FINAL REPORT

Demonstration of a Full-Scale Fluidized Bed Bioreactor for the Treatment of Perchlorate at Low Concentrations in Groundwater

ESTCP Project ER-0543

JANUARY 2009

Todd S. Webster
Basin Water, Inc.

Paul Togna
Basin Water, Inc.

Environmental Security Technology
Certification Program

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* 20-01-2009	**2. REPORT TYPE** Final Report	**3. DATES COVERED** *(From - To)* March 2006-March 2008; January 2009

4. TITLE AND SUBTITLE

DEMONSTRATION OF A FULL-SCALE FLUIDIZED BED BIOREACTOR FOR THE TREATMENT OF PERCHLORATE AT LOW CONCENTRATIONS IN GROUNDWATER

5a. CONTRACT NUMBER W912HQ-06-C-0009

5b. GRANT NUMBER N/A

5c. PROGRAM ELEMENT NUMBER N/A

6. AUTHOR(S)

Webster, Todd, Stephen
Togna, A. Paul

5d. PROJECT NUMBER 200543

5e. TASK NUMBER N/A

5f. WORK UNIT NUMBER N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Basin Water, Inc.
9302 Pittsburgh Avenue, Suite 210
Rancho Cucamonga, CA 91729

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Environmental Security Technology Certification Program
SERDP/ESTCP Support Office, HGL
11107 Sunset Hills Road, Suite 400
Reston, VA 20190

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

N/A

14. ABSTRACT

This study demonstrated the treatment of low and high concentration levels of perchlorate laden groundwater to potable-like water using a biological fluidized bed reactor (FBR) treatment train. The objectives were to demonstrate: (1) complete treatment of nitrate and perchlorate to drinking water standards using a only a biological inoculum from the incoming groundwater and (2) the use of a downstream post aeration vessel, multimedia filter, and LGAC to produce a potable-like effluent water stream. For the study, the objectives were successfully demonstrated. Using only the groundwater, the FBR system was biologically seeded and demonstrated effective removal of the nitrate and perchlorate at the design loading conditions to meet the State of California Public Health Goal standards. In addition, the downstream equipment operated to produce an effluent water of potable quality, meeting all State of California primary and secondary MCL requirements established under Title 22.

15. SUBJECT TERMS

perchlorate treatment, biological fluidized bed reactor, drinking water treatment

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Todd S. Webster
U	U	U	UU	255	**19b. TELEPHONE NUMBER** *(Include area code)* (909)481-6800

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Table of Contents

List of Acronyms and Abbreviations .... **iv**

List of Figures .... **vi**

List of Tables .... **viii**

List of Appendices .... **ix**

Acknowledgements .... **x**

Executive Summary .... **xi**

1.0 Introduction **1**

- **1.1 Background** **1**
- **1.2 Objectives of the Demonstration** **3**
- **1.3 Regulatory Drivers** **5**

2.0 Technology **6**

- **2.1 Technology Description** **6**
- **2.2 Technology Development** **10**
- **2.3 Advantages and Limitations of the Technology** **11**

3.0 Performance Objectives **13**

- **3.1 Qualitative Objectives** **13**
  - *3.1.1 Ability to Treat Multiple Contaminants* *13*
  - *3.1.2 Effectiveness of Self-inoculation Procedure* *13*
  - *3.1.3 Ease of Operation and Maintenance* *15*
  - *3.1.4 Effects of System Shutdown and Restart* *15*
  - *3.1.5 On-Line Analyzer Effectiveness* *15*
  - *3.1.6 Reduce Treatment Costs* *16*
- **3.2 Quantitative Objectives** **16**
  - *3.2.1 Meet Drinking Water Regulatory Standards/Produce Quality Data* *16*
  - *3.2.2 Maximum Concentration Treated* *17*
  - *3.2.3 Downstream Equipment Effectiveness* *17*
  - *3.2.4 Process Robustness* *18*

4.0 Site Description **19**

- **4.1 Site Location and History** **19**
- **4.2 Geology/Hydrogeology** **21**
- **4.3 Contaminant Distribution** **21**

5.0 Test Design **22**

- **5.1 Conceptual Experimental Design** **22**
- **5.2 Baseline Characterization** **24**
- **5.3 Treatability or Laboratory Study Results** **25**
- **5.4 Design and Layout of Technology Components** **25**
  - *5.4.1 Fluidized Bed Reactor* *39*
  - *5.4.2 Aeration Tank* *41*
  - *5.4.3 Multimedia Filter* *41*
  - *5.4.4 Filter Effluent Tank* *43*
  - *5.4.5 Liquid Phase Granular Activated Carbon* *43*
  - *5.4.6 UV Disinfection* *44*
  - *5.4.7 Analytical Equipment* *44*

5.4.7.1 Nitrate Analyzer 44
5.4.7.2 Perchlorate Analyzer 45
5.5 Field Testing 47
5.5.1 System Start-Up 49
5.5.2 Self-inoculation 52
5.5.3 Treatment Effectiveness 53
5.5.4 System Shut-Down Scenarios 54
5.5.4.1 Feed Shutdown 54
5.5.4.2 Plant Electrical Shutdown 55
5.5.4.3 Nutrient Shutdown 55
5.5.5 On-Line Analyzer Effectiveness 55
5.5.6 Chlorination Disinfection Study 57
5.5.7 Ultraviolet Reactor Study 58
5.5.8 Spiking Study 58
5.5.9 Demobilization 62
5.5.9.1 Cleaning of the FBR Treatment System 62
5.5.9.2 Removal of Carbon from the FBR Vessel 63
5.6 Sampling Methods 63
5.6.1 Sample Collection 63
5.6.2 Analytical/Testing Methods 69
5.6.3 Quality Assurance/Quality Control 70
5.7 Sampling Results 70
5.7.1 System Start-Up and Self Inoculation 89
5.7.2 Treatment Effectiveness 89
5.7.2.1 FBR System 89
5.7.2.2 Post Aeration 91
5.7.2.3 Trimite Multimedia Filter 91
5.7.2.4 LGAC 96
5.7.2.5 Overall Plant Effectiveness 98
5.7.3 System Shut-Down Scenarios 104
5.7.3.1 Feed Shutdown 104
5.7.3.2 Plant Electrical Shutdown 104
5.7.3.3 Nutrient Shutdown 105
5.7.4 On-Line Analyzer Effectiveness 105
5.7.4.1 Dionex DX-800 Perchlorate Analyzer 105
5.7.4.2 HACH Nitrate-N Analyzers 107
5.7.4.3 Electron Donor Reduction Experiments 108
5.7.5 Chlorination Disinfection Study 112
5.7.6 Ultraviolet Reactor Study 113
5.7.7 Spiking Study 115

6.0 Performance Assessment 129

6.1 Qualitative Objectives 129
6.1.1 Ability to Treat Multiple Contaminants 129
6.1.2 Effectiveness of Self-inoculation Procedure 129
6.1.3 Ease of Operation 129
6.1.4 Effects of System Shutdown and Restart 131
6.1.5 On-Line Analyzer Effectiveness 131
6.1.5.1 Dionex Analyzer 132
6.1.5.2 HACH Nitrate-N Analyzers 134
6.1.5.3 Electron Donor Reduction Experiments 135
6.1.6 Reduce Treatment Costs 136
6.1.6.1 Electron Donor 136
6.1.6.2 Phosphoric Acid Addition 137
6.1.6.3 Coagulant and Polymer Addition 137
6.1.6.4 Electricity Requirements 138
6.1.6.5 Maintenance Requirements 139

6.2 Quantitative Objectives **139**
6.2.1 Meet Drinking Water Regulatory Standards/Produce Quality Data *139*
6.2.2 Maximum Concentration Treated and Elimination Capacity *142*
6.2.3 Downstream Equipment Effectiveness *143*
6.2.4 Process Robustness *143*

7.0 Cost Assessment **145**

7.1 Cost Model **145**
7.1.1 Project Management & Design *145*
7.1.2 Fabrication & Equipment *147*
7.1.3 Installation *147*
7.1.4 Operation and Maintenance *147*
7.1.4.1 Materials Required 147
7.1.4.2 Labor 148
7.1.5 Monitoring *149*
7.2 Cost Drivers **149**
7.3 Cost Analysis **151**
7.3.1 FBR System *158*
7.3.2 Ion Exchange Treatment System *159*
7.3.3 Cost Comparison of FBR versus IX *160*

8.0 Implementation Issues **163**

8.1 Regulations **163**
8.2 End User Concerns **165**
8.3 Lessons Learned **167**

9.0 References **170**

APPENDICES **172**

List of Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
CADPH	California Department of Public Health
COC	Chain of Custody
COTS	Commercially-off-the-shelf
DO	Dissolved Oxygen
DOC	Dissolve Organic Carbon
DoD	Department of Defense
DSERTS	Defense Site Environmental Restoration Tracking System
ECAM	Economic Cost Analysis Methods
EPA/USEPA	United States Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
EW	Extraction Well
FBR	Fluidized Bed Reactor
Fe	Iron
GAC	Granulated Activated Carbon
gpm	Gallons per minute
HASP	Health & Safety Plan
HRT	Hydraulic Residence Time
IDW	Investigation-Derived Waste
LGAC	Liquid Granular Activated Carbon
LHAAP	Longhorn Army Ammunition Plant, Karnack, TX
LOC	Level(s) of Concern
MCL	Maximum Contaminant Level
MDL	Method Detection Limits
Mn	Manganese
MSL	Mean Sea Level
MW	Monitoring Well
NL	Notification Limit
NSF	National Sanitary Foundation
O&M	Operation & Maintenance
ORP	Oxidation-Reduction Potential
PHG	Public Health Goal
P&ID	Piping and Instrumentation Diagram
P&T	Pump & Treat
PI	Principal Investigator
PQL	Practical Quantitation Limit
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RASP	Rialto Ammunition Storage Point
RCRA	Resource Conservation and Recovery Act

RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RW#2	Rialto Well #2
SARWQCB	Santa Ana Regional Water Quality Control Board
TOC	Total Organic Carbon
USACE	United States Army Corp of Engineers
UV	Ultraviolet
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compounds
WWI, WWII	World War I, World War II

List of Figures

Figure 1.1 Biological treatment of perchlorate.
Figure 1.2 Theoretical biological treatment process within the FBR.
Figure 2.1 Schematic of a fluidized bed bioreactor.
Figure 2.2 Hydraulic and biological expansion of media.
Figure 2.3 Schematic of FBR treatment plant.
Figure 2.4 Process flow diagram for the FBR treatment train system.
Figure 2.5 Three full-scale FBR installations.
Figure 4.1 Rialto-Colton Basin contamination.
Figure 5.1 Rialto Well #2 site map.
Figure 5.2 Feed groundwater pump and gas dispersion tank.
Figure 5.3 FBR vessel(foreground), post-aeration vessel(middle), and multimedia filter (left).
Figure 5.4 LGAC vessel (foreground), multimedia filter (right-side), and the multimedia filter backwash tank (background).
Figure 5.5 Eductor used for biomass separation in the lower portions of the media bed.
Figure 5.6 UV System uninstalled and installed in protective box.
Figure 5.7 FBR P&ID.
Figure 5.8 Aeration vessel P&ID.
Figure 5.9 Multimedia filter P&ID.
Figure 5.10 Chemical feed system P&ID.
Figure 5.11 LGAC P&ID.
Figure 5.12 Air compressor P&ID.
Figure 5.13 FBR treatment system layout.
Figure 5.14 Nitrate analyzer and perchlorate sampling system P&ID.
Figure 5.15 Perchlorate analyzer system P&ID.
Figure 5.16 Operator interface for FBR treatment system.
Figure 5.17 Nitrate analyzer.
Figure 5.18 Sampling system.
Figure 5.19 Perchlorate analyzer.
Figure 5.20 Demonstration schedule.
Figure 5.21 Spiking study backwash water holding tank.
Figure 5.22 Spiking study plant effluent 20,000 gallon holding tanks.
Figure 5.23 Spiking study recycle pump.
Figure 5.24 FBR media bed height.
Figure 5.25 Turbidity in Trimite multimedia filter effluent water.
Figure 5.26 Dissolved oxygen in FBR feed, effluent and post-aeration effluent water.
Figure 5.27 Nitrate-N in FBR effluent water (measured on-site in lab).
Figure 5.28 pH in FBR feed and effluent water.
Figure 5.29 Temperature in FBR feed and effluent water.
Figure 5.30 Orthophosphate-phosphorus in FBR effluent water.
Figure 5.31 DOC in FBR effluent water.
Figure 5.32 ORP in the feed and FBR effluent water.

Figure 5.33 Perchlorate and nitrate on-site analytical results (Days 0-24).
Figure 5.34 Perchlorate and nitrate on-site analytical results (Days 22-40).
Figure 5.35 Perchlorate and nitrate on-site analytical results (Days 38-60).
Figure 5.36 Perchlorate and nitrate on-site analytical results (Days 60-80).
Figure 5.37 Perchlorate and nitrate on-site analytical results (Days 80-102).
Figure 5.38 Perchlorate and nitrate on-site analytical results (Days 102-122).
Figure 5.39 Perchlorate and nitrate on-site analytical results (Days 122-146).
Figure 5.40 Perchlorate and nitrate on-site analytical results (Days 146-168).
Figure 5.41 Perchlorate and nitrate on-site analytical results (Days 168-190).
Figure 5.42 Perchlorate and nitrate on-site analytical results (Days 190-212).
Figure 5.43 Perchlorate and nitrate on-site analytical results (Days 212-234).
Figure 5.44 Inlet and outlet water pressure for the LGAC reactor.
Figure 5.45 Total coliform concentration across FBR treatment system.
Figure 5.46 HPC concentration across FBR treatment system.
Figure 5.47 TTHMs and HAA5 formation potential from Trimite filter effluent water.
Figure 5.48 TTHMs and HAA5 formation potential with components from Trimite filter effluent.
Figure 5.49 TTHMs and HAA5 formation potential from entire FBR treatment system.
Figure 5.50 Comparison of off-site lab and on-site Dionex feed and effluent perchlorate data. Non-detects were reported as the MDLs for each analysis (LAB MDL of 0.5 µg/L, Dionex MDL of 1 µg/L).
Figure 5.51 Comparison of off-site lab and on-site HACH feed and effluent nitrate-N data.
Figure 5.52 Reduction of Electron Donor Experiment #1.
Figure 5.53 Reduction of Electron Donor Experiment #2 (feed Nitrate-N = 6.1 mg/L, feed perchlorate = 40-45 µg/L).
.**Figure 5.54** Reduction of Electron Donor Experiment #3(feed nitrate-N= 6.1 mg/L, feed perchlorate = 45-50 µg/L).
Figure 5.55 Chlorination study results for varying CT values.
Figure 5.56 UV disinfection after the Trimite filter under different plant and UV operating conditions.
Figure 5.57 UV disinfection after LGAC filter under different UV operating conditions.
Figure 5.58 Perchlorate and nitrate on-site analytical results (Days 234-256).
Figure 5.59 Perchlorate and nitrate on-site analytical results (Days 257-277).
Figure 5.60 Perchlorate and nitrate on-site analytical results (Days 277-299).
Figure 5.61 Perchlorate and nitrate on-site analytical results (Days 299-321).
Figure 5.62 Perchlorate and nitrate on-site analytical results (Days 321-343).
Figure 5.63 Perchlorate and nitrate on-site analytical results (Days 343-363).
Figure 5.64 Spiked perchlorate concentrations to 2000 µg/L showing a general improvement in performance over time as the microbial population acclimates.
Figure 5.65 From Day 327 to Day 329, with the feed perchlorate concentration at 1,000 µg/L.
Figure 5.66 Ramp up of perchlorate from 1000 to 4000 µg/L.
Figure 5.67 Effluent perchlorate analyzer chromatograms showing no secondary peak/baseline, a secondary peak/baseline, and a secondary peak/baseline and perchlorate peak.
Figure 7.1 Typical ion exchange technology set-up with a lead/lag vessel configuration (Photo courtesy of Siemens Water Technologies Corporation).

List of Tables

Table 3.1 Performance objectives.
Table 5.1 Feed groundwater baseline data.
Table 5.2 FBR treatment plant process interlock notes.
Table 5.3 FBR treatment plant process alarms.
Table 5.4 Total number and types of samples to be collected.
Table 5.5 Analytical methods for sample analysis.
Table 5.6 California regulatory limits for drinking water.
Table 5.7 Trimite multimedia filter effluent water quality for metals and inorganics under various operating conditions.
Table 5.8 Trimite multimedia filter effluent water quality for metals, inorganics, and organics under steady-state operating conditions on Day 137.
Table 5.9 FBR effluent and Trimite multimedia filter effluent water quality for metals and other inorganics after a plant restart condition (Day 89).
Table 5.10 BOD, COD, and TSS release from the Trimite filter during flush and backwash cycles.
Table 5.11 Clarifier flush water quality.
Table 5.12 LGAC analysis for Toxicity Characteristic Leaching Procedure (TCLP).
Table 5.13 Reduction of Electron Donor Experiment #4.
Table 5.14 Trimite multimedia filter effluent water quality at differing perchlorate concentrations.
Table 6.1 Statistical analysis of off-site and on-site feed and effluent perchlorate analyses prior to the spiking study.
Table 6.2 Statistical analysis of off-site and on-site feed and effluent perchlorate analyses during the spiking study.
Table 6.3 Comparison of perchlorate results from four analytical labs.
Table 6.4 Statistical analysis of off-site and on-site feed and effluent nitrate-nitrogen analyses over the course of the demonstration.
Table 6.5 Demonstration study sample and quality control sample results for perchlorate analysis and the calculated relative percent difference values (RPD).
Table 6.6 Issues with samples submitted for analysis and resulting corrective action.
Table 6.7 Sample results statistically removed from the data set.
Table 6.8 Elimination capacity of nitrate/perchlorate under differing operating scenarios (assumes 100% treatment of feed perchlorate concentration).
Table 7.1 Cost model for small-scale FBR implementation (<100 gpm).
Table 7.2 Sensitivity of electron donor cost as a function of differing inlet contaminant concentrations. Assumes 1000 gpm treatment, 50% acetic acid cost of $0.365/lb, and 25% percent excess electron donor for biomass development.
Table 7.3 FBR full-scale treatment system cost at 1000 gpm and CLO_4= 50 µg/L.
Table 7.4 IX full-scale treatment system cost at 1000 gpm and CLO_4= 50 µg/L.
Table 7.5 FBR full-scale treatment system cost at 1000 gpm and CLO_4= 270 µg/L.
Table 7.6 IX full-scale treatment system cost at 1000 gpm and CLO_4= 270 µg/L.
Table 7.7 FBR full-scale treatment system cost at 1000 gpm, CLO_4= 1000 µg/L.
Table 7.8 FBR full-scale treatment system cost at 1000 gpm, CLO_4= 1000 µg/L.

List of Appendices

Appendix A. Points of Contact
Appendix B. CADPH Conditional Acceptance Letter of FBR Technology
Appendix C. Chlorination Disinfection Study Protocol
Appendix D. UV Disinfection Study Protocol
Appendix E. Quality Assurance Project Plan (QAPP)
Appendix F. Field Monitoring Data
Appendix G. Off-site Laboratory Data
Appendix H. Daily System Modifications Report

Acknowledgements

This Environmental Security Technology Certification Program (ESTCP) project was a collaborative effort amongst scientists and engineers at Basin Water, Inc. (San Diego, CA and Lawrenceville, NJ offices) and personnel from the City of Rialto (Rialto, CA). All of the City of Rialto staff and their consultants provided constant support of the project demonstration. In particular, special thanks to Mr. Peter Fox of the City of Rialto and Mr. William Hunt of Hunt Environmental Services for their consistent dedication to the project and its success. Additional thanks to the operators at the West Valley Water District Oliver Roemer Surface Water Treatment Plant for their extensive advice in optimizing the solids removal portion of the FBR treatment plant operation. Finally, in large degree, the overall success of the project is a direct function of the personnel that operated the system and conducted the experiments on a daily basis. Mr. Sam Wong (Basin Water, Inc. field engineer) demonstrated persistent dedication to the project success. His unrelenting daily efforts ultimately lead to the quality experimental results and findings obtained during this project.

Executive Summary

Perchlorate is a highly soluble salt-anion that can negatively affect the ability of the human thyroid to adequately uptake iodine. Since early 1997, with the improvement of analytical techniques, drinking water testing performed throughout California has revealed contamination in several regions of the state at levels as low as 4 µg/L. The majority of the perchlorate contamination in groundwater is believed to be attributable to historical disposal practices by the aerospace and ordinance industries, the military, and chemical manufacturers. Perchlorate salts have been used in the U. S. defense and space programs for several decades as primary oxidants in the solid propellants that power rocket motors, rocket boosters, and missiles. In past disposal practices, solid perchlorate-containing fuels were often burned in open-burn and open-detonation areas, and aqueous processing waters or wastewaters were released to surface soils or discharged into lagoons or evaporation ponds. With such past disposal practices and the mobility of the anion, a number of drinking water aquifers throughout the state have been contaminated with perchlorate. Based on the prevalence of perchlorate in drinking water aquifers, the further development of cost effective treatment technologies is warranted.

A demonstration study has been conducted at the City of Rialto Wellhead #2 (Rialto, CA) to treat perchlorate laden groundwater to potable water standards using a fluidized bed biological reactor (FBR) treatment train. The FBR is one of two biological treatment technologies approved by the California Department of Public Health as permittable for treating perchlorate laden water to drinking water. The FBR is a fixed-film anoxic reactor in which the bed media is fluidized within the reactor vessel. An electron donor (i.e., acetic acid) is provided to the FBR and utilized for denitrification/perchlorate reduction by the microbes attached to the media. Additional downstream equipment constitutes a typical surface water treatment plant and includes a post aeration tank for oxygen concentration increase of the water, a multimedia filter for solids removal, a liquid granular activated carbon (LGAC) system for color and odor removal (and as a backup to the overall plant), a back flush/effluent tank system for storing backwash water for the multimedia filter system and effluent water that has not reached full-treatment, and an ultraviolet light (UV) reactor for microbial disinfection.

The main objective of this project was to demonstrate the efficacy of the full-scale FBR for the treatment of low concentrations of perchlorate in groundwater to the current Maximum Contaminant Level (MCL) for perchlorate established in the State of California of 6 µg/L. In addition, plant effluent water was also required to meet all Federal Safe Drinking Water Act and California Code of Regulations, Title 22 drinking water requirements. This project was set up to test and validate the following: (1) *ex situ* bioremediation of nitrate and low concentrations of perchlorate contaminated groundwater through a fluidized bed bioreactor via an anoxic biological coupling reaction using an added electron donor; (2) the short- and long-term performance effects in allowing the system to be self-inoculated with the incoming groundwater versus manually inoculating with a non-pathogenic microbial consortium that has been developed in other FBR perchlorate treatment units; (3) the resulting short-term performance effects in the simulation of both a feed pump failure (i.e., system remains in recycle) and an

electrical shutdown; (4) the use of a post aeration vessel, multimedia filter, and LGAC to produce a potable-like effluent water stream; (5) the operational effectiveness of on-line nitrate and perchlorate analyzer systems; (6) a comparison of system effluent disinfection through both chlorination and UV; and (7) long-term monitoring of system robustness and performance under steady-state and spiking perchlorate concentrations.

The operation of the plant was conducted from March, 2007 to March, 2008, with an overall uptime for water production from the plant during the first year of operation at 94%. Using only the feed groundwater at 50 gpm, the FBR system was biologically seeded and demonstrated effective removal of the nitrate and perchlorate to non-detect levels within 28 days from the beginning of system operation. The typical system feed chemical concentrations were recorded as nitrate-nitrogen at 6.1-6.3 mg/L, oxygen at 8.1 mg/L, and perchlorate at approximately 50-53 µg/L. The FBR media hydraulic residence time (HRT) was 12.2 minutes. The electron donor (50% acetic acid) and the nutrient formulation (1.7% phosphoric acid) addition rates were set by fully-automated plant utilizing Programmable Logic Controller (PLC) technology. The PLC operated a proprietary model that accounted for the stoichiometric requirements of 50% acetic acid to theoretically treat the known feed flow and oxygen, nitrate, and perchlorate concentrations. This iterative model used feed forward control logic based on effluent contaminant concentrations to meet the FBR system electron donor requirements for complete nitrate and perchlorate treatment. Based on the non-spiking condition average feed concentrations of oxygen, nitrate-nitrogen, perchlorate, and a feed flow of 50 gpm, the required amount of 50% acetic acid and 1.7% phosphoric acid was 15 mL/min (16.2 mg/L as carbon, including an excess percentage of electron donor of 20-25%) and 10.5 mL/min (0.3 mg/L as P), respectively. This level of 50% acetic acid addition minimized carry over of the electron donor to the effluent and prevented sulfate reducing conditions from developing. Maintaining approximately 2-3 mg/L residual DOC at the FBR effluent ensured that the system operated optimally. Based on the feed contaminant concentrations and the electron donor and nutrient additions rates, the FBR treatment system was capable of removing all three chemical constituents at or below the instrument detection levels. When the system was spiked with perchlorate up to 1,000 µg/L at a feed flowrate of 25 gpm, the PLC model added an incremental amount of electron donor (18.0-19.3 mg/L as carbon) and the perchlorate was treated to below the California State MCL of 6 µg/L. The maximum concentration of perchlorate that was demonstrated to be consistently treated through the FBR at a feed flowrate of 25 gpm was approximately 4,000 µg/L of ClO_4. At this concentration, the required amount of 50% acetic acid was 11 mL/min (23.8 mg/L as C) and 99.65% removal was attained (9.6 g of perchlorate/m^3 expanded media bed/hr).

During the course of the study, the FBR treatment system was demonstrated to effectively and quickly recover from a variety of shutdown scenarios. A simulated feed pump failure was tested twice and the resulting recovery times for complete perchlorate treatment for each experiment were less than 24 hours and 8 hours. A complete plant electrical failure scenario was demonstrated twice and short recovery times of less than 2 hours for nitrate treatment (perchlorate was never observed in the effluent) were observed after both experiments. Some degree of adsorption and biodegradation contributed to the treatment of both the nitrate and perchlorate. The general trend observed for all of the shutdown scenarios was that the longer the plant operated and a mature biomass developed, a more rapid recovery time resulted. During a nutrient shutdown experiment, initial breakthrough of perchlorate was observed within 12 hours. Once the nutrient was restarted, complete nitrate and perchlorate removal occurred within four hours. This result indicated the critical need for the addition of a consistent nutrient source during the operation of the FBR treatment plant to ensure complete perchlorate treatment.

The downstream equipment operated effectively to produce effluent water that met all drinking water standards established under the Federal Safe Drinking Water Act and the California Code of Regulations, Title 22 requirements. The post-aeration vessel raised the dissolved oxygen concentrations from less than 1 mg/L to above 7.5 mg/L consistently at an HRT of 8 minutes. The addition of 1 mL/min (0.4 gpd, 2.5 mg/L dose) of the 48% aluminum sulfate and 4 mL/min (1.5 gpd, 0.17 mg/L dose) of the 0.8% cationic polymer were found optimal for effective filtration to less than 0.1 NTU, resulting in six adsorption clarifier flushes per day and one multimedia filter backwash per day. The LGAC pressure drops were minimal (<1 psi), biomass clogging was not observed for the duration of the LGAC use, and color and/or odor issues (microbiological in origin) in the LGAC effluent were never detected.

Using on-site instrumentation and off-site laboratory analyses, the data collected to demonstrate treatment effectiveness of the downstream surface water treatment equipment included both primary and secondary MCL requirements: organics, inorganics, metals, disinfection byproducts, total coliform, *E. coli*, heterotrophic plate counts, dissolved and suspended solids, alkalinity, pH, and color. All data met the established Quality Assurance/Control guidelines established prior to the commencement of the demonstration. The system was tested and operated under various conditions, including steady-state operation, feed water restart, plant restart, and during the spiking study at 1,000 µg/L, 2,000 µg/L, and 2,500 µg/L. Regardless of the operating condition (i.e., steady-state, feed restart, plant restart, etc.), at feed concentrations up to 1,000 µg/L of ClO_4, all of the State of California regulatory limits for potable water were met. For the spiking studies above 1,000 µg/L ClO_4, all regulatory limits were met with the exception of perchlorate that exceeded the State of California MCL. If more time was afforded the spiking study, this level of perchlorate would have been treated as the biomass acclimated to the higher loads.

Concerns about the potential pathogenic microbiological carryover from the FBR through the entire FBR treatment plant and the possible subsequent disinfection by-product formation potential prompted their measurement. Across the plant, the levels of *E.Coli* were always below the Minimum Detection Limit (<1.0 Most Probable Number/100 mL). The heterotrophic plate count and total coliform data varied, but clearly the heterotrophic plate counts and total coliform were higher from the FBR effluent than the Trimite multimedia filter effluent. In treating the Trimite multimedia filter effluent microbiology, the chlorination and UV studies demonstrated a 3-4 log removal of heterotrophic plate count and complete removal of total coliform at a CT of 4 mg-min/L and a UV residence time of 6 seconds (at a minimum dose of 40 mJ/cm^2). For all measurements of disinfection by-product formation potential under various operating conditions, plant effluent never exceeded 30 µg/L of either total trihalomethanes or haloacetic acid 5 (below the State limits of TTHMs and HAA5 at 80 and 60 µg/L, respectively).

The use of on-line instrumentation to measure nitrate-nitrogen and perchlorate simultaneously at the feed and effluent of the FBR system was effectively performed. Both on-line analyzers met their objective of providing reliable, consistent data. A number of issues were seen throughout the course of the demonstration with both types of on-line analyzers. For the perchlorate analyzer, matrix interference at higher feed concentrations occurred, differing instrument operating characteristics resulted in differences between on-line and off-site laboratory perchlorate measurements, and guard and analytical column replacement were required. For the nitrate analyzers, these issues included solids interference with parameter measurement, mechanical and process issues, and recalibration issues.

Four electron donor reduction experiments were conducted to demonstrate the correlation between nitrate-N removal and perchlorate removal. During the different experiments, the electron donor was reduced to the FBR to observe the nitrate effluent concentration for which the perchlorate concentration would exceed the State of California MCL. Using the on-line nitrate and perchlorate analyzers, the results of the four experiments concluded that as nitrate-N levels approached near 0.3 mg/L, perchlorate concentrations were observed to exceed the State of California MCL. The on-line analyzers demonstrated their effectiveness to accurately measure both nitrate and perchlorate during short intervals of sampling. However, though it is possible to control the FBR effluent nitrate-N concentrations at or below 0.3 mg/L, both instruments are recommended for the first full-scale application.

Long-term operation of the system (greater than six months) allowed for the assessment of the capital and typical operating costs associated with the technology. A cost model was developed for the demonstration. However, a number of caveats were required in the development of the model. This demonstration involved designing, engineering, and fabricating a “first-of-its kind” complete biological perchlorate treatment system to produce drinking water. Project management and design costs were significantly influenced by the labor required to implement this initial system. Additional labor and monitoring were also required for the scientific experiments conducted during the demonstration that would not be necessary for a typical operating plant. Chemical and labor costs were not indicative of typical operating costs because the chemicals were utilized in small batches, while the labor was conducted through an engineering firm. These higher costs are reflected in the model and exceed the actual costs required to operate a typical scaled-up plant. Costs reflected in the model demonstrate that the concentration of contaminants is the critical factor in determining reactor size and chemical usage. As the oxygen, nitrate, and perchlorate increase in concentration, the size of the reactor and chemical usage increases.

A cost analysis comparing the FBR treatment system to the traditional ion exchange (IX) throw-away resin system has been conducted. The two technologies are compared using contaminant concentrations of nitrate at 28 mg/L, oxygen at 6 mg/L, and perchlorate at 50 µg/L, 270 µg/L, and 1000 µg/L. Though difficulties arose in comparing the technology costs for applications because all costs are not accounted equally, a general analysis of the life-cycle capital and operating costs has been undertaken and trends discovered as they relate to different perchlorate concentrations. Life-cycle capital costs for IX are lower compared to the FBR treatment system at all three perchlorate concentrations treated ($17-$546/kg of perchlorate treated compared with $103-$2,069/kg of perchlorate treated). Operating costs are comparable at the lower perchlorate concentration of 50 µg/L (FBR: $2,421/kg of perchlorate treated, IX: $2,202/kg of perchlorate treated). At a perchlorate concentration of 270 µg/L, the FBR treatment system operating costs ($450/kg of perchlorate treated) shown to be significantly lower than the IX operating costs ($767/kg of perchlorate treated). This tips the overall economics of total cost for treatment slightly in favor of the FBR treatment system ($833/kg of perchlorate treated) compared with the IX system ($868/kg of perchlorate treated). The cost-effectiveness of using the FBR treatment system over IX is even greater at a perchlorate concentration of 1000 µg/L. At this concentration, the total life-cycle costs for the FBR treatment system are $226/kg of perchlorate treated, while the IX system is $369/kg of perchlorate treated.

Considerable process development has been implemented in the design of the FBR treatment plant to ensure a consistent supply of potable water. Using only NSF-60 compliant additives, constant on-line instrumentation to ensure contaminant removal, and a sophisticated electron donor addition model to adequately monitor and respond to process changes/requirements, this demonstration project has proven the FBR treatment system to be a robust, dependable treatment technology for perchlorate treatment. The implementation of such a “first-of-its-kind” technology to treat contaminated groundwater, rather than simply rely on phase transfer, to drinking water standards can serve as a new paradigm of water treatment for significantly impaired resources. With quality supplies of water rapidly declining throughout the United States, and existing supplies often hindered by multiple contaminants, the implementation of such a biological treatment plant can be cost-effective for multiple contaminant removal to drinking water standards.

1.0 Introduction

This Environmental Security Technology Certification Program (ESTCP) project (#200543, Contract # W912HQ-06-C-0009) is a collaborative effort amongst scientists at Basin Water, Inc. (San Diego, CA and Lawrenceville, NJ offices) and personnel from the City of Rialto (Rialto, CA). The objective of this project is to demonstrate the applicability of a full-scale fluidized bed biological reactor (FBR) system in the treatment of perchlorate laden groundwater to potential drinking water standards.

The demonstration project was performed at Rialto Well #2, a drinking water well owned by the City of Rialto which has been inactive for the past ten years because of perchlorate contamination. A complete treatment train system to remediate the perchlorate from the groundwater to produce drinking water was installed and included a fluidized bed biological reactor (FBR), a post-aeration tank, a multimedia filter, a liquid granular activated carbon (LGAC) tank, and an ultraviolet (UV) light reactor. Throughout this document, the complete treatment train will be called out as the “FBR treatment system.”

Currently, the FBR technology is one of two treatment technologies listed within the California Code of Regulations as a Best Available Control Technology for treating perchlorate-contaminated water to drinking water (CCR, Title 22, Chapter 15, Section 64447.2). This treatment approach is mature and is anticipated to be widely applicable and cost-effective for *ex situ* remediation of perchlorate laden groundwater at both Department of Defense (DoD) and non-DoD facilities.

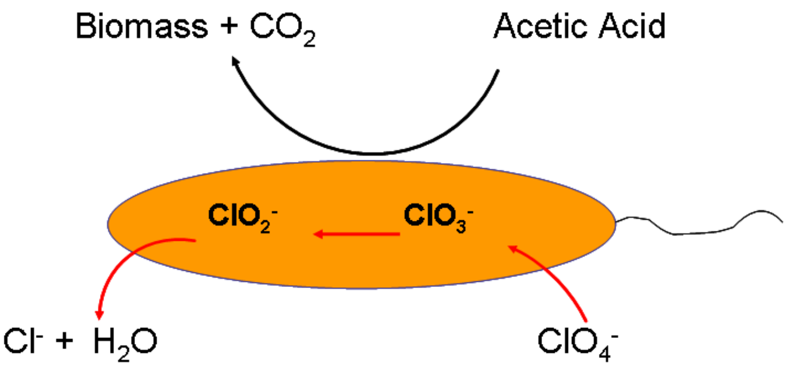
1.1 Background

Perchlorate is a highly soluble salt-anion that can negatively affect the ability of the human thyroid to adequately uptake iodine. Since early 1997, with the improvement of analytical techniques, drinking water testing performed throughout California has revealed contamination in several regions of the state at levels as low as 4 µg/L. The majority of the perchlorate contamination in groundwater is believed to be attributable to historical disposal practices by the aerospace and ordinance industries, the military, and chemical manufacturers. Perchlorate salts have been used in the U. S. defense and space programs for several decades as primary oxidants in the solid propellants that power rocket motors, rocket boosters, and missiles. In past disposal practices, solid perchlorate-containing fuels were often burned in open-burn and open-detonation areas, and aqueous processing waters or wastewaters were released to surface soils or discharged into lagoons or evaporation ponds. With such past disposal practices and the mobility of the anion, a number of drinking water aquifers throughout the state have been contaminated with perchlorate.

Numerous bacteria capable of biologically degrading perchlorate have been isolated over the past six years (Coates and Achenbach, 2004; Zhang et al., 2002). Such bacteria appear to be nearly ubiquitous in soil, groundwater, surface water, and sediment environments (Coates et al., 1999;

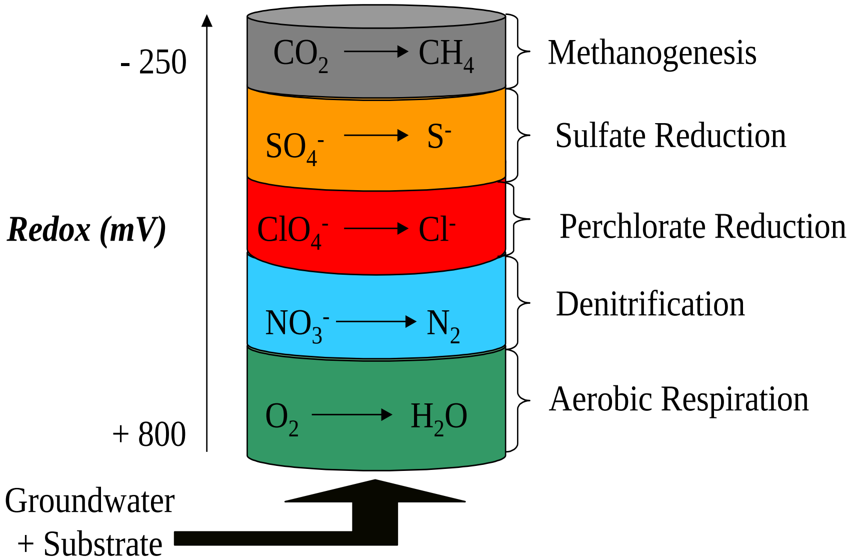
Wu et al., 2001). Through anaerobic respiration, perchlorate-reducing organisms couple the oxidization of an organic substrate (or in some instances hydrogen gas) to the reduction of perchlorate (Kengen et al., 1999; Song and Logan, 2004; Zhang et al., 2002). This respiratory process, which produces chloride and oxygen as degradation products, closely resembles dissimilatory nitrate reduction, where nitrate is reduced to nitrogen gas (Figure 1.1).

Figure 1.1 Biological treatment of perchlorate.



In order to ensure that the perchlorate degrading organisms can effectively treat large volumes of perchlorate laden groundwater to desired levels, the organisms must be maintained at a high density with sufficient contact time. Several fixed film bioreactors exist that allow for high density growth and sufficient contact time to treat the perchlorate. Two of these reactors include the fixed bed bioreactor and the fluidized bed bioreactor. The fixed bed bioreactor is a perchlorate treatment system that allows for a one pass of the feed water through the reactor medium, usually carbon or plastic (Brown et al., 2005). Such a technology requires that the system be shut down for occasional backwashing of the media. For the FBR, the biological media is suspended or fluidized within the reactor vessel by a recirculating water flow upward through the system. Although various media have been tested, usually sand or granular activated carbon is used in these systems for microbial growth attachment. Because the media particles are small and suspended, they present a large surface area for microbial growth and promote a biomass density that is often several times that of other bioreactor designs under similar loading conditions (U.S. EPA, 1993; Sutton and Mishra, 1994). A precise amount of electron donor (i.e., acetic acid) is provided to the FBR where, under anoxic conditions, the attached microorganisms perform an oxidation/reduction reaction in consuming all of the dissolved oxygen, nitrate, and perchlorate (Figure 1.2). The precise amount of electron donor addition allows for complete perchlorate reduction while minimizing the subsequent processes of sulfate reduction or methanogenesis within the FBR. The byproducts of the treatment process are nitrogen gas, chloride ions, carbon dioxide, heat generation, and additional biomass. Unlike phase transfer technologies such as ion exchange, the FBR technology completely destroys the perchlorate. The complete destruction of the perchlorate ion ensures that it will no longer be an environmental hazard for future generations.

Figure 1.2 Theoretical biological treatment process within the FBR.



1.2 Objectives of the Demonstration

For this project, the contaminated groundwater is extracted from the Rialto Well #2 at 50 gpm and biologically treated (destroying essentially all feed perchlorate and nitrate), via anoxic nitrate and perchlorate reduction, through the FBR. The water is then passed through a post-aeration unit operation, where the oxygen concentration is increased. Additional downstream equipment includes a multimedia filter capable of performing solids removal, a liquid granular activated carbon system for color and odor removal (and as a final plant treatment backup, not required), a back flush/effluent tank system capable of storing backwash water for the multimedia filter system and effluent water that has not reached full-treatment, and an UV reactor for microbial disinfection.

The main objective of this project is to demonstrate the efficacy of the full-scale FBR for the treatment of low concentrations of perchlorate in groundwater to the current Maximum Contaminant Level (MCL) for perchlorate established in the State of California of 6 µg/L. This project is set up to test and validate the following: (1) *ex situ* bioremediation of nitrate and low concentrations of perchlorate contaminated groundwater through a fluidized bed bioreactor via an anoxic biological coupling reaction using an added electron donor; (2) the short- and long-term performance effects in allowing the system to be self-inoculated with the incoming groundwater versus manually inoculating with a non-pathogenic microbial consortium that has been developed in other FBR perchlorate treatment units; (3) the resulting short-term performance effects in the simulation of both a feed pump failure (i.e., system remains in recycle) and an electrical shutdown; (4) the use of a post aeration vessel, multimedia filter, and

LGAC to produce a potable-like effluent water stream; (5) the operational effectiveness of on-line nitrate and perchlorate analyzer systems; (6) a comparison of system effluent disinfection through both chlorination and UV; and (7) long-term monitoring of system robustness and performance under steady-state and spiking perchlorate concentrations.

A critical issue in applying such a treatment technology is qualifying the system robustness in effectively operating under various loading conditions. This demonstration study focuses on the effects on system performance due to low perchlorate concentrations, self-seeding of the reactor, and short-term interruptions in system operation. Such effects have not been evaluated with any of the full-scale FBR systems currently in operation across the United States. The study also evaluates the operation of the FBR treatment system in conjunction with additional downstream equipment in producing potable-like water.

Another key aspect of this study is to demonstrate the robustness and operational efficacy in the utilization of an on-line nitrate analyzer in conjunction with an on-line perchlorate analyzer to effectively measure contaminant removal across the FBR. The use of these continuous on line analyzer systems has not been attempted at any other biological field application or project in treating nitrate and perchlorate. A comparison of the influent/effluent nitrate measurements will be made with the influent/effluent perchlorate measurements under various operating scenarios. Based on historical practice from other prior FBR applications, when inlet nitrate concentrations are substantially higher than perchlorate concentrations (by at least 10X-100X), nitrate removal has shown to be an excellent marker for the removal of perchlorate. There is interest in demonstrating the degree to which such a correlation exists. Basin Water, Inc. will strive to determine, based on varying levels of nitrate in the FBR effluent, at which point perchlorate is first detected. This point will serve as an upper nitrate boundary concentration not to be exceeded in the FBR effluent. Using a combination of these nitrate analyzers with the on-line perchlorate analyzer will allow for such a study to be effectively conducted in real-time. The ultimate objective from such a study is to demonstrate that the use of two nitrate analyzers alone for such a biological system provide adequate instrumentation to demonstrate perchlorate removal. Thus, possibly eliminating the necessity of an on-line perchlorate analyzer on such biological drinking water applications where nitrate concentrations far exceed perchlorate concentrations.

Finally, long-term (over one year) robustness and performance data will be collected to assess the FBR treatment systems effectiveness at steady-state and spiking perchlorate concentrations. The higher, spiking perchlorate concentrations added to the FBR feed water will replicate the source plume at the Rialto Army Storage Point. The subsequent treatment of such a feed stream by the FBR treatment system provides the necessary data for the next step in scale-up, design, and implementation.

From these objectives, design data and cost information for the development of a full-scale application will be generated. Such data will be used as a comparison to other traditional perchlorate treatment technologies.

1.3 Regulatory Drivers

There is currently no federal drinking water standard MCL for perchlorate. However, a draft toxicological review on perchlorate was released in 2002 by the U.S. Environmental Protection Agency (USEPA). This review proposed a reference dose (RfD) of 0.03 µg perchlorate/kg body wt/day, equating to a safe drinking water level of approximately 1 µg/L (U.S. EPA, 2002). In 2005, after a review of data by the National Academy of Sciences, it was suggested that a standard of 6 µg/L be established. A federal drinking water standard for perchlorate is not likely for several years to come, though several states have set their own advisory levels, including New Mexico (1 µg/L), New York (5 µg/L), Arizona (14 µg/L), Nevada (18 µg/L), and Maryland (1 µg/L) (Hatzinger, 2005). In July, 2006, Massachusetts became the first state to set an MCL at 2 µg/L (Massachusetts DEP, 2006). California followed in 2007 with the establishment of an MCL of 6 µg/L. Despite the absence of federal regulation, these States have taken a pro-active approach to remove any drinking water well from service where these advisory levels or MCLs are exceeded. Often is the case, this water must be replaced with other outside sources (i.e., bottled water, imported surface water, etc.) at substantially higher costs to the residents in the area. Hence, cost-effective perchlorate remediation technologies are needed to treat such contaminated wells.

2.0 Technology

2.1 Technology Description

For this demonstration, the technology utilized builds upon a number of previously successful fluidized bed biological reactors treating higher concentrations of perchlorate laden groundwater (see Section 2.2 for historical development). The reactor vessel utilized in this study is a 3.0-foot diameter by 17 foot high, stainless steel tank, capable of treating 50 gallons per minute (gpm) and possibly higher flowrates. The contaminated feed water is pumped from the wellhead and fed directly into a recycle line of the reactor. The feed and recycle water enters the vessel through an inlet header at the bottom of the reactor and is distributed through lateral piping and nozzles (Figure 2.1). The fluid passes upward through the media bed consisting of granular activated carbon, causing the media to hydraulically expand approximately 28% of the settled bed height. Through a self-inoculating process from the contaminated feed water, microorganisms attach on to the fluidized media. Adequate quantities of electron donor (i.e., acetic acid) and nutrients are added to the reactor. Utilizing this electron donor and the nutrients, the attached microorganisms perform an oxidation/reduction reaction in consuming all of the dissolved oxygen, nitrate, and perchlorate. As the microorganisms grow, the amount of attached microbes per media particle also increases. Since the microbes primarily consist of water, the volume of the microbe/media particle increases, but the specific density decreases (Figure 2.2). This allows the media bed to expand and fluidize further such that longer hydraulic retention times can be achieved for contaminant removal. The treated fluid flows into a submerged recycle collection header pipe and the effluent collection header pipe at the top of the reactor. A portion of the fluid exits the FBR system to a post-aerator while the balance is recycled back to the suction of the influent pump. An in-bed biomass separation device controls bed height growth by physically separating biomass from the media particles. Typically, a bed expansion of 40-60% of the settled bed height is targeted. Any excess biomass that is separated from the media exits the system through the effluent collection system.

After the FBR vessel, the water is treated through a number of post-treatment steps (Figures 2.3 and 2.4). Through the post-aerator vessel, the level of dissolved oxygen is increased via sparging of ambient air through the water. The effluent from the post-aerator passes through a multimedia filter where solids are removed through a clarifier and media chamber. If necessary, flocculating agent and coagulant can be added to the post-aerator effluent water prior to the multimedia filter. This chemical addition allows for more efficient suspended solids removal by the multimedia filter. The effluent from the multimedia filter then passes through a liquid granular activated carbon tank to remove any color and odor causing compounds and to serve as a final polishing step for the overall treatment train. A back flush/effluent tank system capable of storing backwash water for the multimedia filter system and effluent water that has not reached full-treatment is also a part of the treatment system. To meet the final requirements of potable water production, a slipstream of the water will be passed though an UV reactor to adequately disinfect the effluent of microorganisms. The disinfection capabilities of such a reactor will be compared and combined with results from a chlorination study that will also be demonstrated on the effluent water.

Figure 2.1 Schematic of fluidized bed bioreactor.

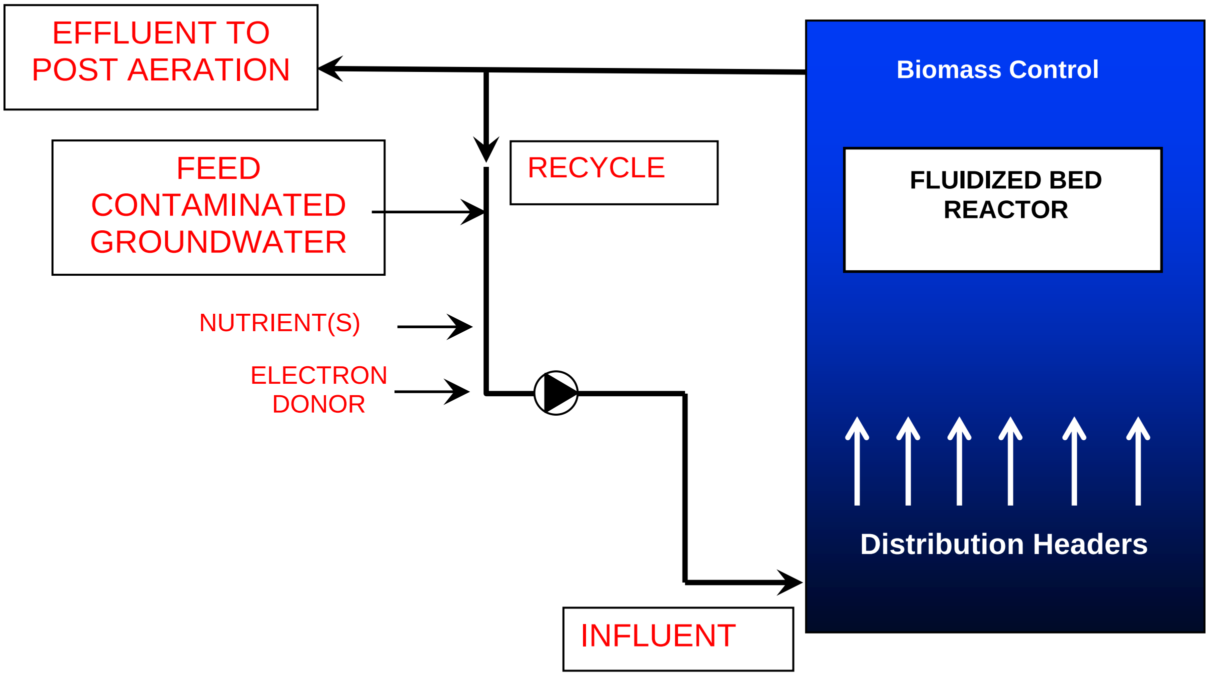


Figure 2.2 Hydraulic and biological expansion of media.

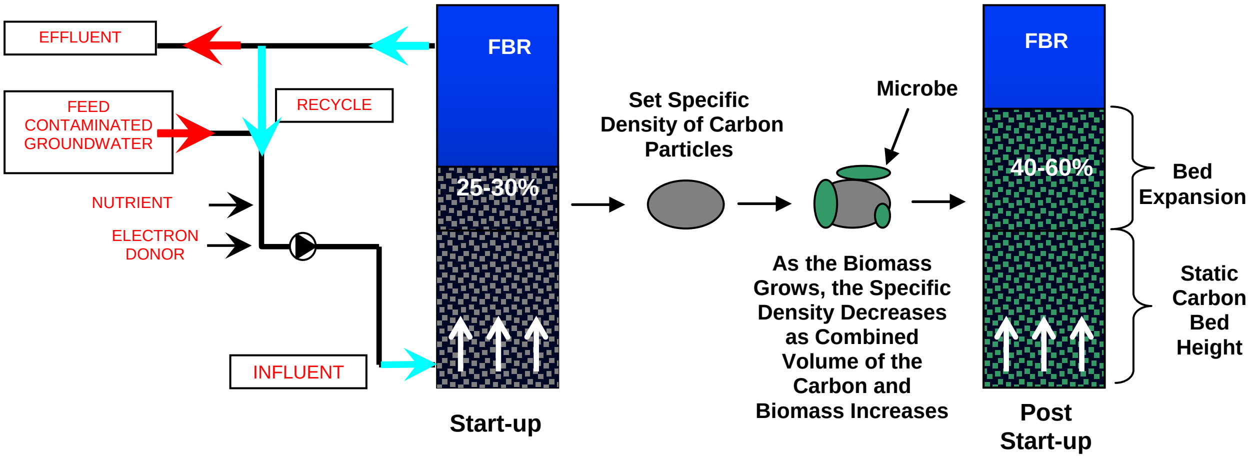
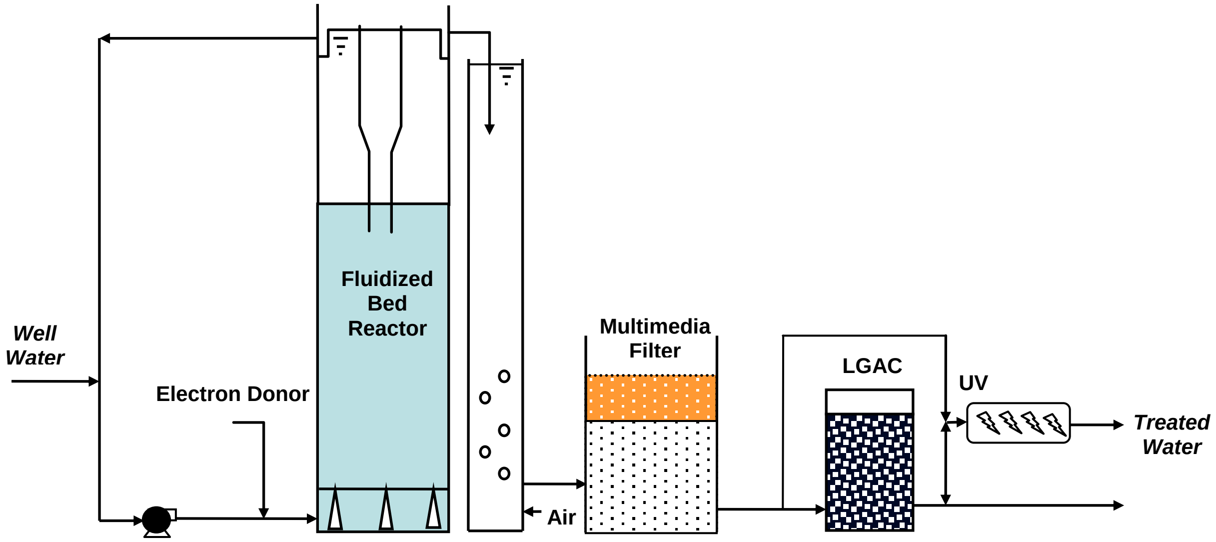


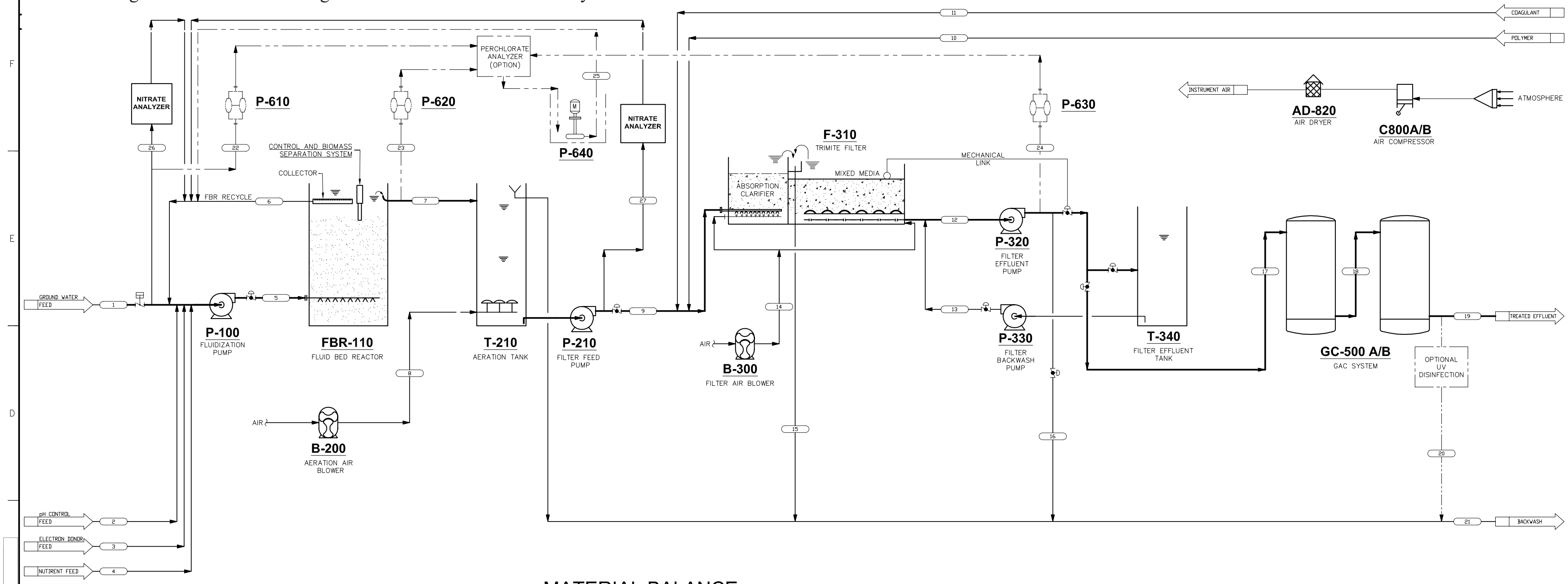
Figure 2.3 Schematic of FBR treatment plant.



The key design criteria for this FBR treatment system include: (1) oxygen, nitrate, and perchlorate feed conditions and removal rates; (2) FBR electron and nutrient donor addition rates; (3) contaminated water feed flow rate; (4) oxidation reduction potential and pH changes; (5) media bed expansion levels and rates of expansion; (6) post aeration blower requirements; (7) flocculating and coagulant addition rates; (8) multimedia backwash frequency; (9) LGAC utilization rate; (9) the chlorination CT values (chlorine concentration multiplied by the contact time) for the inactivation of microorganisms to achieve disinfection; and (10) the UV system dosing rates required to effectively inactivate the microbial population to drinking water standards. Using the feed contaminant concentrations and flows (via on-line analyzers), based on stoichiometric biodegradation rates, feed-forward control logic is established to automatically set the electron donor and nutrient feed addition rates. Through the use of the on-line nitrate and perchlorate analyzers, feed-back control logic will also assist in refining the electron and nutrient donor rates, as well as shut the feed flow down should complete treatment of the contaminants not occur.

There are many potential applications of the FBR groundwater treatment train system. The produced effluent water will meet all of the requirements of Title 22 as established in the California Code of Regulations. This water will be available for groundwater recharge or a domestic water treatment permit could be applied. When such a permit is granted, this water could then be used for distribution to the public water supply.

Figure 2.4 Process flow diagram for the FBR treatment train system.



MATERIAL BALANCE

Values During Effluent Discharge		Line Number																										
Characteristic		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
FLOW (NOTE 4)	gal/min	50	-	-	-	90	39.7	50	-	50	-	-	48.6	(NOTE 5) 1.7	-	(NOTE 7) 1.4	(NOTE 10) 0.3	48.3	48.3	33.3	15	(Note 11) 16.7	(NOTE12) 1.0	(NOTE12) 1.0	(NOTE12) 1.0	<0.3	0.01	0.01
ClO_4 (NOTE 3)	ug/L	0.07	-	-	-	0.04	<0.004	<0.004	-	<0.004	-	-	<0.004	<0.004	-	-	-	<0.004	<0.004	<0.004	<0.004	-	0.07	<0.004	<0.004	NOTE 13) 0.02	0.07	<0.004
$NO_3 - N$ (NOTE 3)	mg/L	5.9	-	-	-	3.3	<0.1	<0.1	-	<0.1	-	-	<0.1	<0.1	-	-	-	<0.1	<0.1	<0.1	<0.1	-	5.9	<0.1	<0.1	(NOTE 13)	5.9	<0.1
DISSOLVED OXYGEN (NOTE 3)	mg/L	4	-	-	-	2.2	<0.1	<0.1	-	>5	-	-	>5	>5	-	-	-	>5	>5	>5	>5	-	4	<0.1	>5	(NOTE 13)	4	>5
TSS	mg/L	0	-	-	-	1.8	4	4	-	4	-	-	<0.2	<0.2	-	-	-	<0.2	<0.2	<0.2	<0.2	-	0	4	<0.2	(NOTE 13)	0	<0.2
TSS	lbs/day	0.0	-	-	-	-	-	2.4	-	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(NOTE13&8)	-	-
NUTRIENT (NOTE 1)	gal/day	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COAGULANT FEED	gal/day	-	-	-	-	-	-	-	-	-	-	(NOTE 6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ELECTRON DONOR (NOTE 2)	gal/day	-	-	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
POLYMER FEED	gal/day	-	-	-	-	-	-	-	-	-	(NOTE 6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH CONTROL FEED	gal/day	-	(NOTE 6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AIR	scfm	-	-	-	-	-	-	-	10	-	-	-	-	-	(NOTE 9) 22	-	-	-	-	-	-	-	-	-	-	-	-	-

GENERAL NOTES:

1. FLOW IS FOR 75% PHOSPHORIC ACID.
2. FLOW IS FOR 50% ACETIC ACID.
3. UNLESS STATED OTHERWISE, CONCENTRATIONS ARE AVERAGE DESIGN CONCENTRATION FOR THE RIALTO #2 WELL.
4. UNLESS STATED OTHERWISE, FLOWS ARE AVERAGE FLOWS FOR THE RIALTO #2 WELL.
5. AVERAGE FLOW INDICATED (BASED ON 1 BACKWASH PER DAY). INSTANTANEOUS FLOW = 180 GPM MAXIMUM
6. COAGULANT, pH CONTROL CHEMICAL, AND POLYMER FEED AS REQUIRED.
7. AVERAGE FLOW INDICATED (BASED ON 1 BACKWASH AND 2 CLARIFIER FLUSHES PER DAY). INSTANTANEOUS FLOW 180 GPM MAXIMUM.
8. SOLIDS FILTERED PRIOR TO ANALYSIS.
9. DURING CLARIFIER FLUSH/BACKWASH CYCLE, RESPECTIVELY.
10. AVERAGE FLOW INDICATED. INSTANTANEOUS FLOW – 50 GPM MAXIMUM.
11. AVERAGE FLOW INDICATED.
12. FLOW WHEN SAMPLE LINE IS BEING PURGED AND USED FOR SAMPLE COLLECTION. COMBINED SAMPLE FLOW IS APPROXIMATELY 360–400 GALLONS PER DAY.
13. COMPOSITION OF SAMPLE WASTE DEPENDS ON SAMPLE BEING COLLECTED.

GENERAL NOTES:

1. REFERENCE P&ID LEGEND SHEETS PID–LA & –LB.

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
△				
△				
0	6–16–06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

DRAWING SCALE NONE
DESIGNED BY/DATE DW/5–18–06
DRAWN BY/DATE JEK/5–18–06
CHECKED BY/DATE DW/5–18–06
SHEET SIZE D
REVISION 0
SHEET 1 OF 1
DRAWING # **PFD-1**
FILE #120466PFD01–0

RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS FLOW DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN
PRODUCTS
Lawrenceville, NJ 08648
609-895-5340
Basin Water

LAST EDITED: 6-13-06 @ LAWRENCEVILLE, NJ
OPERATOR:
COMMENTS:
DM PROJECT #:
PROJECT NAME:

2.2 Technology Development

Currently, there are five full-scale FBR systems that have been designed and constructed by Basin Water, Inc. for perchlorate treatment (Figure 2.5). These reactors are presently treating more than 9 million gallons of groundwater per day at influent perchlorate concentrations ranging from 1,700 to 400,000 µg/L to effluent concentrations of less than 4 µg/L or non-detect values per Method 314.0 (Togna et al., 2001). One system is located at the Aerojet facility in Rancho Cordova, CA. The facility treats up to 5,600 gpm of groundwater using four 14-foot diameter fluidized bed reactors in parallel. Since inoculation and start-up in 1998, these reactors have treated more than 8 billion gallons of groundwater, with influent concentrations averaging approximately 2,500 µg/L to effluent levels consistently below the method detection limit (MDL) of 4 µg/L. A second FBR system is located in Karnack, TX at the Longhorn Army Ammunition Plant where the groundwater is contaminated with volatile organic compounds (VOCs) and perchlorate from past operations at the site (Figure 2.5A). A full-scale FBR (5-foot diameter) system with the capacity to treat 50 gpm is currently operating as designed, producing reactor effluent with less than 4 µg/L of perchlorate from feed concentrations as high as 35,000 µg/L. A third FBR system has been constructed at the McGregor Naval Weapons Industrial Reserve Plant (McGregor TX). This system operates at flowrates up to 400 gpm and the perchlorate influent and effluent concentrations are approximately 2,300 µg/L and 4 µg/L, respectively. A fourth FBR system consists of eight, 14-foot diameter FBRs located at a site in Henderson, Nevada (Delvecchio et al., 2005; Figure 2.5B). These reactors are sequenced such that the influent water flows through sand-based FBRs followed by GAC-based FBRs for polishing. This system treats approximately 1,000 gpm of influent groundwater with perchlorate levels of 400,000 µg/L in the influent to non-detect (per Method 314.0) in the effluent. This system also treats high levels of chlorate and nitrate which are co-mingled with perchlorate at the site. Finally, an 11.5-foot diameter FBR is operating at the Jet Propulsion Lab in Pasadena (Figure 2.5C). This FBR treats up to 350 gpm of groundwater with concentrations of up to 300 µg/L of perchlorate.

