60	0.87	0.36	-	-	0.47	0.50	-	0.74
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	0.19	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	0.19	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	0.40	0.62	-	0.21	-	0.85	1.10	0.59	0.20	-	-	0.26	0.28	-	0.40
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	<0.1	<0.1	-	<0.1	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	0.93	0.92	-	0.39	-	1.30	0.94	0.75	0.40	-	-	0.40	0.38	-	0.86
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	4.80	2.80	-	0.19	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	8.90	6.40	-	0.23	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	8.50	4.30	-	0.23	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	1.00	1.10	-	0.16	-	7.90	4.70	0.76	0.22	-	-	0.22	0.18	-	1.30
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	13.00	13.00	-	14.00	-	14.00	12.00	14.00	13.00	-	-	13.00	13.00	-	13.00
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	8.00	11.00	-	13.00	-	12.00	11.00	13.00	11.00	-	-	12.00	11.00	-	11.00
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	<0.1	-	0.25	0.70	-	<0.1	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	<0.1	-	<0.1	<0.1	-	<0.1	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	<0.1	-	<0.1	<0.1	-	<0.1	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	<0.1	<0.1	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	-	<0.1	<0.1	-	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	<0.03	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	-	<0.03	<0.03	-	<0.03
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	0.14	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	-	<0.03	<0.03	-	<0.03
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	-	<0.03	0.03	-	<0.03	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	-	<0.03	<0.03	-	<0.03	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	-	<0.03	<0.03	-	<0.03	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	<0.03	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	-	<0.03	<0.03	-	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	16/<1.0	16/<1	-	16/<1	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	16/<1.0	15/<1	-	15/<1	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	18/<1.0	15/<1	-	14/<1	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	ND	-	-	0	0	-	0
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	>200.5	0.0	-	0.0	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	>200.5	>200.5	-	>200.5	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	>200.5	>200.5	-	-	-	0.0	>200.5	>200.5	>200.5	-	-	>200.5	>200.5	-	>200.5
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	2279	-	-	3185	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	2311	-	-	7056	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	3720	1375	-	-	-	1721	-	868	1540	-	-	211@.1	211@.1	-	211@.1
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	270.0	300.0	-	290.0	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	280.0	290.0	-	290.0	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	280.0	250.0	-	270.0	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5	<5	-	<5	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5	<5	-	<5	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	6.7	<5	-	6.3	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	<1	<1	-	<1	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	3.5	3.0	-	4.2	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	25.0	21.0	-	34.0	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	100.0	81.0	-	100.0	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	86.0	83.0	-	57.0	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	120.0	32.0	-	120.0	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	170.0	130.0	-	140.0	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	130.0	120.0	-	140.0	-	150.0	120.0	150.0	140.0	-	-	140.0	140.0	-	130.0
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	93.0	63.0	-	67.0	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	93.0	65.0	-	74.0	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	82.0	52.0	-	72.0	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	100.0	65.0	-	80.0	-	84.0	61.0	82.0	72.0	-	-	93.0	78.0	-	76.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	81	74	-	72	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	74	71	-	76	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	75	73	-	75	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	2/26/98	2/27/98	2/28/98	3/1/98	3/2/98	3/3/98	3/4/98	3/5/98	3/6/98	3/7/98	3/8/98	3/9/98	3/10/98	3/11/98	3/12/98	3/13/98	3/14/98
	INFLUENT GW FLOWRATE (GPM)	24.9	25.0	-	25.5	25.3	24.5	25.8	24.8	25.0	-	26.1	26.6	25.5	25.0	25.4	25.0	-
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	63.0	-	73.0	-	83.0	91.0	91.0	-	-	-	76.0	-	110.0	120.0	160.0	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	77.0	-	51.0	-	54.0	74.0	78.0	-	-	-	33.0	-	120.0	120.0	100.0	-
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	22.0	-	-	-	-	-	-	-	-	39.0	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	9.7	-	-	-	-	-	-	-	-	25.0	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	13.0	-	-	-	-	-	-	-	-	24.0	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	<5	-	<5	-	6.0	14.0	15.0	-	-	-	18.0	-	40.0	36.0	21.0	-
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	<5	-	<5	-	<5	<5	<5	-	-	-	<5	-	7.4	<5	6.9	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	<5	-	<5	-	<5	<5	<5	-	-	-	<5	-	<5	<5	<5	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	<5	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	<5	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	<5	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	<5	-	<5	-	<5	<5	<5	-	-	-	<5	-	<5	5.0	<5	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	<5	-	6.8	-	<5	5.1	<5	-	-	-	<5	-	7.2	7.4	8.3	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	<5	-	19.0	-	<5	<5	<5	-	-	-	<5	-	8.1	7.7	7.8	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	9.0	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	9.1	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	8.3	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	<5	-	12.0	-	<5	<5	<5	-	-	-	<5	-	10.0	9.4	8.3	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	27.0	-	38.0	-	34.0	37.0	35.0	-	-	-	46.0	-	52.0	48.0	43.0	-
Bioreactor Influent (C)	Perchlorate (ug/l)	-	29.0	-	34.0	-	40.0	29.0	35.0	-	-	-	35.0	-	40.0	40.0	40.0	-
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	12.0	-	-	-	-	-	-	-	-	22.0	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	5.6	-	-	-	-	-	-	-	-	7.9	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	13.0	-	-	-	-	-	-	-	-	16.0	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	<4	-	<4	-	6.7	8.3	7.2	-	-	-	9.4	-	9.8	12.0	13.0	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	0.0743/<0.02	-	-	-	-	-	-	-	-	0.068/<0.02	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	0.0672/<0.02	-	-	-	-	-	-	-	-	0.056/<0.02	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	<0.02/<0.02	-	-	-	-	-	-	-	-	<0.02/<0.02	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	99.0	-	-	-	-	-	-	-	-	110.0	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	110.0	-	-	-	-	-	-	-	-	110.0	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-	170.0	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	9.0	-	-	-	-	-	-	-	-	8.8	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	11.0	-	-	-	-	-	-	-	-	6.8	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	8.0	-	-	-	-	-	-	-	-	9.0	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	0.10	-	0.10	-	-	0.10	-	-	-	-	-	-	-	-	0.08	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	0.66	-	0.57	-	-	0.60	-	-	-	-	-	-	-	-	0.64	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	0.48	-	0.44	-	-	0.49	-	-	-	-	-	-	-	-	0.41	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	-	<0.1	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	0.69	-	0.73	-	-	0.55	-	-	-	-	-	-	-	-	0.69	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	3.70	-	-	-	-	2.00	-	-	-	-	-	-	-	-	1.10	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	14.00	-	15.00	-	16.00	16.00	14.00	-	-	-	16.00	-	16.00	16.00	16.00	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	23.00	-	13.00	-	13.00	14.00	13.00	-	-	-	12.00	-	13.00	13.00	13.00	-
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	2.10	-	-	-	-	-	-	-	-	0.65	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-	-	<0.1	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-	-	<0.1	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	<0.1	-	<0.1	-	<0.1	0.25	0.20	-	-	-	0.14	-	<0.1	<0.1	<0.1	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	-	-	-	<0.03	-	<0.03	<0.03	<0.03	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	<0.03	-	0.11	-	0.12	0.10	0.08	-	-	-	0.07	-	0.05	0.05	0.06	-
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	0.58	-	-	-	-	-	-	-	-	0.36	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-	-	<0.03	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	0.26	-	-	-	-	-	-	-	-	<0.03	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	<0.03	-	<0.03	-	0.41	0.30	0.36	-	-	-	0.24	-	0.07	<0.03	<0.03	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	16/<1	-	-	-	-	-	-	-	-	14/<1	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	14/<1	-	-	-	-	-	-	-	-	13/<1	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	11/<1	-	-	-	-	-	-	-	-	9.7/<1	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	0	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	0	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	0	-	-	0	-	-	-	-	-	-	-	-	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	0.0	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	109.1	-	-	-	-	-	-	-	-	73.8	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	>200.5	-	-	165.2	-	-	-	-	-	-	-	-	118.4	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	138@.1	-	-	-	-	-	-	-	-	8931	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	211@.1	-	-	-	-	-	-	-	-	7630	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	217@.1	-	-	-	-	-	-	-	-	9711	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	280.0	-	-	-	-	-	-	-	-	290.0	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	270.0	-	-	-	-	-	-	-	-	290.0	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	260.0	-	-	-	-	-	-	-	-	270.0	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	<5	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	<5	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5	-	-	-	-	-	-	-	-	<5	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	<1	-	-	-	-	-	-	-	-	<1	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	<1	-	-	-	-	-	-	-	-	1.3	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	2.1	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	84.0	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	96.0	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	95.0	-	-	-	-	-	-	-	-	110.0	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	110.0	-	78.0	-	-	89.0	-	-	-	-	-	-	-	-	95.0	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	52.0	-	28.0	-	-	36.0	-	-	-	-	-	-	-	-	38.0	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	3/15/98	3/16/98	3/17/98	3/18/98	3/19/98	3/20/98	3/21/98	3/22/98	3/23/98	3/24/98	3/25/98	3/26/98	3/27/98	3/28/98	3/29/98	3/30/98	3/31/98	4/1/98
	INFLUENT GW FLOWRATE (GPM)	-	9.9	10.3	10.3	10.0	10.1	10.0	10.0	9.9	10.8	14.8	-	15.4	-	-	15.3	14.7	14.7
SAMPLING PORT	ANALYTES																		
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	100.0	14.0	97.0	74.0	-	97.0	83.0	-	100.0	100.0	52.0	-	-	84.0	-	66.0
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	31.0	8.7	27.0	24.0	-	38.0	39.0	-	18.0	21.0	< 5.0	-	-	14.0	-	40.0
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	26.0	11.0	14.0	14.0	-	18.0	17.0	-	< 5.0	< 5.0	< 5.0	-	-	< 5.0	-	12.0
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	-	<5	<5	<5	<5	-	<5	<5	-	< 5.0	< 5.0	< 5.0	-	-	< 5.0	-	<5
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	<5	<5	<5	<5	-	<5	<5	-	< 5.0	< 5.0	< 5.0	-	-	< 5.0	-	<5
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	<5	<5	<5	<5	-	<5	<5	-	< 5.0	< 5.0	< 5.0	-	-	< 5.0	-	<5
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	9.7	6.1	8.1	7.5	-	9.7	8.1	-	9.5	7.4	6.7	-	-	-	-	8.3
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	9.4	<5	9.3	8.0	-	9.2	9.0	-	7.1	6.8	< 5.0	-	-	-	-	8.1
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	10.0	7.6	8.3	7.7	-	8.6	8.3	-	< 5.0	< 5.0	< 5.0	-	-	-	-	7.9
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	75.0	70.0	58.0	61.0	-	59.0	71.0	-	70.0	52.0	78.0	-	-	65.0	-	58.0
Bioreactor Influent (C)	Perchlorate (ug/l)	-	-	21.0	26.0	25.0	31.0	-	11.0	28.0	-	39.0	55.0	56.0	-	-	61.0	-	23.0
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	-	7.7	6.3	<4	<4	-	<4	7.9	-	5.0	18.0	56.0	-	-	52.0	-	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	0.11	0.12	0.11	0.11	-	0.11	0.11	-	0.11	0.11	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	-	2.10	1.80	1.60	1.30	-	2.00	1.10	-	1.20	1.20	-	-	-	-	-	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	-	2.20	1.80	1.60	1.40	-	1.90	1.10	-	1.10	1.00	-	-	-	-	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	3.80	3.90	4.10	3.00	-	6.40	3.80	-	2.20	3.20	-	-	-	-	-	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	4.70	4.20	5.30	4.20	-	9.10	5.30	-	3.00	6.40	-	-	-	-	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	18.00	17.00	18.00	17.00	-	17.00	17.00	-	13.00	17.00	-	-	-	-	-	17.00
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	5.20	5.00	6.30	5.70	-	5.40	5.60	-	6.70	8.20	-	-	-	-	-	<0.1
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	-	0.20	< 0.10	-	-	-	-	-	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	<0.03	-	< 0.03	< 0.03	-	-	-	-	-	0.037
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	0.31	0.28	0.06	0.06	-	0.08	0.05	-	0.12	0.38	-	-	-	-	-	<0.03
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	<0.03	<0.03	<0.03	<0.03	-	<0.03	<0.03	-	0.12	0.19	-	-	-	-	-	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	0	0	0	0	-	0	0	-	0	0	-	-	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-	>200.5	>200.5	>200.5	>200.5	-	>200.5	>200.5	-	> 200.5	> 200.5	-	-	-	-	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-	7513	6400	7800	6700	-	1300	2011	-	3711	2713	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	140.0	38.0	55.0	75.0	-	71.0	77.0	-	58.0	54.0	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	42.0	32.0	30.0	54.0	-	60.0	58.0	-	18.0	12.0	-	-	-	-	-	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	4/2/98	4/3/98	4/4/98	4/5/98	4/6/98	4/7/98	4/8/98	4/9/98	4/10/98	4/11/98	4/12/98	4/13/98	4/14/98	4/15/98	4/16/98	4/17/98	4/18/98	4/19/98
	INFLUENT GW FLOWRATE (GPM)	14.8	15.1	19.8	19.9	19.6	-	19.2	19.3	17.5	15.0	-	-	15.3	15.2	15.4	15.0	15.5	15.0
SAMPLING PORT	ANALYTES																		
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	63.0	70.0	100.0	76.0	85.0	-	230.0	250.0	57.0	-	55.0	-	75.0	53.0	-	110.0	-	110.0
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	39.0	38.0	78.0	71.0	63.0	-	120.0	110.0	45.0	-	35.0	-	9.9	26.0	-	80.0	-	69.0
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	12.0	17.0	37.0	42.0	36.0	-	56.0	61.0	12.0	-	<5	-	<5	<5	-	54.0	-	38.0
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	-	<5	<5	<5	-	<5	-	<5	<5	-	<5	-	<5
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	-	<5	<5	<5	-	<5	-	<5	<5	-	<5	-	<5
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	-	<5	<5	<5	-	<5	-	<5	<5	-	<5	-	<5
Undiluted GW (BS)	Isopropyl alcohol mg/l	8.5	8.9	9.7	8.6	8.7	-	15.0	<5	<5	-	<5	-	<5	<5	-	5.1	-	11.0
Bioreactor Influent (C)	Isopropyl alcohol mg/l	7.9	8.2	9.1	9.0	8.9	-	<5	6.4	<5	-	<5	-	<5	<5	-	14.0	-	14.0
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	7.5	7.9	8.6	8.9	8.8	-	<5	7.2	<5	-	<5	-	<5	<5	-	10.0	-	7.0
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	52.0	46.0	50.0	44.0	43.0	-	37.0	44.0	47.0	-	52.0	-	51.0	58.0	-	55.0	-	51.0
Bioreactor Influent (C)	Perchlorate (ug/l)	15.0	41.0	30.0	32.0	33.0	-	32.0	29.0	31.0	-	26.0	-	27.0	40.0	-	34.0	-	29.0
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	<4	8.9	7.5	9.8	5.0	-	10.0	11.0	14.0	-	15.0	-	<4	21.0	-	9.5	-	5.2
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	0.12	-	-	-	-	-	-	-	0.11	-	-	-	-	0.12	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	1.70	-	-	-	-	-	-	-	0.42	-	-	-	-	1.20	-	-	-	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	1.40	-	-	-	-	-	-	-	0.24	-	-	-	-	1.10	-	-	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	17.00	-	-	17.00	-	-	-	16.00	-	-	-	-	18.00	-	15.00	-	15.00
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	7.80	-	-	8.40	-	-	-	11.00	-	-	-	-	9.00	-	6.50	-	7.30
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	<0.1	-	-	<0.1	-	-	-	0.11	-	-	-	-	<0.1	-	<0.1	-	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	<0.03	-	-	<0.03	-	-	-	<0.03	-	-	-	-	<0.03	-	<0.03	-	<0.03
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	0.14	-	-	0.42	-	-	-	0.09	-	-	-	-	0.27	-	0.10	-	0.09
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	0.12	-	-	<0.03	-	-	-	0.14	-	-	-	-	0.48	-	<0.03	-	0.13
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	4/20/98	4/21/98	4/22/98	4/23/98	4/24/98	4/25/98	4/26/98	4/27/98	4/28/98	4/29/98	4/30/98	5/1/98	5/2/98	5/3/98	5/4/98	5/5/98	5/6/98	5/7/98
	INFLUENT GW FLOWRATE (GPM)	16.0	15.9	16.0	-	15.0	15.0/9.8	8.7	10.0	10.2	9.7	9.7				9.8	8.7	9.1	9.9
SAMPLING PORT	ANALYTES																		
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	120.0	100.0	94.0	110.0	100.0	-	130.0	120.0	88.0	110.0	120.0	-	-	-	170.0	140.0	-	150.0
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	47.0	59.0	74.0	78.0	94.0	-	55.0	31.0	41.0	44.0	32.0	-	-	-	86.0	74.0	-	52.0
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	33.0	27.0	39.0	28.0	42.0	-	27.0	16.0	13.0	13.0	18.0	-	-	-	110.0	62.0	-	54.0
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	<5	-	-	-	5.8	5.8	-	11.0
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	<5	-	-	-	7.2	5.5	-	9.9
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	<5	-	-	-	7.0	6.6	-	13.0
Undiluted GW (BS)	Isopropyl alcohol mg/l	7.0	9.3	<5	5.9	<5	-	<5	5.4	<5	<5	<5	-	-	-	<5	<5	-	5.8
Bioreactor Influent (C)	Isopropyl alcohol mg/l	6.9	24.0	<5	<5	5.2	-	5.1	<5	<5	<5	<5	-	-	-	24.0	<5	-	5.2
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	7.7	15.0	<5	<5	<5	-	5.4	5.4	<5	<5	<5	-	-	-	30.0	7.1	-	7.3
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	55.0	55.0	54.0	53.0	56.0	-	54.0	57.0	58.0	59.0	54.0	-	-	-	66.0	61.0	-	59.0
Bioreactor Influent (C)	Perchlorate (ug/l)	16.0	38.0	35.0	35.0	39.0	-	22.0	30.0	31.0	31.0	25.0	-	-	-	44.0	41.0	-	16.0
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	<4	17.0	17.0	17.0	19.0	-	8.3	15.0	12.0	13.0	4.0	-	-	-	32.0	25.0	-	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	0.11	-	-	-	0.11	-	-	-	-	-	0.12	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	-	-	-	0.76	-	-	-	0.89	-	-	-	-	-	2.80	-	-	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	-	-	-	0.54	-	-	-	0.78	-	-	-	-	-	4.00	-	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	< 0.1	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	1.50	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	1.40	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	15.00	-	-	16.00	-	-	-	18.00	-	-	-	-	-	18.00	17.00	-	16.00
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	7.30	-	-	8.20	-	-	-	4.40	-	-	-	-	-	13.00	6.70	-	1.70
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	<0.1	-	-	<0.1	-	-	-	<0.1	-	-	-	-	-	12.00	2.30	-	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	<0.03	-	-	<0.03	-	-	-	<0.03	-	-	-	-	-	<0.03	<0.03	-	<0.03
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	0.09	-	-	0.10	-	-	-	0.11	-	-	-	-	-	0.78	1.90	-	0.99
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	0.13	-	-	0.14	-	-	-	<0.03	-	-	-	-	-	1.20	2.60	-	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	5/8/98	5/9/98	5/10/98	5/11/98	5/12/98	5/13/98	5/14/98	5/15/98	5/16/98	5/17/98	5/18/98	5/19/98	5/20/98	5/21/98	5/22/98	5/23/98	5/24/98
	INFLUENT GW FLOWRATE (GPM)	9.7		10.1	9.8	9.9	10.0	10.1	9.7		9.9	9.8	-	-	-	-	15.2	15.0
SAMPLING PORT	ANALYTES																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	130.0	97.0	130.0	21.0	42.0	100.0	-	140.0	38.0	-	-	-	-	-	-
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	43.0	63.0	45.0	17.0	<5	20.0	-	30.0	30.0	-	-	-	-	-	-
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	44.0	50.0	45.0	24.0	<5	15.0	-	27.0	29.0	-	-	-	-	-	-
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	-	< 5.0	10.0	<5	<5	<5	<5	-	6.0	<5	-	-	-	-	-	-
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	< 5.0	10.0	<5	<5	<5	<5	-	<5	<5	-	-	-	-	-	-
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	< 5.0	11.0	<5	<5	<5	<5	-	<5	<5	-	-	-	-	-	-
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	10.0	6.7	13.0	<5	<5	14.0	-	19.0	5.3	-	-	-	-	-	-
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	8.0	6.4	7.9	6.4	<5	6.6	-	8.7	8.4	-	-	-	-	-	-
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	10.0	8.5	9.7	8.2	<5	6.0	-	7.7	9.3	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	57.0	51.0	67.0	52.0	62.0	61.0	-	60.0	58.0	-	-	-	-	-	-
Bioreactor Influent (C)	Perchlorate (ug/l)	-	-	<4	23.0	<4	4.2	17.0	<4	-	<4	<4	-	-	-	-	-	-
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	-	<4	<4	<4	<4	<4	<4	-	<4	<4	-	-	-	-	-	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	8.1	-	-	-	-	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	0.16	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	-	-	-	0.52	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	-	-	-	0.58	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	17.00	14.00	17.00	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	2.20	4.80	1.20	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	<0.1	<0.1	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	<0.03	<0.03	<0.03	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	1.00	0.08	0.52	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	<0.03	<0.03	<0.03	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

	DATE SAMPLED	5/25/98	5/26/98	5/27/98	6/8/98	6/9/98	6/10/98	6/11/98	6/12/98	6/13/98	6/14/98	6/15/98	6/16/98	6/17/98
	INFLUENT GW FLOWRATE (GPM)			26.0	19.9	19.8	19.9	20.0	19.9	20.1	20.3			19.9
SAMPLING PORT	ANALYTES													
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	<5	-	100.0	88.0	88.0	160.0	-	120.0	110.0	110.0	130.0
Bioreactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	<5	-	88.0	90.0	79.0	36.0	-	48.0	56.0	61.0	52.0
Bioreactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	<5	-	50.0	42.0	23.0	15.0	-	<5	13.0	12.0	8.9
Undiluted GW (BS)	Alcohols, Methanol (mg/l)	-	-	<5	-	<5	<5	14.0	<5	-	<5	<5	<5	<5
Bioreactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	<5	-	<5	<5	<5	<5	-	<5	<5	<5	<5
Bioreactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	<5	-	<5	<5	<5	<5	-	<5	<5	<5	<5
Undiluted GW (BS)	Isopropyl alcohol mg/l	-	-	<5		<5	11.0	10.0	7.4		5.3	8.0	<5	5.3
Bioreactor Influent (C)	Isopropyl alcohol mg/l	-	-	<5		<5	12.0	11.0	<5		<5	5.0	<5	<5
Bioreactor 1/4 (D)	Isopropyl alcohol mg/l	-	-											
Bioreactor 1/2 (E)	Isopropyl alcohol mg/l	-	-											
Bioreactor 3/4 (F)	Isopropyl alcohol mg/l	-	-											
Bioreactor Effluent (G)	Isopropyl alcohol mg/l	-	-	<5		<5	14.0	8.3	<5		5.2	7.0	<5	<5
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	48.0	-	51.0	16.0	48.0	46.0	-	52.0	51.0	48.0	52.0
Bioreactor Influent (C)	Perchlorate (ug/l)	-	-	58.0	-	43.0	13.0	26.0	<4	-	43.0	30.0	37.0	36.0
Bioreactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Perchlorate (ug/l)	-	-	42.0	-	32.0	<4	<4	<4	-	<4	<4	<4	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Effl. (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	100.0	-	-
Undiluted GW (BS)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	8.2	-	-
Undiluted GW (BS)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	0.11	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Total Phosphorus (mg/l)	-	-	0.68	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Total Phosphorus (mg/l)	-	-	0.77	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-											
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-											
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	17.00		15.00			15.00		16.00	15.00	15.00	19.00
Bioreactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	16.00		9.90			8.90		9.50	8.20	6.50	8.80
Bioreactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-											
Bioreactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-											
Bioreactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-											
Bioreactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	14.00		0.58			<0.2		<0.1	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-											
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-											
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	<0.03		<0.03			<0.2		<0.03	<0.03	<0.03	<0.03
Bioreactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	<0.03		0.17			<0.2		0.11	0.47	0.50	0.13
Bioreactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-											
Bioreactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-											
Bioreactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-											
Bioreactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	<0.03		0.46			<0.2		<0.03	<0.03	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-									15.0		
Undiluted GW (BS)	Sulfate, Sulfide (mg/l)	-	-											
Bioreactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-											
Bioreactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-											
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-											
Undiluted GW (BS)	Fecal Coliform (MPN/100ml)	-	-											
Bioreactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-											
Bioreactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-											
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-											
Undiluted GW (BS)	Coliform (MPN/100ml)	-	-											
Bioreactor Influent (C)	Coliform (MPN/100ml)	-	-											
Bioreactor Effluent (G)	Coliform (MPN/100ml)	-	-											
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-											
Undiluted GW (BS)	Bacteria (CFU/ml)	-	-											
Bioreactor Influent (C)	Bacteria (CFU/ml)	-	-											
Bioreactor Effluent (G)	Bacteria (CFU/ml)	-	-											
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-									250.0		
Undiluted GW (BS)	Total Dissolved Solids (mg/l)	-	-											
Bioreactor Influent (C)	Total Dissolved Solids (mg/l)	-	-											
Bioreactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-											
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-											
Undiluted GW (BS)	Total Suspended Solids (mg/l)	-	-											
Bioreactor Influent (C)	Total Suspended Solids (mg/l)	-	-											
Bioreactor Effluent (G)	Total Suspended Solids (mg/l)	-	-											
Air Strip. Infl. (A)	Turbidity (NTU)	-	-											
Undiluted GW (BS)	Turbidity (NTU)	-	-											
Bioreactor Influent (C)	Turbidity (NTU)	-	-											
Bioreactor Effluent (G)	Turbidity (NTU)	-	-											
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-											
Undiluted GW (BS)	Biochemical Oxygen Demand (mg/l)	-	-											
Bioreactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-											
Bioreactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-											
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-											
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-											
Bioreactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-											
Bioreactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-											
Bioreactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-											
Bioreactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-											
Bioreactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-											
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

Phase I Perc , Treatability Study
VOC Analytical Results Summary

	DATE SAMPLED	11/5/97	11/7/97	11/17/97	12/16/97	12/17/97	12/18/97	12/19/97	12/24/97	12/31/97	1/28/98	2/4/98	2/5/98	2/6/98	2/17/98	2/18/98	2/19/98	2/20/98
	INFLUENT GW FLOWRATE (GPM)	-	5.1	4.0	29.4	30.0	29.4	28.3	25.1	20.3	25.0	26.4	25.1	24.9	25.2	25.6	25.1	26.1
SAMPLING PORT	ANALYTES																	
Air Strip. Infl. (A)	Acetone (ug/l) EPA 8260	<100	<100	-	<100	-	-	<100	<100	<100	-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	Acetone (ug/l)	<100	<100	-	<100	-	-	<100	<100	<100	3600.0	<100	-	<100	<100	<100	-	3700.0
Bioreactor Influent (C)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	2000.0	<100	-	340.0	220.0	260.0	-	5200.0
Bioreactor Effluent (G)	Acetone (ug/l)	-	-	<100	<100	-	-	<100	-	-	6700.0	310.0	-	330.0	560.0	530.0	-	710.0
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 8260	<5	<5	-	<5	-	-	<5	<5	<5	-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	Chloroform (ug/l)	-	<5	-	<5	-	-	<5	<5	<5	<100	<5	-	<5	<5	<5	-	<250
Bioreactor Influent (C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	<50	<5	-	<5	<5	<5	-	<250
Bioreactor Effluent (G)	Chloroform (ug/l)	-	-	<5	<5	-	-	<5	-	-	63.0	<5	-	<5	<5	<5	-	<250
Air Strip. Infl. (A)	4-Methyl-2-pentanone (ug/l) EPA 8260	<50	<50	-	<50	-	-	<50	<50	<50	-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	4-Methyl-2-pentanone (ug/l)	-	<50	-	<50	-	-	<50	<50	<50	880.0	210.0	-	220.0	720.0	550.0	-	<1200
Bioreactor Influent (C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	810.0	200.0	-	220.0	640.0	540.0	-	<1200
Bioreactor Effluent (G)	4-Methyl-2-pentanone (ug/l)	-	-	<50	<50	-	-	<50	-	-	<250	87.0	-	95.0	280.0	260.0	-	390.0
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 8260	6.3	6.3	-	6.6	-	-	6.3	6.9	8.0	-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	1,1-Dichloroethene (ug/l)	-	<5	-	<5	-	-	<5	<5	<5	9.2	8.2	-	7.5	9.0	7.4	-	<250
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	7.8	6.2	-	6.3	7.5	8.1	-	<250
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	<5	<5	-	-	<5	-	-	<5	<5	-	<5	<5	<5	-	<250
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 8260	<5	<5	-	<5	-	-	<5	<5	<5	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Tetrachloroethene (ug/l)	-	<5	-	<5	-	-	-	<5	<5	<100	<5	-	<5	<5	<5	-	<250
Bioreactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	<50	<5	-	<5	<5	<5	-	<250
Bioreactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	<5	<5	-	-	<5	-	-	110.0	<5	-	<5	<5	<5	-	<250
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 8260	120	110	-	120.0	-	-	120.0	130.0	150.0	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	<5															
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	36.0	-	-	41.0	53.0	18.0	140.0	120.0	-	120.0	150.0	140.0	-	<250
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	120.0	99.0	-	110.0	130.0	130.0	-	<250
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	<5	20.00	-	-	32.0	-	-	<5	19.0	-	22.0	33.0	33.0	-	35.0
Air Strip. Infl. (A)	Ethanol (mg/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	96.0	-	-	93.0
Bioreactor Influent (C)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-	84.0
Bioreactor Effluent (G)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2	-	-	<5
Air Strip. Infl. (A)	Vinyl chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1
Bioreactor Influent (C)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1
Bioreactor Effluent (G)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Trichlorofluoromethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	10.00	-	12.00	8.50	12.00	-	10.00
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	7.80	-	9.90	6.60	11.00	-	11.00
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	3.00	-	4.00	6.30	6.20	-	5.90
Air Strip. Infl. (A)	Methylene chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.25	<0.1	0.14	-	<0.1
Bioreactor Influent (C)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	0.18	-	0.12	<0.1	<0.1	-	0.29
Bioreactor Effluent (G)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	0.17	-	0.25	0.29	0.25	-	0.47
Air Strip. Infl. (A)	1,1-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.50	-	1.60	1.50	1.50	-	1.50
Bioreactor Influent (C)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.50	-	1.60	1.60	1.50	-	1.50
Bioreactor Effluent (G)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.20	-	1.10	1.50	1.40	-	1.50
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	2.40	-	2.70	2.70	2.60	-	2.60
Bioreactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	2.10	-	2.50	2.70	2.60	-	2.50
Bioreactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	1.10	-	1.10	1.80	1.70	-	1.80
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80	-	1.90	2.00	2.00	-	1.90
Bioreactor Influent (C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80	-	2.00	2.10	2.00	-	2.00
Bioreactor Effluent (G)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	1.60	-	1.70	2.40	2.30	-	2.30
Air Strip. Infl. (A)	1,1,1-Trichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	0.12	-	0.12
Bioreactor Influent (C)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	<0.1	-	0.11
Bioreactor Effluent (G)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	-	<0.1
Air Strip. Infl. (A)	Carbon tetrachloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	2.10	-	2.20	2.40	2.20	-	2.30
Bioreactor Influent (C)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80	-	2.00	2.10	2.00	-	2.00
Bioreactor Effluent (G)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	0.34	-	0.30	0.30	0.32	-	0.29
Air Strip. Infl. (A)	1,2-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.90	-	2.30	2.00	2.10	-	1.70
Bioreactor Influent (C)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80	-	2.30	2.30	2.20	-	1.70
Bioreactor Effluent (G)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.20	-	1.40	1.80	1.50	-	1.40
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	150	-	230	190	190	-	160
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	140	-	190	160	170	-	140
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	28	-	33	45	45	-	38
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	0.26	-	0.46	0.17	0.17	-	0.15
Bioreactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	0.20	-	0.35	0.15	0.16	-	0.13
Bioreactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	<0.1
Air Strip. Infl. (A)	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	<0.1	-	0.20	<0.1	<0.1	-	<0.1
Bioreactor Influent (C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	0.16	-	<0.1	<0.1	<0.1	-	<0.1
Bioreactor Effluent (G)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	<0.1
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 601	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 601	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 601	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	DATE SAMPLED	2/27/98	3/4/98	3/5/98	3/6/98	3/13/98	3/17/98	3/25/98	3/27/98	4/2/98	4/10/98	4/15/98	4/24/98	5/13/98	5/18/98	5/19/98	5/21/98
	INFLUENT GW FLOWRATE (GPM)	25.0	24.8	24.8	25.0	27.0	10.3			14.8	17.5	15.2		10.0	9.8		
SAMPLING PORT	ANALYTES																
Air Strip. Infl. (A)	Acetone (ug/l) EPA 8260	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	Acetone (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Acetone (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Acetone (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 8260	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	Chloroform (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloroform (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Chloroform (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	4-Methyl-2-pentanone (ug/l) EPA 8260	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 8260	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B, BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 8260	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 8260	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)																
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Ethanol (mg/l) EPA 502.2	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Ethanol (mg/l)	-	-	-	-	160.0	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Ethanol (mg/l)	-	-	-	-	100.0	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Ethanol (mg/l)	-	14.0	-	-	21.0	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Vinyl chloride (ug/l) EPA 502.2	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	-	-	-	-	<0.1	-	-
Air Strip. Eff. (B)	Vinyl chloride (ug/l)	-	-	-	<0.1	-	<0.1	-	<0.1	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Vinyl chloride (ug/l)	<0.1	-	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Vinyl chloride (ug/l)	<0.1	-	-	-	<0.1	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Bioreactor Effluent (G)	Vinyl chloride (ug/l)	<0.1	<0.1	-	-	<0.1	0.16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Air Strip. Infl. (A)	Trichlorofluoromethane (ug/l) EPA 502.2	-	-	-	0.22	-	0.31	<0.1	0.15	-	-	-	-	-	0.16	-	-
Air Strip. Eff. (B)	Trichlorofluoromethane (ug/l)	-	-	-	<0.1	-	<0.1		<0.1	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Trichlorofluoromethane (ug/l)	0.18	-	-	-	<0.1	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Trichlorofluoromethane (ug/l)	0.19	-	-	-	<0.1	-			-	-	-	-	-	-	<0.1	<0.1
Bioreactor Effluent (G)	Trichlorofluoromethane (ug/l)	<0.1	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 502.2	-	-	-	11.00	-	15.00	12.00	12.00	-	-	-	-	-	6.00	-	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	0.56	-	1.30	1.10	1.00	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	1,1-Dichloroethene (ug/l)	10.00	-	-	-	12.00	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	10.00	-	-	-	11.00	-	-	-	-	-	-	-	-	-	1.50	2.10
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	6.60	8.90	-	-	8.40	6.30	5.00	4.10	3.20	3.40	3.20	3.10	1.10	-	2.00	2.20
Air Strip. Infl. (A)	Methylene chloride (ug/l) EPA 502.2	-	-	-	<0.1	-	0.10	0.17	0.19	-	-	-	-	-	0.22	-	-
Air Strip. Eff. (B)	Methylene chloride (ug/l)	-	-	-	<0.1	-	0.12	0.53	0.41	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	Methylene chloride (ug/l)	<0.1	-	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Methylene chloride (ug/l)	<0.1	-	-	-	0.11	-	-	-	-	-	-	-	-	-	0.11	<0.1
Bioreactor Effluent (G)	Methylene chloride (ug/l)	0.32	0.32	-	-	0.18	0.25	0.51	0.40	0.37	0.15	0.18	0.22	<0.1	-	0.11	<0.1
Air Strip. Infl. (A)	1,1-Dichloroethane (ug/l) EPA 502.2	-	-	-	1.60	-	1.10	1.60	1.70	-	-	-	-	-	1.60	-	-
Air Strip. Eff. (B)	1,1-Dichloroethane (ug/l)	-	-	-	0.13	-	0.17	0.28	0.23	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	1,1-Dichloroethane (ug/l)	1.40	-	-	-	1.10	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1-Dichloroethane (ug/l)	1.50	-	-	-	1.20	-	-	-	-	-	-	-	-	-	0.15	0.28
Bioreactor Effluent (G)	1,1-Dichloroethane (ug/l)	1.40	1.50	-	-	1.10	1.00	0.86	0.65	0.69	0.52	0.49	0.47	0.21	-	0.23	0.18
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 502.2	-	-	-	2.70	-	4.00	3.40	3.60	-	-	-	-	-	3.30	-	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	0.30	-	0.65	0.68	0.49	-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	cis-1,2-Dichloroethene (ug/l)	2.40	-	-	-	2.80	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	2.50	-	-	-	2.70	-	-	-	-	-	-	-	-	-	0.87	1.50
Bioreactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	1.80	2.00	-	-	2.20	1.90	1.70	1.40	1.50	1.20	1.20	1.30	0.80	-	1.10	1.40
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 502.2	-	-	-	2.00	-	2.30	2.80	2.10	-	-	-	-	-	2.00	-	-
Air Strip. Eff. (B)	Chloroform (ug/l)	-	-	-	0.24	-	0.39	0.55	0.34	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Chloroform (ug/l)	1.80	-	-	-	2.00	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Chloroform (ug/l)	2.00	-	-	-	2.10	-	-	-	-	-	-	-	-	-	0.32	0.52
Bioreactor Effluent (G)	Chloroform (ug/l)	2.20	2.10	-	-	2.20	1.90	1.20	0.97	1.10	0.79	0.74	0.72	0.34	-	0.40	0.40
Air Strip. Infl. (A)	1,1,1-Trichloroethane (ug/l) EPA 502.2	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	-	-	-	-	<0.1	-	-
Air Strip. Eff. (B)	1,1,1-Trichloroethane (ug/l)	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,1,1-Trichloroethane (ug/l)	0.10	-	-	-	0.14	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1,1-Trichloroethane (ug/l)	<0.1	-	-	-	0.16	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Bioreactor Effluent (G)	1,1,1-Trichloroethane (ug/l)	<0.1	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Air Strip. Infl. (A)	Carbon tetrachloride (ug/l) EPA 502.2	-	-	-	1.20	-	2.60	2.10	2.30	-	-	-	-	-	2.30	-	-
Air Strip. Eff. (B)	Carbon tetrachloride (ug/l)	-	-	-	0.23	-	0.22	0.18	0.15	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Carbon tetrachloride (ug/l)	2.00	-	-	-	1.60	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Carbon tetrachloride (ug/l)	2.00	-	-	-	1.50	-	-	-	-	-	-	-	-	-	0.20	<0.1
Bioreactor Effluent (G)	Carbon tetrachloride (ug/l)	0.29	0.83	-	-	0.29	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	0.23	<0.1
Air Strip. Infl. (A)	**1,2-Dichloroethane (ug/l)** EPA 502.2	-	-	-	1.70	-	1.70	3.20	1.80	-	-	-	-	-	1.70	-	-
Air Strip. Eff. (B)	**1,2-Dichloroethane (ug/l)**	-	-	-	0.33	-	0.32	0.27	0.41	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,2-Dichloroethane (ug/l)	1.60	-	-	-	1.50	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,2-Dichloroethane (ug/l)	1.70	-	-	-	1.40	-			-	-	-	-	-	-	0.32	0.52
Bioreactor Effluent (G)	1,2-Dichloroethane (ug/l)	1.30	1.20	-	-	1.10	1.00	0.93	0.82	0.80	0.69	0.67	0.64	0.30	-	0.37	0.36
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 502.2	-	-	-	210	-	250	170	210	-	-	-	-	-	190	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	19	-	35	29	26	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	160	-	-	-	180	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Trichloroethene (ug/l)	160	-	-	-	-	-	-	-	-	-	-	-	-	-	10	15
Bioreactor Effluent (G)	Trichloroethene (ug/l)	45	53	-	-	-	23	19	19	20	19	14	20	9	-	12	16
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 502.2	-	-	-	0.18	-	0.25	0.25	0.24	-	-	-	-	-	0.18	-	-
Air Strip. Eff. (B)	Tetrachloroethene (ug/l)	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Tetrachloroethene (ug/l)	0.19	-	-	-	0.21	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Tetrachloroethene (ug/l)	0.20	-	-	-	0.15	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Bioreactor Effluent (G)	Tetrachloroethene (ug/l)	<0.1	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Air Strip. Infl. (A)	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/l) EPA 502.2	-	-	-	0.14	-	0.28	<0.1	<0.1	-	-	-	-	-	<0.1	-	-
Air Strip. Eff. (B)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	<0.1	-	<0.1	<0.1	<0.1	-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,1,2-Trichloro-1,2,2-trifluoroethane	0.11	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1,2-Trichloro-1,2,2-trifluoroethane	<0.1	-	-	-	0.18	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Bioreactor Effluent (G)	1,1,2-Trichloro-1,2,2-trifluoroethane	<0.1	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 601	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 601	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 601	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Air Strip. Eff. (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Bioreactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-			-	-	-	-	-	-	-	-

	DATE SAMPLED	5/22/98	5/24/98	5/27/98	6/9/98	6/11/98	6/12/98	6/14/98	6/15/98	6/16/98	6/17/98	6/19/98
	INFLUENT GW FLOWRATE (GPM)		15.0	26.0	19.8	20.0	19.9	20.3	20.0	20.0	19.9	
SAMPLING PORT	ANALYTES											
Air Strip. Infl. (A)	Acetone (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (B, BS-C)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (B, BS-C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	4-Methyl-2-pentanone (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (B, BS-C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (B, BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (B; BS-C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (B)	Trichloroethene (ug/l)							-	-	-	-	
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	Ethanol (mg/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	
Air Strip. Eff. (BS-C)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Influent (C)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	
Bioreactor Effluent (G)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	
Air Strip. Infl. (A)	Vinyl chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	<0.10	-	-	
Air Strip. Eff. (B)	Vinyl chloride (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (BS-C)	Vinyl chloride (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	-	-	-	
Bioreactor Influent (C)	Vinyl chloride (ug/l)	-	-	-	0.1	<0.1	<0.1	<0.1	-	-	-	
Bioreactor Effluent (G)	Vinyl chloride (ug/l)	-	-	-	0.3	0.2	<0.1	<0.1	<0.10	-	-	
Air Strip. Infl. (A)	Trichlorofluoromethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	<0.10	-	-	
Air Strip. Eff. (B)	Trichlorofluoromethane (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (BS-C)	Trichlorofluoromethane (ug/l)	-	-	-	0.16	0.38	0.27	0.16	-	-	-	
Bioreactor Influent (C)	Trichlorofluoromethane (ug/l)	-	-	-	<0.1	<0.1	<0.1	0.14	-	-	-	
Bioreactor Effluent (G)	Trichlorofluoromethane (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	6.70	-	-	
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	7.80	10.00	9.40	7.60	-	-	-	
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	6.90	10.00	9.80	8.00	-	-	-	
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	4.80	8.30	8.70	6.10	6.20	-	-	
Air Strip. Infl. (A)	Methylene chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	<0.10	-	-	
Air Strip. Eff. (B)	Methylene chloride (ug/l)	-	-	-	0.39	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (BS-C)	Methylene chloride (ug/l)	-	-	-	0.28	<0.1	<0.1	0.29	-	-	-	
Bioreactor Influent (C)	Methylene chloride (ug/l)	-	-	-	<0.1	0.21	0.13	0.16	-	-	-	
Bioreactor Effluent (G)	Methylene chloride (ug/l)	-	-	-	0.27	0.39	0.15	0.83	0.14	-	-	
Air Strip. Infl. (A)	1,1-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	1.50	-	-	
Air Strip. Eff. (B)	1,1-Dichloroethane (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (BS-C)	1,1-Dichloroethane (ug/l)	-	-	-	1.70	1.80	1.60	1.50	-	-	-	
Bioreactor Influent (C)	1,1-Dichloroethane (ug/l)	-	-	-	1.50	1.70	1.60	1.60	-	-	-	
Bioreactor Effluent (G)	1,1-Dichloroethane (ug/l)	-	-	-	0.46	1.40	1.40	1.30	1.40	-	-	
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	3.10	-	-	
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	0.18	0.25	0.17	<0.1	<0.10	-	-	
Air Strip. Eff. (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	3.70	3.60	3.30	3.10	-	-	-	
Bioreactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	4.00	6.80	4.70	4.80	-	-	-	
Bioreactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	-	-	-	4.10	11.00	6.40	6.20	6.80	-	-	
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 502.2	-	-	-	-	-	-	-	1.70	-	-	
Air Strip. Eff. (B)	Chloroform (ug/l)	-	-	-	0.15	0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (B; BS-C)	Chloroform (ug/l)	-	-	-	2.00	2.10	1.80	1.70	-	-	-	
Bioreactor Influent (C)	Chloroform (ug/l)	-	-	-	1.90	2.20	2.10	2.10	-	-	-	
Bioreactor Effluent (G)	Chloroform (ug/l)	-	-	-	1.50	2.30	2.10	2.10	2.30	-	-	
Air Strip. Infl. (A)	1,1,1-Trichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	<0.10	-	-	
Air Strip. Eff. (B)	1,1,1-Trichloroethane (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (B; BS-C)	1,1,1-Trichloroethane (ug/l)	-	-	-	0.21	0.20	0.15	0.14	-	-	-	
Bioreactor Influent (C)	1,1,1-Trichloroethane (ug/l)	-	-	-	0.15	0.19	0.18	0.15	-	-	-	
Bioreactor Effluent (G)	1,1,1-Trichloroethane (ug/l)	-	-	-	<0.1	0.11	0.11	<0.1	0.11	-	-	
Air Strip. Infl. (A)	Carbon tetrachloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	2.10	-	-	
Air Strip. Eff. (B)	Carbon tetrachloride (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (B; BS-C)	Carbon tetrachloride (ug/l)	-	-	-	2.40	2.40	2.10	2.00	-	-	-	
Bioreactor Influent (C)	Carbon tetrachloride (ug/l)	-	-	-	1.70	1.70	1.60	1.60	-	-	-	
Bioreactor Effluent (G)	Carbon tetrachloride (ug/l)	-	-	-	0.30	0.31	0.40	0.32	0.38	-	-	
Air Strip. Infl. (A)	1,2-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	1.60	-	-	
Air Strip. Eff. (B)	1,2-Dichloroethane (ug/l)	-	-	-	0.15	0.18	0.21	0.12	0.18	-	-	
Air Strip. Eff. (B; BS-C)	1,2-Dichloroethane (ug/l)	-	-	-	1.80	3.90	3.50	1.50	-	-	-	
Bioreactor Influent (C)	1,2-Dichloroethane (ug/l)	-	-	-	1.60	1.80	1.70	1.60	-	-	-	
Bioreactor Effluent (G)	1,2-Dichloroethane (ug/l)	-	-	-	1.30	1.60	0.64	1.80	1.40	-	-	
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	210	-		
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	5.7	1.6	1.9	0.87	1	-	-	
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	-	480	250	250	190	-	-	-	
Bioreactor Influent (C)	Trichloroethene (ug/l)	-	-	-	430	230	210	180	-	-	-	
Bioreactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	220	210	180	170	180	-	-	
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	0.19	-	-	
Air Strip. Eff. (B)	Tetrachloroethene (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (B; BS-C)	Tetrachloroethene (ug/l)	-	-	-	0.26	0.27	0.22	0.20	-	-	-	
Bioreactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	0.17	0.18	0.17	0.16	-	-	-	
Bioreactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Infl. (A)	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	<0.10	-	-	
Air Strip. Eff. (B)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Eff. (B; BS-C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	0.25	<0.1	0.20	0.16	-	-	-	
Bioreactor Influent (C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	0.14	0.15	0.13	<0.1	-	-	-	
Bioreactor Effluent (G)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.10	-	-	
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 601	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	<5	-	-	-	-	<5	<5	<5.0	<5
Air Strip. Eff. (B; BS-C)	1,1-Dichloroethene (ug/l)	-	-	6.1	-	-	-	-	7.8	6.0	<5.0	9.10
Bioreactor Influent (C)	1,1-Dichloroethene (ug/l)	<5	5.8	8.2	-	-	-	-	9.6	<5.0	<5.0	8.90
Bioreactor Effluent (G)	1,1-Dichloroethene (ug/l)	<5	<5	<5	-	-	-	-	7.6	<5.0	<5.0	7.80
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 601	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	13	-	-	-	-	<5	<5.0	<5.0	<5.0
Air Strip. Eff. (B; BS-C)	Trichloroethene (ug/l)	-	-	240	-	-	-	-	280	210	210.0	180.0
Bioreactor Influent (C)	Trichloroethene (ug/l)	2200	250	280	-	-	-	-	330	220	200.0	180.0
Bioreactor Effluent (G)	Trichloroethene (ug/l)	2100	280	230	-	-	-	-	260	170	160	160
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 601	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	<5	-	-	-	-	<5	<5	<5	<5
Air Strip. Eff. (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	-	6.7	-	-	-	-	<5	<5	<5	<5
Bioreactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	<5	<5	<5	-	-	-	-	<5	<5	<5	<5
Bioreactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	<5	<5	<5	-	-	-	-	<5	<5	<5	6.1

Phase I Perchlorate Treatability Study
Title 22 Metals Analytical Results Summary

	DATE SAMPLED	11/5/97	1/29/98	2/4/98	2/5/98	2/6/98	2/17/98	2/18/98	2/19/98	2/20/98	3/4/98	3/13/98	5/18/98	6/15/98
Sampling Port	Flowrate	-	25.0	26.4	-	24.9	25.2	25.6	-	25.5	25.8	25.0	9.8	-
Air Strip. Infl. (A)	Ba	23	-	-	-	-	-	-	-	-	-	-	<100	<100
Undiluted GW (BS)	Ba	-	27	29	-	24	28	26	-	24	24	28	-	-
Bioreactor Influent (C)	Ba	-	26	26	-	24	25	25	-	24	22	25	-	-
Bioreactor Effluent (G)	Ba	-	26	26	-	22	24	25	-	20	22	28	-	-
Air Strip. Infl. (A)	Ca	18000	-	-	-	-	-	-	-	-	-	-	24000	24000
Undiluted GW (BS)	Ca	-	20000	21000	-	19000	19000	18000	-	19000	19000	21000	-	24000
Bioreactor Influent (C)	Ca	-	20000	21000	-	19000	19000	18000	-	20000	18000	21000	-	-
Bioreactor Effluent (G)	Ca	-	20000	21000	-	19000	19000	18000	-	17000	18000	20000	-	-
Undiluted GW (BS)	Fe	-	-	-	-	-	-	-	-	450	<100	<100	<100	<100
Bioreactor Influent (C)	Fe	-	-	-	-	-	-	-	-	<100	<100	<100	-	<100
Bioreactor Effluent (G)	Fe	-	-	-	-	-	-	-	-	<100	<100	<100	-	-
Air Strip. Infl. (A)	Hg						-	-	-	-	-	-	<1	<1
Undiluted GW (BS)	Hg	-	-	-	-	0.39	<0.2	<0.2	-	<0.2	<0.2	<0.2	-	<1
Bioreactor Influent (C)	Hg	-	-	-	-	0.37	>0.2	<0.2	-	<0.2	<0.2	<0.2	-	-
Bioreactor Effluent (G)	Hg	-	-	-	-	0.38	<0.2	<0.2	-	<0.2	<0.2	<0.2	-	-
Air Strip. Infl. (A)	K	1200	-	-	-	-	-	-	-	-	-	-	1400	1500
Undiluted GW (BS)	K	-	1500	1500	-	1300	1400	1300	-	1300	1400	1400	-	1200
Bioreactor Influent (C)	K	-	1400	1300	-	1200	1500	1300	-	1200	1300	1400	-	-
Bioreactor Effluent (G)	K	-	1300	1100	-	1100	1200	1300	-	<1000	1200	1300	-	-
Air Strip. Infl. (A)	Mg	11000	-	-	-	-	-	-	-	-	-	-	13000	14000
Undiluted GW (BS)	Mg	-	13000	13000	-	12000	12000	12000	-	11000	12000	12000	-	14000
Bioreactor Influent (C)	Mg	-	12000	13000	-	12000	12000	12000	-	12000	11000	12000	-	-
Bioreactor Effluent (G)	Mg	-	13000	12000	-	11000	12000	12000	-	10000	11000	12000	-	-
Air Strip. Infl. (A)	Na	30000	-	-	-	-	-	-	-	-	-	-	37000	36000
Undiluted GW (BS)	Na	-	36000	36000	-	34000	35000	33000	-	34000	34000	35000	-	35000
Bioreactor Influent (C)	Na	-	35000	36000	-	34000	33000	33000	-	34000	32000	34000	-	-
Bioreactor Effluent (G)	Na	-	36000	36000	-	33000	34000	33000	-	30000	33000	33000	-	-
Air Strip. Infl. (A)	V	14	-	-	-	-	-	-	-	-	-	-	-	-
Undiluted GW (BS)	V	-	<20	20	-	<20	<20	<20	-	<20	<20	<20	-	-
Bioreactor Influent (C)	V	-	<20	<20	-	<20	<20	<20	-	<20	<20	<20	-	-
Bioreactor Effluent (G)	V	-	<20	<20	-	<20	<20	<20	-	<20	<20	<20	-	-
Air Strip. Infl. (A)	Zn	35	-	-	-	-	-	-	-	-	-	-	<50	<50
Undiluted GW (BS)	Zn	-	<20	<20	-	<20	22	<20	-	<20	55	<20	-	<50
Bioreactor Influent (C)	Zn	-	<20	<20	-	<20	48	<20	-	<20	<20	<20	-	-
Bioreactor Effluent (G)	Zn	-	<20	<20	-	<20	<20	<20	-	<20	<20	<20	-	-

ug/l = microgram per liter, GW = groundwater
Ba = Barium, Ca = Calcium, Fe = Iron, Hg = Mercury, K = Potassium, Na = Sodium, V = Vanadium, Zn = Zinc, Mg = Magnesium

CLS Labs

Harding Lawson Associates
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

07/13/98

Attention: **John Catts**

Reference: **Analytical Results**

Project Name: **Aerojet Perchlorate**
Project No.: **39860.353**
Date Received: **06/18/98**
Chain Of Custody: **NO NUMBER**

CLS ID No.: **P4907**
CLS Job No.: **814907**

The following analyses were performed on the above referenced project:

No. of Samples	*Turnaround Time*	*Analysis Description*
1	10 Days	TCLP Analysis
1	10 Days	EPA Priority Pollutant Metals
1	10 Days	Organochlorine Pesticides, EPA 8080
1	10 Days	PCB Analysis
1	10 Days	EPA Method 8240
1	10 Days	EPA Method 8270
1	10 Days	Dioxin Analysis

These samples were received by CLS Labs in a chilled, intact state and accompanied by a valid chain of custody document.

Calibrations for analytical testing have been performed in accordance to and pass the EPA's criteria for acceptability.

Analytical results are attached to this letter. Please call if we can provide additional assistance.

Sincerely,

George Hampton
Laboratory Director

CLS Labs

Analysis Report: **TCLP Volatile Organic Constituents, EPA Method 8240**
Toxicity Characteristic Leaching Procedure, EPA Method 1311

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: 06/18/98
Date Received: 06/18/98
Date Extracted: N/A
Date Analyzed: 06/25/98
Date Reported: 07/02/98
Client ID No.: R061898

Project No.: 39860.353
Contact: John Catts
Phone: (916)364-0793

Lab Contact: George Hampton
Lab ID No.: P4907-1A
Job No.: 814907
COC Log No.: NO NUMBER
Batch No.: 51512
Instrument ID: MS05
Analyst ID: TERIB
Matrix: SOLID

SURROGATE

Analyte	HW No.	Surr Conc. (mg/L)	Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	0.0500	111
Toluene-d8	N/A	0.0500	106
p-Bromofluorobenzene	460-00-4	0.0500	108

Sample: **R061898**

Analyte	HW No.	Results (mg/L)	Rep. Limit (mg/L)	Dilution (factor)
Benzene	34030	ND	0.050	1.0
Carbon tetrachloride	D019	ND	0.050	1.0
Chlorobenzene	D021	ND	0.050	1.0
Chloroform	32106	ND	0.050	1.0
1,4-Dichlorobenzene	34571	ND	0.050	1.0
1,2-Dichloroethane	34531	ND	0.050	1.0
1,1-Dichloroethene	34501	ND	0.050	1.0
Methyl ethyl ketone	81595	ND	1.0	1.0
Tetrachloroethene	34475	ND	0.050	1.0
Trichloroethene	39180	0.33	0.050	1.0
Vinyl chloride	D043	ND	0.10	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **TCLP Volatile Organic Constituents, EPA Method 8240**
Toxicity Characteristic Leaching Procedure, EPA Method 1311

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/25/98**
Date Reported: **07/02/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51512**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

MB SURROGATE

Analyte	HW No.	Surr Conc. (mg/L)	MB Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	0.0500	107
Toluene-d8	N/A	0.0500	103
p-Bromofluorobenzene	460-00-4	0.0500	106

METHOD BLANK

Analyte	HW No.	Results (mg/L)	Reporting Limit (mg/L)
Benzene	34030	ND	0.050
Carbon tetrachloride	D019	ND	0.050
Chlorobenzene	D021	ND	0.050
Chloroform	32106	ND	0.050
1,4-Dichlorobenzene	34571	ND	0.050
1,2-Dichloroethane	34531	ND	0.050
1,1-Dichloroethene	34501	ND	0.050
Methyl ethyl ketone	81595	ND	1.0
Tetrachloroethene	34475	ND	0.050
Trichloroethene	39180	ND	0.050
Vinyl chloride	D043	ND	0.10

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **TCLP Volatile Organic Constituents, EPA Method 8240**
Toxicity Characteristic Leaching Procedure, EPA Method 1311

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/25/98**
Date Reported: **07/02/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51512**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

MS SURROGATE

Analyte	HW No	MS Surr. Conc. (mg/L)	MS Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	0.250	98
Toluene-d8	N/A	0.250	109
p-Bromofluorobenzene	460-00-4	0.250	101

MATRIX SPIKE

Analyte	HW No.	MS Conc. (mg/L)	MS Recovery (percent)
Benzene	34030	0.250	96
Carbon tetrachloride	D019	0.250	96
Chlorobenzene	D021	0.250	102
Chloroform	32106	0.250	127
1,4-Dichlorobenzene	34571	0.250	102
1,2-Dichloroethane	34531	0.250	98
1,1-Dichloroethene	34501	0.250	158
Methyl ethyl ketone	81595	0.250	77
Tetrachloroethene	34475	0.250	112
Trichloroethene	39180	0.250	140
Vinyl chloride	D043	0.250	171

MSD SURROGATE

Analyte	HW No.	Surr. Conc. (mg/L)	MSD Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	0.250	92
Toluene-d8	N/A	0.250	100
p-Bromofluorobenzene	460-00-4	0.250	101

CA DOHS ELAP Accreditation/Registration Number 1233

CLS Labs

Analysis Report: **TCLP Volatile Organic Constituents, EPA Method 8240**
Toxicity Characteristic Leaching Procedure, EPA Method 1311

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/25/98**
Date Reported: **07/02/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51512**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

MATRIX SPIKE DUPLICATE

Analyte	HW No.	MSD Conc. (mg/L)	MSD Recovery (percent)
Benzene	34030	0.250	102
Carbon tetrachloride	D019	0.250	108
Chlorobenzene	D021	0.250	101
Chloroform	32106	0.250	113
1,4-Dichlorobenzene	34571	0.250	100
1,2-Dichloroethane	34531	0.250	100
1,1-Dichloroethene	34501	0.250	131
Methyl ethyl ketone	81595	0.250	76
Tetrachloroethene	34475	0.250	99
Trichloroethene	39180	0.250	109
Vinyl chloride	D043	0.250	133

RELATIVE % DIFFERENCE

Analyte	HW No.	Relative Percent Difference (percent)
Benzene	34030	6
Carbon tetrachloride	D019	12
Chlorobenzene	D021	1
Chloroform	32106	12
1,4-Dichlorobenzene	34571	2
1,2-Dichloroethane	34531	2
1,1-Dichloroethene	34501	19
Methyl ethyl ketone	81595	1
Tetrachloroethene	34475	12
Trichloroethene	39180	25
Vinyl chloride	D043	25

CLS Labs

Analysis Report: **TCLP Volatile Organic Constituents, EPA Method 8240**
Toxicity Characteristic Leaching Procedure, EPA Method 1311

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/25/98**
Date Reported: **07/02/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51512**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

LCS SURROGATE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	0.0500	114
Toluene-d8	N/A	0.0500	109
p-Bromofluorobenzene	460-00-4	0.0500	111

LAB CONTROL SAMPLE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Recovery (percent)
Benzene	34030	0.0500	87
Carbon tetrachloride	D019	0.0500	74
Chlorobenzene	D021	0.0500	94
Chloroform	32106	0.0500	100
1,4-Dichlorobenzene	34571	0.0500	99
1,2-Dichloroethane	34531	0.0500	108
1,1-Dichloroethene	34501	0.0500	88
Methyl ethyl ketone	81595	0.0500	93
Tetrachloroethene	34475	0.0500	98
Trichloroethene	39180	0.0500	92
Vinyl chloride	D043	0.0500	81

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents-Pesticides**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **06/23/98**
Date Analyzed: **06/27/98**
Date Reported: **07/07/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1A**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667A**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

SURROGATE

Analyte	HW No.	Surr Conc. (mg/L)	Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	0.00250	79
Decachlorobiphenyl	2051-24-3	0.00250	80

Sample: **R061898**

Analyte	HW No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Chlordane	39350	ND	0.020	8080	1.0
Endrin	39390	ND	0.010	8080	1.0
Heptachlor	39410	ND	0.0050	8080	1.0
Lindane	39340	ND	0.0050	8080	1.0
Methoxychlor	39480	ND	0.050	8080	1.0
Toxaphene	39400	ND	0.20	8270	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents-Pesticides**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/27/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667A**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

MB SURROGATE

Analyte	HW No.	Surr Conc. (mg/L)	MB Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	0.00250	61
Decachlorobiphenyl	2051-24-3	0.00250	60

METHOD BLANK

Analyte	HW No.	Results (mg/L)	Reporting Limit (mg/L)	Method
Chlordane	39350	ND	0.020	8080
Endrin	39390	ND	0.010	8080
Heptachlor	39410	ND	0.0050	8080
Lindane	39340	ND	0.0050	8080
Methoxychlor	39480	ND	0.050	8080
Toxaphene	39400	ND	0.20	8080

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents-Pesticides**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/27/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667A**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

MS SURROGATE

Analyte	HW No.	MS Surr. Conc. (mg/L)	MS Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	0.00250	93
Decachlorobiphenyl	2051-24-3	0.00250	77

MATRIX SPIKE

Analyte	HW No.	MS Conc. (mg/L)	MS Recovery (percent)
Endrin	39390	0.00250	98
Heptachlor	39410	0.00125	88
Lindane	39340	0.00125	40

MSD SURROGATE

Analyte	HW No.	Surr. Conc. (mg/L)	MSD Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	0.00250	55
Decachlorobiphenyl	2051-24-3	0.00250	84

MATRIX SPIKE DUPLICATE

Analyte	HW No.	MSD Conc. (mg/L)	MSD Recovery (percent)
Endrin	39390	0.00250	103
Heptachlor	39410	0.00125	76
Lindane	39340	0.00125	39

RELATIVE % DIFFERENCE

Analyte	HW No.	Relative Percent Difference (percent)

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents-Pesticides**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/27/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667A**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

RELATIVE % DIFFERENCE(cont.)

Analyte	HW No.	Relative Percent Difference (percent)
Endrin	39390	5
Heptachlor	39410	15
Lindane	39340	3

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents-Pesticides**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/27/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667A**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

LCS SURROGATE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	0.00250	77
Decachlorobiphenyl	2051-24-3	0.00250	65

LAB CONTROL SAMPLE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Recovery (percent)
Endrin	39390	0.00250	101
Heptachlor	39410	0.00125	121
Lindane	39340	0.00125	46

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **06/23/98**
Date Analyzed: **06/25/98**
Date Reported: **06/29/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1A**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667B**
Instrument ID: **MS003**
Analyst ID: **KALVINL**
Matrix: **SOLID**

R061898

Analyte	HW No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Cresols, total	D026	ND	0.20	8270	1.0
2,4-Dinitrotoluene	D030	ND	0.10	8270	1.0
Hexachlorobenzene	D032	ND	0.10	8270	1.0
Hexachloro-1,3-butadiene	D033	ND	0.10	8270	1.0
Hexachloroethane	D034	ND	0.10	8270	1.0
Nitrobenzene	D036	ND	0.10	8270	1.0
Pentachlorophenol	D037	ND	0.50	8270	1.0
2,4,5-Trichlorophenol	D041	ND	0.10	8270	1.0
2,4,6-Trichlorophenol	D042	ND	0.10	8270	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/25/98**
Date Reported: **06/29/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667B**
Instrument ID: **MS003**
Analyst ID: **KALVINL**
Matrix: **SOLID**

METHOD BLANK

Analyte	HW No.	Results (mg/L)	Reporting Limit (mg/L)	Method
Cresols, total	D026	ND	0.20	8270
2,4-Dinitrotoluene	D030	ND	0.10	8270
Hexachlorobenzene	D032	ND	0.10	8270
Hexachloro-1,3-butadiene	D033	ND	0.10	8270
Hexachloroethane	D034	ND	0.10	8270
Nitrobenzene	D036	ND	0.10	8270
Pentachlorophenol	D037	ND	0.50	8270
2,4,5-Trichlorophenol	D041	ND	0.10	8270
2,4,6-Trichlorophenol	D042	ND	0.10	8270

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/25/98**
Date Reported: **06/29/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667B**
Instrument ID: **MS003**
Analyst ID: **KALVINL**
Matrix: **SOLID**

MATRIX SPIKE

Analyte	HW No.	MS Conc. (mg/L)	MS Recovery (percent)
Cresols, total	D026	3.00	64
2,4-Dinitrotoluene	D030	1.00	77
Hexachlorobenzene	D032	1.00	75
Hexachloro-1,3-butadiene	D033	1.00	55
Hexachloroethane	D034	1.00	53
Nitrobenzene	D036	1.00	81
Pentachlorophenol	D037	1.00	50
2,4,5-Trichlorophenol	D041	1.00	77
2,4,6-Trichlorophenol	D042	1.00	77

MATRIX SPIKE DUPLICATE

Analyte	HW No.	MSD Conc. (mg/L)	MSD Recovery (percent)
Cresols, total	D026	3.00	52
2,4-Dinitrotoluene	D030	1.00	72
Hexachlorobenzene	D032	1.00	77
Hexachloro-1,3-butadiene	D033	1.00	51
Hexachloroethane	D034	1.00	61
Nitrobenzene	D036	1.00	65
Pentachlorophenol	D037	1.00	58
2,4,5-Trichlorophenol	D041	1.00	64
2,4,6-Trichlorophenol	D042	1.00	62

RELATIVE % DIFFERENCE

Analyte	HW No.	Relative Percent Difference (percent)
Cresols, total	D026	21
2,4-Dinitrotoluene	D030	7
Hexachlorobenzene	D032	3
Hexachloro-1,3-butadiene	D033	8
Hexachloroethane	D034	14
Nitrobenzene	D036	22
Pentachlorophenol	D037	15
2,4,5-Trichlorophenol	D041	18

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/25/98**
Date Reported: **06/29/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667B**
Instrument ID: **MS003**
Analyst ID: **KALVINL**
Matrix: **SOLID**

RELATIVE % DIFFERENCE(cont.)

Analyte	HW No.	Relative Percent Difference (percent)
2,4,6-Trichlorophenol	D042	22

CLS Labs

Analysis Report: **TCLP Semi-volatiles Organic Constituents**
TCLP Semi-volatiles Extraction

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/25/98**
Date Reported: **06/29/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22667B**
Instrument ID: **MS003**
Analyst ID: **KALVINL**
Matrix: **SOLID**

LAB CONTROL SAMPLE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Recovery (percent)
Cresols, total	D026	3.00	56
2,4-Dinitrotoluene	D030	1.00	74
Hexachlorobenzene	D032	1.00	70
Hexachloro-1,3-butadiene	D033	1.00	32
Hexachloroethane	D034	1.00	39
Nitrobenzene	D036	1.00	69
Pentachlorophenol	D037	1.00	48
2,4,5-Trichlorophenol	D041	1.00	62
2,4,6-Trichlorophenol	D042	1.00	69

CLS Labs

Analysis Report: **Priority Pollutant Metals, EPA Methods 6010/7000**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **07/07/98**
Date Analyzed: **07/07/98**
Date Reported: **07/10/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1C**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980707B**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

Sample: **R061898**

Analyte	CAS No.	Results (mg/kg)	Rep. Limit (mg/kg)	Method	Dilution (factor)
Ag (Silver)	7440-22-4	ND	2.5	6010	1.0
As (Arsenic)	7440-38-2	ND	0.50	7060	1.0
Be (Beryllium)	7440-41-7	ND	0.50	6010	1.0
Cd (Cadmium)	7440-43-9	ND	1.0	6010	1.0
Cr (Chromium)	7440-47-3	ND	5.0	6010	1.0
Cu (Copper)	7440-50-8	5.8	5.0	6010	1.0
Hg (Mercury)	7439-97-6	ND	0.10	7471	1.0
Ni (Nickel)	7440-02-0	ND	10	6010	1.0
Pb (Lead)	7439-92-1	ND	10	6010	1.0
Sb (Antimony)	7440-36-0	ND	10	6010	1.0
Se (Selenium)	7783-00-8	ND	0.50	7740	1.0
Tl (Thallium)	7440-28-0	ND	1.0	7841	1.0
Zn (Zinc)	7440-66-6	31	5.0	6010	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: TCLP Semi-volatiles Organic Constituents-Herbicides
TCLP Semi-volatiles Extraction

Client: Harding Lawson Associates
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: Aerojet Perchlorate

Date Sampled: 06/18/98
Date Received: 06/18/98
Date Extracted: 06/22/98
Date Analyzed: 06/25/98
Date Reported: 06/26/98
Client ID No.: R061898

Project No.: 39860.353
Contact: John Catts
Phone: (916)364-0793

Lab Contact: George Hampton
Lab ID No.: P4907-1A
Job No.: 814907
COC Log No.: NO NUMBER
Batch No.: 22684
Instrument ID: GC020
Analyst ID: NGOCDUNG
Matrix: SOLID

SURROGATE

Analyte	HW No.	Surr Conc. (mg/L)	Surrogate Recovery (percent)
2,4-Dichlorophenol	120-83-2	500	105

R061898

Analyte	HW No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
2,4-D	39730	ND	5.0	8150	1.0
2,4,5-TP (Silvex)	D017	ND	0.50	8150	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: TCLP Semi-volatiles Organic Constituents-Herbicides
TCLP Semi-volatiles Extraction

Client: Harding Lawson Associates
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: Aerojet Perchlorate

Date Extracted: 06/22/98
Date Analyzed: 06/25/98
Date Reported: 06/26/98

Project No.: 39860.353
Contact: John Catts
Phone: (916)364-0793

Lab Contact: George Hampton
Lab ID No.: P4907
Job No.: 814907
COC Log No.: NO NUMBER
Batch No.: 22684
Instrument ID: GC020
Analyst ID: NGOCDUNG
Matrix: SOLID

MB SURROGATE

Analyte	HW No.	Surr Conc. (mg/L)	MB Surrogate Recovery (percent)
2,4-Dichlorophenol	120-83-2	500	104

METHOD BLANK

Analyte	HW No.	Results (mg/L)	Reporting Limit (mg/L)	Method
2,4-D	39730	ND	5.0	8150
2,4,5-TP (Silvex)	D017	ND	0.50	8150

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: TCLP Semi-volatiles Organic Constituents-Herbicides
TCLP Semi-volatiles Extraction

Client: Harding Lawson Associates
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: Aerojet Perchlorate

Date Extracted: 06/22/98
Date Analyzed: 06/25/98
Date Reported: 06/26/98

Project No.: 39860.353
Contact: John Catts
Phone: (916)364-0793

Lab Contact: George Hampton
Lab ID No.: P4907
Job No.: 814907
COC Log No.: NO NUMBER
Batch No.: 22684
Instrument ID: GC020
Analyst ID: NGOCDUNG
Matrix: SOLID

MS SURROGATE

Analyte	HW No.	MS Surr. Conc. (mg/L)	MS Surrogate Recovery (percent)
2,4-Dichlorophenol	120-83-2	500	89

MATRIX SPIKE

Analyte	HW No.	MS Conc. (mg/L)	MS Recovery (percent)
2,4,5-TP (Silvex)	D017	100	108

MSD SURROGATE

Analyte	HW No.	Surr. Conc. (mg/L)	MSD Surrogate Recovery (percent)
2,4-Dichlorophenol	120-83-2	500	110

MATRIX SPIKE DUPLICATE

Analyte	HW No.	MSD Conc. (mg/L)	MSD Recovery (percent)
2,4,5-TP (Silvex)	D017	100	138

RELATIVE % DIFFERENCE

Analyte	HW No.	Relative Percent Difference (percent)
2.4.5-TP (Silvex)	D017	24

CLS Labs

Analysis Report: TCLP Semi-volatiles Organic Constituents-Herbicides
TCLP Semi-volatiles Extraction

Client: Harding Lawson Associates
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: Aerojet Perchlorate

Date Extracted: 06/22/98
Date Analyzed: 06/25/98
Date Reported: 06/26/98

Project No.: 39860.353
Contact: John Catts
Phone: (916)364-0793

Lab Contact: George Hampton
Lab ID No.: P4907
Job No.: 814907
COC Log No.: NO NUMBER
Batch No.: 22684
Instrument ID: GC020
Analyst ID: NGOCDUNG
Matrix: SOLID

LCS SURROGATE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Surrogate Recovery (percent)
2,4-Dichlorophenol	120-83-2	500	89

LAB CONTROL SAMPLE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Recovery (percent)
2,4,5-TP (Silvex)	D017	100	114

CLS Labs

Analysis Report: **Priority Pollutant Metals, EPA Methods 6010/7000**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **07/07/98**
Date Analyzed: **07/07/98**
Date Reported: **07/10/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980707B**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

METHOD BLANK

Analyte	CAS No.	Results (mg/kg)	Reporting Limit (mg/kg)	Method
Ag (Silver)	7440-22-4	ND	2.5	6010
As (Arsenic)	7440-38-2	ND	0.50	7060
Be (Beryllium)	7440-41-7	ND	0.50	6010
Cd (Cadmium)	7440-43-9	ND	1.0	6010
Cr (Chromium)	7440-47-3	ND	5.0	6010
Cu (Copper)	7440-50-8	ND	5.0	6010
Hg (Mercury)	7439-97-6	ND	0.10	7471
Ni (Nickel)	7440-02-0	ND	10	6010
Pb (Lead)	7439-92-1	ND	10	6010
Sb (Antimony)	7440-36-0	ND	10	6010
Se (Selenium)	7783-00-8	ND	0.50	7740
Tl (Thallium)	7440-28-0	ND	1.0	7841
Zn (Zinc)	7440-66-6	ND	5.0	6010

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Priority Pollutant Metals, EPA Methods 6010/7000**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **07/07/98**
Date Analyzed: **07/07/98**
Date Reported: **07/10/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980707B**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

LAB CONTROL SAMPLE

Analyte	CAS No.	LCS Conc. (mg/kg)	LCS Recovery (percent)
Ag (Silver)	7440-22-4	2.50	84
As (Arsenic)	7440-38-2	2.00	91
Be (Beryllium)	7440-41-7	2.50	95
Cd (Cadmium)	7440-43-9	2.50	85
Cr (Chromium)	7440-47-3	10.0	101
Cu (Copper)	7440-50-8	12.5	93
Hg (Mercury)	7439-97-6	0.525	99
Ni (Nickel)	7440-02-0	25.0	96
Pb (Lead)	7439-92-1	25.0	95
Sb (Antimony)	7440-36-0	25.0	95
Se (Selenium)	7783-00-8	2.00	92
Tl (Thallium)	7440-28-0	2.00	95
Zn (Zinc)	7440-66-6	25.0	89

LAB CONTROL SAMPLE DUPLICATE

Analyte	CAS No.	LCS Conc. (mg/kg)	LCSD Recovery (percent)
Ag (Silver)	7440-22-4	2.50	85
As (Arsenic)	7440-38-2	2.00	85
Be (Beryllium)	7440-41-7	2.50	95
Cd (Cadmium)	7440-43-9	2.50	85
Cr (Chromium)	7440-47-3	10.0	100
Cu (Copper)	7440-50-8	12.5	94
Hg (Mercury)	7439-97-6	0.525	91
Ni (Nickel)	7440-02-0	25.0	96
Pb (Lead)	7439-92-1	25.0	95
Sb (Antimony)	7440-36-0	25.0	96
Se (Selenium)	7783-00-8	2.00	81
Tl (Thallium)	7440-28-0	2.00	94
Zn (Zinc)	7440-66-6	25.0	89

CLS Labs

Analysis Report: **Priority Pollutant Metals, EPA Methods 6010/7000**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **07/07/98**
Date Analyzed: **07/07/98**
Date Reported: **07/10/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980707B**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

LCS RPD

Analyte	CAS No.	LCS Relative Percent Difference (percent)
Ag (Silver)	7440-22-4	1
As (Arsenic)	7440-38-2	7
Be (Beryllium)	7440-41-7	0
Cd (Cadmium)	7440-43-9	0
Cr (Chromium)	7440-47-3	1
Cu (Copper)	7440-50-8	1
Hg (Mercury)	7439-97-6	8
Ni (Nickel)	7440-02-0	0
Pb (Lead)	7439-92-1	0
Sb (Antimony)	7440-36-0	1
Se (Selenium)	7783-00-8	13
Tl (Thallium)	7440-28-0	1
Zn (Zinc)	7440-66-6	0

CLS Labs

Analysis Report: **Inorganic Constituents**
Toxicity Characteristic Leaching Procedure

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **07/01/98**
Date Analyzed: **07/02/98**
Date Reported: **07/10/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1A**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980701A**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

Sample: **R061898**

Analyte	HW No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Arsenic	01002	ND	0.10	7060	1.0
Barium	01007	0.66	0.50	6010	1.0
Cadmium	01027	ND	0.10	6010	1.0
Chromium	01034	ND	0.50	6010	1.0
Mercury	71900	ND	0.050	7470	1.0
Lead	01051	ND	0.50	6010	1.0
Selenium	01147	ND	0.10	7740	1.0
Silver	01077	ND	0.50	6010	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Inorganic Constituents**
Toxicity Characteristic Leaching Procedure

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **07/01/98**
Date Analyzed: **07/02/98**
Date Reported: **07/10/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980701A**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

METHOD BLANK

Analyte	HW No.	Results (mg/L)	Reporting Limit (mg/L)	Method
Arsenic	01002	ND	0.10	7060
Barium	01007	ND	0.50	6010
Cadmium	01027	ND	0.10	6010
Chromium	01034	ND	0.50	6010
Mercury	71900	ND	0.050	7470
Lead	01051	ND	0.50	6010
Selenium	01147	ND	0.10	7740
Silver	01077	ND	0.50	6010

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Inorganic Constituents**
Toxicity Characteristic Leaching Procedure

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **07/01/98**
Date Analyzed: **07/02/98**
Date Reported: **07/10/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **M980701A**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **SOLID**

LAB CONTROL SAMPLE

Analyte	HW No.	LCS Conc. (mg/L)	LCS Recovery (percent)
Arsenic	01002	0.200	106
Barium	01007	10.0	94
Cadmium	01027	0.250	83
Chromium	01034	1.00	95
Mercury	71900	0.0150	110
Lead	01051	2.50	93
Selenium	01147	0.200	98
Silver	01077	0.250	89

LAB CONTROL SAMPLE DUPLICATE

Analyte	HW No.	LCS Conc. (mg/L)	LCSD Recovery (percent)
Arsenic	01002	0.200	115
Barium	01007	10.0	97
Cadmium	01027	0.250	96
Chromium	01034	1.00	102
Mercury	71900	0.0150	109
Lead	01051	2.50	99
Selenium	01147	0.200	95
Silver	01077	0.250	98

LCS RPD

Analyte	HW No.	LCS Relative Percent Difference (percent)
Arsenic	01002	8
Barium	01007	3
Cadmium	01027	15
Chromium	01034	7
Mercury	71900	1
Lead	01051	6
Selenium	01147	3
Silver	01077	10

CLS Labs

Analysis Report: **Organochlorine Pesticides, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **06/22/98**
Date Analyzed: **06/27/98**
Date Reported: **07/07/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1C**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

SURROGATE

Analyte	CAS No.	Surr Conc. (ug/kg)	Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	0.250	HC
Decachlorobiphenyl	2051-24-3	0.250	HC

HC = Recovery data is outside standard QC limits due to the high concentration of this analyte in the sample. LCS recovery data validates methodology.