Past experience with the biological treatment of perchlorate in fluidized bed bioreactors has primarily dealt with significantly higher perchlorate loads then typically present in drinking water aquifers. Recent studies of both FBRs and packed bed bioreactors have shown that groundwater streams at low levels of consistent perchlorate concentrations (50-300 µg/L) can be readily degraded to less than 4 µg/L (Webster at al., 2004; Brown et al., 2004). Continued research on the FBR is needed to assess the effects the effects of transient, unsteady-state loads (based on lower perchlorate concentrations) on reactor perchlorate removal performance.

Figure 2.5 Three full-scale FBR installations.

2.3 Advantages and Limitations of the Technology

The main advantages of utilizing an FBR for perchlorate treatment are as follows:

- Appreciably reduced operating cost compared to traditional phase transfer technologies such as ion exchange or carbon adsorption.
- Complete destruction of the perchlorate rather than transfer to a secondary medium, such as a resin or granular activated carbon.
- Capable of treating both nitrate and perchlorate in one system to drinking water action levels.
- Unlike other treatment technologies, no need to lower the pH for treatment and then raise the pH of the water for corrosion control.
- Limited space requirements for a complete water treatment system.

Technical risks and limitations inherent to the system are:

- The FBR technology has been effectively proven in the field when the system has been inoculated with a non-pathogenic microbial consortium and the nitrate and perchlorate loading rates were appreciably higher. An issue of concern is the time required to effectively establish a microbial population on the media through the self seeding procedure under the low perchlorate loading conditions (due to low perchlorate concentrations).
- The system robustness and ability to recover quickly from both short-term upset conditions (including spikes of perchlorate) and manually imposed shutdown conditions will need to be determined. A concern is that the system could possibly take several hours to achieve complete perchlorate removal at the low perchlorate loading rates after a system upset. The system requirements to maintain a baseline of microbial activity in the FBR during shutdown (i.e., one week plus) scenarios needs to be addressed.
- The quantity of suspended solids that will be generated from the process and released with the effluent water. Historically, these levels have been in the low 1-2 mg/L range of total suspended

solids. A determination is required on the effectiveness of the downstream multimedia filter to effectively remove the solids to within a range that is acceptable in the effluent water such that it may be used for potable use.

- The ability of the downstream equipment to operate effectively to produce potable-like water quality with minimal operator attention/maintenance. For biological treatment systems and their ancillary components, ease of operation is often a key issue raised.
- The ability of the on-line analyzers to effectively operate and control the treatment process. Such instrumentation for the continuous analysis of the target contaminants has only been used prior in a limited capacity. Since these instruments will be used to regulate the electron donor and nutrient addition to the FBR, their inability to effectively operate may allow for unnecessary excess addition of these chemicals. This could cause potential biogrowth problems downstream of the plant in the distribution lines. The robustness of these instruments and their required maintenance is unknown.
- The effects of chlorination and UV light on the disinfection of the microorganisms that exist in the multimedia filter effluent.

A large number of water agencies presently have drinking water aquifers contaminated with low levels of perchlorate throughout California, as well as in other parts of the United States. Primarily, ion exchange technologies have been used to treat the perchlorate found in this water. These ion exchange systems require a moderate initial capital expenditure, but have extensive operational costs. After a period of time, either the resin requires regeneration, producing a brine stream with perchlorate that requires treatment, or replacement. The replaced resin is generally transferred to an out-of-state treatment center where the resin is further treated to destruct the perchlorate. The additional treatment of the brine or the resin incurs further operational costs not associated with the biological treatment of the perchlorate in the FBR. For example, the capital cost of an ion exchange system (Calgon ISEP System) to treat 2,500 gpm of groundwater in the La Puente Valley County Water District, California was 4.95 million dollars, with a daily operational cost of nearly $1,000 dollars for pumping, system maintenance, and brine disposal (Wagner and Drewry, 2000). The operational costs associated with the FBR include the electron donor, nutrients (if required), electricity to operate the pumps, and manpower for maintenance of the system. The latter two costs are required for both the FBR and the ion exchange technologies. Total ion exchange treatment costs have been estimated to be nearly 60% higher than the total treatment costs for the FBR (California EPA, 2004). FBR operational costs at the Aerojet Facility have been estimated to be $61/AF (Aerojet, 2003). Thus, the FBR treatment technology is mature, expected to be more cost effective compared to ion exchange technologies, destroys the perchlorate on-site (eliminating the possibility of perchlorate leaving the site), has received conditional acceptance as a drinking water technology by the California Department of Public Health, and should be widely applicable for the treatment of groundwater laden with perchlorate at numerous water agencies throughout the United States.

3.0 Performance Objectives

The performance objectives of the demonstration study are provided in Table 3.1.

3.1 Qualitative Objectives

3.1.1 Ability to Treat Multiple Contaminants

The presence and concentrations of oxygen, nitrate, and perchlorate in the feed water as electron acceptors dictates the stoichiometric requirement of electron donor (acetic acid). In addition, an excess amount of electron donor is required to account for electron donor adsorption to the media, incorporation for microbial growth (biomass development), and abiotic losses. Feed groundwater oxygen concentration is measured by a hand-held probe. On site, on-line nitrate and perchlorate instruments, corroborated with off site laboratory analysis, provide FBR feed and effluent results that satisfy a proprietary PLC model to provide forward fee control logic to adequately dose the acetic acid so that all of the oxygen, nitrate, and perchlorate are treated. Complete treatment is demonstrated by these on-line instruments and the lack of contaminant presence in the effluent of the FBR reactor. Throughout this experimental study, simultaneous treatment was demonstrated under varying operational conditions.

3.1.2 Effectiveness of Self-inoculation Procedure

No outside inoculum is provided to the FBR system. The adequate environmental conditions to foster the naturally indigenous bacteria population from the groundwater are established within the FBR system. On site, on-line nitrate and perchlorate instruments, corroborated with off site laboratory analysis, provide evidence that the self-inoculation procedure succeeded. Non-detect nitrate and perchlorate values in the FBR effluent water, coupled with visual observation of microbial growth within the FBR and microbial expansion of the FBR bed, were an indication that the self-inoculation procedure was successful. Less than 28 days were required to demonstrate the successful treatment of the nitrate and perchlorate using only the self-inoculation procedure.

Table 3.1 Performance objectives.

Type of Performance Objective	Performance Criteria	Performance Metrics	Actual Performance Objective Met?
Qualitative	1. Ability to treat multiple contaminants	Nitrate and perchlorate removed	Yes. Simultaneous treatment of nitrate and perchlorate achieved.
	2. Effectiveness of Self-inoculation	Days required to bring system on-line	Yes. Non-detect in less than 28 days
	3. Ease of operation and maintenance	Operator training required, hours logged in maintenance repairs	One operator required daily, part-time. Training required was one month.
	4. Effects of system shutdown and restart	Rebound time to achieve acceptable performance	Yes. Initially, rebound time in 24 hours. After maturation of FBR bed, less than 2 hours.
	5. On line analyzer effectiveness	Ability to continuously measure contaminant concentrations	Yes. Ability demonstrated. Nitrate analyzers require more solids filtering upstream to remain effective.
	6. Reduce treatment costs	Maximize contaminant removal while minimizing chemical addition	Yes. Up to 4,000 µg/L of ClO_4 treatment demonstrated. Electron donor, nutrient, coagulant, and polymer increased accordingly to treat higher loads. Chemical addition rates fine tuned to achieve successful plant performance.
Quantitative	1. Meet drinking water standards produce quality data	<1 mg/L NO_3-N and <6 µg/L ClO_4 (CA MCL) 95% Completeness	Yes. For concentrations up to 6.54 mg/L NO_3-N and 1000 µg/L ClO_4, regulatory standards met. Met data quality objectives
	2. Maximum Conc. Treated/ Maximum Elim. Capacity	4000 µg/L of ClO_4 (consistent concentration) Maximum Elimination Capacity (g/m^3/hr)	At 4,000 µg/L of ClO_4, 99.65% removal attained. At 1,000 µg/L of ClO_4, MCL met. ClO_4= 4,000 µg/L, E.C.= 9.6 g/m^3/hr ClO_4= 1,000 µg/L, E.C.= 2.4 g/m^3/hr NO_3-N= 6.1 mg/L, E.C.= 29.3 g/m^3/hr
	3. Downstream Equipment Effectiveness	oxygen > 7.0 mg/L turbidity < 0.3 NTU odor and color removal 4 log inactivation of viruses 4-5 log inactivation of bacteria TTHMs and HAA5 < MCL	oxygen > 7.0 mg/L turbidity < 0.1 NTU odor and color non-detect 3-4 log inactivation of HPC observed at a CT of 4 or a UV contact time of 6 seconds TTMHs and HAA5 < 13 µg/L and 22 µg/L, respectively
	4. Process Robustness	% downtime min. and max. concentrations treated	6% downtime over first year of operation 45.7 µg/L minimum ClO_4 at 50 gpm 4023 µg/L maximum ClO_4 at 25 gpm

3.1.3 Ease of Operation and Maintenance

This demonstration plant requires an initial troubleshooting period, typically 2-4 months, to assess all issues with steady-state and non-steady state operation. The ability for one operator to manage the daily operation and become familiar with the system operation within this time frame is indicative of the ease of operation for future operators at the full-scale. Daily monitoring sheets and maintenance logbooks provide an indication of the issues that readily appear and are problematic. The overall uptime of the plant for the first year of operation is also indicative of the ease of operation and maintenance required.

Typical with any start-up of a water treatment plant, the first two months were needed to address mechanical, electrical, and process issues. However, the operator attention required substantially declined over the course of the demonstration as the system reliability increased. A 94% up-time was achieved for the first year of operation.

3.1.4 Effects of System Shutdown and Restart

The ability of the FBR treatment system to recover in treatment performance from a number of different shutdown scenarios (i.e., both feedwater and electrical shutdowns) is critical to the efficacy of the system. After shutdowns occur and the restart conditions enacted, the on-line instrumentation is utilized to demonstrate the ability of the treatment plant to rebound in performance. Based on reaching nitrate-N concentrations below 0.2 mg/L and perchlorate below 6 μg/L, the system is considered to have fully rebounded from the shutdown scenario. The length of time between the restart of the system and the time that the regulatory values are reached provides a length of rebound time that can be compared based on differing operating conditions at the time of plant shutdown.

As the plant matured, less time was required for rebound of overall treatment performance. Each successive shutdown/restart experiment shown decreasing rebound time, from 24 hours to less than 2 hours.

3.1.5 On-Line Analyzer Effectiveness

The use of on-line instrumentation to measure nitrate-nitrogen and perchlorate simultaneously at the feed and effluent of the FBR system has not been previously performed. Unknowns exist regarding the robustness of either instrument type. Besides the daily requirements to maintain the instruments, long-term operational requirements are evaluated from a maintenance perspective. This includes the replacement of internal parts, removal and replacement of the instruments themselves, and calibration and reliability issues. In addition, the ability of the instruments to provide timely data on a consistent basis is corroborated by split sample analysis using an outside lab.

Both on-line analyzers met their objective of providing reliable, consistent data. A number of issues were seen throughout the course of the demonstration. For the nitrate analyzers, these included solids interference with parameter measurement, mechanical and process issues, and recalibration issues. For the perchlorate analyzer, matrix interference at higher feed concentrations occurred, differing instrument operating characteristics resulted in differences between on-line and off-site laboratory perchlorate measurements, and guard and analytical column replacement were required.

3.1.6 Reduce Treatment Costs

The ability to optimize the required electron donor, nutrients, coagulant, and polymer to the FBR treatment system can significantly reduce the plant operating costs. Over the course of the year demonstration, the electron donor and nutrient addition rates were refined so as to provide adequate chemicals to the plant to ensure treatment, but not in excess that significant amounts were carried downstream from the FBR to the post-aeration and multimedia filter. Measurements of dissolved organic carbon (DOC) at the FBR effluent, coupled with the on-line nitrate and perchlorate measurements on site, allowed the quantity of acetic acid added to the FBR to be strictly regulated. Similarly, the FBR effluent residual phosphorus was measured using an on-site spectrophotometer. Phosphoric acid addition rates were reduced such that 1 mg/L of phosphate-P was available in the FBR effluent. For the coagulant and polymer, different products, concentrations, and loading rates were assessed for addition to the multimedia filter feed water such that less than 0.1 NTUs could be achieved in the effluent water. Based on the data, the chemical addition rates were refined through the course of the project, providing an economic benefit of operating cost reduction for the future full-scale installation.

3.2 Quantitative Objectives

3.2.1 Meet Drinking Water Regulatory Standards/Produce Quality Data

The FBR treatment system effluent water must meet the drinking water standards established under the Federal Safe Drinking Water Act and the California Code of Regulations, Title 22 requirements. Using on-site instrumentation and off-site laboratory analyses, the data collected included both primary and secondary MCL requirements: organics, inorganics, metals, disinfection byproducts, total coliform, *E. coli*, heterotrophic plate counts, dissolved and suspended solids, alkalinity, pH, and color. The data was scrutinized to meet all data quality objectives. For concentrations up to 6.54 mg/L NO_3-N and 1,000 µg/L ClO_4, all primary and secondary regulatory standards were met under all operating conditions.

3.2.2 Maximum Concentration Treated

The maximum concentration of perchlorate treatable is important in determining eventual scale-up factors for the full-scale design. This treatable concentration is dependent on a number of factors including:

- Oxygen concentration
- Nitrate concentration
- Flowrate
- Temperature
- pH
- Nutrient Concentration

All of these factors are measured using on-line analytical equipment or on-site analyzers. The maximum concentration of perchlorate that was demonstrated to be consistently treated through the FBR was approximately 4,000 μg/L of ClO_4. At this concentration, 99.65% removal was attained. At 1,000 μg/L of ClO_4, the treatment plant treated the perchlorate concentration to less than the MCL of 6 μg/L.

3.2.3 Downstream Equipment Effectiveness

In order for the plant effluent water to meet potable water standards, effective treatment of the FBR effluent water was required from the downstream equipment of the post-aeration vessel, the multimedia filter, LGAC, and UV system. Using on-site analytical equipment and off-site laboratory analysis, a number of parameters were analyzed and measured to ensure the water met potable water regulatory standards. These parameters included:

- Post-aeration oxygen concentration
- Multimedia filter effluent turbidity, metals, inorganics, and organics
- LGAC effluent water color and odor (microbiological in origin)
- Disinfection byproduct formation potential
- Chlorination and UV disinfection log removal of bacteria

Based on the results from the demonstration study, the downstream equipment did prove effective and capable of collectively meeting the potable water regulatory requirements. It was shown that the post aeration system could consistently meet greater than 7 mg/L of dissolved oxygen. The multimedia filter effluent turbidity was less than 0.1 NTU and metals, inorganics, and organics met all primary and secondary drinking water MCLs. The LGAC effluent had no color or odor (microbiological in origin) associated with it. Through the chlorination and UV studies, a 3-4 log removal of heterotrophic plate count was obtainable. No disinfection byproduct formation potential exceeded potable water limits.

3.2.4 Process Robustness

The ability of the FBR treatment system to effectively treat all perchlorate and produce quality drinking water is critical to the viability of the system. The demonstration set out to determine the robustness of the technology to treat a variety of perchlorate concentrations at various loading conditions through process interruptions and a spiking study. Results of these tests shown the system to recover quickly from process interruptions and its ability to treat multiple contaminants under different loading scenarios.

In addition to demonstrating process robustness to treat perchlorate under a variety of loading conditions, the plant must be reliable and not prone to short- or long-term shutdowns. The plant downtime was calculated based on mechanical operation only. If the plant was receiving forward flow and treating perchlorate, then the plant was considered to be in operation. Analyzer downtime was not considered (though documented) as a contributing factor when calculating plant downtime. Also, a number of experiments were conducted where shutdowns were enacted for various studies. These occurrences of shutdowns were not incorporated into the plant's downtime as they were artificially employed. Through operating and maintenance logs, and the PLC continuous plant parameter data logging and acquisition system, plant interruptions were recorded and documented for the entire year of operation. In addition, specific equipment malfunctions were documented and recorded so that a preventive maintenance schedule could be developed for the full-scale plant operation. Based on collected data, the plant had a downtime of 6% of the 349 days it was in operation (or approximately 21 days). This downtime was primarily attributable to a malfunctioning blower on the Trimite multimedia filter, a malfunctioning blower vane on the post-aeration blower, and miscellaneous electrical power interruptions that occurred throughout the year.

4.0 Site Description

This demonstration project was conducted for the City of Rialto (California) on water extracted from the Rialto Well #2 wellhead. This well has been chosen because it is located immediately down gradient of the plume source area and has one of the highest groundwater concentrations of perchlorate of all the domestic water supply wells in the area. The well has a pumping capacity of 2045 gpm and is in close proximity to the State Route 210 highway construction project and numerous groundwater recharge locations.

4.1 Site Location and History

Rialto Well # 2 (City of Rialto) is located approximately four miles north of downtown City of Rialto, San Bernardino County, California. The new State Route 210 skirts the northern end of the well site and it is bounded by Ayala Drive to the west and Easton Avenue to the south (Figure 3.1). The land area consists of approximately 7,800 ft^2. In general, the areas that surround the well are industrial in nature, with the City of Rialto Municipal Airport located less than one mile to the west. With the San Bernardino mountain range to the north, groundwater flows southward towards the well. The existing contamination is speculated to have originated from weapons/explosives manufacturing plants, located within the Rialto Ammunition Storage Point (RASP), which operated in the mid-20th century in the northern part of Rialto-Colton basin (Figure 4.1). Sources of contamination from the RASP now include:

- 160 Acre Parcel- In the early 1950's West Coast Loading corporation operated at the parcel, providing loading, assembly, and testing of munitions containing perchlorate. In 1957, Goodrich purchased the 160-acre parcel site and conducted research, development, and production of missiles on site. In 1966, Goodrich sold the property and subsequently, a number of defense contractors, fireworks manufacturers, and pyrotechnic companies have operated at the site using perchlorate based materials.

- Mid-Valley Sanitary Landfill- The County of San Bernardino has operated the Mid-Valley Sanitary Landfill since 1958. The landfill is a Class III solids waste facility. The landfill was expanded in the late 1990's over the majority of the RASP explosive bunkers. Over the prior 40 years, the bunkers were used by various fireworks and pyrotechnic companies in the storage and manufacture of perchlorate-based products.

- Denova Environmental Site- To the west of the 160-acre parcel is an area that was occupied by an explosive waste treatment, storage, and disposal facility operated by Denova Environmental, Inc. This area was shut down in 2002.

XXXXXXXX

APPROVED BY

CHECKED BY

DRAWN BY

OFFICE

MESA

Figure 4.1 Rialto-Colton Basin contamination.

- 🟦 Rialto Ammunition Storage Point
- 🟩 Denova Environmental Site
- 🟥 160-acre parcel
- ▭ Mid-valley Sanitary Landfill

- ● Maximum Perchlorate = 10,000 ppb, 4/5/06
- ● Maximum Perchlorate = 270 ppb, 2/15/07
- ● Maximum Perchlorate = 140 ppb, 11/17/06
- ● Maximum Perchlorate = 1,400 ppb, 2/14/07

N

Source: Map produced using Google Earth, 2008

June, 2008

LOCATION: City of Rialto

Map of Rialto-Colton Basin and City of Rialto Well #2

Tabloid_Landscape_Template.mxd

4.2 Geology/Hydrogeology

The northern two-thirds of the City of Rialto overlie the Rialto-Colton Groundwater basin. Rialto Well #2 is located with the Rialto-Colton Basin. The Rialto-Colton Basin generally consists of alluvial sediments, with groundwater typically at depths of 450 feet or more. The basin is bounded by the San Jacinto Fault on the northeast, the Rialto-Colton Fault on the southwest, the San Gabriel Mountains on the northwest and the Santa Ana River on the southeast. Groundwater flows northwest to southeast toward the Santa Ana River. At approximately halfway in the basin, groundwater flow turns toward the west and passes over the southeastern extent of the Rialto-Colton fault into North Riverside and Chino Basin with the remainder of flow going to the Santa Ana River.

The aquifer system beneath the 160-acre parcel consists primarily of coarse to medium sand, silt and clay with a thickness of 160 to 600 feet (Wolfenden and Kadhim, 1997). Three continuous aquifers exist beneath the RASP and 160-acre parcel. They consist of an upper aquifer (Zone A), an intermediate aquifer (Zone B), and a deep aquifer (Zone C). The majority of water utilized for potable water is pumped from the Zone C aquifer that has a depth from 478 to 700 feet (GLA, 1997, 2003, 2005). The aquifers are separated by aquitards ranging from one to thirty feet in depth.

4.3 Contaminant Distribution

Prior to the start of the perchlorate treatment plant at Rialto Well #2 in early, 2007, concentrations of perchlorate upgradient had been measured as high as 10,000 µg/L (Geosyntec Consultants, 2007) from a groundwater monitoring well located in the 160-acre parcel. Between 2005 and 2007, maximum perchlorate concentration levels have been documented throughout the Rialto-Colton basin (Figure 4.1). In addition, trichloroethylene (TCE) concentrations throughout the basin have been measured and varied from non-detect to 420 µg/L (in the 160-acre parcel).

During the course of the demonstration (March, 2007 to March, 2008), various contaminant parameters were measured:

- the feed perchlorate concentrations ranged from 49.5 to 64.1 µg/L
- the nitrate-nitrogen concentrations remained steady at 5.46 to 6.41 mg/L
- the feed water to the FBR contained oxygen rich water near or at saturation
- organic analysis demonstrated no other detectible co-contaminants besides TCE. Limited analysis demonstrated TCE concentrations at 4.4 µg/L in July, 2007 and 3.1 µg/L in February, 2008

5.0 Test Design

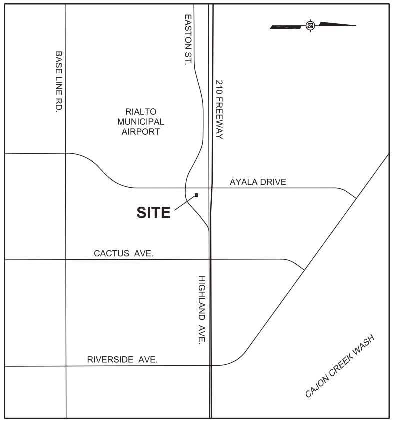
5.1 Conceptual Experimental Design

The California Department of Public Health (CADPH) has adopted the FBR technology as one of two Best Available Control Technologies for the treatment of perchlorate-contaminated water to potable water (CCR, Title 22, Chapter 15, Section 64447.2). A number of operational and performance-based conditions have been imposed on the FBR treatment train in producing drinking water (Appendix B). These conditions were established as minimum requirements to obtain an operating permit that allows the system effluent water to enter into a drinking water distribution network. The system in this study was being used for research purposes only, so a permit for distribution was not requested. However, the CADPH suggested that the conditions required for a potential permit application be demonstrated at this smaller scale. Such actions would then allow the City of Rialto to potentially request a permit for a larger full-scale system without the necessity of demonstrating the various aspects of the conditions. For this reason, this study focused on demonstrating: (1) the bioremediation of nitrate and perchlorate contaminated groundwater to current method reporting limits through a fluidized bed bioreactor with an added electron donor; (2) the short- and long-term performance effects in self-inoculating the system with the incoming groundwater; (3) the resulting short-term performance effects in the simulation of both a feed pump failure and an electrical shutdown; (4) the use of on-line, nitrate and perchlorate analyzers to continuously monitor the system treatment performance and to provide feed-forward control of the electron donor addition; (5) the use of a post aeration vessel, multimedia filter, and liquid granular activated carbon (LGAC) to produce a potable-like effluent water stream; and (6) the disinfection effects via chlorination and ultraviolet light on the system effluent.; and (7) long-term monitoring of system robustness and performance under steady-state and spiking perchlorate concentrations.

The FBR treatment system was operated in the City of Rialto (California) on water extracted from Rialto Well #2 (Figure 5.1). The system operation period of the demonstration lasted approximately 12 months. The first two months focused on performance optimization of the system. Over the next four months, studies were conducted to investigate system shut down scenarios, longer term operation and performance issues, and the effectiveness of chlorination and UV disinfection. During the final six months, the long-term system operation and performance issues were further studied and perchlorate spiking experiments conducted.

During the first eight months of the demonstration study, approximately 50 gpm of contaminated groundwater was biologically treated via anoxic nitrate and perchlorate reduction through the FBR treatment system. During the spiking study, over the last four months of the demonstration, only 25 gpm of contaminated groundwater was treated through the FBR. This reduction in flow was necessary to ensure complete treatment of the spiked perchlorate concentrations. After treatment, this perchlorate and nitrate free water was made available for groundwater recharge.

Figure 5.1 Rialto Well #2 site map.



VICINITY MAP

SCALE
0 2000 4000 FEET

SITE LOCATION

SCALE
0 500 1000 FEET

RIALTO WELL #2
(LOOKING WEST)

RIALTO WELL #2
(LOOKING NORTH)

RIALTO WELL #2
(LOOKING NORTHWEST)

CATCH BASIN
(ON AYALA AVENUE)

6-IN. PIPE DISCHARGE
(LOOKING SOUTH)

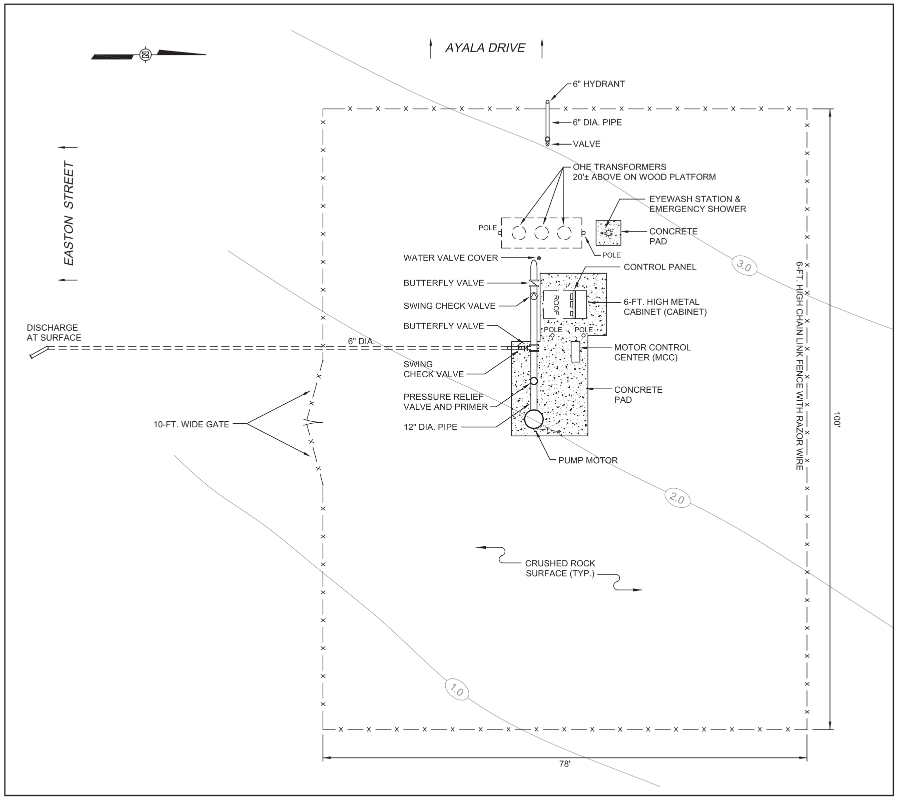
HYDRANT ON WEST SIDE
(OUTSIDE FENCE)

PUMP
(LOOKING WEST)

PUMP
(LOOKING NORTHEAST)

CONTROL PANEL
(LOOKING EAST)

SITE PHOTOS



SITE PLAN

SCALE
0 10 20 FEET

ABREVIATIONS

MCC	MOTOR CONTROL CENTER
OHE	OVERHEAD ELECTRICAL

NOTES

1. CONTOURS SHOWN AS 3.0 ARE ASSUMED AND INTENDED TO INDICATE THE SLOPE OF THE SITE ONLY. DO NOT USE THESE CONTOURS FOR GRADING OR ESTIMATING EARTHWORK QUANTITIES.
2. DRAWING IS INTENDED FOR PRELIMINARY PLANNING PURPOSES ONLY. DIMENSIONS, LOCATIONS, AND EQUIPMENT SHOWN ARE APPROXIMATE AND MAY NOT BE COMPLETE.

PRELIMINARY -
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DATE OF ISSUE MAR. 2006 DWN BY K. BLACK DES BY M. WILLIAMS CHK BY M. WILLIAMS APP BY

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

ENVIROGEN
PRODUCTS
Basin Water

CITY OF RIALTO
RIALTO WELL #2
SAN BERNARDINO COUNTY, CALIFORNIA
SITE PLAN

DRAWING NO.
1
PROJECT NO.
120466

Traditionally, biological treatment of water has been solely focused in the wastewater treatment arena. Through this study, the efficacy of a biological treatment system to produce drinking water was to be demonstrated.

5.2 Baseline Characterization

To determine suitability to biological treat the wellhead water and establish FBR treatment plant initial operating parameters, a baseline characterization of the groundwater chemistry was conducted in February/March, 2007 (Table 5.1). A sample of the wellhead effluent water was sent to an outside laboratory (EMAX Analytical, Inc., Torrance, CA) for analysis. In summary, the data demonstrated:

- Feed perchlorate and nitrate-nitrogen concentrations at 90.50 µg/L and 7.7 mg/L, respectively. Over the course of the entire demonstration, these measured values were the highest observed to the feed of the FBR. Typical values were 50-53 µg/L and 6.1-6.3 mg/L for perchlorate and nitrate-N, respectively.

- Total organic carbon, orthophosphate-phosphorus, nitrite-N, chlorate, chlorite, and total suspended solids were all measured to be non-detect.

- Metals analysis demonstrated non-detect for cadmium, chromium, lead, and nickel. Barium levels measured 29.1 µg/L.

- pH of the water measured 7.46.

In addition to the outside laboratory analysis of the wellhead water, on-site laboratory analysis was also conducted. The results from this analysis demonstrated:

- Dissolved oxygen feed of 7.27 mg/L. Typical value of 8.1 mg/L.

- An oxidation-reduction potential of 170.1 mV.

- pH of 7.88 and a temperature of 19.8 degrees Celsius.

Based on the water chemistry observed during the baseline analysis from both the outside and on-site laboratories, as well as historical operating experience from prior FBR systems, the water from Rialto Well #2 appeared conducive to biological treatment. No chemical constituents within the water were considered harmful to the FBR treatment plant operation or performance.

Table 5.1 Feed groundwater baseline data.

Analyte	Result
Perchlorate (µg/L)	90.50
Nitrate-N (mg/L)	7.72
Chlorate (µg/L)	ND (<20)
Chlorite (µg/L)	ND (<20)
Barium (mg/L)	0.0291
Cadmium (mg/L)	ND (<0.001)
Chromium (mg/L)	ND (<0.0025)
Iron (mg/L)	0.0673J
Lead (mg/L)	ND (<0.003)
Manganese (mg/L)	0.00327J
Nickel (mg/L)	ND (<0.0025)
Zinc (mg/L)	0.00726J
Mercury (µg/L)	ND (<0.1)
Color (CPU)	ND (<2.5)
pH	7.46
TDS (mg/L)	325.00
TSS (mg/L)	ND (<5.0)
Chloride (mg/L)	27.80
Nitrite (mg/L)	ND(<0.05)
Orthophosphate-P (mg/L)	ND (<0.25)
Sulfate (mg/L)	22.10
Ammonia (mg/L)	0.24
TOC (mg/L)	ND (<0.5)

5.3 Treatability or Laboratory Study Results

No treatability or laboratory studies were conducted prior to the field demonstration.

5.4 Design and Layout of Technology Components

In preparation for the arrival of the FBR treatment system equipment, various alterations to the site were conducted:

- The site was graded with crushed gravel and a level surface obtained.
- A new security fence with two gated access points was added around the demonstration site.
- The temporary groundwater pump was tested to ensure that adequate flow be supplied to the FBR treatment system.
- A new distribution and starter panel was installed at the site by others to provide power to the FBR system.

- From the wellhead, plumbing was added that allowed water to proceed directly to a manifold. From this manifold, the water flowed to the FBR system. This manifold allowed other systems on site to receive water in parallel.
- A trench was excavated for a six-inch drain line that fed a catch basin approximately 400 feet to the south of the demonstration site. Piping was laid in this trench.
- Plumbing to a potable water source was connected and made available.

The major unit operations/treatment vessels included in the FBR treatment system delivered to the site include (Figures 5.2-5.6):

- Fluidized bed reactor: 304 SS, 3 ft. diameter x 17 ft. straight side with carbon media with biomass separation devices
- Aeration tank: 304 SS, 3 ft. diameter x 17 ft. straight side (T-210)
- Multimedia filter: A-36 steel, 8 ft.-10 in. L x 6 ft.-2 in. W x 9 ft.-0 in. H (F-310)
- Filter effluent tank: 304 SS, 4 ft.-6 in. diameter x 16 ft. H (T-340)
- Liquid granular activated carbon vessels: Steel coated with fusion bonded epoxy, 4 ft. diameter x 4 ft.-8 in H (GC 500A/B)
- Ultraviolet Light System (10 to 35 gpm throughput)

Piping and instrumentation diagrams (P&IDs) showing the design of the complete FBR treatment train are provided for each of the following component descriptions (Figures 5.7-5.15). System interlock notes are provided in Table 5.2.

Figures 5.2, 5.3, and 5.4 Complete FBR Drinking Water system. Figure 5.3 shows Rialto Well #2, the plant feed pump, and the gas dispersion tank. Figure 5.4 shows the FBR vessel (foreground), post-aeration vessel (middle), and multimedia filter (left). Figure 5.4 shows the LGAC vessel (foreground), multimedia filter (right-side), and the multimedia filter backwash tank (background).


Figure 5.2


Figure 5.3


Figure 5.4

Figure 5.5 Eductor used for biomass separation in the lower portions of the media bed.

Figure 5.6 UV reactor uninstalled and installed in protective box.

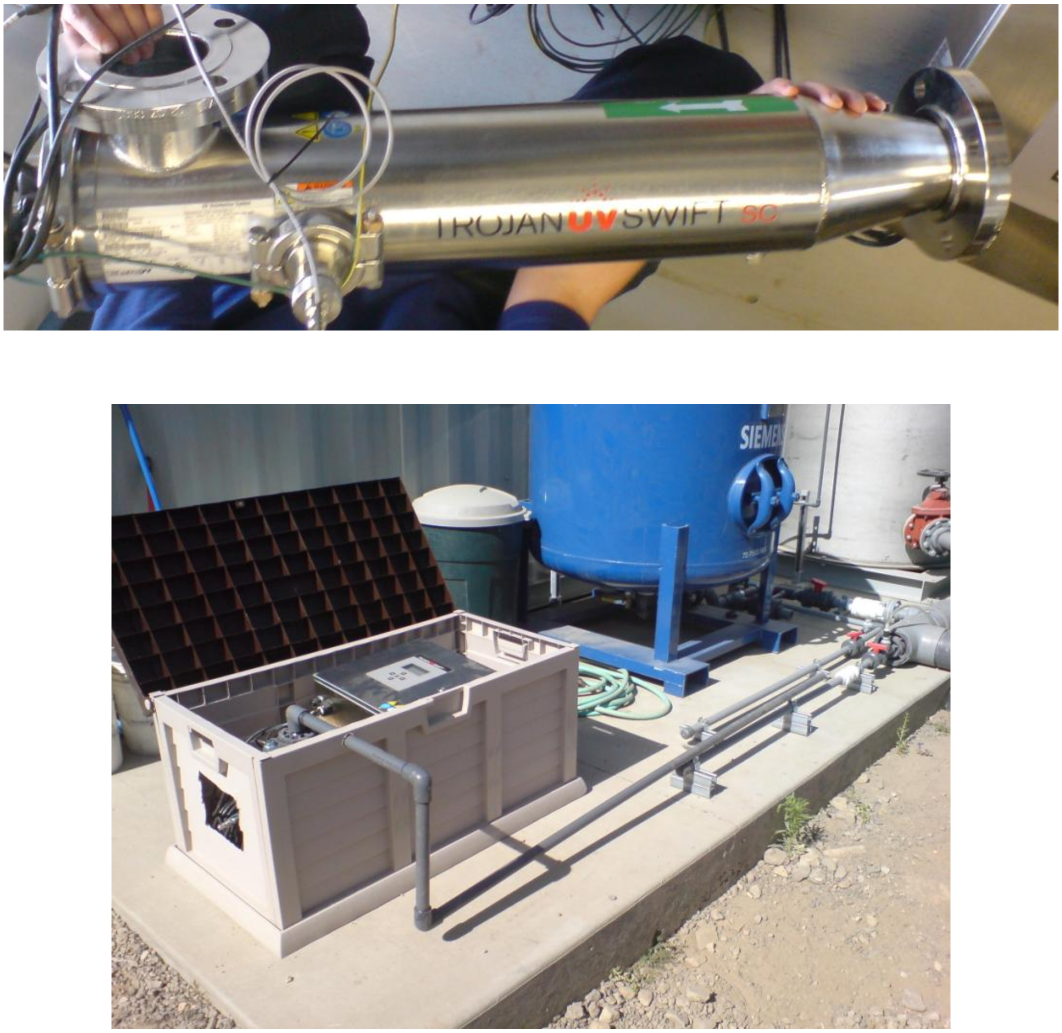
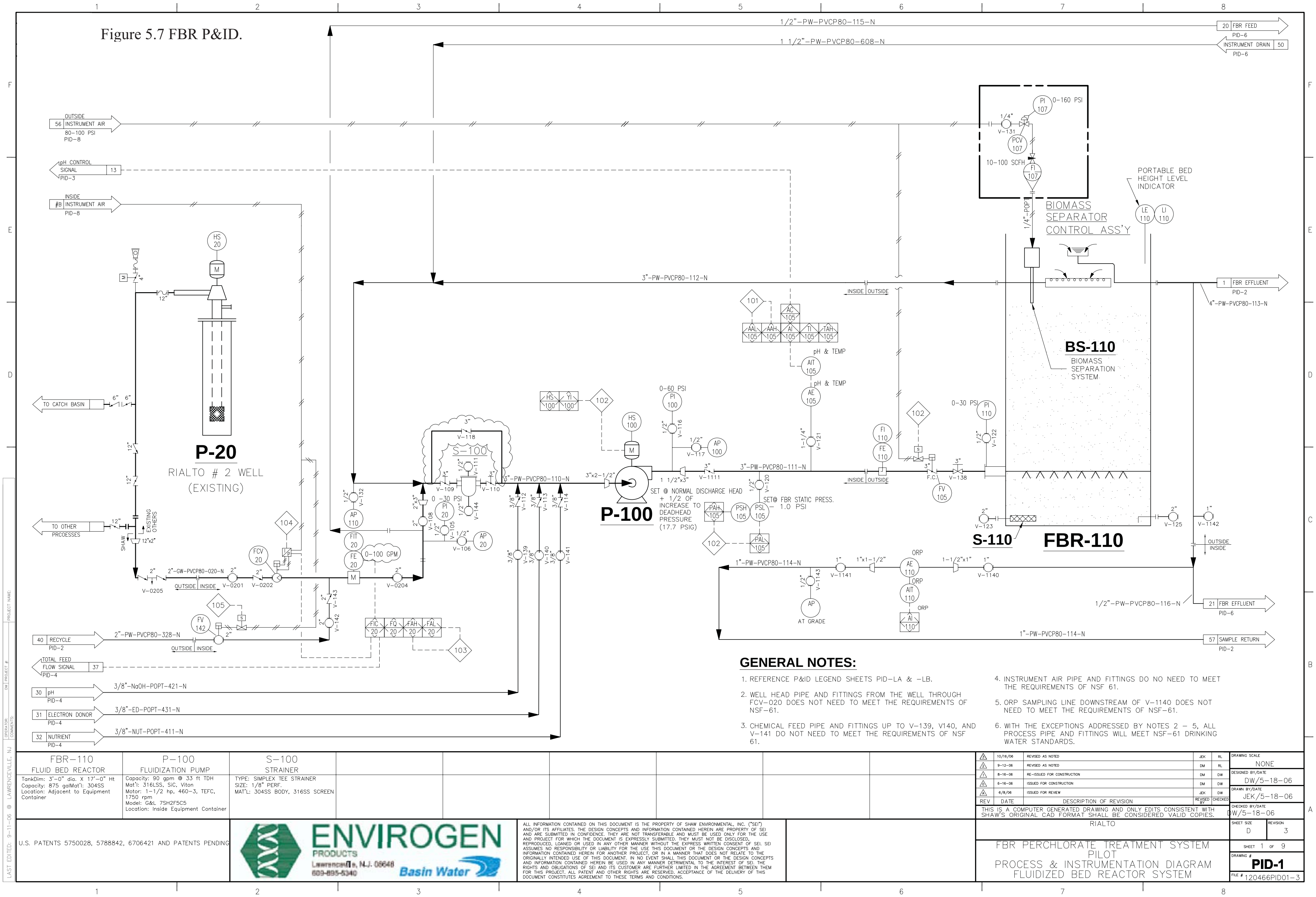


Figure 5.7 FBR P&ID.



GENERAL NOTES:

1. REFERENCE P&ID LEGEND SHEETS PID-LA & -LB.
2. WELL HEAD PIPE AND FITTINGS FROM THE WELL THROUGH FCV-020 DOES NOT NEED TO MEET THE REQUIREMENTS OF NSF-61.
3. CHEMICAL FEED PIPE AND FITTINGS UP TO V-139, V140, AND V-141 DO NOT NEED TO MEET THE REQUIREMENTS OF NSF 61.
4. INSTRUMENT AIR PIPE AND FITTINGS DO NO NEED TO MEET THE REQUIREMENTS OF NSF 61.
5. ORP SAMPLING LINE DOWNSTREAM OF V-1140 DOES NOT NEED TO MEET THE REQUIREMENTS OF NSF-61.
6. WITH THE EXCEPTIONS ADDRESSED BY NOTES 2 - 5, ALL PROCESS PIPE AND FITTINGS WILL MEET NSF-61 DRINKING WATER STANDARDS.

FBR-110 FLUID BED REACTOR	P-100 FLUIDIZATION PUMP	S-100 STRAINER
TankDim: 3'-0" dia. X 17'-0" Ht Capacity: 875 galMat'l: 304SS Location: Adjacent to Equipment Container	Capacity: 90 gpm @ 33 ft TDH Mat'l: 316LSS, SIC, Viton Motor: 1-1/2 hp, 460-3, TEFC, 1750 rpm Model: G&L 7SH2F5C5 Location: Inside Equipment Container	TYPE: SIMPLEX TEE STRAINER SIZE: 1/8" PERF. MAT'L: 304SS BODY, 316SS SCREEN

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
	10/16/06	REVISED AS NOTED	JEK	RL
	9-12-06	REVISED AS NOTED	DM	RL
	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
	6/8/06	ISSUED FOR REVIEW	JEK	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

DRAWING SCALE NONE
DESIGNED BY/DATE DW/5-18-06
DRAWN BY/DATE JEK/5-18-06
CHECKED BY/DATE DW/5-18-06
SHEET SIZE D
REVISION 3
SHEET 1 OF 9
DRAWING # PID-1
FILE # 120466PID01-3

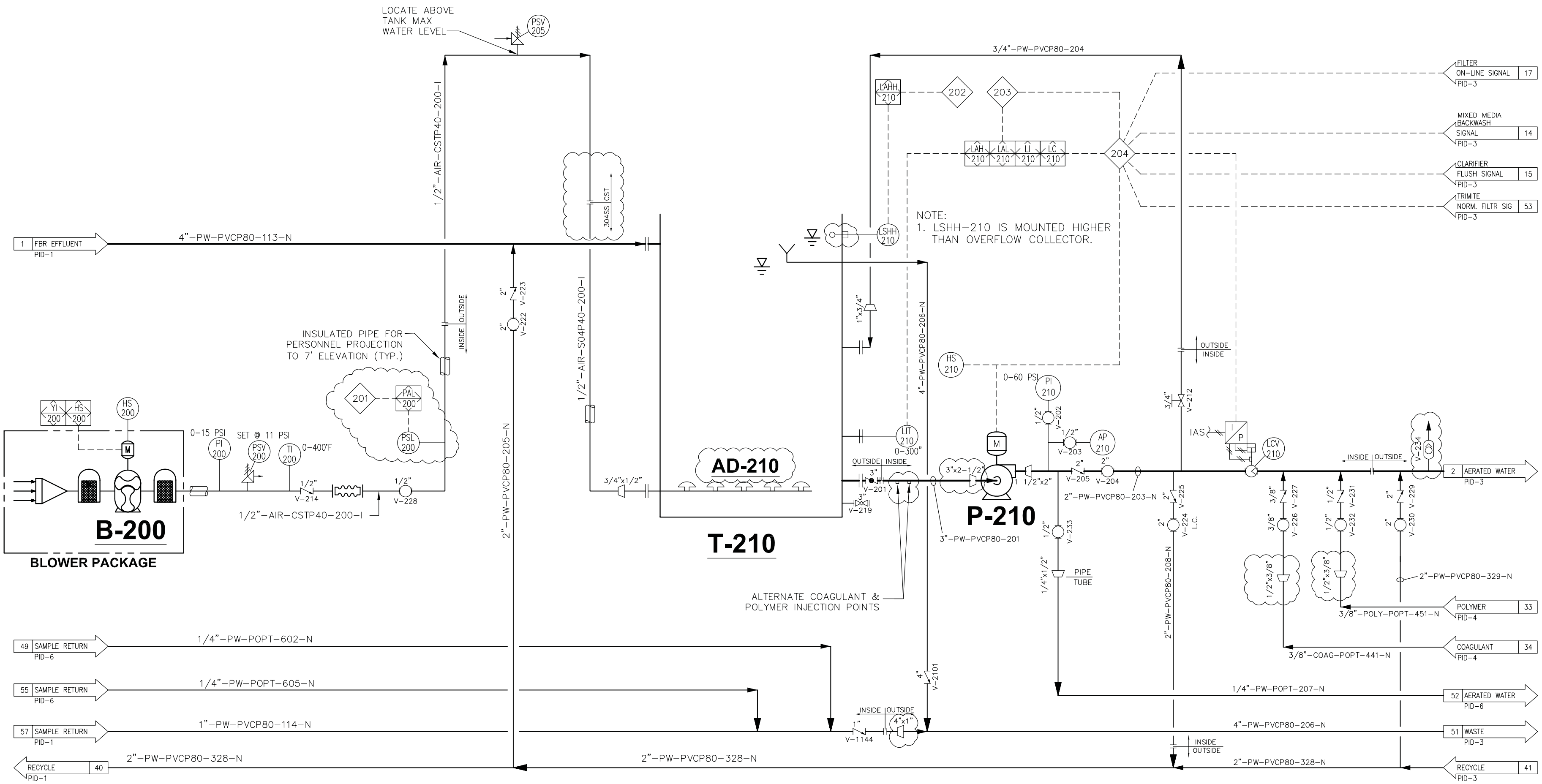
U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

RIALTO
FBR PERCHLORATE TREATMENT SYSTEM PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

LAST EDITED: 9-11-06 @ LAWRENCEVILLE, NJ

Figure 5.8 Aeration vessel P&ID.



GENERAL NOTES:

1. REFERENCE P&ID LEGEND SHEETS PID-LA & -LB.
2. PIPE AND FITTINGS CONNECTING TO THE PROCESS WASTE STREAM 206 DO NOT NEED TO MEET THE REQUIREMENTS OF NSF 61.
3. CHEMICAL FEED PIPE AND FITTINGS UP TO V-227 AND V-231 DO NOT NEED TO MEET THE REQUIREMENTS OF NSF 61.
4. PROCESS AIR PIPE AND FITTINGS DO NO NEED TO MEET THE REQUIREMENTS OF NSF 61.
5. WITH THE EXCEPTIONS ADDRESSED BY NOTES 2 - 4, ALL PROCESS PIPE AND FITTINGS WILL MEET NSF-61 DRINKING WATER STANDARDS.

T-210 AERATION TANK	P-210 FILTER FEED PUMP	B-200 AERATION AIR BLOWER
Dim: 3'-0" dia. X 16'-0" Capacity: 825 galMat'l: 304 SS Location: Adjacent to Equipment Container	Capacity: 50 gpm @ 35 ft TDH Mat'l: 316LSS, SiC, Viton Motor: 1 hp, 460-3, TEFC,1750rpm Model: G&L 4SH2E5B5 Location: Inside Equipment Container	Type: Rotary Vane, Oilless Capacity: 10 SCFM @ 9 psig Motor: 460-3, 1 hp, 1725 rpm Model: Gast 1423-101Q-G625 Location: Inside Equipment Container

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN
PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
2	9-12-06	REV. AS NOTED	DM	RL
1	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
0	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

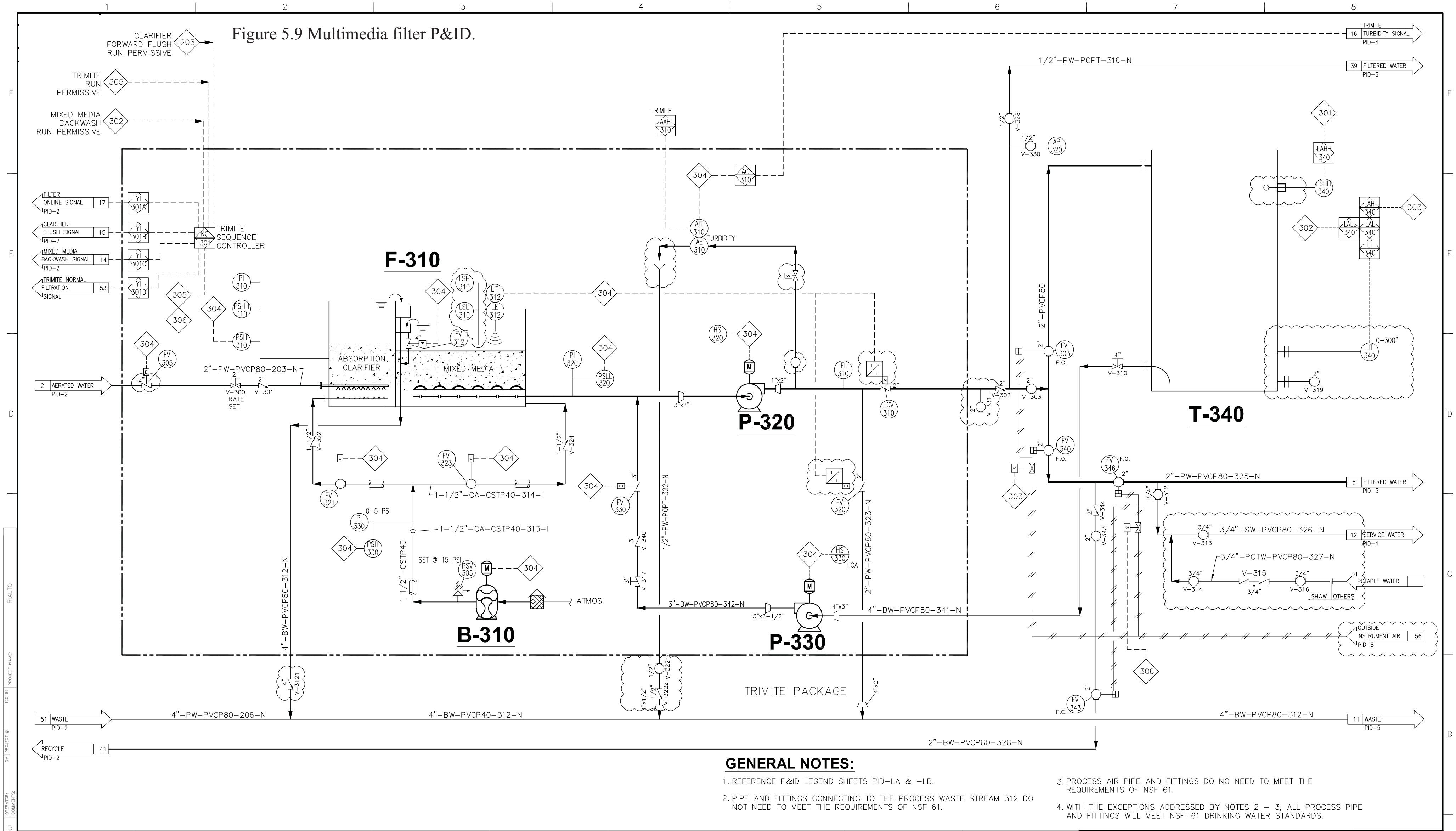
RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

DRAWING SCALE: NONE
DESIGNED BY/DATE: DW/5-18-06
DRAWN BY/DATE: JEK/5-18-06
CHECKED BY/DATE: DW/5-18-06
SHEET SIZE: D
REVISION: 2
SHEET 2 OF 9
DRAWING #: **PID-2**
FILE # 120466PID02-2

LAST EDITED: 9-12-06 @ LAWRENCEVILLE, NJ
OPERATOR:
COMMENTS:
DM PROJECT #:
PROJECT NAME:

Figure 5.9 Multimedia filter P&ID.



GENERAL NOTES:

1. REFERENCE P&ID LEGEND SHEETS PID-LA & -LB.
2. PIPE AND FITTINGS CONNECTING TO THE PROCESS WASTE STREAM 312 DO NOT NEED TO MEET THE REQUIREMENTS OF NSF 61.
3. PROCESS AIR PIPE AND FITTINGS DO NO NEED TO MEET THE REQUIREMENTS OF NSF 61.
4. WITH THE EXCEPTIONS ADDRESSED BY NOTES 2 – 3, ALL PROCESS PIPE AND FITTINGS WILL MEET NSF-61 DRINKING WATER STANDARDS.

F-310 TRIMITE FILTER	P-320 FILTER EFFLUENT PUMP	P-330 FILTER BACKWASH PUMP	B-310 FILTER AIR BLOWER	T-340 FILTER EFFLUENT TANK
Capacity: 50 gpm Dim: 8'-10"L x 6'-2"W x 9'-0"H Mfg: US FilterModel: TM-50A Location: Adjacent to Equipment Container	Capacity: 50 gpm @ 75 ft TDH ~~Mat'l: Cast iron, bronze, SiC, Viton~~ Motor: 230/460-3P-60Hz, 2 hp, ~~TEFC, 3500 rpm~~ Model: Goulds Location: Integral with Trimite Filter	Capacity: 180 gpm @ 54 ft TDH ~~Mat'l:~~ Motor: 230/460-3P, 5 hp, ODP, ~~3500 rpm~~ Model: Goulds Location: Integral with Trimite Filter	Type: Regenerative ~~Capacity: 22 SCFM @ 3.1 psig~~ 230/460-3P-60Hz, 0.75 hp, TEFC ~~Mfg: FPZ~~ Location: Integral with Trimite Filter	Dim: 4'-6" dia. X 16'-6" Capacity: 1900 gal Mat'l: 304 SS

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING.

ENVIROGEN PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
2	9-12-06	REV. AS NOTED	DM	RL
1	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
0	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
A	06-08-06	ISSUED FOR REVIEW	DM	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

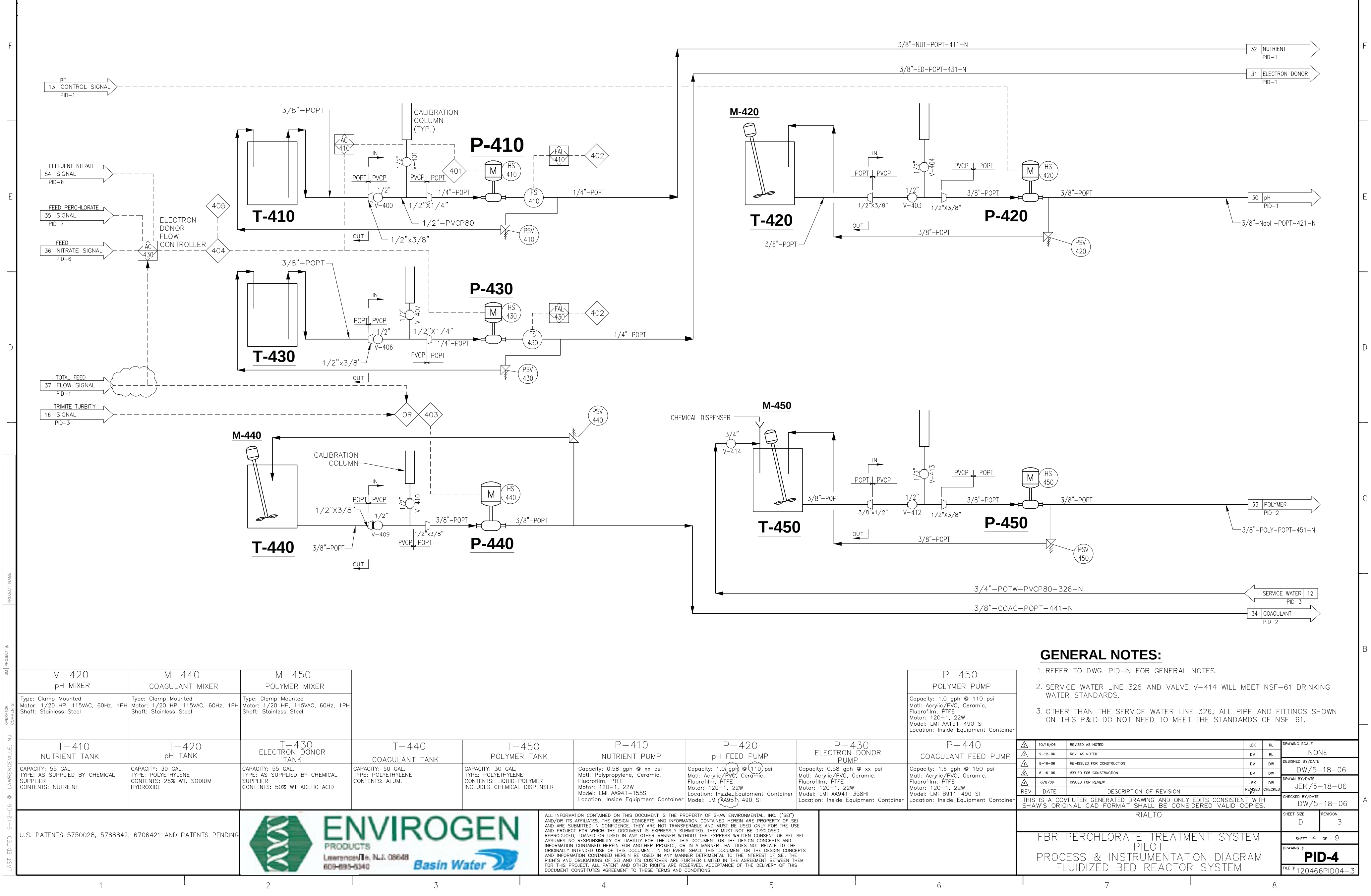
RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUID BED REACTOR

DRAWING SCALE NONE
DESIGNED BY/DATE DW/06-01-06
DRAWN BY/DATE DM/06-05-06
CHECKED BY/DATE DW/06-06-06
SHEET SIZE D
REVISION 2
SHEET 3 OF 9
DRAWING # **PID-3**
FILE # 120466PID03-2

LAST EDITED: 9-12-06 @ LAWRENCEVILLE, NJ RIALTO

Figure 5.10 Chemical feed system P&ID.



M-420 pH MIXER	M-440 COAGULANT MIXER	M-450 POLYMER MIXER
Type: Clamp Mounted Motor: 1/20 HP, 115VAC, 60Hz, 1PH Shaft: Stainless Steel	Type: Clamp Mounted Motor: 1/20 HP, 115VAC, 60Hz, 1PH Shaft: Stainless Steel	Type: Clamp Mounted Motor: 1/20 HP, 115VAC, 60Hz, 1PH Shaft: Stainless Steel

T-410 NUTRIENT TANK	T-420 pH TANK	T-430 ELECTRON DONOR TANK	T-440 COAGULANT TANK	T-450 POLYMER TANK
CAPACITY: 55 GAL. TYPE: AS SUPPLIED BY CHEMICAL SUPPLIER CONTENTS: NUTRIENT	CAPACITY: 30 GAL. TYPE: POLYETHYLENE CONTENTS: 25% WT. SODIUM HYDROXIDE	CAPACITY: 55 GAL. TYPE: AS SUPPLIED BY CHEMICAL SUPPLIER CONTENTS: 50% WT ACETIC ACID	CAPACITY: 50 GAL. TYPE: POLYETHYLENE CONTENTS: ALUM.	CAPACITY: 30 GAL. TYPE: POLYETHYLENE CONTENTS: LIQUID POLYMER INCLUDES CHEMICAL DISPENSER

P-410 NUTRIENT PUMP	P-420 pH FEED PUMP	P-430 ELECTRON DONOR PUMP	P-440 COAGULANT FEED PUMP	P-450 POLYMER PUMP
Capacity: 0.58 gph @ xx psi Matl: Polypropylene, Ceramic, Fluorofilm, PTFE Motor: 120-1, 22W Model: LMI AA941-155S Location: Inside Equipment Container	Capacity: 1.0 gph @ 110 psi Matl: Acrylic/PVC, Ceramic, Fluorofilm, PTFE Motor: 120-1, 22W Location: Inside Equipment Container Model: LMI AA951-490 SI	Capacity: 0.58 gph @ xx psi Matl: Acrylic/PVC, Ceramic, Fluorofilm, PTFE Motor: 120-1, 22W Model: LMI AA941-358HI Location: Inside Equipment Container	Capacity: 1.6 gph @ 150 psi Matl: Acrylic/PVC, Ceramic, Fluorofilm, PTFE Motor: 120-1, 22W Model: LMI B911-490 SI Location: Inside Equipment Container	Capacity: 1.0 gph @ 110 psi Matl: Acrylic/PVC, Ceramic, Fluorofilm, PTFE Motor: 120-1, 22W Model: LMI AA151-490 SI Location: Inside Equipment Container

GENERAL NOTES:

1. REFER TO DWG. PID-N FOR GENERAL NOTES.
2. SERVICE WATER LINE 326 AND VALVE V-414 WILL MEET NSF-61 DRINKING WATER STANDARDS.
3. OTHER THAN THE SERVICE WATER LINE 326, ALL PIPE AND FITTINGS SHOWN ON THIS P&ID DO NOT NEED TO MEET THE STANDARDS OF NSF-61.

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
3	10/16/06	REVISED AS NOTED	JEK	RL
2	9-12-06	REV. AS NOTED	DM	RL
1	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
0	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

DRAWING SCALE NONE
DESIGNED BY/DATE DW/5-18-06
DRAWN BY/DATE JEK/5-18-06
CHECKED BY/DATE DW/5-18-06
SHEET SIZE D
REVISION 3
SHEET 4 OF 9
DRAWING # PID-4
FILE # 120466PID04-3

RIALTO

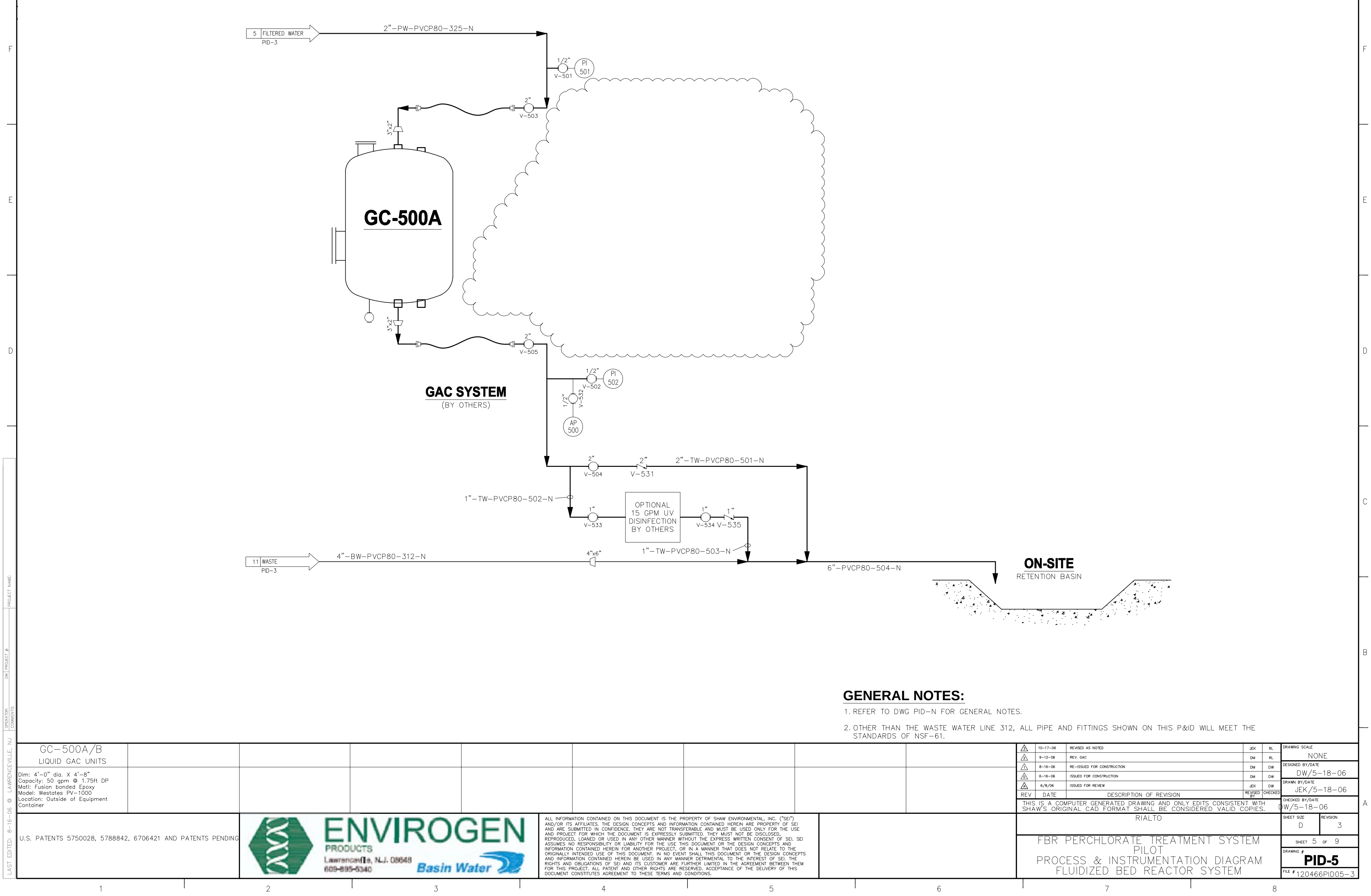
FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

LAST EDITED: 9-12-06 @ LAWRENCEVILLE, NJ

Figure 5.11 LGAC P&ID.



GENERAL NOTES:

1. REFER TO DWG PID-N FOR GENERAL NOTES.
2. OTHER THAN THE WASTE WATER LINE 312, ALL PIPE AND FITTINGS SHOWN ON THIS P&ID WILL MEET THE STANDARDS OF NSF-61.

GC-500A/B
LIQUID GAC UNITS

Dim: 4'-0" dia. X 4'-8"
Capacity: 50 gpm @ 1.75ft DP
Matl: Fusion bonded Epoxy
Model: Westates PV-1000
Location: Outside of Equipment Container

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ALL INFORMATION CONTAINED ON THIS DOCUMENT IS THE PROPERTY OF SHAW ENVIRONMENTAL, INC. ("SEI") AND/OR ITS AFFILIATES. THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN ARE PROPERTY OF SEI AND ARE SUBMITTED IN CONFIDENCE. THEY ARE NOT TRANSFERABLE AND MUST BE USED ONLY FOR THE USE AND PROJECT FOR WHICH THE DOCUMENT IS EXPRESSLY SUBMITTED. THEY MUST NOT BE DISCLOSED, REPRODUCED, LOANED OR USED IN ANY OTHER MANNER WITHOUT THE EXPRESS WRITTEN CONSENT OF SEI. SEI ASSUMES NO RESPONSIBILITY OR LIABILITY FOR THE USE THIS DOCUMENT OR THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN FOR ANOTHER PROJECT, OR IN A MANNER THAT DOES NOT RELATE TO THE ORIGINALLY INTENDED USE OF THIS DOCUMENT. IN NO EVENT SHALL THIS DOCUMENT OR THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN BE USED IN ANY MANNER DETRIMENTAL TO THE INTEREST OF SEI. THE RIGHTS AND OBLIGATIONS OF SEI AND ITS CUSTOMER ARE FURTHER LIMITED IN THE AGREEMENT BETWEEN THEM FOR THIS PROJECT. ALL PATENT AND OTHER RIGHTS ARE RESERVED. ACCEPTANCE OF THE DELIVERY OF THIS DOCUMENT CONSTITUTES AGREEMENT TO THESE TERMS AND CONDITIONS.

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
3	10-17-06	REVISED AS NOTED	JEK	RL
2	9-12-06	REV. GAC	DM	RL
1	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
0	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

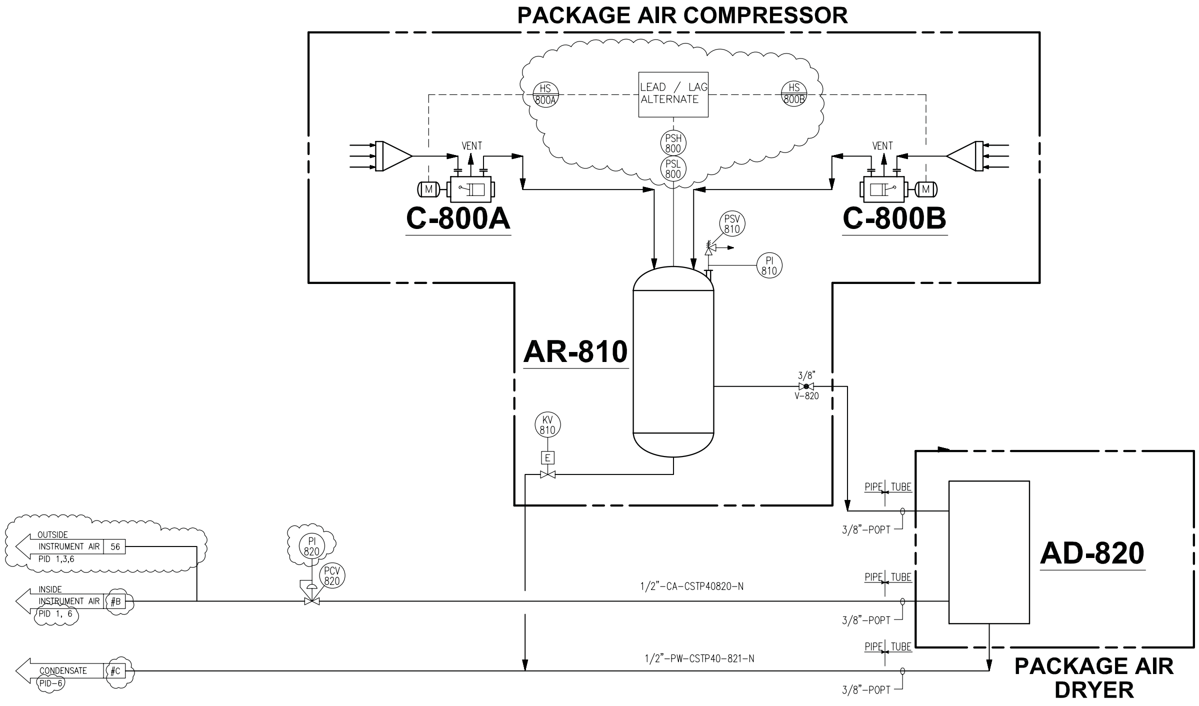
THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

DRAWING SCALE NONE
DESIGNED BY/DATE DW/5-18-06
DRAWN BY/DATE JEK/5-18-06
CHECKED BY/DATE DW/5-18-06
SHEET SIZE D
REVISION 3
SHEET 5 OF 9
DRAWING # PID-5
FILE # 120466PID05-3

Figure 5.12 Air compressor P&ID.



GENERAL NOTES:

1. PIPE AND FITTINGS SHOWN ON THIS P&ID DO NOT NEED TO MEET THE STANDARDS OF NSF-61.

C-800A/B AIR COMPRESSORS	AR-810 COMPRESSED AIR RECEIVER	AD-820 COMPRESSED AIR DRYER
Combined Capacity: 10.5 cfm @ 100 psig Motor: Two ea. 460-3, 1.5 hp, ODP Model: Gast 7HDD-69DTD-M853 Location: Inside Equipment Container	Capacity: 60 gallons ASME Coded Tank Gast K602 Auto Drain Assembly Location: Inside Equipment Container	Type: Refrigerant Capacity: 18 cfm @ 35°F Pressure Dew Point Model: Great Lakes GRF-20A-116 Includes 3 Micron Filter-AutoDrain Motor: 115/-1, 1/5 hp, ODP Location: Inside Equipment Container

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN
PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
2	9-12-06	REVISED AS NOTED	JEK	DW
1	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
0	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

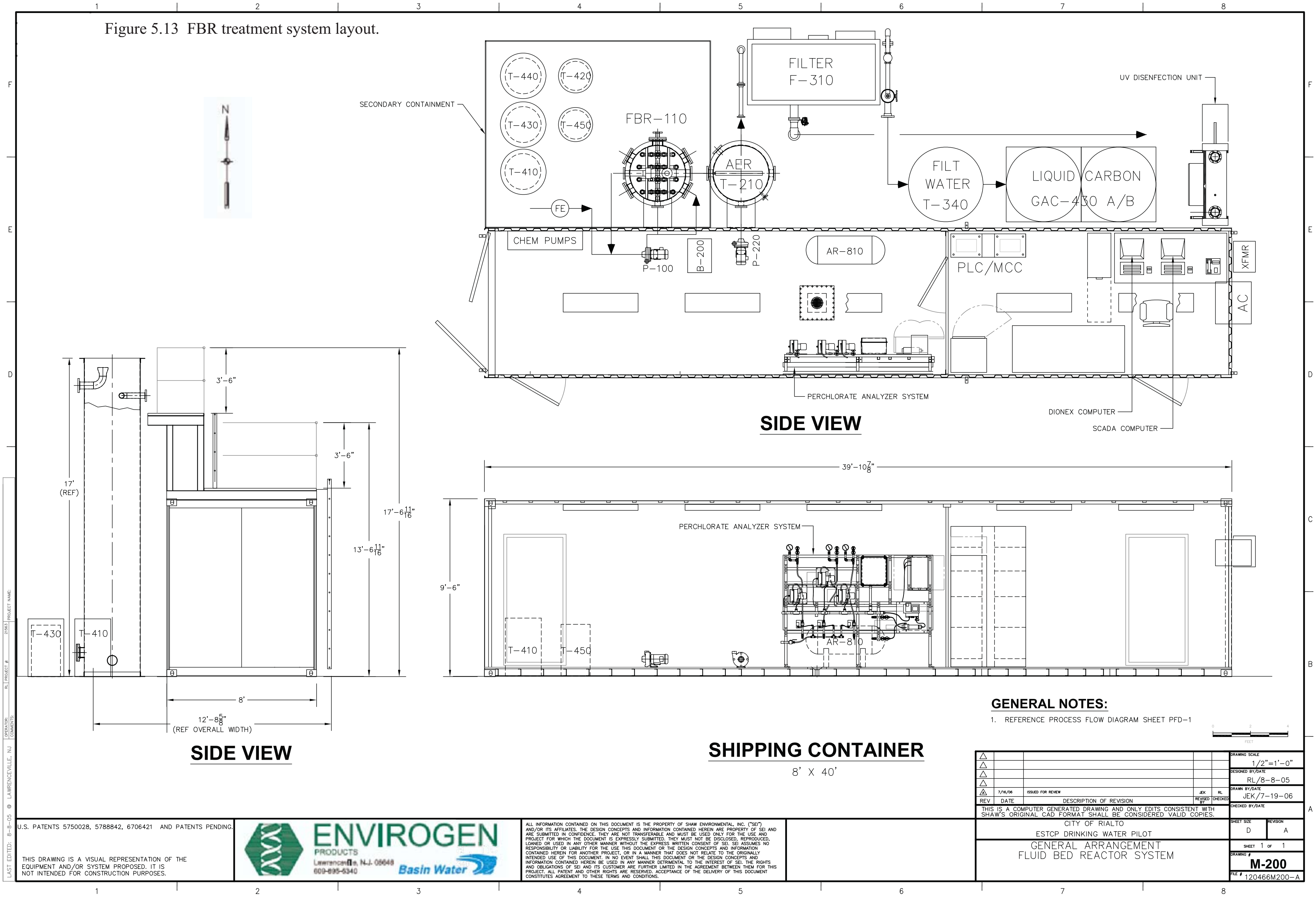
RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

DRAWING SCALE: NONE
DESIGNED BY/DATE: DW/5-18-06
DRAWN BY/DATE: JEK/5-18-06
CHECKED BY/DATE: DW/5-18-06
SHEET SIZE: D
REVISION: 2
SHEET 8 OF 9
DRAWING #: **PID-8**
FILE # 120466PID08-2

LAST EDITED: 9-12-06 @ LAWRENCEVILLE, NJ
OPERATOR:
COMMENTS:
DM PROJECT #:
PROJECT NAME:

Figure 5.13 FBR treatment system layout.



GENERAL NOTES:

1. REFERENCE PROCESS FLOW DIAGRAM SHEET PFD-1

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
△				
△				
△				
A	7/16/06	ISSUED FOR REVIEW	JEK	RL

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

CITY OF RIALTO
ESTCP DRINKING WATER PILOT

GENERAL ARRANGEMENT
FLUID BED REACTOR SYSTEM

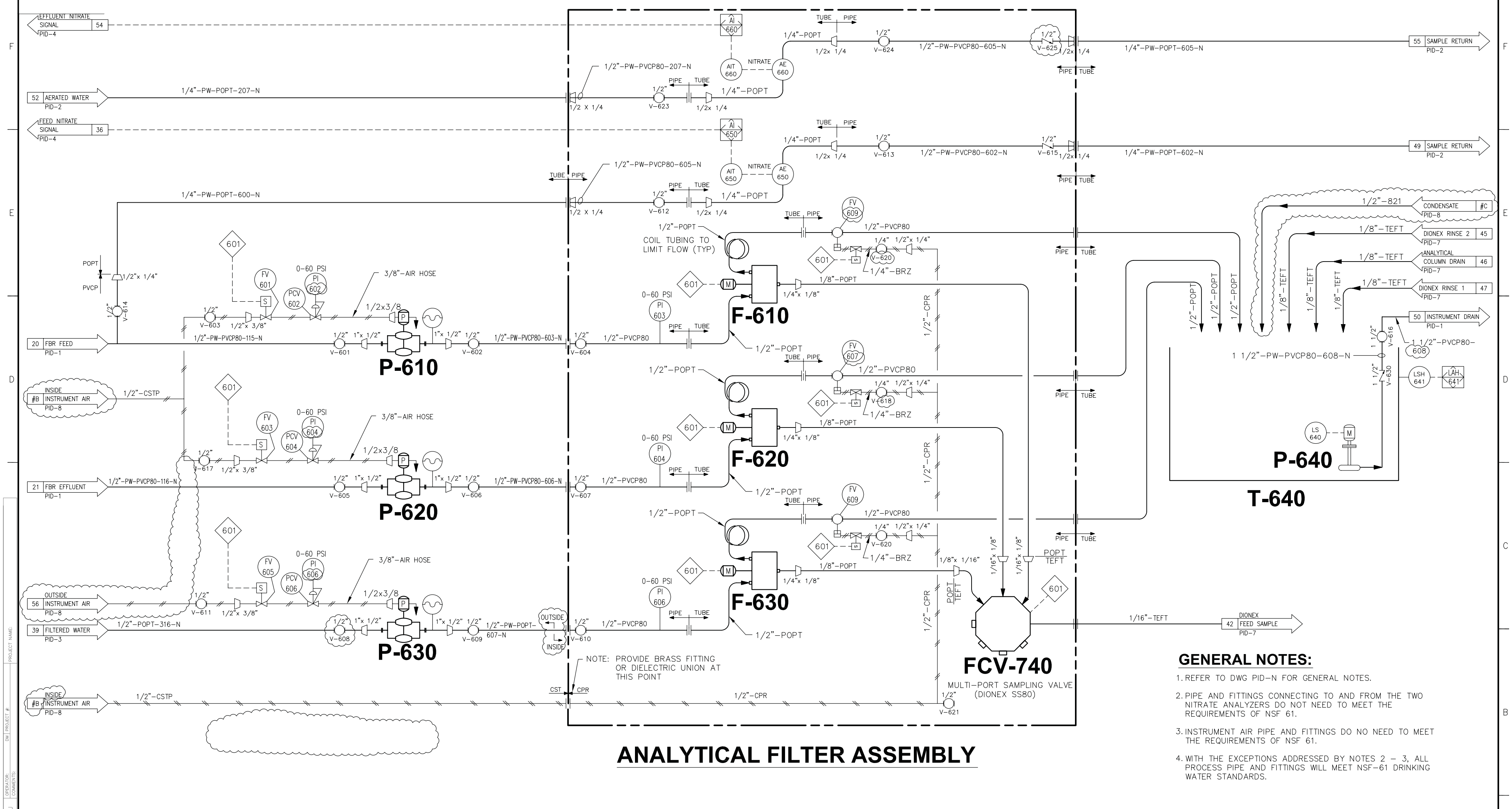
DRAWING SCALE 1/2"=1'-0"
DESIGNED BY/DATE RL/8-8-05
DRAWN BY/DATE JEK/7-19-06
CHECKED BY/DATE
SHEET SIZE D
REVISION A
SHEET 1 OF 1
DRAWING # M-200
FILE # 120466M200-A

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING.

THIS DRAWING IS A VISUAL REPRESENTATION OF THE EQUIPMENT AND/OR SYSTEM PROPOSED. IT IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

ALL INFORMATION CONTAINED ON THIS DOCUMENT IS THE PROPERTY OF SHAW ENVIRONMENTAL, INC. ("SEI") AND/OR ITS AFFILIATES. THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN ARE PROPERTY OF SEI AND ARE SUBMITTED IN CONFIDENCE. THEY ARE NOT TRANSFERABLE AND MUST BE USED ONLY FOR THE USE AND PROJECT FOR WHICH THE DOCUMENT IS EXPRESSLY SUBMITTED. THEY MUST NOT BE DISCLOSED, REPRODUCED, LOANED OR USED IN ANY OTHER MANNER WITHOUT THE EXPRESS WRITTEN CONSENT OF SEI. SEI ASSUMES NO RESPONSIBILITY OR LIABILITY FOR THE USE THIS DOCUMENT OR THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN FOR ANOTHER PROJECT, OR IN A MANNER THAT DOES NOT RELATE TO THE ORIGINALLY INTENDED USE OF THIS DOCUMENT. IN NO EVENT SHALL THIS DOCUMENT OR THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN BE USED IN ANY MANNER DETRIMENTAL TO THE INTEREST OF SEI. THE RIGHTS AND OBLIGATIONS OF SEI AND ITS CUSTOMER ARE FURTHER LIMITED IN THE AGREEMENT BETWEEN THEM FOR THIS PROJECT. ALL PATENT AND OTHER RIGHTS ARE RESERVED. ACCEPTANCE OF THE DELIVERY OF THIS DOCUMENT CONSTITUTES AGREEMENT TO THESE TERMS AND CONDITIONS.

Figure 5.14 Nitrate analyzer and perchlorate sampling system P&ID.



GENERAL NOTES:

1. REFER TO DWG PID-N FOR GENERAL NOTES.
2. PIPE AND FITTINGS CONNECTING TO AND FROM THE TWO NITRATE ANALYZERS DO NOT NEED TO MEET THE REQUIREMENTS OF NSF 61.
3. INSTRUMENT AIR PIPE AND FITTINGS DO NO NEED TO MEET THE REQUIREMENTS OF NSF 61.
4. WITH THE EXCEPTIONS ADDRESSED BY NOTES 2 – 3, ALL PROCESS PIPE AND FITTINGS WILL MEET NSF-61 DRINKING WATER STANDARDS.

F-610/620/630 FILTER	P-610/620/630 FEED PUMP	P-640 SUMP TANK PUMP	T-640 ANALYZER SUMP
FILTER FLOW: 25-40 ML/MIN BYPASS FLOW: 1-6 GPM FILTER SIZE: 0.2 MICRON MOTOR: 1/8 HP, 230/115V, 1ø	TYPE: DIAPHRAGM CAPACITY: 1 GPM @ 92 FT TDH MAT'L: 316SS/ SANTOPRENE MOTOR: AIR DRIVEN AIR REQ'D: 1 SCFM	TYPE: SUBMERSIBLE CAPACITY: 10 GPM @ x 25FT TDH MAT'L: 304SS ELEC: 1/2HP, 115VAC, 1P	SIZE: 19 5/16"ø x 29 3/8" WATER VOLUME: 30 gal. MAT'L: HDPE

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
2	9-12-06	REVISED AS NOTED	JEK	DW
1	8-16-06	RE-ISSUED FOR CONSTRUCTION	DM	DW
0	6-16-06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

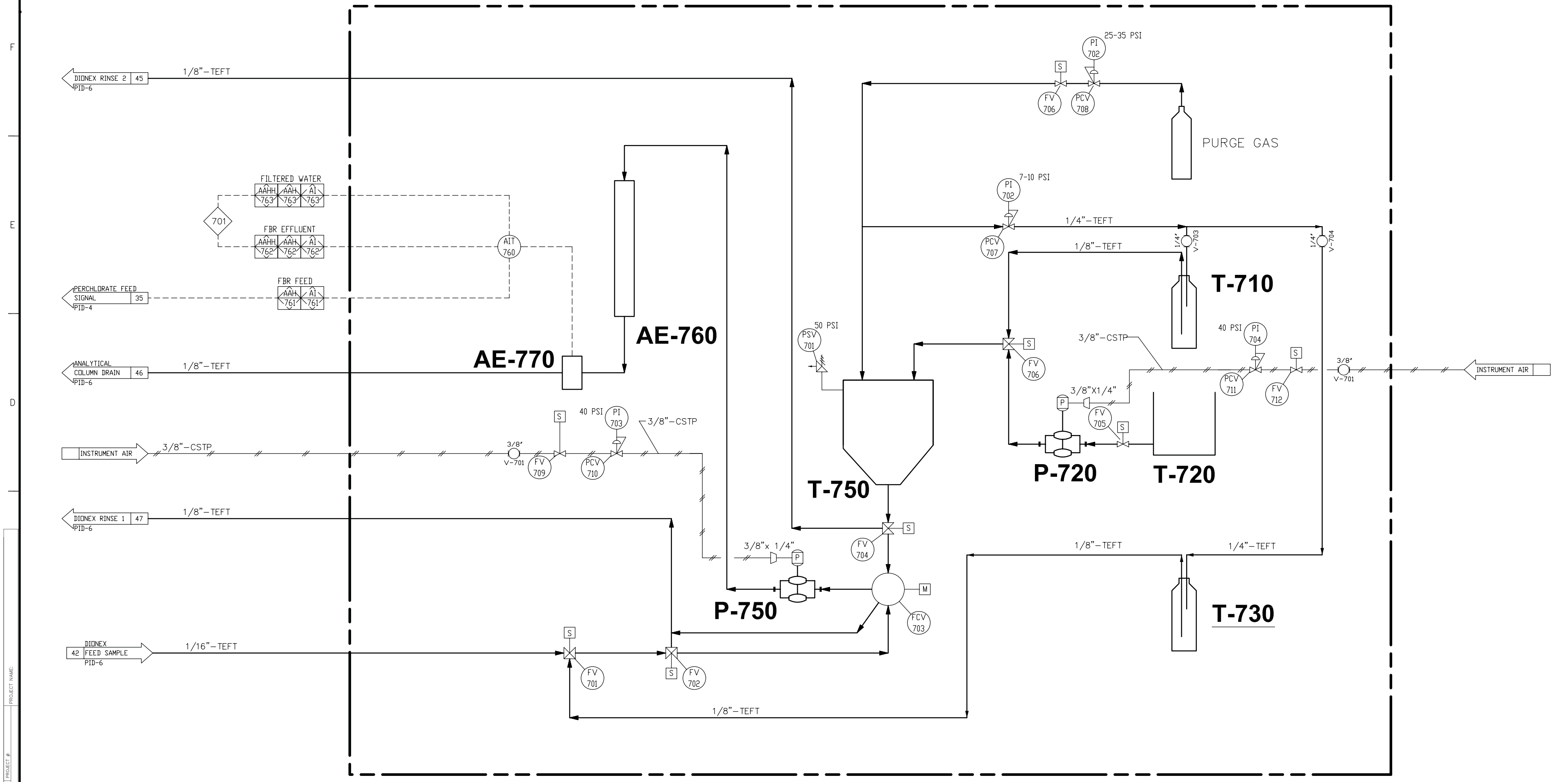
RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

DRAWING SCALE: NONE
DESIGNED BY/DATE: DW/5-18-06
DRAWN BY/DATE: JEK/5-18-06
CHECKED BY/DATE: DW/5-18-06
SHEET SIZE: D
REVISION: 2
SHEET 6 OF 9
DRAWING # **PID-6**
FILE # 120466PID06-2

LAST EDITED: 9-12-06 @ LAWRENCEVILLE, NJ
OPERATOR:
COMMENTS:
DM PROJECT #:
PROJECT NAME:

Figure 5.15 Perchlorate analyzer system P&ID.



OPTIONAL DIONEX DX-800 PERCHLORATE ANALYZER

GENERAL NOTES:

1. REFER TO DWG PID–N FOR GENERAL NOTES.
2. ALL PROCESS TUBING AND TUBE FITTINGS WILL MEET NSF–61 DRINKING WATER STANDARDS.

AE–760 ANALYTICAL COLUMN	AE–770 ANALYTICAL DETECTOR	P–720 DILUENT PUMP	P–750 LOADING PUMP	T–710 STANDARD SOLUTION TANK	T–720 DILUENT TANK	T–730 CHECK STANDARD TANK	T–750 DILUTION TANK	
TYPE: (LATER) CAPACITY: MAT'L:	TYPE: (LATER) CAPACITY: MAT'L:	TYPE: DIAPHRAGM CAPACITY: 15 ML/MIN MAT'L: (LATER)	TYPE: DIAPHRAGM CAPACITY: 3 ML/MIN MAT'L: (LATER)	SIZE: 2 LITER MAT'L: POLYPROPYLENE	SIZE: 19 LITER MAT'L: POLYPROPYLENE	SIZE: 2 LITER MAT'L: POLYPROPYLENE	SIZE: 250 ML MAT'L: POLYPROPYLENE	

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
△				
△				
1	8–16–06	RE–ISSUED FOR CONSTRUCTION	DM	DW
0	6–16–06	ISSUED FOR CONSTRUCTION	DM	DW
A	6/8/06	ISSUED FOR REVIEW	JEK	DW

U.S. PATENTS 5750028, 5788842, 6706421 AND PATENTS PENDING

ENVIROGEN
PRODUCTS
Lawrenceville, N.J. 08648
609-895-5340
Basin Water

THIS IS A COMPUTER GENERATED DRAWING AND ONLY EDITS CONSISTENT WITH SHAW'S ORIGINAL CAD FORMAT SHALL BE CONSIDERED VALID COPIES.

RIALTO

FBR PERCHLORATE TREATMENT SYSTEM
PILOT
PROCESS & INSTRUMENTATION DIAGRAM
FLUIDIZED BED REACTOR SYSTEM

DRAWING SCALE: NONE
DESIGNED BY/DATE: DW/5–18–06
DRAWN BY/DATE: JEK/5–18–06
CHECKED BY/DATE: DW/5–18–06
SHEET SIZE: D
REVISION: 1
SHEET 7 OF 9
DRAWING #: **PID-7**
FILE # 120466PID07–1

LAST EDITED: 8–16–06 @ LAWRENCEVILLE, NJ
OPERATOR:
COMMENTS:
DM PROJECT #
PROJECT NAME:

Table 5.2 FBR treatment plant process interlock notes.

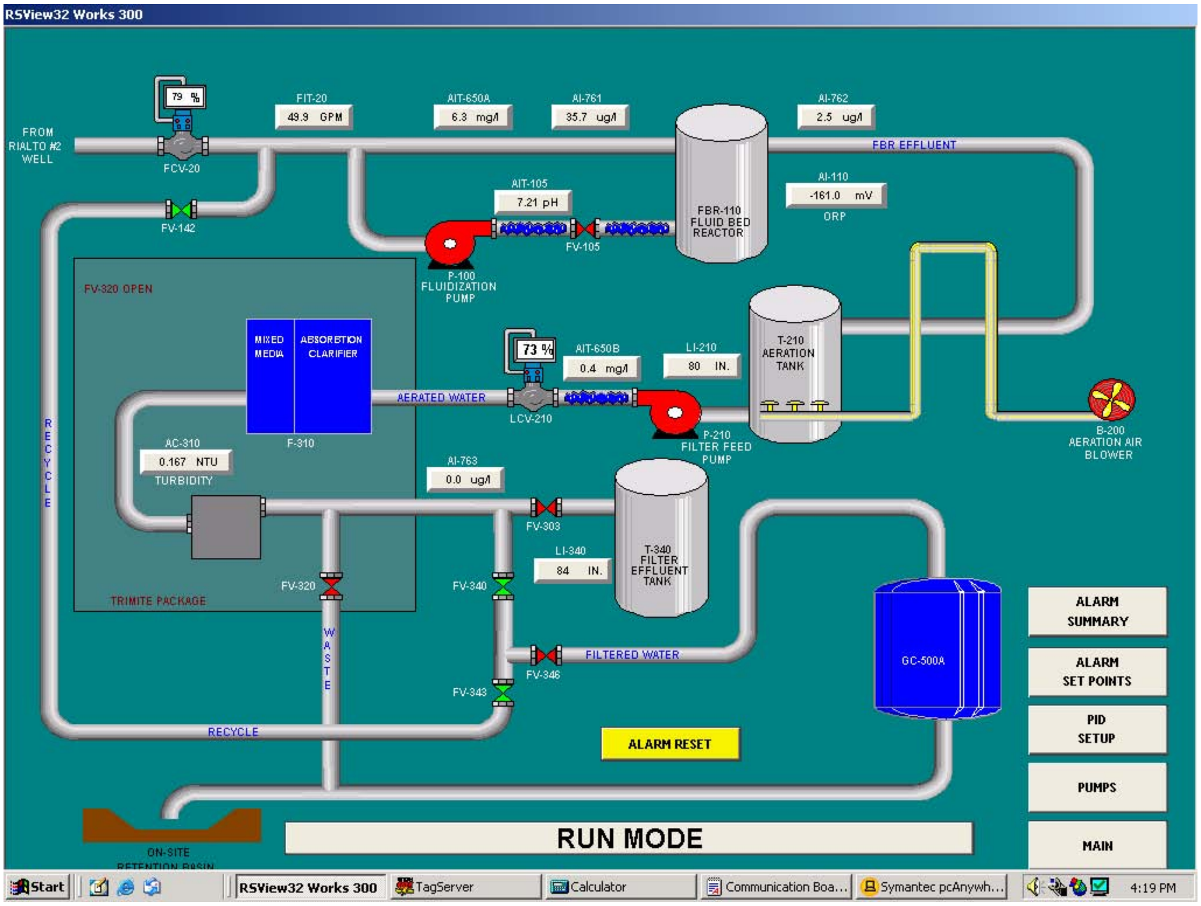
#	Interlock Description	Resultant Action	Notes
101	High or Low pH (AC-105)	Feed Shutdown FCV-20 closes P-410 stops – nutrient P-430 stops – electron donor Trimite Run Permissive is withdrawn	The process remains in Feed Shutdown Mode until the pH is corrected.
102	High or Low Fluidization Pump discharge pressure (PAH/L-105)	FBR System Shutdown FCV-20 closes P-100 stops – fluidization pump P-410 stops – nutrient P-430 stops – electron donor	The process remains in FBR System Shutdown Mode until the operator corrects the cause for a high or low fluidization pump discharge pressure
103	High or Low Feed Flow (FAH/L-20)	Feed Shutdown FCV-20 Closes P-410 stops – nutrient P-430 stops – electron donor Trimite Run Permissive is withdrawn	The process remains in Feed Shutdown Mode until the out of bounds flow is corrected.
105	System Start	System Recycle Mode FV-305, FV-343, and FV-142 open during System Recycle Operations. FCV-20, FV-303 and FV-346 close during System Recycle Operations	System Recycle Mode initiates operations from a cold start or if nitrate or perchlorate concentrations rise to the interlocked concentration.
201	Low Aeration Blower Pressure (PAL-200)	B-200 shutdown Feed Shutdown FCV-20 closes P-410 stops – nutrient P-430 stops – electron donor Trimite Run Permissive is withdrawn	The process remains in Feed Shutdown Mode until the cause for low blower pressure is corrected.
202	Aeration Tank High-High Level (LAHH-210)	Trimite Filter Run Permissive is withdrawn Feed Shutdown FCV-20 Closes P-410 stops – nutrient P-430 stops – electron donor	The process remains in Feed Shutdown Mode until the cause for the Aeration Tank High-High Level is corrected.

#	Interlock Description	Resultant Action	Notes
204	Aeration Tank Level Control Valve LCV-210	Multiple Mode Control	During normal operations, LC-210 output modulates the position of LCV-210 During Clarifier Flush Operations, LCV-210 moves to preset valve position during a Mixed-Media Bed Flush cycle or applicable alarm, LCV-210 closes.
301	Filter Effluent Tank High-High Level (LAHH-340)	Feed Shutdown FCV-20 Closes P-410 stops – nutrient P-430 stops – electron donor Trimite Run Permissive is withdrawn	The process remains in Feed Shutdown Mode until the level falls below the position of LSHH-340.
302	Filter Effluent Tank Low-Low Level (LALL-340)	Trimite Filter Run Permissive is withdrawn Feed Shutdown FCV-20 Closes P-410 stops – nutrient P-430 stops – electron donor	The process remains in Feed Shutdown Mode until the cause for the Filter Effluent Tank Low-Low Level is corrected.
303	Filter Effluent Tank High Level (LAH-340)	FV-303 is closed FV-305 is opened	FV-303 is opened and FV-305 is closed when the Filter Effluent Tank Level drops 6-inches below set point.
401			Nutrient Flow is proportional to the electron donor flow. The proportionality constant is operator adjustable at the PLC
402	Nutrient or electron donor low flow (FAL-410 and FAL-430)	Feed Shutdown FCV-20 Closes P-410 stops – nutrient P-430 stops – electron donor Filter Permissive is withdrawn	The process remains in Feed Shutdown Mode until the low flow condition is corrected.
405	Electron Donor Feed Controller (AC-430) Excessive mass loading increase	Feed Shutdown FCV-20 Closes P-410 stops – nutrient P-430 stops – electron donor Filter Permissive is withdrawn	The process returns to the Recycle Mode of operation to restart the process

5.4.1 *Fluidized Bed Reactor*

The FBR system is designed to accept groundwater feed up to 50 gpm maximum hydraulic loading (7 gpm/ft^2). Rialto Well #2 pump (P-20) provides feed water to a common manifold (Figure 5.7). A portion of this water (50 gpm) passes through an actuator valve (FCV-20) and enters the FBR recycle flow pumped by the fluidization pump (P-100). The operator controls the feed at the Operator Interface Terminal (or Human Machine Interface, HMI) that provides the ability to set the system feed flow at a constant rate (Figure 5.16).

Figure 5.16 Operator interface for FBR treatment system.



The groundwater feed to the FBR vessel that is combined with the recycle water passes through a strainer basket (S-100). After the strainer basket, three National Sanitary Federation (NSF) 61 certified solutions are added to the combined feed/recycle water: (1) 25 wt.% sodium hydroxide; (2) 50% acetic acid solution (v/v); and (3) nutrient solution (consisting of 85 wt.% phosphoric acid, Figure 5.10). The 25 wt.% sodium hydroxide solution, if required, is automatically added to the process to maintain the FBR feed at the desired pH set on the HMI. This caustic is added from T-420 by pump P-420 and the rate of addition is controlled by AIT-105, the pH controller. The acetic acid and nutrient solution are automatically controlled in proportion to the feed flow to the FBR and an operator-adjustable proportionality constant on the HMI. The acetic acid solution from tank T-430 is added to the FBR via pump P-430, while the nutrient solution from tank T-410 is added to the FBR via pump P-410. The acetic acid and nutrient dosing proportionality constants are dictated by a PLC program that estimates the stoichiometric volume of acetic acid and nutrients required to treat the feed concentrations of oxygen, nitrate, and perchlorate. The nutrient feed is adjusted based on residual phosphorus in the effluent in order to maintain effluent levels within permitted values.

The combined feed and recycled water (92 gpm) is pumped (via P-100) through an air actuated valve (FV-105) to the base of the FBR vessel (FBR-110). At 50 gpm, a recycle ratio of 0.84 is established. At the base of the vessels, an integral fluidization distribution system exists to enhance uniform flow distribution upward through the FBR. This pumped water hydraulically fluidizes the bed media consisting of coconut shell based activated carbon sized from 0.9-1.1 mm (Jacobi Carbons Aquasorb, Philadelphia, PA). A portion of this water, the feed volume, exits the vessel via an overflow weir located at the top of the reactor. The remaining portion of water is pumped through an effluent manifold, combines with fresh feed water, passes through the strainer basket (S-100), and returns to the head of the recycle pump (P-100).

Within the FBR vessel, microorganisms metabolize the acetic acid solution and utilize the oxygen, nitrate, and perchlorate contained in the feed water as electron acceptors. These contaminants are converted to harmless products such as nitrogen, chloride, and carbon dioxide in the process. As the contaminants are converted, the microbes grow and form a film on the fluidized carbon media. As the specific density of the individual carbon particles decreases, the bed fluidizes upward.

At some point, to prevent the carbon/biomass from exiting the system, the media must be cleaned by a biomass separation device and/or an in-bed cleaning eductor. The biomass separation device (BS-110) is operated on a continuous or intermittent basis, as dictated by the system operating conditions. Normally, it will be operated continuously. The separator lifts media from the top of the fluidized media bed using an air lift tube. Media with attached biomass and water is directed through the lift tubes into the mixing chamber located at the water surface. Both lifting and mixing are controlled by airflow to the biomass separator. The media and biomass are separated in the mixing chamber. The media and biomass lift and fall in the 1 inch pipe into an outer 3 inch diameter pipe splash shield. Below the water level, the 3 inch pipe directs the media and biomass to fall. The lighter biomass exits the system with the effluent across the overflow weir and the carbon particles settle back downward into the reactor media bed.

The following parameters are operator-adjustable:

- Airflow rate 0 to 50 standard cubic feet per hour (SCFH). The airflow will determine the media lift rate and the degree of mixing imparted. A normal setting is 15 SCFH. To control bed height more effectively, the air lift flow will be increased while closely monitoring the effluent biomass.

- Separator elevation is adjustable using the nuts and threaded rod which hold the biomass separator in place. Raising the pipe in the separator will reduce the biomass overflow flow rate and increases the retention time of media particles in the separator, thus increasing the mixing intensity while decreasing flow.

The optimum adjustment of the aforementioned parameters will yield effective biomass removal. If the bed height exceeds the 150 inch expanded bed elevation in the reactor, the biomass separation device should be inspected and if nothing is found to be wrong, the airflow should be increased and/or the elevation adjusted.

In certain instances, the biomass growth does not occur at the top of the media bed, but closer to the bottom. In that case, the biomass separator alone can not control bed height, and the operator should perform a manual in-bed cleaning. This requires the implementation of an eductor. A 10 foot length of ½ inch diameter schedule 80 PVC pipe, an eductor (Penberthy 3/8 inch TME), and a schedule 80 PVC elbow to attach the pipe to the educator (Figure 5.5). A submersible pump placed just below the water height at the top of the FBR provides the water flow to the eductor. For this demonstration, both the biomass separator and the in-bed eductor were required.

5.4.2 Aeration Tank

Oxygen, nitrate, and perchlorate are expected to be reduced to effluent design concentrations in the effluent of the FBR. This stream flows over the weir in the FBR to the aeration tank (T-210). The water enters the top of the aeration tank (Figure 5.8). A blower, B-200 produces compressed air for fine bubble aeration to approach saturation concentrations of dissolved oxygen in the water. The benefits of this aeration process include meeting the discharge dissolved oxygen requirements and the partial oxidation of residual organics and trace amounts of reduced sulfur that may be present in the FBR effluent. The air effluent from the aeration tank discharges to the atmosphere. A level transmitter (LIT-210) and a high level switch (LSHH-210) relay information to the PLC to ensure that set levels are maintained within the aeration vessel at all times. See Table 5.2 for interlock notes regarding these switches. The aeration effluent water containing biomass and treated water is pumped to the multimedia filter by pump P-210.

5.4.3 Multimedia Filter

The multimedia filter for this application is a Siemens Trimite TM-50A Multimedia Filter (Ames, IA), designed to reduce turbidity by removing suspended solids and improving water quality (Figure 5.9). The USEPA and the State of California set filtration standards for the production of drinking water from surface water. The Trimite multimedia Filter is accepted by the USEPA and meets the filtration requirements of the California Surface Water Treatment Rule (CSWTR) as an alternative filtration technology.

Excess biomass and solids from the FBR pass through the well-mixed aeration tank and are pumped (via P-210) with the treated water into the Trimite multimedia filter (F-310). Before the water enters the multimedia filter, NSF approved coagulating agent (48% aluminum sulfate, Sterling Water Technologies, Columbia, TN) and 0.8 % diluted polymer (stock of 20% cationic Callaway polymer, Kemiron, Fontana, CA) are added to the multimedia feed water to promote coagulation and flocculation of the solids present. The coagulant pump P-440 provides the coagulant from tank T-440. Similarly, the polymer pump P-450 is used to mix the polymer from tank T-450 with service water and to transfer the resulting polymer mix to the multimedia filter feed. The polymer feed to the filter is controlled based on the flow of water, as measured by the FBR flow meters, and is operator-adjustable.

The multimedia feed water enters the adsorption clarifier (of the multimedia filter) where an upflow treatment process combines flocculation and clarification (10 gpm/ft^2). The chemically treated water flows upward through the adsorption media and the media retainer. The water is distributed by the influent header and by the head loss through the media. The water then flows over the trough weir and onto the mixed media filter (5 gpm/ft^2). The final product water passes through the filter media into the under drain system. From there, it is then pumped out of the filter tank via pump P-320 where the water turbidity is measured via the turbidimeter (AE-310). This turbidity meter value is used to set the coagulant and polymer addition rates. The multimedia filter water effluent is pumped to the filter effluent tank (T-340) through valve FV-303 or to the LGAC treatment vessels (GC-500A/B) through valve FV-340. The majority of time, except after a mixed media backwash event, the filter effluent water proceeds to the LGAC units. When this occurs, FV-303 closes and FV-340 opens.

The effluent discharge line contains a modulating effluent valve (LCV-310). This valve is used for ON/OFF operation as well as flow rate control from the filter section. An ultrasonic level controller (LE-312) located in the filter provides a signal (LIT-312) to the positioner on the effluent valve. By maintaining a constant level in the filter, the water flow out of the filter is held the same as the flow into the adsorption clarifier regardless of head loss variations caused by solids capture in the filter bed or changes in the flow into the clarifier.

As the typical filter cycle proceeds, solids are removed by the adsorption clarifier media. As the solids accumulate, they cause the head loss across the clarifier to increase. This is detected by a pressure gauge and switch assembly measuring the pressure in the area beneath the media. When the pressure increase reaches a preset level (1.8 psi) set by the Field Engineer, the switch closes and a flush (cleaning) cycle is initiated. Blower B-310 turns on and will provide aerated air to agitate the adsorption clarifier media. This agitation will remove solids from the media, allowing the solids and motive water to carry over to the water discharge line to the catch basin. There is also a second pressure switch, set at a higher level, which, if actuated, will shut down the treatment unit. This is a precaution against damage to the tankage and/or retaining assembly.

Besides as a result of high head loss, an adsorption media flush cycle can also be initiated by a timer (programmed into the PLC) or by manual means (push-button on the control panel). In addition, the plant is designed so that a flush cycle takes place during a mixed media filter backwash cycle. The adsorption clarifier flush cycle can be expected to take place more often than a mixed media filter backwash. It is normal to have two to four adsorption media flushes during a filter run.

After a period of time, sufficient solids will be trapped in the mixed media filter to increase the head loss at which time a backwash cycle is started. The method of initiation is similar to the adsorption clarifier flush initiation, by means of a head loss gauge and vacuum switch (-3.5 psi). When a mixed media filter backwash cycle is initiated, it generally includes a flush cycle for the adsorption clarifier that occurs concurrently as described above.

5.4.4 Filter Effluent Tank

If the flush cycle is not initiated concurrently with the media backwash cycle, pump P-210 shuts down (Figure 5.9). Forward feed to the aeration tank continues, but the aeration tank level rises above a header which releases water to the gravity-fed discharge line. The media backwash cycle continues as valve LCV-310 closes, pump P-320 shuts down, and pump P-330 and blower B-310 turn on. The filter effluent tank is the source of backwash water pumped by P-330 to the mixed media filter. The backwash water and air agitate and scour the media. The generated suspended solids and the backwash water proceed over the weir in the mixed media chamber to the gravity fed discharge line. After a preset amount of time, P-330 and B-310 are turned off for a minute to allow the media to relax and settle. After this relaxation period, P-210 and pump P-320 turn on and valve FV-320 opens. Forward feed is once again initiated through the multimedia filter and valve FV-320 until residual suspended solids are removed from the system. Once the turbidity level reaches an acceptable preset level (< 1.0 NTU), the PLC opens valves LCV-310 and FV-303 and closes valves FCV-320 and FV-340. The filter effluent tank proceeds to fill with new backwash water until the level in the tank reaches a preset height as measured by LIT-340. Once this level is reached, valve FV-303 closes and valve FV-340 opens. Forward flow then proceeds under normal operation to the LGAC tanks (GC-500A).

5.4.5 Liquid Phase Granular Activated Carbon

Water from the multimedia filter is pumped via P-320 into the LGAC treatment vessel (GC-500A) at 4 gpm/ft^2 (Figure 5.11). The LGAC unit is provided by Westates Carbon (Model Number ASC-1000). Removal of color and odor compounds (microbiological in origin) will occur by contacting the Trimite multimedia filter effluent water with the liquid phase granular activated carbon (8 x 30 mesh). In addition, any volatile organic compounds (VOCs) present that have not been removed in the prior treatment steps of the FBR treatment system will be removed through the LGAC vessel (though only for a temporary period until the carbon reaches adsorptive capacity for the specific VOC).

Treated water exits the LGAC unit and is discharged to the effluent drain line that feeds the catch basin. A portion of this water (up to 35 gpm) is available as a sidestream to pass through a UV disinfection pilot reactor

5.4.6 UV Disinfection

The final step in the production of drinking water is disinfection (Figure 5.11). It is known that the UV disinfection process is a proven technology for other drinking water applications. The UV system is provided by Trojan Technologies Inc. and is a 10-35 gpm Trojan SWIFT^{TM} SC A02 UV Reactor (Ontario, CA). This unit was rented from Trojan Technologies Inc. for a three month period and returned at the end of the rental period.

The unit is delivered with 4 amalgam lamps (2 spare), 3 quartz sleeves (1 spare), 1 sensor, and 2 ballasts. The minimum target UV dose rate is 40 mJ/cm^2. Other unit particulars are listed:

• Lamp Type:	Low Pressure, High intensity, amalgam
• Number & Arrangement of Lamps:	2, parallel to flow
• Physical Dimensions:	6-inch diameter x 35-inch length
• Weight:	35 pounds (dry weight)
• Piping Connections:	2-inch, 150 lb. ANSI flange
• Electrical requirement:	0.29 kVA, 120 VAC, 1 phase, 60 Hz, 2 wire
• Ground Clearances:	40-inches required, one side
• Installation Requirements:	5 pipe diameters upstream of obstructions
• Flow Rate (minimum):	10 GPM
• Flow Rate (maximum):	35 GPM
• Physical Dimensions:	16 inch x 14 inch x 6 inch
• Weight:	20 pounds

5.4.7 Analytical Equipment

Monitoring of the feed groundwater and the effluent from the FBR reactor and downstream equipment was performed throughout the demonstration under various phases of operation in order to evaluate overall treatment effectiveness of the system with respect to the target contaminants of nitrate and perchlorate. The on-line nitrate and perchlorate analytical systems are incorporated into the FBR treatment system (Figures 5.14 and 5.15).

5.4.7.1 Nitrate Analyzer

The nitrate analyzers are supplied by HACH, Inc. (Denver, CO). The model used is the NITRATAX plus sc Sensors, 5 mm path length with a nitrate-N range of 0.1-25 mg/L $NO_{2/3}$-N. Feed water and FBR effluent continuously pass through two nitrate analyzers (AE-650 and AE-660), providing continuous monitoring through the HACH sc100 Universal Controller with measurements logged every minute (Figure 5.17). Such analyzers are tied into the feed forward control logic to modify the electron donor addition rate by the pump as needed to ensure consistently effective nitrate removal. A HACH supplied nitrate standard was available to calibrate the instrument per the manufacturer's recommendations.

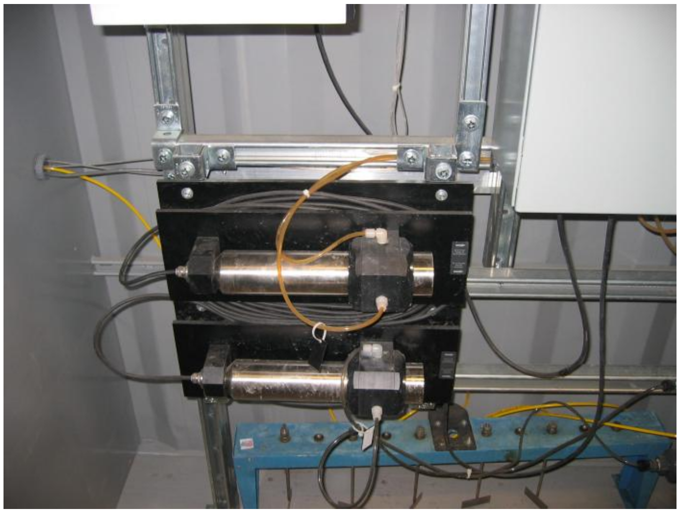
5.4.7.2 Perchlorate Analyzer

The on-line, continuous perchlorate analysis is conducted utilizing:

- 1 Dionex DX-800 Process Analyzer (Sunnyvale, CA)
- 2 IonPac AS16 Analytical Columns, 2 x 250 mm
- 4 IonPac AG16 Guard Columns, 2 x 50 mm
- 4 IonPacAG16 Concentrators, 4 x 50 mm
- 2 ASRS-ULTRA 92 mm) Anion Self-Regenerating Suppressors
- 1 EluGen II Hydroxide Cartridge
- 3 Sandpiper Double Diaphragm Sampling Pumps
- 3 Collins Membrane Sampling Filters
- 1 Dionex SS80 Multiport Sampling Valve
- 1 Miscellaneous valves, hardware, tubing, and cases

This complete on-line perchlorate analyzer and sampling system allows samples of water to be collected at the influent and effluent of the FBR system and analyzed by the instrumentation in alternating fashion (Figures 5.18 and 5.19). Using pumps P-610, P-620, and P-630 (if samples are desired post the multimedia filter), water samples are acquired from the FBR influent, FBR effluent, and multimedia filter. A portion of each sample is fed to a flow control valve FCV-740, with the balance of the sample going to a sump tank (T-640). From FCV-740, the sample is directed to the Dionex DX-800 Process analyzer. Within the analyzer, a 40 mM potassium hydroxide solution is used as an eluent. The sample and eluent are injected onto the perchlorate detector (AE-770). After analysis, the sample is returned to the sump tank T-640. Using the PLC to control the sampling and analyzer activity, a maximum of twenty-four combined samples per day can be obtained and analyzed for the influent and effluent of the FBR. From such readings, feed forward control logic is implemented to modify the electron donor addition rate to ensure complete removal of the perchlorate by the FBR. Per the manufacturer's recommendations, a 50 µg/L and a 1,000 µg/L calibration standard (Accustandard, New Haven, CT) are available to calibrate the on-line perchlorate analyzer.

Figure 5.17 Nitrate analyzers.



Figures 5.18 and 5.19 Sampling system and perchlorate analyzer.

The electron donor pump (P-430) is automatically controlled via a PLC proprietary model in proportion to feed flow (FIT-20), the dissolved oxygen concentration of the feed water, the nitrate concentration of the feed (AE-650), and the perchlorate concentration of the feed (AE-770). The dissolved oxygen concentration is an operator entered parameter that is measured manually with a handheld dissolved oxygen probe (Hach SensION, Denver, CO). Operator adjustable factors are provided in the software for the pump to adjust the proportionality constants for nitrate, perchlorate, oxygen, and feed flow parameters.

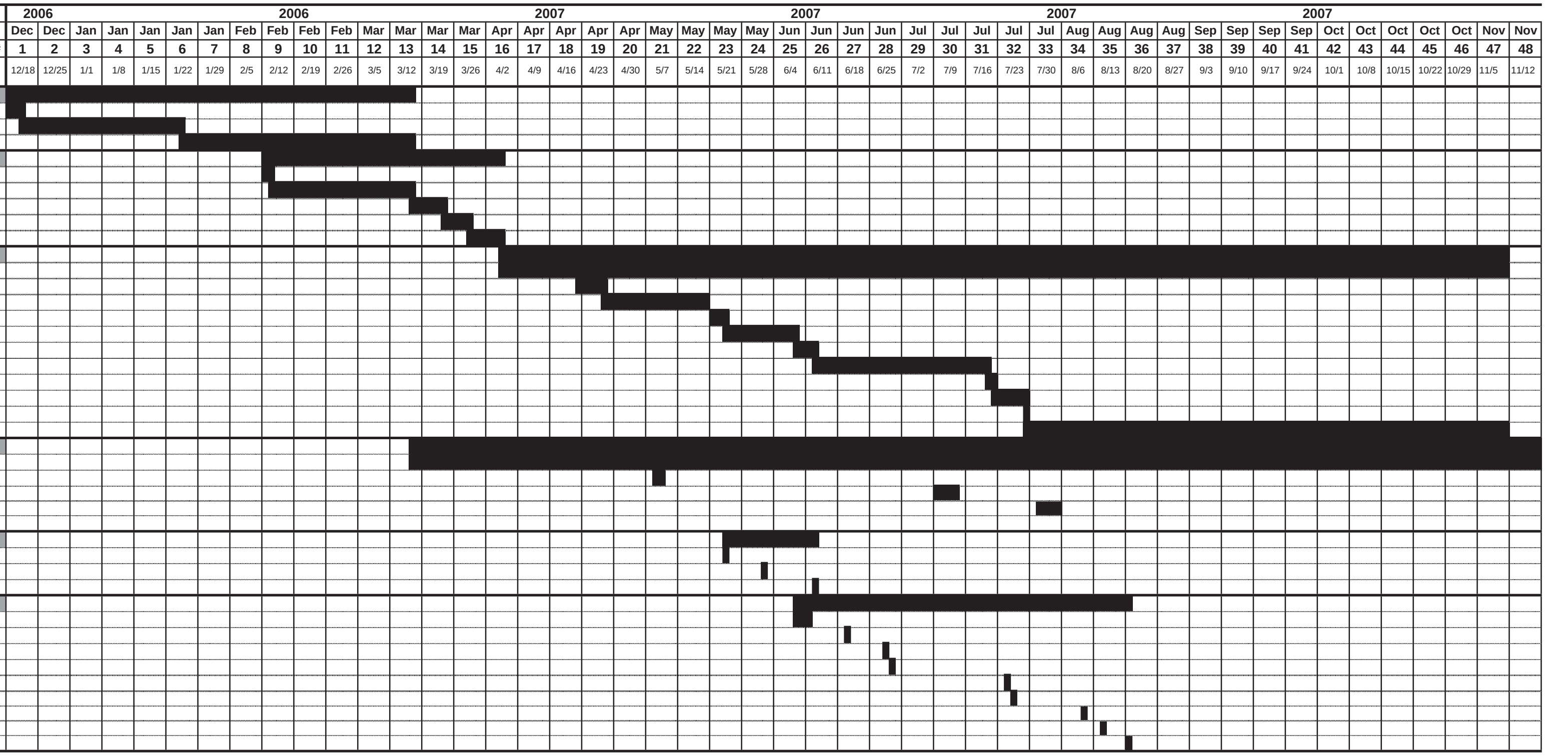
5.5 Field Testing

Several critical system and treatment operations have been evaluated over the one-year demonstration period of operation that involved experiments to test the robustness of the FBR technology while continuing to produce water with a perchlorate concentration less than 6 µg/L. A schedule of these experiments can be seen in Figure 5.20. These components of the study included start-up issues, the ability of the FBR treatment system to be self-inoculated with incoming groundwater, the treatment effectiveness under steady-state and transient loadings (including complete shut-down scenarios), the effectiveness of the on-line target contaminant analyzers, chlorination and UV disinfection study on the system effluent, and a perchlorate spiking study. These experimental design components are discussed in detail in the following sections.

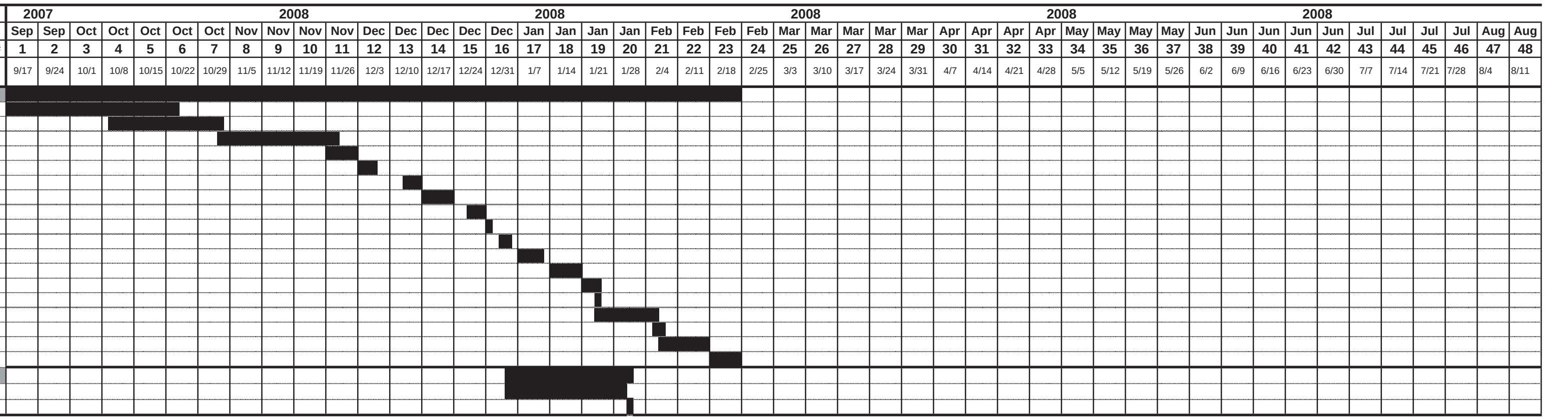
Figure 5.20 Demonstration Schedule.

PROJECT NAME: City of Rialto FBR
PROJECT MANAGER: Todd Webster

TASK #	TASKS	RESOURCE	START DATE	FINISH DATE	Work Days
1	**System Installation**		**12/18/06**	**3/15/07**	**64**
1.1	System Delivery	Shaw E&I	12/18/06	12/20/06	3
1.2	System Installation	Shaw E&I	12/20/06	1/24/07	26
1.3	System Shakedown	Shaw E&I	1/24/07	3/15/07	37
2	**Process Startup/Self-Inoculation**		**2/12/07**	**4/4/07**	**38**
2.1	Carbon Addition to FBR	Shaw E&I	2/12/07	2/13/07	2
2.2	Batch Operation of FBR	Shaw E&I	2/13/07	3/15/07	23
2.3	Forward Feed through FBR-20 gpm	Shaw E&I	3/15/07	3/22/07	6
2.4	Forward Feed through FBR-30 gpm	Shaw E&I	3/22/07	3/28/07	5
2.5	Forward Feed through FBR-40 gpm	Shaw E&I	3/28/07	4/4/07	6
3	**Treatment Effectiveness/System Shutdowns**		**4/4/07**	**11/9/07**	**158**
3.1	Forward Feed through FBR-50 gpm	Shaw E&I	4/4/07	11/9/07	158
3.2	Feed Shutdown Experiment #1	Shaw E&I	4/20/07	4/26/07	5
3.3	Recovery to Steady-state	Shaw E&I	4/26/07	5/19/07	17
3.4	Feed Shutdown Experiment #2	Shaw E&I	5/19/07	5/23/07	3
3.5	Recovery to Steady-state	Shaw E&I	5/23/07	6/7/07	12
3.6	Electrical Shutdown #1	Shaw E&I	6/7/07	6/12/07	4
3.7	Recovery to Steady-state	Shaw E&I	6/12/07	7/19/07	28
3.8	Nutrient Shutdown Experiment	Shaw E&I	7/19/07	7/20/07	2
3.9	Recovery to Steady-state	Shaw E&I	7/20/07	7/27/07	6
3.10	Electrical Shutdown #2 (8 hr)	Shaw E&I	7/27/07	7/27/07	1
3.11	Long-term Operation	Shaw E&I	7/27/07	11/9/07	76
4	**Analyzer Study**		**3/15/07**	**2/27/08**	**177**
4.1	Continuous Operation Study	Shaw E&I	3/15/07	2/27/08	177
4.2	Reduction in Electron Donor #1	Shaw E&I	5/8/07	5/9/07	2
4.3	Reduction in Electron Donor #2	Shaw E&I	7/9/07	7/12/07	4
4.4	Reduction in Electron Donor #3	Shaw E&I	7/31/07	8/3/07	4
4.5	Reduction in Electron Donor #5	Shaw E&I	2/27/08	2/27/08	1
5	**Chlorination Study**		**5/23/07**	**6/12/07**	**15**
5.1	Restart After Feed Shutdown (Post-LGAC)	Shaw E&I	5/23/07	5/23/07	1
5.2	Steady-State Operation (Post-Trimite)	Shaw E&I	5/31/07	5/31/07	1
5.3	Restart After Plant Shutdown (Post-Trimite)	Shaw E&I	6/12/07	6/12/07	1
6	**UV Study**		**6/7/07**	**8/20/07**	**53**
6.1	UV System Set Up	Shaw E&I	6/7/07	6/11/07	3
6.2	UV Steady-State (15 gpm)	Shaw E&I	6/19/07	6/19/07	1
6.3	UV Steady-State (25 gpm)	Shaw E&I	6/27/07	6/27/07	1
6.4	UV Steady-State (20 gpm)	Shaw E&I	6/28/07	6/28/07	1
6.5	UV Before/After Backwash (25 gpm)	Shaw E&I	7/24/07	7/24/07	1
6.6	UV Post LGAC (25 gpm)	Shaw E&I	7/25/07	7/25/07	1
6.7	UV Post LGAC (15/20/25 gpm)	Shaw E&I	8/9/07	8/9/07	1
6.8	UV Before/After Backwash (15/20/25 gpm)	Shaw E&I	8/14/07	8/14/07	1
6.9	Removal of UV Unit	Shaw E&I	8/20/07	8/20/07	1



TASK #	TASKS	RESOURCE	START DATE	FINISH DATE	Work Days
7	**Spiking Study**		**9/17/07**	**2/22/08**	**158**
7.1	Design of Spiking Study Equipment	Shaw E&I	9/17/07	10/23/07	36
7.2	Installation of Equipment	Shaw E&I	10/9/07	11/1/07	23
7.3	Testing of Equipment without Perchlorate	Shaw E&I	11/1/07	11/27/07	26
7.4	Spiking Test 1 (100 ppb, 25 gpm)	Shaw E&I	11/26/07	11/30/07	4
7.5	Spiking Test 2 (500 ppb, 25 gpm)	Shaw E&I	12/3/07	12/5/07	3
7.6	Spiking Test 3 (500 ppb, 25 gpm)	Shaw E&I	12/12/07	12/14/07	2
7.7	Spiking Test 4 (1000 ppb, 25 gpm)	Shaw E&I	12/17/07	12/21/07	4
7.8	Spiking Test 5 (1000 ppb, 25 gpm)	Shaw E&I	12/26/07	12/28/07	3
7.9	Spiking Test 6 (4000 ppb, 25 gpm)	Shaw E&I	12/31/07	12/31/07	1
7.10	Spiking Test 7 (2000 ppb, 25 gpm)	Shaw E&I	1/2/08	1/3/08	2
7.11	Spiking Test 8 (1500 ppb, 25 gpm)	Shaw E&I	1/7/08	1/10/08	4
7.12	Spiking Test 9 (2000 ppb, 25 gpm)	Shaw E&I	1/14/08	1/18/08	4
7.13	Spiking Test 10 (2000 ppb, 25 gpm)	Shaw E&I	1/21/08	1/23/08	3
7.14	Spiking Test 11 (1000 ppb, 25 gpm)	Shaw E&I	1/23/08	1/23/08	1
7.15	Spiking Test 12 (2000 ppb, 25 gpm)	Shaw E&I	1/23/08	2/5/08	13
7.16	Spiking Test 13 (1500 ppb, 25 gpm)	Shaw E&I	2/5/08	2/6/08	2
7.17	Spiking Test 14 (2000-4000 ppb, 25 gpm)	Shaw E&I	2/6/08	2/15/08	9
7.18	Removal of Equipment	Shaw E&I	2/18/08	2/22/08	5
8	**Demobilization**		**2/28/08**	**3/26/08**	**28**
8.1	Tear down of equipment	Shaw E&I	2/28/08	3/25/08	27
8.2	Load for Shipment	Shaw E&I	3/26/08	3/26/08	1



5.5.1 System Start-Up

The months of December, 2006 and January, 2007 were utilized to install all of the FBR treatment system equipment. Though the scale of the plant was a demonstration, significant mechanical, electrical, and civil work were required during the installation. Following the system installation, the shakedown of the system occurred. Using potable water, all of the vessels in the FBR treatment train were filled to normal operating levels. All of the pumps, blowers, and valves were cycled for proper operation. The in-line instruments (pH, ORP, nitrate and perchlorate analyzers, etc.) were calibrated per the manufacturer's recommendations. The chemical feed pumps were tested and calibrated. Chemical feed drums were set up and all system alarms were tested to ensure proper operation (Table 5.3). Forward flow of water was tested through all components of the plant.

Typical issues associated with the start-up of any water treatment plant were encountered. These issues included faulty actuator valves, PLC programming changes due to communication issues between individual pieces of equipment of the plant, and changes in instrument wiring. Approximately six weeks (latter January through March, 2007) were required to resolve all mechanical, electrical, and communication issues associated with the plant operation.

After the majority of systems proved to work correctly with forward feed flow of water only, the carbon media was introduced into the FBR vessel. The upper half the FBR vessel was drained of water and the carbon was placed manually into the vessel through the top opening. A scissor-lift was utilized to raise the carbon to the top of the reactor. A settled bed height of approximately 85 inches, as measured with a tape measure, was obtained. A hydraulically expanded bed height of 114 inches (1.34X) was established and the system was placed in recycle for the next two weeks. A Markland 10 sludge depth meter (Toronto, Ontario Canada), that can be lowered from the surface of the FBR to the water/carbon interface, allowed the operator to efficiently determine this fluidization of the bed. Fines were removed from the system and the recycled water pH was adjusted downward from 8.93 to 7.93 using a concentrated 85% phosphoric acid solution. After determining the fluidization pressures and flow to be out of design specifications, approximately 37 gallons of carbon was removed from the system so that the new settled bed height of 72 inches and the hydraulically expanded bed height of 102 inches were achieved.

Table 5.3 FBR treatment plant process alarms.