Sample: **R061898**

Analyte	CAS No.	Results (ug/kg)	Rep. Limit (ug/kg)	Dilution (factor)
Aldrin	309-00-2	ND	1.7	1.0
alpha BHC	319-84-6	ND	1.7	1.0
beta BHC	319-85-7	ND	1.7	1.0
delta-BHC	319-86-7	ND	1.7	1.0
Lindane	58-89-9	ND	1.7	1.0
Chlordane	57-74-9	ND	80	1.0
4,4'-DDD	72-54-8	ND	3.3	1.0
4,4'-DDE	72-55-9	ND	3.3	1.0
4,4'-DDT	50-29-3	ND	3.3	1.0
Dieldrin	60-57-1	ND	3.3	1.0
Endosulfan I	959-98-8	ND	1.7	1.0
Endosulfan II	33213-65-9	ND	3.3	1.0
Endosulfan sulfate	1031-07-8	ND	3.3	1.0
Endrin	72-20-8	ND	3.3	1.0
Endrin aldehyde	7421-93-4	ND	3.3	1.0
Heptachlor	76-44-8	ND	1.7	1.0
Heptachlor epoxide	1024-57-3	ND	1.7	1.0
Kepone	143-50-0	ND	3.3	1.0
Methoxychlor	72-43-5	ND	17	1.0
Mirex	2385-85-5	ND	3.3	1.0
Toxaphene	8001-35-2	ND	160	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Organochlorine Pesticides, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **06/26/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

MB SURROGATE

Analyte	CAS No.	Surr Conc. (ug/kg)	MB Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	8.33	64
Decachlorobiphenyl	2051-24-3	8.33	80

METHOD BLANK

Analyte	CAS No.	Results (ug/kg)	Reporting Limit (ug/kg)
Aldrin	309-00-2	ND	1.7
alpha BHC	319-84-6	ND	1.7
beta BHC	319-85-7	ND	1.7
delta-BHC	319-86-7	ND	1.7
Lindane	58-89-9	ND	1.7
Chlordane	57-74-9	ND	80
4,4'-DDD	72-54-8	ND	3.3
4,4'-DDE	72-55-9	ND	3.3
4,4'-DDT	50-29-3	ND	3.3
Dieldrin	60-57-1	ND	3.3
Endosulfan I	959-98-8	ND	1.7
Endosulfan II	33213-65-9	ND	3.3
Endosulfan sulfate	1031-07-8	ND	3.3
Endrin	72-20-8	ND	3.3
Endrin aldehyde	7421-93-4	ND	3.3
Heptachlor	76-44-8	ND	1.7
Heptachlor epoxide	1024-57-3	ND	1.7
Kepone	143-50-0	ND	3.3
Methoxychlor	72-43-5	ND	17
Mirex	2385-85-5	ND	3.3
Toxaphene	8001-35-2	ND	160

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Organochlorine Pesticides, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **06/26/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

MS SURROGATE

Analyte	CAS No.	MS Surr. Conc. (ug/kg)	MS Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	8.33	61
Decachlorobiphenyl	2051-24-3	8.33	52

MATRIX SPIKE

Analyte	CAS No.	MS Conc. (ug/kg)	MS Recovery (percent)
Lindane	58-89-9	4.17	42
Aldrin	309-00-2	4.17	61
Heptachlor	76-44-8	4.17	71
Dieldrin	60-57-1	8.33	72
Endrin	72-20-8	8.33	73
4,4'-DDT	50-29-3	8.33	65

MSD SURROGATE

Analyte	CAS No.	Surr. Conc. (ug/kg)	MSD Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	8.33	58
Decachlorobiphenyl	2051-24-3	8.33	51

MATRIX SPIKE DUPLICATE

Analyte	CAS No.	MSD Conc. (ug/kg)	MSD Recovery (percent)
Lindane	58-89-9	4.17	46
Aldrin	309-00-2	4.17	59
Heptachlor	76-44-8	4.17	64
Dieldrin	60-57-1	8.33	68
Endrin	72-20-8	8.33	71
4,4'-DDT	50-29-3	8.33	76

CLS Labs

Analysis Report: **Organochlorine Pesticides, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **06/26/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

RELATIVE % DIFFERENCE

Analyte	CAS No.	Relative Percent Difference (percent)
Lindane	58-89-9	9
Aldrin	309-00-2	3
Heptachlor	76-44-8	10
Dieldrin	60-57-1	6
Endrin	72-20-8	3
4,4'-DDT	50-29-3	16

CLS Labs

Analysis Report: **Organochlorine Pesticides, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **06/26/98**
Date Reported: **07/07/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC021**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

LCS SURROGATE

Analyte	CAS No.	LCS Conc. (ug/kg)	LCS Surrogate Recovery (percent)
2,4,5,6-tetrachloro-m-xylene	877-09-8	8.33	73
Decachlorobiphenyl	2051-24-3	8.33	82

LAB CONTROL SAMPLE

Analyte	CAS No.	LCS Conc. (ug/kg)	LCS Recovery (percent)
Lindane	58-89-9	4.17	56
Aldrin	309-00-2	4.17	100
Heptachlor	76-44-8	4.17	95
Dieldrin	60-57-1	8.33	99
Endrin	72-20-8	8.33	101
4,4'-DDT	50-29-3	8.33	81

CLS Labs

Analysis Report: **Polychlorinated Biphenyls, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **06/22/98**
Date Analyzed: **07/08/98**
Date Reported: **07/09/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1C**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC019**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

Sample: **R061898**

Analyte	CAS No.	Results (ug/kg)	Rep. Limit (ug/kg)	Dilution (factor)
Aroclor 1016	12674-11-2	ND	2000(AI)	100
Aroclor 1221	1104-28-2	ND	2000	100
Aroclor 1232	11141-16-5	ND	2000	100
Aroclor 1242	53469-21-9	ND	2000	100
Aroclor 1248	12672-29-6	ND	2000	100
Aroclor 1254	11097-69-1	ND	2000	100
Aroclor 1260	11096-82-5	ND	2000	100

AI = All report limits have been elevated due to matrix interference.

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Polychlorinated Biphenyls, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **07/08/98**
Date Reported: **07/09/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC019**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

METHOD BLANK

Analyte	CAS No.	Results (ug/kg)	Reporting Limit (ug/kg)
Aroclor 1016	12674-11-2	ND	20
Aroclor 1221	1104-28-2	ND	20
Aroclor 1232	11141-16-5	ND	20
Aroclor 1242	53469-21-9	ND	20
Aroclor 1248	12672-29-6	ND	20
Aroclor 1254	11097-69-1	ND	20
Aroclor 1260	11096-82-5	ND	20

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Polychlorinated Biphenyls, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **07/08/98**
Date Reported: **07/09/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC019**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

MATRIX SPIKE

Analyte	CAS No.	MS Conc. (ug/kg)	MS Recovery (percent)
Aroclor 1260	11096-82-5	8.33	SD

SD = Surrogate standard recovery data could not be generated due to sample dilution during analysis.

MATRIX SPIKE DUPLICATE

Analyte	CAS No.	MSD Conc. (ug/kg)	MSD Recovery (percent)
Aroclor 1260	11096-82-5	8.33	SD

SD = Surrogate standard recovery data could not be generated due to sample dilution during analysis.

RELATIVE % DIFFERENCE

Analyte	CAS No.	Relative Percent Difference (percent)
Aroclor 1260	11096-82-5	SD

SD = Surrogate standard recovery data could not be generated due to sample dilution during analysis.

CLS Labs

Analysis Report: **Polychlorinated Biphenyls, EPA Method 8080**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/22/98**
Date Analyzed: **07/08/98**
Date Reported: **07/09/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22677**
Instrument ID: **GC019**
Analyst ID: **NGOCDUNG**
Matrix: **SOLID**

LAB CONTROL SAMPLE

Analyte	CAS No.	LCS Conc. (ug/kg)	LCS Recovery (percent)
Aroclor 1260	11096-82-5	8.33	110

LAB CONTROL SAMPLE DUPLICATE

Analyte	CAS No.	LCS Conc. (ug/kg)	LCSD Recovery (percent)
Aroclor 1260	11096-82-5	8.33	96

LCS RPD

Analyte	CAS No.	LCS Relative Percent Difference (percent)
Aroclor 1260	11096-82-5	14

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **N/A**
Date Analyzed: **06/25/98**
Date Reported: **07/08/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1B**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

SURROGATE

Analyte	CAS No.	Surr Conc. (ug/kg)	Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	5000	109
Toluene-d8	N/A	5000	108
p-Bromofluorobenzene	460-00-4	5000	102

Sample: **R061898**

Analyte	CAS No.	Results (ug/kg)	Rep. Limit (ug/kg)	Dilution (factor)
1,1,1-Trichloroethane	71-55-6	ND	500	1.0
1,1,2,2-Tetrachloroethane	79-34-5	ND	500	1.0
1,1,2-Trichloroethane	79-00-5	ND	500	1.0
1,1-Dichloroethane	75-34-3	ND	500	1.0
1,1-Dichloroethene	75-35-4	ND	500	1.0
1,2-Dichlorobenzene	95-50-1	ND	500	1.0
1,2-Dichloroethane	107-06-2	ND	500	1.0
1,2-Dichloropropane	78-87-5	ND	500	1.0
1,3-Dichlorobenzene	541-73-1	ND	500	1.0
1,4-Dichlorobenzene	106-46-7	ND	500	1.0
2-Butanone	78-93-3	ND	2500	1.0
2-Hexanone	591-78-6	ND	2500	1.0
4-Methyl-2-pentanone	108-10-1	4200	2500	1.0
Acetone	67-64-1	4900	2500	1.0
Benzene	71-43-2	ND	500	1.0
Bromodichloromethane	75-27-4	ND	500	1.0
Bromoform	75-25-2	ND	500	1.0
Bromomethane	74-83-9	ND	1000	1.0
Carbon disulfide	75-15-0	ND	500	1.0
Carbon tetrachloride	56-23-5	ND	500	1.0
Chlorobenzene	108-90-7	ND	500	1.0
Chloroethane	75-00-3	ND	1000	1.0
Chloroform	67-66-3	ND	500	1.0
Chloromethane	74-87-3	ND	1000	1.0
Dibromochloromethane	124-48-1	ND	500	1.0
Ethylbenzene	100-41-4	ND	500	1.0
Methylene chloride	75-09-2	ND	500	1.0
Styrene	100-42-5	ND	500	1.0
Tetrachloroethene	127-18-4	ND	500	1.0
Toluene	108-88-3	ND	500	1.0
Trichloroethene	79-01-6	4900	500	1.0
Trichlorofluoromethane	75-69-4	ND	1000	1.0
Vinyl chloride	75-01-4	ND	1000	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **N/A**
Date Analyzed: **06/25/98**
Date Reported: **07/08/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1B**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

Sample: **R061898(cont.)**

Analyte	CAS No.	Results (ug/kg)	Rep. Limit (ug/kg)	Dilution (factor)
cis-1,2-Dichloroethene	156-59-2	ND	500	1.0
cis-1,3-Dichloropropene	10061-01-5	ND	500	1.0
m/p-Xylenes	N/A	ND	500	1.0
o-Xylenes	95-47-6	ND	500	1.0
trans-1,2-Dichloroethene	156-60-5	ND	500	1.0
trans-1,3-Dichloropropene	10061-02-6	ND	500	1.0

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/24/98**
Date Reported: **07/08/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

MB SURROGATE

Analyte	CAS No.	Surr Conc. (ug/kg)	MB Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	5000	90
Toluene-d8	N/A	5000	103
p-Bromofluorobenzene	460-00-4	5000	96

METHOD BLANK

Analyte	CAS No.	Results (ug/kg)	Reporting Limit (ug/kg)
1,1,1-Trichloroethane	71-55-6	ND	500
1,1,2,2-Tetrachloroethane	79-34-5	ND	500
1,1,2-Trichloroethane	79-00-5	ND	500
1,1-Dichloroethane	75-34-3	ND	500
1,1-Dichloroethene	75-35-4	ND	500
1,2-Dichlorobenzene	95-50-1	ND	500
1,2-Dichloroethane	107-06-2	ND	500
1,2-Dichloroethene, total	540-59-0	ND	500
1,2-Dichloropropane	78-87-5	ND	500
1,3-Dichlorobenzene	541-73-1	ND	500
1,4-Dichlorobenzene	106-46-7	ND	500
2-Butanone	78-93-3	ND	2500
2-Hexanone	591-78-6	ND	2500
4-Methyl-2-pentanone	108-10-1	ND	2500
Acetone	67-64-1	ND	2500
Benzene	71-43-2	ND	500
Bromodichloromethane	75-27-4	ND	500
Bromoform	75-25-2	ND	500
Bromomethane	74-83-9	ND	1000
Carbon disulfide	75-15-0	ND	500
Carbon tetrachloride	56-23-5	ND	500
Chlorobenzene	108-90-7	ND	500
Chloroethane	75-00-3	ND	1000
Chloroform	67-66-3	ND	500
Chloromethane	74-87-3	ND	1000
Dibromochloromethane	124-48-1	ND	500
Ethylbenzene	100-41-4	ND	500
Methylene chloride	75-09-2	ND	500
Styrene	100-42-5	ND	500
Tetrachloroethene	127-18-4	ND	500

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/24/98**
Date Reported: **07/08/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

METHOD BLANK(cont.)

Analyte	CAS No.	Results (ug/kg)	Reporting Limit (ug/kg)
Toluene	108-88-3	ND	500
Trichloroethene	79-01-6	ND	500
Trichlorofluoromethane	75-69-4	ND	1000
Vinyl chloride	75-01-4	ND	1000
cis-1,2-Dichloroethene	156-59-2	ND	500
cis-1,3-Dichloropropene	10061-01-5	ND	500
m/p-Xylenes	N/A	ND	500
o-Xylenes	95-47-6	ND	500
trans-1,3-Dichloropropene	10061-02-6	ND	500

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/24/98**
Date Reported: **07/08/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

MS SURROGATE

Analyte	CAS No.	MS Surr. Conc. (ug/kg)	MS Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	5000	93
Toluene-d8	N/A	5000	106
p-Bromofluorobenzene	460-00-4	5000	120

MATRIX SPIKE

Analyte	CAS No.	MS Conc. (ug/kg)	MS Recovery (percent)
1,1-Dichloroethene	75-35-4	5000	104
Benzene	71-43-2	5000	115
Chlorobenzene	108-90-7	5000	112
Toluene	108-88-3	5000	132
Trichloroethene	79-01-6	5000	99

MSD SURROGATE

Analyte	CAS No.	Surr. Conc. (ug/kg)	MSD Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	5000	93
Toluene-d8	N/A	5000	110
p-Bromofluorobenzene	460-00-4	5000	121

MATRIX SPIKE DUPLICATE

Analyte	CAS No.	MSD Conc. (ug/kg)	MSD Recovery (percent)
1,1-Dichloroethene	75-35-4	5000	120
Benzene	71-43-2	5000	118
Chlorobenzene	108-90-7	5000	113
Toluene	108-88-3	5000	130
Trichloroethene	79-01-6	5000	103

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/24/98**
Date Reported: **07/08/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

RELATIVE % DIFFERENCE

Analyte	CAS No.	Relative Percent Difference (percent)
1,1-Dichloroethene	75-35-4	14
Benzene	71-43-2	3
Chlorobenzene	108-90-7	1
Toluene	108-88-3	2
Trichloroethene	79-01-6	4

CLS Labs

Analysis Report: **Volatile Organic Compounds by GC/MS, EPA Method 8240**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **N/A**
Date Analyzed: **06/24/98**
Date Reported: **07/08/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **51508**
Instrument ID: **MS05**
Analyst ID: **TERIB**
Matrix: **SOLID**

LCS SURROGATE

Analyte	CAS No.	LCS Conc. (ug/kg)	LCS Surrogate Recovery (percent)
1,2-Dichloroethane-d4	N/A	5000	84
Toluene-d8	N/A	5000	103
p-Bromofluorobenzene	460-00-4	5000	96

LAB CONTROL SAMPLE

Analyte	CAS No.	LCS Conc. (ug/kg)	LCS Recovery (percent)
1,1-Dichloroethene	75-35-4	5000	109
Benzene	71-43-2	5000	116
Chlorobenzene	108-90-7	5000	107
Toluene	108-88-3	5000	106
Trichloroethene	79-01-6	5000	102

CLS Labs

Analysis Report: **Semivolatile Organic Compounds by GC/MS EPA Method 8270**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Sampled: **06/18/98**
Date Received: **06/18/98**
Date Extracted: **06/23/98**
Date Analyzed: **06/26/98**
Date Reported: **06/30/98**
Client ID No.: **R061898**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907-1B**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22691**
Instrument ID: **MS001**
Analyst ID: **KALVINL**
Matrix: **SOLID**

SURROGATE

Analyte	CAS No.	Results (ug/kg)	Surr Conc. (ug/kg)	Surrogate Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)
Phenol-d5	4165-62-2	SD	2500	SD	24	113
2-Fluorophenol	367-12-4	SD	2500	SD	25	121
2,4,6-Tribromophenol	118-79-6	SD	2500	SD	19	122
Nitrobenzene-d5	4665-60-0	SD	1670	SD	23	120
2-Fluorobiphenyl	321-60-8	SD	1670	SD	30	115
Terphenyl-d14	98904-43-9	SD	1670	SD	18	137

SD = Surrogate standard recovery data could not be generated due to sample dilution during analysis.

R061898

Analyte	CAS No.	Results (ug/kg)	Rep. Limit (ug/kg)	Dilution (factor)
Acenaphthene	83-32-9	ND	6600(AI)	20
Acenaphthylene	208-96-8	ND	6600	20
Anthracene	120-12-7	ND	6600	20
Benzo(a)anthracene	56-55-3	ND	6600	20
Benzo(b)fluoranthene	205-99-2	ND	6600	20
Benzo(k)fluoranthene	207-08-9	ND	6600	20
Benzo(g,h,i)perylene	191-24-2	ND	6600	20
Benzo(a)pyrene	50-32-8	ND	6600	20
Benzyl alcohol	100-51-6	ND	13000	20
Bis(2-chloroethoxy)methane	111-91-1	ND	6600	20
Bis(2-chloroethyl)ether	111-44-4	ND	6600	20
Bis(2-chloroisopropyl)ether	108-60-1	ND	6600	20
Bis(2-ethylhexyl)phthalate	117-81-7	ND	6600	20
4-Bromophenyl phenyl ether	101-55-3	ND	6600	20
Butylbenzyl phthalate	85-68-7	ND	6600	20
4-Chloroaniline	106-47-8	ND	13000	20
2-Chloronaphthalene	91-58-7	ND	6600	20
4-Chlorophenyl phenyl ether	7005-72-3	ND	6600	20
Chrysene	218-01-9	ND	6600	20
Dibenzo(a,h)anthracene	53-70-3	ND	6600	20
Dibenzofuran	132-64-9	ND	6600	20
Di-n-butylphthalate	84-74-2	ND	6600	20
1,2-Dichlorobenzene	95-50-1	ND	6600	20
1,3-Dichlorobenzene	541-73-1	ND	6600	20
1,4-Dichlorobenzene	106-46-7	ND	6600	20
3,3'-Dichlorobenzidine	91-94-1	ND	13000	20
Diethylphthalate	84-66-2	ND	6600	20

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: Semivolatile Organic Compounds by GC/MS EPA Method 8270

Client: Harding Lawson Associates
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: Aerojet Perchlorate

Date Sampled: 06/18/98
Date Received: 06/18/98
Date Extracted: 06/23/98
Date Analyzed: 06/26/98
Date Reported: 06/30/98
Client ID No.: R061898

Project No.: 39860.353
Contact: John Catts
Phone: (916)364-0793

Lab Contact: George Hampton
Lab ID No.: P4907-1B
Job No.: 814907
COC Log No.: NO NUMBER
Batch No.: 22691
Instrument ID: MS001
Analyst ID: KALVINL
Matrix: SOLID

R061898(cont.)

Analyte	CAS No.	Results (ug/kg)	Rep. Limit (ug/kg)	Dilution (factor)
Dimethylphthalate	131-11-3	ND	6600	20
24DNT (2,4-Dinitrotoluene)	121-14-2	ND	6600	20
26DNT (2,6-Dinitrotoluene)	606-20-2	ND	6600	20
Di-n-octylphthalate	117-84-0	ND	6600	20
Fluoranthene	206-44-0	ND	6600	20
Fluorene	86-73-7	ND	6600	20
Hexachlorobenzene	118-74-1	ND	6600	20
Hexachlorobutadiene	87-68-3	ND	6600	20
Hexachlorocyclopentadiene	77-47-4	ND	6600	20
Hexachloroethane	67-72-1	ND	6600	20
Indeno(1,2,3-c,d)pyrene	193-39-5	ND	6600	20
Isophorone	78-59-1	ND	6600	20
2-Methylnaphthalene	91-57-6	ND	6600	20
Naphthalene	91-20-3	ND	6600	20
2-Nitroaniline	88-74-4	ND	17000	20
3-Nitroaniline	99-09-2	ND	17000	20
4-Nitroaniline	100-01-6	ND	17000	20
NB (Nitrobenzene)	98-95-3	ND	6600	20
N-Nitrosodiphenylamine	86-30-6	ND	6600	20
N-Nitroso-di-n-propylamine	621-64-7	ND	6600	20
Phenanthrene	85-01-8	ND	6600	20
Pyrene	129-00-0	ND	6600	20
1,2,4-Trichlorobenzene	120-82-1	ND	6600	20
Benzoic Acid	65-85-0	ND	17000	20
4-Chloro-3-methylphenol	59-50-7	ND	6600	20
2-Chlorophenol	95-57-8	ND	6600	20
2,4-Dichlorophenol	120-83-2	ND	6600	20
2,4-Dimethylphenol	105-67-9	ND	6600	20
2,4-Dinitrophenol	51-28-5	ND	17000	20
2-Methyl-4,6-dinitrophenol	534-52-1	ND	17000	20
2-Methylphenol	95-48-7	ND	6600	20
3/4-Methylphenol	N/A	18000	6600	20
2-Nitrophenol	88-75-5	ND	6600	20
4-Nitrophenol	100-02-7	ND	17000	20
Pentachlorophenol	87-86-5	ND	17000	20
Phenol	108-95-2	ND	6600	20
2,4,5-Trichlorophenol	95-95-4	ND	6600	20
2,4,6-Trichlorophenol	88-06-2	ND	6600	20

AI = All report limits have been elevated due to matrix interference.

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Semivolatile Organic Compounds by GC/MS EPA Method 8270**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/26/98**
Date Reported: **06/30/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22691**
Instrument ID: **MS001**
Analyst ID: **KALVINL**
Matrix: **SOLID**

MB SURROGATE

Analyte	CAS No.	Observed Conc. (ug/kg)	Surr Conc. (ug/kg)	MB Surrogate Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)
Phenol-d5	4165-62-2	1500	2500	60	24	113
2-Fluorophenol	367-12-4	1100	2500	44	25	121
2,4,6-Tribromophenol	118-79-6	1410	2500	56	19	122
Nitrobenzene-d5	4665-60-0	830	1670	50	23	120
2-Fluorobiphenyl	321-60-8	980	1670	59	30	115
Terphenyl-d14	98904-43-9	1320	1670	79	18	137

METHOD BLANK

Analyte	CAS No.	Results (ug/kg)	Reporting Limit (ug/kg)
Acenaphthene	83-32-9	ND	330
Acenaphthylene	208-96-8	ND	330
Anthracene	120-12-7	ND	330
Benzo(a)anthracene	56-55-3	ND	330
Benzo(b)fluoranthene	205-99-2	ND	330
Benzo(k)fluoranthene	207-08-9	ND	330
Benzo(g,h,i)perylene	191-24-2	ND	330
Benzo(a)pyrene	50-32-8	ND	330
Benzyl alcohol	100-51-6	ND	670
Bis(2-chloroethoxy)methane	111-91-1	ND	330
Bis(2-chloroethyl)ether	111-44-4	ND	330
Bis(2-chloroisopropyl)ether	108-60-1	ND	330
Bis(2-ethylhexyl)phthalate	117-81-7	ND	330
4-Bromophenyl phenyl ether	101-55-3	ND	330
Butylbenzyl phthalate	85-68-7	ND	330
4-Chloroaniline	106-47-8	ND	670
2-Chloronaphthalene	91-58-7	ND	330
4-Chlorophenyl phenyl ether	7005-72-3	ND	330
Chrysene	218-01-9	ND	330
Dibenzo(a,h)anthracene	53-70-3	ND	330
Dibenzofuran	132-64-9	ND	330
Di-n-butylphthalate	84-74-2	ND	330
1,2-Dichlorobenzene	95-50-1	ND	330
1,3-Dichlorobenzene	541-73-1	ND	330
1,4-Dichlorobenzene	106-46-7	ND	330
3,3'-Dichlorobenzidine	91-94-1	ND	670
Diethylphthalate	84-66-2	ND	330

ND = Not detected at or above indicated Reporting Limit

3249 Fitzgerald Road Rancho Cordova, CA 95742 (916) 638-7301 Fax (916) 638-4510

CLS Labs

Analysis Report: **Semivolatile Organic Compounds by GC/MS EPA Method 8270**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/26/98**
Date Reported: **06/30/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22691**
Instrument ID: **MS001**
Analyst ID: **KALVINL**
Matrix: **SOLID**

METHOD BLANK(cont.)

Analyte	CAS No.	Results (ug/kg)	Reporting Limit (ug/kg)
Dimethylphthalate	131-11-3	ND	330
24DNT (2,4-Dinitrotoluene)	121-14-2	ND	330
26DNT (2,6-Dinitrotoluene)	606-20-2	ND	330
Di-n-octylphthalate	117-84-0	ND	330
Fluoranthene	206-44-0	ND	330
Fluorene	86-73-7	ND	330
Hexachlorobenzene	118-74-1	ND	330
Hexachlorobutadiene	87-68-3	ND	330
Hexachlorocyclopentadiene	77-47-4	ND	330
Hexachloroethane	67-72-1	ND	330
Indeno(1,2,3-c,d)pyrene	193-39-5	ND	330
Isophorone	78-59-1	ND	330
2-Methylnaphthalene	91-57-6	ND	330
Naphthalene	91-20-3	ND	330
2-Nitroaniline	88-74-4	ND	830
3-Nitroaniline	99-09-2	ND	830
4-Nitroaniline	100-01-6	ND	830
NB (Nitrobenzene)	98-95-3	ND	330
N-Nitrosodiphenylamine	86-30-6	ND	330
N-Nitroso-di-n-propylamine	621-64-7	ND	330
Phenanthrene	85-01-8	ND	330
Pyrene	129-00-0	ND	330
1,2,4-Trichlorobenzene	120-82-1	ND	330
Benzoic Acid	65-85-0	ND	830
4-Chloro-3-methylphenol	59-50-7	ND	330
2-Chlorophenol	95-57-8	ND	330
2,4-Dichlorophenol	120-83-2	ND	330
2,4-Dimethylphenol	105-67-9	ND	330
2,4-Dinitrophenol	51-28-5	ND	830
2-Methyl-4,6-dinitrophenol	534-52-1	ND	830
2-Methylphenol	95-48-7	ND	330
3/4-Methylphenol	N/A	ND	330
2-Nitrophenol	88-75-5	ND	330
4-Nitrophenol	100-02-7	ND	830
Pentachlorophenol	87-86-5	ND	830
Phenol	108-95-2	ND	330
2,4,5-Trichlorophenol	95-95-4	ND	330
2,4,6-Trichlorophenol	88-06-2	ND	330

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **Semivolatile Organic Compounds by GC/MS EPA Method 8270**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/26/98**
Date Reported: **06/30/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22691**
Instrument ID: **MS001**
Analyst ID: **KALVINL**
Matrix: **SOLID**

LCS SURROGATE

Analyte	CAS No.	LCS Surr Conc. (ug/kg)	LCS Conc. (ug/kg)	LCS Surrogate Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)
Phenol-d5	4165-62-2	1650	2500	66	24	113
2-Fluorophenol	367-12-4	1440	2500	58	25	121
2,4,6-Tribromophenol	118-79-6	1930	2500	77	19	122
Nitrobenzene-d5	4665-60-0	990	1670	59	23	120
2-Fluorobiphenyl	321-60-8	1060	1670	63	30	115
Terphenyl-d14	98904-43-9	1430	1670	86	18	137

LAB CONTROL SAMPLE

Analyte CAS No.	Observed Value (ug/kg)	LCS Conc. (ug/kg)	LCS Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)
1,2,4-Trichlorobenzene 120-82-1	1350	1670	81	38	107
Acenaphthene 83-32-9	1240	1670	74	31	137
24DNT (2,4-Dinitrotoluene) 121-14-2	1100	1670	66	28	89
Pyrene 129-00-0	1590	1670	95	35	142
N-Nitroso-di-n-propylamine 621-64-7	1590	1670	95	41	126
1,4-Dichlorobenzene 106-46-7	1200	1670	72	28	104
Pentachlorophenol 87-86-5	1670	2500	67	17	109
Phenol 108-95-2	1940	2500	78	26	90
2-Chlorophenol 95-57-8	1990	2500	80	25	102
4-Chloro-3-methylphenol 59-50-7	2130	2500	85	26	103
4-Nitrophenol 100-02-7	1220	2500	49	11	114

LCS DUPLICATE SURROGATE

Analyte	CAS No.	LCSD Surr Conc. (ug/kg)	LCSD Conc. (ug/kg)	LCSD Surrogate Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)

CA DOHS ELAP Accreditation/Registration Number 1233

CLS Labs

Analysis Report: **Semivolatile Organic Compounds by GC/MS EPA Method 8270**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: 06/23/98
Date Analyzed: 06/26/98
Date Reported: 06/30/98

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22691**
Instrument ID: **MS001**
Analyst ID: **KALVINL**
Matrix: **SOLID**

LCS DUPLICATE SURROGATE(cont.)

Analyte	CAS No.	LCSD Surr Conc. (ug/kg)	LCSD Conc. (ug/kg)	LCSD Surrogate Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)
Phenol-d5	4165-62-2	1670	2500	67	24	113
2-Fluorophenol	367-12-4	1290	2500	52	25	121
2,4,6-Tribromophenol	118-79-6	1760	2500	70	19	122
Nitrobenzene-d5	4665-60-0	1000	1670	60	23	120
2-Fluorobiphenyl	321-60-8	1060	1670	63	30	115
Terphenyl-d14	98904-43-9	1360	1670	81	18	137

LAB CONTROL SAMPLE DUPLICATE

Analyte CAS No.	Observed Value (ug/kg)	LCS Conc. (ug/kg)	LCSD Recovery (percent)	Lower Spec (Limit)	Upper Spec (Limit)
1,2,4-Trichlorobenzene 120-82-1	1370	1670	82	38	107
Acenaphthene 83-32-9	1270	1670	76	31	137
24DNT (2,4-Dinitrotoluene) 121-14-2	920	1670	55	28	89
Pyrene 129-00-0	1520	1670	91	35	142
N-Nitroso-di-n-propylamine 621-64-7	1520	1670	91	41	126
1,4-Dichlorobenzene 106-46-7	1280	1670	77	28	104
Pentachlorophenol 87-86-5	1430	2500	57	17	109
Phenol 108-95-2	1980	2500	79	26	90
2-Chlorophenol 95-57-8	2020	2500	81	25	102
4-Chloro-3-methylphenol 59-50-7	2050	2500	82	26	103
4-Nitrophenol 100-02-7	880	2500	35	11	114

3249 Fitzgerald Road Rancho Cordova, CA 95742 (916) 638-7301 Fax (916) 638-4510

CLS Labs

Analysis Report: **Semivolatile Organic Compounds by GC/MS EPA Method 8270**

Client: **Harding Lawson Associates**
10265 Rockingham Dr. STE 150
Sacramento, CA 95827

Project: **Aerojet Perchlorate**

Date Extracted: **06/23/98**
Date Analyzed: **06/26/98**
Date Reported: **06/30/98**

Project No.: **39860.353**
Contact: **John Catts**
Phone: **(916)364-0793**

Lab Contact: **George Hampton**
Lab ID No.: **P4907**
Job No.: **814907**
COC Log No.: **NO NUMBER**
Batch No.: **22691**
Instrument ID: **MS001**
Analyst ID: **KALVINL**
Matrix: **SOLID**

LCS RPD

Analyte	CAS No.	LCS Relative Percent Difference (percent)	Lower Spec (Limit)	Upper Spec (Limit)
1,2,4-Trichlorobenzene	120-82-1	1	0	23
Acenaphthene	83-32-9	3	0	19
24DNT (2,4-Dinitrotoluene)	121-14-2	18	0	47
Pyrene	129-00-0	4	0	36
N-Nitroso-di-n-propylamine	621-64-7	4	0	38
1,4-Dichlorobenzene	106-46-7	7	0	27
Pentachlorophenol	87-86-5	16	0	47
Phenol	108-95-2	1	0	35
2-Chlorophenol	95-57-8	1	0	50
4-Chloro-3-methylphenol	59-50-7	4	0	33
4-Nitrophenol	100-02-7	33	0	50

Quanterra Environmental Services

Quanterra Incorporated
880 Riverside Parkway
West Sacramento, California 95605

916 373-5600 Telephone
916 372-1059 Fax

July 2, 1998
QUANTERRA INCORPORATED PROJECT NUMBER: **099963**
PO/CONTRACT: **P4907**

George Hampton
California Laboratory Services
3249 Fitzgerald Road
Rancho Cordova, CA 95742

Dear Mr. Hampton:

This report contains the analytical results for the one solid sample which was received under chain of custody by Quanterra Incorporated on 22 June 1998.