Parameter	Alarm Name	Range	Default Value	Result of Alarm	Time Delay
FAL-20	LOW FEED FLOW RATE	0 – 93 gpm	30 gpm	FEED SHUTDOWN	2 sec.
FAH-20	HIGH FEED FLOW RATE	0 – 93 gpm	70 gpm	FEED SHUTDOWN	2 sec.
AAH-105	HIGH PH, FBR FEED	1 – 14	8	FEED SHUTDOWN	30 sec.
AAL-105	LOW PH, FBR FEED	1 – 14	6	FEED SHUTDOWN	30 sec.
TAH-105	HIGH FBR TEMPERATURE	0 – 50°C	40°C	INFORMATION ONLY	2 sec.
PAL-105	LOW FBR FLUIDIZATION PRESSURE	Fixed point switch – set at Switch (1 psi below static pressure)		FBR SYSTEM SHUTDOWN Alarms reset w/ SYSTEM RECYCLE MODE	2 sec.
PAH-105	HIGH FBR FLUIDIZATION PRESSURE	Fixed point switch – set at Switch (Normal discharge head plus ½ of increase to dead-head pressure)		FBR SYSTEM SHUTDOWN Alarms reset w/ SYSTEM RECYCLE MODE	2 sec.
PAL-200	LOW AERATION AIR PRESSURE	Alarm is monitored 30 seconds after the start of B-200. Fixed point switch – set at Switch (2.0 psi)		SHUTDOWN B-200, FEED SHUTDOWN	2 sec.
LAL-210	LOW AERATION TANK LEVEL	PLC Loop configured level switch		WITHDRAW CLARIFIER FLUSH PERMISSIVE	2 sec.
LAH-210	HIGH AERATION TANK LEVEL	PLC Loop configured level switch		INFORMATION ONLY	2 sec.
LAHH-210	HIGH-HIGH AERATION TANK LEVEL	Fixed point level switch		WITHDRAW FILTER RUN PERMISSIVE, FEED SHUTDOWN	2 sec.
AAH-310	HIGH TURBIDITY ALARM	Trimite PLC Loop Configured Alarm		INFORMATION ONLY	2 sec.
LAHH-340	HIGH-HIGH FILTER EFFLUENT TANK LEVEL	Fixed point level switch		FEED SHUTDOWN	2 sec.

Parameter	Alarm Name	Range	Result of Alarm	Time Delay
LAH-340	HIGH FILTER EFFLUENT TANK LEVEL	PLC Loop configured level switch	CLOSE FV-303 OPEN FV-305 POSITIONS REVERT AFTER LEVEL DROPS 6-IN. BELOW LSH-340	2 sec.
LAL-340	LOW FILTER EFFLUENT TANK LEVEL	PLC Loop configured level switch	INFORMATION ONLY	2 sec.
LALL-340	LOW-LOW EFFLUENT TANK LEVEL	PLC Loop configured level switch	WITHDRAW TRIMITE RUN PERMISSIVE, FEED SHUTDOWN	2 sec.
FAL-410	LOW FLOW NUTRIENT	See note 1	FEED SHUTDOWN	60 sec.
FAL-430	LOW FLOW ELECTRON DONOR	See note 1	FEED SHUTDOWN	60 sec.
LAH-641	HIGH LEVEL, ANALYZER SUMP	Fixed point level switch	INFORMATION ONLY	2 sec.
AAH-761	HIGH PERCHLORATE CONC., FBR FEED	PLC Loop configured level switch	INFORMATION ONLY	2 sec.
AAH-762	HIGH PERCHLORATE CONC., FBR EFFLUENT	PLC Loop configured level switch	INFORMATION ONLY	2 sec.
AAHH-762	HIGH-HIGH PERCHLORATE CONC., FBR EFFLUENT	PLC Loop configured level switch	SYSTEM RECYCLE	2 sec.
AAH-763	HIGH PERCHLORATE CONC., FILTERED WATER	PLC Loop configured level switch	INFORMATION ONLY	2 sec.
AAHH-763	HIGH-HIGH PERCHLORATE CONC., FILTERED WATER	PLC Loop configured level switch	SYSTEM RECYCLE	2 sec.
Note 1: Reference LMI literature related to flow switch operation.				

During February, 2007, the system was operated in recycle mode for one week. During this time, the water was analyzed in the field for oxygen, nitrate and perchlorate, pH, temperature, oxidation-reduction potential (ORP), DOC, bed height, and ortho-phosphate-phosphorus. While in recycle mode, biological growth was visually evident within the FBR. After one week of batch operation, the continuous forward feed flow mode of operation began. However, it was quickly discovered that the feed groundwater oxygen concentrations were near saturation and fine air bubbles existed in the extracted groundwater. Due to the formation of bubbles in the feed water, this continuous mode of operation had to be interrupted numerous times. These fine air bubbles had a tendency to agglomerate at the bottom of the fluidized bed, eventually releasing as a large air bubble. This air release caused a portion of the fluidized media bed to be carried over the top of the FBR. Repeated media carry-over could potentially damage the recycle pump (P-100). Therefore, a load equalization tank (Harrington Plastics, San Diego, CA) with a gas dispersion spray nozzle (Hengst Company, Laguna, CA) was added between the wellhead and the FBR to disperse the fine air bubbles (Refer to Figure 5.2). The introduction of this load equalization tank remedied the problem and the presence of the fine air bubbles was eliminated.

After the bubble formation issue was resolved, the system was restarted at 20 gpm and ramped up to 50 gpm over a period of four weeks. Complete oxygen, nitrate, and perchlorate removal were observed during the ramp up process. Electron donor and nutrient requirements for the feed water stream were bracketed and fine tuned.

5.5.2 Self-inoculation

Typically, fluidized bed bioreactors are inoculated with a seed population of microorganisms to rapidly initiate the system operation and increase target contaminant removal performance. For this experimental study, a seed microbial population was not utilized. Instead, the natural flora of the incoming groundwater to the FBR was allowed to inoculate the system. A key objective was to determine how quickly and efficiently an FBR can be started and operated without the addition of an outside source of microbiological seed. For the first month of the demonstration, the system was started in such a manner to promote as much bioactivity in the FBR as possible. During the first week of operation, nutrients, electron donor, and perchlorate laden water were introduced into the reactor in batch mode. The concentration and quantity of electron donor and nutrients added were initially based on the results from the baseline well water analysis studies and the stoichiometric requirements of the electron acceptors oxygen, nitrate, and perchlorate. The FBR system was placed in recycle, allowing the natural flora in the groundwater to inoculate the reactor. On-site and off-site analytical tests for dissolved oxygen, nitrate, and redox potential were conducted daily to determine the effectiveness of the natural flora to establish bioactivity in the reactor. Perchlorate analysis was conducted as needed based on the demonstrated precursor bioactivity of oxygen and nitrate removal. Based on the bioactivity results observed in the FBR over the first month of operation (in February, 2007), it was determined (by removal performance data) that the media had sufficient denitrifiers and perchlorate reducers to allow for acceptable treatment of continuous feedwater. Once the system was placed in continuous mode of operation, the feed was started at 20 gpm and increased to 50 gpm stepwise over the first month of feed-forward operation.

5.5.3 Treatment Effectiveness

Over the course of the study, the complete FBR treatment system was monitored to determine the ability of the system to adequately produce drinking water. The system was monitored to determine how it adjusts to changes in feed characteristics while continuously treating the perchlorate concentrations to acceptable levels.

While the nitrate and perchlorate treatment effectiveness was being demonstrated across the FBR system, the downstream systems were also monitored and tested to ensure their ability to effectively perform under varying conditions (i.e., increasing flowrates, concentrations, etc.). The post-aeration device was tested to effectively and continuously reaerate the water and remove any residual electron donor from the FBR effluent. In addition, the necessary coagulant and polymer loading rates required by the multimedia filter were established to ensure adequate solids removal and produce a filter effluent water quality below 0.1 NTU.

Extensive analytical water testing using on-site measurements and off-site California certified analytical laboratories (EMAX Laboratory, Inc., Torrance, CA and E.S. Babcock & Sons, Inc., Riverside, CA) demonstrated the FBR, post-aeration, multimedia filter, and LGAC effectiveness to produce potable-like water quality effluent (See Section 5.6).

During the batch-mode and continuous modes of operation, all system operating parameters were monitored by field personnel on a daily basis. Key operating parameters monitored included:

- system feed flowrate
- FBR recycle flowrate and inlet pressure
- FBR bed height
- electron donor and nutrient addition rates
- FBR recycle water pH, temperature, and ORP
- blower outlet pressure and temperature
- coagulant and polymer addition rates
- multimedia filter flush cycle and backwash frequency
- multimedia filter effluent turbidity measurements
- system pressure readings

During the various operating scenarios of the FBR treatment system, this data was evaluated to ensure the FBR was operating properly and the downstream equipment was adequately producing potable-like water.

Routine maintenance of the system was conducted to ensure that the performance was optimized throughout the study and to chronicle those items that required a preventive maintenance schedule to be developed. Such routine maintenance items included:

- perform the daily checklists of the key mechanical parameters
- filling the electron donor and nutrient tanks on a weekly basis
- calibrating the electron donor and nutrient delivery pumps on a weekly basis
- calibrating the pH and ORP electrodes on a weekly basis
- filling the coagulant and polymer tanks on a weekly basis
- calibrating the coagulant and polymer delivery pumps on a weekly basis
- cleaning the nitrate analyzers and turbidimeter on an as needed basis
- cleaning the UV system on an as needed basis
- attending to the on-line perchlorate analyzer system to ensure continuous operation

A number of additional tests were performed on the FBR treatment plant downstream equipment to optimize and detail their performance. The Trimite multimedia filter was tested utilizing a variety of coagulants and polymers for solids removal performance based on effluent turbidity values and clarifier and multimedia filter backwash frequencies. In addition, analysis of clarifier and multimedia backwash water was conducted for COD, BOD, TSS, and metals. Such data is necessary to assess the quantity and quality of backwash water constituents that may be released to a POTW at the full-scale level. Because the adsorption clarifier flush and the multimedia backwash event occurred over an extended period (minutes), sampling during each event was conducted at the beginning, middle, and end of each process.

5.5.4 System Shut-Down Scenarios

The robustness of the FBR system to respond to shut down and restart scenarios was tested. In one case (repeated twice), a simulated feed pump failure was tested. For the second case (repeated twice), a complete plant electrical failure scenario was demonstrated by shutting the system completely down. For the third case, a nutrient pump failure was simulated.

5.5.4.1 Feed Shutdown

A simulated feed pump failure experiment was conducted shortly after the FBR treatment plant began operation (Day 38). The FBR system was placed in recycle mode of operation for five days without forward feed flow. Such a situation simulated a temporary well shut-down scenario for maintenance or a feed pump failure where the system is temporarily without feed water. No electron donor or nutrients were added to the FBR system over the five-day period. After the five-day shutdown period concluded, electron donor and nutrient addition were restarted and the plant received full forward feed flow. Analysis of the influent and effluent water chemical parameters were conducted several times as the system came back on-line to establish how quickly the system was capable of rebounding from the short-term shutdown.

In order to determine if/how the rebound time for system treatment is effected by the maturity of the biological population within the FBR, the experiment was repeated after the plant had been operating for 75 days. From such an experiment, it was desirable that effective procedures could be developed for maintaining biological activity in an FBR system during short-term shutdown scenarios.

5.5.4.2 Plant Electrical Shutdown

A simulated complete plant electrical shutdown scenario, simulating a complete system electrical failure, was performed on Day 84 for five days. The entire plant was shutdown such that no forward feed of water flow occurred and the FBR was not in recycle mode. The media was not hydraulically fluidized and subsequently settled to the bottom of the FBR tank. After five days of no operation, the system was restarted similarly as with the feed pump failure experiment and the ability of the system to rebound was analyzed.

Most plant shutdowns will occur over a shorter duration than five days and generally will not last longer than one day. For this reason, on Day 134, a second electrical shutdown experiment was conducted for a shorter duration (8 hours) and the system was analyzed for performance rebound upon restart.

5.5.4.3 Nutrient Shutdown

The addition of NSF phosphoric acid to the FBR as a phosphorus source occurred continuously. However, experience from the operation of other FBR plants has shown that the need for phosphorus addition is site specific. If the feed groundwater contains trace amounts of phosphorus, the need to add it to the FBR to complete the perchlorate degradation process may not be required. For this reason, on Day 126 through the morning of Day 127, the nutrient addition was stopped for 21 hours while the electron donor addition continued. Analysis of the influent and effluent water chemical parameters was conducted several times over the eight hour period to determine if nitrate and perchlorate removal performance declined as a function of the lack of phosphorus addition.

5.5.5 On-Line Analyzer Effectiveness

The on-line nitrate and perchlorate analyzers were operated continuously throughout the year of operation of the FBR treatment system. Nitrate samples were analyzed every minute while perchlorate samples were collected per the individual experimental requirements. However, under typical steady-state operating conditions, perchlorate samples were analyzed every four hours at the effluent and at twice a day at the feed to the system. Data was collected, analyzed, and compared with off-site analysis for comparison.

Besides daily on-line measurements of nitrate and perchlorate, additional experiments were conducted and data collected to assess the importance or need for each on-line analyzer. Based on historical practice from other prior FBR applications, when nitrate concentrations are substantially higher than perchlorate concentrations in the feed water, nitrate removal across the FBR has shown to be an excellent marker for the removal of perchlorate. Under steady-state operating conditions, the degree to which such a correlation exists was demonstrated by limiting the electron donor addition to the FBR system such that varying levels of nitrate in the FBR effluent were observed (up to 5 mg/L as nitrate-N) via the on-line effluent nitrate analyzer. At the various levels of nitrate breakthrough, perchlorate concentrations were continuously monitored in real-time and concurrently at the FBR effluent. The ultimate goal from such a study was to establish a protocol for continuous operation and to demonstrate to CADPH that for sites with a mixture of nitrate and low concentrations of perchlorate, the use of two nitrate analyzers alone on such a biological system could provide adequate instrumentation to demonstrate perchlorate removal. Overall, four electron donor reduction experiments were conducted.

Whenever a biological FBR plant is started, a number of adjustments to the electron donor addition rate are required over the first few months of operation. These various adjustments allow for a precise determination of upper and lower electron donor addition requirements for the complete treatment of the feed oxygen, nitrate, and perchlorate. The Electron Donor Reduction Experiment #1 (Day 54) occurred as a result of one of these periods of adjustment in operation. During this experiment, the electron donor rate of addition was decreased below the stoichiometric requirements such that a breakthrough of both nitrate and perchlorate were observed.

The Electron Donor Reduction Experiment #2 (Day 116) was performed differently than the first experiment. For this case, the acetic acid was cut back rapidly. With the rapid decrease in acetic acid, a correlation between treatment and available, stored acetic acid could be identified. The perchlorate analyzer was set up to take samples every 45 minutes (most rapid sampling frequency available), while the nitrate analyzer measured nitrate-N every minute.

In order to confirm the results observed for the Electron Donor Reduction Experiment #2, Experiment #3 (Day 138) was conducted where the acetic acid was slowly reduced (as opposed to rapidly reduced as in Experiment #2). With the slower decrease in acetic acid, a correlation between treatment and time to exhaust available, stored acetic acid could be identified. The perchlorate analyzer was set up to take samples every 45 minutes (most rapid sampling frequency available), while the nitrate analyzer measure nitrate-N every minute.

Electron Donor Reduction Experiment #4 (Day 349) was conducted at the end of the demonstration study (Day 349). The goal of the experiment was to determine the DOC concentrations (from the acetic acid) in the mature, operating FBR effluent treatment plant required to ensure that complete nitrate and perchlorate treatment occurred. The experimental protocol was:

- Collect a DOC sample of the FBR effluent water and analyze using the on-site HACH DR 2800 Spectrophotometer (Loveland, CA).
- Turn OFF the acetic acid pump. Note the exact time.
- Set up the Dionex automatically sampling of perchlorate from the FBR effluent for every 60 minutes. Have the Dionex take the first sample 30 minutes after turning the acetic acid pump OFF.
- Thirty (30) minutes later, approximately 60 minutes after the acetic acid pump has been turned OFF, collect a sample of FBR effluent water and place the bottle on ice. Collect subsequent samples every 30 minutes in between automatic perchlorate analysis sampling.
- Observe nitrate-N FBR effluent values and write down values every 30 minutes. Effluent nitrate-N values >0.3 mg/L will likely correlate to some degree of perchlorate breaking through.
- Collect a DOC sample of the FBR effluent water and analyze every 30 minutes until breakthrough of perchlorate (> 6 µg/L) is observed in the FBR effluent water.
- Upon breakthrough, take one final DOC sample from the FBR effluent.
- Note time and restart acetic acid pump at prior addition rate immediately.
- Continue to automatically sample perchlorate from the FBR effluent every 60 minutes until system rebounds and the perchlorate is ND. Have the Dionex take the first sample 30 minutes after turning the acetic acid pump back ON.
- Thirty (30) minutes later, approximately 60 minutes after the acetic acid pump has been turned back ON, collect a sample of FBR effluent water and place on ice. Collect subsequent samples every 30 minutes in between automatic perchlorate analysis sampling.
- Collect a DOC sample of the FBR effluent water and analyze every 30 minutes until perchlorate is ND in the FBR effluent water (maximum of 4 samples).
- Once perchlorate is again ND, manually analyze all perchlorate samples that have been collected.

5.5.6 Chlorination Disinfection Study

An issue of concern regarding the biological treatment of drinking water is the potential for release of harmful microorganisms from the effluent of the treatment system. Based on this concern, an experimental study was performed to demonstrate the effectiveness of chlorination disinfection of finished water from the FBR treatment system. According to Title 22 of the California Code of Regulations, the required level of disinfection is a 4.0-log inactivation of viruses; however, inactivation of other microorganisms potentially present was also verified. The objectives of the disinfection protocol were to demonstrate:

- The effectiveness of several CT values (chlorine concentration multiplied by the contact time) for the inactivation of microorganisms to achieve disinfection
- Impacts of any variability in finished water quality on disinfection
- The potential for formation of disinfection byproducts (total trihalomethanes [TTHMs] and haloacetic acids [HAA5])

The chlorination study consisted of three experiments to assess chlorination requirements under varying operating conditions. These three experiments were conducted:

- After the Feed Shutdown Experiment #2 on the LGAC effluent water (Day 69)
- During steady-state operation on the Trimite multimedia filter effluent water (Day 77)
- After the Electrical Shutdown #1 Experiment (Day 89)

Prior to initiating the three experiments of the chlorination study, microbiological samples were sampled and analyzed for the total coliform, *E. Coli*, and heterotrophic plate counts from the FBR feed, FBR effluent, multimedia filter effluent, and the LGAC effluent. These initial samples served to provide baseline microbiological activity.

For the three chlorination study experiments, the chlorination disinfection protocol was developed to essentially cover a range of CTs to demonstrate an inactivation of viruses/bacteria. After the first experiment was completed on the LGAC effluent water, the protocol was adjusted to focus on the Trimite multimedia filter effluent water. The number of samples acquired at various CTs and for disinfection byproduct potential were adjusted based on the first experimental results. The complete protocol that was followed is described in Appendix C.

5.5.7 Ultraviolet Reactor Study

An additional disinfection study was recommended by the CADPH regarding the testing of an ultraviolet light reactor on a slipstream of the plant effluent. Through a cooperative agreement with Trojan Technologies Inc., a 10-35 gpm Trojan SWIFT^{TM} SC A02 UV Reactor was supplied to treat the slipstream of FBR effluent. The specifics of the unit are described in Section 5.4.6.

An experimental study to determine the efficacy of the combination of the FBR reactor with the UV disinfection reactor was conducted. Due to limitations in the pilot- UV system, UV dosage was varied only by modifying the time of exposure (intensity remained constant for the pilot). An experimental protocol for the UV disinfection study is provided in Appendix D. From such a study, the exposure time required to effectively inactivate the microbial population to drinking water standards was determined under differing operating scenarios. Such data, in conjunction with the chlorination study, can assist the City of Rialto and the CADPH to determine the most effective and economical combination of disinfection protocols for the FBR effluent.

5.5.8 Spiking Study

In producing quality drinking water from higher perchlorate loaded feedwater, the FBR treatment performance, in conjunction with the downstream equipment performance, requires validation before the California Department of Public Health would permit such a system at the full-scale. System performance is based on the ability of the FBR to effectively treat the higher influent perchlorate concentrations to the State of California MCL (6 µg/L) while performing under a variety of loading conditions. Significantly higher perchlorate loading conditions (25 gpm with perchlorate up to 4,000 µg/L) were implemented to determine the robustness of the entire plant to effectively operate. At this flow, a 24.3 minute media bed HRT and a 2.67 recycle ratio were established. The ability of the FBR system to operate at higher perchlorate loads after short- and longer-term interruptions was also studied. From such data, operational costs for items such as required additional reactors, pumps, and ancillary equipment were determined. In addition, operational costs were formulated for scaled-up systems that will account for the increased demand of acetic acid, nutrients (if required), replacement carbon, and maintenance.

The perchlorate spiking experiments occurred via the addition of potassium perchlorate (non-NSF certified) using an LMI diaphragm pump downstream of the wellhead but upstream of the FBR treatment plant. Over the course of four months, the feed perchlorate concentrations were ramped up from the existing groundwater perchlorate concentrations in the feedwater (currently 50 µg/L) to 100 µg/L, 500 µg/L, 1,000 µg/L, 1,500 µg/L, 2,000 µg/L, and 4,000 µg/L. Short-term perchlorate spiking interruptions (1 to 12 hours) and longer-term interruptions (over weekends) occurred which allowed the stakeholders and Basin Water, Inc. to demonstrate to CADPH the capabilities of the treatment system under some of the most stressful operating conditions. For the downstream treatment equipment after the FBR, the necessary coagulant/flocculating agent addition rates were determined for the multimedia filter. Microbiological, chemical, and disinfection byproduct potential analyses were conducted for the plant effluent water.

During the spiking studies, the Trimite multimedia filter effluent dirty backwash water (after a clarifier flush and mixed media backwash) was directed to a 1,550 gallon Chemtainer (Harrington Plastics, San Diego, CA) holding tank (Figure 5.21). Water from this holding tank and all FBR treatment plant water were directed to two 20,000 gallon Baker Tanks (Los Angeles, CA) to ensure that no perchlorate laden water was released to the catch basin that exceeded the baseline perchlorate levels (50 µg/l) in the feed groundwater (Figures 5.22). The 20,000 gallon Baker Tanks were filled twice daily and checked for perchlorate levels. If the perchlorate concentrations were measured to be below 30 µg/l (this incorporated a safety factor), the water was then released to the catch basin through a network of pipes. If the levels of perchlorate in the two tanks were not below 30 µg/l of perchlorate, the water from the Baker Tanks was recycled to the front of the plant until the perchlorate was treated sufficiently (Figure 5.23).

These spiking studies allowed maximum elimination capacity rates of nitrate and perchlorate to be determined (gram of target contaminant removed per m^3 of media per hour) so that the system could be scaled accordingly for larger flows and loading rates.

Figure 5.21 Spiking study backwash water holding tank.

Figure 5.22 Spiking study plant effluent 20,000 gallon holding tanks.

Figure 5.23 Spiking study recycle pump.

5.5.9 Demobilization

A number of demobilization activities were associated with this study. Elements of demobilization included:

- Disconnection and termination of electrical power to the FBR treatment system by a certified electrician
- Removal of the carbon from the FBR vessel
- Cleaning out of the FBR vessel, post aeration vessel, multimedia filter, LGAC unit, UV unit, and piping with potable water
- Removal of piping runs between equipment
- Disconnection of all equipment from the water feed and effluent discharge lines
- Capping off of the water feed and effluent discharge lines
- Removal of chemicals from the site
- Removal of demonstration trailer, associated controls, pumps, and equipment
- Shipment of all equipment off site
- Of these items, the cleaning of the equipment and the carbon removal procedure requires further detailed explanation of the necessary procedures.

5.5.9.1 Cleaning of the FBR Treatment System

The LGAC and UV units were rentals. After completion of their use, these units were flushed with groundwater and returned to the manufacturers. The carbon from the LGAC was tested for hazardous waste characteristics. It was shown to not be hazardous and fully accepted by the manufacturer.

After the final experiments were conducted for the FBR treatment plant demonstration, all FBR chemical additions (i.e., electron donor and nutrient) were stopped. The FBR was then placed in recycle for two days and the eductor and biomass separator were turned on simultaneously to agitate and reduce the bed volume within the FBR. After the two days in recycle, the FBR bed had decreased to levels representing only hydraulic expansion. The FBR treatment plant was placed in forward feed with groundwater for a day to allow the agitated biomass to be flushed out of the system. The post-aeration and Trimite multimedia filter continued to operate as normal. The system was flushed out completely with feed groundwater. The chemical addition was stopped to the Trimite multimedia filter and numerous clarifier flushes and mixed media backwashes were conducted until the flush and backwash water was clear. Once the water leaving the FBR, post-aeration unit, and the Trimite multimedia filter appeared visibly clear, the plant was placed in shut down mode. The post-aeration vessel and the Trimite multimedia filter were drained of all liquids, manually flushed with a hose from above using potable water, and packaged for shipment. The FBR was prepared for carbon removal and clean-out.

5.5.9.2 Removal of Carbon from the FBR Vessel

After the plant shutdown occurred, the water from the FBR was pumped out from the top of the FBR using the biomass separator pump to the catch basin and the carbon settled to the bottom of the reactor. Using a handway flange at the bottom of the FBR, the carbon was removed from the FBR and disposed of as solid waste. Once all of the carbon had been removed from the FBR vessel, a hose was used to clean out the internals with potable water.

5.6 Sampling Methods

A comprehensive and accurate performance evaluation of the FBR treatment system depends on obtaining a complete, representative, and consistent data set chronicling the results of the demonstration. The data must define the original and changing contaminant concentrations with the amount and rates of contaminant removal.

Sampling activities to support the demonstration and provide the necessary data include two primary phases:

- startup sampling, which includes limited site characterization and initial system performance sampling
- demonstration sampling under steady-state conditions, which includes performance optimization and long-term monitoring and sampling

The primary matrix sampled during the demonstration was the raw feed groundwater (i.e., FBR influent), treated FBR effluent water, and the post-treatment water (post-aeration, Trimite multimedia filter, LGAC, and UV effluent). This section describes the sample collection and analysis methods performed during the technology demonstration. A discussion on the sample collection methods and the selection of the laboratory and analytical methods are provided. All sampling and performance monitoring was carried out in accordance with the Quality Assurance Project Plan (QAPP, Appendix E).

5.6.1 Sample Collection

Table 5.4 lists the parameters tested, the locations where the samples were obtained, and their frequency of sampling. The sample locations for all of the parameters are shown in Figures 5.7 through 5.11. From Figure 5.7, the FBR influent sampling location was AP-20 and the FBR effluent sampling location was AP-110. From Figures 5.8 and 5.9, the influent and effluent Trimite multimedia filter sampling locations were AP-210 and AP-320. From Figure 5.10, the effluent LGAC sampling location was AP-500. All of the samples were obtained by the Field Technician, with the exception of the on-line nitrate, perchlorate, pH, ORP, and temperature readings. These values were recorded continuously in the PLC. All field measurements were recorded in a logbook by the Field Technician and copied to an EXCEL spreadsheet for review by the Field Project Manager.

All sample bottles for off-site analysis were shipped to the Rialto Well #2 site in an insulated cooler to arrive at least one day prior to the scheduled sampling event. All sample bottles for the upcoming round of sampling were supplied by the off-site laboratory and contained the necessary preservative. Clean plastic bottles (1 liter) were used for anions (nitrate, bromide, sulfate, chloride), TSS, TDS, color, and corrosivity. Clean 500 ml plastic bottles were used for metals and ammonia. Clean 125 ml plastic bottles were used for perchlorate and TOC. Amber glass vials of 40 ml and 60 ml were used for the HAA5 and THM formation potentials, respectively. The bottle size, type and preservative are shown in Table 5.5.

When sampling, the Field Engineer ensured that a representative sample was collected by allowing the sample line to adequately purge before collecting the actual sample. The bottles were completely filled and capped with zero head-space and the samples chilled in coolers immediately after collection. Coolers were kept out of direct sunlight as much as possible. The samples were stored at less than 4°C in a cooler before shipment to the laboratories. Shock absorbent packing was added to the cooler to prevent breakage or damage of the sample containers during shipment. A chain-of-custody (COC) form, sealed in a plastic bag to protect it from water, was added to the inside of the cooler.

The Field Engineer performing the sampling filled out and signed the COC. Samples were shipped or delivered on the day of collection. For any coolers destined for off-site analysis, the Field Engineer was tasked to pack with sufficient ice to maintain sample temperatures at 4°C during shipment. To ensure safe transport of the samples, the coolers were securely taped all the way around. The sampler relinquished custody of the coolers to an express carrier or delivered them to the off-site laboratories on the same day of collection. The sampler and off-site laboratories maintained a copy of the COC as part of the sample custody file (from time of collection to analysis). Upon receipt of each sample shipment, the coolers were inspected. Any problems were noted on the COC record and reported to the Field Project Manager. All samples sent to the off-site laboratories were to be analyzed within the proper hold times for the requested analyses. The QAPP provides a more in-depth discussion of sample documentation procedures (Appendix E).

Table 5.4 Total number and types of samples to be collected.

Analyte/Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (At Steady-State)	Drinking Water Standards[1]	Sample Location	Reason for Monitoring Parameter
Acetic Acid Flow	Field	Calibration Columns	1x per day	1x per week	NA	FBR Skid	Used to determine amount of acetic acid fed to reactors.
Dissolved Oxygen (DO)	Field	Probe	Daily (3x per week)	1x per week	Not Specified as having a Secondary MCL	FBR Feed FBR Effluent	Used to determine acetic acid dosage.
FBR Bed Height	Field	Markland Model 10 Sludge Level Detector	5x per week	5x per week	NA	FBR Vessel	Used to determine FBR bed height.
Fluidization Flow	Field	System Flow Indicator	Continuous (checked 5x per week)	Continuous (checked 5x per week)	NA	FBR Skid	Used to determine bed expansion vs. recycle flow.
Nitrate-N	Field	On-line System Analyzer-HACH NITRATAX	Continuous	Continuous	10 mg/L for primary MCL	FBR Feed	Used to determine acetic acid dosage.
Nutrient Flow	Field	Calibration Columns	1x per day	1x per week	NA	FBR Skid	Used to determine amount of inorganic nutrients (P) fed to FBR.
Oxidation-Reduction Potential (ORP)	Field	On-line Probe	Continuous (checked 3x per week)	Continuous (checked 3x per week)	NOT APPLICABLE (NA)	FBR Effluent	Used to help estimate acetic acid dosage. Measurement below negative (-) 100 mV is usually good.
Perchlorate	Field	On-line System Analyzer-Dionex DX-800	Daily (6x per day minimum)	Daily (6x per day minimum).	6 µg/L as action level	FBR Feed FBR Effluent	Influent analyses used to set acetic acid dosage. Effluent analyses used to screen (only) for perchlorate treatment.
pH - Fluidization	Field	Probe	3x per week	1x per week	NA	FBR Fluidization	Used to determine if system pH probe is out of calibration.
pH - Fluidization	Field	System pH Analyzer	Continuous (checked 3x per week)	Continuous (checked 3x per week)	NA	FBR Skid	Used to determine operating pH
Pressure Gauges	Field	System Pressure Gauges	Daily (5x per week)	5x per week	NA	FBR System	Used to determine normal operating line pressures.
System Feed Flow	Field	System Feed Flow Indicator	Continuous (checked 5x per week)	5x per week	NA	FBR Skid	Used to determine load on reactor.
Temperature	Field	Thermometer	5x per week	1x per week	NA	FBR Feed FBR Effluent	Used to monitor system temperature.

Analyte/Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (At Steady-State)	Drinking Water Standards[1]	Sample Location	Reason for Monitoring Parameter
Turbidity	Field	Hach 2100 Portable Turbidimeter	5x per week	1x per week	Report Value	Filter Influent	To determine filter efficiency and as required by Title 22 Div 4 Ch 17 Sec 64655 (a)
Turbidity	Field	On-line Analyzer	Continuous	Continuous	0.3 NTU for 95% of operation and <1.0 NTU for any one hour of operation	Filter Effluent	Required by Title 22 Div 4 Ch 17 Sec 64655 (f)
Free Chlorine	On-Site Laboratory	Hach Method 8021 (DPD)[2]	As required by Disinfection Protocol	As required by Disinfection Protocol	Report Value	Filter Effluent	Used in establishing CT during disinfection protocol
Nitrite-N	On-site Laboratory	Hach Method 8507 (Diazotization) [2]	2x per week	1x per week	10 mg/L for primary MCL	FBR Feed	Used to determine acetic acid dosage. If present at <0.5 ppm consistently, analysis can be discontinued.
Ortho-phosphate (reactive)	On-site Laboratory	Hach Method 8048 (Ascorbic Acid) [2]	3x per week	3x per week	Not Specified as having a Secondary MCL	FBR Effluent	Used to determine if adequate nutrients are available. Measurement greater than 1 ppm is usually good.
Total Chlorine	On-Site Laboratory	Hach Method 8167 (DPD)[2]	As required by Disinfection Protocol	As required by Disinfection Protocol	Report Value	Filter Effluent	Used in establishing CT during disinfection protocol
Total Organic Carbon/ Dissolved Organic Carbon	On-site Laboratory	Hach Method (Digestion, Persulfate, Sulfuric Acid)	3x per week	1x per week	Organic Contaminant Specific	FBR Effluent (filtered samples – 0.45 um filter) GAC Effluent	Used to confirm reactor operation – residual acetic acid – and finished water requirements.
Chloride	Off-Site Laboratory	EPA 300.0	1x week	Final week	Secondary MCLs established in Table 64449-A/B of Title 22	FBR Feed FBR Effluent	Required by Title 22 Div 4 Ch 15 Section 64449
Chlorate/Chlorite	Off-Site Laboratory	EPA 314.0	One time before feed water introduced to the system	Final week	None specified	FBR Feed FBR Effluent	To determine if perchlorate daughter products are formed
Color	Off-Site Laboratory	EPA 110.2/SM 2150	1x week	Final week	Secondary MCLs established in Table 64449-A/B of Title 22	FBR Feed FBR Effluent	Required by Title 22 Div 4 Ch 15 Section 64449

Analyte/Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (At Steady-State)	Drinking Water Standards[1]	Sample Location	Reason for Monitoring Parameter
Corrosivity	Off-Site Laboratory	EPA 150.1/SM 2330B	1x week	Final week	Secondary MCLs established in Table 64449-A/B of Title 22	FBR Feed FBR Effluent	Required by Title 22 Div 4 Ch 15 Section 64449
Haloacetic Acids Formation Potential (HAA5)	Off-Site Laboratory	EPA SM6251B/5710A/ 5710B (modified)	As required by Disinfection Protocol	As required by Disinfection Protocol	0.060 mg/L	Filter Effluent LGAC Effluent	Required by Title 22 Div 4 Ch 15 Section 64439
Metals (Barium, Cadmium, Chromium, Mercury, Nickel, Lead, Zinc, Manganese, Iron)	Off-Site Laboratory	EPA 200.7/200.8/6010B/7470	One time before feed water introduced to the system	1x week at Filter Effluent	MCLs as established in Table 64431-A of Title 22	Filter Feed Filter Effluent	Required by Title 22 Div 4 Ch 15 Section 64431
Nitrate-N	Off-site Laboratory	EPA 300.0	3x per week	As needed, bi-weekly schedule otherwise.	10 mg/L for primary MCL	FBR Feed FBR Effluent	Influent analyses used as QA/QC for on-line analyzer - can be discontinued once confirmation of analyzer performance is established.
Perchlorate	Off-site Laboratory	EPA 314.0	3x per week	As needed, bi-weekly schedule otherwise.	6 µg/L as action level	FBR Feed FBR Effluent	Influent analyses used as QA/QC for on-line analyzer - can be discontinued once confirmation of analyzer performance is established. Objective of FBR operation is to remove perchlorate to < 4 µg/L.
Sulfate	Off-Site Laboratory	EPA 300.0	1x week	Final week	MCLs established in Table 64449-A/B of Title 22	FBR Feed FBR Effluent	Required by Title 22 Div 4 Ch 15 Section 64449
Total Dissolved Solids	Off-Site Laboratory	EPA 160.1	1x week	Final week	Secondary MCLs established in Table 64449-A/B of Title 22	FBR Feed FBR Effluent	Required by Title 22 Div 4 Ch 15 Section 64449
Total Suspended Solids	Off-site Laboratory	EPA 160.2	1x per week	1x per week	Not Specified as having a Secondary MCL	FBR Effluent Filter Effluent	Provides potential loading characteristics on filter and corroborates turbidity measurements.

Analyte/Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (At Steady-State)	Drinking Water Standards[1]	Sample Location	Reason for Monitoring Parameter
Total Trihalomethanes Formation Potential (TTHM)	Off-Site Laboratory	EPA 524/8260/5710A/ 5710B (modified)	As required by Disinfection Protocol	As required by Disinfection Protocol	0.080 mg/L	Filter Effluent LGAC Effluent	Required by Title 22 Div 4 Ch 15 Section 64439
HPC	Off-site Microbe Laboratory	SM 9215B	As required by Disinfection Protocol	Weekly (or as required by Disinfection Protocol)	Report Value	FBR Feed FBR Effluent Filter Effluent LGAC Effluent Post Chlorination Post UV	Required by Title 22 Div 4 Ch 17 Sec 64655 (b)
Total Coliform	Off-site Microbe Laboratory	MMO/MUG Quanti-Tray 2000- SM 9223 B	As required by Disinfection Protocol	Weekly (or as required by Disinfection Protocol)	Report Value	FBR Feed FBR Effluent Filter Effluent LGAC Effluent Post Chlorination Post UV	Required by Title 22 Div 4 Ch 17 Sec 64655 (b)
E.Coli	Off-site Microbe Laboratory	MMO/MUG Quanti-Tray 2000- SM 9223 B	As required by Disinfection Protocol	Weekly (or as required by Disinfection Protocol)	Report Value	FBR Feed FBR Effluent Filter Effluent LGAC Effluent Post Chlorination Post UV	Required by Title 22 Div 4 Ch 17 Sec 64655 (b)

[1] California Code of Regulations. Title 22. 2005.

[2] USEPA-Accepted or Approved Hach Methods Used for Water and Wastewater Reporting

Table 5.5 Analytical methods for sample analysis.

Analytes	Method	Bottle Size	Bottle Type	Preservative[1]
Perchlorate	314	125 mL	HDPE	None
Ammonia	350.2	500 mL	HDPE	H_2SO_4
TOC (DOC)	415.1	125mL	HDPE	H_2SO_4
Metals (Ba, Cd, Cr, Fe, Pb, Mn, Ni, Zn, Hg)	6010B/7470	500 mL	HDPE	HNO_3
Anions (Nitrate, nitrite, phosphate, sulfate, chloride)	300	1 L	HDPE	None
TSS	160.2			
TDS	160.1			
Color	110.2			
Corrosivity (as pH)	150.1			
Haloacetic Acids (sub)	SM6251B	40 ml	Amber Glass	None
TTHMs (sub)	SM 524.2	60 ml	Amber Glass	None
HPC (sub)	SM 9215B	100 ml	COLILERT container	THIO xls
Total/*E.Coli* (sub)	MMO/MUG Quanti-Tray 2000- SM 9223 B	100 ml	COLILERT container	THIO xls

[1] All samples will be stored and shipped on ice at 4°C.

5.6.2 Analytical/Testing Methods

Tables 5.4 and 5.5 provide the parameters measured, the sampling frequency, and the method of analysis. Field measurements were conducted using hand-held and on-line instruments (i.e. a HACH turbidimeter, HACH NITRATAX meter, etc.) and conventional methods. For the on-site water quality analysis, various EPA approved HACH methods were utilized. For the off-site laboratory analysis, the selected methods represented standard EPA procedures or modifications of these procedures for the analytes of concern.

EMAX Laboratories, Inc. (Torrance, CA) performed the off-site laboratory analysis (non microbiological). EMAX is a nationally certified laboratory (NELAP #02116CA) accredited by the CADPH and has been evaluated and approved by several governmental agencies including the US Naval Facility Engineering Services Center (NFESC), the Air Force Center for

Environmental Excellence (AFCEE), the United States Army Corps of Engineers (USACE), and several state programs. The Shaw Group Inc. (before selling this project to Basin Water, Inc.) awarded an Analytical Alliance Agreement to EMAX on May 20, 2003 to meet Shaw's Analytical Laboratory Requirements nationwide. EMAX was identified and selected as one of the "best-in-class" provider of analytical laboratories and has been fully reviewed and approved by Shaw's analytical group to perform the drinking water analysis under subcontract.

The microbiological analysis and disinfection by-product formation potential was subcontracted out by EMAX to E.S. Babcock & Sons, Inc. (Riverside, CA). E.S. Babcock & Sons, Inc. has been certified by the California Department of Public Health since 1928. They are CADPH Environmental Laboratory Accreditation Program (ELAP) certified (ELAP #1156). In addition, they have been certified by the National Environmental Laboratory Accreditation Program (NELAP) (NELAC #02101CA) since January 2002. This subcontracted lab was chosen for its reputation as a drinking water laboratory and the proximity to the demonstration site. The time sensitive samples were delivered and submitted the same day that they were collected. Additional analyses were conducted by E.S. Babcock & Sons, Inc. in order to corroborate data from EMAX Laboratories.

5.6.3 Quality Assurance/Quality Control

The Quality Assurance Plan (QAPP) in Appendix E describes the quality control samples (i.e., field blanks, equipment blanks, etc) that were collected during sampling. In addition, the QAPP describes at length the measures that were taken to ensure the representativeness, completeness, comparability, accuracy, and precision of the data, calibration procedures, quality control checks, and corrective action. Data quality indicators are also found in the QAPP.

For key data parameters acquired in the field, from the on-site laboratory and the off-site laboratory, statistical analyses were conducted. For data with multiple samples under the same operating conditions and normally distributed about the mean, Grubb's outlier tests were utilized to determine any outlier data that should be flagged and considered for removal from the data set. For statistical tests between two process variables or parameters (i.e., nitrate and perchlorate concentrations in the effluent), parametric methods such as t-tests, linear regression analysis, and/or correlation coefficients were employed where appropriate.

5.7 Sampling Results

The success of the demonstration and the effectiveness of the FBR treatment system was primarily based on the ability of the incoming groundwater to effectively colonize the fluidized bed media, the functionality of the on-line instruments to measure the flowrate and the contaminants of interest and appropriately adjust the electron donor dosing rates, and the ability of the downstream equipment to meet the requirements of the surface water treatment rules for drinking water. In addition to steady-state operation and performance of the FBR system, the robustness of the technology was tested by increasing flowrates and inducing system upset conditions (feed shutdown and complete system shutdown). Under all of these conditions, the criteria for success was that nitrate-N and perchlorate in the FBR effluent were consistently measured at levels less than 1 mg/L and 6 μg/L, respectively. Over the course of start-up and throughout the duration of the demonstration, on-site and off-site laboratory and field parameters were collected to assess the FBR treatment system's effectiveness and robustness. Samples acquired post the multimedia filter were analyzed by off-site laboratories and the entire treatment plant was considered effective if it met all of the requirements of the CCR Title 22, Div. 14, Ch. 17 for drinking water (Table 5.6). This collected data is provided in graphical form in Figures 5.24-5.43 and is referenced throughout this document. On-line perchlorate and nitrate-N data is presented for Days 0-234. For the spiking study (Days 234-349), the on-line perchlorate and nitrate-N data is presented in Section 5.7.7.

The sampling results are provided below per the various phases of the demonstration project as described in Section 5.5. These components of the study included start-up issues, the ability of the FBR treatment system to be self-inoculated with incoming groundwater, the treatment effectiveness under steady-state and transient loadings (including complete shut-down scenarios), the effectiveness of the on-line target contaminant analyzers, chlorination and UV disinfection study on the system effluent, and a perchlorate spiking study. The complete field monitoring data, off-site laboratory data, and the daily systems modification report are provided in Appendices F, G, and H, respectively.

Table 5.6 California regulatory limits for drinking water.

Analytes	California State Regulatory Limits
Inorganics MCL	
Antimony	0.006 mg/L
Arsenic	0.01 mg/L
Barium	1.0 mg/L
Beryllium	0.004 mg/L
Cadmium	0.005 mg/L
Chromium	0.05 mg/L
Cyanide	0.15 mg/L
Lead	0.015 mg/L
Mercury	0.002 mg/L
Perchlorate	6 µg/L
Nickel	0.1 mg/L
Nitrate (as NO_3)	45 mg/L
Nitrite (as N)	1 mg/L
Nitrate-N/Nitrite-N	<10 mg/L (combined)
Selenium	0.05 mg/L
Thallium	0.002 mg/L
Disinfection By-products MCL	
Haloacetic Acids (five)	60 µg/L
Total Trihalomethanes	80 µg/L
Secondary MCLs	
Aluminum	0.2 mg/L
Chloride	<250 mg/L (recommended)
Color	15 units
Copper	1.0 mg/L
Foaming Agents (MBAS)	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor-Threshold	3 units
Silver	0.1 mg/L
Specific Conductance	<900 µS/cm (recommended)
Sulfate	<250 mg/L (recommended)
Total Dissolved Solids	<500 mg/L (recommended)
Turbidity	<0.3 NTUs
Zinc	5.0 mg/L
Microbiological Requirements	
Heterotrophic Plate Counts	<500 CFUs/ml
Total Coliform/*E. Coli*	<1 MPN/100 ml

Figure 5.24 FBR media bed height.

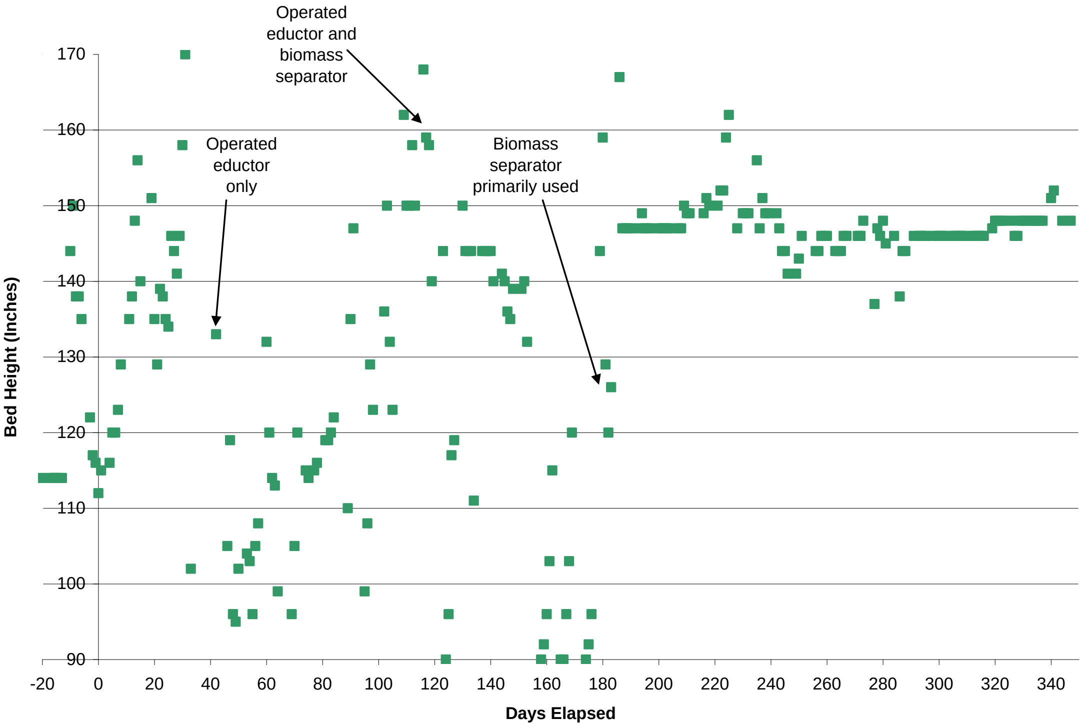


Figure 5.25 Turbidity in Trimite multimedia filter effluent water.

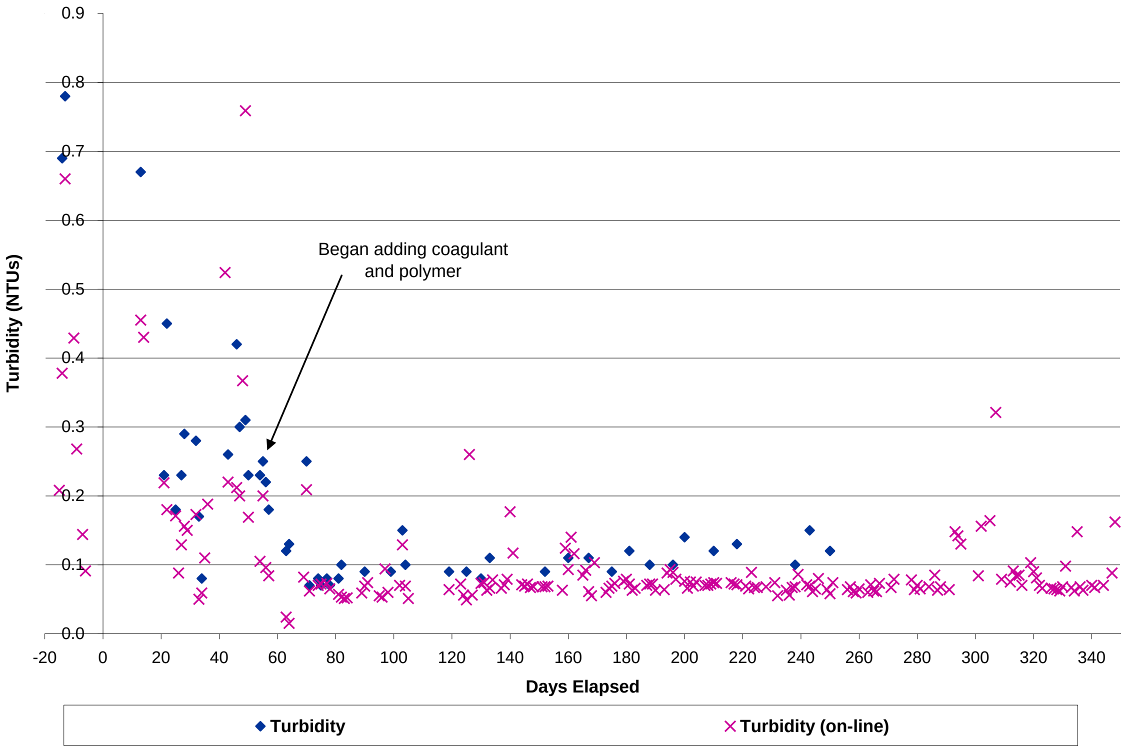


Figure 5.26 Dissolved oxygen in FBR feed, effluent and post-aeration effluent water.

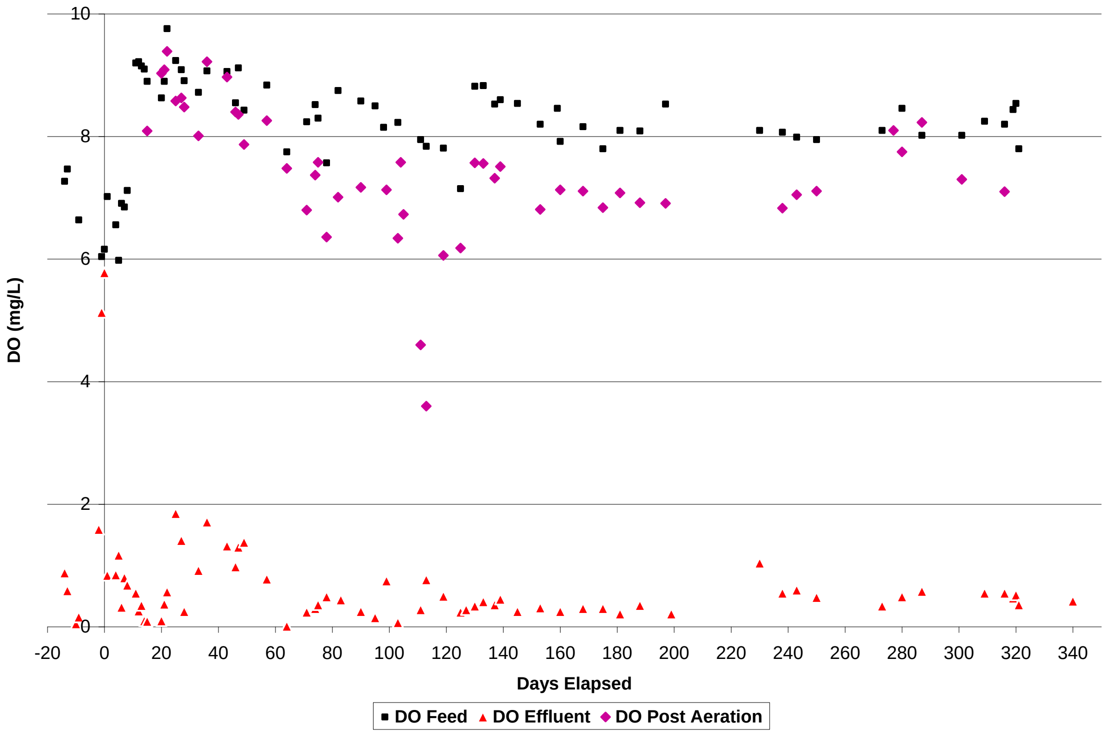


Figure 5.27 Nitrate-N in FBR effluent water (measured on-site in lab).

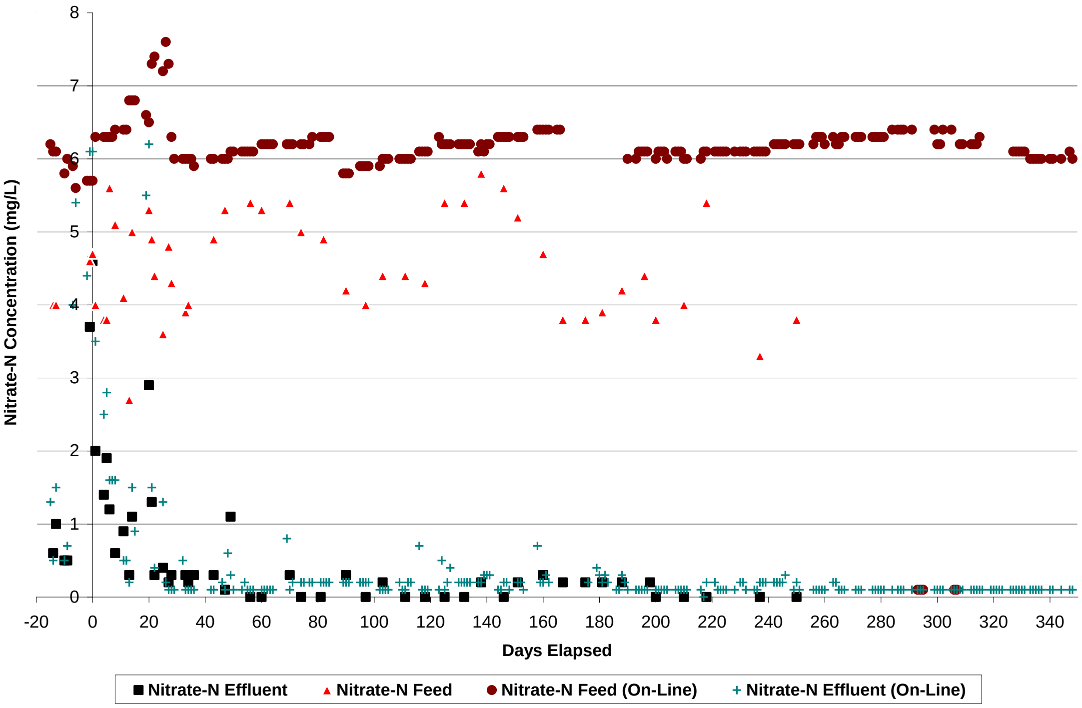


Figure 5.28 pH in FBR feed and effluent water.

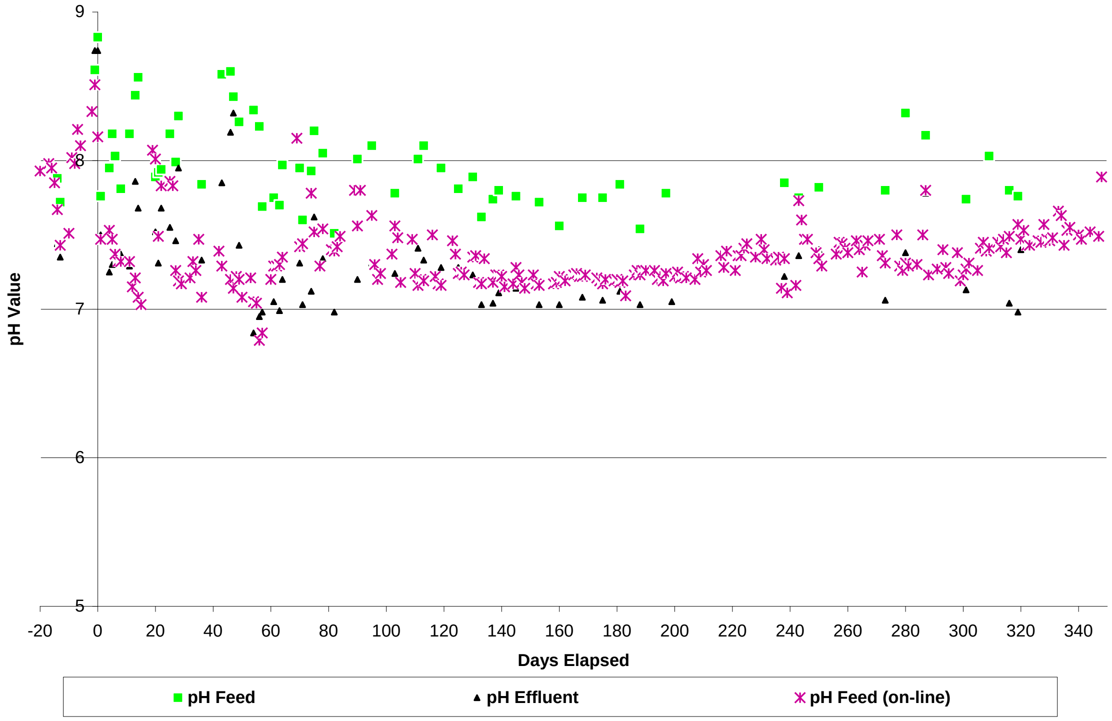


Figure 5.29 Temperature in FBR feed and effluent water.

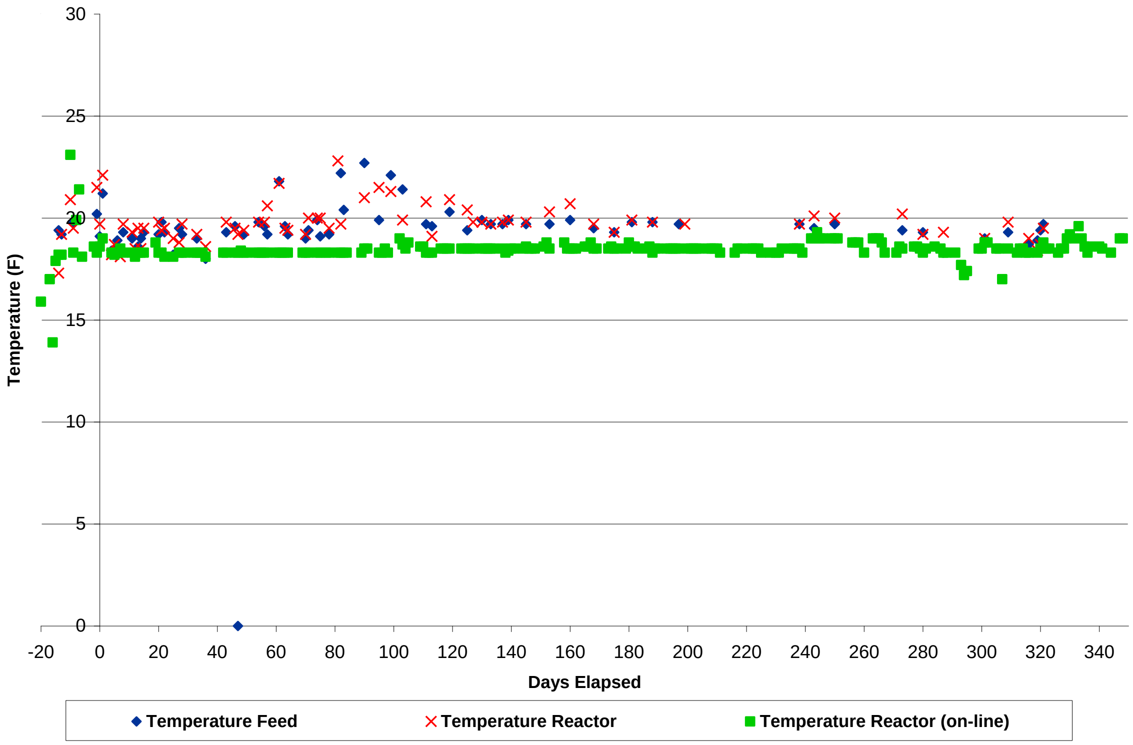


Figure 5.30 Orthophosphate-phosphorus in FBR effluent water.

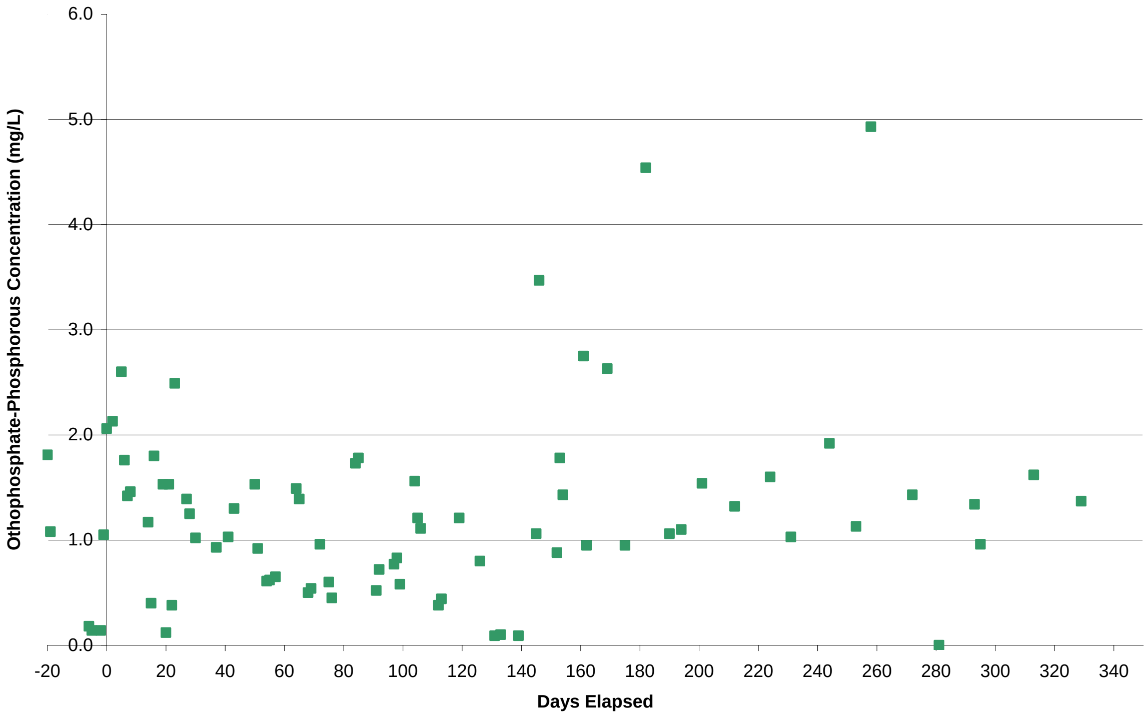


Figure 5.31 DOC in FBR effluent water.

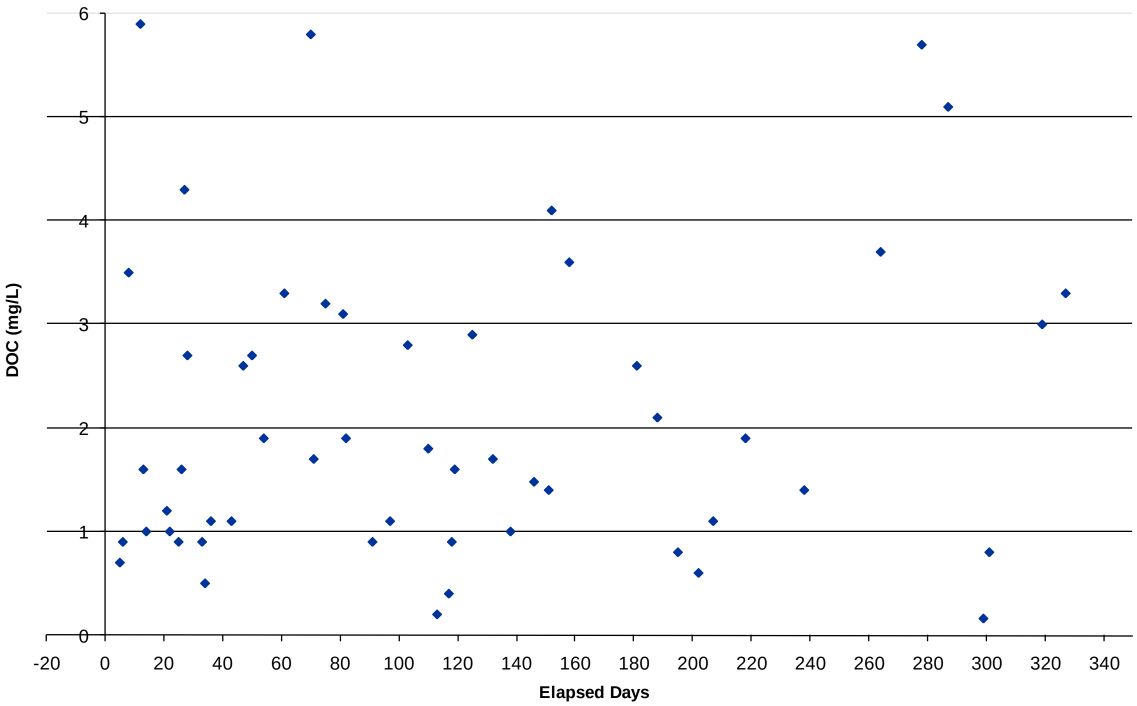


Figure 5.32 ORP in the feed and FBR effluent water.