The case narrative is an integral part of this report.

If you have any questions, please feel free to call.

Sincerely,

Robert Hrabak
Project Manager
Advanced Technology

RH/rr

Quanterra
Environmental Services

TABLE OF CONTENTS

QUANTERRA INCORPORATED PROJECT NUMBER 099963

Quanterra
Environmental Services

CASE NARRATIVE

QUANTERRA INCORPORATED PROJECT NUMBER 099963

Detection limits for dioxins and furans are reported on a sample specific basis and all results are recovery corrected per the isotope dilution technique.

There were no anomalies associated with this report.

Quanterra
Environmental Services

QUANTERRA INCORPORATED QUALITY CONTROL PROGRAM

Quanterra has implemented an extensive Quality Control (QC) program to ensure the production of scientifically sound, legally defensible data of known documentable quality. This QC program is based upon requirements in "Test Methods for Evaluating Solid Waste", USEPA SW-846, Third Edition. It applies whenever SW-846 analytical methods are used. It also applies in whole or in part whenever project requirements fail to specify some aspect of QC practices described here. It does not apply when other well defined QC programs (e.g. CLP or CLP-like) are specified. This is Quanterra's base QC program for environmental analysis.

Definitions:

Quality Control Batch. The quality control (QC) batch is a set of up to 20 field samples plus associated laboratory QC samples that are similar in composition (matrix) and that are processed within the same time period with the same reagent and standard lots.

Surrogate. A surrogate (or internal standard) is an organic compound similar in chemical behavior to the target analyte, but not normally found in environmental samples. Surrogates (or IS) are added to all samples in a batch to monitor the effects of both the matrix and the analytical process on accuracy.

Method Blank. A method blank (MB) is a control sample prepared using the same reagents used for the samples. As part of the QC batch, it accompanies the samples through all steps of the sample extraction and cleanup procedure. The method blank is used to monitor the level of contamination introduced to a batch of samples as a result of processing in the laboratory.

Laboratory Control Sample. A laboratory control sample (LCS) is prepared using a well characterized matrix (e.g., reagent water or Ottawa sand) that is spiked with known amounts of representative analytes. Alternate matrices (e.g., glass beads) may be used for soil analyses when Ottawa sand is not appropriate. As part of a QC batch, it accompanies the samples through all steps of the sample extraction and cleanup process. The LCS is used to monitor the accuracy of the analytical process independent of possible interference effects due to sample matrix.

Duplicate Control Sample. A duplicate laboratory control sample (DCS) consists of a pair of LCSs analyzed within the same QC batch to monitor precision and accuracy independent of sample matrix effects.

Quanterra
Environmental Services

SAMPLE DESCRIPTION INFORMATION
for
California Laboratory Services

Lab ID	Client ID	Matrix	Sampled Date	Sampled Time	Received Date
099963-0001-MB	Method Blank	SOLID			22 JUN 98
099963-0001-SA	R061898	SOLID	18 JUN 98		22 JUN 98

CLS – Labs

CHAIN OF CUSTODY

CLS ID No.: _____ LOG NO. 52000

REPORT TO:

NAME AND ADDRESS: CLS

PROJECT MANAGER: _____ PHONE#: _____

PROJECT NAME: _____

SAMPLED BY: _____

JOB DESCRIPTION: _____

SITE LOCATION: _____

CLIENT JOB NUMBER: PY907

DESTINATION LABORATORY

☐ CLS (916) 638-7301
3249 FITZGERALD RD.
RANCHO CORDOVA, CA
95742

☒ OTHER

Quanterra

ANALYSIS REQUESTED

PRESERVATIVES

8270 SVOA

FIELD CONDITIONS:

COMPOSITE:

TURN AROUND TIME

1 DAY	2 DAY	5 DAY	10 DAY
			X

SPECIAL INSTRUCTIONS

DATE	TIME	SAMPLE IDENTIFICATION	MATRIX	CONTAINER NO.	CONTAINER TYPE	PRESERVATIVES	ANALYSIS REQUESTED
6/18/98		R061898	SOIL	1	JAR	3	X

INVOICE TO:

P.O. #

QUOTE #

SUSPECTED CONSTITUENTS

SAMPLE RETENTION TIME

PRESERVATIVES: (1) HCL (2) HNO_3 (3) = COLD (4)

RELINQUISHED BY (SIGN)	PRINT NAME / COMPANY	DATE / TIME	RECEIVED BY (SIGN)	PRINT NAME / COMPANY
	M THOMPSON / CLS	6/22 08-0945		Conrado / CLS
	CLS	6/22/98-		

RECD AT LAB BY: _____ DATE/TIME: 062298 @ 11:10 CONDITIONS / COMMENTS:

SHIPPED VIA: ☐ FED X ☐ UPS ☑ OTHER CLS AIR BILL #

Quanterra
Environmental Services

2,3,7,8-TCDD

LOW RESOLUTION

Client Name: California Laboratory Services
Client ID: Method Blank
Lab ID: 099963-0001-MB
Matrix: SOLID Sampled: NA Received: NA
Authorized: 22 JUN 98 Prepared: 30 JUN 98 Analyzed: 01 JUL 98

Sample Amount 10.0 G
Column Type DB-5

Parameter	Result	Units	Detection Limit	Data Qualifiers
Dioxins				
2,3,7,8-TCDD	ND	ng/g	0.11	
	% Recovery			
13C-2,3,7,8-TCDD	72			

ND = Not detected
NA = Not applicable

Reported By: Maricel Baquerfo Approved By: Robert Hrabak

The cover letter is an integral part of this report.
Rev 230787

Quanterra
Environmental Services

2,3,7,8-TCDD

LOW RESOLUTION

Client Name: California Laboratory Services
Client ID: R061898
Lab ID: 099963-0001-SA
Matrix: SOLID Sampled: 18 JUN 98 Received: 22 JUN 98
Authorized: 22 JUN 98 Prepared: 30 JUN 98 Analyzed: 02 JUL 98

Sample Amount 10.1 G
Column Type DB-5

Parameter	Result	Units	Detection Limit	Data Qualifiers
Dioxins				
2,3,7,8-TCDD	ND	ng/g	0.083	
	% Recovery			
13C-2,3,7,8-TCDD	64			

ND = Not detected
NA = Not applicable

Reported By: Maricel Baquerfo Approved By: Robert Hrabak

The cover letter is an integral part of this report.
Rev 230787

Quanterra
Environmental Services

LABORATORY CONTROL SAMPLE REPORT
Special Services - Low Resolution Mass Spectrometry
Project: 099963

Category: TCDD1-S 2,3,7,8-TCDD - by Low Resolution MS
Test: TCDD-S
Matrix: SOLID
QC Lot: 30 JUN 98-A QC Run: 01 JUL 98-A
Concentration Units: ng/g

Analyte	Concentration Spiked	Concentration Measured	Accuracy(%) LCS	Accuracy(%) Limits
2,3,7,8-TCDD	2.50	2.74	110	60-164
13C-2,3,7,8-TCDD	2.5	1.6	64	40-120

Calculations are performed before rounding to avoid round-off errors in calculated results.

APPENDIX E
FIELD DATA, DO PROFILE SUMMARY

Phase I Perchlorate Treatability Study
Summary of Collected Operational Data

Date	Flowrate		pH							T							ORP							D.O.							Ethanol
	AS-Effl. gpm	Reactor gpm	AS-Infl.	AS-Effl.	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	AS-Infl. °C	AS-Effl. °C	R-Infl. °C	R-25%	R-50%	R-75%	R-Effl. °C	AS-Infl. mV	AS-Effl. mV	R-Infl. mV	R-25%	R-50%	R-75%	R-Effl. mV	R-Infl.-Inline ppm	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	R-Effl.-Inline ppm	Flowrate ml/min
7-Nov	5.1	30.1	-	-	8.38	-	-	-	7.15	-	-	22.1	-	-	-	22.1	-	-	-	-	-	-	-	1.4	-	-	-	-	-	0.1	-
8-Nov	3.9	30.1	-	-	8.22	-	-	-	8.34	-	-	18.3	-	-	-	18.6	-	-	-	-	-	-	-	1.6	-	-	-	-	-	0.1	-
9-Nov	3.8	29.7	-	-	8.43	-	-	-	8.39	-	-	19.6	-	-	-	19.9	-	-	-	-	-	-	-	1.1	-	-	-	-	-	0.1	-
10-Nov	3.6	29.5	-	-	8.34	-	-	-	7.93	-	-	18.6	-	-	-	19.1	-	-	-	-	-	-	-	1.0	-	-	-	-	-	0.0	-
11-Nov	3.5	30.1	-	-	8.76	-	-	-	8.70	-	-	18.0	-	-	-	18.7	-	-	-	-	-	-	-	0.7	-	-	-	-	-	0.1	-
12-Nov	4.1	30.6	-	-	8.55	-	-	-	8.62	-	-	20.2	-	-	-	19.6	-	-	-	-	-	-	-	0.6	-	-	-	-	-	0.0	-
13-Nov	3.8	30.0	-	-	8.50	-	-	-	7.17	-	-	19.1	-	-	-	18.8	-	-	-	-	-	-	-	1.2	-	-	-	-	-	0.0	-
14-Nov	4.0	30.0	-	-	8.92	-	-	-	8.90	-	-	19.3	-	-	-	19.3	-	-	-	-	-	-	-	1.5	-	-	-	-	-	0.6	-
15-Nov	3.8	29.9	-	-	-	-	-	-	8.00	-	-	15.0	-	-	-	15.9	-	-	-	-	-	-	-	1.2	-	-	-	-	-	0.1	-
16-Nov	3.9	30.1	-	-	-	-	-	-	7.48	-	-	17.1	-	-	-	17.2	-	-	-	-	-	-	-	1.3	-	-	-	-	-	0.1	-
17-Nov	4.0	29.9	-	-	8.67	-	-	-	8.81	-	-	19.1	-	-	-	19.2	-	-	-	-	-	-	-	0.9	-	-	-	-	-	1.0	-
18-Nov	4.3	27.0	-	-	8.35	-	-	-	8.41	-	-	18.2	-	-	-	18.4	-	-	-	-	-	-	-	0.7	-	-	-	-	-	0.0	-
19-Nov	4.4	29.6	-	-	8.36	-	-	-	8.36	-	-	18.6	-	-	-	18.5	-	-	-	-	-	-	-	1.1	-	-	-	-	-	0.0	-
20-Nov	10.1	29.5	-	-	-	-	-	-	8.07	-	-	18.7	-	-	-	18.6	-	-	-	-	-	-	-	0.7	-	-	-	-	-	0.0	-
21-Nov	9.8	30.7	-	-	-	-	-	-	8.21	-	-	18.9	-	-	-	19.2	-	-	-	-	-	-	-	0.5	-	-	-	-	-	0.0	-
22-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-Nov	10.9	30.8	-	-	8.21	-	-	-	8.27	-	-	19.9	-	-	-	20.1	-	-	-	-	-	-	-	0.4	-	-	-	-	-	0.1	-
25-Nov	10.6	30.5	-	-	7.99	-	-	-	8.07	-	-	19.5	-	-	-	19.3	-	-	-	-	-	-	-	0.4	-	-	-	-	-	0.2	-
26-Nov	15.2	30.2	-	-	8.45	-	-	-	8.61	-	-	14.5	-	-	-	15.4	-	-	-	-	-	-	-	0.4	-	-	-	-	-	0.1	-
27-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Nov	20.1	31.1	-	-	8.34	-	-	-	8.46	-	-	17.7	-	-	-	17.4	-	-	-	-	-	-	-	0.4	-	-	-	-	-	0.1	-
29-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Nov	20.2	31.3	-	-	8.46	-	-	-	8.61	-	-	13.9	-	-	-	14.3	-	-	-	-	-	-	-	5.3	-	-	-	-	-	0.5	-
1-Dec	20.7	30.8	-	-	8.38	-	-	-	8.53	-	-	13.9	-	-	-	14.7	-	-	-	-	-	-	-	4.6	-	-	-	-	-	0.1	-
2-Dec	19.6	25.0	-	-	8.10	-	-	-	8.29	-	-	15.2	-	-	-	15.7	-	-	-	-	-	-	-	4.1	-	-	-	-	-	0.0	-
3-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Dec	20.5	29.9	-	-	8.20	-	-	-	8.09	-	-	15.3	-	-	-	14.4	-	-	-	-	-	-	-	6.0	-	-	-	-	-	3.3	-
6-Dec	20.0	30.2	-	-	8.30	-	-	-	8.05	-	-	16.6	-	-	-	16.6	-	-	-	-	-	-	-	6.1	-	-	-	-	-	2.7	-
7-Dec	5.0	29.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Dec	10.3	29.8	-	-	7.83	-	-	-	7.72	-	-	13.3	-	-	-	14.7	-	-	-	-	-	-	-	5.2	-	-	-	-	-	2.5	-
9-Dec	10.0	31.0	-	-	8.00	-	-	-	8.08	-	-	18.3	-	-	-	18.1	-	-	110.0	-	-	-	96.3	4.3	-	-	-	-	-	1.5	-
10-Dec	10.0	30.3	-	-	7.29	-	-	-	7.00	-	-	17.5	-	-	-	18.0	-	-	-41.1	-	-	-	-72.1	-	-	-	-	-	-	1.5	-
11-Dec	29.9	30.8	-	-	7.96	-	-	-	7.64	-	-	18.3	-	-	-	18.6	-	-	118.5	-	-	-	35.0	8.3	-	-	-	-	-	0.3	4.1
12-Dec	29.9	31.0	-	-	7.67	-	-	-	7.87	-	-	17.5	-	-	-	16.3	-	-	153.3	-	-	-	180.5	8.1	-	-	-	-	-	2.0	10.4
13-Dec	29.4	30.4	-	-	7.49	-	-	-	7.56	-	-	17.8	-	-	-	16.7	-	-	228.6	-	-	-	172.7	-	-	-	-	-	-	0.5	2.0
14-Dec	29.6	30.4	-	-	7.60	-	-	-	8.17	-	-	18.3	-	-	-	17.3	-	-	108.6	-	-	-	71.4	8.2	-	-	-	-	-	0.2	7.0
15-Dec	29.0	30.2	-	-	8.22	-	-	-	8.58	-	-	18.5	-	-	-	18.5	-	-	104.6	-	-	-	96.0	8.4	-	-	-	-	-	0.2	9.4
16-Dec	29.4	30.0	-	-	7.91	-	-	-	8.36	-	-	18.6	-	-	-	18.7	-	-	90.8	-	-	-	42.5	8.0	-	-	-	-	-	0.2	6.4
17-Dec	30.0	31.0	-	-	7.75	-	-	-	8.19	-	-	18.7	-	-	-	18.8	-	-	76.0	-	-	-	40.8	8.5	-	-	-	-	-	0.2	5.9
18-Dec	29.4	29.7	-	-	7.28	-	-	-	7.72	-	-	17.2	-	-	-	17.7	-	-	-	-	-	-	-	8.3	-	-	-	-	-	0.3	5.6
19-Dec	28.3	28.9	-	-	7.82	-	-	-	7.99	-	-	19.0	-	-	-	19.1	-	-	65.5	-	-	-	65.0	9.2	-	-	-	-	-	0.3	5.9
20-Dec	28.6	29.6	-	-	-	-	-	-	-	-	-	17.2	-	-	-	17.4	-	-	105.6	-	-	-	37.8	9.3	-	-	-	-	-	0.5	8.2
21-Dec	28.9	29.2	-	-	-	-	-	-	7.77	-	-	18.8	-	-	-	18.8	-	-	74.9	-	-	-	38.0	9.8	-	-	-	-	-	0.6	9.3
22-Dec	29.0	29.5	-	-	7.75	-	-	-	7.91	-	-	18.5	-	-	-	18.1	-	-	60.4	-	-	-	30.0	10.6	-	-	-	-	-	0.3	8.3
23-Dec	29.1	29.4	-	-	7.60	-	-	-	7.47	-	-	18.6	-	-	-	18.6	-	-	101.3	-	-	-	98.2	11.1	-	-	-	-	-	0.4	9.4
24-Dec	25.1	30.3	-	-	7.65	-	-	-	7.74	-	-	18.8	-	-	-	18.8	-	-	53.1	-	-	-	21.3	9.5	-	-	-	-	-	0.7	2.9
25-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Phase I Perchlorate Treatability Study
Summary of Collected Operational Data

Date	Flowrate		pH						T							ORP							D.O.							Ethanol
	AS-Effl. gpm	Reactor gpm	AS-Infl.	AS-Effl.	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	AS-Infl. °C	AS-Effl. °C	R-Infl. °C	R-25%	R-50%	R-75%	R-Effl. °C	AS-Infl. mV	AS-Effl. mV	R-Infl. mV	R-25%	R-50%	R-75%	R-Effl. mV	R-Infl.-Inline ppm	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	R-Effl.-Inline ppm	Flowrate ml/min
26-Dec	24.0	30.1	-	-	7.87	-	-	-	8.00	-	-	18.7	-	-	-	18.8	-	-	92.8	-	-	-	35.0	8.4	-	-	-	-	-	0.2	5.4
27-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Dec	20.0	30.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	-	-	-	-	-	0.2	4.9
29-Dec	20.1	30.0	-	-	7.72	-	-	-	7.94	-	-	18.5	-	-	-	19.1	-	-	100.7	-	-	-	62.3	6.6	-	-	-	-	-	0.2	7.2
30-Dec	20.6	29.9	-	-	7.64	-	-	-	7.99	-	-	19.2	-	-	-	19.4	-	-	105.5	-	-	-	63.0	6.0	-	-	-	-	-	0.3	7.1
31-Dec	20.3	30.0	-	-	8.13	-	-	-	8.26	-	-	19.3	-	-	-	19.3	-	-	-7.0	-	-	-	-22.1	6.2	-	-	-	-	-	0.3	7.7
1-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Jan	19.5	28.8	-	-	8.03	-	-	-	8.24	-	-	18.3	-	-	-	18.0	-	-	87.8	-	-	-	35.2	5.1	-	-	-	-	-	0.3	6.5
3-Jan	20.7	28.8	-	-	8.00	-	-	-	8.16	-	-	18.6	-	-	-	18.6	-	-	114.8	-	-	-	70.4	5.2	-	-	-	-	-	0.2	10.2
4-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Jan	19.5	28.9	7.31	8.17	8.05	-	-	-	8.54	18.6	18.3	18.2	-	-	-	18.4	144.5	148.7	107.0	-	-	-	32.0	5.3	-	-	-	-	-	0.3	4.7
6-Jan	20.0	29.5	7.26	8.13	8.25	-	-	-	8.49	18.6	18.2	18.1	-	-	-	18.2	118.7	130.1	-26.0	-	-	-	-94.0	5.7	-	-	-	-	-	0.3	5.3
7-Jan	20.8	29.5	7.14	8.01	8.12	-	-	-	8.51	18.1	18.4	18.3	-	-	-	18.4	138.4	120.9	43.8	-	-	-	-130.0	6.3	-	-	-	-	-	0.3	15.2
8-Jan	20.1	30.0	6.88	7.75	8.04	-	-	-	8.25	18.7	18.5	18.6	-	-	-	18.6	95.6	75.5	25.0	-	-	-	-116.6	5.8	-	-	-	-	-	0.3	17.6
9-Jan	20.0	30.0	6.88	7.73	7.97	-	-	-	8.18	18.7	18.6	18.7	-	-	-	18.7	58.0	45.0	28.0	-	-	-	-103.0	6.0	-	-	-	-	-	0.4	16.9
10-Jan	20.0	30.1	7.00	7.84	8.09	-	-	-	8.28	19.0	18.8	18.9	-	-	-	18.8	82.5	75.9	5.0	-	-	-	-180.0	5.3	-	-	-	-	-	0.3	18.8
11-Jan	19.0	30.0	-	-	8.20	-	-	-	8.48	-	-	18.9	-	-	-	18.8	-	-	49.2	-	-	-	-20.0	5.1	-	-	-	-	-	0.3	21.1
12-Jan	19.2	29.3	-	-	8.10	-	-	-	8.09	-	-	18.8	-	-	-	17.7	-	-	29.5	-	-	-	16.0	2.5	-	-	-	-	-	0.3	22.4
13-Jan	19.5	29.8	7.01	7.80	7.95	-	-	-	8.21	19.2	19.1	19.2	-	-	-	19.2	85.1	68.1	-19.0	-	-	-	-180.0	6.0	-	-	-	-	-	0.2	18.4
14-Jan	19.2	29.8	7.12	7.92	8.07	-	-	-	8.33	18.9	18.8	18.9	-	-	-	18.9	64.0	52.0	-49.0	-	-	-	-212.0	6.1	-	-	-	-	-	0.2	18.9
15-Jan	19.8	30.0	7.16	7.88	7.96	-	-	-	8.30	19.1	18.9	18.9	-	-	-	18.9	39.0	28.5	-63.0	-	-	-	-161.0	5.3	-	-	-	-	-	0.2	22.0
16-Jan	20.0	30.5	7.22	7.94	8.09	-	-	-	8.34	19.2	19.2	19.3	-	-	-	19.3	107.6	96.8	-5.0	-	-	-	-182.0	5.9	-	-	-	-	-	0.3	16.3
17-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-Jan	20.1	29.2	-	-	8.15	-	-	-	8.29	-	-	19.2	-	-	-	19.1	-	-	-107.6	-	-	-	-244.0	5.2	-	-	-	-	-	0.2	17.2
19-Jan	19.5	27.5	7.21	7.98	8.01	-	-	-	8.21	18.8	18.7	18.6	-	-	-	18.6	70.1	53.4	-100.0	-	-	-	-275.0	5.6	-	-	-	-	-	0.2	23.4
20-Jan	19.5	29.0	7.16	7.82	7.80	-	-	-	7.87	18.8	18.6	18.6	-	-	-	18.6	124.0	102.0	-97.0	-	-	-	-205.0	6.6	-	-	-	-	-	0.3	21.0
21-Jan	20.0	29.0	6.97	7.76	7.77	-	-	-	7.82	18.6	18.3	18.1	-	-	-	18.3	105.5	100.0	-93.0	-	-	-	-215.0	7.0	-	-	-	-	-	0.2	18.8
22-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Jan	20.6	31.0	7.14	7.26	7.42	-	-	-	7.84	18.7	18.8	18.9	-	-	-	18.8	122.5	123.4	-125.0	-	-	-	-208.0	4.2/0.9	-	-	-	-	-	0.2	8.7
24-Jan	20.2	29.4	7.10	7.11	7.31	-	-	-	7.88	19.0	19.1	19.2	-	-	-	19.3	64.5	-5.9	-178.3	-	-	-	-225.0	0.8	-	-	-	-	-	0.1	6.1
25-Jan	19.8	29.5	7.17	7.25	7.40	-	-	-	8.02	18.7	18.7	19.0	-	-	-	19.0	-	19.7	-188.0	-	-	-	-214.0	0.5	-	-	-	-	-	0.1	11.9
26-Jan	20.0	30.0	7.17	7.16	7.36	-	-	-	7.97	18.7	19.0	19.0	-	-	-	19.0	-	129.0	-204.0	-	-	-	-239.0	0.8	-	-	-	-	-	0.1	13.3
27-Jan	20.0	30.5	7.19	7.20	7.38	-	-	-	7.83	19.3	19.3	19.4	-	-	-	19.5	134.5	126.2	-203.0	-	-	-	-235.0	0.8	-	-	-	-	-	0.2	12.2
28-Jan	25.0	29.9	-	7.11	7.30	-	-	-	7.83	-	19.1	19.1	-	-	-	19.1	-	21.6	-191.9	-	-	-	-263.0	0.9	-	-	-	-	-	0.2	11.5
29-Jan	25.0	29.7	-	7.17	7.22	7.80	7.7	7.76	7.81	-	19.2	19.2	18.6	18.4	18.7	19.2	-	-16.4	-208.8	-229.5	-250.7	-216.2	-274.0	0.8	-	0.1*	0.1*	0.1*	-	0.2	10.7
30-Jan	25.5	30.1	-	7.13	7.27	-	-	-	8.27	-	18.9	18.8	-	-	-	19.0	-	25.4	-202.7	-	-	-	-281.0	0.9	-	-	-	-	-	0.2	8.6
31-Jan	25.8	29.1	-	-	7.33	-	-	-	7.97	-	-	18.9	-	-	-	18.9	-	-	-201.6	-	-	-	-286.2	0.7	-	-	-	-	-	0.2	1.0
1-Feb	25.9	28.9	-	-	7.19	7.96	7.76	7.87	7.86	-	-	19.0	17.9	17.6	17.9	18.5	-	-	-226.0	-284.5	-274.2	-263.2	-304.2	1.2	-	0.6	1.0	1.5	-	0.2	9.6
2-Feb	25.0	28.8	-	7.35	7.41	8.02	7.93	7.80	7.93	-	19.1	19.2	18.0	18.0	18.0	19.1	-	-100.2	-243.8	-273.8	-279.0	-280.1	-310.0	0.7	0.5*	0.1*	0.1*	0.08*	0.08*	0.3	7.2
3-Feb	24.2	30.8	-	7.27	7.37	7.95	7.9	7.81	7.82	-	19.0	19.0	17.7	17.8	17.8	48.9	-	-	-253.9	-260.5	-240.3	-320.0	-323.0	0.5	0.5*	0.1*	0.1*	0.08*	0.08*	0.3	9.3
4-Feb	26.4	29.2	-	7.20	7.27	7.87	7.61	7.70	7.71	-	19.0	19.2	19.2#	19.2#	19.2#	19.1	-	106.0	-249.5	-242.5	-252.0	-276.5	-318.0	0.8	-	.12*	0.1*	0.1*	-	0.3	7.7
5-Feb	25.1	30.7	-	7.44	7.47	-	-	-	7.83	-	18.8	18.9	-	-	-	18.8	-	84.3	-231.5	-	-	-	-308.7	1.0	-	-	-	-	-	0.3	8.4
6-Feb	24.9	29.0	-	7.08	7.20	7.88	7.69	7.67	7.69	-	18.9#	19.2#	19#	19#	19#	18.9#	-	-33.5	-241.0	-249.9	-292.0	-267.0	-314.1	1.0	.35*	0.08*	0.06*	0.06*	.11*	0.4	9.8
7-Feb	24.5	30.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.6
8-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Feb	14.0	30.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-	-	-	-	-	3.0	-
11-Feb	14/20	32.1	-	-	7.68	-	-	-	7.98	-	-	19.3#	19.3#	19.4#	19.4#	19.4#	-	-	-313.9	-	-	-	-318.1	0.6	.14*	0.09*	0.08*	0.08*	0.07*	0.5	-

Phase I Perchlorate Treatability Study
Summary of Collected Operational Data

Date	Flowrate		pH						T							ORP							D.O.							Ethanol
	AS-Effl. gpm	Reactor gpm	AS-Infl.	AS-Effl.	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	AS-Infl. °C	AS-Effl. °C	R-Infl. °C	R-25%	R-50%	R-75%	R-Effl. °C	AS-Infl. mV	AS-Effl. mV	R-Infl. mV	R-25%	R-50%	R-75%	R-Effl. mV	R-Infl.-Inline ppm	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	R-Effl.-Inline ppm	Flowrate ml/min
12-Feb	20.6/25.2	32.2	-	-	7.58	7.92	7.78	7.90	7.85	-	-	19.0#	19.2#	19.2#	19.1#	19.1#	-	-	-286.8	-311.0	-322.8	-247.4	-328.2	0.7	0.14*	0.09*	0.07*	0.06*	0.06*	0.3	5.9
13-Feb	25.1	29.8	-	7.27	7.35	7.99	7.75	7.85	7.85	-	19.1	19.3#	19.3#	19.3#	19.3#	19.3#	-	81.0	-259.4	-309.6	-325.8	-265.5	-317.1	0.9	0.43*	0.20*	0.10*	0.10*	0.12*	0.4	5.9
14-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-Feb	25.2	29.0	-	6.92	7.13	7.65	7.35	7.41	7.36	-	18.8	18.9#	19#	19.1#	19.1#	19.0#	-	48.9	-191.3	-185.2	-265.1	-270.5	-273.6	0.8	0.13*	0.1*	0.09*	0.09*	0.08*	0.4	9.4
16-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-Feb	25.2	30.1	-	7.50	7.59	8.03	7.81	7.86	7.87	-	19.2	19.2#	19.3#	19.4#	19.3#	19.4#	-	-77.3	-206.9	-219.5	-274.7	-270.8	-298.5	0.9	.6*	.18*	.15*	.15*	.2*	0.5	7.3
18-Feb	25.6	29.0	-	7.18	7.24	7.90	7.65	7.72	7.69	-	18.9	19.2#	19.2#	19.3#	19.2#	19.3#	-	-87.2	-235.2	-220.0	-278.6	-250.8	-314.5	0.9	.7*	.28*	.17*	.15*	.22*	0.4	9.9
19-Feb	25.1	30.8	-	6.99	7.11	-	-	-	7.37	-	18.8	18.8#	-	-	-	18.8#	-	-82.7	-230.5	-	-	-	-290.5	0.8	-	-	-	-	-	0.4	6.7
20-Feb	25.5	30.8	-	7.14	7.17	7.63	7.40	7.49	7.57	-	19.1	19.3#	19.3#	19.3#	19.3#	19.2#	-	-29.6	-244.9	-288.0	-306.5	-257.7	-265.1	0.9	.45*	.18*	.14*	.15*	.22*	0.4	10.6
21-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Feb	25.0	30.5	-	6.93	6.95	-	-	-	7.20	-	16.7	16.7	-	-	-	16.3	-	96.0	-229.6	-	-	-	-284.5	1.2	-	-	-	-	-	0.5	-
24-Feb	25.0	30.0	-	7.19	7.25	-	-	-	7.65	-	19.0	19.3#	19.3#	19.3#	19.3#	19.2#	-	108.1	-230.3	-	-	-	-285.0	0.9	.35*	.17*	.13*	.13*	.13*	0.5	8.4
25-Feb	25.0	30.0	-	7.02	7.04	-	-	-	7.39	-	19.1	19.3#	19.3#	19.3#	19.3#	19.2#	-	75.4	-238.9	-	-	-	-294.0	0.9	.52*	.18*	.12*	.12*	.14*	0.4	7.6
26-Feb	24.9	29.2	-	7.23	7.28	-	-	-	7.78	-	19.1	19.20	-	-	-	19.20	-	34.3	-217.8	-	-	-	-281.0	0.8	-	-	-	-	.11*	0.0	7.8
27-Feb	25.0	29.8	-	7.04	7.16	-	-	-	8.05	-	19.3	19.3#	19.3#	19.3#	19.3#	19.3#	-	122.0	-219.5	-	-	-	-287.0	0.9	.31*	.1*	.06*	.06*	.05*	0.1	5.8
28-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Mar	25.5	29.0	-	7.15	7.29	-	-	-	8.22	-	20.0	19.4#	19.4#	19.5#	19.5#	19.5#	-	136.5	-104.0	-	-	-	-167.4	0.8	.4*	.14*	.09*	.09*	.1*	0.1	5.5
2-Mar	25.3	30.0	-	7.24	7.35	-	-	-	8.30	-	19.4	19.4#	19.4#	19.4#	19.4#	19.4#	-	116.7	-89.0	-	-	-	-155.0	0.9	.34*	.17*	.1*	.1*	.11*	0.1	5.4
3-Mar	24.5	30.6	-	7.17	7.23	-	-	-	8.19	-	19.6	19.3#	19.3#	19.4#	19.4#	19.4#	-	107.0	-87.0	-	-	-	-157.7	0.8	.5*	.16*	.11*	.11*	.1*	0.0	5.4
4-Mar	25.8	29.8	-	7.12	7.17	-	-	-	8.19	-	19.5	19.5	-	-	-	19.6	-	10.2	-91.2	-	-	-	-161.1	0.9		-	-	-	-	0.1	5.5
5-Mar	24.8	29.4	-	7.20	7.30	-	-	-	8.30	-	18.6	18.8	-	-	-	18.9	-	108.1	-102.7	-	-	-	-148.1	0.7		-	-	-	-	0.1	6.4
6-Mar	25.0	30.0	-	7.21	7.32	-	-	-	8.34	-	19.1	19.2#	19.2#	19.2#	19.2#	19.2#	-	113.6	-102.4	-	-	-	-184.7	1.0	.45*	.14*	.1*	.1*	.1*	0.1	4.9
7-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Mar	26.1	28.2	-	-	7.17	-	-	-	7.91	-	-	19.4#	-	-	-	19.5#	-	-	-92.7	-	-	-	-170.6	0.7	.32*	-	-	-	.17*	0.1	7.2
9-Mar	26.6	28.0	-	7.24	7.39	-	-	-	8.20	-	19.4	19.6#	19.6#	19.6#	19.6#	19.6#	-	-1.7	-121.4	-	-	-	-179.5	0.9	.42*	.12*	.1*	.1*	.09*	0.1	6.4
10-Mar	25.5	31.2	-	7.22	7.35	-	-	-	8.19	-	19.9	19.8#	19.8#	19.8#	19.8#	19.8#	-	-32.0	-132.0	-	-	-	-201.1	0.7	.38*	.15*	.07*	.07*	.06*	0.1	5.5
11-Mar	25.0	29.9	-	7.20	7.31	-	-	-	8.02	-	19.9	19.8#	19.8#	19.8#	19.9#	19.8#	-	19.0	-143.0	-	-	-	-201.1	0.9	.4*	.11*	.08*	.1*	.08*	0.1	9.4
12-Mar	25.4	28.4	-	7.15	7.25	-	-	-	7.93	-	19.8	19.7#	19.7#	19.7#	19.7#	19.7#	-	-19.5	-164.0	-	-	-	-221.5	0.8	.5*	.09*	.08*	.08*	.07*	0.1	8.3
13-Mar	25.0	30.5	-	7.05	7.16	7.9	7.9	7.9	7.95	-	19.4	19.6#	19.6#	19.6#	19.6#	19.6#	-	-51.1	-175.2	-185.7	-194.1	-217.7	-227.5	0.8	.22*	.11*	.08*	.09*	.05*	0.1	7.8
14-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-Mar	9.9	29.9	6.94	7.90	8.05	-	-	-	8.11	20.6	20.8	21.3	-	-	-	21.3	-	112.9	-119.1	-	-	-	-185.4	3.9	-	-	-	-	-	0.1	-
17-Mar	10.3	29.8	7.14	8.03	8.43	8.5	8.5	8.5	8.55	21.5	21.9	21.5#	21.5#	21.5#	21.5#	21.5#	-	17.2	-182.7	-225.7	-225.1	-243.1	-250.8	2.2	2.25*	0.25*	0.07*	0.05*	0.05*	0.1	3.5
18-Mar	10.3	29.5	7.11	8.03	8.49	8.6	8.6	8.6	8.60	20.9	20.9	21.1#	21.1#	21.1#	21.2#	21.1#	-	50.0	-172.5	-237.7	-303.7	-266.3	-305.5	3.7	2.2*	0.23*	0.06*	0.05*	0.04*	0.1	1.7
19-Mar	10.0	29.6	7.03	7.96	8.35	8.5	8.5	8.5	8.47	20.8	21.1	20.5#	20.6#	20.6#	20.6#	20.6#	-	-57.5	-162.1	-180.5	-186.2	-155.0	-216.3	3.1	2.6*	0.66*	0.12*	0.06*	0.06*	0.1	4.3
20-Mar	10.1	29.9	7.06	7.94	8.40	8.5	8.5	8.5	8.52	20.8	21.0	21#	21#	21#	21#	21#	-41.5	-24.4	-162.9	-197.5	-220.0	-196.7	-253.0	2.5	2.53*	0.4*	0.08*	0.05*	0.06*	0.1	2.2
21-Mar	10.0	29.7	7.06	7.99	8.39	-	-	-	8.51	20.6	20.6	20.5#	20.5#	20.5#	20.5#	20.5#	-	-29.4	-195.1	-	-	-	-277.2	3.0	2.84*	0.42*	0.06*	0.06*	0.06*	0.1	3.2
22-Mar	10.0	30.5	7.12	8.00	8.56	8.7	8.6	8.7	8.67	20.6	20.8	20.9#	20.9#	20.9#	20.9#	20.9#	-10.0	15.4	-157.8	-209.9	-226.0	-192.0	-230.9	3.3	2.5*	0.4*	0.06*	0.05*	0.05*	0.1	2.2
23-Mar	9.9	30.2	7.13	8.02	8.53	8.7	8.7	8.7	8.65	20.4	20.5	20.6#	20.6#	20.6#	20.6#	20.6#	-	56.5	-183.4	-207.4	-223.7	-180.3	-225.1	2.4	2.4*	0.35*	0.09*	0.06*	0.06*	0.1	2.3
24-Mar	10.8	29.9	7.12	7.98	8.46	-	-	-	8.63	20.6	20.7	20.9#	20.9#	20.9#	20.9#	20.9#	95.0	55.4	-165.6	-	-	-	-212.5	2.8	3.32*	0.79*	0.2*	0.08*	0.08*	0.1	2.8
25-Mar	14.8	29.0	7.09	7.97	8.22	8.42	8.43	8.40	8.44	19.9	19.8	20.1#	20.3#	20.3#	20.3#	20.2#	-	65.5	8.5	-67.0	-68.6	-60.0	-61.5	4.3	-	-	-	-	-	0.1	2.8
26-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-Mar	15.4	29.9	-	8.1	8.3	-	-	-	8.5	-	19.5	19.5#	-	-	-	19.5#	-	78.3	61.5	-	-	-	26.0	4.1	4.08*	1*	0.1*	0.1*	0.1*	0.1	1.3
28-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-Mar	-	-	-	-	-	-	-	-	-	-	-	19.8#	-	-	-	20#	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Mar	15.3	28.6	-	8.0	8.1	-	-	-	8.4	-	19.8	-	-	-	-	-	-	153.1	140.1	-	-	-	86.1	4.8	2.83*	0.7*	0.1*	0.1*	0.1*	0.1	2.5
31-Mar	14.7	30.1	-	-	-	-	-	-	-	-	-	19.4#	-	-	-	19.5#	-	-	-	-	-	-	-	3.7	-	-	-	-	-	0.1	-
1-Apr	14.7	30.1	-	8.0	8.2	-	-	-	8.4	-	19.3	19.3#	-	-	-	19.4#	-	1.9	-117.5	-	-	-	-179.7	4.0	3.1*	0.5*	0.1*	0.1*	0.1*	0.1	4.3
2-Apr	14.8	29.6	-	8.0	8.5	-	-	-	8.7	-	19.3	19.3	-	-	-	19.4	-	55.7	-116.0	-	-	-	-199.7	4.0	3.8*	0.4*	0.1*	0.1*	0.1*	0.1	4.5
3-Apr	15.1	29.8	-	8.07	8.53	-	-	-	8.79	-	19.4	19.4	-	-	-	19.4	-	68.1	-108.1	-	-	-	-199.7	4.3	3.5*	0.3*	0.1*	0.1*	0.1*	0.1	4.4