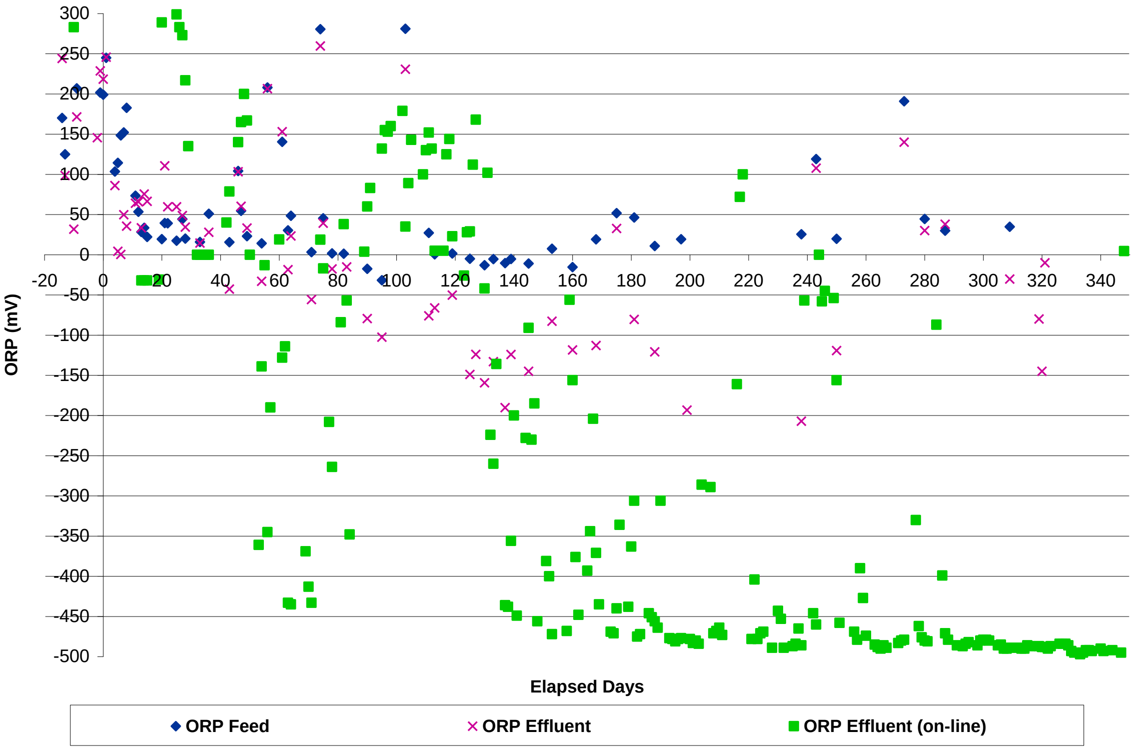
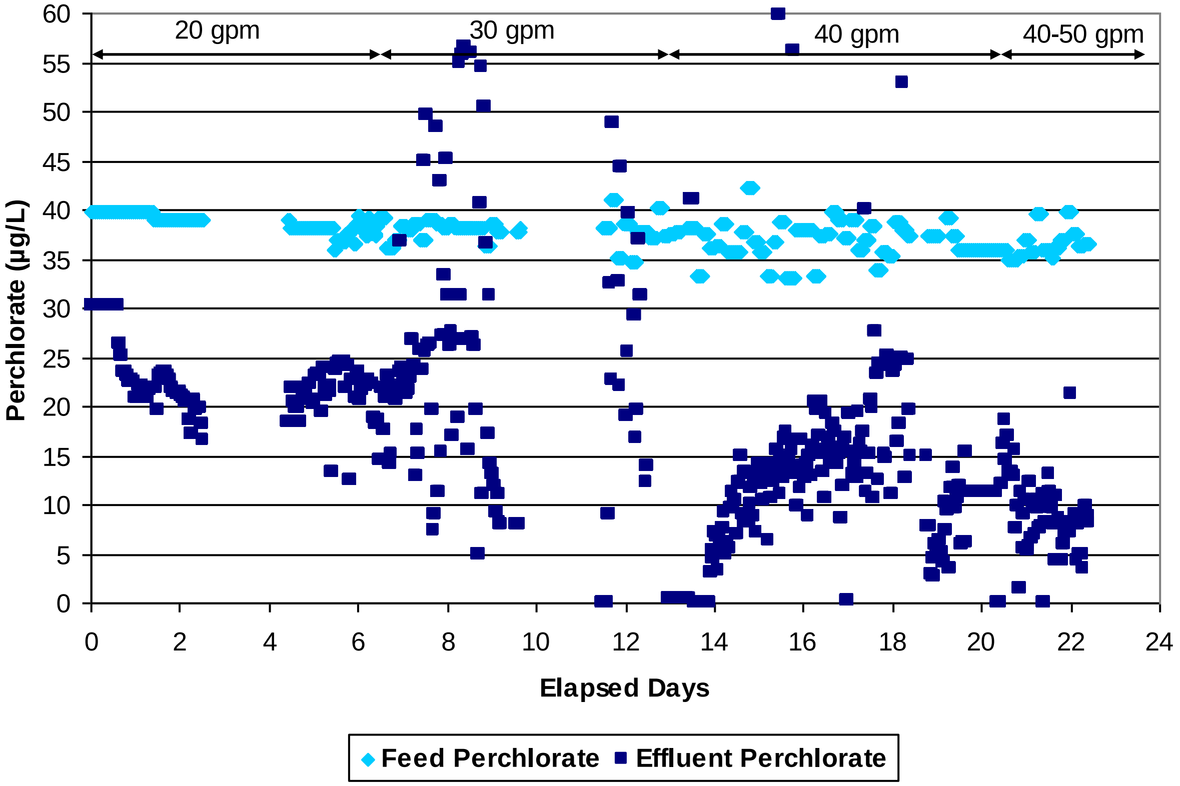


Figure 5.33 Perchlorate and nitrate on-site analytical results (Days 0-24).



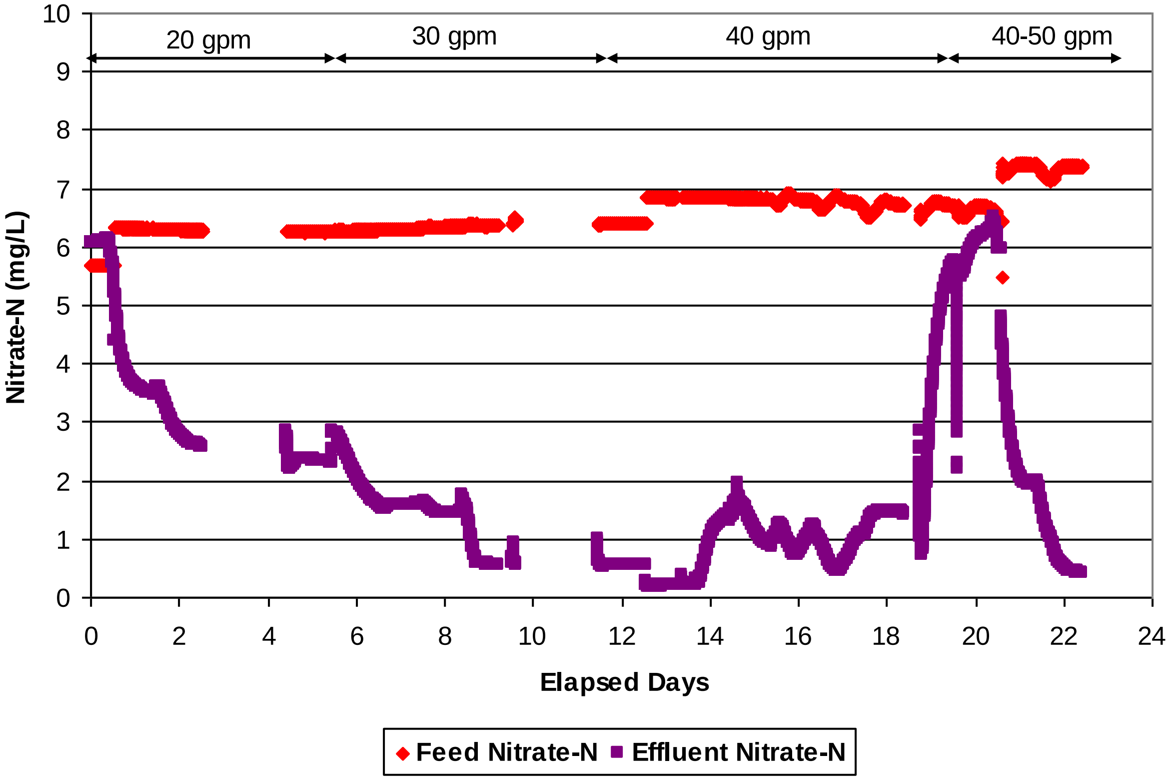
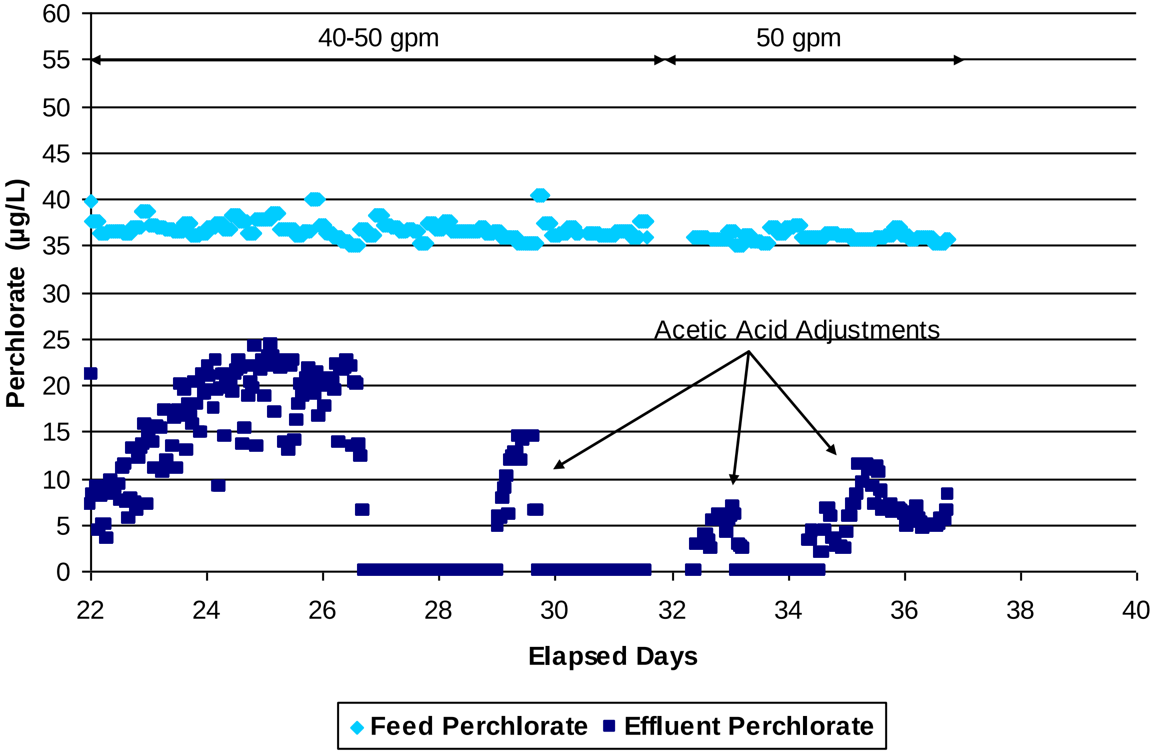


Figure 5.34 Perchlorate and nitrate on-site analytical results (Days 22-40).



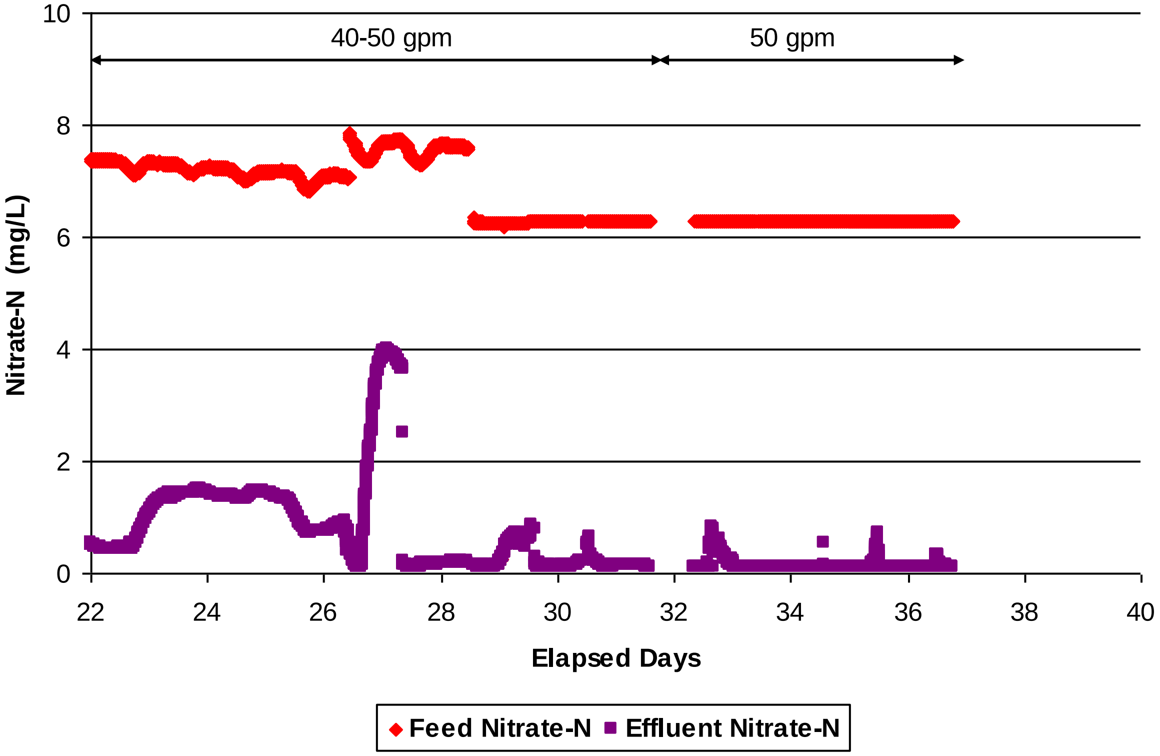


Figure 5.35 Perchlorate and nitrate on-site analytical results (Days 38-60).

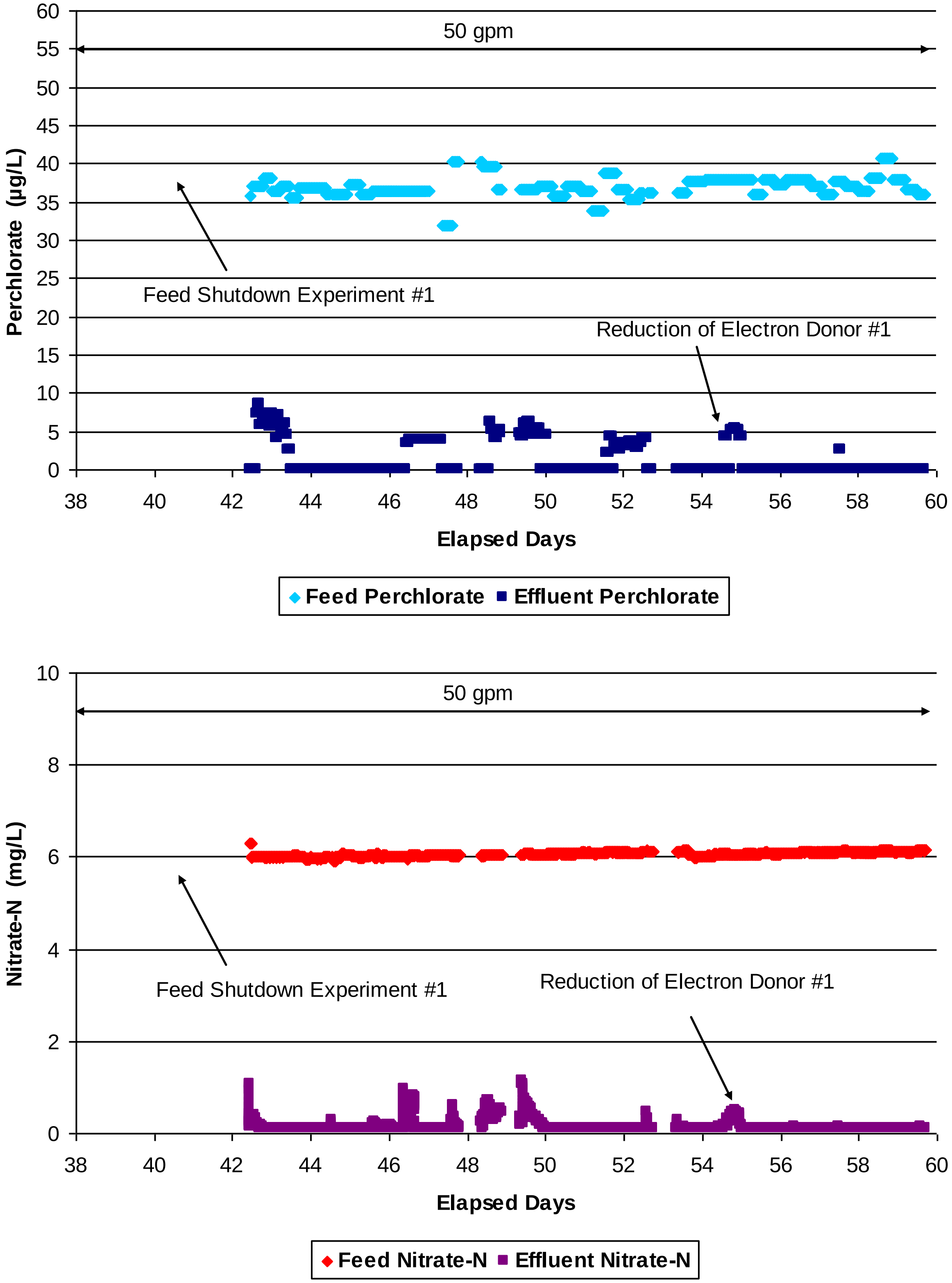


Figure 5.36 Perchlorate and nitrate on-site analytical results (Days 60-80).

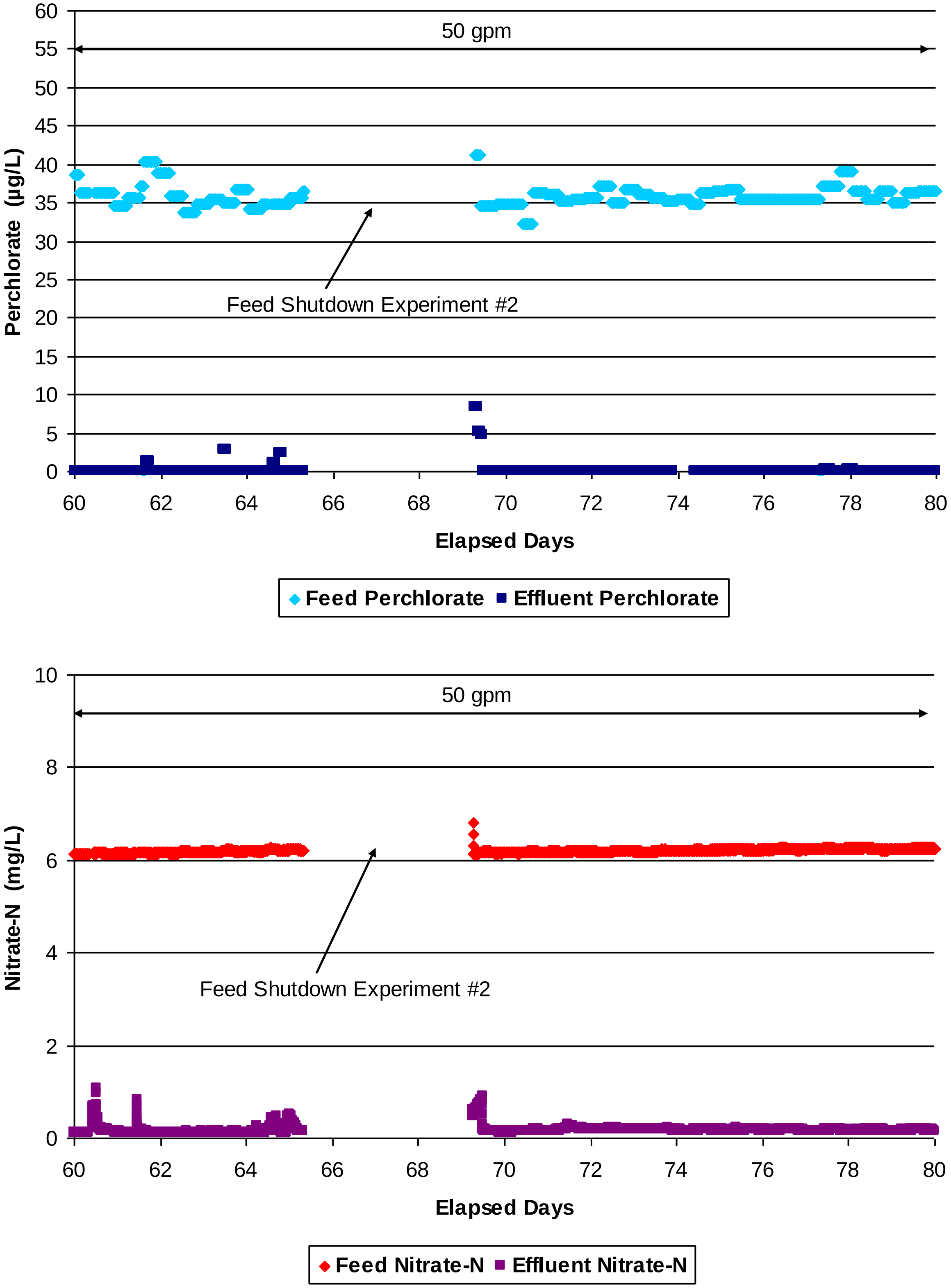


Figure 5.37 Perchlorate and nitrate on-site analytical results (Days 80-102).

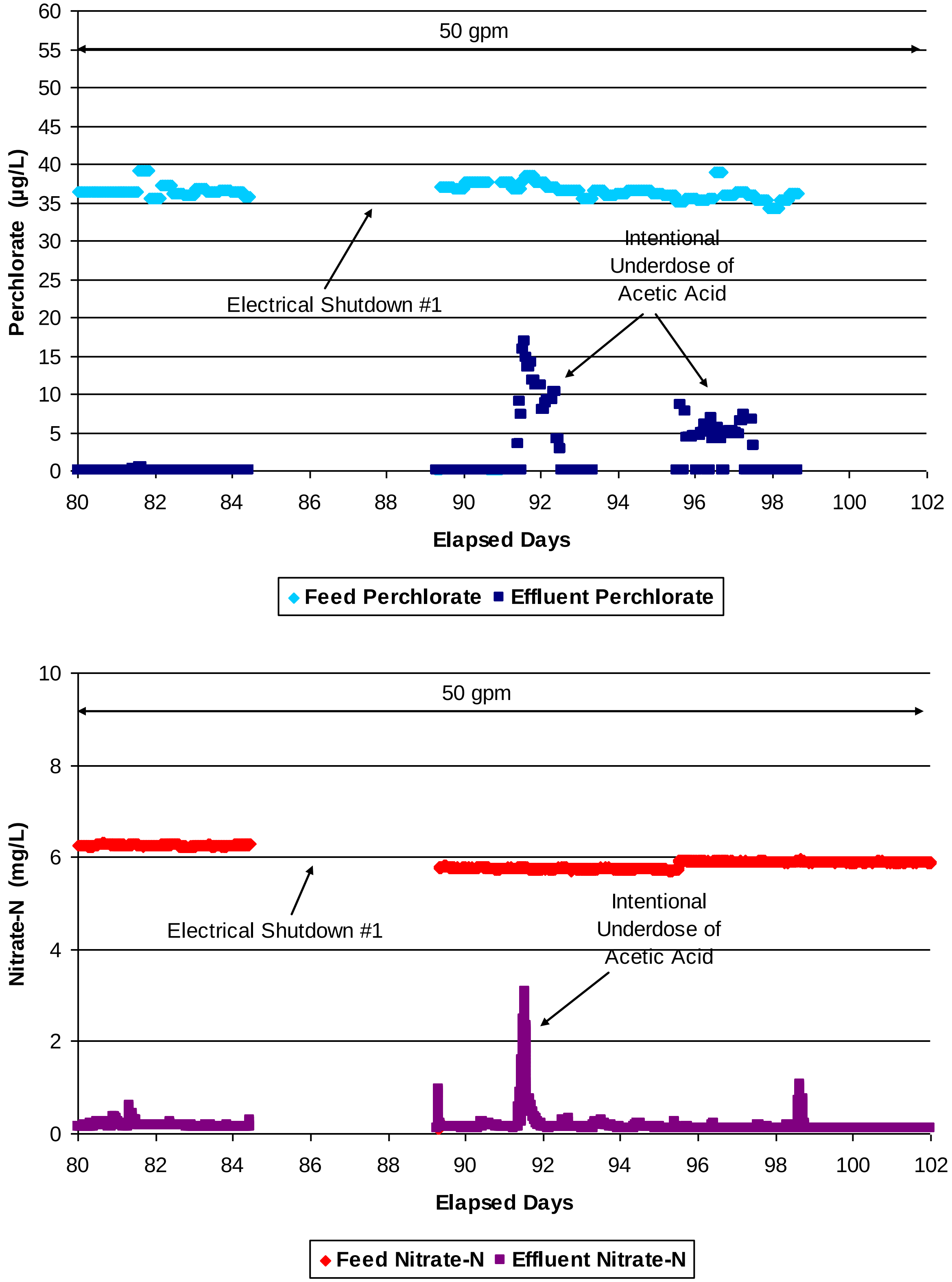
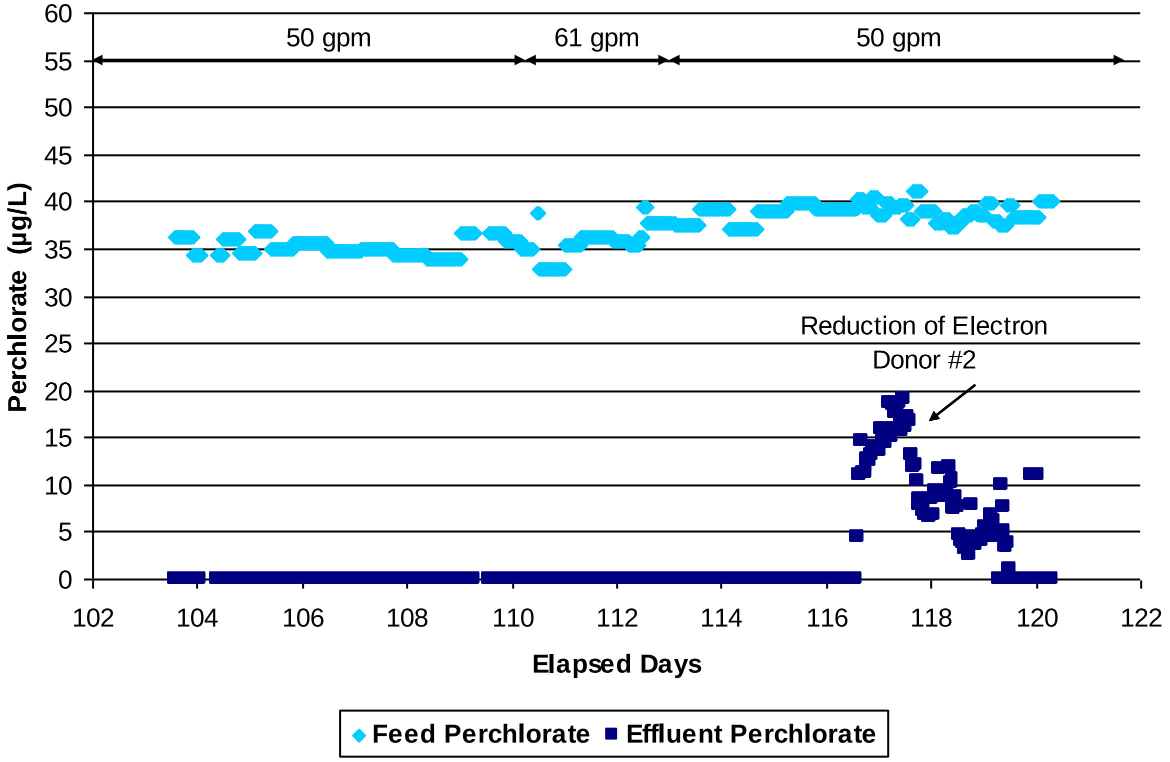


Figure 5.38 Perchlorate and nitrate on-site analytical results (Days 102-122).



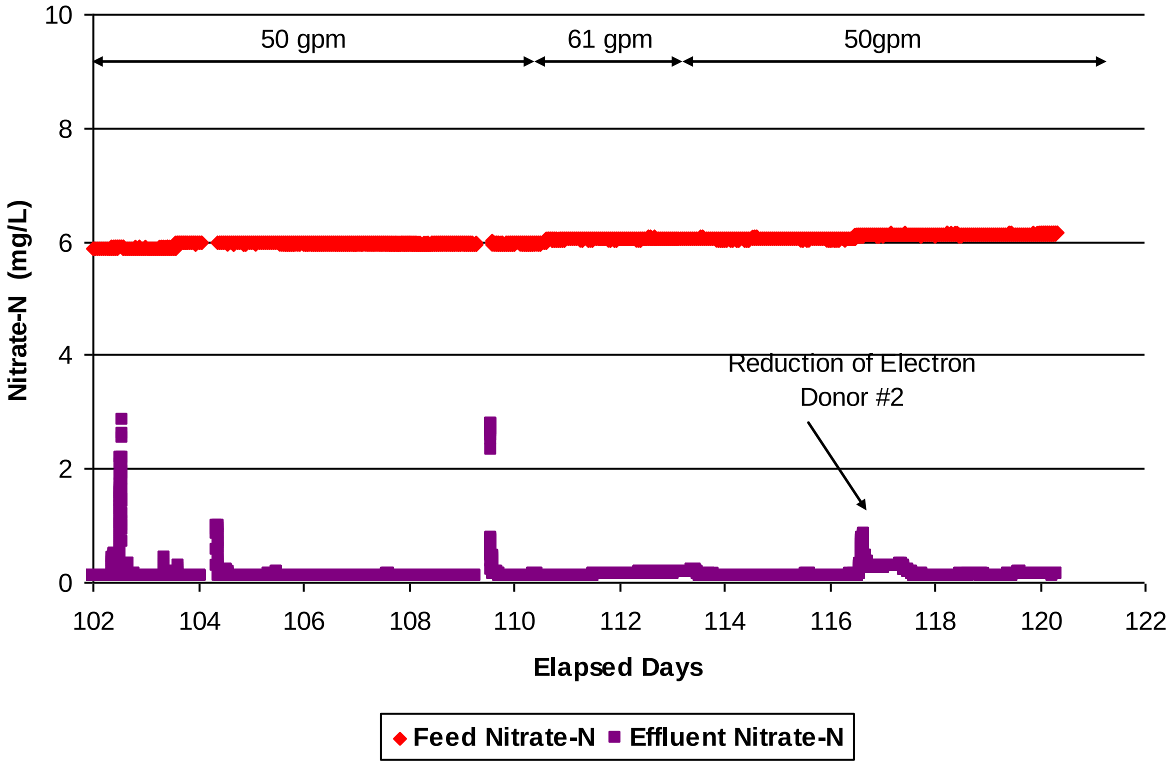
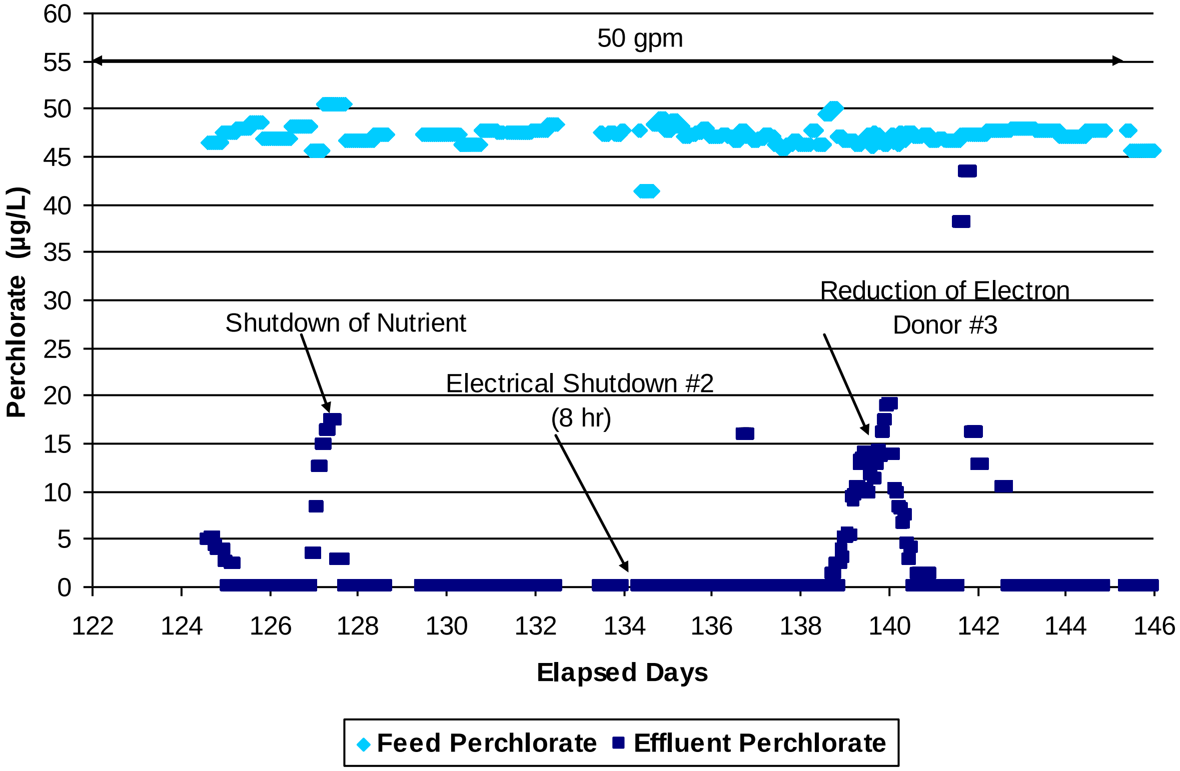


Figure 5.39 Perchlorate and nitrate on-site analytical results (Days 122-146).



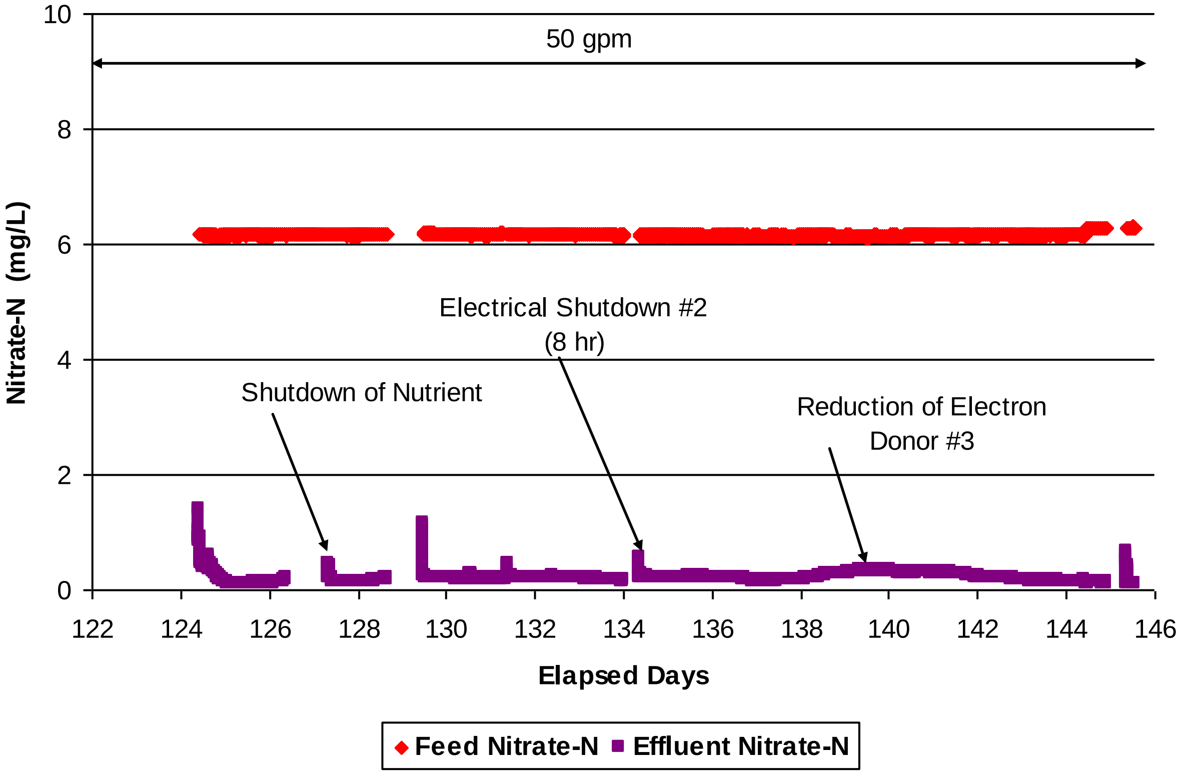


Figure 5.40 Perchlorate and nitrate on-site analytical results (Days 146-168).

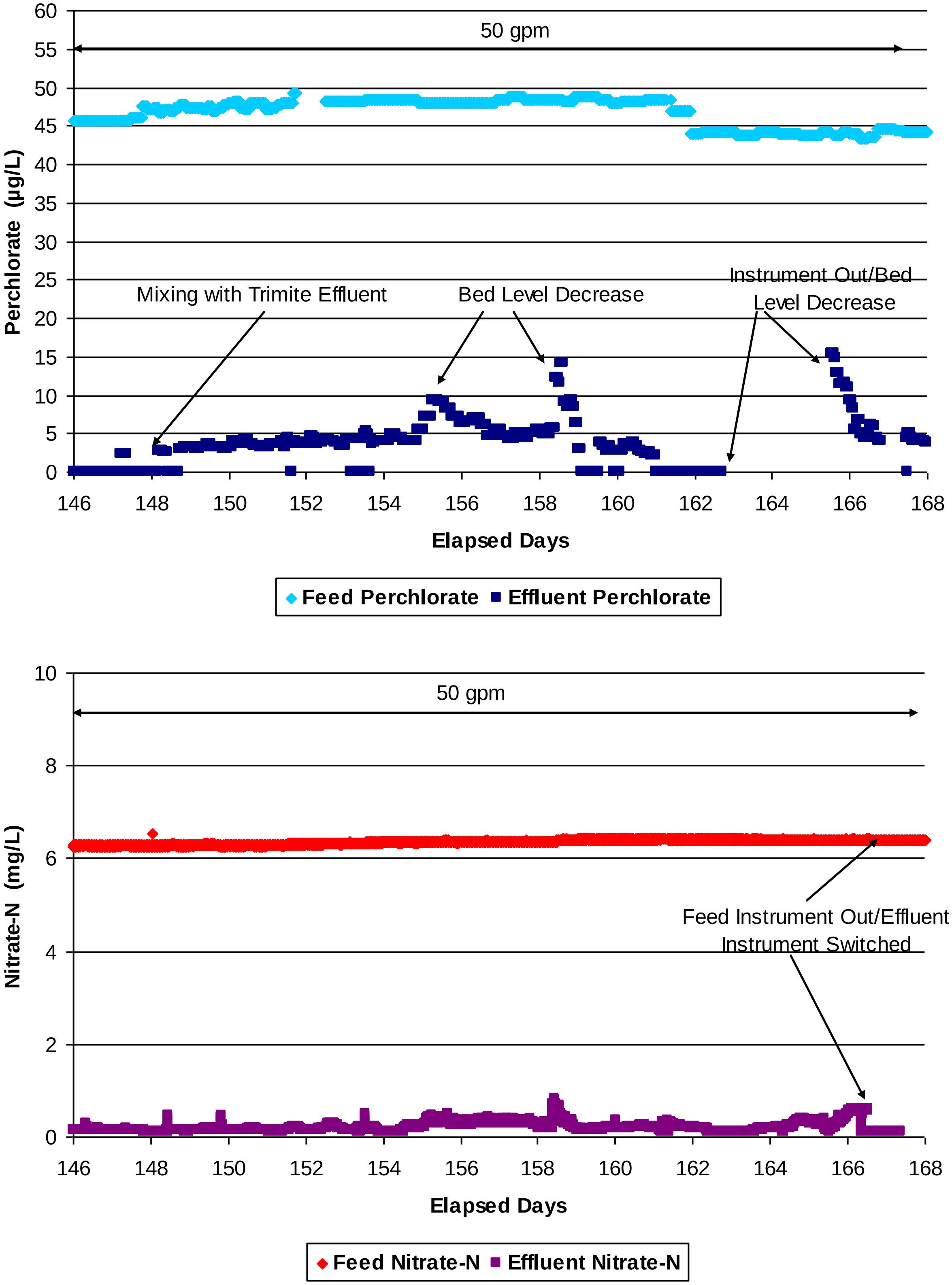
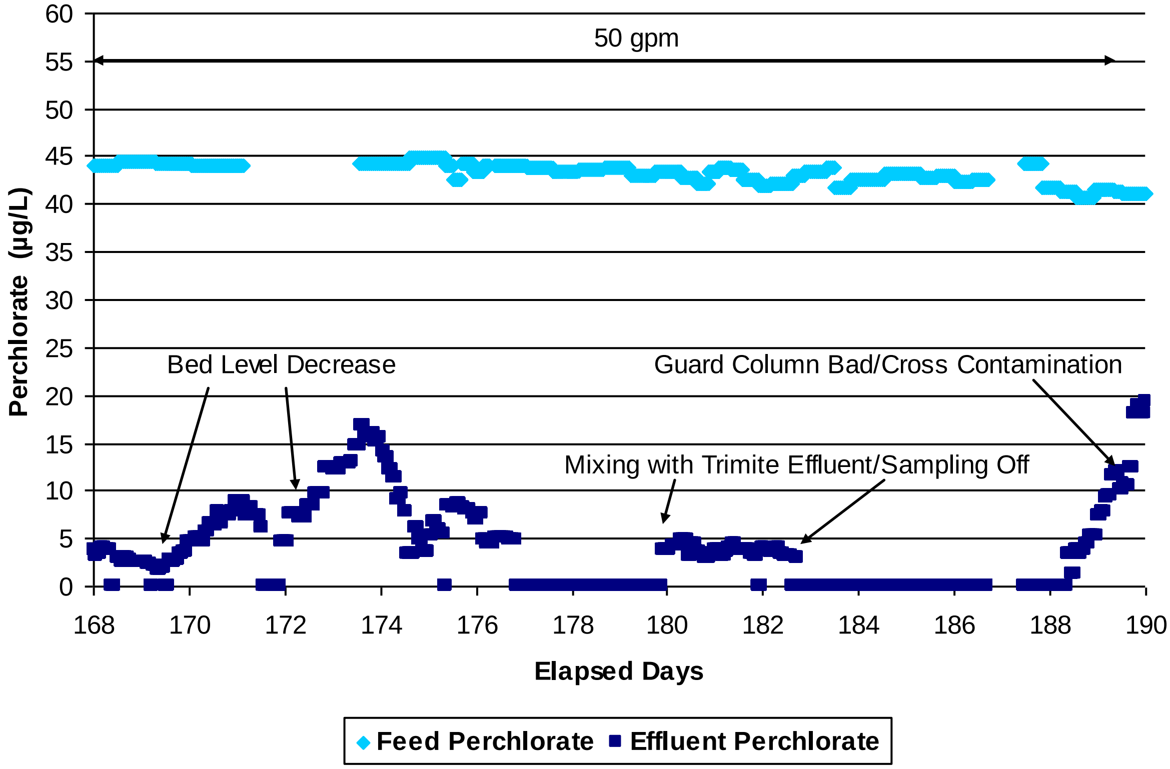


Figure 5.41 Perchlorate and nitrate on-site analytical results (Days 168-190).



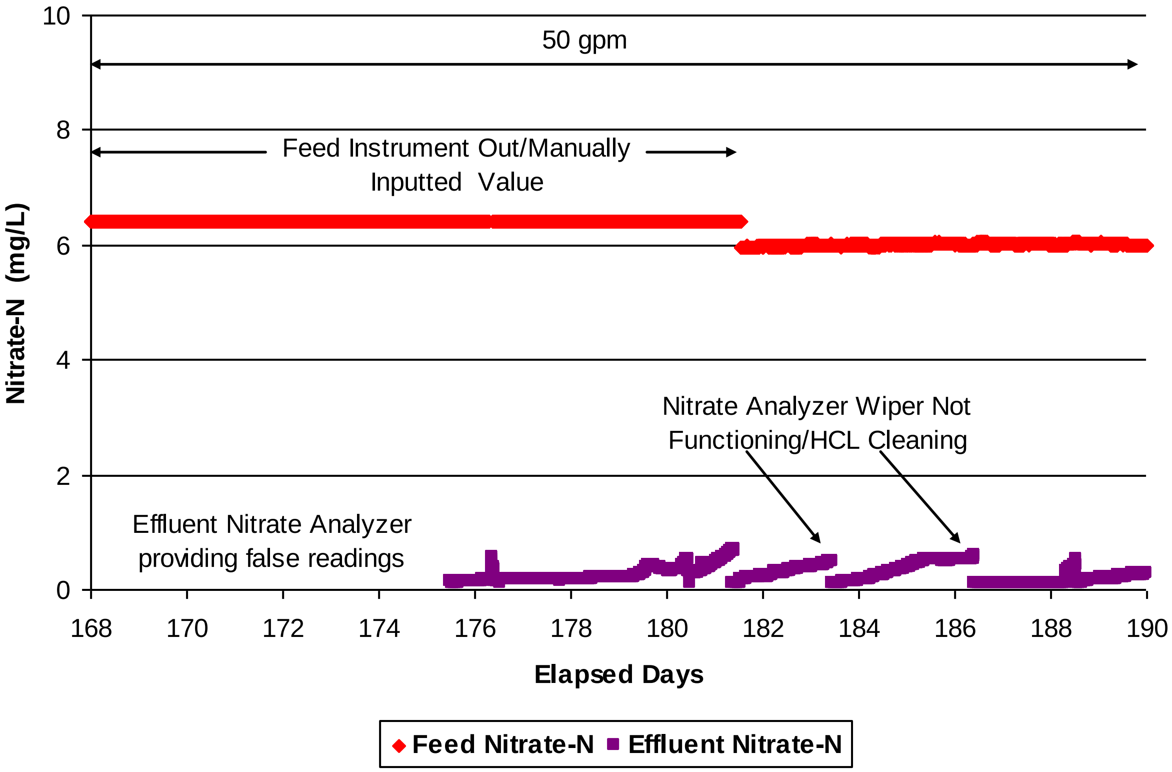
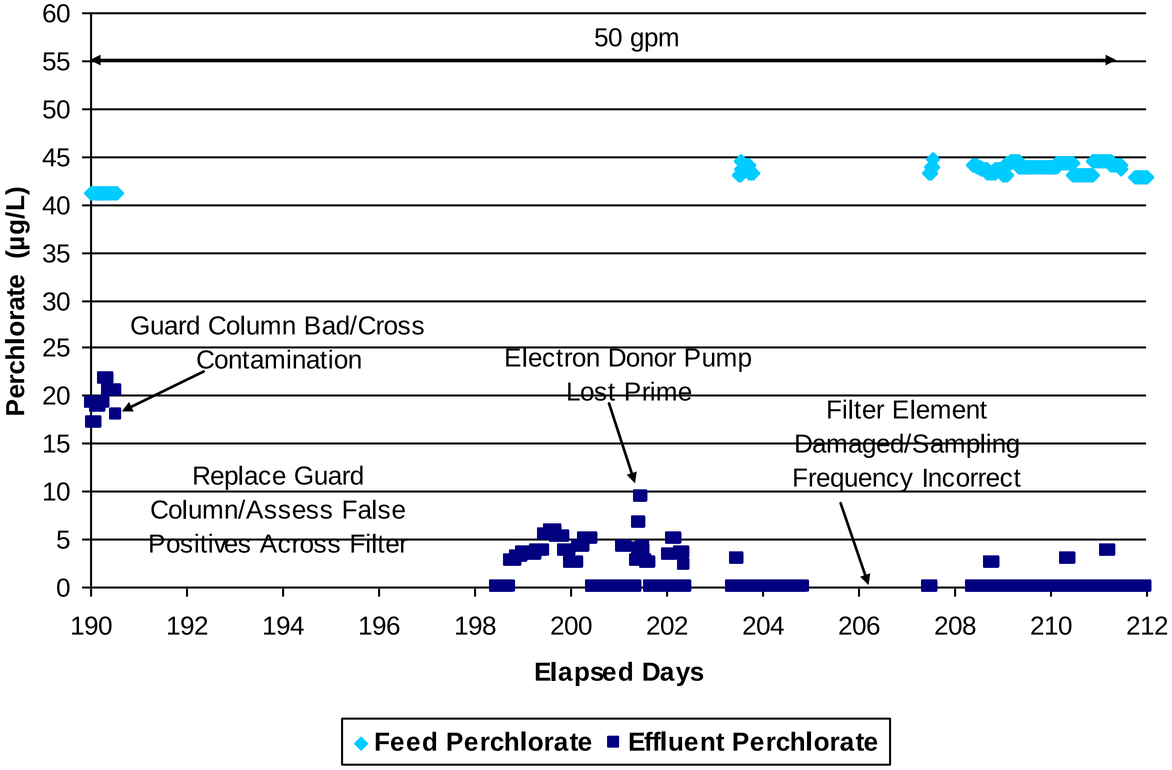


Figure 5.42 Perchlorate and nitrate on-site analytical results (Days 190-212).



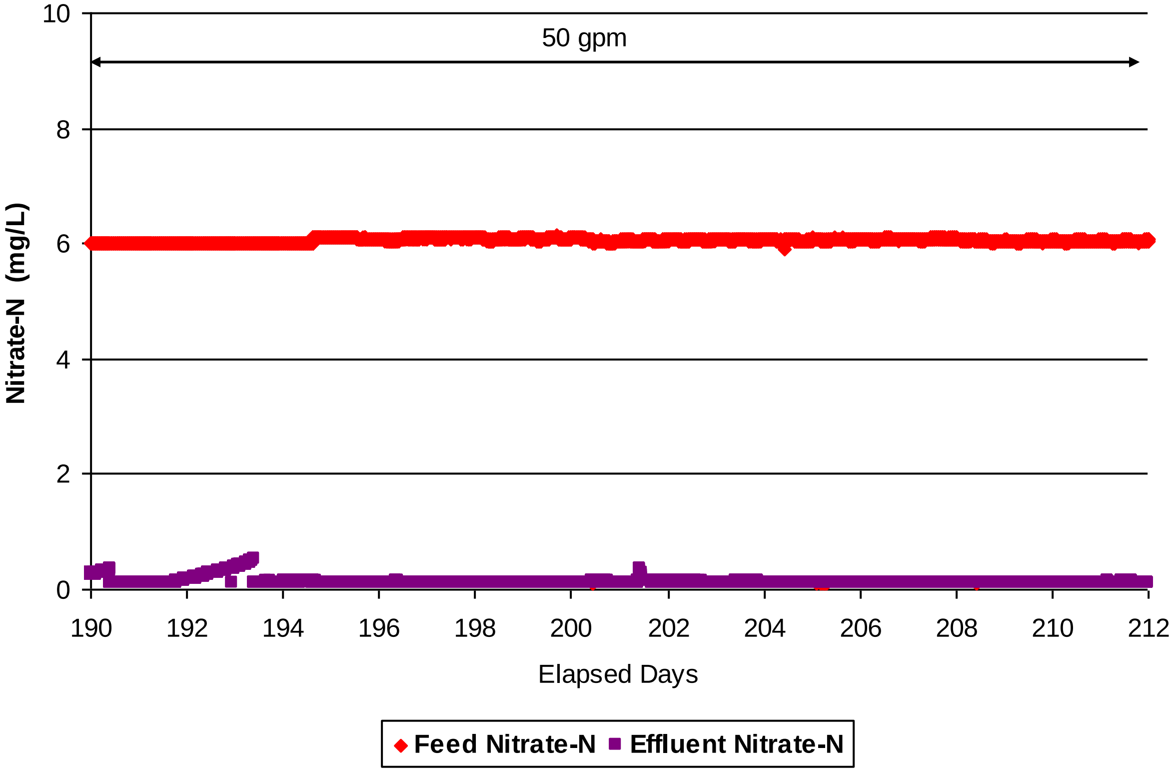
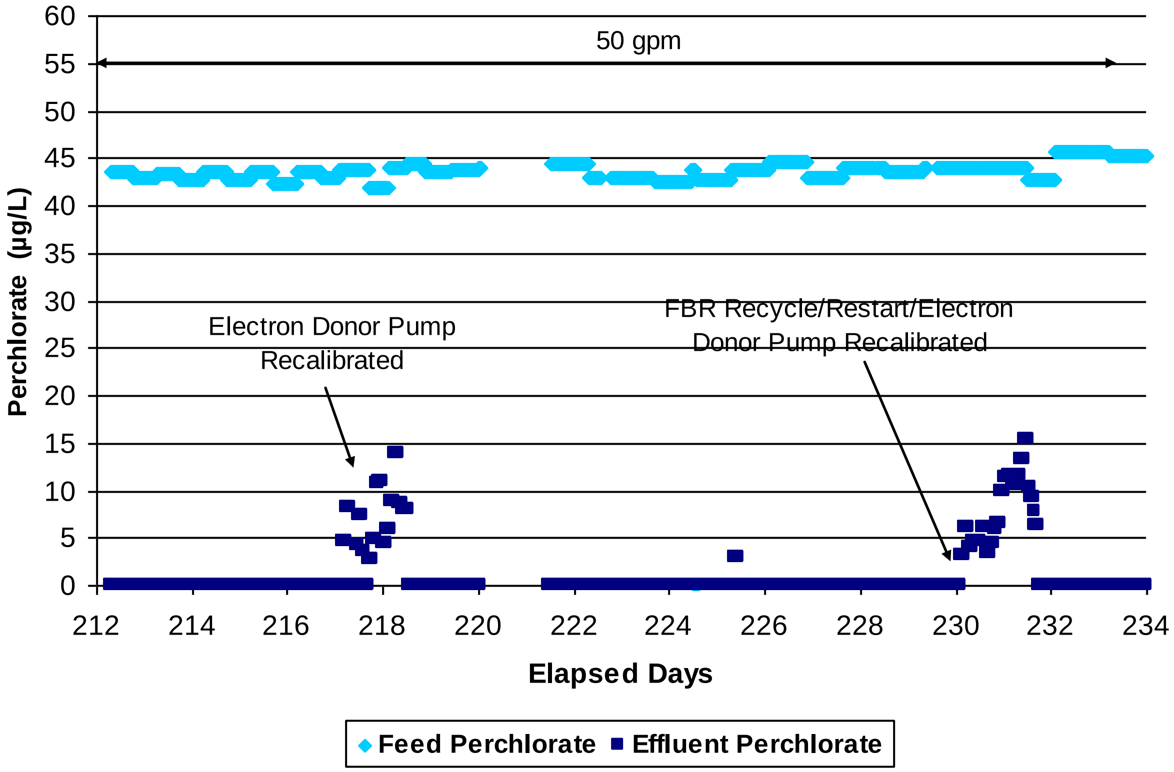
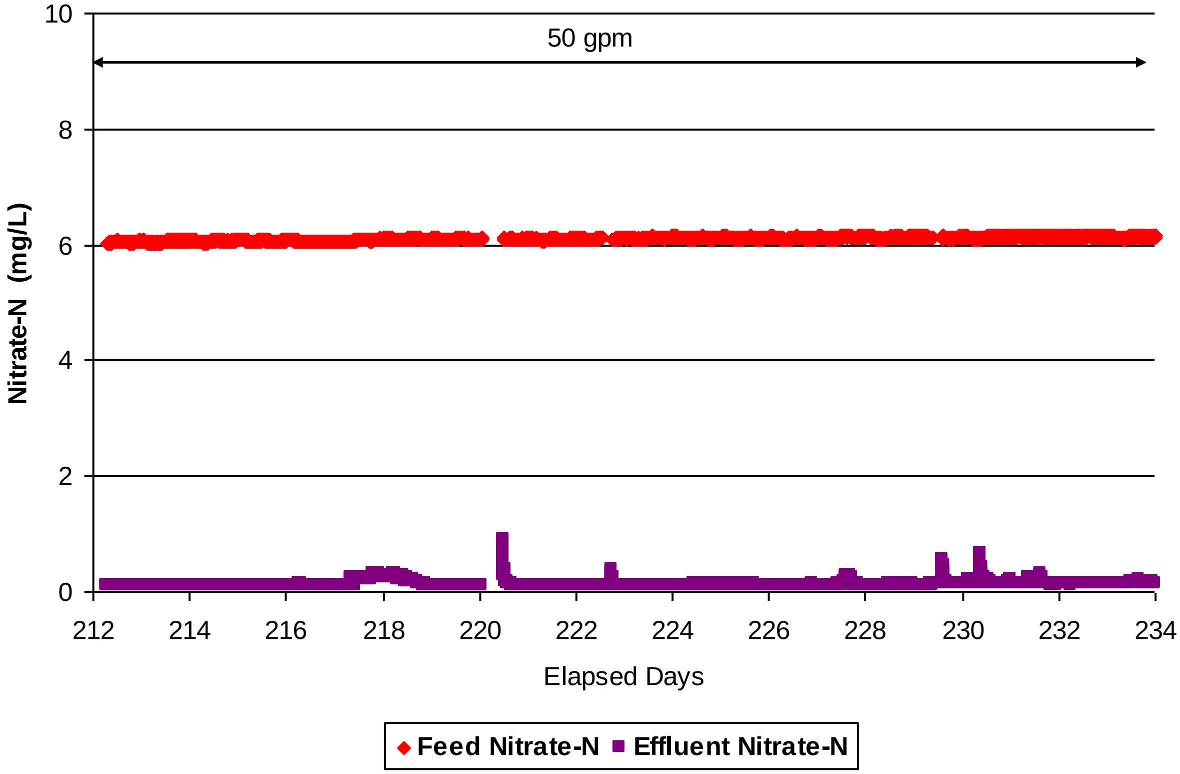


Figure 5.43 Perchlorate and nitrate on-site analytical results (Days 212-234).





5.7.1 System Start-Up and Self Inoculation

The contaminated well water was added to the FBR treatment system during the month of February, 2007. The FBR reactor was allowed to operate in batch mode with contaminated water, electron donor, and nutrient for a period of one week. This batch mode of operation was followed by continuous forward feed flow. However, numerous interruptions (mechanical, electrical, process, etc.) occurred such that the official continuous start-up of the plant was designated on March 15, 2007 (Day 0).

The water from the groundwater well was near saturation with respect to oxygen (8.1-9.1 mg/L). This is considered highly unusual for most groundwater wells. However, this was not uncommon for this aquifer situated at the foothills of the San Bernardino Mountains. This oxygen saturated water provided a favorable breeding ground for aerobic microbes when acetic acid was fed to the system. The media bed at the base of the system rapidly grew via aerobic growth. This bed expansion was controlled with an in-bed eductor, but the frequency and duration of its operation to control the bed growth required about one month to consistently control the height of the bed (Figure 5.24). Any solids removed from the FBR were released to the Trimite multimedia filter. Without the addition of coagulant or polymer, the effluent turbidity value from the filter could not be controlled below 0.3 NTU (Figure 5.25).

Once a number of the initial plant start-up issues were addressed, the actual effectiveness of self-inoculating the system was observed. The plant was operated in continuous mode to achieve steady-state performance. The feed was ramped up from 20 to 50 gpm (Figures 5.33 and 5.34). Within approximately thirty days (by day 28), the system was completely removing all nitrate and perchlorate to non-detectable levels. The 50% acetic acid and the 1.7% phosphoric acid addition rates were set at 15 mL/min (16.2 mg/L as C) and 10.5 mL/min (0.3 mg/L as P), respectively. Fine adjustments to these values were made from Day 28 through Day 36 to maximize the nitrate and perchlorate removal while minimizing costs associated with the addition of these chemicals.

5.7.2 Treatment Effectiveness

5.7.2.1 FBR System

By Day 30 of the plant operation, minimal flow interruptions due to mechanical, electrical, and process issues occurred. Dissolved oxygen was rapidly consumed and was measured to be less than 0.9 mg/L in the FBR effluent based on grab sample analysis in the field (Figure 5.26). The complete removal of nitrate and perchlorate was readily observed across the FBR (Figures 5.27 and 5.34). pH of the feed water dropped slightly from an average of 8.0 to 7.4 in the FBR effluent, while temperature in the reactor averaged 18.5 ^{o}C (standard deviation of 0.6 ^{o}C, Figures 5.28 and 5.29). Ortho-phosphate phosphorus concentration was maintained above 1 mg/L, while DOC from acetic acid varied per experiments but typically ranged between 1 mg/L and 3 mg/L (Figures 5.30 and 5.31). Like the DOC, the ORP varied per the experiments conducted (Figure

5.32). The feed groundwater was generally positive in the 0 to +50 mV range. The FBR effluent was shown to be negative with both on-line and grab sample analyses. However, the on-line instrument appeared to be failing after six months of operation. The on-line ORP measurements continued to be collected, but the grab samples for ORP provided more accurate data (per check standards).

Bed growth was excessive (Figure 5.24) due to the saturated oxygen concentrations in the feed groundwater which promoted excessive aerobic bed growth. An in-bed eductor to effectively control the biomass growth in the lower portion of the media bed was installed in the first month of operation and was operated from Day 30 to Day 183. The field engineer assessed the bed height on a daily to weekly basis and set the eductor to operate intermittently or continuously for some period of time as needed. The eductor operated at 8-10 psi of water pressure to assist in breaking apart the lower portions of the bed where the aerobic microorganisms dominated. To assist in controlling height in the upper portions of the media bed, the biomass separator was installed on Day 117. This controlled operation could maintain the bed between 110 inches and 150 inches of height (Days 30-150). However, during the month of August, 2007 (Day 150) the reactor was left unattended for an extended period (five days). Both the in-bed eductor and biomass separator remained operating. Upon return to the site by the field engineer, the bed height within the FBR was measured and had decreased to the original hydraulic expanded levels (Day 160). Differing levels of operation of the in-bed eductor and the biomass separator were conducted. Each time the bed began to regrow, the continuous eductor operation caused the bed to decrease rapidly. Such a decline in the bed height when the eductor and the biomass separator were operating was not observed during earlier operation. It is believed that changes in pumping capacity by the eductor pump and with the eductor casing caused more dramatic agitation of the bed material. For this reason, the eductor was turned off and only the biomass separator was allowed to operate continuously (Day 183). Once this change occurred, the bed grew to a stable height of approximately 146 inches and remained there throughout the remainder of the demonstration. This proved an med bed hydraulic residence time (HRT) of 12.2 minutes. If necessary, the eductor was operated intermittently to assist in maintaining the bed height at this level. Lancing of the bed was periodically required to ensure that the carbon agglomeration near the bottom of the FBR did not occur.

For a three day period (Days 110-112), an experiment was performed where an increase in the load to the FBR reactor was conducted (Figure 5.38). Typically, the feed flow was 50 gpm to the system. For this experiment, the flow was increased to approximately 61 gpm (most flow available to the system). During this test period, no breakthrough of nitrate or perchlorate was observed. Additional biomass was created within the system that required control, but no other effects on the system operation were observed. These results indicated that for a full-scale system, the theoretical reactor volume could be reduced while continuing to treat equivalent loading rates observed at 50 gpm. For 50 µg/L perchlorate and 6.1 mg/L of nitrate-N at 50 gpm, the perchlorate elimination capacity across the expanded fluidized bed (using 146 inches of height) was calculated to be 0.24 g/m^3 hr.

In a few instances (Days 202, 218, and 230), due to continuous operation, the electron donor pump exhibited reduced pumping capacity (Figure 5.43). The reduction in pumping capacity translated into declines in nitrate and perchlorate removal. This occurred because the excess electron donor was intentionally set to a minimum. Such a procedure reduced electron donor cost and prevented the growth of sulfate reducing bacteria. However, when the electron donor pump lost 5-10% pumping capacity, the potential for contaminant breakthrough increased. For the full-scale, this can be avoided by: (a) providing weekly checks of the electron donor pump pumping capacity and adjusting accordingly; (b) providing an extra excess of electron donor consistently; or (c) using a different pump that does not exhibit this decline in pumping capacity.

5.7.2.2 Post Aeration

The post-aeration vessel raised the dissolved oxygen concentrations from less than 1 mg/L to above 7.5 mg/L consistently at an HRT of 8 minutes throughout the study (Figure 5.26). No blockage or operational issues were observed with the blower utilized to reaerate the water until Day 274. On this day, the post-aeration blower failed in operation. The motor assembly of the blower still functioned correctly, but two of the four impeller vanes cracked. Hence, the plant was placed into recycle, a repair kit was purchased from the manufacturer, and the blower was repaired after four days of operation in recycle mode. The performance of the system upon restart was not affected. The blower was operated continuously for the prior nine months with minimal issues. However, this incident highlighted a need at the full-scale: a repair kit should always be on-site in the event that a blower failure occurs and a service agreement with the blower manufacturer is warranted.

5.7.2.3 Trimite Multimedia Filter

Operation

Continuous operation of the in-bed eductor resulted in the requirement of chemical addition to the downstream equipment. Initially, the amount of biomass removed from the FBR caused the Trimite multimedia filter to produce water with a turbidity above 0.5 NTUs (Figure 5.25). For this reason, 48% NSF approved aluminum sulfate and 20% NSF approved cationic polymer (diluted to 0.8%) were added as coagulating and flocculating agents, respectively. Upon addition of these chemicals (Day 55), the effluent turbidity of the Trimite multimedia filter was reduced to less than 0.1 NTU. There was an observed trade-off in the amount of chemical addition versus the necessary frequencies of the adsorption clarifier forward flush and multimedia backwash frequency. After a number of iterations at different chemical dosing rates, the addition of 1 mL/min (0.4 gpd, 2.5 mg/L dose) of the 48% aluminum sulfate and 4 mL/min (1.5 gpd, 0.17 mg/L dose) of the 0.8% cationic polymer were found optimal. Such additions resulted in six adsorption clarifier flushes per day and one multimedia filter backwash per day.

Effluent Water Quality

Over the first four months of the demonstration, under various operating conditions, limited analytical of metals and inorganics was performed on the Trimite multimedia filter effluent (Table 5.7). During selected events of the demonstration study, complete analytical for drinking water contamination of inorganics, organics, and metals was performed (Table 5.8). This complete analytical was collected during steady-state operation (Day 137), and during the spiking study at 1,000 µg/L (Days 301 and 327), at 2,000 µg/L (Day 329), and at 2,500 µg/L (Day 335). The spiking data results are provided in Section 5.7.7. For all of the effluent results from the Trimite multimedia filter, regardless of the operating condition (i.e., steady-state, feed restart, plant restart, etc.), all of the State of California regulatory limits for potable water were met.

In addition to the measurements at the effluent of the Trimite multimedia filter during steady-state operating conditions, on Day 89 after the plant restart, both the FBR effluent (Trimite influent) and the Trimite effluent water quality data were collected (Table 5.9). Even under the most rigorous operating conditions after a plant restart, the analyses demonstrated that no significant change in water quality was observed.

Table 5.7 Trimite multimedia filter effluent water quality for metals and inorganics under various operating conditions.

Days Elaspsed (Reactor Operation)	**47 (Steady-State)**	**63 (Steady-State)**	**69 (Feed Restart)**	**77 (Steady-State)**	**89 (Plant Restart)**	**96 (Steady-State)**	**103 (Steady-State)**	**105 (Steady-State)**	**119 (Steady-State)**	**125 (Steady-State)**	**California State Limit**
Metals											
Barium (mg/L)	0.0286	0.0274	0.0278	0.0283	0.0252	0.0276	0.0265	0.0275	0.0262	0.0258	**1**
Cadmium (mg/L)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	**0.005**
Chromium (mg/L)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	.00268J	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	**1**
Iron (mg/L)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	**0.3**
Lead (mg/L)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	**0.015**
Manganese (mg/L)	ND (<0.003)	ND (<0.003)	ND (<0.003)	.00309J	ND (<0.003)	ND (<0.003)	ND (<0.003)	0.00784J	ND (<0.003)	ND (<0.003)	**0.05**
Mercury (µg/L)	ND (<0.1)	ND (<0.1)	ND (<0.1)	ND (<0.1)	ND (<0.1)	ND (<0.1)	ND (<0.1)	ND (<0.1)	0.136J	ND (<0.1)	**2**
Nickel (mg/L)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	ND (<0.0025)	**0.1**
Zinc (mg/L)	0.0580	0.012	0.00598J	.00702J	.00811J	0.0132	0.0117	0.0124	0.0137	0.0199	**5**
Other Inorganics											
Carbonate (mg/L)		ND (<1)	ND (<1)	ND (<1)	ND (<1)						
Bicarbonate (mg/L)		185	183	180	175						
Hydroxide Alkalinity (mg/L)		ND (<1)	ND (<1)	ND (<1)	ND (<1)						
Total Hardness (mg/L)		204	212	211	194						
Calcium (mg/l)		63.3	66.3	65.8	60.3						
Magnesium (mg/L)		11.1	11.3	11.3	10.6						
Sodium (mg/L)		12.7	12.4	11.6	12.9						
Filter TSS (mg/L)	ND (<5.0)	ND (<5.0)	ND (<5.0)	ND (<5.0)	ND (<5.0)						

Table 5.8 Trimite multimedia filter effluent water quality for metals, inorganics, and organics under steady-state operating conditions on Day 137.

Metals	**Value**	**California State Limit**	**Other Inorganics**	**Value**	**California State Limit**
Aluminum (mg/L)	0.053	**0.2**	Chloride (mg/L)	15	
Antimony (mg/L)	<0.006	**0.006**	Fluoride (mg/L)	0.3	
Arsenic (mg/L)	<0.002	**0.01**	Magnesium (mg/L)	9.7	
Barium (mg/L)	<0.1	**1**	MBAS (mg/L)	<0.10	**0.5**
Beryllium (mg/L)	<0.001	**0.004**	Nitrate (mg/L)	<1.0	**45**
Cadmium (mg/L)	<0.001	**0.005**	Nitrite (mg/L as N)	<0.1	**1**
Chromium (mg/L)	0.0039	**0.05**	Potassium (mg/L)	1.7	
Copper (mg/L)	<0.05	**1**	Sodium (mg/l)	11	
Cyanide (mg/L)	<0.1	**0.15**	Sulfate (mg/L)	16	**<250**
Iron (mg/L)	<.1	**0.3**	Total Cations (me/L)	4	
Lead (mg/L)	<.005	**0.015**	Total Alkalinity (mg/L)	180	
Manganese (mg/L)	<0.02	**0.05**	Total Anions (mg/L)	4.37	
Mercury (µg/L)	<0.001	**0.002**	**Physical Characteristics**		
Nickel (mg/L)	<0.01	**0.1**	Aggressive Index	12	
Selenium (mg/L)	<0.005	**0.05**	Color (CPU)	<2.5	**15 units**
Silver (mg/L)	<0.01	**0.1**	Langlier Index at 25 C	0.2	
Thallium (mg/L)	<0.001	**0.002**	Odor (TON)	<1.0	**3 units**
Zinc (mg/L)	<0.05	**5**	pH	7.6	
Other Inorganics			Specific Conductance (µS/cm)	430	**<900**
Carbonate (mg/L)	ND (<1)		TDS (mg/L)	250	**<500**
Bicarbonate (mg/L)	220		Temperature (degrees C)	25	
Hydroxide Alkalinity (mg/L)	ND (<1)		Turbidity (NTU)	<0.20	**<0.3**
Total Hardness (mg/L)	170		**Organics**		
Calcium (mg/L)	54		VOCs (µg/L)	ND	

Table 5.9 FBR effluent and Trimite multimedia filter effluent water quality for metals and other inorganics after a plant restart condition (Day 89).

Metals	**FBR Effluent**	**Trimite Effluent**
Barium (mg/L)	0.0258	0.0252
Cadmium (mg/L)	ND (<0.001)	ND (<0.001)
Chromium (mg/L)	ND (<0.0025)	ND (<0.0025)
Iron (mg/L)	0.0447J	ND (<0.04)
Lead (mg/L)	ND (<0.003)	ND (<0.003)
Manganese (mg/L)	ND (<0.003)	ND (<0.003)
Nickel (mg/L)	ND (<0.0025)	ND (<0.0025)
Zinc (mg/L)	0.0113	.00811J
Other Inorganics		
Carbonate (mg/L)	ND (<1)	ND (<1)
Bicarbonate (mg/L)	180	175
Hydroxide Alkalinity (mg/L)	ND (<1)	ND (<1)
Total Hardness(mg/L)	197	194
Calcium (mg/L)	60.9	60.3
Magnesium (mg/L)	10.8	10.6
Sodium (mg/L)	12.9	12.9

Backwash Water Quality

Multiple experiments were conducted to determine the levels of BOD, COD, and TSS that would be produced by the effluent of the Trimite multimedia filter during an adsorption clarifier flush and multimedia backwash event. The COD and BOD data were collected after restarting the system after a feed shutdown (Day 69), during steady-state operation (Day 77), and after restart from a plant shutdown (Day 89). The TSS data was collected at higher perchlorate loads (during the spiking study) when the system was operating at steady-state, treating 1000 µg/L (Day 280). It was necessary to collect such data to assess what levels of BOD, COD, and TSS may be released to a POTW at the full-scale level. Because the adsorption clarifier flush and the multimedia backwash events occurred over an extended period, sampling during each event was conducted at the beginning, middle, and end of each process (Table 5.10). As expected, for both the BOD and COD results for both processes, the initial values (sampled at the beginning) were the highest and declined as the process continued. The maximum adsorption clarifier flush BOD and COD values were 57.5 and 1000 mg/L, respectively. The maximum multimedia backwash BOD and COD values were 23.1 and 277 mg/L. From these maximum values, over the course of each process, the levels of the BOD and COD quickly declined so that by the end, samples declined to near non-detect levels. Presumably, the COD values were greater than the BOD values for each process because the added polymer makes up a significant fraction of the solids removed during an adsorption clarifier flush and a multimedia backwash. The adsorption clarifier is responsible for the majority of the solids removal across the Trimite filter. As demonstrated by the data, the levels of BOD and COD from the adsorption clarifier were higher than those values obtained during the multimedia filter backwash. TSS values also showed a similar decline over time as the adsorption clarifier went from rinse to waste. This decline to less than 5.0 mg/L demonstrated that all solids had been removed from the clarifier. For the mixed media filter, a baseline level of solids in the flush water appeared to be reached at approximately 59 mg/L. These values are being used in the design of the full-scale equipment.

Table 5.10 BOD, COD, and TSS release from the Trimite filter during flush and backwash cycles.

	Restart After Feed Shutdown (Day 69)		Steady-State (Day 77)		Restart after Plant Shutdown (Day 89)		Steady-State (1000 µg/L ClO_4) (Day 280)
Parameter and Condition	**BOD (mg/L)**	**COD (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**	**TSS (mg/L)**
Clarifier (forward flush initial)	44.9	851	57.5	1000	22	789	640
Clarifier (forward flush middle)	22.4	79.9	18.8	356	<1.0	180	154
Clarifier (forward flush end)	17.1	39.3	<1.0	<5.0	<1.0	<5.0	<5.0
Mixed Media (back flush initial)	23.1	277	5.93	137	<1.0	124	280
Mixed Media (back flush middle)	4.94	25	<1.0	45.4	<1.0	52.5	54.0
Mixed Media (back flush end)	3.37	10.8	<1.0	18.9	2.35	<5.0	59.0

Besides COD, BOD, and TSS, on Day 347, a complete analysis of the clarifier flush water was conducted to determine what other constituents were present in the flush water (Table 5.11). All parameters of the flush water were consistent with the Trimite multimedia filter effluent water with the exception of the aluminum, iron, selenium, color, MBAS, turbidity, and potassium. The metals originate from the chemical additives of coagulant and flocculant agents. The color and turbidity are expected to be higher as the backwash water consists of concentrated organics from the FBR. This discharge water will likely be sent to a POTW for further processing and will be site specific in regards to the POTW requirements. However, the constituents in the clarifier flush water are dilute enough that no special handling or pretreatment requirements should be necessary for most/all POTWs to accept.

Table 5.11 Clarifier flush water quality.

Parameter	Value	Parameter	Value
Metals and Metalloids		**General Mineral-Cations**	
Aluminum (mg/L)	**3.5**	Total Hardness (mg/L)	200
Antimony (mg/L)	<0.006	Calcium (mg/L)	62
Arsenic (mg/L)	<0.002	Magnesium (mg/L)	12
Barium (mg/L)	<0.1	Potassium (mg/L)	**3.2**
Beryllium (mg/L)	<0.001	Sodium (mg/L)	13
Cadmium (mg/L)	<0.001	Total Cations (me/L)	4.7
Chromium (mg/L)	0.02	**General Mineral-Anions**	
Copper (mg/L)	<0.05	Total Alkalinity (mg/L)	180
Iron (mg/L)	**0.110**	Bicarbonate (mg/L)	220
Lead (mg/L)	<.005	Carbonate (mg/L)	ND < 3.0
Manganese (mg/L)	<0.02	Chloride (mg/L)	16
Mercury (µg/L)	<0.001	Fluoride (mg/L)	0.3
Nickel (mg/L)	<0.01	Hydroxide Alkalinity (mg/L)	ND < 3.0
Selenium (mg/L)	**0.0068**	Nitrate (mg/L)	ND <1.0
Silver (mg/L)	<0.01	Sulfate (mg/L)	17
Thallium (mg/L)	<0.001	Total Anions (mg/L)	4.42
Zinc (mg/L)	<0.05	**Aggregate Properties**	
General Organics		pH	7.4
Cyanide (mg/L)	ND < 0.1	Specific Conductance (µmhos/cm)	430
Nitrite (mg/L as N)	ND < 0.1	Temperature (degrees C)	25
Perchlorate (mg/L)	<.004	Aggressive Index	11.7
General Physical		Langlier Index at 25 C	0.02
Color (CPU)	**3.0**		
MBAS (mg/L)	**0.16**		
Odor (TON)	ND<1.0		
Turbidity (NTU)	**180**		
TDS (mg/L)	280		

5.7.2.4 LGAC

The plant was programmed such that an excessive turbidity condition in the effluent water from the Trimite multimedia filter would cause an alarm condition and the PLC operating the plant would subsequently place the entire plant into an FBR recycle mode. Hence, the downstream LGAC system was always protected from higher turbidity water by the PLC. Typically, only drinking quality water passed through this vessel. Pressure drops were minimal (<1 psi) and biomass clogging was not observed for the duration of the LGAC use (Figure 5.44). Microbiological analysis after the LGAC system showed minimal amount of total coliform or

HPC breakthrough. No *E.Coli* in the LGAC effluent was ever detected. Upon completion of the demonstration of the LGAC reactor, the carbon was analyzed for Toxicity Characteristic Leaching Procedure (TCLP) to assess how the material could be disposed (Table 5.12). The material met all TCLP requirements.

Figure 5.44 Inlet and outlet water pressure for the LGAC reactor.

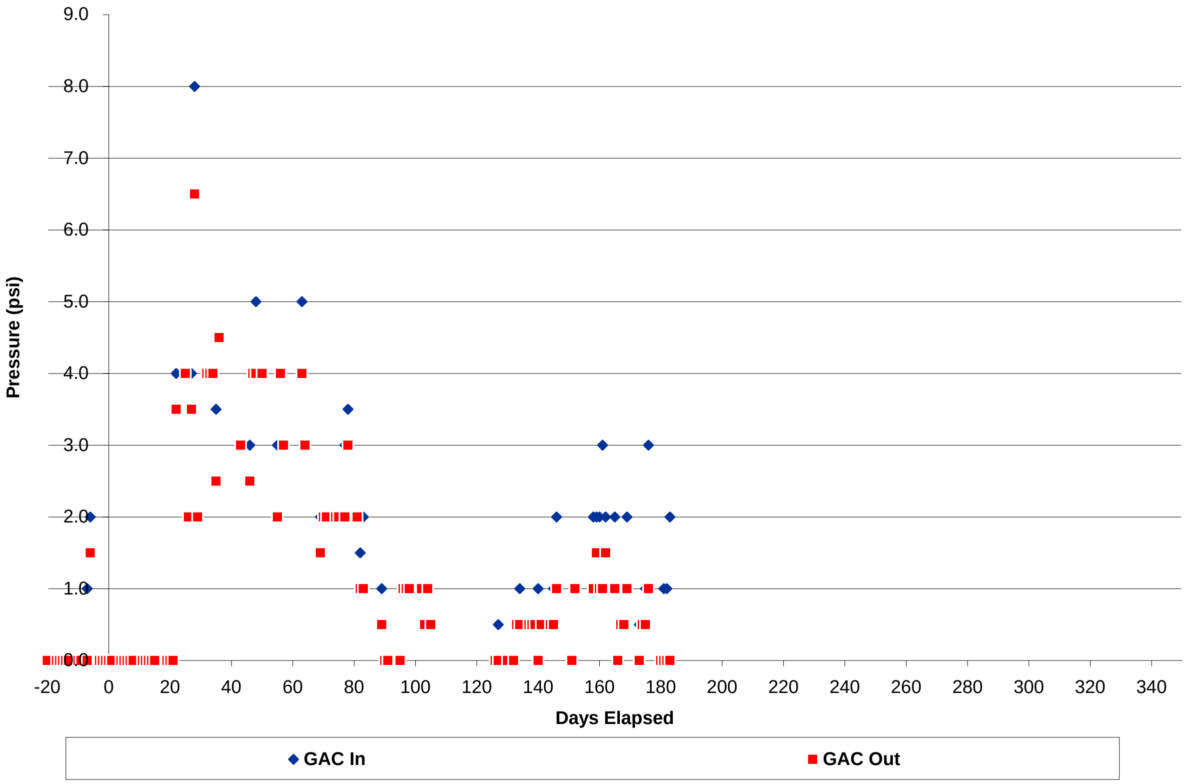


Table 5.12 LGAC analysis for Toxicity Characteristic Leaching Procedure (TCLP).

ANALYTICAL REPORT

Customer:	Shaw E & I	Lab I.D. #:	24138
C/o:	City of Rialto Well # 2	Date Reported:	08/31/07
Address:	980 West Easton Street Rialto, CA 92376	Date Sampled:	08/24/07
		Date Received:	08/28/07
WES Contact:	Los Angeles Sales	Date Analyzed:	08/30/07
Sampler:		Date Extracted:	08/29/07

EPA METHOD 1311 AND 8260
VOLATILE ORGANIC COMPOUNDS

Compound	CAS #	Concentration (mg/L) ppm in TCLP extract	Limit of detection (mg/L)	TCLP limits (mg/L)
Vinyl Chloride	75-01-4	<0.030	0.03	0.2
1,1-Dichloroethene	75-35-4	<0.005	0.005	0.7
Chloroform	67-66-3	<0.005	0.005	6.0
1,2-Dichloroethane	107-06-2	<0.005	0.005	0.5
Methyl Ethyl Ketone Butanone	78-93-3	<0.50	0.50	200
Carbon Tetrachloride	56-23-5	<0.010	0.010	0.5
Trichloroethene	79-01-6	<0.005	0.005	0.5
Benzene	71-43-2	<0.005	0.005	0.5
Tetrachloroethene	127-18-4	<0.005	0.005	0.7
Chlorobenzene	108-90-7	<0.005	0.005	100

5.7.2.5 Overall Plant Effectiveness

For the duration of the demonstration project (Day 0 to Day 350), the FBR treatment system uptime was calculated to be 94%. This included all mechanical and electrical shutdowns (see Appendix H) for maintenance logs. Because a number of different experiments were conducted, this uptime does not account for instances when incomplete perchlorate removal occurred.

Per discussions with the California Department of Public Health, a number of studies were conducted to assess the presence/existence of particular organic and inorganic compounds across the FBR treatment system. It was suspected that these compounds would not be present, but testing was still conducted to confirm this supposition. From these experiments, samples were collected to determine the presence of volatile organic compounds (VOCs) and n-nitrosodimethylamine (NDMA). On two occasions (Days 137 and 329), the levels of VOCs were measured across the plant. At the feed to the FBR, the only observed VOC measurement was TCE at 4.4 µg/L and 3.1 µg/L on Day 137 and Day 329, respectively. All VOC concentrations after the FBR shown non-detect. Though possible to treat chlorinated solvents in the FBR, since the FBR HRT was less than 20 minutes, it was unlikely treatment occurred. Instead, it is more likely that a combination of adsorption, stripping, and volatilization occurred across the entire plant to provide the non-detect values. On Day 307, the presence of NDMA was also measured and not detected (<0.004 µg/L) in the Trimite multimedia filter effluent water. Since only one sample was obtained for NDMA analysis in the effluent water of the Trimite multimedia filter, limited conclusions can be made. However, per the manufacturer, the historical operation of Trimite multimedia filters has not demonstrated NDMA formation after the initial start-up of the equipment. Therefore, the presence of NDMA in the Trimite multimedia filter effluent water was not expected.

Concerns about the potential pathogenic microbiological carryover from the FBR through the entire FBR treatment plant and the possible subsequent disinfection by-product formation potential prompted the measurement of total coliform, *E. Coli*, and heterotrophic plate counts at the FBR feed, FBR effluent, Trimite multimedia filter effluent, and LGAC effluent throughout the demonstration via an off-site laboratory. The amount of microorganisms produced across the entire plant varied depending on the operating conditions (Figures 5.45 and 5.46). With all microbial enumeration techniques, variabilities existed that were often difficult to quantify between samples. These variabilities may have been a result of differing sampling techniques, heterogeneities in the sample matrix, and differing analytical interpretation of results (both false-positives and negatives). However, definitive conclusions could be made about the microbiological results collected over the course of the demonstration. The levels of *E.Coli* were always below the MDL (<1.0 MPN/100 mL, data not shown). The heterotrophic plate count and total coliform data varied, but clearly the heterotrophic plate counts were higher from the FBR effluent than the Trimite multimedia filter effluent. This pattern was followed for the total coliform until the spiking studies were conducted. During the spiking studies, this data routinely showed higher total coliform concentrations from the Trimite multimedia filter effluent compared to the FBR effluent. It is suggested that this was a function of the higher perchlorate loads producing more biomass from the FBR to the Trimite multimedia filter. This biomass then acclimated to the Trimite multimedia filter and appeared at higher values in the effluent water.

Figure 5.45 Total coliform concentration across FBR treatment

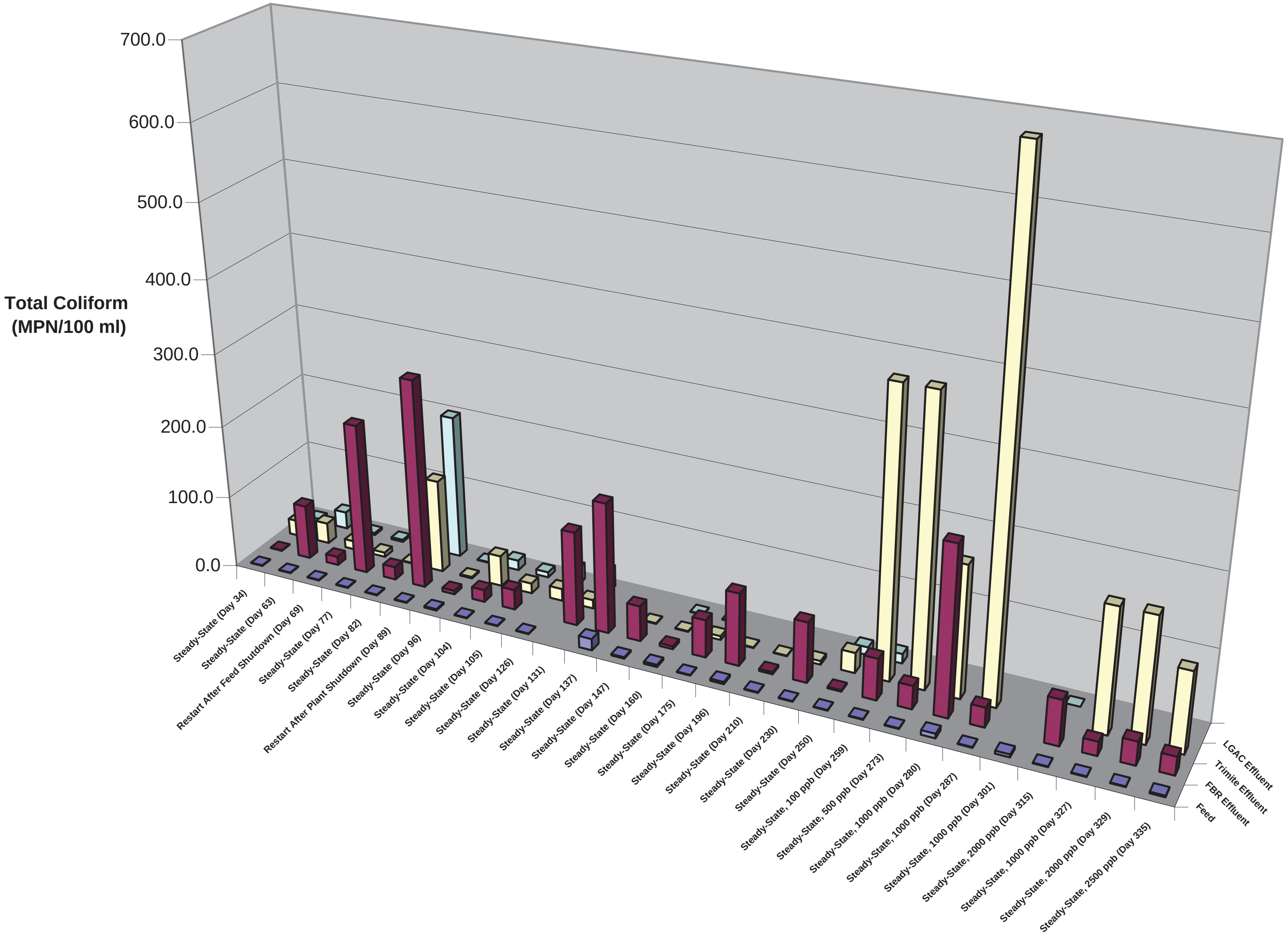
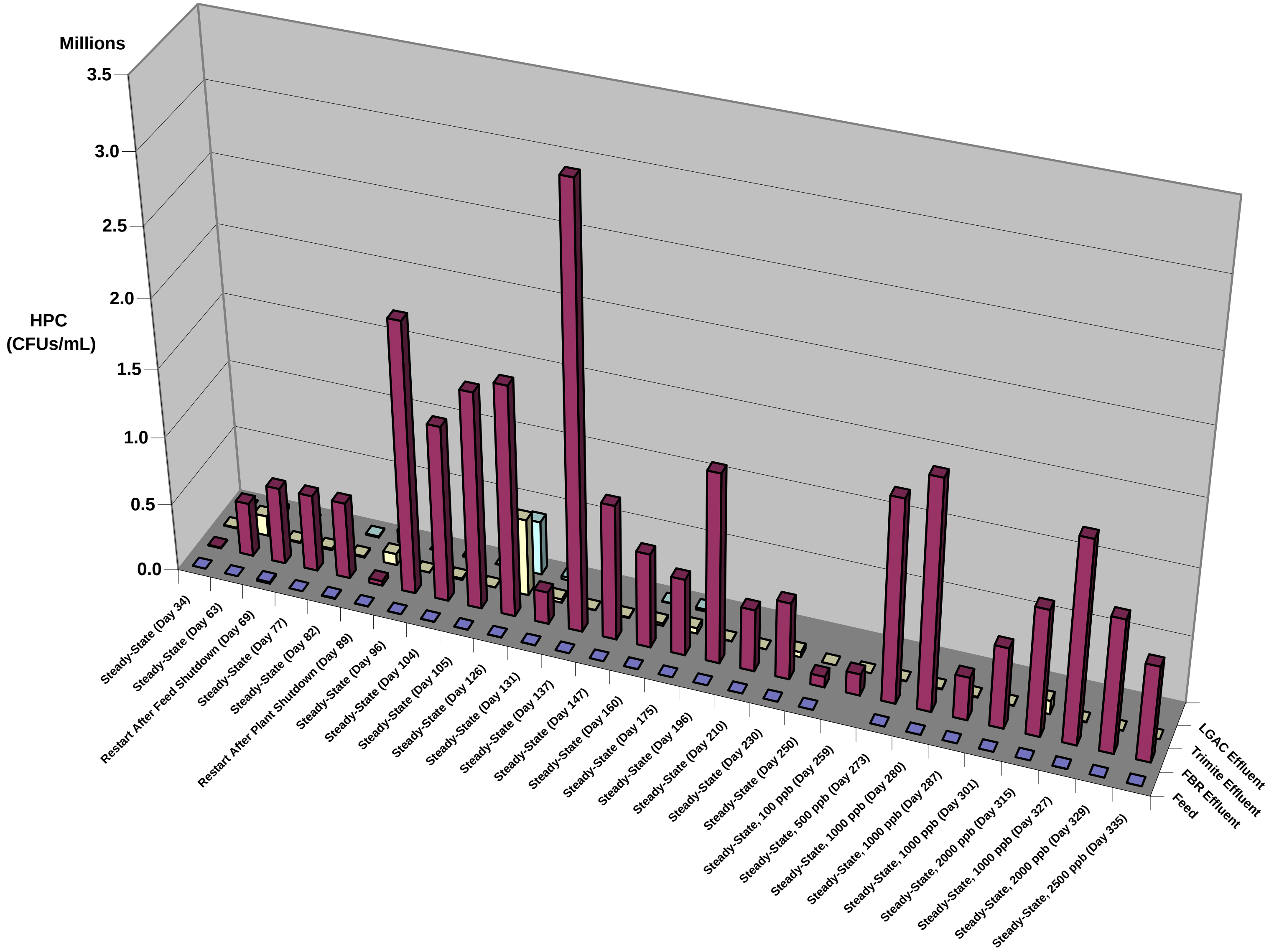


Figure 5.46 HPC concentration across FBR treatment



The potential generation of disinfection by-products (DBPs) from the plant was a concern. Hence, total trihalomethane (TTHM) and haloacetic acid 5 (HAA5) formation potential were measured at the Trimite multimedia filter effluent during system steady-state operation (Days 34, 77, and 96), after the last feed shutdown experiment (Day 69), after the plant shutdown experiment (Day 89), and during the spiking study (Days 301 and 327, Figures 5.47 and 5.48). On two separate occasions under steady-state operation of the plant (Days 34 and 96), TTHM and HAA5 formation potential data was collected across the entire plant (Figure 5.49). For all analyses, Standard Methods were followed with a minimum of 1 mg/L of free residual chlorine, contact time of 7 days, temperature at 25 degrees Celsius, and the pH of 7-8. The State of California regulates the disinfection byproducts for TTHMs and HAA5 at 80 and 60 µg/L, respectively. For all measurements of disinfection by-product formation potential, the State limits were never exceeded. During the initial operation of the plant (Day 34), higher concentrations of DBPs were observed at the Trimite multimedia filter effluent as a result of fine tuning of the chemical addition (ALUM and polymer) to the filter. Higher concentrations of DBPs were also observed during the spiking studies (Days 301 and 327) because of the larger contaminant loads being treated by the FBR that resulted in more biomass carryover to the Trimite multimedia filter. For the DBP formation potential across the entire plant, the FBR effluent had a considerably larger organic fraction of material as biomass compared with the effluent of the other system equipment. Hence, the potential for the formation of disinfection by-products was consistently higher in the FBR effluent. In all cases, effluent water from the plant never exceeded 30 µg/L of either TTHM or HAA5.

Figure 5.47 TTHMs and HAA5 formation potential from Trimite filter effluent water.

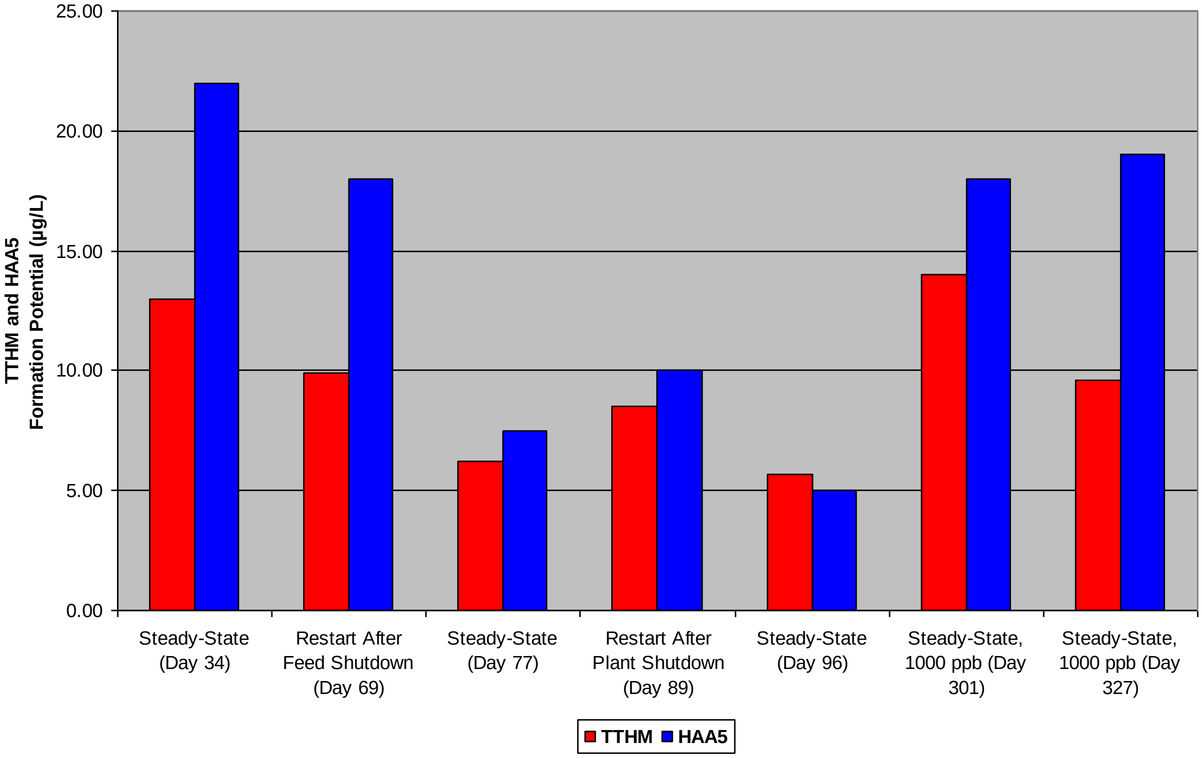


Figure 5.48 TTHMs and HAA5 formation potential (with components) from Trimite filter effluent.

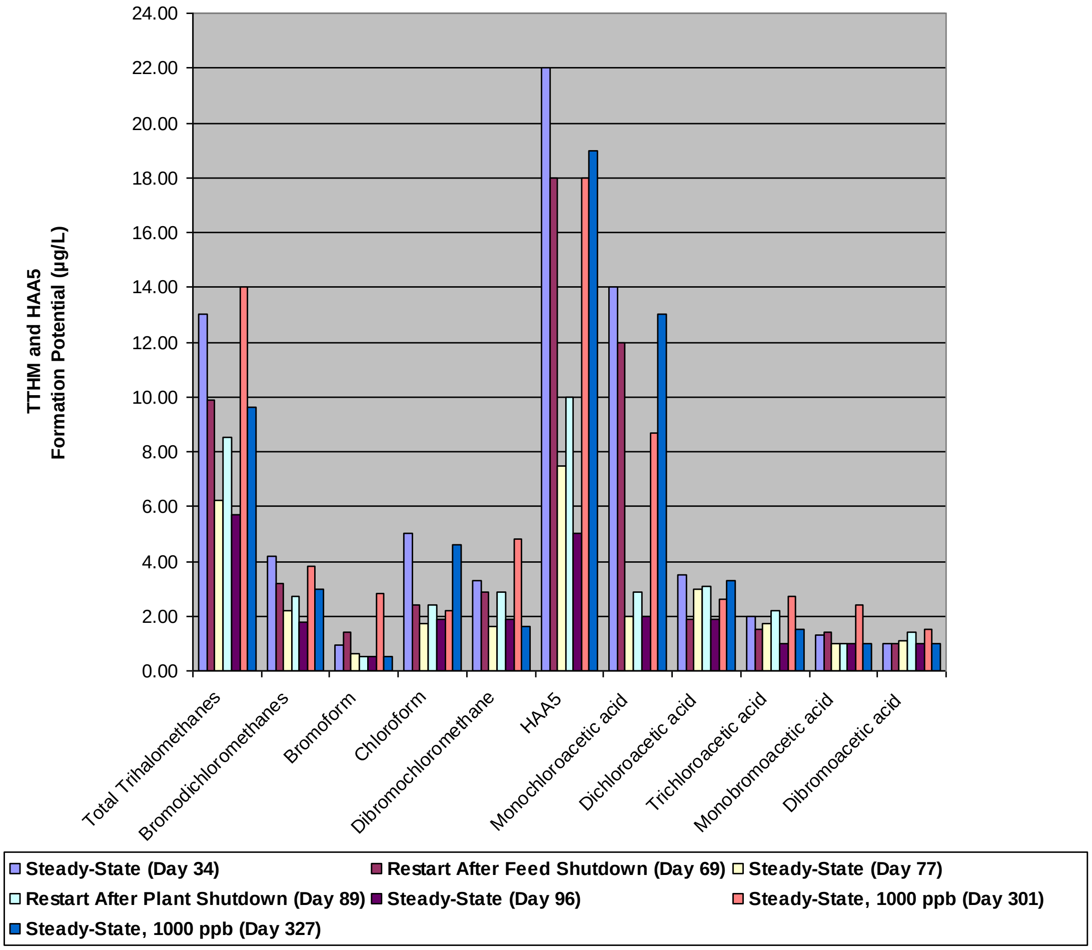
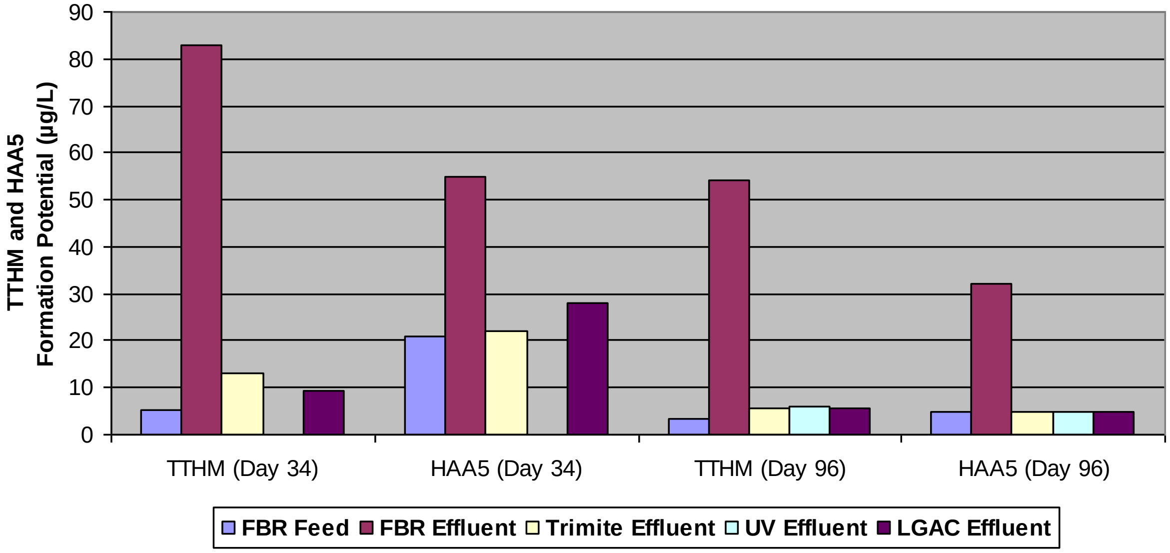


Figure 5.49 TTHMs and HAA5 formation potential from entire FBR treatment system.



5.7.3 System Shut-Down Scenarios

Two feed water shutdown experiments, two plant electrical interruption experiments and one nutrient interruption experiment were conducted during the demonstration study.

5.7.3.1 Feed Shutdown

The first feed interruption experiment was conducted Days 37-42 (Figure 5.35). The FBR was placed in recycle and electron donor and nutrient were not fed to the system. Upon restart of the feed water, the nitrate-N and perchlorate breakthrough were observed for approximately a 24 hour period before the system effluent nitrate-N and perchlorate concentrations were returned to non-detect levels. After some maturation of the microbial community in the FBR, a second feed interruption experiment was conducted from Days 65-69 (Figure 5.36). Upon restart of the feed water, the removal recovery of nitrate-N and perchlorate to non-detect levels required less than eight hours. Presumably, a more robust denitrifier and perchlorate degrading population colonized the filter bed providing shorter recovery times.

5.7.3.2 Plant Electrical Shutdown

The first plant electrical shutdown experiment occurred on Days 84-89 (Figure 5.37). This experiment replicated a long-term electrical outage to the plant. Upon restart of the plant, a breakthrough of nitrate-N was quickly observed, but no corresponding breakthrough of perchlorate occurred. The recovery period for the nitrate-N was less than two hours, while breakthrough of perchlorate was not observed. Presumably, this latter result was a combination of adsorption and biodegradation. Upon restart, the initial primary mechanism for nitrate-N and perchlorate removal was adsorption, but as the microbes were reactivated by the addition of forward flow, electron donor, and nutrients, the primary removal mechanism of both the nitrate-N and perchlorate shifted to biodegradation. It is postulated that because a perchlorate degrading population had matured in the bed over the course of the demonstration study (over 80 days), the biological activity was able to rebound quickly and remove the perchlorate before the carbon had reached its adsorptive capacity.

A similar plant electrical shutdown experiment was conducted on Day 134 for 8 hours (Figure 5.39). This test replicated a realistic short-term electrical failure and subsequent system restart. Similar to the long-term plant electrical interruption, nitrate-N was observed to breakthrough while perchlorate did not appear in the FBR effluent. The recovery time for the nitrate-N was approximately 90 minutes. Again, adsorption coupled with biological treatment allowed the FBR to quickly recover from a short-term electrical outage. Both of these experiments demonstrated that long- and short-term electrical shutdowns for a mature microbiological FBR system do not lead to extensive downtime in performance or procedures upon system restart.

5.7.3.3 Nutrient Shutdown

An experiment was conducted to determine the necessity of the nutrient addition to the FBR process. The phosphoric acid addition was stopped to the FBR for a 21 hour period on Day 127 (Figure 5.39). Within the first 12 hours after phosphoric acid addition stopped, perchlorate began to break through. After restarting the phosphoric acid addition, the nitrate removal improved to near non-detect within one hour and the perchlorate removal to within near non-detect within 4 hours. The experiment demonstrated a clear correlation between phosphorus requirements and nitrate/perchlorate removal rates.

5.7.4 On-Line Analyzer Effectiveness

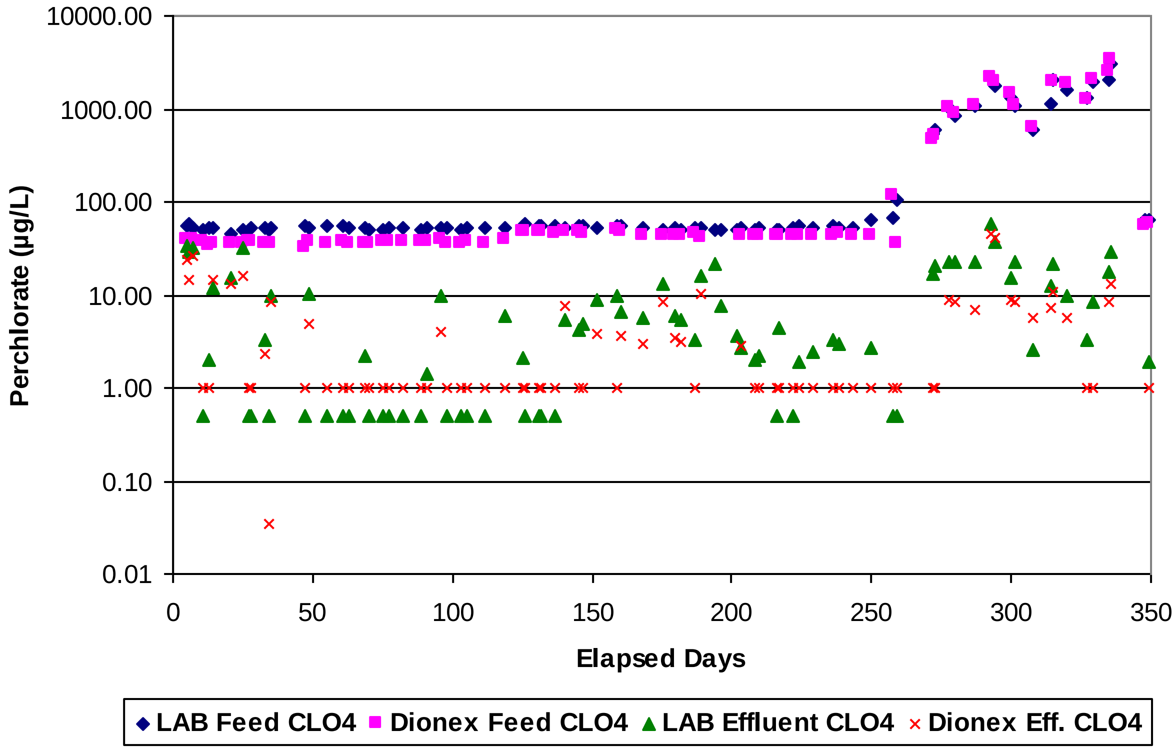
The operation of the on-line perchlorate and nitrate analyzers worked effectively in providing feed forward control of the electron donor. The analyzer data is provided in Figures 5.33 to 5.43.

5.7.4.1 Dionex DX-800 Perchlorate Analyzer

Initially, the on-line instrument had a consistent, low bias in reportable perchlorate concentrations compared with the off-site laboratory analyses. On average, the on-site instrument reported the feed concentration to be 36.2 µg/L, while the outside laboratory reported 52.1 µg/L. This difference was partly attributable to sample preparation technique within the Dionex instrument compared to the outside laboratory. Dionex engineers attempted to determine and correct the specific reason for this inherently low bias in the reported feed perchlorate concentrations by the field instrument. It was thought that the dilution pump within the DX-800 perchlorate analyzer was delivering a lower volume of water during the internal calibration preparation steps. This caused the real sample to read low. Using a certified perchlorate standard (Accustandard, New Haven, CT), a 50 µg/L perchlorate standard was prepared and analyzed on-site by the on-line instrument and off-site at Emax Laboratories, Inc. The on-site analyzer detected the sample at 44.5 µg/L, while the off-site lab showed the sample to be at 53.8 µg/L. These results confirmed the Dionex Engineers suspicions. Hence, on Day 124, the Dionex engineers adjusted the dilution volume utilized by the dilution pump of the DX-800, replaced the analytical column, and made modifications to the Dionex program. These adjustments allowed the on-site instrument and the laboratory analytical FBR feed results to compare within 10-20% (Figure 5.50). Even with the difference observed between the reported on-site and the off-site laboratory perchlorate values, the effects on the PLC to adequately control the electron donor were minimal. An excess of electron donor was always provided to the FBR to account for variabilities in the feed water composition that absorbed this difference in readings. This inherently low bias was not observed repeatedly for the reported effluent perchlorate concentrations by the on-line instrument. The minimum reporting limit (MRL) for the on-line instrument was determined to be 2.3 µg/L, while the detection limit (DL) was 1 µg/L. The outside, off-site laboratory MRL was 2 µg/L and the instrument DL was 0.5 µg/L.

During the month of August (Day 148), in addition to taking samples from the FBR feed and effluent, samples from the Trimite multimedia filter effluent were also analyzed with the automatic sampling system. Over the course of the month, it was noticed that sampling from the Trimite multimedia filter effluent created false-positives in the FBR effluent perchlorate analyses. It is believed that changes in pressure and flow by sampling from the Trimite multimedia filter effluent somehow affected the multiport sampling valve, as well as the sampling filter, that contributed to cross-contamination occurring (leading to the false-positive results). Possibly, the multiport sampling valve failed and allowed the feed water to cross contaminate both the FBR effluent and Trimite multimedia filter effluent lines. A major effort was undertaken to remove all sources of possible cross-contamination (i.e., standards removed, feed isolated, etc.). Also, all lines were removed and replaced and the multiport sampling valve was cleaned out. After such corrective actions, the FBR effluent values returned to non-detect values.

Figure 5.50 Comparison of off-site lab and on-site Dionex feed and effluent perchlorate data. Non-detects were reported as the MDLs for each analysis (LAB MDL of 0.5 µg/L, Dionex MDL of 1 µg/L).



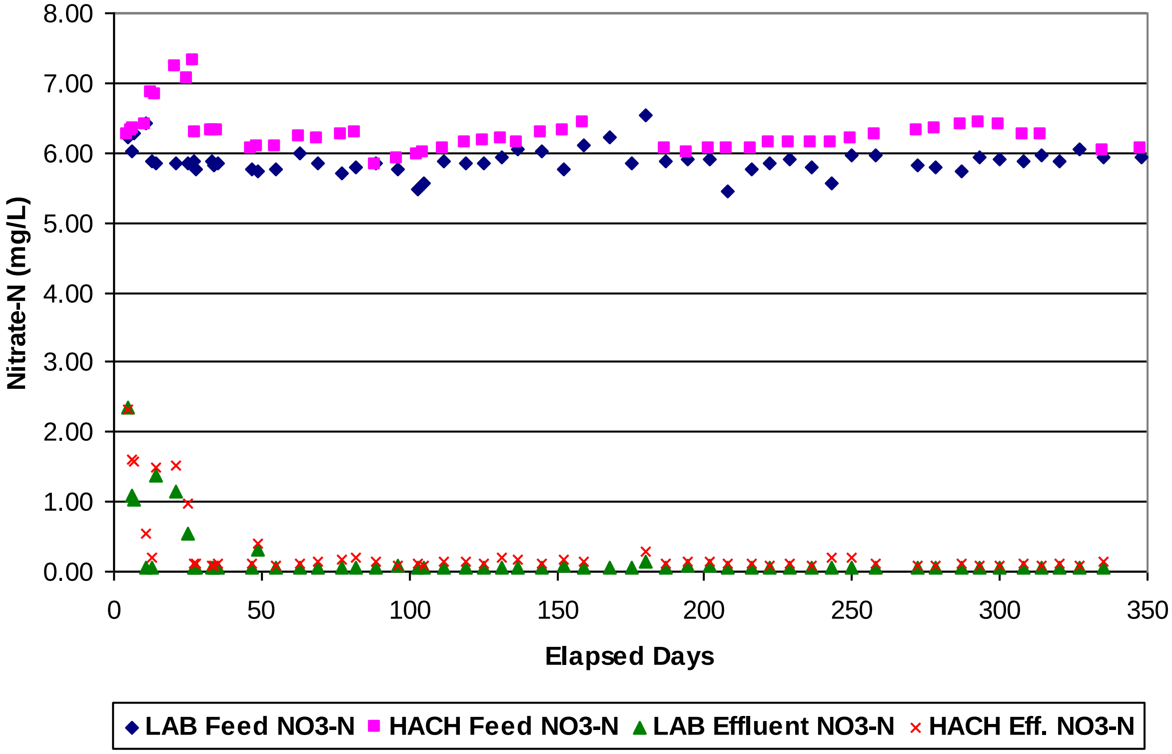
During the spiking study (after Day 299), with higher loads of acetic acid added to the FBR, a change in the baseline in the FBR effluent sample chromatogram was observed. This baseline change affected the ability of the DX-800 to accurately, automatically integrate the chromatographic peak of perchlorate. This issue is detailed further in Section 5.7.7.

5.7.4.2 HACH Nitrate-N Analyzers

The feed and effluent nitrate analyzers worked effectively throughout the demonstration (Figures 5.33 to 5.43). Typically, the instrument lines would be cleaned out once per week, with the effluent FBR line requiring more care than the FBR feed line. Still, instances when one or both analyzers failed did occur and these instruments were returned to the manufacturer for repair and recalibration. On Day 167 and 168, both the feed and effluent nitrate-N analyzers failed and provided no values or false-positive values. The manufacturer visited the site, but was only able to repair one of the two on-site instruments. The second instrument was sent back to the manufacturing facility for repairs. These instruments operated approximately four months without issue. While one of the instruments was out for repair, the working nitrate analyzer was placed on the FBR effluent stream. This problem reoccurred on Day 317 with the effluent nitrate-N analyzer failing. The feed nitrate-N analyzer was rotated to the effluent sample and the malfunctioning instrument was sent back to the manufacturer for repair.

Data registered between the on-line HACH instrumentation and the off-site laboratory analysis for nitrate-N agreed on average within 6.5% for the feed and 60% for the effluent (Figure 5.51). The large percentage difference in the effluent values is a result of the outside laboratory having a minimum detection limit (MDL) of 0.05 mg/L nitrate-N while the on-line instrument MDL was 0.1 mg/L. This difference in MDLs skews the data for comparison when the majority of the values are at the MDL. The on-line nitrate-N analyzer consistently demonstrated its MDL for the effluent water during steady-state operation.

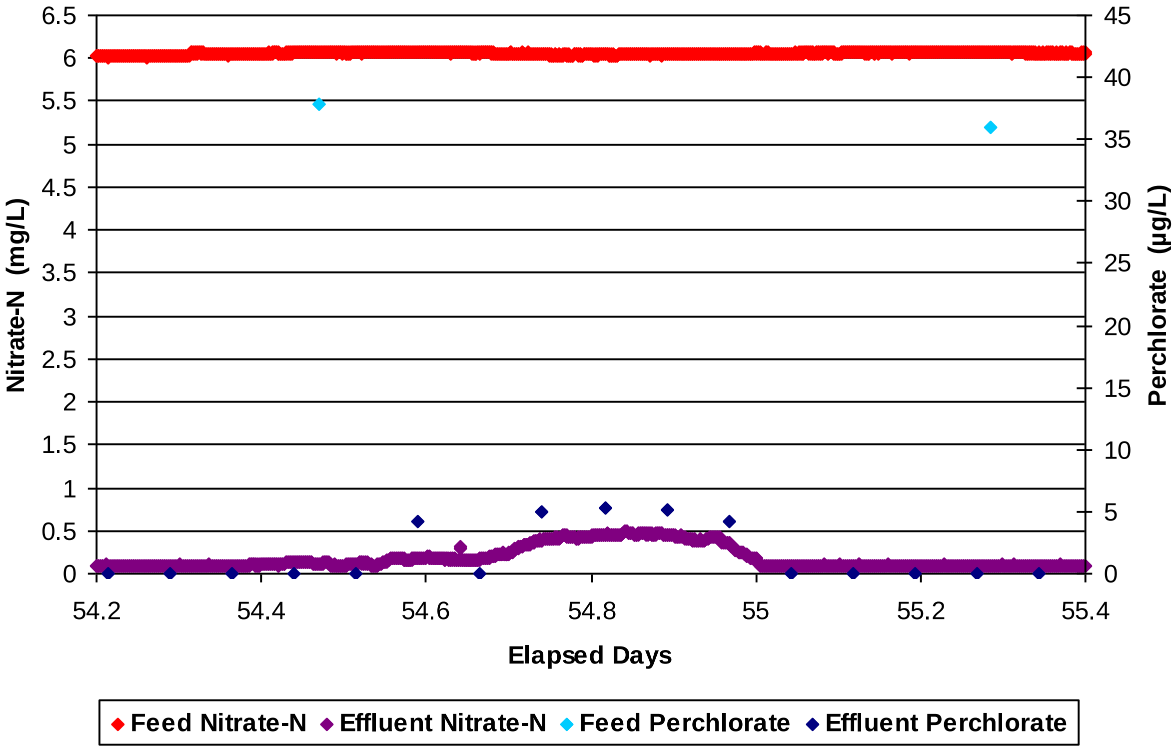
Figure 5.51 Comparison of off-site lab and on-site HACH feed and effluent nitrate-N data.



5.7.4.3 Electron Donor Reduction Experiments

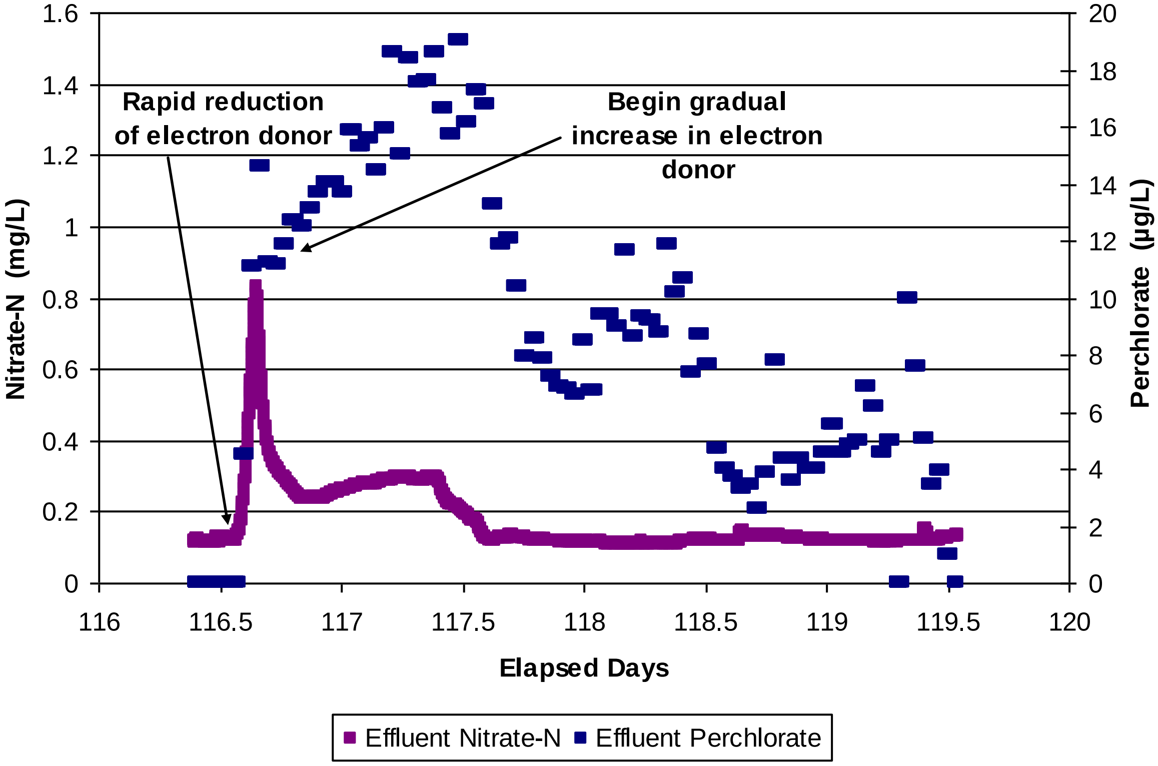
Four experiments were conducted to demonstrate the correlation between nitrate-N removal and perchlorate removal. In the Experiment #1 (Day 54), a fine tuning of the acetic acid was conducted over a week between 16.2 and 17.3 mg/L as Carbon to attempt to minimize the electron donor required (Figure 5.52). From this initial experiment, a general observation was made that at FBR effluent nitrate-N concentrations as low as 0.5 mg/L, some breakthrough of perchlorate was seen (up to 5.3 µg/L) in the FBR effluent water. This perchlorate breakthrough first occurred approximately 1 hour after the first signs of nitrate-N breakthrough. Higher concentrations of perchlorate were not observed until almost 5 hours after the initial nitrate-N breakthrough. However, these perchlorate concentrations never exceeded the California State MCL of 6 µg/L before the nitrate-N FBR effluent concentrations began to decline again to non-detect levels (after 13 hrs from initial breakthrough). Experiment #1 demonstrated that a small window of nitrate-N breakthrough concentration (<0.5 mg/L) is available before perchlorate breakthrough may occur and set up the protocol for the ensuing electron donor reduction experiments.

Figure 5.52 Reduction of Electron Donor Experiment #1.



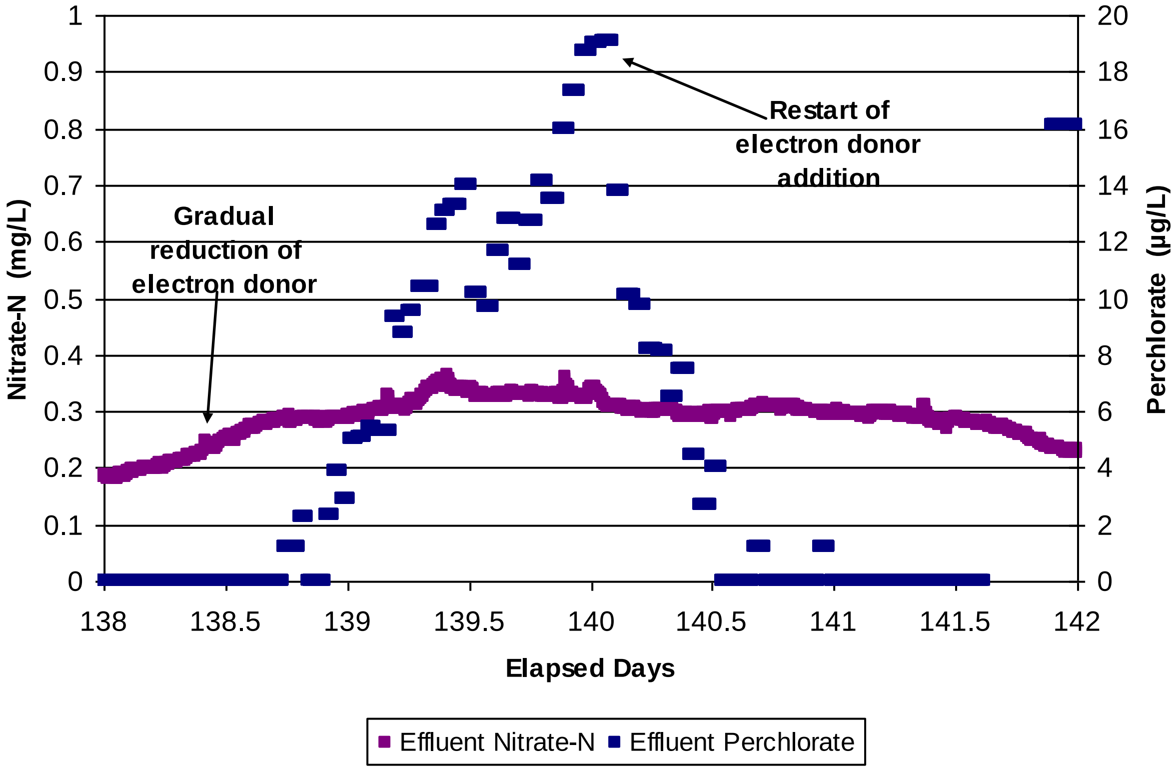
For Experiment #2 (Day 116), the excess acetic acid was cut back rapidly from 16.2 to 13.5 mg/L as Carbon (Figure 5.53). This experiment simulated a rapid loss of electron donor addition (i.e., electron donor pump failure). Upon this rapid cutback of electron donor, a fairly quick response of the nitrate-nitrogen concentration was observed as an increase from 0.1 mg/L to 0.8 mg/L. The perchlorate analyzer was set up to take samples every 45 minutes (most rapid sampling frequency achievable). Within two hours of the rapid cutback of electron donor, the perchlorate began to increase in the FBR effluent. This increase in FBR effluent perchlorate continued until the excess acetic acid was gradually increased from 13.5 to 16.2 mg/L as Carbon over the next two days. Based on the results of this experiment, a point at which the nitrate-N effluent concentration correlated to a perchlorate breakthrough above the MCL (6 µg/L) was difficult to determine for multiple reasons. The nitrate-N analyzer produced analytical results every minute, while the perchlorate analyzer required 45 minutes to produce one result. Such a discrepancy in sampling frequency made it difficult to define how the two contaminant effluent concentrations were related. In addition, the FBR effluent perchlorate concentration increased rapidly at low nitrate-N effluent values. Such a rapid increase was observed when the nitrate-N exceeded 0.4 mg/L. However, based on sampling frequency difference between the two instruments, this intersection crossover point may have been as low as 0.2 or 0.3 mg/L (see Experiment #3). Another observation made was that when the acetic acid was slowly increased and the resultant nitrate-N decreased below the 0.4 mg/L value, a resulting rapid drop in perchlorate was not observed. This lag in perchlorate removal may be a function of the lack of bound acetic acid available for perchlorate removal (as would be present right after the acetic acid is shut off) or even a slow enzymatic response by the microorganisms to the increase in acetic acid. A more rapid recovery of perchlorate treatment may have been observed had much higher loads of acetic acid been continually supplied prior to the rapid cutback of the electron donor. These higher loads would have provided more adsorbed, stored acetic acid on the carbon from which the microbes could have sequestered the electron donor for perchlorate removal.

Figure 5.53 Reduction of Electron Donor Experiment #2 (feed nitrate-N= 6.1 mg/L, feed perchlorate = 40-45 µg/L).



In order to confirm and corroborate the results of the first two nitrate-N and perchlorate correlation experiments, Experiment #3 (Day 138) was conducted where the acetic acid was slowly reduced over a 15 hour period from 16.2 to 13.9 mg/L as Carbon (as opposed to rapidly reduced as in Experiment #2, Figure 5.54). The result of this experiment was that the FBR effluent nitrate-N gradually increased from 0.22 mg/L to 0.34 mg/L over a 23 hour period. Within the first 19 hours of this 23 hour period, when the nitrate-N was 0.31 mg/L, the FBR effluent perchlorate first exceeded the MCL. Upon restart of the acetic acid at the original addition rate of 16.2 mg/L as Carbon, the FBR effluent perchlorate decreased below the State MCL at approximately 8.5 hours later, when the nitrate-N was at a value of 0.29 mg/L. The results from this experiment demonstrate that the actual intersection point for this system is closer to 0.3 mg/L of nitrate-N than 0.4 mg/L nitrate-N (as demonstrated by Experiment #2). With the nitrate-N/perchlorate concentration intersection point demonstrated to be near 0.3 mg/L, for this operating scenario of treating lower levels of perchlorate (50 µg/L), it may be possible to utilize the nitrate-N FBR effluent analyzer as the sole effective determination method of perchlorate concentrations above/below the MCL. However, it is essential that the nitrate analyzer be accurately calibrated and maintained to ensure that continuous analyzer results are accurate. However, if the perchlorate loads were significantly higher so that a more robust, more densely populated perchlorate population existed within the FBR, the results may be different. The data generated from this experiment is not completely transferable to other operating scenarios and should be repeated at the larger full-scale installation before final drinking water permit conditions are established.

Figure 5.54 Reduction of Electron Donor Experiment #3 (feed nitrate-N= 6.1 mg/L, feed perchlorate = 45-50 µg/L).



Experiment #4 (Day 349) attempted to correlate the level of DOC (from acetic acid) in the effluent of the FBR with the nitrate-N and perchlorate after a reduction in electron donor (Table 5.13). The acetic acid was shut off abruptly in the morning. The general trend observed was that the DOC concentration in the FBR effluent declined from 1.2 mg/L to non-detect while the nitrate-N and perchlorate concentrations increased. Within approximately 2.5 hours, the perchlorate levels exceeded the State MCL for perchlorate. However, once the acetic acid was restarted, with the more mature perchlorate degrading population having colonized the bed for nearly one year, the perchlorate levels returned to non-detect within 47 minutes. Based on the results from this experiment, residual TOC levels in the FBR effluent should be kept at a minimum of 1.0 mg/L to ensure complete nitrate-N and perchlorate treatment.

Table 5.13 Reduction of Electron Donor Experiment #4.