Phase I Perchlorate Treatability Study
Summary of Collected Operational Data

Date	Flowrate		pH							T							ORP							D.O.							Ethanol
	AS-Effl. gpm	Reactor gpm	AS-Infl.	AS-Effl.	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	AS-Infl. °C	AS-Effl. °C	R-Infl. °C	R-25%	R-50%	R-75%	R-Effl. °C	AS-Infl. mV	AS-Effl. mV	R-Infl. mV	R-25%	R-50%	R-75%	R-Effl. mV	R-Infl.-Inline ppm	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	R-Effl.-Inline ppm	Flowrate ml/min
4-Apr	19.8	30.1	-	8.04	8.32	-	-	-	8.67	-	18.7	19.7#	-	-	-	19.7#	-	83.1	-61.3	-	-	-	-194.1	5.3	5.3*	0.4*	0.1*	0.1*	0.1*	0.1	5.5
5-Apr	19.9	29.1	-	7.97	8.26	-	-	-	8.65	-	19.1	19.7#	-	-	-	19.7#	-	98.3	-73.1	-	-	-	-207.4	5.3	3.7*	0.3*	0.1*	0.1*	0.1*	0.1	7.2
6-Apr	19.6	30.2	-	8.06	8.38	-	-	-	8.73	-	18.8	19.7#	-	-	-	19.2#	-	75.9	-77.9	-	-	-	-199.7	5.2	5.3*	0.5*	0.1*	0.1*	0.1*	0.1	7.4
7-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Apr	19.2	28.0	-	7.90	7.90	-	-	-	8.52	-	20.5	19.6#	-	-	-	19.6#	-	67.5	-53.1	-	-	-	-139.6	4.4	0.9*	0.18*	0.09*	0.08*	0.08*	0.1	-
9-Apr	19.3	29.5	-	7.90	8.18	-	-	-	8.55	-	19.9	19.7#	-	-	-	19.9#	-	147.4	-57.5	-	-	-	-175.8	4.4	1.9*	0.11*	0.07*	0.06*	0.06*	0.1	8.4
10-Apr	17.5	28.4	-	8.02	8.30	-	-	-	8.66	-	20.7	19.9#	-	-	-	20.0#	-	191.0	-45.3	-	-	-	-156.7	4.0	1.28*	0.16*	0.07*	0.07*	0.07*	0.1	4.0
11-Apr	15.0	27.5	-	8.19	8.47	-	-	-	8.74	-	19.8	19.7	-	-	-	19.2	-	187.4	102.1	-	-	-	-57.5	7.7	-	-	-	-	-	0.1	-
12-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13-Apr	-	26.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-61.7	-	-	-	-	-	-	-	-	-	-	-	-	0.0
14-Apr	15.3	28.5	-	7.73	8.07	-	-	-	8.37	-	19.4	19.5#	-	-	-	19.7#	-	63.4	56.3	-	-	-	-86.1	4.3	0.98*	0.14*	0.06*	0.05*	0.05*	0.1	4.8
15-Apr	15.2	30.3	-	7.78	7.92	-	-	-	8.44	-	19.4	19.5#	-	-	-	19.8#	-	121.0	-54.9	-	-	-	-117.2	4.0	1.18*	0.15*	0.08*	0.07*	0.07*	0.1	4.2
16-Apr	15.4	29.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3	-	-	-	-	-	0.1	2.7
17-Apr	15.0	30.0	-	7.93	8.24	-	-	-	8.51	-	19.9	20.1#	20.0	20.0	20.0	19.9#	-	52.0	-119.7	-	-	-	-198.0	3.7	2.7*	0.22*	0.07*	0.07*	0.07*	0.1	4.6
18-Apr	15.5	31.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-197.1	3.0	-	-	-	-	-	0.1	5.4
19-Apr	15.0	30.0	-	7.87	8.21	-	-	-	8.47	-	20.2	20.2#	-	-	-	20.3#	-	87.5	-83.7	-	-	-	-212.0	3.4	3.42*	0.45*	0.06*	0.06*	0.06*	0.1	6.9
20-Apr	16.0	29.8	-	8.29	8.60	-	-	-	8.83	-	21.5	21.1#	-	-	-	21.1#	-	76.0	-49.4	-	-	-	-172.3	2.2	0.82*	0.13*	0.08*	0.08*	0.07*	0.1	7.0
21-Apr	15.9	30.5	-	8.05	8.34	-	-	-	8.63	-	21.1	20.7#	-	-	-	20.8#	-	200.9	-37.5	-	-	-	-143.5	3.7	0.99*	0.1*	0.07*	0.06*	0.06*	0.1	5.6
22-Apr	16.0	28.3	-	7.99	8.25	-	-	-	8.50	-	21.0	20.7#	-	-	-	20.8#	-	-	-	-	-	-	-	3.2	1.12*	0.15*	0.08*	0.10*	0.09*	0.1	5.9
23-Apr	-	-	-	8.16	8.44	-	-	-	8.70	-	20.2	19.9#	-	-	-	19.9#	-	-	-	-	-	-	-	2.6	1.06*	0.16*	0.06*	0.06*	0.06*	0.1	4.6
24-Apr	15.0	30.6	-	7.86	8.31	-	-	-	8.52	-	20.2	20.2#	-	-	-	20.3#	-	51.9	-123.9	-	-	-	-193.1	3.3	0.66*	0.14*	0.07*	0.06*	0.06*	0.1	6.9
25-Apr	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-Apr	8.7	31.6	-	8.10	8.42	-	-	-	8.48	-	20.7	20.5#	-	-	-	20.7#	-	13.3	-168.4	-	-	-	-227.2	2.0	0.25*	0.1*	0.05*	0.05*	0.05*	0.1	5.1
27-Apr	10.0	30.0	-	8.05	8.38	-	-	-	8.49	-	21.5	21.4#	-	-	-	21.5#	-	22.2	-157.0	-	-	-	-231.5	2.4	0.55*	0.07*	0.06*	0.05*	0.05*	0.1	4.8
28-Apr	10.2	27.3	-	8.06	8.37	-	-	-	8.49	-	22.1	21.9#	-	-	-	21.9#	-	24.5	-165.0	-	-	-	-208.8	1.6	0.65*	0.08*	0.06*	0.06*	0.07*	0.1	4.8
29-Apr	9.7	26.0	-	8.02	8.34	-	-	-	8.50	-	22.5	22.5#	-	-	-	22.4#	-	2.4	-145.5	-	-	-	-188.0	2.4	0.21*	0.08*	0.08*	0.08*	0.06*	0.1	3.3
30-Apr	9.7	26.1	-	8.05	8.36	-	-	-	8.49	-	21.9	21.8#	-	-	-	21.9#	-	-14.9	-139.8	-	-	-	-187.4	1.3	0.41*	0.07*	0.06*	0.06*	0.06*	0.1	3.4
1-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-May	9.8	30.2	-	8.24	8.71	-	-	-	8.79	-	21.4	21.1#	-	-	-	21.2#	-	177.4	155.5	-	-	-	132.1	6.5	3.68*	-	-	-	2.82*	0.5	-
5-May	8.7	29.6	-	-	-	-	-	-	-	-	20.2	21.0	-	-	-	20.8	-	155.1	140.7	-	-	-	120.7	3.3	3.1	-	-	-	2.1	0.1	4.8
6-May	9.1	30.5	-	8.25	8.25	-	-	-	8.26	-	19.6#	20.2#	-	-	-	20.4#	-	144.6	137.5	-	-	-	108.9	3.7	0.72*	-	-	-	0.07*	0.0	2.5
7-May	9.9	30.6	-	8.21	8.32	-	-	-	8.38	-	20.3#	20.8#	20.9#	20.9#	20.9#	20.9#	-	100.3	95.8	-	-	-	48.9	0.7	1.22*	-	-	-	0.07*	0.1	-
8-May	9.7	30.6	-	8.13	8.36	-	-	-	8.46	-	20.3#	20.6#	20.7#	20.7#	20.7#	20.5#	-	99.9	95.2	-	-	-	59.2	3.9	0.72*	-	-	-	0.06*	0.0	1.8
9-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-May	10.1	30.2	-	8.22	8.52	-	-	-	8.62	-	18.5#	19.2#	19.6#	19.7#	19.8#	19.3	-	111.7	85.9	-	-	-	53.1	3.2	0.74*	-	-	-	0.09*	0.1	5.5
11-May	9.8	30.1	-	8.22	8.46	-	-	-	8.54	-	18.9#	19.3#	19.8#	19.8#	19.8#	19.2	-	108.9	68.9	-	-	-	42.0	2.3	0.6*	-	-	-	0.09*	0.1	3.1
12-May	9.9	30.4	-	8.22	8.41	-	-	-	8.49	-	19.0#	19.4#	19.7#	19.8#	19.9#	19.3	-	109.0	33.6	-	-	-	-25.1	1.6	1.25*	-	-	-	0.11*	0.0	4.9
13-May	10.0	30.4	-	8.09	8.26	-	-	-	8.28	-	19.5#	21.2#	-	-	-	20.1#	-	105.9	54.0	-	-	-	-1.3	3.2	0.68*	-	-	-	0.08*	0.1	-
14-May	10.1	30.7	-	8.14	8.33	-	-	-	8.38	-	19.9#	20.2#	-	-	-	20.3#	-	113.9	79.5	-	-	-	32.5	2.5	1.26*	-	-	-	0.11*	0.1	-
15-May	9.7	30.9	-	8.08	8.38	-	-	-	8.38	-	20.2#	21.0#	-	-	-	20.8#	-	95.9	45.5	-	-	-	-43.8	1.2	0.91*	0.10*	0.07*	0.08*	0.07*	0.1	-
16-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-May	9.9	30.5	-	8.14	8.38	-	-	-	8.44	-	18.9#	19.3#	-	-	-	19.4#	-	92.3	-4.9	-	-	-	-78.5	1.6	1.09*	0.08*	0.06*	0.10*	0.07*	0.1	-
18-May	9.8	30.8	-	8.18	8.36	-	-	-	8.45	-	18.7#	19.3#	-	-	-	19.5#	-	86.6	-22.9	-	-	-	-81.7	1.3	0.94*	0.08*	0.05*	0.08*	0.05*	0.1	-
19-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-May	15.2	30.0	-	-	-	-	-	-	-	-	20.8	-	-	-	-	-	-	60.0	-31.2	-	-	-	-119.0	1.5	-	-	-	-	-	0.1	-
24-May	15.0	29.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-42.9	1.0	0.35*	0.14*	0.11*	0.11*	0.14*	0.1	-

Phase I Perchlorate Treatability Study
Summary of Collected Operational Data

Date	Flowrate		pH							T							ORP							D.O.							Ethanol
	AS-Effl. gpm	Reactor gpm	AS-Infl.	AS-Effl.	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	AS-Infl. °C	AS-Effl. °C	R-Infl. °C	R-25%	R-50%	R-75%	R-Effl. °C	AS-Infl. mV	AS-Effl. mV	R-Infl. mV	R-25%	R-50%	R-75%	R-Effl. mV	R-Infl.-Inline ppm	R-Infl.	R-25%	R-50%	R-75%	R-Effl.	R-Effl.-Inline ppm	Flowrate ml/min
25-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-May	26.0	32.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-47.0	1.0	0.17*	0.13*	0.11*	0.2*	0.21*	0.1	-
28-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Jun	19.9	29.9	-	7.34	7.50	-	-	-	8.15	-	20.5	20.9	-	-	-	20.9	-	94.0	31.3	-	-	-	-120.0	1.1	0.5*	0.21*	0.08*	0.08*	0.10*	0.1	-
9-Jun	19.8	29.8	-	7.29	7.47	-	-	-	8.03	-	20.8	21.0	-	-	-	21.3	-	16.0	-59.5	-	-	-	-184.0	1.1	0.48*	0.13*	0.06*	0.06*	0.06*	0.1	-
10-Jun	19.9	29.6	-	7.27	7.40	-	-	-	7.75	-	20.4	19.9#	-	-	-	19.9#	-	-35.5	-149.0	-	-	-	-240.0	0.7	0.8*	0.22*	0.07*	0.06*	0.06*	0.1	7.1
11-Jun	20.0	30.0	-	7.29	7.42	-	-	-	7.73	-	19.8#	19.8#	-	-	-	19.8#	-	-132.8	-251.7	-	-	-	-338.5	0.9	0.70*	0.22*	0.08*	0.08*	0.10*	0.1	6.8
12-Jun	19.9	29.9	-	7.21	7.42	-	-	-	7.76	-	20.7	20.0#	-	-	-	20.1#	-	-38.5	-204.5	-	-	-	-290.0	1.7	0.72*	0.20*	0.08*	0.08*	0.08*	0.1	7.8
13-Jun	20.1	30.0	-	7.30	7.45	-	-	-	7.85	-	21.0	20.9	-	-	-	21.3	-	-77.0	-180.0	-	-	-	-296.7	0.6	-	-	-	-	-	0.1	6.1
14-Jun	20.3	30.0	-	7.26	7.43	-	-	-	7.89	-	20.7	20.0#	-	-	-	20.5#	-	-55.0	-200.4	-	-	-	-285.5	1.2	0,99*	0.07*	0.08*	0.08*	0.10*	0.1	6.3
15-Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-282.0	-	-	-	-313.0	-	0.14*	0.09*	0.09*	0.09*	0.08*	-	-
16-Jun	-	-	-	7.37	7.54	-	-	-	7.97	-	20.9	21.2	-	-	-	21.7	-	31.7	-164.5	-	-	-	-231.5	-	-	-	-	-	-	-	-
17-Jun	19.9	29.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-178.1	-	0.45*	0.25*	0.24*	0.24*	0.25*	-	-

* = DO measurements taken inside bioreactor not at sample ports, all other non-starred, non-inline readings taken with held at sample port
# = temperature recorded with ysi DO probe inside bioreactor not at sample ports, all others measured with handheld at sample ports.

Phase I Perchlorate Treatability Study
Bioreactor D.O. Profiles

Date		1/25/98	1/29/98	3/17/98	3/18/98	3/19/98	3/20/98	3/21/98	3/22/98	3/23/98	3/24/98	3/25/98	3/30/98	4/1/98	4/2/98	4/3/98	4/4/98
		19.8	25.0	10.3	10.3	10.0	10.1	10.0	10.0	9.9	10.8	14.8	15.3	14.7	14.8	15.1	19.8
Status		AS turned off															
ft in direction of flow																	
Bioreactor Bottom	0'	0.50	0.65	2.25	2.20	2.60	2.53	2.84	2.50	2.40	3.32	4.60	2.83		3.80	3.80	3.80
	1'	0.10	0.20	1.25	1.00	1.95	2.00	1.48	2.25	0.81	2.16	4.00	2.00	2.10	2.00	2.00	2.00
	2'	0.10	0.12	0.35	0.54	1.23	0.73	0.68	1.05	0.68	2.02	2.30	1.20	0.80	0.80	0.80	0.80
1/4 h	3'	0.10	0.10	0.25	0.23	0.66	0.40	0.42	0.40	0.35	0.79	1.20	0.70	0.50	0.40	0.40	0.40
	4'	0.10	0.08	0.15	0.17	0.30	0.24	0.25	0.22	0.20	0.40	1.00	0.70	0.20	0.30	0.30	0.30
	5'	0.10	0.08	0.09	0.14	0.25	0.19	0.18	0.18	0.16	0.30	0.75	0.20	0.20	0.30	0.30	0.30
	6'	0.10	0.08	0.10	0.09	0.20	0.12	0.12	0.13	0.14	0.18	0.40	0.20	0.10	0.10	0.10	0.10
1/2 h	7'	0.10	0.08	0.07	0.06	0.12	0.08	0.06	0.06	0.09	0.20	0.19	0.10	0.10	0.10	0.10	0.10
	8'	0.10	0.08	0.06	0.05	0.07	0.07	0.06	0.05	0.08	0.15	0.16	0.10	0.10	0.10	0.10	0.10
	9'	0.10	0.08	0.06	0.06	0.07	0.06	0.06	0.05	0.06	0.08	0.14	0.10	0.10	0.10	0.10	0.10
	10'	0.10	0.08	0.05	0.06	0.06	0.06	0.06	0.05	0.06	0.08	0.14	0.10	0.10	0.10	0.10	0.10
3/4 h	11'	0.10	0.08	0.05	0.05	0.06	0.05	0.06	0.05	0.06	0.08	0.14	0.10	0.10	0.10	0.10	0.10
	12'	0.10	0.08	0.05	0.05	0.06	0.06	0.06	0.05	0.06	0.08	0.14	0.10	0.10	0.10	0.10	0.10
	13'	0.10	0.08	0.05	0.05	0.06	0.06	0.06	0.05	0.06	0.08	0.14	0.10	0.10	0.10	0.10	0.10
	14'	0.10	0.08	0.05	0.04	0.06	0.06	0.06	0.05	0.06	0.08	-	0.10	0.10	0.10	0.10	0.10
Bioreactor Top	15'	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Phase I Perchlorate Treatability Study
Bioreactor D.O. Profiles

Date		4/5/98	4/6/98	4/8/98	4/9/98	4/10/98	4/14/98	4/15/98	4/17/98	4/19/98	4/20/98	4/21/98	4/22/98	4/23/98	4/24/98
		19.9	19.6	19.2	19.3	17.5	15.3	15.2	15.0	15.0	16.0	15.9	16.0	-	15.0
Status												AS turned on			
ft in direction of flow															
Bioreactor Bottom	0'	3.70	3.70	0.90	1.90	1.28	0.98	1.18	2.70	3.42	0.82	0.99	1.12	1.06	0.66
	1'	2.30	2.30	0.55	0.34	0.70	0.62	0.47	1.12	2.19	0.68	0.25	0.65	0.55	0.46
	2'	1.20	1.20	0.29	0.24	0.33	0.36	0.24	0.70	1.20	0.48	0.18	0.35	0.30	0.30
1/4 h	3'	1.00	1.00	0.20	0.11	0.28	0.22	0.15	0.31	0.55	0.27	0.10	0.15	0.19	0.26
	4'	0.30	0.30	0.18	0.11	0.16	0.14	0.15	0.22	0.45	0.13	0.10	0.15	0.16	0.14
	5'	0.30	0.30	0.16	0.08	0.10	0.08	0.11	0.18	0.20	0.10	0.08	0.10	0.09	0.11
	6'	0.20	0.20	0.10	0.08	0.08	0.07	0.09	0.10	0.22	0.08	0.07	0.08	0.07	0.08
1/2 h	7'	0.10	0.10	0.09	0.07	0.08	0.06	0.08	0.07	0.09	0.08	0.07	0.08	0.06	0.07
	8'	0.10	0.10	0.09	0.07	0.07	0.06	0.08	0.07	0.06	0.08	0.07	0.08	0.06	0.07
	9'	0.10	0.10	0.09	0.07	0.07	0.06	0.08	0.07	0.06	0.07	0.06	0.08	0.06	0.07
	10'	0.10	0.10	0.08	0.06	0.07	0.05	0.08	0.07	0.06	0.07	0.06	0.14	0.06	0.07
3/4 h	11'	0.10	0.10	0.08	0.06	0.07	0.05	0.07	0.07	0.06	0.07	0.06	0.10	0.06	0.06
	12'	0.10	0.10	0.08	0.06	0.07	0.05	0.07	0.06	0.06	0.08	0.06	0.10	0.06	0.06
	13'	0.10	0.10	0.08	0.06	0.07	0.05	0.07	0.07	0.06	0.07	0.06	0.09	0.06	0.06
	14'	0.10	0.10	-	-	-	-	-	-	0.06	-	-	-	-	-
Bioreactor Top	15'	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date		4/26/98	4/27/98	4/28/98	4/29/98	4/30/98	5/4/98	5/6/98	5/7/98	5/8/98	5/10/98	5/11/98	5/12/98	5/13/98	5/14/98
		8.7	10.0	10.2	9.7	9.7	9.8	9.1	9.9	9.7	10.1	9.8	9.9	10.0	10.1
Status															
ft in direction of flow															
Bioreactor Bottom	0'	0.25	0.55	0.65	0.21	0.41	3.68	0.72	1.22	0.72	0.74	0.60	1.25	0.68	1.26
	1'	0.45	0.12	0.13	0.13	0.30	3.20	0.61	0.62	0.44	0.28	0.39	0.61	0.38	0.57
	2'	0.20	0.07	0.10	0.10	0.17	3.30	0.44	0.37	0.20	0.13	0.28	0.27	0.16	0.22
1/4 h	3'	0.15	0.07	0.09	0.09	0.09	3.44	0.44	0.23	0.13	0.11	0.09	0.14	0.14	0.15
	4'	0.10	0.07	0.08	0.08	0.07	3.46	0.34	0.17	0.10	0.10	0.11	0.14	0.13	0.08
	5'	0.06	0.07	0.07	0.08	0.06	2.82	0.22	0.10	0.10	0.09	0.11	0.13	0.10	0.08
	6'	0.06	0.06	0.07	0.07	0.06	2.74	0.18	0.09	0.09	0.09	0.10	0.12	0.08	0.06
1/2 h	7'	0.05	0.06	0.07	0.07	0.06	2.71	0.08	0.07	0.07	0.07	0.09	0.12	0.08	0.06
	8'	0.05	0.06	0.06	0.08	0.06	2.63	0.07	0.07	0.06	0.07	0.07	0.11	0.08	0.06
	9'	0.05	0.06	0.06	0.07	0.06	2.57	0.07	0.06	0.06	0.07	0.06	0.11	0.08	0.05
	10'	0.05	0.05	0.06	0.07	0.05	2.58	0.07	0.06	0.06	0.08	0.09	0.11	0.07	0.06
3/4 h	11'	0.05	0.05	0.06	0.08	0.06	4.42	0.08	0.38	0.44	0.84	0.25	0.31	0.12	0.24
	12'	0.05	0.05	0.07	0.07	0.06	3.08	0.07	0.36	0.22	0.47	0.52	0.35	0.08	0.35
	13'	0.05	0.05	0.07	0.06	0.06	2.82	0.07	0.07	0.06	0.09	0.30	0.37	0.08	0.11
	14'	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioreactor Top	15'	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Phase I Perchlorate Treatability Study
Bioreactor D.O. Profiles

Date		5/15/98	5/17/98	5/18/98	5/23/98	5/24/98	5/27/98	6/8/98	6/9/98	6/10/98	6/11/98	6/12/98	6/14/98	6/15/98	6/17/98
		9.7	9.9	9.8	15.2	15.0	26.0	19.9	19.8	19.9	20.0	19.9	20.3	-	19.9
Status								AS runs after Reactor							
ft in direction of flow															
Bioreactor Bottom	0'	0.91	1.09	0.94	-	0.35	0.17	1.10	0.48	0.80	0.90	1.70	0.99	0.14	0.45
	1'	0.32	0.42	0.36	-	0.28	0.30	0.50	0.32	-	0.70	0.72	0.99	0.16	0.29
	2'	0.15	0.18	0.13	-	0.31	0.22	0.40	0.25	-	0.84	0.33	0.37	0.11	0.28
1/4 h	3'	0.12	0.11	0.09	-	0.14	0.14	0.29	0.17	-	0.44	0.30	0.17	0.10	0.26
	4'	0.10	0.08	0.08	0.15	0.14	0.13	0.21	0.13	0.22	0.22	0.20	0.07	0.09	0.25
	5'	0.08	0.07	0.07	-	0.12	0.11	0.08	0.06	-	0.08	0.09	0.08	0.09	0.24
	6'	0.07	0.07	0.05	-	0.12	0.11	0.08	0.06	-	0.08	0.08	0.07	0.09	0.24
1/2 h	7'	0.07	0.07	0.05	-	0.12	0.11	0.10	0.05	-	0.08	0.08	0.08	0.09	0.24
	8'	0.07	0.06	0.05	0.07	0.11	0.11	0.08	0.06	0.07	0.08	0.08	0.08	0.09	0.24
	9'	0.07	0.06	0.05	-	0.12	0.11	-	0.06	-	0.08	0.08	0.08	0.09	0.24
	10'	0.07	0.06	0.05	-	0.12	0.17	-	0.06	-	0.08	0.08	0.08	0.09	0.23
3/4 h	11'	0.08	0.10	0.08	-	0.11	0.20	-	0.06	0.06	0.08	0.08	0.08	0.09	0.24
	12'	0.12	0.11	0.05	-	0.14	0.19	-	0.06	-	0.08	0.08	0.08	0.09	0.24
	13'	0.07	0.07	0.05	-	-	0.21	-	0.06	0.06	0.10	0.08	0.10	0.08	0.25
	14'	-	-	-	0.07	-	-	0.10	-	-	-	-	-	-	-
Bioreactor Top	15'	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX F
ANALYTICAL SAMPLING ERROR DATA SUMMARY

Analytical Sampling Error Data Summary

DATE ANALYZED	RELATIVE PERCENT DIFFERENCE (RPD)			
	PERCHLORATE	NITRATE	METHANOL	ETHANOL
11/6/97	9	4		2
11/7/97		4		***
11/10/97		2		***
11/11/97	1	2		
11/12/97	0			10
11/13/97	13	0	2	
11/14/97	24	7	15	
11/17/97			25	
11/18/1997 *	6	4	38	
11/19/97		3	15	
11/20/97		5		
11/21/97		3	8	
11/24/97	6	1		
11/25/97	0	1	3	
11/26/97		6	6	
12/1/97	17	3	10	
12/2/97		1	7	
12/5/97		0	4	
12/8/97		5	14	
12/9/97			**	
12/11/97		4		
12/12/97	5	5	8	
12/15/97	14	6	7	
12/16/97		5		
12/17/97	11		5	
12/18/97		1	4	
12/19/97	13		5	
12/20/97	11	1	20	
12/22/97	11	3		
12/23/97			3	
12/24/97		4		
12/26/97	2	4	16	
12/29/97			6	
12/31/97	6		13	
1/2/98		2	0	
1/5/98	18	3	3	

Analytical Sampling Error Data Summary

DATE ANALYZED	RELATIVE PERCENT DIFFERENCE (RPD)			
	PERCHLORATE	NITRATE	METHANOL	ETHANOL
1/8/98	4		7	
1/9/98	3		5	
1/12/98	8	2		
1/13/98			4	
1/14/98	2	3	15	
1/15/98		2	7	
1/16/98	1	2	2	
1/19/98		5	8	
1/20/98		3	2	
1/21/98			3	
1/23/98		2	22	
1/26/98		5	15	
1/27/98		1	3	
1/28/98		2	15	
1/29/98		2		
1/30/1998 *		1	35	
2/2/98		1		
2/3/98	2	6	0	
2/4/98		1		
2/5/98			6	
2/6/98	6	4		
2/9/98			20	
2/10/1998 *	27			
2/12/98		2	12	
2/13/98	22	2	13	
2/17/98	21	1	14	
2/18/98	4	3	10	
2/20/98	8	4	2	
2/23/98	13	1	5	
2/24/98	13			
2/25/97			4	
2/27/98	8	1		
3/2/98	3	2		
3/3/98		1	12	
3/4/98	9	2	11	
3/5/98	3			

Analytical Sampling Error Data Summary

DATE ANALYZED	RELATIVE PERCENT DIFFERENCE (RPD)			
	PERCHLORATE	NITRATE	METHANOL	ETHANOL
3/6/98	1	2	13	
3/9/98	17	3		
3/10/98			4	
3/11/98		4		
3/12/98	9	2	2	
3/13/98	3	2	12	
3/17/98		2		
3/18/98	10	2	12	
3/19/98	0	0	11	
3/20/98		1	9	
3/23/98	11	1	7	
3/24/98	11			
3/25/98		4		
3/26/98	3	0		
3/27/98	13		8	
3/30/98	7		3	
3/31/98			1	
Statistics				
Minimum RPD:	0	0	0	2
Maximum RPD:	27	7	38	10
Average RPD:	**8.7**	**2.6**	**9.4**	**6.0**

Notes:

* Relative Percent Difference (RPD) data is not within standard QC limits.

** Recovery data is outside standard QC limits due to coextracted interference. LCS recovery data validates methodology (RPD data not provided in laboratory reports).

*** Recovery data is outside standard QC limits due to the high concentration of this analyte in the sample. LCS recovery data validates methodology (RPD data not provided in laboratory reports).

APPENDIX G
U.S. EPA COMMENTS ON PHASE 1 TREATABILITY STUDY DRAFT REPORT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

July 28, 1998

Baldwin Park Operable Unit Steering Committee
c/o Donald E. Vanderkar
Aerojet General Corporation
Box 13222
Sacramento, CA 95813

Subject: EPA Review of 20 May 1998 Phase 1 Treatability Study Draft Report and Phase 2 Treatability Study Work Plan, Baldwin Park Operable Unit, San Gabriel Basin

Dear Mr. Vanderkar:

We have completed our review of the Draft Perchlorate Treatability Study Phase 1 Report and Phase 2 Workplan, prepared by Harding Lawson Associates for the Baldwin Park Operable Unit Steering Committee. The full titles of the reports are:

Phase 1 Treatability Study Draft Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin, 20 May 1998; and

Phase 2 Treatability Study Work Plan, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin, 20 May 1998.

Our enclosed comments incorporate observations and suggestions made by EPA staff, as well as Metropolitan Water District (Metropolitan), the California Department of Health Services (DHS), and McGuire Environmental Consultants (consultant to the Main San Gabriel Basin Watermaster). We understand that Metropolitan, DHS, and McGuire Environmental Consultants have sent their comments directly to the Steering Committee. Metropolitan's comments are dated 9 and 22 June 1998; DHS's comments are dated 10 July 1998; and McGuire Environmental Consultants' comments are dated 12 June 1998.

The Phase 1 results are promising. The Phase 1 study appears to have met its primary goal of demonstrating that the biological process is capable of reducing perchlorate concentrations from the tens of ug/l to below 4 ug/l. More work must be completed, however, to convincingly demonstrate that the process can produce water that reliably meets all State and Federal water quality standards.

Please submit a revised Phase 1 report and Phase 2 workplan within 21 days of receipt of these comments. As we have discussed, the revised Phase 1 report should include data collected after 13 March 1998, the last date for data included in the draft report.

Sincerely,

Wayne Praskins
EPA Project Manager

Enclosure

cc: Rick Sakaji, DHS
Nabil Saba, DHS
Gary Yamamoto, DHS
Jeanne-Marie Bruno, Metropolitan Water District
Carol Williams, Main San Gabriel Basin Watermaster
Mike McGuire, McGuire Environmental Consultants
Michael Berlien, La Puente Valley County Water District
John Catts, Harding Lawson Associates

7/28/98 EPA Comments on
Phase 1 Treatability Study Draft Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin

Location	Comment
page v, 5th bullet [and p13, last sentence]	This finding should be rewritten, since the Phase 1 study did not include testing of filtration or disinfection processes, and did not appear to include analysis for all Title 22 water quality parameters. More work is needed to demonstrate that the treatment process will reliably produce potable water meeting all current and anticipated drinking water standards.
p3, § 2.4	The text states that pilot-scale work at Aerojet's Sacramento facility demonstrated that pathogens were not present in the pilot plant effluent. What analyses were conducted to support this statement?
p4, §3.0, ¶ 4	Please explain the operation of the biological growth control system and carbon capture and return system in more detail. Were waste solids produced in the Phase 1 study? If so, what was its composition, rate of production, and methods of handling and disposal? If no waste solids were produced, what was the fate of the carbon lost from the bioreactor (as described on page C-3)?
p5, § 4.0	In a few cases, perchlorate concentrations in the bioreactor increase slightly from one sampling location to the next (e.g., between sampling ports E and F on 2/18 and 2/20, and between ports F and G on 12/18 and 2/17). Do you think the increase is real? What data are available to support one explanation over another? (e.g., analytical error? incomplete mixing within the bioreactor? desorption from carbon?) Were replicate samples analyzed to estimate the precision of the perchlorate analyses? What and where are the results? What data are available to evaluate how well-mixed the groundwater is as it passes through the bioreactor? Could there be significant variability in microbial activity, flow, or perchlorate concentration perpendicular to the direction of flow? Do the sampling ports draw water from deep within the bioreactor (i.e., near the center), or close to the bioreactor wall? Also, measured perchlorate influent concentrations (pre-recycle) vary day to day, oftentimes by more than 20% (e.g., 51 to 36 ug/l, 57 to 35 ug/l, 39 to 27 ug/l). In contrast, nitrate concentrations varied little. Do you believe that this variability is real? Or due to analytical error or some other cause?

p6, § 5.1	Is there any experimental basis for the equation describing the reduction of perchlorate? Other researchers report that the conversion of perchlorate to chloride primarily occurs through the reduction of perchlorate to chlorate and chlorite, followed by the dismutation of chlorite: $ClO_4^- + 2e^- + 2H^+ \Rightarrow ClO_3^- + H_2O$ $ClO_3^- + 2e^- + 2H^+ \Rightarrow ClO_2^- + H_2O$ $ClO_2^- \Rightarrow O_2 + Cl^-$ Also, the text states the following: "Note that nitrate and perchlorate are completely destroyed..." The ability to write a balanced chemical reaction does not guarantee that the reaction will go to completion or that there aren't other competing reactions with other products.
p6, § 5.2	The text provides an equation for estimating effluent substrate concentration (S_e). How was this relationship used? If it was used, how were the parameters determined and what were their values?
p7, § 5.3	Please discuss the quality of the data generated as part of the study, with reference to the quality control analyses. Were the BOD or COD data evaluated? If so, for what purpose?
p8, § 5.3.2, ¶ 2	Please clarify the statement that "...most of the nitrate is 25% destroyed..."
p8, § 5.3.2, ¶ 3	What is the basis for the statement that "In general, nitrate destruction occurred ...before perchlorate destruction."?
p8, § 5.3.3, ¶ 2	The text states that the microorganisms introduced into the bioreactor were aerobic. How was that established?
p9, § 5.3.3	Was any analysis attempted to relate the actual rates at which reactants and products were consumed and produced to the stoichiometric ratios predicted by theory? Would this type of analysis help identify which chemical species is limiting?
p9, 3rd and 4th ¶	Please explain the relationship between bioreactor flow path and retention time. The 3rd paragraph states that a retention time of less than 4 minutes corresponds to flow through 4' of bioreactor. The 4th paragraph states that a retention time of 5.4 minutes corresponds to flow through 9' of bioreactor.
p9, § 5.3.4	The text discusses the use of DO and ORP to monitor bioreactor performance. Have any other indicators been considered for monitoring reactor performance?

p11, ¶ 2	The text describes Plate 12 as demonstrating that "the top of the ethanol working range...is approximately 140 mg/l ... [and that] at concentrations above 180 mg/l, perchlorate destruction degrades and is incomplete." The statement appears true, but is the cause of the poor perchlorate destruction the high ethanol dose or high influent DO? All of the high ethanol data points (i.e., above 140 mg/l) represent high DO influent water (i.e., before 1/24).
p12, § 5.3.9	Was any attempt made to identify the types of organisms observed in the bioreactor? (e.g., bacteria, yeasts, molds)
p12, § 5.3.10	Was any attempt made to calculate a mean cell residence time? Would such a calculation help determine the time required for the bioreactor to respond to a change in influent conditions?
p13, § 5.4	The text states that "Analytical results shown in Appendix D demonstrate that with an influent ethanol concentration of 60 to 70 mg/l, ethanol in bioreactor effluent was less than the 5 mg/l laboratory reporting limit." This relationship is shown for only a short period. For influent ethanol concentrations between 60 to 70 mg/l, perchlorate and ethanol were reduced to below their reporting limits in only two samples collected over a three day period (2/27-3/1). Subsequent samples (collected on 3/3, 3/4, and 3/5) had perchlorate concentrations above 4 ug/l. Appendix D show that two ketones (acetone and 4-methyl-2-pentanone) were present in the reactor effluent in the hundreds of ug/l. In each of the five days in which EPA Method 8260 results are presented, acetone increased in concentration in the bioreactor. Please discuss the likely source and significance of these ketones. Primary and secondary alcohols are readily oxidized to aldehydes and ketones.

p13, § 5.4 (continued)	Although the acetone does not appear to originate solely from the alcohol, could ketones be present in the alcohol? Was the ethanol analyzed for the presence of impurities or denaturing agents? What information is available from the supplier or manufacturer on the composition of the alcohol? If any impurities are present, are higher grade, more purified forms of alcohol available? We also note that isopropyl alcohol was detected on several occasions between 3/1 and 3/13 at concentrations between 5 and 19 mg/l. Do you believe that isopropyl alcohol was present in the alcohol when purchased, or originated elsewhere? How can its presence be limited in the future? Did the source or vendor of alcohol change over the duration of the study? The text states that "it was concluded that the slightly reducing, anoxic conditions present in the bioreactor are not sufficiently reducing to cause VOC degradation." In all samples analyzed for VOCs , the TCE concentration decreased through the bioreactor - on average by about 75%. What evidence is available to suggest that the decrease is due to carbon adsorption, biological degradation, or some other mechanism? Could VOCs have been lost by volatilization?
p14, 4th bullet	The text states that "laboratory analyses indicated a lack of pathogens that may be of concern..." Is this statement based on any test results other than for fecal coliform?
p14, § 6.0, 5th bullet	This conclusion is overstated. See comment on page 1, 5th bullet.
p14, § 6.0, 6th bullet	The test states that the *conceptual model* agrees well with the actual results. Are you referring to the description of fluidized bed behavior included in Section 5.2? Please explain the ways in which the study results support and/or differ from the *conceptual model.*
Plate 1	Plate 1 includes the statement "Confidential Business Information," yet we understand that the report has been distributed to several agencies and groups without specific instructions to keep any part of the report confidential. Please clarify whether the Steering Committee is claiming Plate 1 or any other part of the report as Confidential Business Information.
page B-2, 6th bullet	The text states that EPA Method 502.2 was used for VOC analysis, but Appendix D lists results for both EPA Methods 502.2 and 8260. How do the two methods compare in their ability to identify and quantify aldehydes and ketones?
Appendix C	Please describe in more detail how the microorganisms were added. Was the sludge added directly to the bioreactor? Or were extracts or isolates used? What provisions were taken to avoid introducing harmful organisms?

page C-4, ¶ 4	The text mentions that the DO profile in the bioreactor was measured before the air stripper was taken offline. Please include these data in Appendix E.
page C-6, ¶ 6	The text states: "Therefore, the range of ethanol concentrations at which complete perchlorate and nitrate destruction is lost lies between 50 and 70 mg/L." The definitiveness of the statement seems unwarranted given the short, one-time test of the relationship. I recommend presenting the relationship between ethanol concentration and perchlorate destruction as a hypothesis in need of further evaluation.
Appendix D	Can the coliform results that are presented as MPN>200.5/100ml be quantified? Please include results from all blanks and replicate analyses.
Appendix D, last page	A metals result on 2/19/98 (for iron) is reported as "TEQUILA." Please explain.