Sample Time After Pump OFF (minutes)	Automatic or Manual Sample??	DOC of FBR Effluent (mg/L)	Perchlorate of FBR Effluent (µg/L)	Nitrate-N of FBR Effluent (mg/L)
0 (8:23am)	None	1.2	ND	0.1011
31 (8:54am)	Dionex		2.4	0.1011
61 (9:24am)	Manual	0.5		0.1
95 (9:58am)	Dionex		3.2	0.1011
118 (10:21am)	Manual	1.1		0.1227
154 (10:57am)	Dionex		6.1	0.1705
187 (11:30am)	Manual	0.0	8.6	0.2387
Sample Time After Pump ON (minutes)	**Dionex or Manual Sample??**	**DOC of FBR Effluent (mg/L)**	**Perchlorate of FBR Effluent (µg/L)**	**Nitrate-N of FBR Effluent (mg/L)**
0 (11:30am)	None			0.2387
47 (12:17pm)	Dionex		ND(DOC peak)	0.1

5.7.5 Chlorination Disinfection Study

A chlorination study was conducted to determine what CT (concentration of chlorine dosage x contact time) was required for effective disinfection. Three different experiments were conducted:

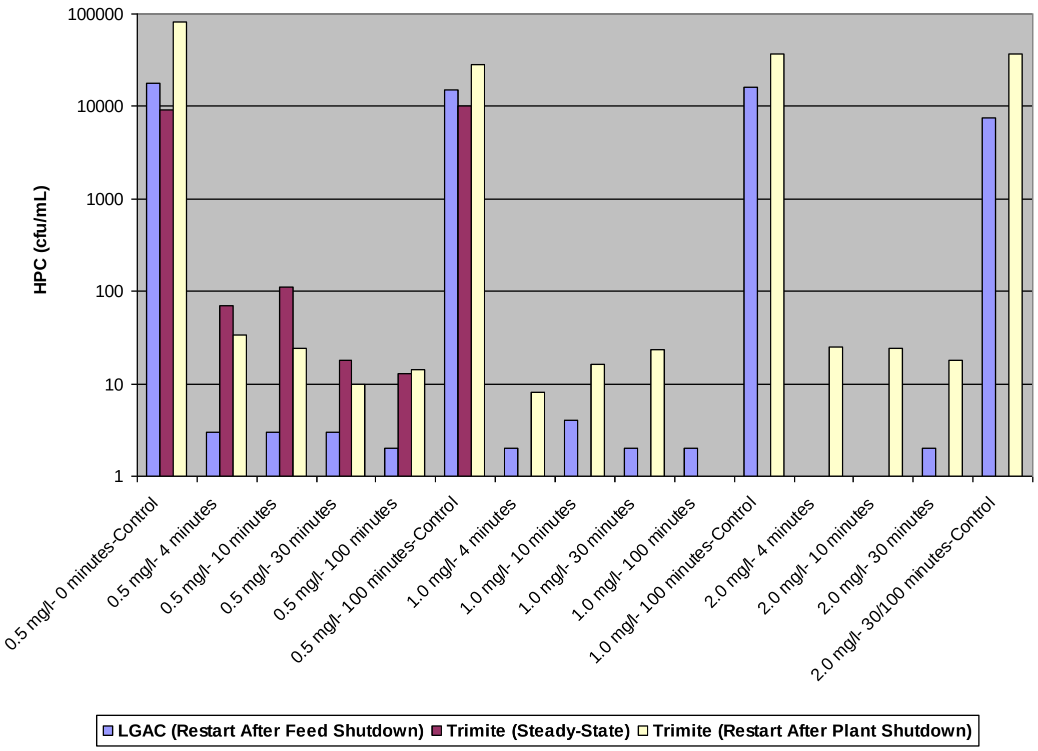
- After the Feed Shutdown Experiment #2 on the LGAC effluent water (Day 69)
- During steady-state operation on the Trimite effluent water (Day 77)
- After the Electrical Shutdown #1 Experiment (Day 89)

Baseline results from microbiological data collected from the FBR treatment system indicated low, initial concentrations of total coliform and *E.coli*. Hence, it was not possible to demonstrate a four-log removal using these microbiological measurements. However, after discussions with the CADPH, it was recommended to perform the chlorination study using heterotrophic plate counts (HPC) from the effluent of the LGAC and Trimite multimedia filter.

From the HPC collective measurements, the overall experimental data demonstrated that the concentrations of HPC could be effectively reduced via chlorination (Figure 5.55). For the LGAC effluent, chlorination at all CT levels resulted in significant HPC reductions (log 3+). For the Trimite multimedia filter effluent under steady-state conditions, the log removal of HPC was 2-3 and increased at a higher CT of 15 (0.5 mg/L at 30 minute contact time). With the likely worst-case scenario, after the restart of the Trimite multimedia filter after a plant shutdown (Day 89), it was determined that a three to four log inactivation of HPC could be observed at a CT of 4 (ideally 1.0 mg/L at a contact time of 4 minutes). The data for this condition failed to demonstrate a linear correlation of higher CT's and reduced HPC concentrations. This discrepancy is likely due to variabilities in plant operation, sample collection and analyses.

Hence, though the general robustness of the chlorination process was demonstrated, additional analyses on the full-scale plant effluent are warranted.

Figure 5.55 Chlorination study results for varying CT values.



5.7.6 Ultraviolet Reactor Study

As part of the continuing assessment of the surface water treatment equipment after the FBR system, the Trojan UV low intensity lamp disinfection system was installed. A number of UV studies were conducted on the effluent from the Trimite multimedia filter and the LGAC.

In the first part of the study, the effluent water from the Trimite multimedia filter was fed directly into the UV system at 15 gpm (8.1 second residence time), 20 gpm (6.08 second residence time), and 25 gpm (4.86 second residence time) under steady state operating conditions, before a Trimite multimedia filter backwash, and after a Trimite multimedia filter backwash (Figure 5.56). At first glance, based on heterotrophic plate counts for the steady-state operating period, a trend appears that shows higher levels of HPC at the effluent of the UV reactor with decreasing residence time. However, due to variabilities in the feed HPC measurements, the percentage removal of HPC actually increases with decreasing residence time (greater than 99%). Under all scenarios, a log 2+ removal of HPC is observed with the greatest reduction seen at the 4.86 residence time (11,000 cfu/mL to 32 cfu/mL). After the backwash of the Trimite multimedia filter occurred, when the filter was not ripened and bacteria could pass into the Trimite multimedia filter effluent, a log 3+ HPC removal was observed at a UV residence time of 6.08 seconds. Total coliform numbers (MPN/100 ml) across the UV were completely removed, regardless of the feed concentration (highest observed level of 43 MPN/100 ml), plant operating condition (steady-state, pre- or post filter backwash), or UV residence time. Based on the data observed from this study, whether operating during steady-state or before/after a backwash scenario, a 6.08 second residence time is recommended for a larger full-scale installation.

In the second part of the study, water was fed from the Trimite multimedia filter to the LGAC unit, then to the UV reactor (Figure 5.57). In this configuration, HPC values were significantly lower than those observed from the Trimite multimedia filter. Hence, only a log 2+ removal could be demonstrated, regardless of UV residence time.

Figure 5.56 UV disinfection after the Trimite filter under different plant and UV operating conditions.

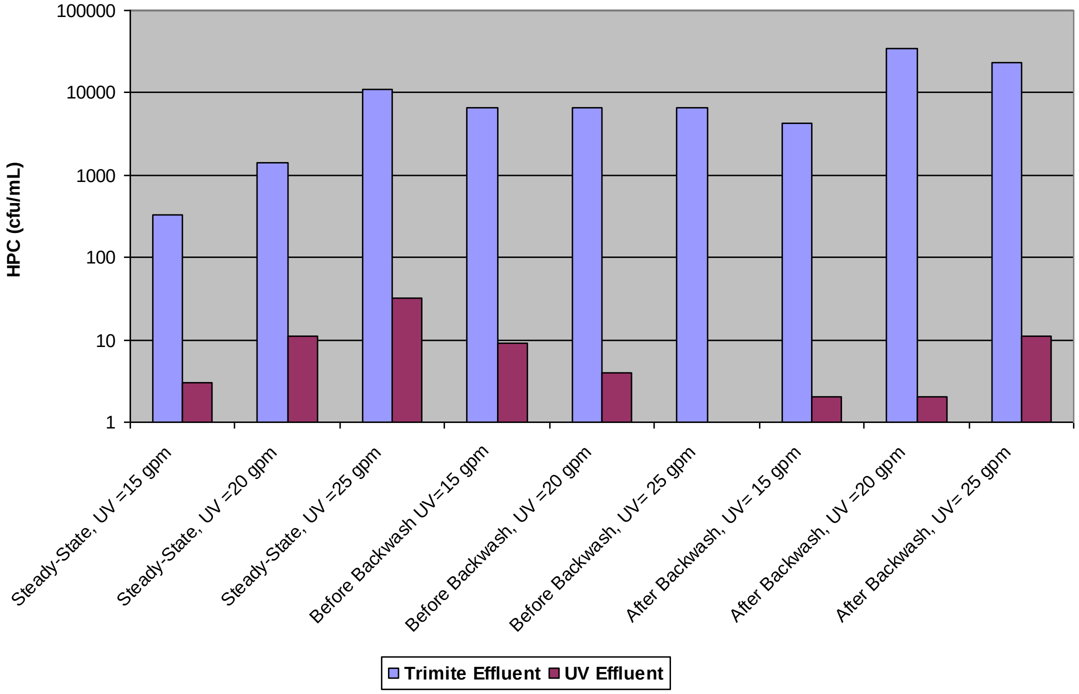
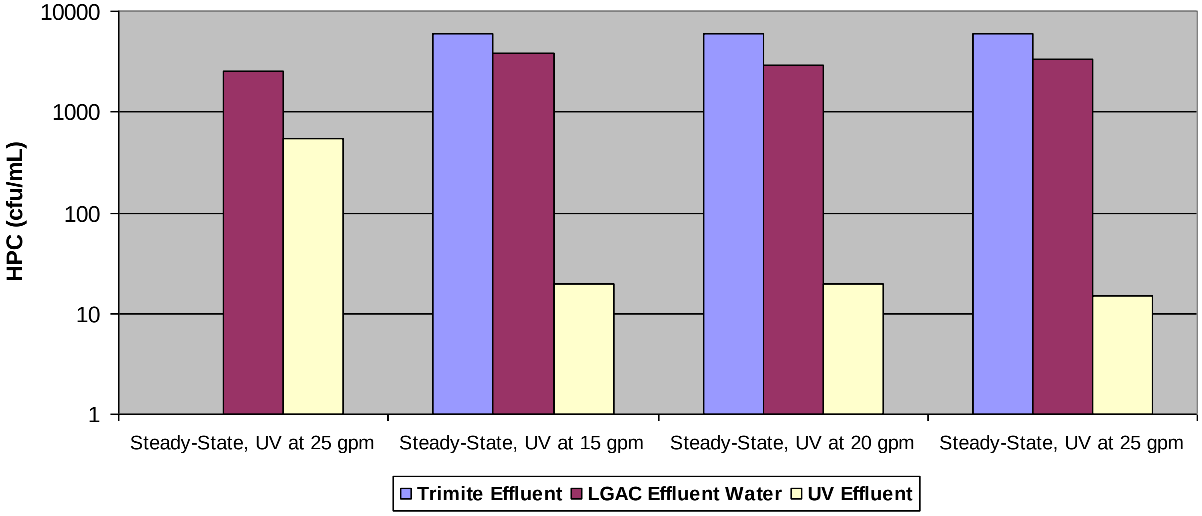


Figure 5.57 UV disinfection after LGAC filter under different UV operating conditions.



5.7.7 Spiking Study

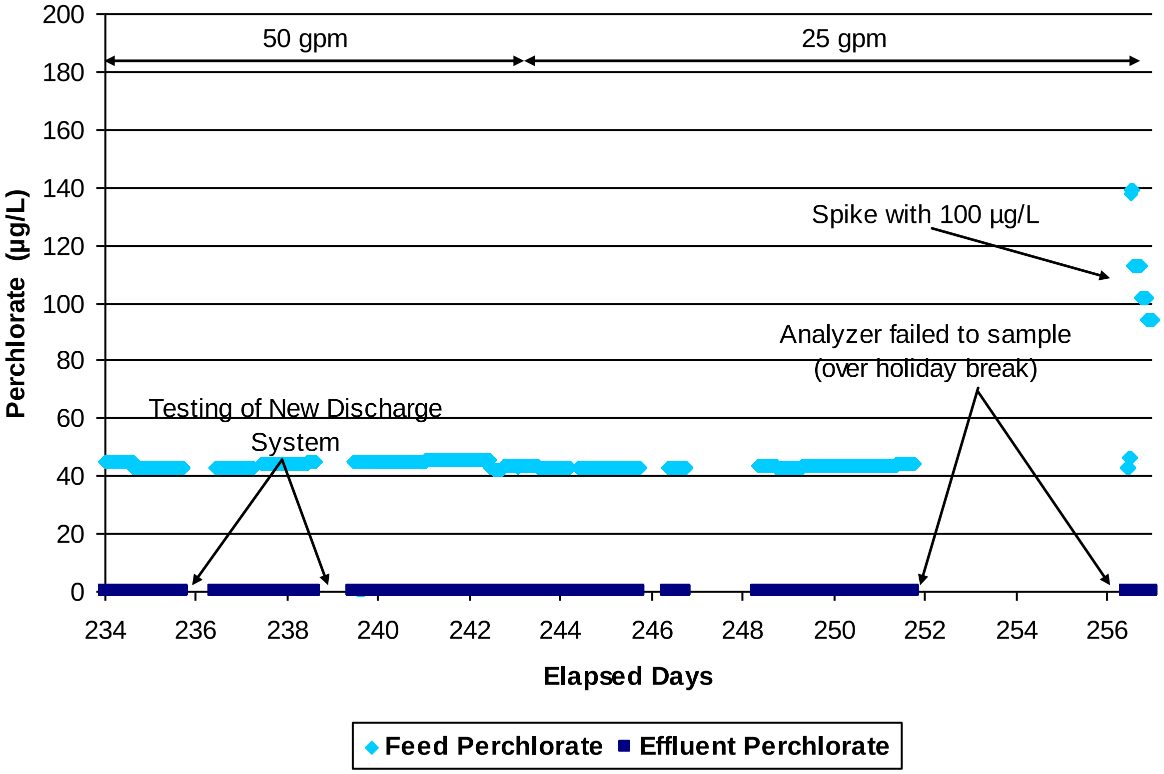
Graphs of the perchlorate and nitrate-N on-line analysis during the spiking experiment are presented (Figures 5.58-5.63). The complete perchlorate spiking system was operated for three weeks (without perchlorate addition) to ensure that all systems under all operating configurations worked properly (Days 236-253). Once these systems were checked out, perchlorate was spiked into the FBR system at concentrations of 100 µg/L, 500 µg/L, and 1,000 µg/L (Figures 5.58-5.60). Each spiking experiment lasted approximately five days. Some conditions were repeated. For the 100 µg/L and 500 µg/L, non-detect values were reached by the end of the five day operating period. For the 1,000 µg/L concentration, the FBR effluent water gradually decreased over the course of the five days to less than 6 µg/L. The 50% acetic acid dosing was 18 mg/L as Carbon.

Over the course of a month (Days 299-335), the perchlorate feed concentrations were ramped up from 1,000 µg/L to 4,000 µg/L (Figures 5.61 and 5.62). A definitive trend with perchlorate removal over time at higher feed concentrations was observed for spiked perchlorate concentrations over 1,000 µg/L. At perchlorate concentrations up to 2,000 µg/L (Days 313-321), as the biomass in the FBR matured and acclimated, a declining trend of effluent perchlorate concentration was observed (Figure 5.64). The 50% acetic acid dosing was increased to 19.3 mg/L as Carbon. A zero-order to first-order removal kinetic regime dominated. The spiking experiments were conducted for short periods of time (days to weeks) and a true steady-state operating condition was not reached. Hence, the microbiology within the system was still developing under these spiking conditions and perchlorate removal appears only to be a function of a temporary reaction limitation due to lack of biomass development. When the feed perchlorate concentration was reduced from 2,000 µg/L to 1,000 µg/L (Days 327-329), a distinct pattern of complete perchlorate removal was observed (Figures 5.65). The downstream filtration equipment also continued to produce consistent effluent water characteristics that met all of the Title 22 MCL requirements regardless of the perchlorate feed spiking concentration (Table 5.14).

Minimal increase in the adsorption clarifier and mixed media backwash frequency of the Trimite multimedia filter was observed regardless of the spiking condition.

A gradual increase in perchlorate concentration in the feed water occurred again from Days 329-335 (Figure 5.66). Once the biomass started to acclimate and accrue within the system, perchlorate performance continued to improve. At perchlorate concentrations spiked to 4,000 µg/L, with 50% acetic acid dosed up to 23.8 mg/L as Carbon, the rate of removal was near first-order and greater than 99.6% removal. The elimination capacity of the FBR system was calculated to be 9.6 g ClO_4/m^3 media/hr and 14.6 g NO_3-N/m^3 media/hr. If longer, uninterrupted operation of the spiking study could have been conducted, complete treatment of the perchlorate at concentrations as high as 4,000 µg/L to non-detect values presumably could have been demonstrated.

Figure 5.58 Perchlorate and nitrate on-site analytical results (Days 234-256).



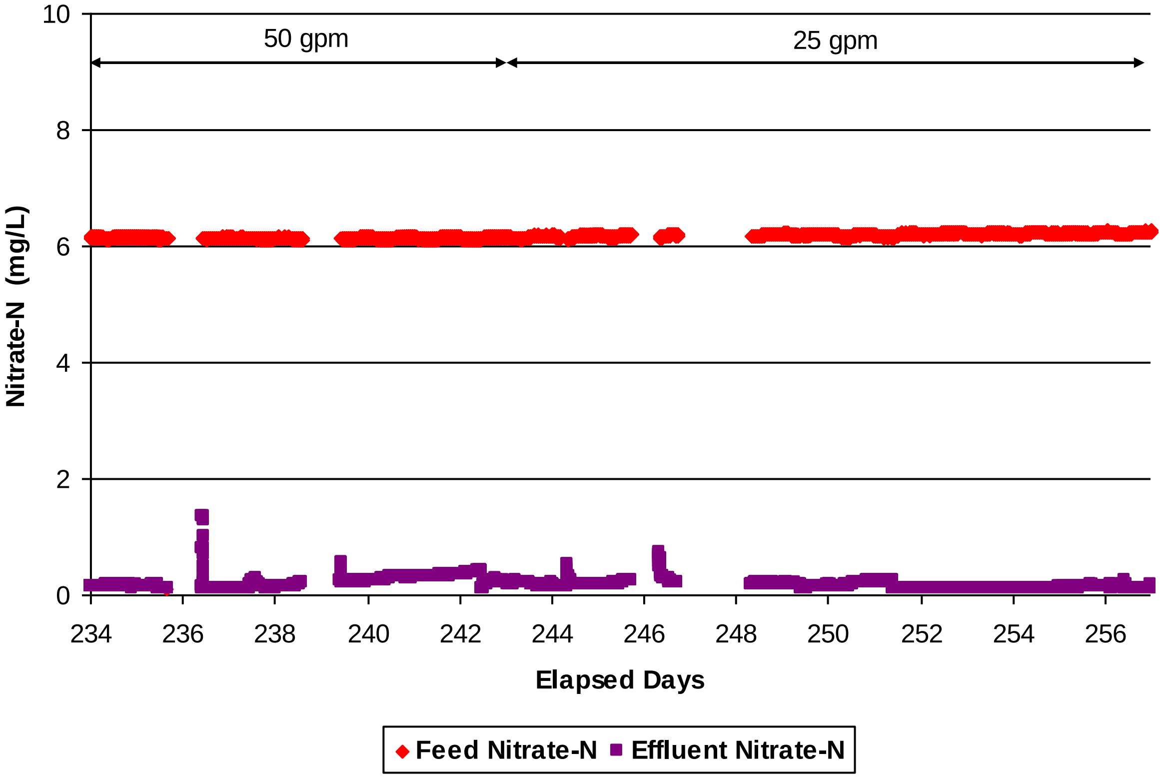
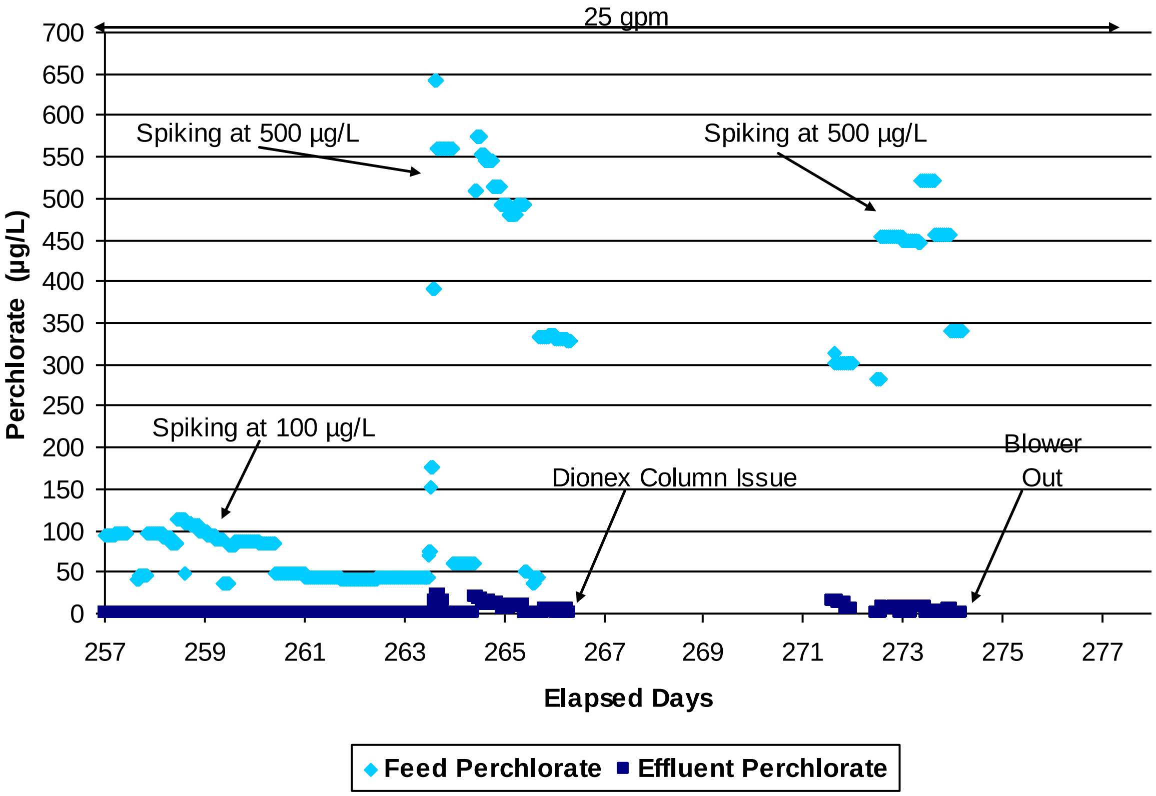


Figure 5.59 Perchlorate and nitrate on-site analytical results (Days 257-277).



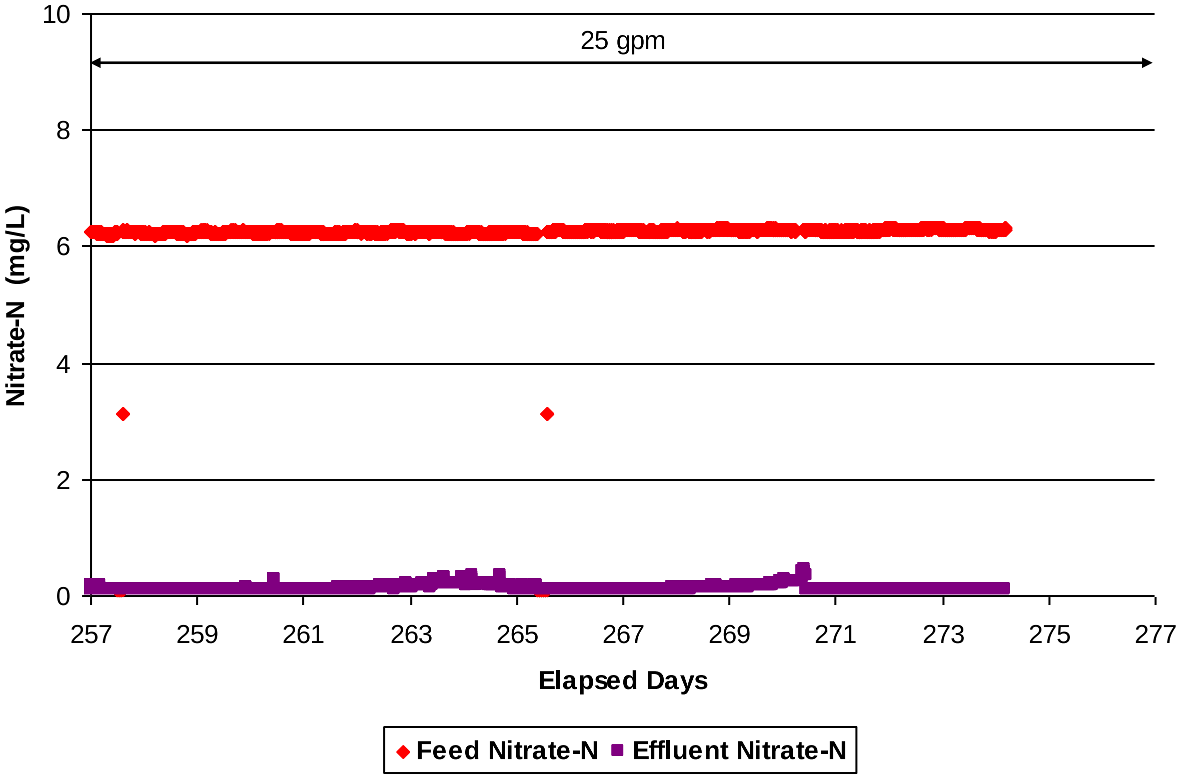


Figure 5.60 Perchlorate and nitrate on-site analytical results (Days 277-299).

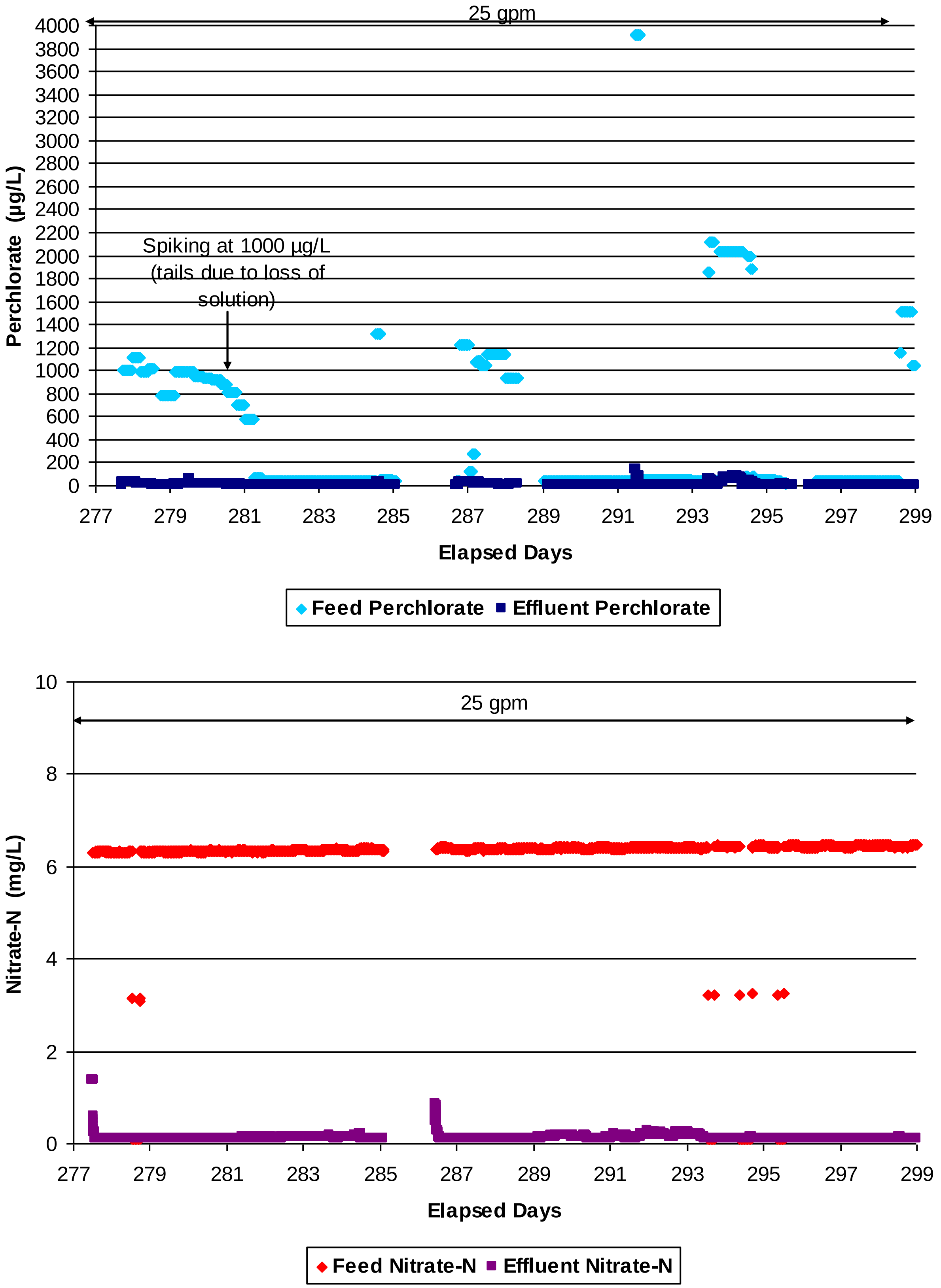
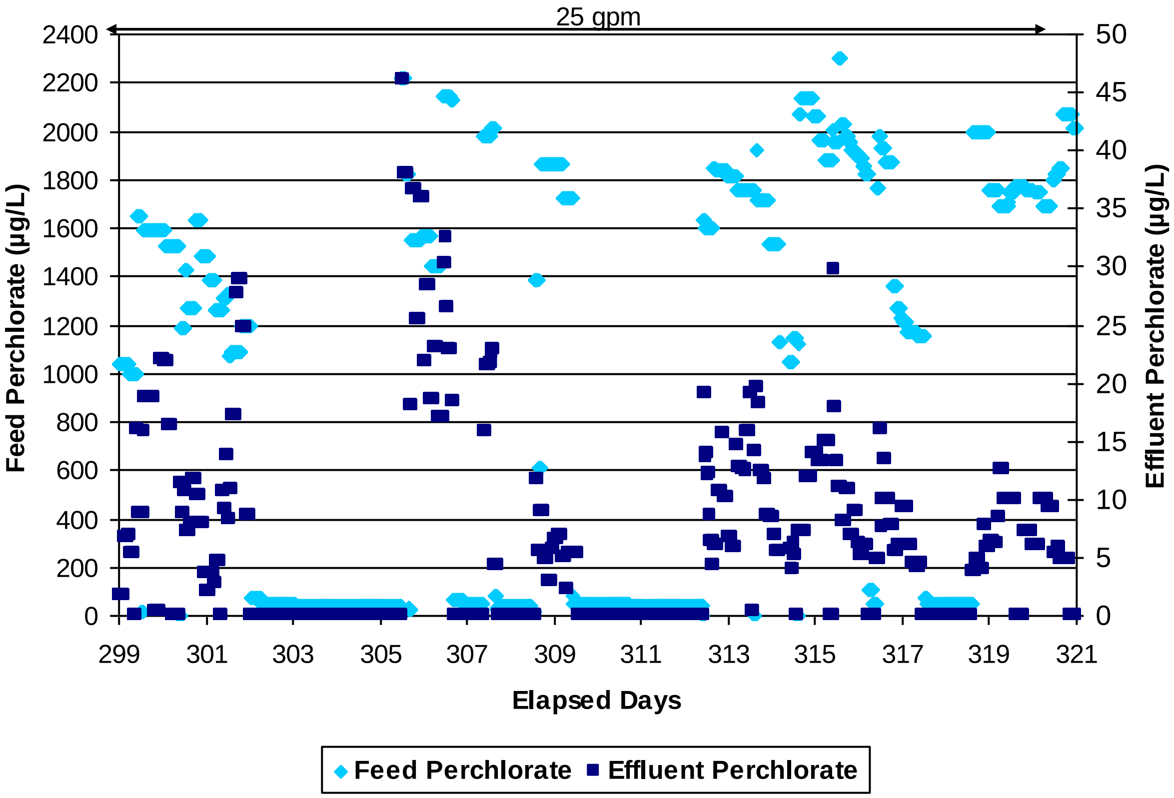


Figure 5.61 Perchlorate and nitrate on-site analytical results (Days 299-321).



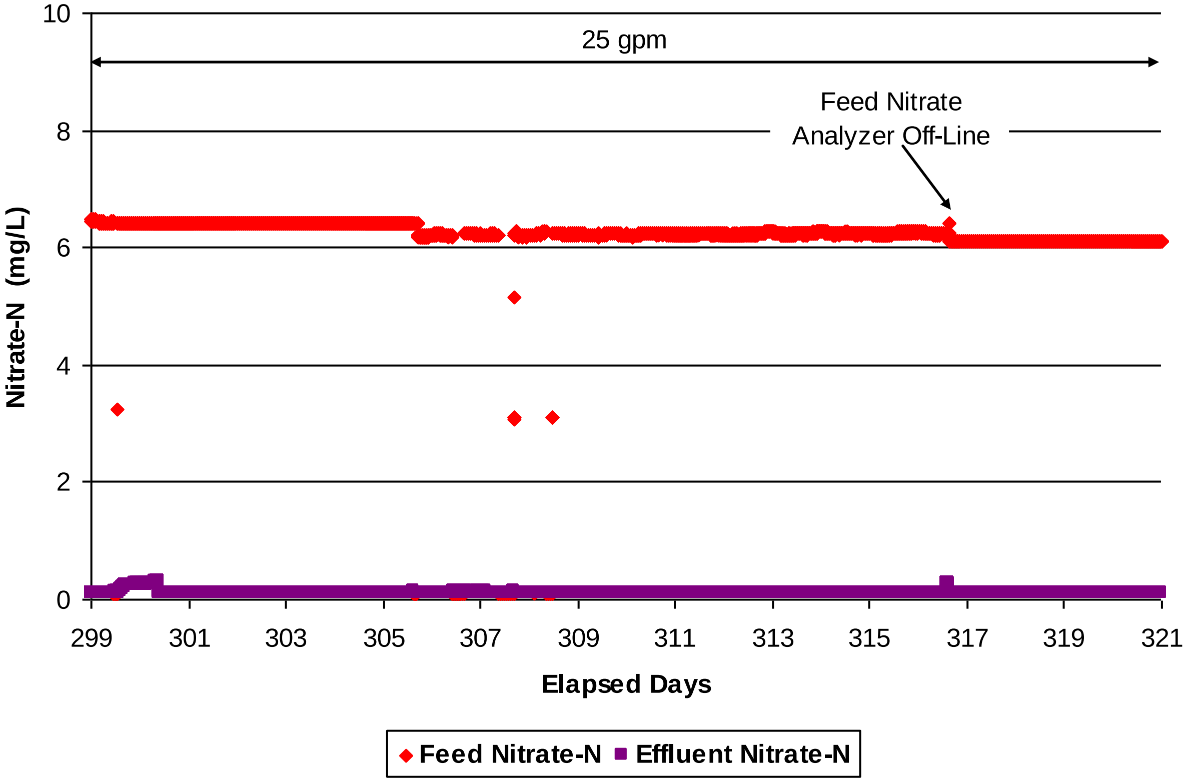
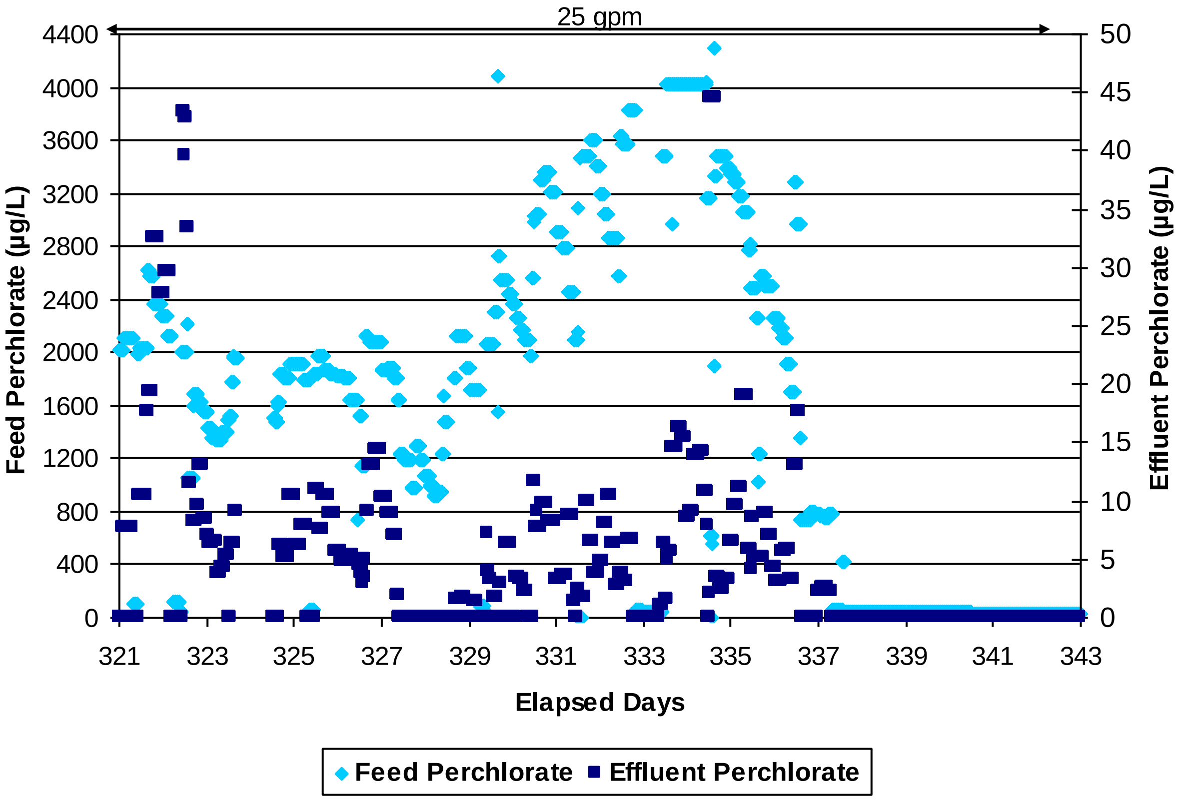


Figure 5.62 Perchlorate and nitrate on-site analytical results (Days 321-343).



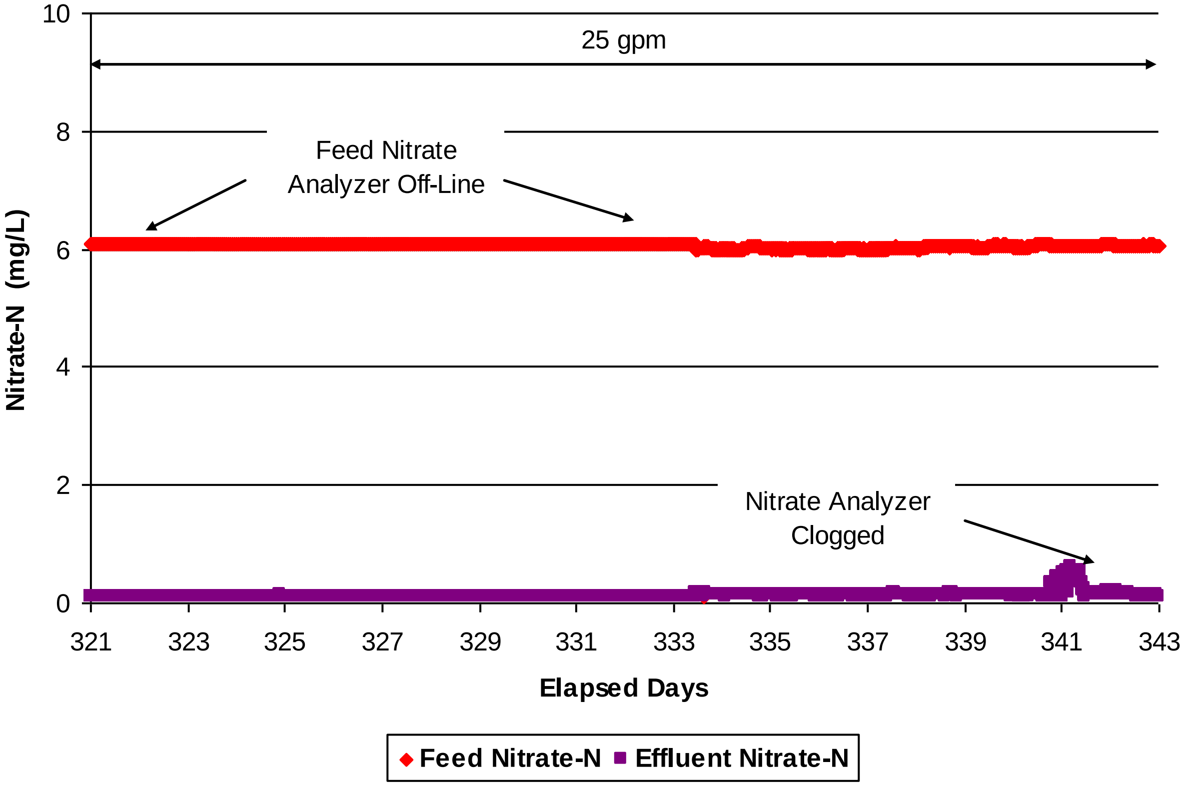
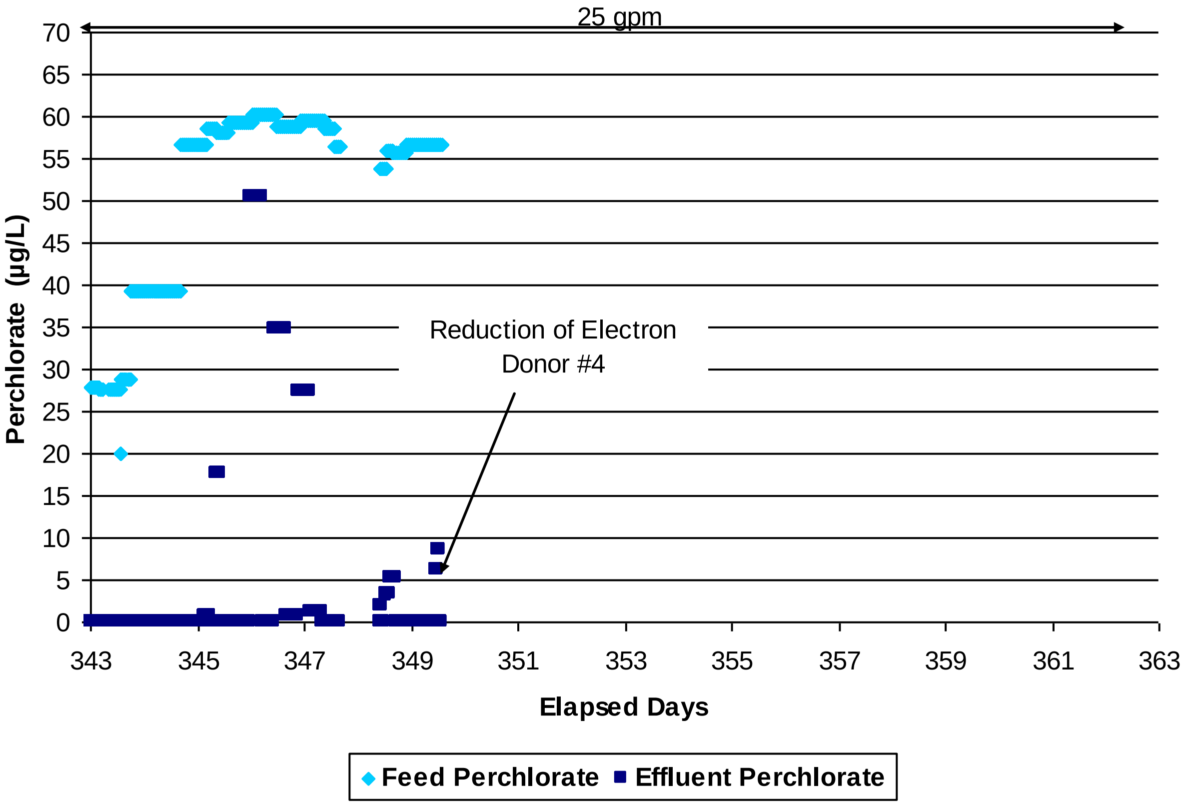


Figure 5.63 Perchlorate and nitrate on-site analytical results (Days 343-363).



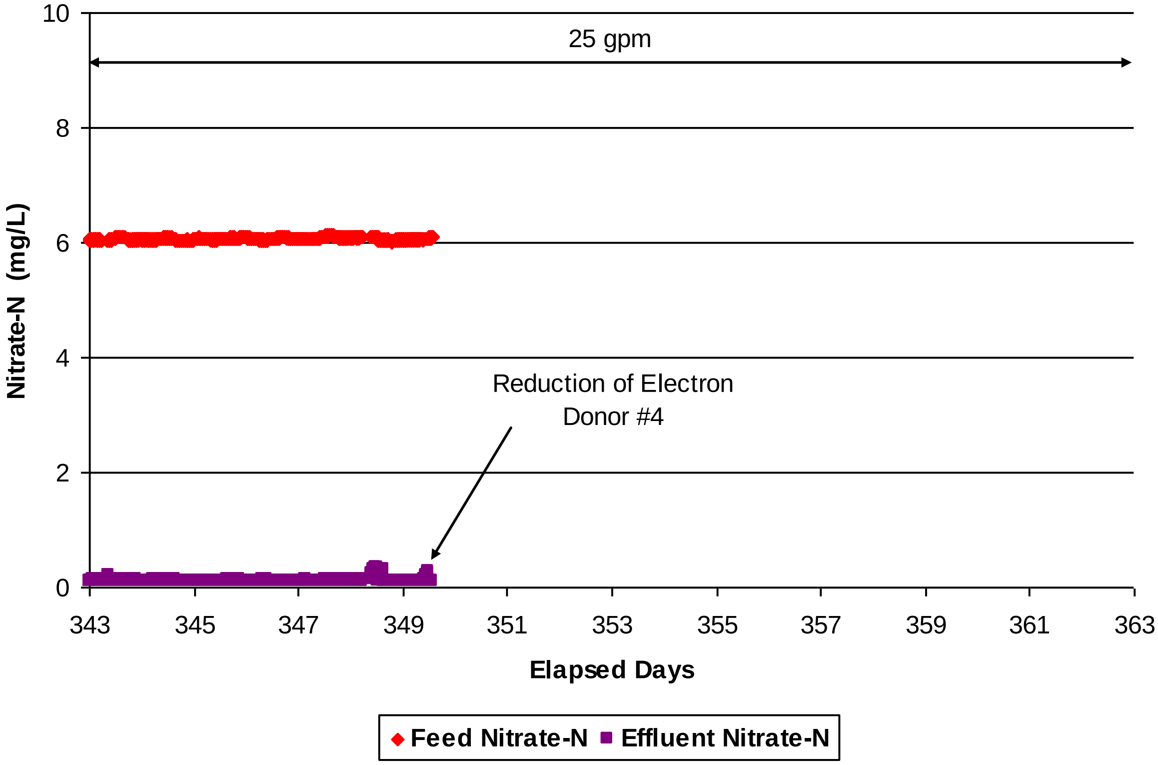


Figure 5.64 Spiked perchlorate concentrations to 2,000 µg/L showing a general improvement in performance over time as the microbial population acclimates.

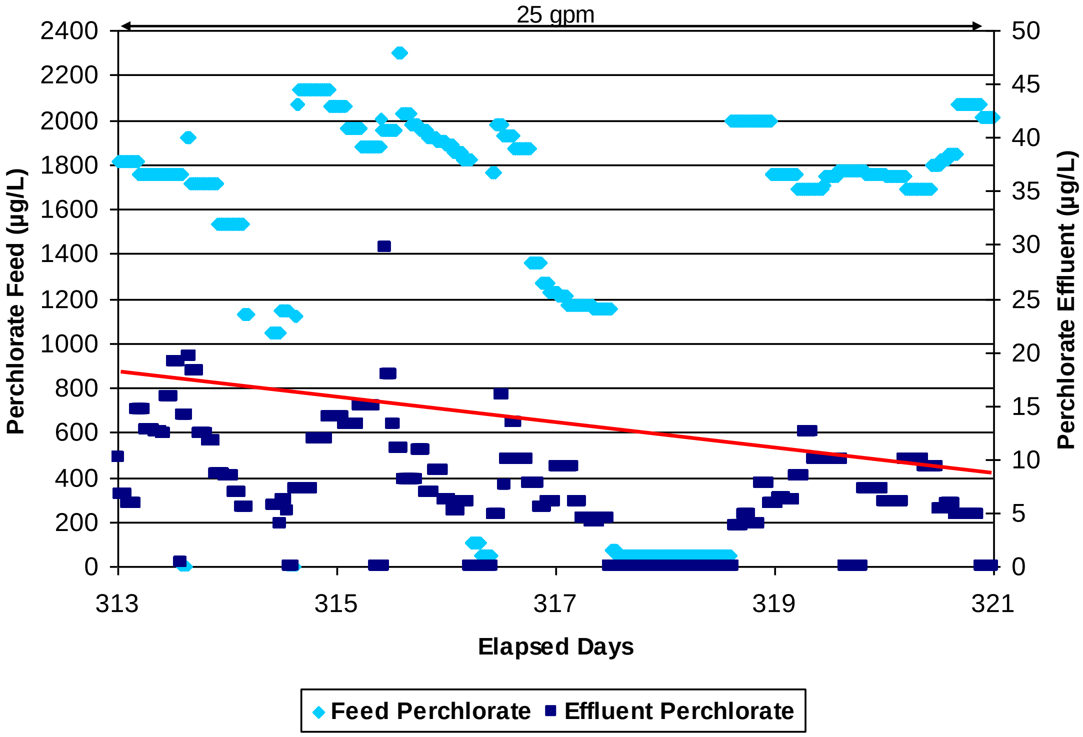


Figure 5.65 From Day 327 to Day 329, with the feed perchlorate concentration at 1,000 µg/L.

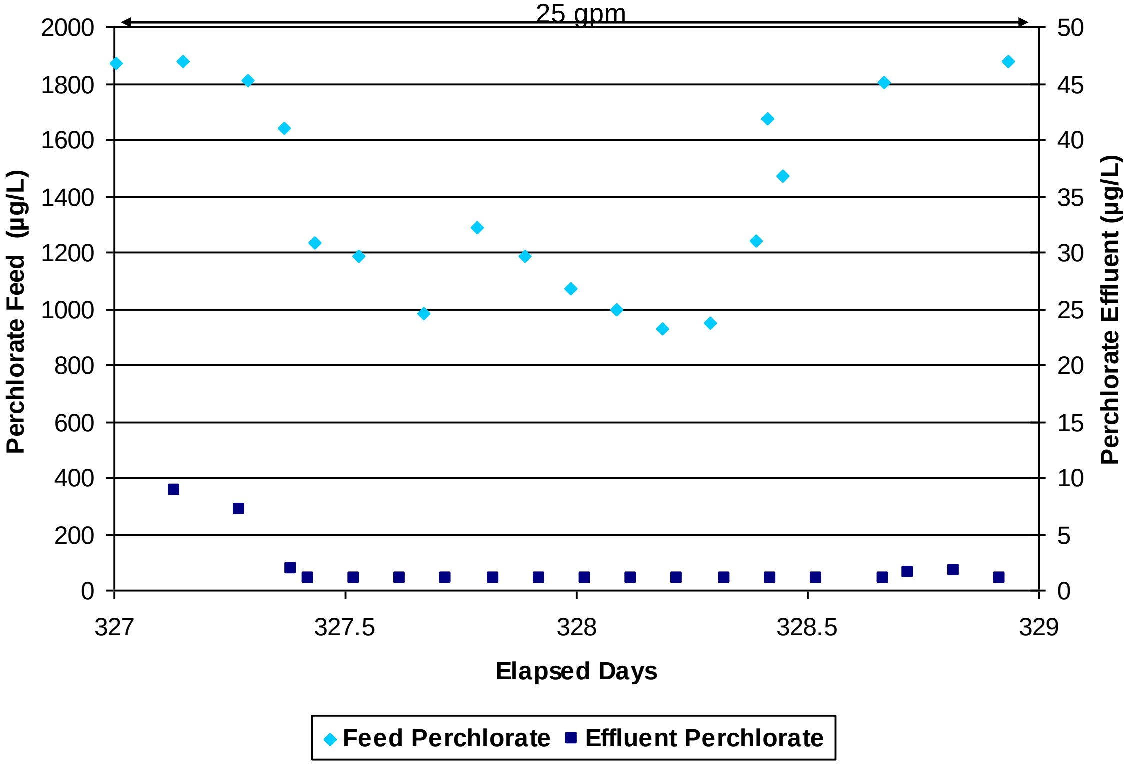


Figure 5.66 Ramp up of perchlorate from 1,000 to 4,000 µg/L.

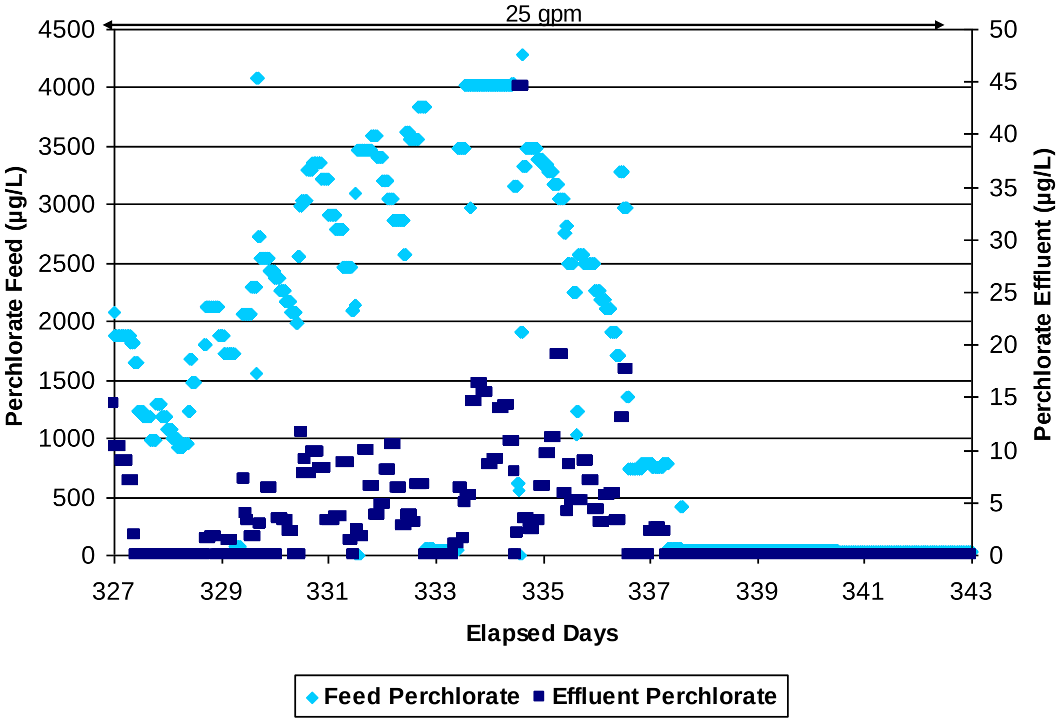


Table 5.14 Trimite multimedia filter effluent water quality at differing perchlorate concentrations.

Spiking Condition	**Perchlorate (1,000 µg/L)**	**Perchlorate (1,000 µg/L)**	**Perchlorate (2,000 µg/L)**	**Perchlorate (2,500 µg/L)**	
Days Elapsed	**301**	**327**	**329**	**335**	
Metals					**Calif. Limit**
Aluminum (mg/L)	0.064	0.056	0.062	0.076	**0.2**
Antimony (mg/L)	<0.006	<0.006	<0.006	<0.006	**0.006**
Arsenic (mg/L)	<0.002	<0.002	<0.002	<0.002	**0.01**
Barium (mg/L)	<0.1	<0.1	<0.1	<0.1	**1**
Beryllium (mg/L)	<0.001	<0.001	<0.001	<0.001	**0.004**
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001	**0.005**
Chromium (mg/L)	0.0033	0.003	0.0019	0.0024	**0.05**
Copper (mg/L)	<0.05	<0.05	<0.05	<0.05	**1**
Cyanide (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	**0.15**
Iron (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	**0.3**
Lead (mg/L)	<0.005	<0.005	<0.005	<0.005	**0.015**
Manganese (mg/L)	<0.02	<0.02	<0.02	<0.02	**0.05**
Mercury (µg/L)	<0.001	<0.001	<0.001	<0.001	**0.002**
Nickel (mg/L)	<0.01	<0.01	<0.01	<0.01	**0.1**
Selenium (mg/L)	<0.005	<0.005	<0.005	<0.005	**0.05**
Silver (mg/L)	<0.01	<0.01	<0.01	<0.01	**0.1**
Thallium (mg/L)	<0.001	<0.001	<0.001	<0.001	**0.002**
Zinc (mg/L)	<0.05	<0.05	<0.05	<0.05	**5**
Other Inorganics					
Carbonate (mg/L)	< 3.0	< 3.0	< 3.0	< 3.0	
Bicarbonate (mg/L)	220	210	220	210	
Hydroxide Alkalinity(mg/L)	< 3.0	< 3.0	< 3.0	< 3.0	
Total Hardness (mg/L)	200	190	200	200	
Calcium (mg/L)	61	60	61	61	
Chloride (mg/L)	16	16	16	16	
Fluoride (mg/L)	0.3	0.3	0.3	0.3	
Magnesium (mg/L)	10	10	10	11	
MBAS (mg/L)	<0.05	<0.05	<0.05	<0.05	**0.5**
Nitrate (mg/L)	<1.0	<1.0	<1.0	<1.0	**45**
Nitrite (mg/L as N)	< 0.1	< 0.1	< 0.1	< 0.1	**1**
Potassium (mg/L)	2.4	2.4	2.5	2.7	
Sodium (mg/L)	12	12	12	12	
Sulfate (mg/L)	17	17	16	17	**<250**
Total Cations (me/L)	4.5	4.5	4.5	4.5	
Total Alkalinity (mg/L)	180	170	180	180	
Total Anions (mg/L)	4.42	4.22	4.4	4.42	

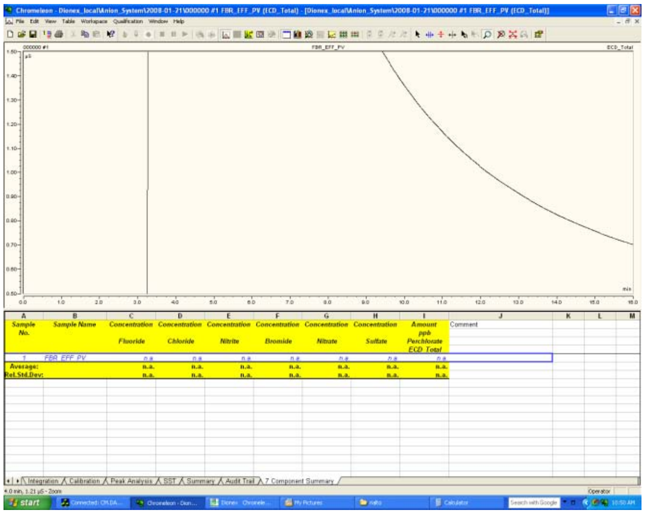
Table 5.14 (continued) Trimite multimedia filter effluent water quality at differing perchlorate concentrations.

Spiking Condition	**Perchlorate (1,000 µg/L)**	**Perchlorate (1,000 µg/L)**	**Perchlorate (2,000 µg/L)**	**Perchlorate (2,500 µg/L)**	
Days Elapsed	**301**	**327**	**329**	**335**	
General Physical					**Calif. Limit**
Aggressive Index	12.2	12.1	12.2	12.2	
Color (CPU)	< 3.0	< 3.0	< 3.0	< 3.0	**15 units**
Langlier Index at 25 C	0.35	0.26	0.32	0.32	
Odor (TON)	<1.0	<1.0	<1.0	<1.0	**3 units**
pH	7.7	7.7	7.7	7.7	
Specific Conductance (µmhos/cm)	410	420	420	430	**<900**
TDS (mg/L)	230	290	300	280	**<500**
Temperature (degrees C)		25	25	25	
Turbidity (NTU)	<0.2	<0.2	<0.2	<0.2	**<0.3**
Organics					
VOCs (µg/L)	ND		ND		

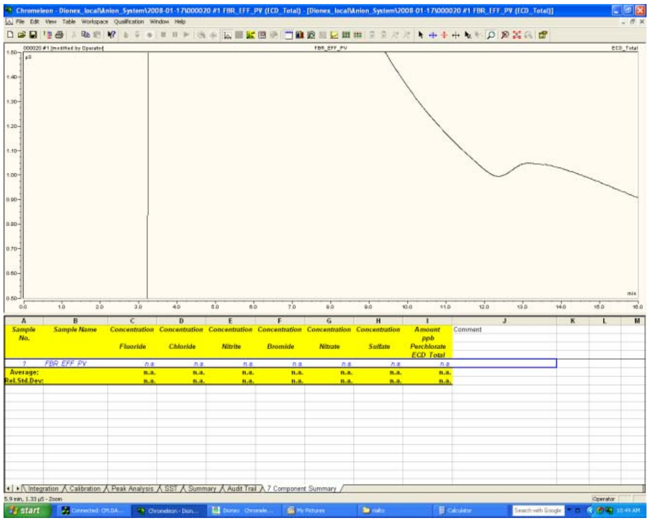
Initially, the FBR plant was to be spiked with concentrations of perchlorate up to 10,000 µg/L. Due to the logistical need of placing all the effluent water into holding tanks (to ensure perchlorate treatment has occurred) before releasing to the catch basin, the possibility of operating at such high perchlorate concentrations was not feasible. Based on past experience with other operating FBR plants, the perchlorate load on a typical system is ramped up over time to allow for adequate microbial growth. For this system, the experiment is limited by the duration of each experiment (five to fourteen days), a required feed flowrate, and the holding capacity of the tanks. The feed flow had to be at least 25 gpm, or else process issues occurred through the downstream Trimite multimedia filter. Since a minimum flow was required, as the perchlorate concentration increased, so did the load. At the higher concentrations, more time was needed by the microbial population to adjust to the higher loads. Unfortunately, the holding tanks filled up before complete treatment could be demonstrated. Thus, the water from the holding tank had to be recycled to the front of the plant. Subsequently, the loading was significantly reduced and the system subjected to cyclical higher and lower loadings. Such a cyclical event was not conducive to adequate, effective microbial growth. Hence, feed perchlorate concentrations greater than 4,000 µg/L could not be effectively demonstrated.

Over the course of the spiking experiment, for the effluent water of the FBR only, the on-line DIONEX DX-800 perchlorate analyzer continually demonstrated a secondary baseline peak that eluted out at the same time as the perchlorate peak (Figure 5.67). Typically, this only occurred for higher perchlorate concentrations (greater than 500 µg/L) when larger loads of feed TOC (acetic acid) were introduced to the FBR system. This secondary peak was speculated by the instrument manufacturer to be a fatty acid, developed as a by-product of the oxidation/reduction treatment process of the feed acetic acid and perchlorate. Attempts were made to change the operating characteristics of the on-line perchlorate analyzer so that the baseline secondary peak could be eluted out before/after the perchlorate peak. With limited time in the field, such a remedy could not be determined. A set of samples were sent to an outside laboratory to observe/identify the secondary peak. A number of testing conditions were conducted, including operating the instrument at a higher KOH eluent concentration (up to 100 mM), providing an anion prefilter trap column, and operating the analyzer instrument using a gradient eluent KOH program. The secondary peak was still observed under all conditions, but appeared prior to the perchlorate peak (unlike demonstrated in the field). This observation indicated that additional refinement in the field DIONEX DX-800 operating program is required for higher perchlorate feed concentrations. The only additives to the FBR influent are phosphoric acid, acetic acid, and perchlorate. In the laboratory, it was determined that the secondary peak was not excess phosphate or a degradation product of perchlorate (chlorate/chlorite). After further investigation, a determination of the peak could not be made. In the field, the secondary peak did not obscure the perchlorate peak. However, a change in the baseline caused by the secondary peak made it difficult for the instrument to automatically integrate the perchlorate peak. Hence, for some samples, the Field Engineer had to manually integrate the peak to obtain an accurate effluent perchlorate concentration value. At the full-scale level, when perchlorate concentrations are high, a dilution program will likely need to be instituted via the PLC and the on-line perchlorate analyzer to remove the secondary baseline peak. In addition, the manufacturer will need to provide more resources to investigate this issue and provide guidance on modifying the analytical instrument operating program.

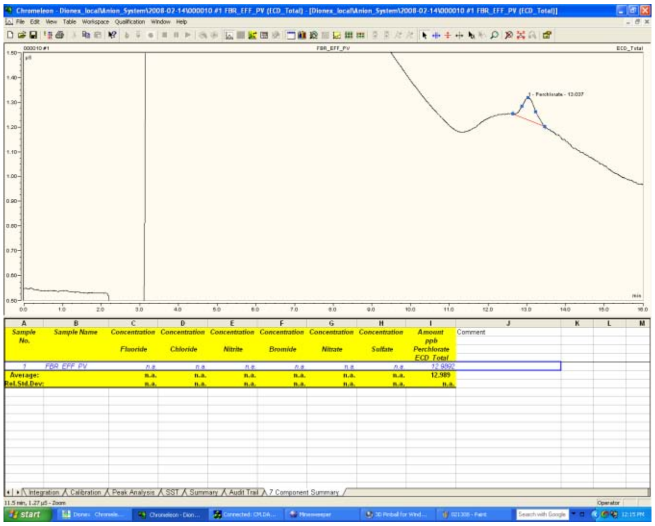
Figure 5.67 Effluent perchlorate analyzer chromatograms showing no secondary peak/baseline, a secondary peak/baseline, and a secondary peak/baseline and perchlorate peak.