7/28/98 EPA Comments on
Phase 2 Treatability Study Work Plan, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin

Location of Comment	Comment
p1, col 2, ¶ 3	The text states that: "Finally, the results of the treatability study indicate that the effluent water quality (following disinfection and filtration) should meet all applicable standards..." This sentence should be revised, since the Phase 1 study did not include testing of filtration or disinfection processes, and did not appear to include analysis for all Title 22 water quality parameters.
p3 , col 2, ¶ 3, last sentence	The text states that: "... the microorganisms multiply to a steady-state level, determined by the organic loading to the system." What does the phrase "steady-state" mean here? Doesn't the need for a biological growth control system indicate that microbial growth exceeds death? Don't the rates of microbial growth and reproduction also depend on factors other than organic loading to the system?
p3 , col. 2, ¶ 4	The text states that: "Nonviable microorganisms eventually become detached from the medium and exit the system..." Is there evidence that microbes are exiting the system? If so, is there evidence that the exiting microbes are dead or dying? The text states that "...The reaction takes place under anoxic conditions...," but Appendix E in the Phase 1 report indicates that low levels of DO remain in the bioreactor. Please comment.
p3, § 3	Please explain further the rationale for selection of ethanol as an organic substrate, and discuss other possible substrates.

p4, § 4.0	Phase 2 objectives should be clarified or supplemented to include the following: i) demonstration that perchlorate and alcohol concentrations can be consistently reduced to below laboratory reporting limits (i.e., for much longer than the several day period demonstrated in Phase 1); ii) evaluation of the potential for the production of byproducts of alcohol degradation and cell metabolism and growth. Please comment on the value of isolating and/or identifying the microorganisms present in the bioreactor in order to evaluate the potential for the microorganisms to release toxic substances into the water. Is there a potential for the trace metals present in bacterial enzymes to be released at toxic levels? Is there a potential for changing redox conditions to result in the formation of organic-metal complexes? Is it known whether the microorganisms make use of molybdenum, as do nitrate-reducing bacteria (and the perchlorate-reducing bacterium identified by the Air Force Research Lab), or another potentially more toxic metal?; iii) verification of the Phase 1 finding that vinyl chloride and other unwanted byproducts are not produced in the bioreactor; iv) evaluation of the potential for the treated effluent to cause microbial growth in a drinking water distribution system; v) testing the treated effluent for taste and odor and other secondary drinking water parameters; vi) determination of optimal phosphorous dosage; vii) testing to fully characterize the treatment process' response to plausible operational problems and perturbations (e.g., power outages, interruption of chemical feed, changes in influent composition). The characterization should include the nature of the response (e.g., changes in perchlorate removal effectiveness and other physical and chemical indicators of system performance), recovery time, and evaluation of the need for backup systems. The workplan should include a discussion of the value of adding each of the following objectives, and add objectives deemed worthwhile: i) identification of the active microorganisms in the inoculum and in the bioreactor periodically after startup; ii) identification of microbial nutrient requirements in addition to C, N, and P (e.g., trace metals); iii) evaluation of bioreactor performance using an alternate organic substrate; iv) laboratory analysis of biomass and/or bioreactor effluent for pathogens or other indicators of the presence of pathogens; v) improved understanding of the bioreactor's hydraulic characteristics, in order to better predict the bioreactor's response to changes in influent conditions.

p5, § 4.2, ¶ 1	Please comment on the capability of ion selective electrodes to measure perchlorate and nitrate in water (e.g., Are they capable of reliably measuring perchlorate concentrations in water, but only at high concentrations?). In any case, if improvements in ion selective electrodes are possible in the near future, their use should be reevaluated during design of the BPOU treatment facilities.
p5, § 4.2, ¶ 2	Phase 1 study results show relationships between DO, ORP, and bioreactor performance, but did not demonstrate that "bioreactor performance could be predicted..." It seems premature to claim that all variables significantly affecting bioreactor performance have been identified. What additional work is planned to demonstrate that DO and ORP are good surrogates for perchlorate and nitrate reduction? Which other parameters are being considered for monitoring reactor performance? Has consideration been given to periodically measuring the ratio of perchlorate consumption/cell mass, and determining its relationship to bioreactor performance?
p5, § 4.3, ¶ 1	The text states that "...there is a potential that treated water may contain bacteria..." The bioreactor effluent in Phase 1 consistently had high levels of bacteria. Please comment.
p5, § 4.3, ¶ 2	We suggest that the "characterization of Disinfection Byproducts include a discussion of disinfection options, disinfection location(s), disinfection byproduct (DBP) formation potential, and the relationship between organic substrate and production of DBPs. (Alcohols may produce methyl-bearing aldehydes or ketones that are known to react with chlorine to produce chloroform, a trihalomethane [THM]. Chloroform was measured on 1/28/98 in the bioreactor effluent at 63 ug/l, along with acetone at 6,700 ug/l.). If appropriate, the laboratory reporting limits for alcohol should be reduced.
p6, 1st line [also p10, § 10, ¶ 2]	The text states that "the microorganism inoculum will be characterized." Please describe further. Please describe the origin of the microorganisms in greater detail. If they originate at a baby food processing plant, where in the processing operation are they collected? Please describe the type of environment to which the microbes would have been exposed and acclimated.
p6, § 4.4, col 1	Given that the La Puente VCWD's wells have been shut down for some time, perchlorate concentrations may change after startup as steady state conditions are approached. Should samples be collected at increased frequency during startup to evaluate the bioreactor's performance over a range of influent conditions?
p6, § 5.0	Has the Steering Committee considered operating the 30 gpm pilot scale treatment unit to address some of the Phase 2 objectives, rather than attempting to address all of the Phase 2 objectives at a much higher flow rate?
p7, col 1, ¶ 5	Will the presence and use of ethanol require special equipment beyond the "hazardous duty diaphragm metering pump" mentioned in the text?
p7, col 2	How will samples collected from sampling ports 7 and 8 differ?

p7, col2, middle ¶	Please explain further the statement that biomass discharged from the bioreactor will not affect operation of the air stripper.
p8, col 1, ¶ 3	DHS provides the following comments, which may affect the treatment equipment tested during Phase 2: (i) the bioreactor effluent must be approved by DHS as a water source; (ii) post-bioreactor treatment must meet or exceed that required by the Surface Water Treatment Rule (which includes specified removal rates for viruses and other pathogens) ; (iii) a tracer study may be required to demonstrate adequate disinfectant residual and contact time; (iv) a filtration system study will be required to demonstrate compliance with Title 22, Section 64653 if the loading rate specified in Title 22, Section 64660 (b) is exceeded; (v) the treatment train must meet turbidity standards established in section 64653(c); (vi) that issuance of a domestic water supply permit for use of the biological treatment process will, if warranted, occur after a review process subsequent to and separate from the Phase 2 study; Please include dates in the schedule for obtaining DHS approval for use of the bioreactor effluent as a water source; for submission, review, and approval of a filtration system study protocol (to the DHS internal Surface Water Treatment Committee); and for satisfying any other DHS requirements. Also, DHS indicates that coagulation and flocculation may be needed. Please discuss.
p8, col 1	The treatment equipment description does not include provision for establishing a chlorine residual. Please comment. Where in the treatment process will waste sludge or solids be produced? Please describe the nature of the wastes, volumes produced, and methods of handling and/or disposal
p8, § 8.0	The text discusses "key permitting requirements." What other permits are needed beyond those listed?
p8, § 8.2	Please include a timetable for applying for and obtaining a Regional Board discharge permit.

p9, § 8.3	Please include a timetable for obtaining an ATF permit.
p9, § 8.4	Please identify the chemicals requiring certification, and include a timetable for applying for and obtaining certification.
p9, § 9.1, col 2	Please describe the procedure for adding the microbial seed.
p10, § 10	The SAP/QAPP should be submitted for review by EPA, DHS, and other relevant agencies. Sample collection and analysis should reflect additional objectives added in response to the comment on page 4, section 4.0. The SAP/QAPP should briefly describe non-EPA methods and provide complete references. If a reference is <u>not</u> to a commonly-available journal or textbook, a description of the method should be included as an appendix to the SAP.
p11, §10.3	Please supplement the list of analytes to account for the expanded list of objectives. Total Organic Carbon (TOC) should be included. Also note that new or revised MCLs and MCLGs have been proposed for chlorite, trihalomethanes, chloroform, haloacetic acids, and several other chemicals as part of the Disinfectants/Disinfection Byproducts Rule.
p11, §10.4	Given the apparent variability in measured perchlorate concentrations during Phase 1 testing, a sufficient number of replicate samples should be analyzed to better estimate the precision of the analytical method.
p12, sect 11.1	Does the project team include individuals with expertise in microbiology, bacteriology, and related disciplines?
p12, §11.2, last ¶	Please include provisions for frequent interim reporting to EPA after startup (weekly to biweekly). Reporting can be by mail, fax, telephone or email. Please include provisions for less frequent interim written reporting. There is no communications plan in Section 10 as stated in the text.

2 le)	Please add items to schedule as appropriate in res: p8, § 8.2 p9, § 8.3 p9, § 8.4 p8, col 1, ¶ 3 p10, § 10 p12, § 11.2 , last ¶ The two month design and six month procureme: appear unnecessarily long. Please shorten and pr the revised schedule. In addition, incorporate a two week period for D: and O&M plans. We also suggest that you delete the line item for

7/28/98 EPA EDITORIAL COMMENTS ON
PHASE 1 REPORT AND PHASE 2 WORKPLAN (Respond at your discretion.)

Phase 1 Report Editorial Comments:

p1, ¶ 1	Metropolitan prefers that their role be described as assisting Three Valley. They request that the 1st sentence be modified as follows: "... U.S. EPA Region IX (EPA) and Three Valleys Municipal Water District (TVMWD), in association with Metropolitan Water District of Southern California (MWD), have been planning..."
p1, ¶ 4, sentence 3	The revised RfD may or may not lead to an enforceable standard.
p1, ¶ 4, last sentence	Other factors, including demands by users of the treated water, may affect the decision whether to treat for perchlorate.
p3, § 2.3	There appears to be an extra "than" in the 1st sentence.
p4, 3rd line	Not all parameters were analyzed for. Suggest deleting the word "all."
p4, § 3.2	The text states that the "...the biomass will be 15 feet high." Presumably, this is the height of the fluidized bed (i.e., suspended carbon granules) with attached biomass.
p5, § 4.0	To support findings made in the text (e.g., relationship between DO loading and perchlorate removal), we suggest you add references to data presented in the Tables. No reference is made in the text to Table 3.
p6, § 5.1	Denitrification is misspelled. Electrical charge doesn't balance in the denitrification reaction. As written, the text incorrectly states that ethanol is converted to chloride and nitrogen.
p8, § 5.3.3	There appears to be an extra "at" at the beginning of the 5th line.
p9, § 5.3.3	The rate constants listed above the arrow in each equation appear superfluous.
p9, § 5.3.3, ¶ 2	There appears to be an extra word (".... reactor bioreactor...") in the 5th line.
p9, § 5.3.3, ¶ 4	In the first line, the word "stripper" is misspelled.
p12, § 5.3.9	Since the microbes were not identified, is there really any evidence that Voltera's principle applies?
p13, sect 5.4, par 4 [and p15, 1st bullet]	The text states that "Testing for VOC degradation products showed no detectable concentrations of VOC degradation products..." Couldn't TCE be a degradation product?

Table 3	We suggest adding a note specifying where the influent DO is measured. It appears that it was measured at port C, after internal recycle.
plate 6	For this and any other figures showing perchlorate concentrations near the detection limit, indicating the quantitation limit on the figure would help the reader correctly interpret the data (i.e., the perchlorate concentration did not necessarily stabilize at 4 ug/l).
page B-1, 3rd bullet	In the 5th line, eductor is misspelled.
page B-2, 1st bullet	In the 6th line, the word "of" is missing.
page C-2, ¶ 4	Some words appear to be missing from the last sentence.
page C-4, ¶ 3	In the 1st line, should the sentence be corrected to state that the ORP decreased (rather than rose)?
page C-4, ¶ 5	The last line in the paragraph states that the DO was reduced to a range of 9.5 to 1 mg/L. Should the 9.5 mg/L be 0.95 mg/L?

Phase 2 Report Editorial Comments:

p2, §2.0	EPA has established a Reference Dose, but has not established an acceptable level for perchlorate in water.
p3, § 2.2, ¶ 2	After completion of the toxicological studies, the RfD may no longer be "provisional." Suggest deleting the word provisional.
p3 , col. 2, 1st line	There is a comma missing after the word "chloride" in the 1st line.
p5, col 2, 2nd line	Volt is usually abbreviated with a capital V.
p6, 1st sentence	Inoculum is misspelled .
p9, § 8.5	We suggest that you delete the phrase "Phase 2 Treatability Study" in the second line.
p10, § 10.0, ¶ 2, line 4	Inoculum is misspelled
p11	No need to repeat the list of ten sample locations twice in the report (pages 7 and 11)

APPENDIX H
BPOUSC RESPONSE TO U.S. EPA COMMENTS

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
Page v., 5th bullet [and p. 13 last sentence]	This finding should be rewritten, since the Phase 1 study did not include testing of filtration or disinfection processes, and did not appear to include analysis for all Title 22 water quality parameters. More work is needed to demonstrate that the treatment process will reliably produce potable water meeting all current and anticipated drinking water standards.	Effluent from the GAC/FB bioreactor was analyzed for parameters used to regulate the quality of drinking water (see Table 4). Additional work is needed to establish disinfection and filtration requirements and demonstrate that the treatment processes will reliably produce potable water. This objective will be fully addressed in a Phase 2 Perchlorate Treatability Study.
Page 3, Section 2.4	The text states that pilot-scale work at Aerojet's Sacramento facility demonstrated that pathogens were not present in the pilot plant effluent. What analyses were conducted to support this statement?	In the pilot scale study this statement refers to, the effluent was tested for coliform, fecal coliform, and e.coli. In this study, the effluent was analyzed for bacteria, coliform, and fecal coliform. The effluent was not analyzed for parasitology or viruses. The text has been revised to reflect actual testing.
Page 4, Section 3.0, Paragraph 4	Please explain the operation of the biological growth control system and carbon capture and return system in more detail. Were waste solids produced in the Phase 1 study? If so, what was its composition, rate of production, and methods of handling and disposal? If no waste solids were produced, what was the fate of the carbon lost from the bioreactor (as described on page C-3)?	See the revised section 3.0 for a description of the growth control and carbon capture systems. Biomass was the only waste solid produced by the study. The amount of biomass generated was not quantified. Waste carbon was gathered into drums and disposed of accordingly. Small amounts of carbon and fines and waste biomass were discharged to the GET B wastewater treatment facility. The text has been revised to: A biological growth control system installed at the top of the bioreactor removed excess biomass from the GAC. Biomass exited the bioreactor in the effluent and "cleaned" GAC particles were returned to the carbon bed. The effluent then exited the bioreactor and flowed through a

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
		carbon separator system that captured and returned any carbon that flowed out of the bioreactor. Once through the separator, the effluent flowed to a 500-gallon polyethylene equalization tank equipped with level controls. From the equalization tank, the effluent was discharged directly to an Aerojet groundwater extraction and treatment (GET-B) system. Carbon and fines that escaped the carbon separator system were discharged in the effluent to the GET-B facility.
Page 5, Section 4.0	In a few cases, perchlorate concentrations in the bioreactor increase slightly from one sampling location to the next (e.g. between sampling ports E and F on 2/18 and 2/20, and between ports F and G on 12/18 and 2/17). Do you think the increase is real? What data are available to support one explanation over another? (e.g., analytical error? Incomplete mixing within the bioreactor? Desorption from carbon?) Were replicate samples analyzed to estimate the precision of the perchlorate analyses? What and where are the results? What data are available to evaluate how well-mixed the groundwater is as it passes through the bioreactor? Could there be significant variability in microbial activity, flow, or perchlorate concentration perpendicular to the direction of flow? Do the sampling ports draw water from deep within the bioreactor (i.e. near the center), or close to the bioreactor wall? Also, measured perchlorate influent concentrations (pre-recycle) vary day to day, oftentimes by more than 20%	The variations in perchlorate concentrations in the bioreactor noted are slight and are within the expected analytical error (Section 5.3.1 and Appendix F) detail potential analytical errors. We feel it is unlikely that incomplete mixing occurred within the reactor. A fluidized bed is inherently turbulent. For the same reason, we feel it is unlikely that there was significant variation in any parameter perpendicular to the direction of flow. The sampling ports draw water from near the reactor wall. The relative variability of perchlorate to nitrate is approximately equal. Nitrate concentrations were 3 orders of magnitude above perchlorate concentrations. Analytical variability that is easily observed at low concentrations is masked by the higher nitrate concentrations (Section 5.3.1 and Appendix F).

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
	(e.g. 51 to 36 µg/L, 57 to 35 µg/L, 39 to 37 µg/L). In contrast, nitrate concentrations varied little. Do you believe that this variability is real? Or due to analytical error or some other cause?	
Page 6, Section 5.1	Is there any experimental basis for the equation describing the reduction of perchlorate? Other researchers report that the conversion of perchlorate to chloride primarily occurs through the reduction of perchlorate to chlorate and chlorite, followed by the dismutation of chlorite: $ClO_4^- + 2e^- + 2H^+ \rightarrow ClO_3^- + H_2O$ $ClO_3^- + 2e^- + 2H^+ \rightarrow ClO_2^- + H_2O$ $ClO_2^- \rightarrow O_2 + Cl^-$ Also, the text states the following: "Note that nitrate and perchlorate are completely destroyed..." The ability to write a balanced chemical reaction does not guarantee that the reaction will go to completion or that there aren't other competing reactions with other products.	The equation is a representation of the mineralization of perchlorate from biological processes. It is not intended to be a representation of the kinetic reaction sequence of perchlorate reduction. The mechanism shown can be represented by an overall reaction that is equivalent to that shown in the text. The reduction of perchlorate and nitrate proceed to complete mineralization. This has been documented in previous studies and is favored thermodynamically. In the case of perchlorate reduction, the rate-limiting step is the reduction of perchlorate to chlorate. Under favorable conditions, the complete reduction of chlorate to chlorine ion is rapid.
Page 6, Section 5.2	The text provides an equation for estimating effluent substrate concentrations (S_e). How was this relationship used? If it was used, how were the parameters determined and what were the parameters and what were their values?	This equation has been removed from the text.
Page 7, Section 5.3	Please discuss the quality of the data generated as part of the study, with reference to the quality control analyses.	Section 5.3.1 details potential analytical errors.

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
	Were the BOD or COD data evaluated? If so, for what purpose?	BOD and COD are typical parameters that are used by waste water treatment plants and were tested to provide a basis of comparison to other processes. BOD measures the amount of oxidizable compounds available biologically to sustain metabolic processes. BOD would measure ethanol concentration because it is readily metabolized and would exert significant oxygen demand. COD measures all readily oxidizable compounds.
Page 8, Section 5.3.2, Paragraph 2	Please clarify the statement that "...most of the nitrate is 25% destroyed..."	The sentence has been corrected to: "Within the bioreactor, most of the nitrate is destroyed within a distance of approximately 4 feet along the reactor flow path." The section number has changed to 5.4.2.
Page 8, Section 5.3.2, Paragraph 3	What is the basis for the statement that "In general, nitrate destruction occurred...before perchlorate destruction."?	Nitrate destruction occurred at a *faster* rate than perchlorate destruction in all samples, with one exception (12 of 13 samples. [see Appendix D]). This is in good agreement with published literature detailing nitrate is relatively easy to reduce whereas perchlorate is more persistent. The text has been modified accordingly. The section number has changed to 5.4.2.
Page 8, Section 5.3.3, Paragraph 2	The text states that the microorganisms introduced into the bioreactor were aerobic. How was this established?	The microorganisms were harvested from an aerobic environment where aerobic microorganisms would be expected to predominate. Thus, it would be expected that the organisms were aerobic; however, no testing was conducted to identify the specific type of microorganisms present. The section number has changed to 5.4.3.

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
Page 9, Section 5.3.3	Was any analysis attempted to relate the actual rates at which reactants and products were consumed and produced to the stoichiometric ratios predicted by theory? Would this type of analysis help identify which chemical species is limiting?	Yes. Chlorate, chlorite, and chlorine ion analysis were designed to evaluate the mechanisms and kinetics of perchlorate reduction; however, the analytical detection limit and/or the concentration variation of each constituent limited the ability to perform such analyses. The operating parameters with the greatest impact on perchlorate reduction are dissolved oxygen and ORP. The study was designed to determine the operating ranges of the chemical reactants and reactor conditions. Sections 5.3 details the operating ranges for each parameter. The section number has changed to 5.4.3.
Page 9, Paragraphs 3 and 4	Please explain the relationship between bioreactor flow path and retention time. The 3rd paragraph states that a retention time of less that 4 minutes corresponds to flow through 4 feet of bioreactor. The 4th paragraph states that a retention time of 5.4 minutes corresponds to flow through 9 feet of bioreactor.	Section 5.0 has been modified to detail this calculation.
Page 9, Section 5.3.4	The text discusses the use of DO and ORP to monitor bioreactor performance. Have any other indicators been considered for monitoring reactor performance?	Yes. The study evaluated a number of operating parameters that were regressed statistically. ORP and DO demonstrated the best correlation. Section 5.3 discusses the use of a variety of parameters as a general indicator of performance. The section number has changed to 5.4.4.
Page 11, Paragraph 2	The text describes Plate 12 as demonstrating that "the top of the ethanol working range...is approximately 140 mg/L... [and that] at concentrations above 180 mg/L, perchlorate destruction degrades and is incomplete." The	Perchlorate destruction at high ethanol dose and low influent DO was not evaluated; however, at high ethanol dose the GAC agglomerated and decreased the surface area available for reaction. Thus, while the data is not

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
	statement appears true, but is the cause of the poor perchlorate destruction the high ethanol dose or high influent DO? All of the high ethanol data points (i.e. above 140 mg/L) represent high DO influent water (i.e., before 1/24).	available to isolate ethanol dosage as a single variable in perchlorate destruction, the data suggests that high ethanol dosage inhibits fluidized bed performance by limiting mass transfer. The text has been modified to reflect this discussion. The section number has changed to 5.4.5.
Page 12, Section 5.3.9	Was any attempt made to identify the types of organisms observed in the bioreactor? (e.g. bacteria, yeasts. molds)	No attempt was made to speciate the types of mircroorganisms present in the reactor. Based on existing literature concerning nitrate and perchlorate reduction, it is likely that bacteria would play a significant role in the bioreactor. Further studies to speciate the predominant microorganisma may be performed in Phase 2. The section number has changed to 5.4.6.
Page 13, Section 5.4	The text states that "Analytical results shown in Appendix D demonstrate that with an influent ethanol concentration of 60 to 70 mg/L, ethanol in bioreactor effluent was less than the 5 mg/L laboratory reporting limit." This relationship is shown for only a short period. For influent ethanol concentrations between 60 to 70 mg/L, perchlorate and ethanol were reduced to below their reporting limits in only two samples collected over a three day period (2/27-3/1). Subsequent samples (collected on 3/3, 3/4, and 3/5) had perchlorate concentrations above 4 µg/L. Appendix D shows that two ketones (acetone and 4-methyl-2-pentanone) were present in the reactor effluent in the hundreds of µg/L. In each of the five days in which	Data gathered after March 13 indicated higher residual ethanol concentrations. Additional work will be done in the Phase 2 Treatability Study to evaluate optimal ethanol dosing accounting for filtration and disinfection processes as well. The 4-methyl,2-pentanone (methyl isobutyl ketone [MIBK]) was introduced as an impurity from the ethanol substrate feed (see ethanol analysis in Appendix D). Acetone was also probably introduced as an impurity but it was not detected at a detection limit 0.5 percent. The five 8260 samples were all gathered under reducing conditions (ORP of –209 mV to –250 mV). Acetone may have been formed by reaction of ethanol with other alcohol impurities

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
	EPA Method 8260 results are presented, acetone increased in concentration in the bioreactor. Please discuss the likely source and significance of these ketones. Primary and secondary alcohols are readily oxidized to aldehydes and ketones.	in the bioreactor. We believe a significant portion of the acetone increase across the reactor is attributable to the reduction of MIBK; however, this does not entirely explain the increase. This will be studied further in Phase 2. The section numbers have been changed to 5.4.5 and 5.4.7.
Page 13, Section 5.4	Although the acetone does not appear to originate solely from the alcohol, could ketones be present in the alcohol? Was the ethanol analyzed for the presence of impurities or denaturing agents? What information is available from the supplier or manufacturer on the composition of the alcohol? If any impurities are present, are higher grade, more purified forms of alcohol available? We also note that isopropyl alcohol was detected on several occasions between 3/1 and 3/13 at concentrations between 5 and 19 mg/L. Do you believe that isopropyl alcohol was present in the alcohol when purchased, or originated elsewhere? How can its presence be limited in the future? did the source or vendor of alcohol change over the duration of the study? The text states that "it was concluded that the slightly reducing, anoxic conditions present in the bioreactor are not sufficiently reducing to cause VOC degradation." In all samples analyzed for VOCs, the TCE concentration decreased through the bioreactor – on average by about 75%. What evidence is available to suggest that the decrease is due to carbon adsorption, biological	The ketones and isopropyl alcohol appear to have originated in the alcohol. On 2/11/98 the ethanol was analyzed: ethanol >90%, methanol 30,000 mg/L (3%), isopropyl alcohol 53,000 mg/L (5.3%), and MIBK 8,200 mg/L (0.82%) (see Appendix D). Aerojet is evaluating the availability of higher grades of alcohol or the possibility of using an alternate denaturant. The supplier has indicated flexibility regarding the denaturing agent. The reduction in TCE across the bioreactor was likely caused by carbon adsorption; however, refer to Section 5.4.7 for a complete discussion. The section number has been changed to 5.5.

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
	degradation, or some other mechanism? Could VOCs have been lost by volatilization?	
Page 14, 4th bullet	The text states that "laboratory analyses indicated a lack of pathogens that may be of concern..." Is this statement based on any test results other than for fecal coliform?	The text has been revised to: "...Laboratory analysis indicated a general lack of fecal coliform in the treatment system effluent; however, further evaluation of filtration and disinfection of the effluent will be necessary to ensure that potable water quality standards are reliably met."
Page 14, Section 6.0, 5th bullet	This conclusion is overstated. See comment on page 1, 5th bullet.	The text has been revised to: "Effluent from the GAC/FB bioreactor was analyzed for parameters used to regulate the quality of drinking water and other chemicals mentioned by DHS to be of concern. Additional work is needed to establish disinfection and filtration requirements and demonstrate that the treatment processes will reliably produce potable water. This objective will be fully addressed in a Phase 2 Perchlorate Treatability Study."
Page 14, Section 6.0, 6th bullet	The test states that the *conceptual model* agrees well with the actual results. Are you referring to the description of fluidized be behavior included in Section 5.2? Please explain the ways in which the study results support and/or differ from the *conceptual model*.	The conceptual model refers to the expected kinetic model: oxygen depletion > nitrate reduction > perchlorate reduction.

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
Plate 1	Plate 1 includes the statement "Confidential Business Information," yet we understand that the report has been distributed to several agencies and groups without specific instructions to keep any part of the report confidential. Please clarify whether the Steering Committee is claiming Plate 1 or any other part of the report as Confidential Business Information.	Aerojet is claiming Plate 1 as Confidential Business Information. Instructions for the Phase 1 report reproduction and distribution dictated that Phase 1 not be distributed to other agencies and groups. To assist in management if Confidential Business Information all copies of this report contain a blank sheet labeled as such. Plate 1 has been distributed separately to U.S. EPA and their consultant CH2M Hill.
Page B-2, 6th bullet	The text states that EPA Method 502.2 was used for VOC analysis, but Appendix D lists results for both EPA Methods 502.2 and 8260. How do the two methods compare in their ability to identify and quantify aldehydes and ketones?	EPA Method 502.2 is more sensitive then Method 8260 at low concentrations. Method 502.2 is the Drinking Water method, and does not test for alcohols or ketones. Method 8260 tests alcohols and includes some ketones.
Appendix C	Please describe in more detail how the microorganisms were added. Was the sludge added directly to the bioreactor? Or were extracts or isolates used? What provisions were taken to avoid introducing harmful organisms?	The inoculum sludge arrived in liter bottles. The bottles were kept sealed and refrigerated to avoid contamination. After carbon addition, the reactor was run in full recycle mode. The sludge was then added directly in the top of the reactor.
Page C-4, Paragraph 4	The text mentions that the DO profile in the bioreactor was measured before the air stripper was taken offline. Please include these data in Appendix E.	Complete. See revised appendix.
Page C-6, Paragraph 6	The text states: "Therefore, the range of ethanol concentrations at which complete perchlorate and nitrate destruction is lost lies between 50 and 70 mg/L." The	Agree. Additional data gathered since the Draft report was issued suggest that additional work is needed to

Baldwin Park Operable Unit Steering Committee Response to EPA Comments Phase 1 Treatability Study Draft Report		
Location	**EPA Comment**	**Response**
	definitiveness of the statement seems unwarranted given the short one-time test of the relationship. I recommend presenting the relationship between ethanol concentration and perchlorate destruction as a hypothesis in need of further evaluation.	optimize ethanol addition.
Appendix D	Can the coliform results that are presented as MPN>200.5/100mL be quantified? Please include results from all blanks and replicate analyses.	Yes; however, no attempt was made to quantify MPN > 200.5 for samples collected during this treatability study. Quantification for MPN > 200.5/100 mL requires dilution of the sample or that the Quantitray method be used. Please see Appendix D for blank and replicate samples.
Appendix D, last page	A metals result on 2/19/98 (for iron) is reported as "TEQUILA." Please explain.	This has been corrected.

	Baldwin Park Operable Unit Steering Committee EPA Editorial Comments Phase 1 Draft Report	
Location	**Comment**	**Response**
Page 1, Paragraph 1	Metropolitan prefers that their role be described as assisting Three Valley. They request that the 1st sentence be modified as follows: "...U.S. EPA Region IX (EPA) and Three Valleys Municipal	Agreed. The text has been modified accordingly.

	Baldwin Park Operable Unit Steering Committee EPA Editorial Comments Phase 1 Draft Report	
Location	**Comment**	**Response**
	Water District (TVMWD), in association with Metropolitan Water District of Southern California (MWD), have been planning..."	
Page 1, Paragraph 4, Sentence 3	The revised RfD may or may not lead to an enforceable standard.	Agree. This sentence has been changed to: The U.S. Air Force with EPA review is presently performing toxicity studies that will be the basis for a revised Reference Dose (RfD), which will in turn be evaluated to develop an enforceable water quality standard.
Page 1, Paragraph 4, last sentence	Other factors, including demands by users of the treated water, may affect the decision whether to treat for perchlorate.	Agree. This paragraph has been modified to include: In addition, the demands of water users may affect the decision whether to treat for perchlorate. Once this numerical value is established and the demands of water users have been evaluated, a determination regarding whether BPOU groundwater must be treated for perchlorate can be made.
Page 3, Section 2.3	There appears to be an extra "than" in the 1st sentence.	We believe this sentence to read correctly.
Page 4, 3rd line	Not all parameters were analyzed for. Suggest deleting the word "all."	Primary and secondary water quality parameters were analyzed on 5/18 and 6/15/98. The text has been modified accordingly.

	Baldwin Park Operable Unit Steering Committee EPA Editorial Comments Phase 1 Draft Report	
Location	**Comment**	**Response**
Page 4, Section 3.2	The text states that the "...the biomass will be 15 feet high." Presumably, this is the height of the fluidized bed (i.e. suspended carbon granules) with attached biomass.	Unable to locate this comment. The height of the bioreactor bed is 10 feet.
Page 4, Section 4.0	To support findings made in the text (e.g., relationship between DO loading and perchlorate removal), we suggest you add references to data presented in the Tables. No reference is made in the text to Table 3.	The text has been modified accordingly.
Page 6, Section 5.1	Denitrification is misspelled. Electrical charge doesn't balance in the denitrification reaction. As written, the text incorrectly states that ethanol is converted to chloride and nitrogen.	The spelling has been corrected. The equation has been corrected. The text has been corrected to: Note that nitrate and perchlorate are completely destroyed, and the carbon substrate (ethanol) is oxidized by bacteria. The end products for the process are biomass, carbon dioxide, water, chloride, and nitrogen.
Page 8, Section 5.3.3	There appears to be an extra "at" at the beginning of the 5th line.	The text has been corrected to: At higher DO concentrations (4 to 8 mg/L), or low recycle rates, complete reduction of perchlorate and nitrate was not achievable regularly or reliably (higher DO concentrations

	Baldwin Park Operable Unit Steering Committee EPA Editorial Comments Phase 1 Draft Report	
Location	**Comment**	**Response**
		result from use of the air stripper). The new section number is 5.4.3.
Page 9, Section 5.3.3.	The rate constants listed above the arrow in each equation appear superfluous.	The rate constants are shown to highlight that each reaction occurs at an independent rate. The new section number is 5.4.3.
Page 9, Section 5.3.3, Paragraph 2	There appears to be an extra word ("...reactor bioreactor...") in the 5th line.	This sentence has been removed from the text. The new section number is 5.4.3.
Page 9, Section 5.3.3, Paragraph 4	In the first line, the word "stripper" is misspelled.	This sentence has been removed from the text. The new section number is 5.4.3.
Page 12, Section 5.3.9	Since the microbes were not identified, is there really any evidence that Voltera's principle applies?	The text has been changed to: This phenomenon is best understood in the context of variations in the biomass population and competing reactions. At low and high DO, different organisms likely competed for dominance. In a high DO environment, the microorganisms utilized oxygen as their preferred electron acceptor. In a low DO environment, microorganisms that utilize nitrate and perchlorate as their preferred electron acceptors dominated. It is likely that there were microorganisms that were present in both high and low DO conditions. The new section number is 5.4.3.

	Baldwin Park Operable Unit Steering Committee EPA Editorial Comments Phase 1 Draft Report	
Location	**Comment**	**Response**
Page 13, Section 5.4, Paragraph 4 Page 15, 1st bullet	The text states that "Testing for VOC degradation products showed no detectable concentrations of VOC degradation products..." Couldn't TCE be a degradation product?	Influent sample data collected from 3/6/98 to 3/27/98 indicated PCE was detected four times ranging from 0.18 to 0.25 µg/L. TCE in these same samples ranged from 170 to 250 µg/L. Thus, while it is possible some TCE was generated from degradation of PCE, it does not appear likely to be a significant source. Please refer to Section 5.4.7 for further discussion.
Table 3	We suggest adding a note specifying where the influent DO is measured. It appears that it was measured at port C, after internal recycle.	DO is measured at Port C (bioreactor influent and after internal recycle) and at the G port (bioreactor effluent). Table 3 has been modified accordingly.
Plate 6	For this and any other figures showing perchlorate concentrations near the detection limit, indicating the quantitation limit on the figure would help the reader correctly interpret the data (i.e. the perchlorate concentration did not necessarily stabilize at 4 µg/L).	A quantitation limit for perchlorate has been added to the appropriate figures.
Page B-1, 3rd bullet	In the 5th line, eductor is misspelled.	The text has been changed to: The oxygen generation system, bubble contactor, and eductor will not be used during this study.
Page B-2, 1st bullet	In the 6th line, the word "of" is missing.	The text has been changed to: However, the groundwater well flow rate was

	Baldwin Park Operable Unit Steering Committee EPA Editorial Comments Phase 1 Draft Report	
Location	**Comment**	**Response**
		increased slowly during this startup because of a concern that if the groundwater well flow rate was increased too quickly, the biomass might wash out of the system before it was completely attached to the GAC.
Page C-2, Paragraph 4	Some words appear to be missing from the last sentence.	The text has been changed to: The average influent reactor temperature was 18.2°C.
Page C-4, Paragraph 3	In the 1st line, should the sentence be corrected to state that the ORP decreased (rather than rose)?	The text has been changed to: The ORP value in the effluent averaged -103 mV. From January 13 through 23, 1998, the ORP fell to an average of -209 mV; however, nitrate or perchlorate destruction did not improve.
Page C-4, Paragraph 5	The last line in the paragraph states that the DO was reduced to a range of 9.5 to 1 mg/L. Should the 9.5 mg/L be 0.95 mg/L?	The text has been changed to: To test this theory, the air stripper was taken offline on January 24, 1998, effectively decreasing the undiluted influent DO from a range of 8 to 10 mg/L to about 1 mg/L.

APPENDIX I
U.S. EPA COMMENTS ON PHASE 1 TREATABILITY STUDY DRAFT FINAL REPORT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

December 11, 1998

Baldwin Park Operable Unit Steering Committee
c/o Donald E. Vanderkar
Aerojet General Corporation
Box 13222
Sacramento, CA 95813

Subject: EPA Review of the *August 21, 1998 Phase 1 Treatability Study Report, Perchlorate in Groundwater,* and *October 29, 1998 Phase 2 Treatability Study Work Plan (Baldwin Park Operable Unit, San Gabriel Basin)*

Dear Mr. Vanderkar:

We have completed our review of the August 21, 1998 *Phase 1 Treatability Study Report* and the October 29, 1998 *Phase 2 Treatability Workplan*, prepared by Harding Lawson Associates for the Baldwin Park Operable Unit Steering Committee. The August draft of the Phase 1 Report is a revised version of the initial May 20, 1998 draft; the October draft of the Phase 2 Workplan is a substantially revised version of the initial May 20, 1998 draft.

I understand that DHS representatives also intend to submit comments on the reports.

Our comments on the Phase 2 Workplan are enclosed. At your discretion, the comments can be addressed in a revised workplan or in separate submittals such as the Operation and Maintenance Manual or Sampling and Analysis Plan. We do not plan to submit additional comments on the Phase 1 Report.

Sincerely,

Wayne Praskins
EPA Project Manager

Enclosure

cc: Rick Sakaji, DHS
Nabil Saba, DHS
Gary Yamamoto, DHS
Michael Berlien, La Puente Valley County Water District
John Catts, Harding Lawson Associates

APPENDIX J
DHS COMMENTS ON PHASE 1 TREATABILITY STUDY DRAFT REPORT AND PHASE 2 TREATABILITY STUDY WORK PLAN

STATE OF CALIFORNIA - HEALTH AND WELFARE AGENCY
DEPARTMENT OF HEALTH SERVICES
DRINKING WATER FIELD OPERATIONS BRANCH
1449 West Temple Street, Room 202
Los Angeles, CA 90026
(? 580-5723
30-5711/FAX

July 10, 1998

Mr. Wayne Praskins
Superfund Project Manager
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street (H-6-5)
San Francisco, CA 94105-3901

Dear Mr. Praskins:

DRAFT PERCHLORATE "PHASE I TREATABILITY STUDY DRAFT REPORT" AND " PHASE 2 TREATABILITY STUDY WORK PLAN" FOR BALDWIN PARK OPERABLE UNIT, SAN GABRIEL BASIN BY HARDING LAWSON ASSOCIATES (HLA)

The Department have received and reviewed the above reports. Thank you for giving us the opportunity to provide comments on the reports. Before going into details on the comments, the Department would like to clarify our thoughts on the different phases of the project.

It is our understanding is that Phase 1 was to assess if the biological reduction technology could achieve the target effluent goal with influent perchlorate and nitrate concentrations similar to the Baldwin Park Operable Unit (BPOU) water. The Phase 1 study results have demonstrated that the bioreactor might be able to remove perchlorate and nitrate from water sources that have perchlorate and nitrate levels similar to those found in the BPOU. In Phase 2, as HLA quoted in their Phase 1 Draft Report, "Scientific and Engineering data needed to design and construct a full scale treatment system will be collected." The Department believe during this phase, destruction of perchlorate and nitrate in the San Gabriel Basin groundwater matrix should be confirmed; issues that were not fully addressed in the Phase 1 study should be answered; scientific and engineering data for the design and construction of a full scale treatment facility should be gathered; and a multi-barrier treatment train should be provided and tested to demonstrate that drinking water that is pure, wholesome and potable can be produced reliably. Scaling factors should be considered when choosing the pilot treatment units' sizes. This phase is the pilot-testing stage. Therefore, the issuance of a domestic water supply permit by the Department should not be included in Phase 2. A report on the results of the Phase 2 study should be prepared and submitted for the Department's review. If the Department determines that the Phase 2 treatment

scheme will produce water that is pure, wholesome, and potable reliably, then plans for a full-scale unit should be submitted to the Department for review and approval as part of the permitting process. In addition, Policy No. 97-005 (Enclosure) will be followed by the Department in deciding whether a domestic water permit will be issued. Before any treated water enters any domestic water system, the treatment plant operating party must obtain a domestic water supply permit and the entity(s) that receives the effluent must have their domestic water supply permit amended or secure a new domestic water supply permit.

The following paragraphs provide the Department's comments on the Phase 1 study draft report and the issues that the Department believe should be considered during Phase 2.

Phase 1 Treatability Study Draft Report:

1. Bacteria are responsible for using the nitrate and perchlorate as an electron donor thereby facilitating the oxidation and ultimately the removal of nitrate and perchlorate. The report briefly mentions the biomass control unit without providing the details regarding what is the microbial density maintained in the biofilm (or bioreactor), how to control the biofilm, and what is the quantitative parameter used for the control.

2. The conclusions of the report (page 14) state that "The conceptual model agrees well with the actual results. A sound conceptual model assists with interim and full-scale design." A conceptual model was provided in page 6 of the report, which clearly indicates that substrate utilization is a function of microbial density and the characters of the bio-particle (carbon media plus biofilm). There is no discussion regarding how the model was used, how the parameters for the model were derived, what were the values of the model parameters, and how well the model predicted changes in reactor performance. We could not locate the information regarding the microbial density, the size of the bio-particle, and the reaction rate constant.

   The report briefly discusses the stoichiometric equations for substrate utilization and the competing nature of various electron acceptors (dissolved oxygen, nitrate, perchlorate etc.). No attempt was made to discuss which substrate was the limiting specie in the overall process of nitrate/perchlorate destruction and how to derive optimized ethanol loading accordingly.

   If a scaled-down bioreactor is going to be used in Phase 2 study, tracer studies of the reactor, with and without recycle, should be performed in Phase 2 as the equation on page 6 is for a plug-flow reactor. With re-circulation and due to the tower and solids handling unit, the hydraulic characteristic of this reactor may lie between a completely-mixed reactor and plug-flow reactor.

3. We would like to see information on cell yields and an attempt to close a mass balance on the perchlorate, i.e., to account for where it is going. A mass balance would be a good way to build confidence in the results and the ability to identify the pathways of removal.

4. The report states that little or no sensitivity to temperature was observed. Literatures such as those cited in the report's reference list indicate that coefficients used to model biological reactors follow Arrenhius type temperature dependence. It is not surprising that no sensitivity to temperature was observed as the short time frame of these experiments and continual changing of variables may have masked any influence of temperature.

5. In the executive summary (last bullet) and the last paragraph on page 13, the phrase "These results demonstrate that **with disinfection and filtration** ..." should be deleted. These studies were not conducted with disinfection and filtration on the finished water, and therefore, there is no basis for such a conclusion.

   The last paragraph on page 13 states "analysis of bioreactor influent and effluent for the full range of water quality parameters required under Title 22 was performed. Results are reported in Appendix D." We could not locate the full range of Title 22 water quality parameters analysis results in Appendix D.

   We agree that a multi-barrier treatment, equivalent to what is required to meet the Surface Water Treatment Rule (STWR) requirements is the minimum that may be required. As it was discussed in a previous meeting with Aerojet and HLA, some work on disinfection by-product (DBP) production needs to be conducted. The presence of low molecular weight compounds (ethanol and methanol) may result in significant DBP production when strong oxidizing agents (e.g. chlorine) are used to disinfect the water.

6. On page 12, the report indicates that it took 2 days or longer to establish a complete perchlorate and nitrate destruction after a startup of the system. This means any upset in the bioreactor could leave the water utility without water for an extended period of time, unless sufficient storage or emergency sources is available. This should be considered prior to the installation of the system for any water utility. The startup and shutdown procedures for the bioreactor need to be detailed in the operations manual.

7. Page 13 states that "Analytical results shown in Appendix D demonstrate that with an influent ethanol concentration of 60 to 70 mg/L, ethanol in bioreactor effluent was less than 5 mg/L laboratory reporting limit." However, there were only five instances when the ethanol concentrations were between 60 and 70 mg/L, among

which only two had the effluent concentration report less than 5 mg/L. There are no sufficient data to support such a conclusion.

8. On Page 14, in the conclusion under bullet 4, the report states "Laboratory analysis indicated a lack of pathogens that may be of concern." What were the exact pathogens that were analyzed? We would like to have a copy of the analysis result.

9. The analysis results in Appendix E indicates that the existence of acetone and other ketones in the bioreactor influent. Also, acetone concentration increased after the bioreactor. What is the source of acetone? What happened in the bioreactor?

10. Several coliform analysis results in the Appendix D were reported as an MPN of coliform organisms of >200.5/100ml. We would like to know what was the exact number of total coliform bacteria presented in the sample.

11. The bio-solid (sludge) generated from the bioreactor represents a substantial and important by-product of the total process. There is no discussion regarding to the rate of bio-solid production, the characteristic of bio-solid (such as the constituents of the bio-solid, percentage of dry solids, etc.) and bio-solid handling operation in the report. The impact of bio-solid handling operation should be evaluated.

Phase 2 Treatability Study Work Plan:

1. Page 1 states "Finally, the results of the treatability study indicate that the effluent water quality (following disinfection and filtration) should meet all applicable standards for use as potable water". Again, this statement should be deleted for the reason mentioned earlier (Item 5 above).

2. According to the work plan, a high-rate, multimedia filtration system will be added to the Phase 2 treatment train. Page 8 states "Multimedia filtration using filter loading rates of between 4 and 6 gpm per square foot will be evaluated for performance effectiveness. Based on initial treatability results, higher filter loading rates may be considered for further evaluation." If the filtration system is going to be operated at a higher loading rate than the flow rate specified in Title 22, Section 64660 (b), a study should be performed to demonstrate that the filtration system can comply with the performance requirement of Title 22, Section 64653 (Title 22, Section 64660 (4)). A study protocol should be submitted to this office so that we could forward it to our internal Surface Water Treatment Committee for review and approval.

   We could not find detailed design information on the filtration system. The other piece of information we found is on Page 8 stating "The filtration system will

include a filter-aid polymer feed system and turbidity meters." It appears to us that the proposed treatment train does not include coagulation, flocculation and sedimentation processes.

The Department will evaluate the bioreactor effluent in a similar manner as a surface water source. Similar to the compliance with the Surface Water Treatment Rule, first, the effluent from the bioreactor should be an **approved water source.** In order to obtain an approval from the Department for the bioreactor effluent as a water source, the information on the total coliform concentration in the bioreactor effluent and pathogen analysis results must be submitted to the Department. It is the Department policy that any source with the median monthly total coliform concentration exceeding an MPN of 100,000/100 ml will not be considered as a water source.

Second, the multi-barrier treatment train should be able to at least provide (1) a total of 99.9 percent reduction of Giardia cysts through filtration and disinfection; and (2) a total of 99.99 percent reduction of viruses through filtration and disinfection. If the bacteriological quality of the bioreactor effluent is worse than those expected in a reasonable quality source, higher removal credit will be required.

The proposed treatment train does not fit in any filtration technology categories specified in Title 22, Section 64653 (a). According to Title 22 Section 64653(f), the operator of the treatment system shall demonstrate to the Department that the proposed treatment train must (1) provides a minimum of 99 percent Giardia cyst removal and 90 percent virus removal and (2) meets the turbidity performance standards established in section 64653 (c) before a permit could be issued. We noticed that the turbidity in the bioreactor effluent got as high as 34 NTU in Phase 1. According to our experience, pretreatment (coagulation and flocculation) and sedimentation should be provided to ensure the performance standard could be meet.

3. As mentioned previously, the treatment train should be able to provide 3 logs or higher Giardia cysts reduction and 4 logs or higher viruses reduction through the filtration and disinfection processes. Depending upon what removal credit is granted to the high-rate, multimedia filtration system, the remaining reduction credit should be provided by the disinfection process.

   The work plan proposes the use of sodium hypochlorite as the disinfectant. Page 7 of the work plan states "After the effluent exits the bioreactor, it will flow by gravity to an equalization/disinfection tank equipped with level controls. From the equalization tank, the effluent will be pumped to the air stripper with disinfection occurring en-route." This is the only disinfection point proposed for the treatment train. Two issues arisen here: (1) Is the chlorine the best disinfectant of choice?

(considering the formation of DBP etc.); and (2) The disinfection process described in the plan looks more like air stripper bio-fouling control. Unless extremely high dosage is used here (which is not advisable considering DBP formation), it is very likely that not enough residual would remain at the distribution system entry point.

We believe a study on the DBP (total trihalomethanes (THMs) and other by-products, such as aldehyde, haloacetic acids (HAA5), etc., depending on what disinfectant is chosen for the study) should be performed. Also, we believe a post-disinfection unit should be provided to meet the CT_{10} (disinfectant residual concentration, C in mg/L times, contact time, T_{10} in minutes) requirement of the SWTR. A tracer study should be conducted for the disinfection basins to establish the contact time for the CT_{10} calculation. Residual disinfection concentration should be measured at different points based on the locations of disinfection points so that CT_{10} calculation could be performed. In addition, to ensure the performance standard could be met, the disinfection residual should be measured and recorded continuously at the end of the treatment train.

4. Page 6 states that "the microorganism innoculum will be characterized". How will the microorganism innoculum be characterized?

5. Page 7 states that "there was an initial concern that biological treatment of water containing VOCs may produce unwanted by-products (e.g. vinyl chloride). The Phase 1 Treatability Study demonstrated that this is not the case and that air stripping can be performed following biological treatment." The matrix of San Gabriel Water is different from the water tested in Phase 1. There is no guarantee that the PCE/TCE will not breakdown into vinyl chloride, which is difficult to remove by air-stripping.

6. Optimization of phosphorus loading should be performed during Phase 2.

7. Page 4, the objective of the Phase 2 study includes "Filter and disinfect treatment plant effluent and monitor the quality of this effluent to assure that the water will meet drinking water standards". However, chlorine residual testing was not mentioned in the plan. The project should demonstrate that a disinfectant residual of at least 0.2 mg/L could be maintained at the plant's effluent at all time.

8. Steady state condition should be reached and sufficient data must be gathered before changing operational parameters. The criteria for measuring steady state should be provided.

9. We are looking forward to a detailed sampling plan. The specific goals of what is to be determined by the study must be clearly defined. The sampling and analysis plan must be design to generate the type and amount data sufficient to satisfy the specific

plan objectives. Phase 1 results should be taken into account while choosing the number of samples and sampling frequency. The plan should indicate what constituents will be analyzed. The plan should also indicate sampling locations and sampling frequencies for each constituent. EPA approved drinking water methods should be used for the constituents with an established method. The analytical method and the method PQL for each constituent should be provided in the plan.

10. As mentioned previously, adequate data should be collected so that statistically-sound-conclusions could be reached. We would accept that a difference of 10% (95% confidence level) in any of operational parameters could be determined as statistically significant.

11. The chemical additives used in the study must be on the NSF or UL drinking water additives certified list. If proposed chemical is not on the list, the chemical that will be submitted for the certification process (American National Standard Institute/National Sanitation Foundation Standard 60) must be used.

12. We need detailed design information on all treatment facilities and piping.

In addition, we understand more data had been collected after the completion of the draft Phase 1 report, we would like to have a copy of these testing results.

In conclusion, more data should be gathered in Phase 2 to demonstrate that reliable perchlorate destruction could be achieved if optimized operating ranges of various parameters (ORP, pH, DO level, substrate and nutrient loading etc.) are maintained. The Department is very concerned that the construction of a biological treatment system at a flow rate approaching the size of a treatment unit planned for the larger Consensus Project before the perchlorate/nitrate destruction for San Gabriel Basin water was confirmed and the successful demonstration of water that is pure, wholesome and potable can be produced reliably. The Department would like to propose a meeting to further discuss the issues mentioned in this letter. Please contact Shu-Fang Peng at (213) 580-3140 to set up the meeting.

Sincerely Yours,

Gary H. Yamamoto

Gary H. Yamamoto, P.E., Chief
South Coastal Region
Drinking Water Field Operations Branch

Enclosure

cc: BPOU Steering Committee-Don Vanderkar
MWDSC-Jeanne-Maric Bruno

Enclosure

State of California — Department of Health Services

Memorandum

Date: November 5, 1997

Drinking Water Program
Regional and District Engineers

From: Division of Drinking Water and
Environmental Management
601 North 7th Street, MS 216
322-2308

Subject: Policy Memo 97-005 Policy Guidance for Direct Domestic Use of Extremely Impaired Sources

A. General Philosophy

The primary goal of the Drinking Water Program (DWP) is to assure that all Californians are, to the extent possible, provided a reliable supply of safe drinking water. In furtherance of this goal, the DWP continues to subscribe to the basic principle that only the best quality sources of water reasonably available to a water utility should be used for drinking. When feasible choices are available, the sources presenting the least risk to public health should be utilized. Furthermore, these sources should be protected against contamination. Whenever possible, lower quality source waters should be used for nonconsumptive uses, such as irrigation, recreation, or industrial uses, which pose lower health risks.

The use of contaminated water as a drinking water source always poses a greater health risk and hazard to the public than the use of an uncontaminated source because of the chance that the necessary treatment may fail.

The use of an extremely impaired source should not be approved unless the additional health risk, relative to the of other available drinking water sources, are known, minimized, and considered acceptable.

Water utilities (including wholesalers) should be encouraged to minimize the concentration of man-made toxic substances, naturally occurring contaminants, and pathogenic microorganisms in drinking water supplies, maximum contaminant levels (MCLs) notwithstanding.

Extremely impaired sources that contain or are likely to contain high concentrations of contaminants, multiple contaminants, or unknown contaminants (such as groundwater subject to contamination from a hazardous waste disposal site) should not be considered for direct human consumption where alternatives are available.

Where reasonable alternatives are available, high quality drinking water should not be allowed to be degraded by the planned addition of contaminants. In other words, the MCLs should not be used to condone contamination up to those levels where the addition of those contaminants can be reasonably avoided.

Drinking water quality and public health shall be given greater consideration than costs or cost savings when evaluating alternative drinking water sources or treatment processes.

The DWP recognizes that there are extremely impaired sources in California that need to be cleaned up and for which the resulting product water represents a significant resource that should not be wasted. In some situations, it may be reasonable to consider the use of these treated extremely impaired sources for domestic use. Some communities may not have any choice. In such cases, the public health principles as set forth in this policy should be used to guide the evaluation of such situations.

B. Purpose of Policy Guidance

The purpose of this guidance document is to set forth the position and the basic tenets by which DWP would evaluate proposals, establish appropriate permit conditions, and approve the use of an extremely impaired source for any direct potable use.

An extremely impaired source meets one or more of the following criteria:

- exceeds 10 times an MCL or action level (AL) based on chronic health effects,
- exceeds 3 times an MCL or AL based on acute health effects,
- is a surface water that requires more than 4 log *Giardia*/5 log virus reduction,
- is extremely threatened with contamination due to proximity to known contaminating activities
- contains a mixture of contaminants of health concern
- is designed to intercept known contaminants of health concern.

Examples include:

- Extremely contaminated ground water
- Effluent dominated surface water
- Oilfield produced water
- Water that is predominantly recycled water; urban storm drainage; treated or untreated wastewater; or agricultural return water
- Products of toxic site cleanup programs

It is recognized that the circumstances surrounding each situation may be different. Proposals for the use of extremely impaired sources, therefore, must be considered on a case-by-case basis.

C. Elements of an Evaluation Process for an Extremely Impaired Drinking Water Source

1. Source Water Assessment:

The purpose of the source water assessment for the extremely impaired source is to determine the extent to which the aquifer or surface water is vulnerable to contaminating activities in the area. There may be other contaminants associated with activities that contribute to the known contamination, or other contamination sources that have yet to impact the drinking water source. There may not be drinking water MCLs, ALs or monitoring requirements established for these additional contaminants, but health related information may be available through other programs. The appropriate level of monitoring and treatment to produce a safe drinking water cannot be determined unless the activities that are affecting or may impact raw water quality are understood. The assessment should include:

- Delineation of the source water capture zone
- Identification of contaminant sources
  - Identify the origin of known contaminants found in the source water and predict contaminant level trends
  - Identify chemicals or contaminants used at or generated by facilities responsible for the known contamination
  - Identify all potential contaminant sources and determine the vulnerability of the water source to these contaminant sources

2. Full characterization of the raw water quality:

The appropriate level of monitoring and treatment to produce a safe drinking water cannot be determined unless the raw water quality is fully understood. The following categories should be considered to fully characterize the source water quality:

- Title 22 drinking water regulated and unregulated chemicals
- All chemicals for which drinking water action levels are established
- All chemicals listed pursuant to Safe Drinking Water and Toxic Enforcement Act of 1986
- Microbiological quality
- Priority pollutants
- Gross contaminant measures [total organic carbon (TOC), etc.]
- Any compounds identified under source water assessment.
- Determine variability of contaminant concentrations with time (seasonal and long term)
- Determine variability of contaminant concentrations with pumping rate
- The detection of any contaminant identified in the raw water quality characterization (step 2) should require assessment of the impact on the source water pursuant to the source water assessment (step 1).

3. Source Protection:

There must be a program in place to control the level of contamination. At a minimum, best management practices for waste handling and waste reduction should be required. In addition, monitoring at the source should be conducted to determine the level of contamination and to reasonably assure that the contamination level will not increase. Unless the level of contamination is known a determination cannot be made that the proposed treatment is sufficiently adequate and reliable to render the water potable.

If the use of an extremely impaired source is to be approved, the source of the contamination must be controlled

- Prevent the level of contamination from rising.
- Minimize the dependence on treatment.

4. Effective Monitoring and Treatment:

The treatment process used to treat the extremely impaired source prior to direct usage in a domestic water distribution system must be commensurate with the degree of risk associated with the contaminants present. As a minimum, treatment for extremely impaired sources shall include use of the best available treatment technology defined for the contaminant(s) by the Environmental Protection Agency. Furthermore, the treatment processes must have reliability features consistent with the type and degree of contamination.

All treatment processes used must be optimized to reliably produce water that contains the lowest concentration of contaminants feasible at all times. The entire flow from the extremely impaired source must pass through the complete treatment process or processes. Any water from other sources that is available for blending prior to entry into the distribution system should be used to provide an additional safety factor.

Multi-barrier treatment is a set of independent treatment processes placed in series, and designed and operated to reduce the levels of a contaminant. Each barrier should effectively reduce the contaminant by a significant fraction of the total required reduction. The treatment processes should address all the contaminants of public health concern in an extremely impaired source. Multi-barrier treatment may be appropriate when:

- The primary treatment is not sufficiently reliable;
- The primary treatment is of uncertain effectiveness;
- There is no direct way to measure the contaminant(e.g., pathogenic microorganisms);
- The health effect of the contaminant is acute; and/or
- Very large reductions in contaminant concentration are required.

The description of the proposed monitoring and treatment should include the following:

- Performance standards (field measurable indicator of treatment efficiency);
  - Identify level to assure compliance with the treatment objective
  - the treatment objective for all contaminants should be optimized to the lowest extent feasible and must assure compliance with the MCL/AL at all times
  - Facilities for treating water containing specific contaminants for which the MCL is higher than the maximum contaminant level goal (MCLG) should be designed and operated to meet the MCLG where this can be accomplished in a cost effective manner.

- Operations plan that identifies all operational procedures, failure response triggers, and loading rates, including:

  - Process monitoring plan
  - Process optimization procedures
  - Established water quality objectives or goals
  - Level of operator qualification

- Reliability features

  - Response Plan for failure to meet the treatment objective
  - Alternative disposal methods
  - Shutdown triggers and restart procedures

- Compliance monitoring and reporting program

- Notification plan

- Extremely impaired source water quality surveillance plan

  The water quality surveillance plan should include monitoring between the origin of the contamination and the extremely impaired source that is proposed for drinking water.

5. Human Health Risks Associated with Failure of Proposed Treatment:

   Treatment technologies are not failure proof, and insufficiently treated or untreated water may, on occasion, pass through the treatment process and into the distribution system. An assessment must be performed that includes:

   - An evaluation of the risks of failure of the proposed treatment system

     The proposed treatment system must be evaluated in terms of its probability to fail, thereby exposing customers to insufficiently treated or untreated drinking water from the extremely impaired source.

All treatment failure modes are to be evaluated. The evaluation must include an assessment of the proposed frequency of monitoring as it relates to protection of the public from insufficiently treated or untreated drinking water.

- An assessment of potential health risks associated with failure of the proposed treatment system. The health assessment must take into account:
  - the duration of exposure to contaminated drinking water that would result from such a failure
  - the human health risks associated with such exposure to insufficiently treated or untreated water over the course of that failure, considering the risks of disease from microbiological organisms, and the risks of acute and chronic effects (including cancer risks) from chemical contaminants
  - potential cumulative risks, due to multiple failures

When risks of adverse health effects from treatment failure are not acceptable, then additional treatment safeguards must be used for the protection of public health, or the proposal must be rejected.

6. Identification of alternatives to the use of the extremely impaired source and compare the potential health risk associated with these to the project's potential health risk.

   Use of alternative sources of drinking water reasonably available to a water utility should be evaluated as to health risk (assuming MCLs are, or can be, met), and compared to the use of the extremely impaired source.

   In evaluating the relative risk comparison of the extremely impaired source and alternative drinking water sources, additive effects of multiple contaminants are an important consideration. Generally, consideration of allowing direct potable use of an extremely impaired source should be limited to a single toxic contaminant or a limited number of similar chemicals that can be reliably treated with the same process.

   The comparison of alternatives should include a comparison of the risks of treatment failure for the alternatives, as well as for the extremely impaired source (step 5).

7. Completion of the California Environmental Quality Act (CEQA) review of the project:

   CEQA review of the project must be completed.

8. Submittal of a permit application:

   The public water system(s) collecting, treating and distributing water from the extremely impaired source must submit a permit application for the use of the extremely impaired source that includes the items identified above. A supplier of treated water to a public water system is a water wholesaler and must be permitted as a public water system, as required by the Safe Drinking Water Act.

9. Public hearing:

   A public hearing must be held to identify concerns of consumers who will be served water from the extremely impaired source and to assure that all parties have a chance to provide relevant information.

10. DHS evaluation:

DHS staff shall conduct an evaluation of the application and make recommendations.

11. Requirements for DHS approval:

The following findings are required of DHS for approval to use an extremely impaired source:

- Drinking water MCLs and ALs will not be exceeded if the permit is complied with, and
- The potential for human health risk is minimized, and the risk associated with the project is less than or equal to the alternatives.

12. Issuance or denial of permit:

DHS either issues a permit or denies a permit for the use of the extremely impaired source. If a permit is issued, it shall include all necessary treatment, compliance monitoring, operational, and reporting requirements.

David P. Spath

David P. Spath, Ph.D., P.E., Chief

APPENDIX K
HLA RESPONSE TO DHS COMMENTS ON PHASE 1 TREATABILITY STUDY DRAFT REPORT

Harding Lawson Associates

September 29, 1998

Mr. Gary N. Yamamoto, P.E., Chief
California Department of Health Services
South Coastal Region
Drinking Water Field Operations Branch
1449 West Temple Street, Room 202
Los Angeles, California 90026

Re: Response to Comments
Phase I Treatability Study Draft Report
Perchlorate in Groundwater
Baldwin Park Operable Unit

Dear Mr. Yamamoto:

Attached you will find a copy of our revised report "Draft Final Phase 1 Treatability Study Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin." We believe this draft addresses comments submitted by the California Department of Health Services (DHS) dated July 10, 1998. U.S. E.P.A.'s (EPA) comments and the Baldwin Park Operable Unit Steering Committee's (BPOUSC) responses are included as Appendices G and H. Responses to your department's comments on the Phase 2 Treatability Study Work Plan will follow under separate cover. Your comments followed by our responses to DHS are detailed below.

1. Bacteria are responsible for using the nitrate and perchlorate as an electron donor thereby facilitating the oxidation and ultimately the removal of nitrate and perchlorate. The report briefly mentions the biomass control unit without providing the details regarding what is the microbial density maintained in the biofilm (or bioreactor), how to control the biofilm, and what is the quantitative parameter used for the control.

   Response: The biofilm is not controlled directly; environmental conditions control the characteristics of the biofilm. The microbial density of the biofilm was not measured. The bed height control unit mechanically controls the maximum biomass bed height; operational details of the bed height control unit are confidential business information. Information on the bioreactor conditions which influence biofilm performance are provided in the report.

2. The conclusions of the report (page 14) state that "the conceptual model agrees well with the actual results. A sound conceptual model assists with interim and full-scale design." A conceptual model was provided in page 6 of the report, which clearly indicates that substrate utilization is a function of microbial density and the characters of the bio-particle (carbon media plus biofilm). There is no discussion regarding how the model was used, how the parameters for the model were derived, what were the values of the model parameters, and how well the model predicted changes in reactor performance. We could not locate the information regarding the microbial density, the size of the bio-particle, and the reaction rate constant.

Response: The fluidized bioreactor model has been removed from the report. Initial perchlorate concentrations were so low that it was not possible to gather sufficient data to confirm the model postulated in Bailey and Ollis. The size of the bioparticle was estimated to be 2 mm. Microbial density was not measured. The reaction rate constant was not calculated directly; however, the required reactor residence time was.

The report briefly discusses the stoichiometric equations for substrate utilization and the competing nature of various electron acceptors (dissolved oxygen, nitrate, perchlorate etc.). No attempt was made to discuss which substrate was the limiting species in the overall process of nitrate/perchlorate destruction and how to derive optimized ethanol loading accordingly.

Response: The data generally supports that consumption of dissolved oxygen occurs first and that nitrate destruction generally occurred more rapidly than perchlorate destruction. Therefore, perchlorate concentration in the effluent was used as a gauge of the limiting species in the overall process of nitrate and perchlorate destruction. Therefore, the optimized ethanol loading rate was derived by reducing substrate concentration until perchlorate destruction ceased.

If a scaled-down bioreactor is going to be used in Phase 2 study, tracer studies of the reactor, with and without recycle, should be performed in Phase 2 as the equation on page 6 is for a plug-flow reactor. With re-circulation and due to the tower and solid handling unit, the hydraulic characteristic of this reactor may lie between a completely-mixed reactor and plug-flow reactor.

Response: As the technology proceeds to full-scale implementation, "modular" bioreactors will be used. The bioreactor proposed for the Phase 2 study will be a "modular" bioreactor with a capacity similar to that planned for the full scale system. The Phase 2 study is planned with tracer studies to evaluate the hydraulic characteristics of the reactor module.

3. We would like to see information on cell yields and an attempt to close a mass balance on perchlorate, i.e., to account for where it is going. A mass balance would be a good way to build confidence in the results and the ability to identify the pathways of removal.

Response: Due to limits of laboratory technology for species thought to be intermediate perchlorate breakdown products (chlorate, chlorite, and hypochlorile) and due to the low perchlorate concentration in the study and presence of moderate background levels of chloride, an accurate mass balance could not be performed nor were cell yields estimated. Additional work will be conducted on this in Phase 2; however, given the anticipated perchlorate concentration in the San Gabriel Valley, we may not be able to calculate an accurate mass balance in Phase 2.

4. The report states that little or no sensitivity to temperature was observed. Literatures such as those cited in the report's reference list indicate that coefficients used to model biological reactors follow Arrenhius type temperature dependence. It is not surprising that no sensitivity to temperature was observed as the short time frame of these experiments and continual changing of variables may have masked any influence of temperature.

   Response: We agree that it is unlikely the temperature could be isolated as a single variable given the other variability in the study. The study did confirm that it is likely that biological activity will be stable at the temperatures present in the San Gabriel Valley.

5. In the executive summary (last bullet) and the last paragraph on page 13, the phrase "These results demonstrate that with disinfection and filtration..." should be deleted. These studies were not conducted with disinfection and filtration on the finished water, and therefore, there is no basis for such a conclusion.

   Response: This statement has been modified to: The study demonstrated that water produced from the intended treatment train will potentially meet State and Federal potable water standards. Additional work is needed to evaluate disinfection and filtration and demonstrate that the treatment processes will reliably produce potable water.

   The last paragraph on page 13 states "analysis of bioreactor influent and effluent for the full range of water quality parameters required under Title 22 was performed. Results are reported in Appendix D." We could not located the full range of Title 22 water quality parameters analysis results in Appendix D.

   Response: The Treatment train effluent was tested for Primary and Secondary State and Federal potable water quality standards on 5/18 and 6/15. The results are presented in Appendix D.

   We agree that a multi-barrier treatment, equivalent to what is required to meet the Surface Water Treatment Rule (SWTR) requirements is the minimum that may be required. As it was discussed in a previous meeting with Aerojet and HLA, some work on disinfection by-product (DBP) production needs to be conducted. The presence of low molecular weight compounds (ethanol and methanol) may result in significant DBP production when strong oxidizing agents (e.g. chlorine) are used to disinfect the water.

   Response: Phase 2 will evaluate a multi-barrier treatment, equivalent to what is required to meet the Surface Water Treatment Rule (SWTR). Phase 2 will also evaluate DBP production.

6. On page 12, the report indicates that it took 2 days or longer to establish a complete perchlorate and nitrate destruction after a startup of the system. This means any upset of the bioreactor could leave the water utility without water for an extended period of time, unless sufficient storage or emergency sources is [sic] available. This should be considered prior to the installation of the system for any water utility. The startup and shutdown procedures for the bioreactor need to be detailed in the operations manual.

   Response: Design of a system for use by a water utility will contain the level of redundancies and back up systems necessary to ensure a reliable source of water. The design for the Phase 2 system contains redundance in the form of liquid phase granular activated carbon. This will provide 8 to 12 days of perchlorate adsorption. All start up and shut down procedures will be detailed in the operations manual.

7. Page 13 states that "Analytical results shown in Appendix D demonstrate that with an influent ethanol concentration of 60 to 70 mg/L, ethanol in bioreactor effluent was less than the 5 mg/L laboratory reporting limit." However, there were only five instances when the ethanol concentrations were between 60 and 70 mg/L, among which only two had the effluent concentration report less than 5 mg/L. There are no sufficient data to support such a conclusion.

   Response: Work conducted after the draft report was issued indicated that the minimum influent ethanol concentration was approximately 40 mg/L. At this influent concentration, ethanol was generally absent from the effluent. In the Phase 2 treatment train the bioreactor will be followed by a biologically active multimedia filter and UV/Oxidation. Therefore, residual ethanol, if present in bioreactor effluent, will be degraded before the water exists the treatment plant.

8. On page 14, in the conclusion under bullet 4, the report states "Laboratory analysis indicated a lack of pathogens that may be of concern." What were the exact pathogens that were analyzed? We would like to have a copy of the analysis result.

   Response: The text has been revised to "...Laboratory analysis indicated a general lack of coliform and fecal coliform; however, further evaluation of filtration and disinfection of the effluent will be necessary to ensure that potable water quality standards are reliably met. A copy of a typical analysis result is attached; the full analysis results are summarized in Appendix D.

9. The analysis results in Appendix E indicates that the existence of acetone and other ketones in the bioreactor influent. Also, acetone concentration increased after the bioreactor. What is the source of acetone? What happened in the bioreactor?

Response: The ketones and isopropyl alcohol appear to have originated in the alcohol. On 2/11/98 the ethanol was sampled: ethanol >90%, methanol 30,000 mg/L (3%), isopropyl alcohol 53,000 mg/L (5.3%), and MIBK 8,200 mg/L (0.82%). The BPOUSC is evaluating the availability and expense of higher grades of alcohol. The Phase 2 treatment train should result in complete destruction of all ethanol impurities.

10. Several coliform analysis results in the Appendix D were reported as an MPN of coliform organisms of >200.5/100 mL. We would like to know what was the exact number of total coliform bacteria presented in the sample.

    Response: No attempt was made to quantify MPN > 200.5. Quantification for MPN > 200.5/100 mL requires dilution of the sample or that the Quantitray method be used. The laboratory did not take these steps during sample analysis.

11. The bio-solid (sludge) generated from the bioreactor represents a substantial and important by-product of the total process. There is no discussion regarding to the rate of bio-solid production, the characteristic of bio-solid (such as the constituents of the bio-solid, percentage of dry solids, etc.) and bio-solid handling operation in the report. The impact of bio-solid handling operation operation should be evaluated.

    Response: At the scale of the Phase 1 treatability study, the produced bio-solid was too low to measure, and therefore evaluate. The production, handling, and disposal of the bio-solid will be addressed during the Phase 2 treatability study.

Thank you for the opportunity to respond to your comments. We are looking forward to meeting with your staff next week. Please call me at (415) 899-8825 if we can assist you in any way.

Yours very truly,

HARDING LAWSON ASSOCIATES

John Catts, Ph.D.
Vice President

Matthew McCullough, P.E.
Principal Engineer

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cc: Rick Sakaji – DHS
Robert Brownwood - DHS

APPENDIX L
McGUIRE ENVIRONMENTAL CONSULTANTS COMMENTS ON PHASE 1 TREATABILITY STUDY AND PHASE 2 EXPERIMENTAL DESIGN DOCUMENT

McGuire
Environmental
Consultants, Inc.

"Quality services that ensure safe drinking water"

June 12, 1998

Dr. John G. Catts
Harding Lawson Associates
30 Corporate Park, Suite 400
Irvine, CA 92606

Dear Dr. Catts:

Thank you for the opportunity to review your draft report entitled "Phase 1 Treatability Study Draft Report Perchlorate in Groundwater Baldwin Park Operating Unit San Gabriel Basin" and the Phase 2 experimental design document. Attached are my comments on the reports. I think the report does a good job describing the biological process and its ability to remove perchlorate (and nitrate). However, the report does a poor job of illustrating how the process would fit into a water plant treatment train. I believe more work should be done to see if the possibly serious problems with disinfection by-product formation could be resolved before the demonstration-scale project is built. If the organic products from the reactor are significant precursors for the formation of disinfection by-products, the entire process may not be viable.

I would be glad to discuss my comments with you at any time. If I can be of any further assistance, please give me a call.

Very truly yours,

Michael J. McGuire, Ph.D.

Cc: C. Williams/R. Sase
R. Bowcock
J.-M. Bruno
W. Praskins

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1919 Santa Monica Boulevard, Suite 350 Santa Monica, CA 90404-1950 Telephone (310) 829-1441 Fax (310) 829-2155

Review of Reports Entitled "Phase 1 Treatability Study Draft Report Perchlorate in Groundwater Baldwin Park Operating Unit San Gabriel Basin" and "Phase 2..."

I have several concerns with the reports' conclusions and with the presentation of some of the data. I have divided my general comments into topics as noted below.

Organic By-products of GAC/FB Process

Only a limited number of organics were monitored for in the reactor effluent. Because a biological process of any kind (and especially one conducted in anoxic conditions) can produce a wide variety of organic compound by-products, it is important to look for a wide variety of organics. Equations on pages 6 and 9 in the text are not correct because they grossly oversimplify the reactions taking place. A lot more material than carbon dioxide and water are produced in the reactor. Not only is cellular material being produced as a result of using ethanol as a carbon source, but also a wide variety of bacterial metabolic by-products such as aldehydes, ketones and organic acids may be produced. While not mentioned in the text, the data tables in Appendix D show the production of several hundred micrograms per liter of acetone in the reactor effluent. Broad-scan analytical methods for more polar organic compounds should be used to identify the by-products of ethanol degradation and cell metabolism and growth. Derivatization techniques followed by GC/MS and liquid chromatography/mass spectroscopy (LC/MS) should be used to identify these organic compounds and quantify their amounts.

More volatile organic compounds (VOCs) must be analyzed for in the reactor effluent. It is unlikely that the disappearance of VOCs noted in Appendix D means that the compounds were biologically converted to carbon dioxide and water. Results for only a limited number VOCs are listed in Appendix D. A purge-and-trap isolation methodology followed by GC/MS with compound identification and quantification should be carried out at maximum process efficiency and at sub-maximum process efficiency such as during start up. The investigators may wish to do a preliminary scan with purge-and-trap/GC with an electron capture detector (ECD) to screen for halogenated volatile organic by-products.

It is most important that an analytical method with a very low (low ppb) method detection level be used to analyze for ethanol (and methanol, for that matter). A level of "less than 5 mg/L" will not be acceptable to the public. The actual level of ethanol must be quantified in the reactor effluent.

This biological process is undoubtedly producing food that other microorganisms could use in an aerobic environment such as a water utility distribution system. Acetone which is acknowledged to be produced during perchlorate reduction in the GAC/FB reactor will act as a food source. The investigators should have taken samples from the reactor

influent and effluent and submitted them for Assimilable Organic Carbon (AOC) or Biodegradable Organic Carbon (BDOC) analysis. These tests have been able to estimate the amount of "food" that the ozonation process can produce when it oxidizes natural organic matter. Also, there is not even any total organic carbon (TOC) data from the study. The reader does not even know if there is a net production of TOC through the process (as compared to the groundwater values). BOD and COD do not even begin to address the issue of organic production in the process. The distribution system downstream of the treatment process could be subject to regrowth of bacteria if a high concentration of food is passed into it.

Disinfection By-Products (DBPs)

I was very surprised to note that the critical issue of disinfection by-product production was not addressed in the Phase 1 study in even a cursory manner. Given the amount and type of organics present in the reactor effluent (especially as noted by the increase in acetone), it is expected that chlorination of the reactor effluent will produce hundreds of ppb of trihalomethanes and other DBPs. The authors stated that the effluent met all Title 22 parameters, but I did not see any THM or other DBP data. Therefore, we do not know if the reactor (followed by chlorination and filtration) can meet drinking water standards or not. This must be addressed before the process can be considered for use in a drinking water distribution system. The work plan for Phase 2 mentions collecting data on DBPs but not much detail is provided. I recommend analyzing for the same DBPs as are monitored for in the Information Collection Rule after the chlorination step that is sufficient to kill the resident bacteria (see discussion below).

Secondary Drinking Water Standards

Utilities must not only meet primary drinking water standards but they must also produce water that is aesthetically acceptable to its customers. At no place in the reports is there a discussion of the taste and odor or color characteristics of the water. A Flavor Profile Panel should assess the taste and odor quality of the reactor product water.

Microbiological Quality of the Reactor Effluent

The report deals in only passing fashion with the issue of microbiological quality of the reactor effluent. There is an error on page 13 where an "upper quantifiable limit" for coliforms is stated to be 200.5. In fact, much higher concentrations of coliforms can be determined if the dilutions tested are properly planned. Also, there are limited total plate count bacteria levels (or at least that is what they appear to be) in Appendix D. They are not discussed in the text. All of the data indicate that a significant and potentially troublesome level of bacteria are shed by the reactor and end up in the reactor effluent.

The report assumes that disinfection with chlorine and filtration will fix the biological problem, but they do not discuss any of the treatment process integration or confounding issues. For example, it may be necessary to operate the filter in a " biologically active" mode to remove the organics created by the GAC/FB reactor. If so, chlorination must

follow the filter and not precede it as noted in the experimental plan for Phase 2. Also, adding chlorine at the level to kill the bacteria could cause production of very high levels of DBPs given the production of precursors I referred to above.

Chlorination after the filter is also a good idea because the clumps of bacteria will likely be removed in the filter. Clumping of bacteria has been demonstrated by many researchers to impede the action of disinfectants like chlorine. The bacteria in the center of the clump can be protected by the bodies of the surrounding bacteria. It is important to remove or kill the majority of bacteria before the water is put into a distribution system to avoid "seeding" the system with coliforms or other nuisance organisms.

Parameter Selection and Data Presentation

Measuring BOD and COD as parameters for understanding the process is not advisable. Total organic carbon (TOC) and ultraviolet absorbance at 254 nm (UV254) are much more relevant to drinking water treatment.

It would be easier for the reader to assess the importance of elevated perchlorate levels in the reactor effluent on plate 3 if the y-axis began at zero as it does for all the other graphs. Also, the method detection level (MDL) should be noted on the various graphs to put the "plateauing" or "steady-state" effect on the graphs in perspective.

Reactor Response after Process Upset

The report clearly documents that the biological reactor is subject to upset during power outages or interruptions in the chemical feeds. Recovery times were on the order of days. Unit processes used in water treatment must be reliable a very high percentage of the time or backup systems must be in place to deal with process upsets. There is no discussion of this in the report which I believe is a major weakness and should be corrected. If backup systems will have to be included in a full-scale system, that will adversely affect the economics of the treatment process.

Summary

I do not believe that the study has demonstrated that filtration and disinfection that the water produced by the treatment train will meet "potable standards." A number of parameters included in Title 22 were not analyzed and no assessment of DBP formation was performed. Also, no assessment of the secondary maximum contaminant levels has been done. Consumers will reject the water produced by the reactor if it is colored, has a bad odor or an off-taste. The authors can only speculate on compliance with Title 22 since they have not done the work.

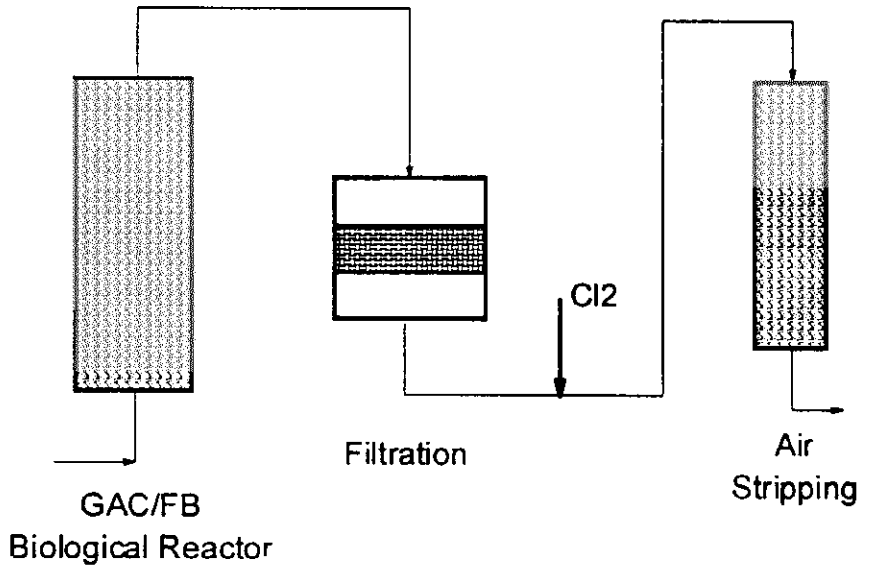
Recommendation

Before Aerojet and La Puente Water District go to the expense of a demonstration-scale test of the technology, I recommend that the pilot plant in Sacramento be restarted and

additional analyses be conducted (see above discussion topics). I believe more work should be done to see if the possibly serious problems with disinfection by-product formation could be resolved before the demonstration-scale project is built. If the organic products from the reactor are significant precursors for the formation of disinfection by-products, the entire process may not be viable.

Should the DBP tests prove to be satisfactory, I recommend that an alternate arrangement of unit processes be considered. Figure 1 below shows the filtration process following immediately after the biological reactor with chlorination (or disinfection) following after that and preceding the air stripper. This arrangement will allow further removal of organics on a biologically active filter (an oxygen source may have to be added prior to filtration). In addition, the majority of the particles will be removed prior to chlorination which should improve the chlorination process significantly (lower dose. less contact time to get equivalent kill).

Figure 1. Alternate Arrangement of Unit Processes for Phase 2 Testing



Michael J. McGuire, Ph.D.
McGuire Environmental Consultants, Inc
June 12, 1998

APPENDIX M
HLA RESPONSE TO McGUIRE ON PHASE 1 TREATABILITY STUDY AND PHASE 2 EXPERIMENTAL DESIGN DOCUMENT

Harding Lawson Associates

October 1, 1998

Dr. Michael J. McGuire
McGuire Environmental Consultants, Inc.
1919 Santa Monica Boulevard, Suite 350
Santa Monica, CA 90404-1950

Re: Response to Comments
Phase I Treatability Study Draft Report
Perchlorate in Groundwater
Baldwin Park Operable Unit, San Gabriel Basin

Dear Mr. McGuire:

Attached you will find a copy of our revised report "Draft Final Phase 1 Treatability Study Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin". We believe that this revised report addresses your comments dated June 12, 1998. Comments made by the U.S. Environmental Protection Agency (EPA) and the Baldwin Park Operable Unit Steering Committee's (BPOUSC) responses to these comments are included as Appendices G and H respectively. Our responses to your comments are detailed below. A revised Phase 2 Treatability Study Work Plan will follow under separate cover.

Organic By-Products of GAC/FB Process

1. Only a limited number of organics were monitored for in the reactor effluent. Because a biological process of any kind (and especially one conducted in anoxic conditions) can produce a wide variety of organic compound by-products, it is important to look for a wide variety of organics. Equations on pages 6 and 9 in the text are not correct because they grossly oversimplify the reactions taking place. A lot more material than carbon dioxide and water are produced in the reactor. Not only secular material being produced as a result of using ethanol as a carbon source, but also a wide variety of bacterial metabolic by-products such as aldehydes, ketones and organic acids may be produced. While not mentioned in the text, the data tables in Appendix D show the production of several hundred micrograms per litre of acetone in the reactor effluent. Broad-scan analytical methods for more polar organic compounds should be used to identify the by-products of ethanol degradation and cell metabolism and growth. Derivatization techniques followed by GC/MS and liquid chromatography/mass spectroscopy (LC/MS) should be used to identify these organic compounds and quantify their amounts.

   Response: (i) In Phase 2, the BPOUSC will analyze the effluent for Title 22 parameters using methodologies consistent with regulatory levels. In addition Phase 2 analytical work will include testing for a broad range of organic compounds. Although specific test methods have not yet been selected, input has been gathered from the appropriate parties and the Phase 2 Treatability Study Work Plan will propose specific methods. (ii) The equations in the text represent perchlorate and nitrate reduction neglecting cell synthesis. They are not intended to represent all reactions

occurring in the bioreactor. (iii) Methanol, methyl isobutyl acetone, and isopropyl alcohol were detected as impurities in the ethanol. Although acetone was not detected as an impurity in the ethanol the limit of detection was 0.5 percent. Therefore, concentrations of acetone consistent with bioreactor influent concentrations would not have been detected. Acetone increased across the bioreactor while MIBK decreased. We hypothesis most of this increase was due to breakdown of MIBK. Alternative mechanisms, such as the oxidation of the alcohols, could have a role in the acetone increase; however, with the bioreactor in reducing conditions this is not a favored mechanism. To simplify these issues during the Phase 2 Treatability Study a higher grade of ethanol will be located and used.

2. More volatile organic compounds (VOCs) must be analyzed for in the reactor effluent. It is unlikely that the disappearance VOCs noted in Appendix D means that the compounds were biologically converted to carbon dioxide and water. Results for only a limited number of VOCs are listed in Appendix D. A purge-and-trap isolation methodology followed by GC/MS with compound identification and quantification should be carried out at maximum process efficiency and at sub-maximum process efficiency such as during start up. The investigators may wish to do a preliminary scan with purge-and-trap/GC with an electron capture detector (ECD) to screen for halogenated volatile organic by-products.

   Response: In Phase 2, the BPOUSC will analyze the effluent for Title 22 parameters using methodologies consistent with regulatory levels. In addition purge-and-trap sample extraction followed by GC/MS including compound identification and quantification will be used to scan for a broader range of volatile organic compounds. Details will be provided in the Phase 2 Treatability Study Work Plan.

3. It is most important that an analytical method with a very low (low ppb) method detection level be used to analyze for ethanol (and methanol, for that matter). A level of "less than 5 mg/L" will not be acceptable o the public. The actual level of ethanol must be quantified in the reactor effluent.

   Response: In the Phase 2 study, we will evaluate water quality parameters consistent with the regulatory limits for various constituents detailed in Title 22. Because of concerns regarding the presence of ethanol and methanol in water produced by the treatment plant, analytical methods which achieve the lowest possible detection limit using standard and accepted methods will be used. During Phase 1 the analyses provided in Appendix D were used to evaluate perchlorate reduction in the bioreactor and were not used for a comprehensive constituent analysis as will be performed to ensure potability of produced water.

4. This biological process is undoubtedly producing food that other microorganisms could use in an aerobic environment such as a water utility distribution system. Acetone which is acknowledged to be produced during perchlorate reduction in the GAC/FB reactor will act as a food source. The investigators should have taken samples from the reactor influent and effluent and submitted them for Assimilable Organic Carbon (AOC) or Biodegradable Organic Carbon (BDOC) analysis. These tests have been able to estimate the amount of "food" that the ozonation process can produce when it oxidizes natural organic matter. Also, there is not even any total organic carbon (TOC) data from the study. The reader does not even know if there is a net production of TOC through the process (as compared to the groundwater values). BOD and COD do not even begin to address the issue of organic production in the process. The distribution system downstream of the treatment process could be subject to regrowth of bacteria if a high concentration of food passed into it.

   Response: The Phase 1 study was not intended to evaluate production of organic compounds across the bioreactor. This will be addressed in Phase 2. The Phase 2 study will employ AOC, BDOC, and TOC analyses as suggested. The BOD and COD analyses in Phase 1 were not intended to evaluate the potential for downstream distribution of food for regrowth of bacteria. BOD and COD are typical parameters that are used by wastewater treatment plants and were tested to provide a basis of comparison to other processes. During Phase 2 a comprehensive treatment train which includes unit processes that will remove or destroy total organic carbon will be employed and the influent and produced water will be monitored as recommended.

Disinfection By-Products (DBPs)

1. I was very surprised to note that the critical issue of disinfection by-product production [DBP] was not addressed in the Phase 1 study in even a cursory manner. Given the amount and type of organics present in the reactor effluent (especially as noted by the increase in acetone), it is expected that chlorination of the reactor effluent will produce hundreds of ppb of trihalomethanes and other DBPs. The authors stated that the effluent met all Title 22 parameters, but did not see any THM or other DBP data. Therefore, we do not know if the reactor (followed by chlorination and filtration) can meet drinking water standards or not. This must be addressed before the process can be considered for use in a drinking water distribution system. The work plan for Phase 2 mentions collecting data on DBPs but not much detail is provided. I recommend analyzing for the same DPBs as are monitored for in the Information Collection Rule after the chlorination step that is sufficient to kill the resident bacteria (see discussion below).

   Response: The Phase 1 study was not intended to address DBP production. DBP will be analyzed in a manner consistent with the Information Collection Rule. The effluent was evaluated for primary and secondary water quality parameters on 5/18 and 6/15/98. The text has been modified accordingly. Although this pilot-scale study included the analysis of bioreactor effluent for the range of water quality parameters used to regulate potable water it was not an objective of this

testing to produce potable water. To produce potable water and to fully evaluate the effectiveness of filtration and disinfection technologies, these unit processes must be part of the treatment train. Testing of filtration and disinfection technologies will be performed during a Phase 2 perchlorate treatability study. This study will be designed to meet treatment requirements of the Surface Water Treatment Rule.

Secondary Drinking Water Standards

1. Utilities must not only meet primary drinking water standards but they must also produce water that is aesthetically acceptable to its customers. At no place in the reports is there a discussion of the taste and odor or color characteristics of the water. A Flavor Profile Panel should assess the taste and odor quality of the reactor product water.

   Response: The taste, color, and odor of the produced water will be addressed during the Phase 2 Treatability Study. We agree that these are important water quality characteristics but since the Phase 1 Treatability Study did not include filtration or disinfection unit processes testing of the effluent from the bioreactor for taste, color, and odor would not have produced meaningful results.

Microbiological Quality of the Reactor Effluent

1. The report deals in only passing fashion with the issue of microbiological quality of the reactor effluent. There is an error on page 13 where an "upper quantifiable limit" for coliforms is stated to be 200.5. In fact, much higher concentrations of coliforms can be determined if the dilutions tested are properly planned. Also, there are limited total plate count bacteria levels (or at least that is what they appear to be) in Appendix D. They are not discussed in the text. All of the data indicate that a significant and potentially troublesome of level of bacteria are shed by the reactor and end up in the reactor effluent.

   Response: No attempt was made to quantify MPN > 200.5. Quantification for MPN > 200.5/100 mL requires dilution of the sample or that the Quantitray method be used. Unfortunately provisions were not made with the laboratory to dilute samples or perform the Quanitray method at the time the samples were submitted for analysis. Testing of water produced following filtration and disinfection unit processes will be performed during the Phase 2 study.

2. The report assumes that disinfection with chlorine and filtration will fix the biological problem, but they do not discuss any of the treatment process integration or confounding issues. For example, it may be necessary to operate the filter in a "biologically active" mode to remove the organics created by the GAC/FB reactor. If so, chlorination must follow the filter and not precede it as noted in the experimental for Phase 2. Also, adding chlorinate at the level to kill the bacteria could cause production of very high levels of DBPs given the production of precursors I referred to above.

   Response: As discussed above, the text has been modified to reflect that further testing needs to be completed on disinfection and filtration of the effluent. Although a more complete description of the proposed treatment train for the Phase 2 Treatability Study will be provided in the Work Plan, modification to this treatment train have been made to address these concerns. The bioreactor will be followed by a biologically active multimedia filter. Disinfection will follow all other unit processes.

3. Chlorination after the filter is also a good idea because the clumps of bacteria will likely be removed in the filter. Clumping of bacteria has been demonstrated by many researchers to impede the action of disinfectants like chlorine. The bacteria in the center of the clump can be protected by the bodies of the surrounding bacteria. It is important to remove or kill the majority of bacteria before the water is put into a distribution system to avoid "seeding" the system with coliforms or other nuisance organisms.

   Response: Agreed. See response (2). Filtration is the unit process that will immediately will follow the bioreactor as suggested.

Parameter Selection of Data Presentation

1. Measuring BOD and COD as parameters for understanding the process is not advisable. Total organic carbon (TOC) and ultraviolet absorbance at 254 nm (UV254) are much more relevant to drinking water treatment.

   Response: BOD and COD are typical parameters that are used by wastewater treatment plants and were tested to provide a comparison to other processes. Parameters used to monitor operational performance will be more fully developed in Phase 2. This will include analysis for TOC. In addition the proposed treatment train for the Phase 2 Treatability Study will include ultraviolet light to remove N-nitrosodimethylamine (NDMA) and therefore ultraviolet absorbance at 254 nm (UV254) will be addressed.

2. It would be easier for the reader to assess the importance of elevated perchlorate levels in the reactor effluent on Plate 3 if the y-axis began at zero as it does for all the other graphs. Also, the method detection level (MDL) should be noted on the various graphs to put the "plateauing" or "steady-state" effect on the graphs in perspective.

Response: A quantitation limit for perchlorate has been added to the appropriate figures. Although the axis on Plate 3 was not fixed in the Draft Final report we will fix it to show a y-axis that starts at zero in the Final Report.

Reactor Response after Process Upset

1. The report clearly documents that the biological reactor is subject to upset during power outages or interruptions in the chemical feeds. Recovery times were on the order of days. Unit processes used in water treatment must be reliable a very high percentage of the time or backup systems must be in place to deal with process upsets. There is no discussion of this in the report which I believe is a major weakness and should be corrected. If backup systems will have to be included in a full-scale system, that will adversely affect the economics of the treatment process.

   Response: Please see Section 5.4.6 "Bioreactor Response and Biomass Stability." There are three conditions under which bioreactor stability was evaluated; planned shutdowns, unplanned shutdown, and flow ramp up. Under planned shutdowns, bioreactor circulation was maintained and system recovery was rapid (approximately 24 hours) but analyses at less than 24 hour increments were not performed. During unplanned shutdowns, no bioreactor circulation was maintained. Although system recovery occurred within two days, samples were not collected at a more frequent interval. Therefore, the system could have recovered significantly faster. During flow ramp up when the biomass was healthy, the bioreactor typically responded within 24 hours. Our conclusion is that bioreactor response is rapid as long as the maximum design rate is not exceeded. This is the expected planning case. Other types of bioreactor upset would only occur in rare circumstances where the biomass is poisoned by a toxin, an unlikely event when using a groundwater supply.

Summary

1. I do not believe the study has demonstrated that filtration and disinfection that the water produced by the treatment train will meet "potable standards". A number of parameters included in Title 22 were not analyzed and no assessment of DBP formation was performed. Also, no assessment of the secondary maximum contaminant levels has been done. Consumers will reject the water produced by the reactor if it is colored, has a bad odor or an off-taste. The authors can only speculate on compliance with Title 22 since they have not done the work.

   Response: The report has been modified accordingly: "The study demonstrated that water produced from the intended treatment train will potentially meet State and Federal potable water standards. Additional work is needed to evaluate disinfection and filtration and demonstrate that the treatment processes will reliably produce potable water." Responses to previous comments

address the issues related to testing which will be performed during the Phase 2 Treatability Study. These issues include the removal of biological material prior to disinfection, the identification and quantification of disinfection by-products, analyses for other organic compounds by GC/MS, analysis for ethanol impurities and possible bioreactor by-products using methods with lower detection limits, and analysis for color, odor, and taste.

Recommendation

1. Before Aerojet and La Puente Water District go to the expense of a demonstration-scale test of technology, I recommend that the pilot plant in Sacramento be restarted and additional analyses be conducted (see above discussion topics). I believe more work should be done to see if the possibly serious problems with disinfection by-product formation could be resolved before the demonstration-scale project is built. If the organic products from the reactor are significant precursors for the formation of disinfection by-products, the entire process may not be viable.

   Should the DBP tests prove to be satisfactory, I recommend that an alternate arrangement of unit processes be considered. Figure 1 below shows the filtration process following immediately after the biological reactor with chlorination (or disinfection) following after that and preceding the air stripper. This arrangement will allow further removal of organics on a biologically active filter (an oxygen source may have to be added prior to filtration). In addition, the majority of the particles will be removed prior to chlorination which should improve the chlorination process significantly (lower dose, less contact time to get equivalent kill).

   Response: The Phase 1 treatment system was not designed to include filtration or disinfection, and unfortunately the Phase 1 Treatability Study has been concluded. Phase 2 will include these unit process. The Phase 2 Treatability Study will treat groundwater extracted directly from the San Gabriel Basin. Groundwater tested during the Phase 1 Treatability Study contained concentrations of nitrate and perchlorate similar to that expected in San Gabriel Basin, but was different with respect to other water quality parameters.

   The proposed design for the Phase 2 Treatability Study has been revised both to address your comments and to address the presence of additional chemicals in groundwater at the La Puente Valley County Water District facility. Modifications include placement of a multimedia filter after the bioreactor. This filter will be operated in a biologically active mode. Treatment by uv/oxidation will be added to remove NDMA and 1,4 dioxane. Disinfection will follow all other unit processes.

Thank you for the opportunity to respond to your comments. Perhaps next week we can have a discussion on our proposed treatment train for the Phase 2 Treatability Study and details of the study so that we may properly address your comments before we issue the next draft of this work plan.

Yours very truly,

HARDING LAWSON ASSOCIATES

John G. Catts, Ph.D.
Vice President

for Matthew McCullough P.E.
Principal Engineer

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APPENDIX N
MWD COMMENTS ON PHASE 1 TREATABILITY STUDY

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Office of the General Manager

June 9, 1998

Mr. Wayne Praskins
U.S. EPA Region IX
75 Hawthrone Street (H-6)
San Francisco, California 94105

Dear Mr. Praskins:

Comments on Phase 1 Treatability Study Draft Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin

The draft report entitled; "Phase 1 Treatability Study Draft Report, Perchlorate in Groundwater, Baldwin Park Operable Unit (BPOU), San Gabriel Basin;" prepared by Harding Lawson Associates, was reviewed by the Metropolitan Water District of Southern California (Metropolitan). It is important to note that the following comments are only focusing on perchlorate removal by an anoxic biological treatment. Comments on any issues regarding the integration of this anoxic biological treatment with other treatment processes for removing other contaminants are not included.

General Comments

Metropolitan understood the subject study was designed to demonstrate an anoxic biological treatment technology for perchlorate to treat groundwater with low perchlorate levels to achieve 18 μg/L perchlorate limit or lower. This Phase 1 study was not intended to demonstrate that the product water met all Title 22 drinking water quality regulations. Therefore, all statements suggesting the treated water from the treatment technology for perchlorate removal will meet Title 22 drinking water regulations should be deleted or modified.

The subject study demonstrates that an anoxic biological treatment technology using a GAC/FB reactor is promising to reduce perchlorate levels from a range between 25 μg/L and 57 μg/L to below the detection limit (< 4 μg/L). However, this study did not provide information regarding the treatment process reliability, the operational margin of safety, and the stability of the treatment performance.

Some water quality issues such as the formation of disinfection by-products, biological regrowth due to high nutrient levels in the product water (ethanol, methanol, total phosphorus, and ammonia nitrogen), and intermediate by-products from biodegradation were not addressed.

It is suggested that references should be provided for all equations listed in the report.

Specific Comments

(1) Page v — This subject study did not analyze any pathogens and disinfection by-products or investigate the biological regrowth issue in the distribution systems; therefore, the fifth bullet under the study objectives accomplished is not a true statement and should be modified.

(2) Page 1 — Paragraph one, lines one to four - Metropolitan is to assist the Three Valleys Municipal Water District in this BPOU project; therefore, the statement should be changed to ".....(EPA) and Three Valleys Municipal Water District (TVMWD) in association with Metropolitan Water District of Southern California (MWD)....."

(3) Page 1 — Paragraph four, lines six to seven - Metropolitan's criteria for acceptance of treated water into the distribution systems include that the downstream customers determine the acceptable perchlorate level in Metropolitan's distribution system. The U.S. Air Force toxicity study results may not change the aforementioned criteria. If the downstream customers demand that the perchlorate level in Metropolitan's distribution systems be very low or non-detect, a treatment process for perchlorate removal may be required regardless of the level of reference for dose (RfD) for perchlorate. The statement needs to be modified.

(4) Page 3 — Paragraph five (under Subtitle 2.4 Evaluation Different Source ofMicroorganism), lines six to eight - the waste sludge from the food processing industry is not necessarily lacking the pathogens. Please clarify the statement to characterize the waste sludge.

(5) Page 4 — Paragraph five, lines two to three - what is the commercial name of coal-based carbon used? How much was added to the system?

(6) Page 14 — The fifth bullet under Subtitle 6.0 - same as comment (1).

(7) Page 14 The sixth bullet under Subtitle 6.0 - no demonstration of the conceptual model with the actual results was described in this report.

(8) Page 14 The ninth bullet under Subtitle 6.0 - since the detection limit for ethanol is 5 mg/L, it is inappropriate to state that "little to no ethanol in the effluent."

Conclusion

The subject study successfully determined the reduction of perchlorate below detection limits; however, it did not demonstrate the potability of the product water produced from an anoxic biological treatment process. Metropolitan will be glad to work with the BPOU Steering Committee to resolve our concerns.

Metropolitan appreciates the opportunity to provide input into this draft report. If you have any questions regarding our comments, please call Dr. Sun Liang at (909) 392-5273.

Very truly yours,

Jeanne-Marie Bruno

Jeanne-Marie Bruno, P.E.
Acting Associate Director of Water Quality

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APPENDIX O
HLA RESPONSE TO MWD COMMENTS ON PHASE 1 TREATABILITY STUDY

October 21, 1998

Ms. Jeanne-Marie Bruno, P.E.
Acting Associate Director of Water Quality
Metropolitan Water District of Southern California
350 South Grand Avenue
Los Angeles, CA 90054

Re: Response
"Comments on Phase I Treatability Study Draft Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin"

Dear Ms. Bruno:

Attached you will find two copies of our revised report "Draft Final Phase 1 Treatability Study Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin." We believe that this revised report addresses your (Metropolitan Water District of Southern California [Metropolitan]) comments dated June 22, 1998. Comments made by the U.S. Environmental Protection Agency (EPA) and the Baldwin Park Operable Unit Steering Committee's (BPOUSC) responses to these comments are included as Appendices G and H of the report. Our responses to your specific comments are detailed below. A revised Phase 2 Treatability Study Work Plan will follow under separate cover.

1.0 General Comments

1. Metropolitan understood the subject study was designed to demonstrate an anoxic biological treatment technology for perchlorate to treat groundwater with low perchlorate levels to achieve 18 ug/L perchlorate limit or lower. This Phase I study was not intended to demonstrate that the product water met all Title 22 drinking water quality regulations. Therefore, all statements suggesting the treated water from the treatment technology for perchlorate removal will meet Title 22 drinking water regulations should be deleted or modified.

   Response: We agree. Although the Phase I study included an analysis of bioreactor effluent for primary and secondary water quality parameters on 5/18 and 6/15/98, it was not an objective of this testing to produce potable water that met all Title 22 drinking water regulations. To accomplish this, and to fully evaluate the effectiveness of filtration and disinfection technologies, these unit processes must be part of the treatment train. Testing of filtration and disinfection technologies, the formation of disinfection-by-products (DBP), biological regrowth, and the formation of intermediate by-products will be addressed during the Phase 2-perchlorate treatability study. The report has been modified in accordance with: "The study demonstrated that water produced from the intended treatment train will potentially meet State and Federal potable water standards. Additional work is needed to evaluate disinfection and filtration and demonstrate that the treatment processes will reliably produce potable water."

2. The subject study demonstrates that an anoxic biological treatment technology using a GAC/FB reactor is promising to reduce perchlorate levels from a range between 25 ug/L and 57 ug/L to below the detection limit (<4 ug/L). However, this study did not provide information regarding the treatment process reliability, the operational margin of safety, and the stability of the treatment performance.

   Response: We agree. The Phase 1 was not designed to evaluate process reliability, the operational margin of safety, and the stability of the treatment performance. The Phase 2 study is designed to evaluate these parameters in more detail.

3. Some water quality issues such as the formation of disinfection by-products, biological regrowth due to high nutrient levels in the product water (ethanol, methanol, total phosphorus, and ammonia nitrogen), and intermediate by-products from biodegradation were not addressed.

   Response: We agree. See the response to General Comment (1).

4. It is suggested that references should be provided for all equations listed in the report.

   Response: This has been completed where applicable.

2.0 Specific Comments

1. Page v. The subject study did not analyze any pathogens and disinfection by-products or investigate the biological regrowth issue in the distribution systems; therefore; the fifth bullet under the study objectives accomplished is not a true statement and should be modified.

   Response: We agree. See response to General Comment (1). The text has been revised to "the study demonstrated that water produced from the intended treatment train will potentially meet State and Federal potable water standards. Additional work is needed to evaluate disinfection and filtration and demonstrate that the treatment processes will reliably produce potable water."

2. Page 1, paragraph one, lines one to four. Metropolitan is to assist the Three Valleys Municipal Water District in this BPOU project; therefore, the statement should be changed to ".....(EPA) and Three Valleys Municipal District (TVMWD) in association with Metropolitan Water District of Southern California (MWD)....."

   Response: The text has been modified as requested.

3. Page 1, Paragraph four, lines six to seven. Metropolitan's criteria for acceptance of treated water into the distribution systems include that the downstream customers determine the acceptable perchlorate level in Metropolitan's distribution system. The U.S. Air Force toxicity study results may not change the aforementioned criteria. If the downstream customers demand that the perchlorate level in Metropolitan's distribution systems be very low or non-detect, a treatment process for perchlorate removal may be required regardless of the level of reference for dose (RfD) for perchlorate. The statement needs to be modified.

   Response: The text has been revised to "The U.S. Air Force with EPA review is presently performing toxicity studies that will be the basis for a revised Reference Dose (RfD), which will in turn be evaluated to develop an enforceable water quality standard. In addition, the demands of water users may affect the decision whether to treat for perchlorate. Once this numerical value is established and the demands of water users have been evaluated, a determination regarding whether BPOU groundwater must be treated for perchlorate can be made."

4. Page 3, Paragraph five (under Subtitle 2.4 Evaluation Different Source of Microorganism [sic]) lines six to eight – the waste sludge from the food processing industry is not necessarily lacking the pathogens. Please clarify the statement to characterize the waste sludge.

   Response: Aerojet conducted characterization of the innoculum sludge in a previous study. This characterization indicated the sludge lacked human pathogens such as fecal coliform and coliform. Unfortunately, no specific characterization of the innoculum sludge was conducted in this study; however, we did characterize the bioreactor effluent for total bacteria, total coliform, and fecal coliform. This provides an indirect characterization of the innoculum sludge. We will directly characterize the innoculum sludge as part of the Phase 2-perchlorate treatability study.

5. Page 4, paragraph five, lines two to three. What is the commercial name of coal-based carbon used? How much was added to the system?

   Response: Approximately 300 pounds of a specialized coal-based carbon was added to the bioreactor. Calgon developed the carbon for Envirex for use in fluidized beds. The carbon is a 10x30 mesh but has a more uniform size distribution to increase carbon retention in the bed.

6. Page 14, the fifth bullet under Subtitle 6.0. Same as comment (1).

   Response: see Specific Comment (1) response.

7. Page 14, the sixth bullet under Subtitle 6.0. No demonstration of the conceptual model with the actual results was described in this report.

   Response: The conceptual model refers to the expected kinetic model: oxygen depletion > nitrate reduction > perchlorate reduction. This is well supported by the data. The fluidized bioreactor model has been removed from the report. Initial perchlorate concentrations were so low that it was not possible to gather sufficient data to confirm the model.

8. Page 14, the ninth bullet under Subtitle 6.0. Since the detection limit for ethanol is 5 mg/L, it is inappropriate to state that "little to no ethanol in the effluent."

   Response: The text has been modified to reflect the detection limit of 5 mg/L for ethanol.

3.0 Conclusion

The subject study successfully determined the reduction of perchlorate below detection limits; however, it did not demonstrate the potability of the product water produced from an anoxic biological treatment process. Metropolitan will be glad to work with the BPOU Steering Committee to resolve our concerns.

Response: We agree and look forward to working with Metropolitan to resolve outstanding concerns. As you are aware, the scope and objectives of the Phase 1 study were limited. The study primarily was intended to demonstrate that perchlorate could be reduced from concentrations similar to those present in the San Gabriel Valley to less than the laboratory detection limit of 4 ug/L. Additional objectives were to evaluate nitrate reduction, to evaluate a different source of microorganisms, and to evaluate the potability of treated water. Although this pilot-scale study included the analysis of bioreactor effluent for the range of water quality parameters used to regulate potable water, it was not an objective of this testing to produce potable water. To produce potable water, it was not an objective of this testing to produce potable water. To produce potable water and to fully evaluate the effectiveness of filtration and disinfection technologies, these unit processes must be part of the treatment train. Testing of filtration and disinfection technologies will be performed during a Phase 2-perchlorate treatability study.

October 21, 1998
Ms. Jeanne-Marie Bruno, P.E.
Acting Associate Director of Water Quality
Metropolitan Water District of Southern California
Page 5

Thank you for the opportunity to respond to your comments. Responses to your department's comments on the Phase 2 Treatability Study Work Plan will follow under separate cover. Please call John Catts at (415) 899-8825 or Matthew McCullough (949) 260-1800 if we can assist you in any way.

Yours very truly,

HARDING LAWSON ASSOCIATES

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Vice President

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DISTRIBUTION

FINAL
Phase 1 Treatability Study Report
Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

April 12, 1999

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