Sample No.	Sample Name	Concentration Fluoride	Concentration Chloride	Concentration Nitrite	Concentration Bromide	Concentration Nitrate	Concentration Sulfate	Amount ppb Perchlorate ECD_Total	Comment
1	FBR_EFF_PV	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Average:		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Rel.Std.Dev:		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	



Sample No.	Sample Name	Concentration Fluoride	Concentration Chloride	Concentration Nitrite	Concentration Bromide	Concentration Nitrate	Concentration Sulfate	Amount ppb Perchlorate ECD_Total	Comment
1	FBR_EFF_PV	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Average:		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Rel.Std.Dev:		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	



Sample No.	Sample Name	Concentration Fluoride	Concentration Chloride	Concentration Nitrite	Concentration Bromide	Concentration Nitrate	Concentration Sulfate	Amount ppb Perchlorate ECD_Total	Comment
1	FBR_EFF_PV	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.9892	
Average:		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.989	
Rel.Std.Dev:		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	

6.0 Performance Assessment

The performance of the system during the demonstration included both qualitative and quantitative objectives as described in Section 3.0 and Table 3.1. Each of these objectives is assessed in this section and supported by the Sample Results provided in Section 5.7

6.1 Qualitative Objectives

6.1.1 Ability to Treat Multiple Contaminants

During the project, the average system feed chemical concentrations were nitrate-nitrogen at 6.1 mg/L, oxygen at 8.1 mg/L, and perchlorate at approximately 53 µg/L. Based on these feed concentrations, the FBR treatment system was capable of removing all three chemical constituents at or below the instrument detection levels (See Figures 5.26-5.27, 5.33-5.43, and 5.58-5.63). When the system was spiked with perchlorate up to 1,000 µg/L, the perchlorate was treated to below the State MCL of 6 µg/L. At perchlorate spiked concentrations above 1,000 µg/L, the nitrate and oxygen were still completely removed. Above 1000 µg/L of perchlorate, FBR effluent concentrations began to exceed the State of California MCL. At concentrations approaching 3,600 µg/L of perchlorate, less than 20 µg/L of perchlorate was observed at the FBR effluent. Over time, as the perchlorate concentration was spiked at approximately 2,000 µg/L, a noticeable declining trend in FBR effluent perchlorate concentration was observed (Figure 5.64). This declining trend is evidence of the acclimation of the biomass to the higher perchlorate concentrations. Even for the short time that the spiking study experiment was conducted and the difficulties encountered in consistently achieving steady-state loading while spiking 25 gpm with perchlorate, the FBR system continued to respond with nearly complete treatment of the perchlorate at the higher spiking concentrations. If the spiking study could have been conducted longer under ideal spiking conditions (i.e., no loss of prime of the spiking pump), the data trends for higher spiking concentrations up to 4,000 µg/L suggest that the effluent perchlorate concentration would have decreased below the MCL.

6.1.2 Effectiveness of Self-inoculation Procedure

The FBR was naturally inoculated with only the incoming contaminated groundwater. No outside inoculum was provided to the FBR system. Non-detect nitrate and perchlorate values in the FBR effluent water (Figures 5.33-5.43), coupled with visual observation of microbial growth within the FBR and microbial expansion of the FBR bed (Figure 5.24), were an indication that the self-inoculation procedure was successful. Within 28 days of system start-up, complete nitrate and perchlorate treatment were observed (Figure 5.33).

6.1.3 Ease of Operation

A daily monitoring report was completed and any modifications to the system were tabulated (Appendices F and H). These reports detail daily operating issues that were encountered in operating the plant. However, the focus of this study was to primarily demonstrate the overall effectiveness of the FBR treatment system in treating nitrate and perchlorate. During the course of this demonstration, multiple experiments were conducted to demonstrate the efficacy of the technology. Hence, many of the system requirements and generated issues were specific for this demonstration and are not directly applicable to a full-scale operating system.

The demonstration plant required an initial troubleshooting period that is typical for any drinking water plant during start-up. During this time (typically 2-4 months), additional manpower and support is required to assess and troubleshoot electrical, mechanical, and process issues. Once these issues were resolved, one full-time operator (5 days a week, 8 hours per day) was required to manage the daily operation of the system and conduct all of the scientific experiments. If such experiments were not required, the level of manpower could be reduced at least 50%. In addition, the operator attention required substantially declined over the course of the demonstration as the system reliability increased.

The overall uptime of the plant for the first year of operation was 94% and indicative of the ease of operation and maintenance required. The major mechanical problems that occurred during the year of operation involved a blower malfunction in the post-aerator and a blower malfunction on the Trimite multimedia filter. For each of these incidents, within three days, the issues were quickly resolved with a repair kit and a replacement blower. Additional shutdowns of the system occurred due to random electrical outages in Southern California. However, overall, the system required care to prevent shutdowns was minimal.

Additional time was required by the operator to address issues which did not shut the plant down, but did regularly affect performance in some way. Periodic clean-out of the perchlorate analyzer effluent filter was required. Depending on the number of samples analyzed daily by the perchlorate analyzer, the frequency of the filter clean-out could be daily (with 24 samples analyzed per day) to twice weekly (with 8-12 samples per day). This task was conducted in less than 15 minutes. The effluent nitrate analyzer also required weekly cleaning to ensure accurate readings. On a few occasions, it was required to return the nitrate analyzers to the manufacturer for factory calibration. During this time, a back-up analyzer was utilized. Weekly checks of the electron donor pump were required to ensure accurate rates of addition of acetic acid. This check required less than 10 minutes using a calibration column. Finally, daily checks of all instruments, gauges, and some basic water chemistry occurred that required less than one hour per day. In general, these daily checks could be conducted less frequently at the full-scale level.

This demonstration study highlighted the robustness of the design of the FBR treatment system. Minimal shut-downs occurred and limited operator attention was required. Future minor design changes for the full-scale were noted that can further minimize operator attention required and the increase the ease of use of the technology. These design changes are highlighted in Section 8.3 Lessons Learned.

6.1.4 Effects of System Shutdown and Restart

During the course of the study, the FBR treatment system was demonstrated to effectively and quickly recover from a variety of shutdown scenarios. In one case (repeated twice), a simulated feed pump failure was tested. For the second case (repeated twice), a complete plant electrical failure scenario was demonstrated by shutting the system completely down. For the third case, a nutrient pump failure was simulated. The general trend observed for the shutdown scenarios was that the longer the plant operated and a mature biomass developed, a more rapid recovery time resulted.

The feed interruption experiments were conducted after 37 and 65 days of operation. Subsequently, the recovery times for each experiment were less than 24 hours and 8 hours (Figures 5.35 and 5.36). On Days 84 and 134, the plant electrical shutdown scenarios were conducted (Figures 5.37 and 5.39). With a longer duration of plant operation and the development of more robust denitrifier and perchlorate degrading population, short recovery times of less than 2 hours for nitrate treatment (perchlorate was never observed in the effluent) were observed after both experiments. Some degree of adsorption and biodegradation contributed to the treatment of both the nitrate and perchlorate (See Section 5.7.3.2 for further details).

The nutrient interruption experiment was conducted on Day 127 (Figure 5.39). Initial breakthrough of perchlorate was observed within 12 hours. Once the phosphoric acid was restarted, complete nitrate and perchlorate removal occurred within four hours. It is evident from this experiment that a correlation exists between phosphorus requirements and nitrate/perchlorate removal rates. The results of this study indicate that it is critical to the operation of the FBR treatment plant that a consistent phosphorus source be provided to ensure perchlorate removal. To accomplish this, a two pump in series system is recommended at the full-scale level. One pump will serve as the primary delivery mechanism for phosphoric acid addition. The secondary pump will serve as an automatic back-up pump in the event that the primary pump loses prime or malfunctions. When the secondary pump is activated, an alarm can be triggered such that the primary pump fault can be investigated. Based on the results demonstrated, even if the secondary pump fails and the alarm fails, up to 12 hours of stored phosphorus in the FBR bed is available for perchlorate treatment.

6.1.5 On-Line Analyzer Effectiveness

The use of on-line instrumentation to measure nitrate-nitrogen and perchlorate simultaneously at the feed and effluent of the FBR system was effectively performed. Both on-line analyzers met their objective of providing reliable, consistent data. A number of issues were seen throughout the course of the demonstration with both types of on-line analyzers. For the perchlorate analyzer, matrix interference at higher feed concentrations occurred, differing instrument operating characteristics resulted in differences between on-line and off-site laboratory perchlorate measurements, and guard and analytical column replacement were required. For the nitrate analyzers, these issues included solids interference with parameter measurement, mechanical and process issues, and recalibration issues.

6.1.5.1 Dionex Analyzer

For the Dionex perchlorate analyzer, the instrument was robust in the field. However, certain precautions were warranted. The sampling filtration system consisted of a fine Teflon 0.2 micron filter that worked effectively to protect the internal components of the Dionex IC system. The filters required daily cleaning when sample acquisition was as high as twelve samples per day. For a full-scale system, the use of a roughing filter prior to the sampling filtration system is suggested, and could provide adequate protection to extend the life of the fine filter.

The on-line perchlorate analyzer ion analytical column failed on Day 266. The column lasted approximately five months since it was changed out by the Dionex engineers (Day 124). This particular column saw extensive use (up to 24 samples per day). Hence, at lower sampling rates, the ion column life may be extended well past five months. The column was replaced and the instrument was recalibrated. For the full-scale operation, it is desirable to have one guard column and one ion analytical column on site as a back-up at all times. This will prevent any unnecessary downtime of the plant due to either column failure.

Initially, comparisons between the on-line perchlorate analyzer (Dionex) and the off-site analyses (Emax Lab) demonstrated up to 40% difference in the feed concentrations measured. The effluent values did not demonstrate this difference (Figure 5.50). Adjustments were implemented to the on-line instrument sampling protocol by the instrument manufacturer to bring the on-site and off-site analysis closer. Standard statistical tests were performed on the perchlorate analysis data after the Dionex instrument was adjusted but before the spiking study (Table 6.1), as well as during the spiking study (Table 6.2).

Table 6.1 Statistical analysis of off-site and on-site feed and effluent perchlorate analyses prior to the spiking study.

	Mean	**Stand. Deviation**	**Confidence Limits**	**Pearson Correlation Coefficient**	**F-test Calc.**	**F-test (95%)**	**T-test Calc.**	**T-test (95%, two tail)**
LAB Feed CLO_4	52.88	2.10	0.74	0.63	1.09	1.87	14.12	2.00
Dionex Feed CLO_4	44.92	2.19	0.83					
LAB Effluent CLO_4	4.20	3.80	1.38	0.81	2.31	1.90	2.24	2.01
Dionex Eff. CLO_4	2.33	2.50	0.93					

Table 6.2 Statistical analysis of off-site and on-site feed and effluent perchlorate analyses during the spiking study.

	Mean	Stand. Deviation	Confidence Limits	Pearson Correlation Coefficient	F-test Calc.	F-test (95%)	T-test Calc.	T-test (95%, two tail)
LAB Feed CLO_4	1220.50	791.52	346.89	0.99	1.30	2.18	0.19	2.03
Dionex Feed CLO_4	1270.98	901.65	405.42					
LAB Effluent CLO_4	16.25	14.18	6.21	0.86	1.31	2.17	1.05	2.09
Dionex Eff. CLO_4	8.94	12.40	5.43					

For the non-spiking perchlorate conditions, the statistical analyses performed demonstrated a potential lower bias in the measurement of the feed perchlorate concentrations by the on-line Dionex instrument. Such a bias was not as prevalent at higher feed concentrations demonstrated during the spiking study. The standard deviation was much greater during the spiking study because spiked perchlorate concentrations in the feed water varied in range from approximately 50 µg/L to 3000 µg/L.

To better understand the repeatability of the perchlorate analysis and potentially determine the validity of the bias demonstrated by the lower Dionex perchlorate measurements, multiple split samples were sent to two additional off site laboratories for analysis. These samples included feed, effluent, and/or a common 50 µg/L standard (Accustandard, new Haven, CT) The two laboratories utilized were the University of California at Riverside Chemistry Lab (Riverside, CA) and Shaw E&I Analytical Lab (Lawrenceville, NJ). The Shaw laboratory is considered a New Jersey State certified laboratory for perchlorate analysis. These results are presented in Table 6.3. The effluent perchlorate analyses compared well between laboratories. For the feed perchlorate concentrations, variabilities existed between laboratories in the reported measurements. For Days 33 and 55, the Dionex readings were reported prior to adjustments to the internal sample preparation procedure by the manufacturer. Hence, these results were systematically lower. However, the Shaw E&I, Inc. laboratory also measured lower feed concentrations on Day 55 compared with the Emax Laboratory. Shaw E&I analyzed the samples using two different perchlorate injection programs. The first program was run using a 55 mM KOH eluent concentration and the results indicated a feed perchlorate sample at 37.4 ug/L. With this method, the perchlorate peak was on the downslope of the bulk anions that eluted first. This indicated the possibility of anion interference and an excessive sample conductivity. The second program was then run using a gradient elution. The program started at 25 mM KOH to elute off the anions first and then switched to 55 mM to elute off the perchlorate. The results under this method produced perchlorate feed at 42.7 ug/L. Using these two programs, the 50 ug/L standard was measured at 47.5 ug/L and 47.7 ug/L, respectively. Some key conclusions can be suggested from the results demonstrated by these outside laboratories. The differences seen between analyzer results are likely due to the operating conditions for the analysis. If different pre-traps, operating current, sample volume preparation, or elution programs are utilized, differences in perchlorate results will occur. Hence, it is critical to identify these issues that will provide the most accurate perchlorate analysis and compare it with similar operating instruments.

Table 6.3 Comparison of perchlorate results from four analytical labs.

Days Elapsed	**33**	**55**	**216**
Feed CLO_4			
Emax Labs	**51.7**	**54.1**	**49.5**
Dionex	**35.6**	**36.0**	**43.5**
UC Riverside	**48.2**	NM	NM
Shaw E&I	NM	**37.4/42.7**	**37.8**
Effluent CLO_4			
Emax Labs	**3.3**	NM	**0.5**
Dionex	**2.3**	NM	**1.0**
UC Riverside	**3.1**	NM	NM
Shaw E&I	NM	NM	**0.5**
50 µg/L Standard of CLO_4			
Emax Labs	NM	**53.1**	NM
Dionex	NM	**44.5**	NM
UC Riverside	NM	NM	NM
Shaw E&I	NM	**47.5/47.7**	NM

Based on the comparison of perchlorate results, after the Dionex was adjusted for internal sample preparation by the manufacturer, the lower perchlorate values observed compared to the Emax results are likely a function of different system operating programs. For the full-scale application, any instrument operating programs will be continually compared between the on-site and off-site analysis to ascertain the most accurate perchlorate measurements. For the demonstration, the 6-8 ug/L of perchlorate difference between the feed on-site and off-site results did not affect system performance as the FBR PLC had a number of safety factors built in to add sufficient electron donor to treat above the stoichiometric requirement of the chemical contaminants.

6.1.5.2 HACH Nitrate-N Analyzers

The feed and effluent nitrate analyzers worked effectively throughout the demonstration (Figures 5.33-5.43 and 5.58-5.63), but did require periodic factory recalibration on Days 167, 168, and 317. The instruments also required weekly cleaning to ensure that accurate effluent nitrate data was collected. Additional sample filtration of the FBR effluent water is recommended at the full-scale prior to samples entering the nitrate analyzer. This will minimize operator attention and prolong the life of the analyzer.

Throughout the project demonstration, the feed nitrate-N varied minimally (+/- 0.5 mg/L as nitrate-N). Hence, a feed analyzer is not necessarily required for a full-scale plant and only one HACH nitrate analyzer instrument could be utilized to provide nitrate-N concentrations from the FBR effluent. This instrument could be used for daily spot-checks of the feed nitrate-N (the use of a solenoid valve to occasionally divert feed water to the instrument), but its primary use should be for FBR effluent nitrate-N measurements. A regular maintenance procedure/service contract with the manufacturer, conducted every three months, should be established. A back-up instrument should be kept on site to minimize downtime of analytical data collection if factory recalibration of an instrument is required.

Statistical analysis of the on-line and off-site nitrate-nitrogen analysis was conducted (Table 6.4). The results of such analysis demonstrate that the on-line instrumentation averaged approximately 0.4 mg/L higher of nitrate-N on the feed and 0.1 mg/L on the effluent compared with the off-site analysis. The effluent nitrate-nitrogen concentration difference between instruments is primarily a result of the difference in reporting limits (the off-site lab of 0.05 mg/L, on-site lab of 0.1 mg/L). For the feed, the differences may be attributable to more frequent calibrations required. Like the perchlorate data, the slight difference between laboratories did not hinder FBR treatment performance of the nitrate-N as excess electron donor was always provided to the system for complete contaminant treatment.

Table 6.4 Statistical analysis of off-site and on-site feed and effluent nitrate-nitrogen analyses over the course of the demonstration.

	Mean	Stand. Dev.	Confidence Limits	Pearson Correlation Coefficient	F-test Calc.	F-test (95%)	T-test Calc.	T-test (95%, two tail)
LAB Feed NO_3-N	5.89	0.19	0.05	0.19	2.66	1.56	7.38	1.99
HACH Feed NO_3-N	6.26	0.31	0.09					
LAB Effluent NO_3-N	0.19	0.42	0.11	0.97	1.31	1.59	1.35	1.98
HACH Eff. NO_3-N	0.30	0.48	0.13					

6.1.5.3 Electron Donor Reduction Experiments

Four electron donor reduction experiments were conducted to demonstrate the correlation between nitrate-N removal and perchlorate removal. During the different experiments, the electron donor was reduced to the FBR to observe the nitrate effluent concentration for which the perchlorate concentration would exceed the State of California MCL. Using both the on-line nitrate and perchlorate analyzers, the results of the four experiments concluded that as nitrate-N levels approached near 0.3 mg/L, perchlorate concentrations were observed to exceed the State of California MCL (Figures 5.52-5.54). The on-line analyzers demonstrated their effectiveness to accurately measure both nitrate and perchlorate during short intervals of sampling. However, since controlling FBR effluent nitrate-N concentrations at or below 0.3 mg/L requires very accurate control, both instruments are recommended for the first full-scale application. For the full-scale, if the perchlorate loads are significantly higher so that a more robust, more densely populated perchlorate population exists within the FBR, the results may be different. Such experiments should be repeated at the full-scale installation before final drinking water permit conditions are established.

6.1.6 Reduce Treatment Costs

Treatment costs using the FBR treatment system include electron donor, nutrients, coagulant, polymer, electricity, and maintenance. In order to reduce these associated costs, numerous controls were put in place during the demonstration study.

6.1.6.1 Electron Donor

The electron donor costs constitute the majority of additive costs associated with the technology. For this demonstration, 50% NSF acetic acid was used as the electron donor. Other electron donors are available for use such as ethanol, lactic acid, methanol, and sodium benzoate. Many others exist as well that may be less expensive than acetic acid, but the 50% acetic acid is currently the only suitable NSF 60 approved chemical. Other vendors are being investigated for certification of acetic acid and other potential substrates, but one firm (Univar, Los Angeles, CA) currently sets the price of the 50% acetic acid. Hence, its use and cost for this project were directly tied to the manufacturer’s cost.

Using the 50% NSF acetic acid throughout this demonstration, a number of trends were observed with the electron donor addition:

- Changes in feed nitrate, oxygen, and perchlorate concentrations had a direct correlative effect on the amount of electron donor required (See Section 7.2 for further analysis).
- The addition of too much electron donor was costly and wasteful.
- The addition of too much electron donor had a harmful effect on perchlorate removal. As additional electron donor was added to the system, sulfate reducing bacteria were capable of competing with denitrifiers and perchlorate reducers for available electron donor, nutrients, and micronutrients. The reduction of sulfate also produced an offensive hydrogen sulfide odor that required control.

To maximize nitrate and perchlorate removal while supplying the minimal amount of electron donor, the PLC utilized a proprietary model that accounted for the stoichiometric requirements of 50% acetic acid required to theoretically treat the known feed flow and oxygen, nitrate, and perchlorate concentrations. An additional percentage of acetic acid was inputted by the operator into the PLC to provide for abiotic losses and microbial uptake to form biomass. An operator inputted the oxygen concentration from a hand-held instrument. The nitrate, perchlorate, and feed flow were measured on-line. An initial acetic acid addition rate was established at the beginning of the demonstration based on the proprietary model (patent pending). Once a baseline of treatment was established, the PLC model decreased the level of acetic acid addition until a nitrate or perchlorate breakthrough above the instrument detection limit occurred. From that point, the PLC increased the acetic acid addition until this breakthrough of effluent nitrate or perchlorate was no longer observable. The model continued iterations around this known acetic acid addition as long as feed flow, nitrate, oxygen, and perchlorate concentrations remained constant. No additional operator attention was required once the percentage of excess electron donor and oxygen concentration were inputted into the model. Changes in the excess percentage of electron donor and the electron donor addition rate occurred throughout the demonstration as changes occurred in flow or feed concentrations (shown throughout Figures 5.33-5.43). Based on the non-spiking condition feed concentrations of nitrate-nitrogen of 6.1 mg/L, oxygen of 8.1 mg/L, perchlorate of 50 µg/L, and a feed flow of 50 gpm, the required amount of 50% acetic acid was 15 mL/min (16.2 mg/L as Carbon, including an excess percentage of electron donor of 20-25%). This level of 50% acetic acid addition minimized carry over of the electron donor to the effluent and prevented sulfate reducing conditions from developing. Maintaining approximately 2-3 mg/L residual DOC at the FBR effluent ensured that the system operated optimally, but did not create disinfection by-product formation potential issues (Figures 5.47-5.49).

For the spiking studies, 99.65% removal of perchlorate was achieved at concentrations of perchlorate up to 4,000 µg/L. At this feed perchlorate concentration, the rate of addition of electron donor (and nutrient) was proportionally increased based on the PLC model. Based on nitrate-nitrogen of 6.1 mg/L, oxygen of 8.1 mg/L, perchlorate of 4,000 µg/L, and a feed flow of 25 gpm, the required amount of 50% acetic acid was 11 mL/min (23.8 mg/L as Carbon). Concentrations below 4,000 µg/L required less electron donor as adjusted by the PLC model.

6.1.6.2 Phosphoric Acid Addition

Through the demonstration, it was observed that phosphorus addition to the FBR for this particular feed groundwater was necessary to ensure complete nitrate and perchlorate removal (Section 6.2.4). For this study, the 85% NSF phosphoric acid was diluted 50X and added to the FBR feed as a nutrient source. For complete treatment of the nitrate, oxygen, and perchlorate for the non-spiking conditions, the diluted phosphoric acid requirement was 10.5 mL/min (0.3 mg/L as P). The PLC model directed the phosphoric acid addition as a function of the electron donor addition. No additional operator attention was required for the phosphoric addition with the exception of filling the chemical drum. Throughout the demonstration, efforts were made to maintain the FBR effluent orthophosphate-phosphorus concentration at 1 mg/L to ensure adequate nitrate and perchlorate treatment and to minimize cost.

6.1.6.3 Coagulant and Polymer Addition

Initially, the Trimite multimedia filter was operated without the addition of any coagulating agent or polymer. Effluent turbidity levels exceeded the State of California Title 22 requirements (Figure 5.25). Subsequently, numerous experiments were conducted to test different coagulating agents and polymers at varying addition rates. Two products that were significantly tested were an NSF approved coagulating agent of 48% aluminum sulfate (Sterling Chemical, Columbia, TN) and 0.8 % diluted polymer of a stock of 20% cationic Callaway polymer (Kemiron, Fontana, CA). These products were chosen because a local drinking water plant, the Oliver Roemer Surface Water Treatment Plant, utilized the same products on their Trident multimedia filters and provided their experience with the required dosages. Experiments that were conducted utilizing only the coagulating or flocculating agent failed to produce water of suitable turbidity (<0.3 NTU). Hence, the addition of both chemicals were required at dosages of 1 mL/min of the 48% aluminum sulfate (2.5 mg/L dose) and 4 mL/min of the 0.8% polymer (0.17 mg/L dose). Though the Trimite multimedia filter was capable of adding the necessary chemicals based on effluent turbidity values observed, the chemical addition was operated in manual mode and presented no operational issues. The only operator attention required was ensuring that the two drums were filled with chemicals.

Additional efforts were undertaken through the first eight months of the study to test other coagulant and polymer products to determine if costs could be further minimized. Specifically, Sterling Chemical (Columbia, TN) provided a unique polymer blend called Sterling 8807 that could be used in lieu of the existing ALUM/polymer addition. Presumably, the increased cost for this unique polymer could be offset by the reduction in cost in eliminating the ALUM. However, adding the experimental supplied polymer to the Trimite multimedia filter, excessive amounts were required that offset any benefit in cost by not using ALUM. A second polymer titled Sterling AgeFLOC WT20-P was tested that worked in conjunction with ALUM. This particular product caused the periods between forward flushes and backwashes to increase nearly 100% each. This is problematic as an increase in forward flushes and backwashes causes more downtime for the system. At the full-scale, multiple Trident multimedia filters would be present so that when one filter is flushing or backwashing, the other filter(s) could take on the full-forward feed. However, if more frequent flushes and backwashes were required, then more frequent stress will be placed on available systems more often. Due to time constraints, hundreds of polymer formulations exist that were not tested during the demonstration. Additional polymer testing is recommended at the full-scale where costs may be further reduced. However, during this demonstration under the specific site operating conditions, a cost-effective coagulant/polymer combination and the respective addition rates were developed that effectively reduce the turbidity at the multimedia filter effluent.

6.1.6.4 Electricity Requirements

The electricity requirements were not measured during this demonstration study because only one source of electricity was available for use by the groundwater pump and the three demonstration projects at the site. Hence, there was no mechanism to measure electrical demand for just one of the projects. In addition, the electricity used for the demonstration at 50 gpm can not be directly correlated to flow as the plant expands. As the plant size and flow increases, efficiencies are observed for larger pumps, blowers, etc. which are not available in the smaller models. In addition, electrical costs fluctuate for large systems based on “time of use” cost models. Hence, variable electrical costs occur at the full-scale that were not available at the demonstration FBR treatment system. Section 7.3 provides a cost estimate for a full-scale system in accounts for electrical usage costs for an actual design.

<u>6.1.6.5 Maintenance Requirements</u>

Since multiple scientific experiments were conducted during the demonstration study, the operator time required during the demonstration was not necessarily indicative of the requirements for a full-scale plant. An operator was on site five days per week for eight hours per day to conduct the various experiments on the system. Such a time commitment would not be required by an operator for the full-scale system. Depending on the size and complexity of the system, one to two operators may be required to effectively operate the plant. This level of operator attention is similar to the requirements observed for the local surface water treatment plant. Details of the maintenance requirements are available in Appendix H and Sections 6.1.3 and 8.3.

6.2 Quantitative Objectives

6.2.1 Meet Drinking Water Regulatory Standards/Produce Quality Data

The FBR treatment system effluent water was extensively tested throughout the demonstration study to ensure that the water met the drinking water standards established under the Federal Safe Drinking Water Act and the California Code of Regulations, Title 22 requirements (Table 5.6). Using on-site instrumentation and off-site laboratory analyses, the data collected included both primary and secondary MCL requirements: organics, inorganics, metals, disinfection byproducts, total coliform, *E. Coli*, heterotrophic plate counts, dissolved and suspended solids, alkalinity, pH, and color. The partial or complete analytical was collected during steady-state operation (Days 47, 63, 77, 96, 103, 105, 119, 125, and 137), system restart (Day 69), plant restart (Day 89), and during the spiking study at 1,000 µg/L (Days 301 and 327), at 2,000 µg/L (Day 329), and at 2,500 µg/L (Day 335). For each condition, the nitrate and oxygen concentrations remained constant at approximately 6.1 mg/L of NO_3-N and 8.1 mg/L of O_2. The maximum nitrate concentration treated was 6.54 mg/L NO_3-N. Regardless of the operating condition (i.e., steady-state, feed restart, plant restart, etc.), at feed concentrations up to 1,000 µg/L of ClO_4, all of the State of California regulatory limits for potable water were met (Tables 5.7-5.9, Table 5.14, and Figures 5.33-5.43). For the spiking studies above 1,000 µg/L ClO_4, all regulatory limits were met with the exception of perchlorate that exceeded the State of California MCL. If more time was afforded the spiking study, this level of perchlorate would have been treated as the biomass acclimated to the higher loads.

To ensure that all the data collected and reported was valid in demonstrating that the plant met the drinking water regulatory standards, extensive quality assurance and quality control was undertaken per the QAPP in Appendix E. Appendix G provides the complete QA/QC data set, method detection limits, method reporting limits, and notes that highlight any unique events concerning the sample collection, analyses, or result reporting. For the off-site laboratory, a total of 87 samples were submitted for analysis of perchlorate. Per the QAPP, five percent of these samples were collected with appropriate quality control samples. For Day 336, samples were submitted as blind samples (Table 6.5).

The relative percent difference values between the various feed and effluent samples, collection duplicates, and split duplicates demonstrate less than 7% discrepancy for all samples with the exception of one outlier on Day 13 (RPD of 23.86%). At the lower perchlorate concentrations, small differences between sample results produce large RPD errors. Internal QA/QC procedures for the instrument when this particular sample was analyzed did not demonstrate any anomalies with the matrix spikes, internal duplicates, etc. Therefore, this one outlier is likely a result of some sample preparation error either in the field or within the laboratory.

Table 6.5 Demonstration study sample and quality control sample results for perchlorate analysis and the calculated relative percent difference values (RPD).

Days Elapsed	Feed Sample (µg/L)	Feed Collection Duplicate (µg/L)	Feed Collection Duplicate RPD	Feed Field Split Duplicate (µg/L)	Feed Split Duplicate RPD	Trip Blank (µg/L)	Field Blank (µg/L)
11	50.0	51.8	**3.54**	N/A	N/A	N/A	N/A
336	2990	2860	**4.44**	2880	**3.75**	<0.5	<0.5
348	63.5	61.1	**3.85**	62.7	**1.27**	<0.5	<0.5
Days Elapsed	**Effluent Sample (µg/L)**	**Effluent Collection Duplicate (µg/L)**	**Effluent Collection Duplicate RPD**	**Effluent Field Split Duplicate (µg/L)**	**Effluent Split Duplicate RPD**	**Trip Blank (µg/L)**	**Field Blank (µg/L)**
13	2.03	2.17	**6.67**	2.58	**23.86**	<0.5	<0.5
82	0.50	0.50	**0.00**	0.50	**0.00**	<0.5	<0.5

Over the course of the one-year demonstration project, isolated incidents with the outside laboratory regarding sample collection, analysis, and reporting occurred (Table 6.6). Whenever possible, corrective actions were taken to salvage the sample(s) for analysis. When improper procedures were followed in the field or in the lab, additional training was administered to ensure the problem was not repeated. For those instances where the quality of data was not believed to be in question but a holding time or preservative issue was violated, the sample was still analyzed and the data appropriately flagged in the notes section of Appendix G. For samples that could not be analyzed, this data was accounted for per the QAPP data completeness requirement. The completeness objective for all validated data was 95 percent. In total, 87 samples were submitted to an outside laboratory for perchlorate analysis. Of these 87 samples, two samples were not measured due to issues with holding time or shipping. The percentage completeness for the perchlorate analysis was 97.7%. For all other chemical parameters measured, the completeness objective of 95% was met.

For all of the samples collected and the analyses conducted, three results were flagged and investigated further to determine if they should statistically be discarded from the entire data set. These three results were data collected for total coliform analysis from the FBR effluent on Day 126 and the Trimite multimedia filter on Days 137 and 315. The data from Days 126 and 137 were compared within a subset of data collected for steady-state operation prior to the spiking study. For Day 315, this data was compared within a subset of only data collected during the spiking study. Performing the statistical Grubb's outlier test on these three points, using a value of false rejection of 5%, the three data points statistically exceeded the critical Grubb's T-test for outliers (calculated T-value exceeded T-test critical value) and were discarded from the data set (See Table 6.7).

Table 6.6 Issues with samples submitted for analysis and resulting corrective action.

Days Elapsed	Discrepancy	Action Taken
27	Original lab feed perchlorate result reported incorrectly	Lab contacted and data reviewed and corrected.
28	Original lab feed perchlorate result reported incorrectly	Lab contacted and data reviewed and corrected.
35	Original lab effluent perchlorate reported non-detect, then changed to 9.8 µg/L	Lab caught internal error and reissued report.
56	Sample received by lab was above required temperature range.	Analysis was not conducted on sample.
77	Bottles used for COD and metal samples arrived without preservative	Samples were collected and shipped on ice. Consultation with lab resulted in analysis still being conducted. Results flagged.
96	Bottles metal samples arrived without preservative	Samples were collected and shipped on ice. Consultation with lab resulted in analysis still being conducted. Results flagged.
259	Laboratory failed to analyze feed sample for HPC analysis	Sample not analyzed. Lab project manager consulted regarding improper procedures. Corrective action taken with additional training.
301	Color, odor, and turbidity samples were not analyzed within required holding time	Lab still analyzed the samples. Data was flagged.
301	Laboratory failed to follow proper procedures in diluting FBR and Trimite effluent samples for total coliform and analyze feed sample for HPC analysis	Sample reporting limit increased. Lab project manager consulted regarding improper procedures. Corrective action taken with additional training.
307	Sample cooler arrived open and bottles broken.	Samples were not analyzed. Another sample collected and shipped to the lab on Day 308.

Table 6.7 Sample results statistically removed from the data set.

Days Elapsed	Reported Value (MPN/100 mL)	Average Value (MPN/100 mL)	Standard Deviation (MPN/100 mL)	Calculated T-Value	Number of Samples	Grubb's T-Test Critical Value
126	650	100	174	3.161	13	>2.3
137	310	34	84	3.286	13	>2.3
315	2400	563	766	2.398	8	2.032

6.2.2 Maximum Concentration Treated and Elimination Capacity

The maximum concentration of perchlorate treatable in the demonstration-scale FBR treatment systems is critical to determining eventual scale-up factors for the full-scale design. The concentration of treatable perchlorate depends on:

- Oxygen concentration
- Nitrate concentration
- Flowrate
- Expanded bed height
- Temperature
- pH
- Nutrient Concentration

All of these factors are measured using on-line analytical equipment or on-site analyzers. The FBR treatment system is operated under optimal conditions so that the largest amount of perchlorate can be removed in the smallest bed volume in the shortest time duration (defined as the maximum elimination capacity). The maximum concentration of perchlorate that was demonstrated to be consistently treated through the FBR was approximately 4,000 μg/L of ClO_4 (Figures 5.62 and 5.66). At this concentration, 99.65% removal was attained (9.6 g of perchlorate/m^3 expanded media bed/hr). At 1,000 μg/L of ClO_4, the treatment plant treated the perchlorate concentration to less than the MCL of 6 μg/L. Assuming the expanded bed height of 146 inches, various perchlorate and nitrate elimination capacities with respect to feed concentration and flowrate that were observed during the demonstration are provided in Table 6.8.

Table 6.8 Elimination capacity of nitrate/perchlorate under differing operating scenarios (assumes 100% treatment of feed perchlorate concentration).

Scenario	1	2	3	4	5	6	7	8
Flowrate (gpm)	50	25	25	25	25	25	25	25
Perchlorate Concentration (μg/L)	50	50	100	500	1000	1500	2000	4000
EC (g perchlorate/m^3 media/hr)	0.24	0.12	0.24	1.2	2.4	3.6	4.8	9.6
Nitrate-N Concentration (mg/L)	6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.10
EC (g Nitrate-N/m^3 media/hr)	29.3	14.6	14.6	14.6	14.6	14.6	14.6	14.6

Knowing the level of treatment at these contaminant concentrations and the associated elimination capacities, the required FBR reactor system size can be estimated at higher feed flowrates.

6.2.3 Downstream Equipment Effectiveness

For the plant effluent water to meet potable water standards, effective treatment of the FBR effluent water was required from the downstream equipment of the post-aeration vessel, the multimedia filter, LGAC, and UV system. The water was required to be processed for a number of parameters:

- Post-aeration oxygen concentration to be raised above 7 mg/L
- Multimedia filter effluent turbidity, metals, inorganics, and organics to be below MCLs
- LGAC effluent water color and odor to be non-detect or below MCL
- Disinfection byproduct formation potential to be below MCLs
- Chlorination and UV disinfection log removal of bacteria to meet HPC requirements

As described in Section 5.7.2 Treatment Effectiveness, the downstream equipment proved effective in treating the FBR effluent to meet the potable water regulatory requirements. The post-aeration vessel was capable of consistently producing water with dissolved oxygen concentrations above 7.5 mg/L (Figure 5.26). The multimedia filter effluent met all of the primary and secondary MCLs for turbidity, metals, inorganics, and organics (Tables 5.7-5.9, 5.14). The backwash water generated by the Trimite multimedia filter produced a water of quality that should be treatable by most POTWs (Tables 5.10 and 5.11). Disinfection by-product potential from the Trimite multimedia filter never exceeded 15 µg/L for total trihalomethanes or 25 µg/L for haloacetic acid five. The presence of *E.Coli* was also never detected at the Trimite multimedia filter effluent. The presence of total coliform and heterotrophs were observed in the Trimite multimedia filter effluent (Figures 5.45 and 5.46). However, the chlorination and UV studies demonstrated a 3-4 log removal of heterotrophic plate count and complete removal of total coliform at a CT of 4 and a UV residence time of 6 seconds (See Section 5.7.5 and 5.7.6). Finally, the LGAC effluent had no color or odor (microbiological in origin) associated with it and the observed pressure drop across the vessel was less than 1 psi (Figure 5.44).

6.2.4 Process Robustness

In treating the nitrate and perchlorate, the system robustness to treat a variety of concentrations of contaminants effectively and reliably was demonstrated. For a short period of time, perchlorate concentrations as high as 4023 µg/L at 25 gpm were treated in the FBR with greater than 99.65% removal (Figure 5.62). Table 6.8 also demonstrates the elimination capacities achievable by the system under differing operating scenarios. The ability of the FBR treatment system to respond to changing nitrate and perchlorate concentrations in a relatively short timeframe demonstrates the technology process robustness.

Additionally, the FBR treatment system must demonstrate mechanical robustness as this dictates system down time, maintenance required, and manpower required. Appendix H provides modifications to the system that were required throughout the demonstration. Many of these modifications were not directly related to process robustness, but instead were a function of the numerous scientific experiments conducted throughout the year. Section 6.1.3 describes the occurrences of plant shutdowns due to mechanical failures. This downtime was primarily attributable to a malfunctioning blower on the Trimite multimedia filter, a malfunctioning blower vane on the post-aeration blower, and miscellaneous electrical power interruptions that occurred throughout the year. The plant downtime was calculated based on mechanical operation only. If the plant was receiving forward flow and treating perchlorate, then the plant was considered to be in operation. Analyzer downtime was not considered (though documented) as a contributing factor when calculating plant downtime. Also, a number of experiments were conducted where shutdowns were enacted for various studies. These occurrences of shutdowns were not incorporated into the plant's downtime as they were artificially employed. Based on collected data, the plant had a downtime of 6% of the 349 days it was in operation (or approximately 21 days). Over the year of the demonstration, a few instances of the system shutting down occurred and the operator was unable to return to the plant immediately. Hence, a day or more of the plant remaining down ensued. For a full-scale plant, an alarm would be sent via telemetry to a control room such that the alarm could be immediately addressed and the plant restarted as quickly as feasible. Since the operating plant for this demonstration did not have such telemetry to call out alarms, response to system shutdowns was delayed. Thus, the 6% downtime demonstrated for this plant could be reduced significantly for a full-scale plant with telemetry.

7.0 Cost Assessment

The FBR treatment system operation was demonstrated for approximately a one year period (March 15, 2007 through March 1, 2008). During the course of the demonstration, a number of variables were tracked to further understand their cost implication as the technology was scaled from 50 gpm to 1,000 gpm.

7.1 Cost Model

A cost model has been developed and is provided with all of the cost elements of the FBR treatment system that are required for implementing the technology at a real site (Table 7.1). Many caveats must be placed on this cost data. The installation costs provided are only applicable for systems in this size range (<100 gpm). For larger systems, though scaling of the costs may be directly proportional in some cases (i.e., electrical design), costing is not always directly scaled. For instance, for this demonstration, the concrete pad was formed and poured using minimal labor and a small portable mixer. The minimal amount of concrete utilized to pour the pad required that a premium be paid per cubic yard of concrete. For much larger installations, significantly more design, labor, and materials would be required due to the volume of concrete and the potential loads. Although a cost reduction might be observed based on an economy of scale, this reduction may be offset by the need for larger delivery trucks, fuel fees, additional labor, etc. These differences are not accounted for in the cost model and are typically on a case-by-case basis (see Section 7.3 for a cost example). Additional caveats must be realized with the costs presented because the associated labor and monitoring costs were a direct result of the intense number of scientific experiments that were conducted. This level of labor and monitoring effort would not be required for a typical operating system of any scale. Finally, like all drinking water plant start-ups, typically the initial two to three months of operation require more troubleshooting and are more labor intensive. Hence, the first year of labor required is greater than subsequent years of operation.

7.1.1 Project Management & Design

This demonstration involved designing, engineering, and fabricating a “first-of-its kind” complete biological perchlorate treatment system to produce drinking water. Hence, project management and design costs are significantly influenced by the labor required to implement this initial system. In addition, a number of project management tasks were associated with this project that, though integral to the overall success of the FBR treatment system project, were not solely associated with the FBR treatment plant development. Significant labor was required to develop site improvements for all of the projects that were to be tested at Rialto Wellhead #2. These improvements included a new security fence around the site perimeter, the addition of a second waste discharge line to the catch basin, and the grading and clearing of the site. These improvements were conducted through this demonstration by Basin Water, Inc. for the benefit of the City of Rialto and the other site demonstrations. These improvements required significant planning, the production of statement of work documents, bidding and awarding of subcontracts, and oversight in the implementation of such improvements. All of these activities are part of the project management costs presented in Table 7.1 and can not be effectively separated out from the total costs.

Table 7.1 Cost model for small-scale FBR implementation (<100 gpm).

Element	Data Tracked During the Demonstration	Description	Cost
Treatability Study	•Not Performed		
Baseline Characterization	•Detailed groundwater assessment	Analytical assessment of groundwater	$600
Project Management	•Coordination of system design, procurement, reporting, administrative		$70,000
Design	•Vessels and process design	Multiple engineers	$146,000
	•Piping and mechanical engineering	Multiple engineers	$47,000
	•Electrical	Multiple engineers	$21,000
Fabrication & Equipment	•FBR system with post aeration, Trimite multimedia filter, and LGAC	Equipment cost	$403,000
	•Office/controls room assembly	Labor and materials	$56,000
	•UV system	Equipment cost rental	$8,000
Installation	•Shipping cost, rigging, unloading	Findlay, Ohio to Rialto, CA	$9,000
	•Design of piping, electrical, concrete pad	One engineer, 50 hrs	$4,000
	•Materials required	Piping, supports, concrete, rental equipment	$25,000
	•Labor required for installation of piping, equipment, and concrete pad	One Construction Manager, 120 hours	$10,000
		One Foreman, 60 hours	$3,500
		One project manager, 160 hours	$16,000
		Two field laborers, 120 hours each	$6,000
		One journeymen laborer, 80 hours	$3,500
	•Travel and incidentals required to work on site	Hotels, per diem, mileage, rental vehicles	$6,000
	•Labor and materials required for installation of electrical	Multiple projects served at the site, two man crew	$66,000
Operation and Maintenance	•Chemicals required (acetic acid, phosphoric acid, aluminum sulfate, polymer) for plant operation	Chemicals	$15,000
	•Laboratory supplies, analytical instrument supplies for monitoring	Guard and analytical columns, filters, replacement chemistry kits	$5,000
	•Labor required	Field Engineer, 40 hrs/wk	$134,000
		Project Manager, 20 hrs/wk	$101,000
	•Electricity required	Not able to measure	N/A
Monitoring	•Laboratory analytical services	Analytical	$49,000
Waste Disposal	•Trash service	Rental/haul away on monthly basis	$1,400

7.1.2 Fabrication & Equipment

The associated costs for the fabrication of the FBR treatment system included the use of in-house labor for the FBR and associated controls, and subcontracted vendors for the surface water treatment plant equipment. Due to the size of the system (50 gpm), the equipment provided by the subcontracted vendors was the smallest available "off-the-shelf" size available. Numerous vendors were solicited for quotes on the equipment. The choice of the particular equipment purchased and tested during the demonstration was based on the equipment price, availability, and historical operation at other plants. Scale-up to larger equipment was also a factor in choosing which equipment to test. The local surface water treatment plant near the site, the Oliver Roemer Surface Water Treatment Plant, utilized the same vendor equipment and was familiar with its operation. Based on their own experience, the operators from the local plant were able to assist Basin Water, Inc. with the FBR treatment system operation.

7.1.3 Installation

Installation costs included labor and materials required for installation of the electrical at the site. All of the electrical installation costs provided in Table 7.1 are not directly associated with the implementation of the FBR treatment system. City of Rialto Wellhead #2 had not been operated consistently for more than 10 years. The available electrical power was dated, undersized, and out of code in terms of safety requirements. Hence, an upgrade of some of the electrical parts was required to make the electrical panel functional for all of the demonstration projects. In addition, the electrical installation costs provided account for electrical hook up for all of the demonstration projects at the site, not just the FBR treatment system. The provided electrical costs were under a blanket subcontract work order for the entire site and could not be separated out per specific project very effectively. If implementing only the FBR treatment technology at another site, significantly lower costs associated with the necessary electrical connections and installation would be expected.

7.1.4 Operation and Maintenance

7.1.4.1 Materials Required

During the course of the demonstration, the FBR treatment system was operated in continuous forward feed mode (6% downtime). Chemicals were consistently added to the treatment process to ensure that all oxygen, nitrate, and perchlorate were effectively oxidized/reduced and that all solids were collected and concentrated. These chemicals included NSF approved 50% acetic acid, 85% phosphoric acid, and 48% aluminum sulfate from Univar (Los Angeles, CA). A Callaway 4080 proprietary 20% polymer was also utilized during the demonstration. The costs provided are based small quantity purchase (55 gallon drums). Usage was tracked on a monthly basis and the costs for the one year demonstration reported. Presumably, significant cost reductions would be observed for larger quantity purchases. For instance, the small quantity purchase of 50% acetic acid was $0.52/lb while bulk 50% acetic acid costs were quoted at $0.375/lb (Univar, 2008). Additionally, these costs do not include fuel transportation surcharges which have been extremely volatile in the transportation marketplace. Volumes of chemicals can be considered linearly scaled with feed flow being treated, but the associated costs actually are reduced per kilogram of perchlorate treated because of the reduction in bulk chemical costs.

7.1.4.2 Labor

A portion of the costs associated with the operation and maintenance (O&M) of the 50 gpm plant are applicable of a plant of a much larger size (i.e., 1,000 gpm). The issues dealt with at the demonstration plant during start-up and operation would likely be observed and resolved in a similar manner at a much larger scale plant. Hence, the manpower and time required during start-up can be considered conveyable at either scale of plant. The manpower utilized during this demonstration after start-up issues were resolved was primarily utilized for performing a variety of experiments that would not necessarily be required on a day-to-day operation of a much larger full-scale plant. Hence, a reduction in manpower by greater than 75% may be observed. Based on such information, the manpower listed for the demonstration study is unique to this particular study. For a scaled-up plant, O&M costs must be carefully evaluated on a case-by-case basis.

A few caveats must be noted regarding the O&M cost values presented:

- The start-up process of any drinking water plant will typically require significantly more labor until the mechanical, electrical, and process issues are addressed and remedied. From experience, this process can take from 2 to 4 months depending on the complexity of the process. A significant gap in start-up and operating labor costs for different size units will be negligible if the complexity of the systems is similar. This assumption is valid in scaling up from 50 gpm to 1000 gpm.
- The labor costs associated with the plant operation in the field are derived based on industry standards for a service contractor to conduct the operation. A licensed drinking water plant operator did not service this plant during the study. Rates for a municipality or utility companies will differ based on location, operator experience and requirements, and the level of system complexity. For the system presented, because of the complexity, a T5 certified drinking water plant operator will likely be required to be on staff. However, such a level of operator will not be required to actually operate the plant.
- Significant project management costs were required as this was a scientific demonstration of the FBR treatment system. The demonstration required collection, compilation, assessment, evaluation, and reporting of all data to meet the requirements of the project as outlined in Section 3.0. Such labor intensive requirements would not be required for a typical drinking water treatment plant application. Project management labor costs would be minimal once the plant reached steady-state and operational issues were addressed.

7.1.5 Monitoring

The monitoring data presented for the implementation of the technology, which was tracked during the demonstration, will not be directly applicable for a similar size plant or as the plant is scaled-up for a number of reasons:

- The demonstration study that was conducted involved a number of scientific experiments to test the robustness of the technology. Hence, there was additional monitoring in frequency and the variety of analytes that would not be required under normal operation of any size FBR treatment system.
- In terms of monitoring, every domestic water operating permit is unique with respect to the requirements of the CADPH. This fact is even more prevalent when dealing with an already impaired resource as a drinking water source. Although the CADPH was consulted on the frequency and variety of analytes that were measured over the duration of the project, unique monitoring analysis may be required based on the location of the plant. For instance, n-nitrosodimethylamine and VOCs were monitored on a limited basis during the demonstration. However, such analysis is expensive and would increase the monitoring costs significantly if additional analyses were required based on the domestic water operating permit. A case-by-case evaluation is required.

7.2 Cost Drivers

The major anticipated cost driver of the technology is the concentration levels of oxygen, nitrate, and perchlorate in the feed stream. The use of electron donor is a direct function of these three chemical components. However, for drinking water applications, the concentrations of oxygen and nitrate drive the electron donor usage more than the concentration of perchlorate. Assuming stoichiometric treatment of the nitrate, oxygen, and perchlorate, three times as much acetic acid is required to treat a known concentration of nitrate compared to a known concentration of oxygen. In comparison with perchlorate treatment, five times as much acetic acid is required to treat a known concentration of nitrate. These differences in electron donor requirements result in larger increases in operating costs as the nitrate concentrations increase compared with the oxygen and perchlorate concentrations. Accordingly, changes in oxygen concentration affect operating cost more than perchlorate concentration as the oxygen increases up to the water solubility limit (approximately 9 mg/L). Since the amount of electron donor required for a typical drinking water application constitutes a significant portion of the overall operating costs, changes in electron donor demand based on chemical water composition can effect the overall operating cost budget. A number of examples are provided to demonstrate the effect of electron donor requirement based on feed water chemical composition (Table 7.2).

Table 7.2 Sensitivity of electron donor cost as a function of differing inlet contaminant concentrations. Assumes 1000 gpm treatment, 50% acetic acid cost of \$0.375/lb, and 25% percent excess electron donor for biomass development.

	Nitrate Concentration (mg/L)	Oxygen Concentration (mg/L)	Perchlorate Concentration (μg/L)	\$/AF	\$ for 50% Acetic Acid/kg of perchlorate treated
Example 1	28	9	50	81	1313
Example 2	28	4.5	50	67	1086
Example 3	28	9	1000	83	67
Example 4	14	9	50	54	876

The concentrations of the three chemical components of oxygen, nitrate, and perchlorate also affect the size of the FBR reactor that can drive the capital cost of the technology. As these concentrations increase, the required bed volume to treat these components increases based on the maximum elimination capacities of each component (see Table 6.8). Since the FBR bed is not completely stratified with treatment of these three components, mixing of treatment across the bed height and within the biofilm on each media particle can occur. This ensures that maximum efficiency is observed by utilizing all of the fluidized bed to treat the incoming chemical components. Typically, the full-scale FBR reactors are provided at a minimum of 3-foot diameter up to a maximum of a 14-foot diameter bed. If more bed volume is required, multiple 14-foot diameter beds are provided. The major limitation for the 14-foot diameter bed size is based on a transportation permit limitation. As the reactors increase in diameter, an economy-of-scale factor is observed in the design and fabrication requirements. However, this economy-of-scale savings can be off-set by the increase of material costs.

Another major factor that can significantly affect the operating cost of the FBR treatment system is the power consumption. The cost of coal based electricity is a volatile market, so any increase in costs will have some impact on the overall operating costs of the FBR treatment system. Typical drinking water treatment plants operate on a "Time of Use" basis where electricity costs are tiered based on peak demand. Hence, a plant will develop operating practices so that during the highest peak demand times (mid-day), the plant operates at significantly reduced capacity. Typical electrical costs in Southern California range from \$0.07/kW hr to \$0.12/kW hr based on the time of use. An average of \$0.10/kW hr is used for the cost model and analysis for the full-scale in Section 7.3 (West Valley Water District, 2008). Utilizing flow and contaminant concentration feed-forward control logic, the FBR drinking water system can be operated to minimize electrical consumption during peak demand. During peak times of the day (i.e., noon), the feed flow can be limited to the FBR. During non-peak times of the day, the full capacity of the plant can be utilized. The PLC is capable of adjusting the electron donor accordingly to flow and nitrate/perchlorate concentrations so that changes in feed flow do not affect treatment performance. Such effective control will minimize the electrical operating costs.

7.3 Cost Analysis

The site chosen is hypothetical in nature but mimics a number of the production well characteristics observed throughout the Rialto-Colton Basin. The project assumptions are:

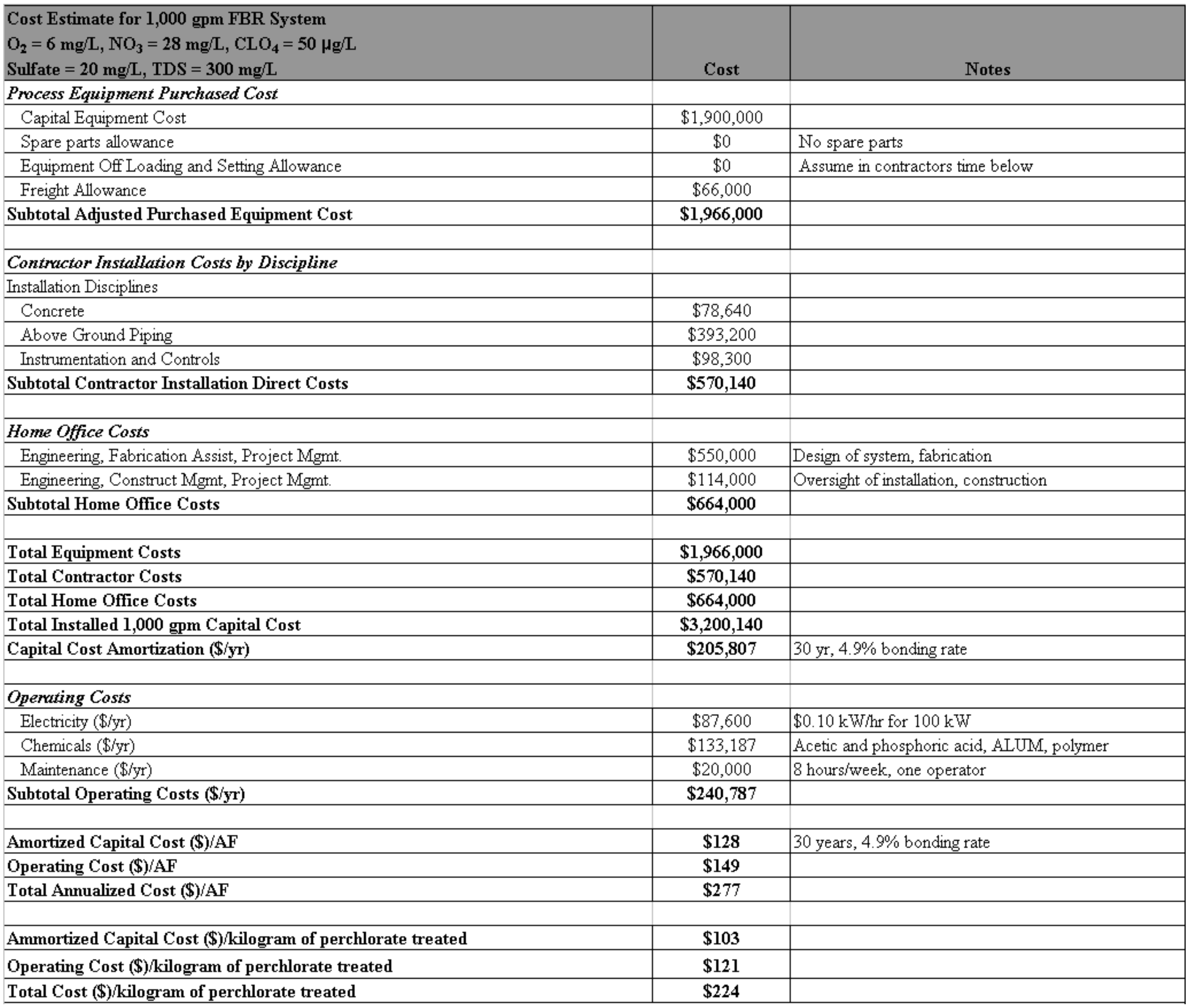
- 30 year remediation/drinking water project
- 1,000 gpm design treatment (1613 AF/year)
- Existing production well available
- Nitrate concentration = 28 mg/L
- Oxygen concentration = 6 mg/L
- Perchlorate concentration(s) = 50 µg/L, 270 µg/L, and 1000 µg/L
- Temperature = 19 ^{o}C
- pH = 8.0
- ORP > 100 mV
- TDS = 300 mg/L
- Sulfate = 20 mg/L
- Total hardness = 210 mg/L as $CaCO_3$

The life-cycle costs are estimated for the FBR drinking water production plant utilizing both the capital/investment and operating costs:

- Investment and operating costs based on 2008 dollars
- Well operation and chlorination not included in costs
- Engineering costs are included
- Installation costs are included with exceptions noted below
- Electrical energy costs at $0.10 kW/hr (averaged for time-of-use)
- Amortized costs based on 30 years, 4.9% bonding rate (OMB, 2008)
- NSF 50% acetic acid at $0.375/lb
- NSF 85% phosphoric acid at $1.115/lb
- NSF 48% aluminum sulfate at $0.085/lb
- NSF 20% polymer at $10/gallon

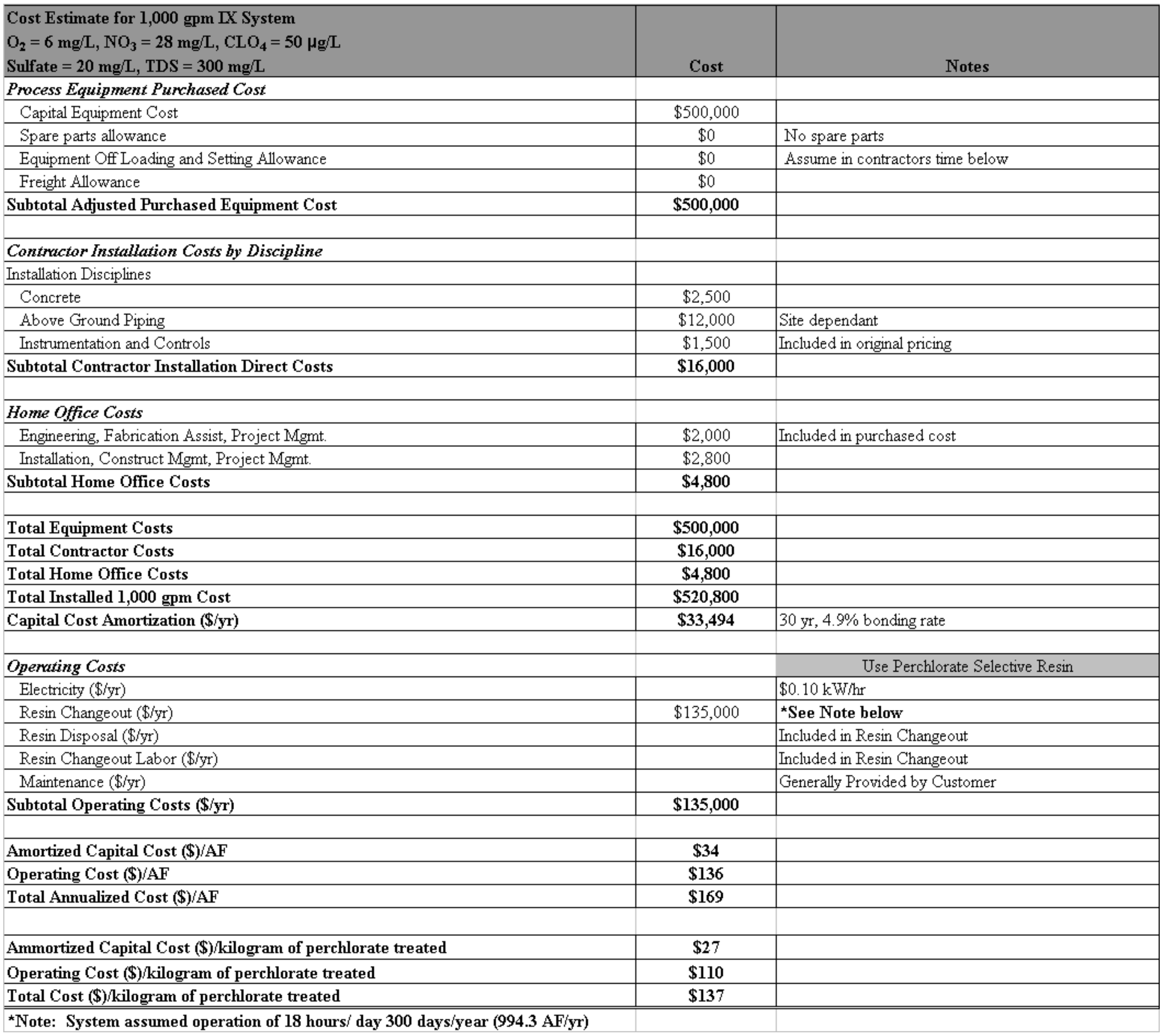
The FBR treatment system and the throw-away resin ion exchange design, fabrication, installation, and operation costs are provided (Tables 7.3-7.8).

Table 7.3 FBR full-scale treatment system cost at 1000 gpm and CLO_4= 50 µg/L.



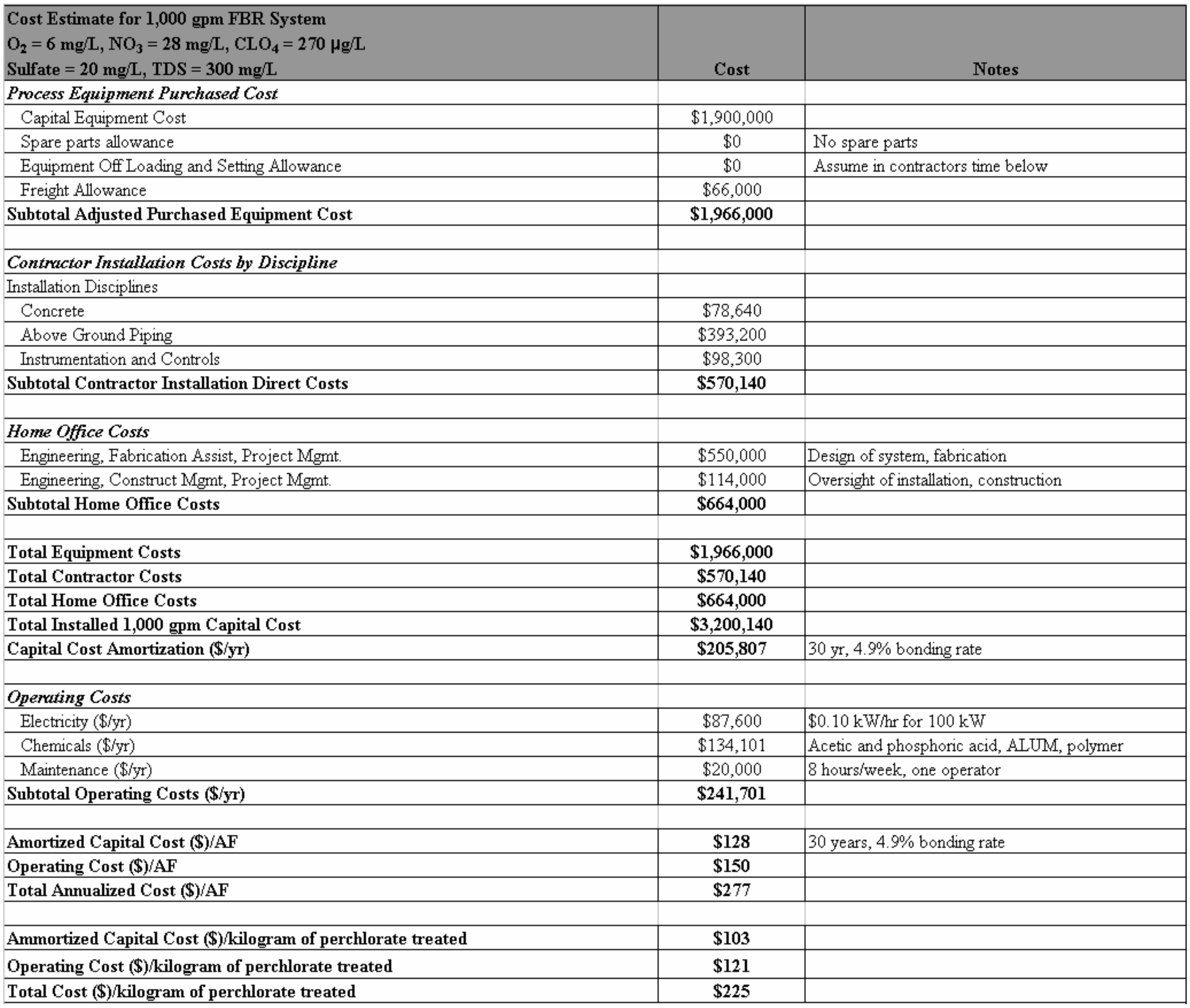
Cost Estimate for 1,000 gpm FBR System **O_2 = 6 mg/L, NO_3 = 28 mg/L, CLO_4 = 50 µg/L** **Sulfate = 20 mg/L, TDS = 300 mg/L**	**Cost**	**Notes**
Process Equipment Purchased Cost		
Capital Equipment Cost	$1,900,000	
Spare parts allowance	$0	No spare parts
Equipment Off Loading and Setting Allowance	$0	Assume in contractors time below
Freight Allowance	$66,000	
Subtotal Adjusted Purchased Equipment Cost	**$1,966,000**	
Contractor Installation Costs by Discipline		
Installation Disciplines		
Concrete	$78,640	
Above Ground Piping	$393,200	
Instrumentation and Controls	$98,300	
Subtotal Contractor Installation Direct Costs	**$570,140**	
Home Office Costs		
Engineering, Fabrication Assist, Project Mgmt.	$550,000	Design of system, fabrication
Engineering, Construct Mgmt, Project Mgmt.	$114,000	Oversight of installation, construction
Subtotal Home Office Costs	**$664,000**	
Total Equipment Costs	**$1,966,000**	
Total Contractor Costs	**$570,140**	
Total Home Office Costs	**$664,000**	
Total Installed 1,000 gpm Capital Cost	**$3,200,140**	
Capital Cost Amortization ($/yr)	**$205,807**	30 yr, 4.9% bonding rate
Operating Costs		
Electricity ($/yr)	$87,600	$0.10 kW/hr for 100 kW
Chemicals ($/yr)	$133,187	Acetic and phosphoric acid, ALUM, polymer
Maintenance ($/yr)	$20,000	8 hours/week, one operator
Subtotal Operating Costs ($/yr)	**$240,787**	
Amortized Capital Cost ($)/AF	**$128**	30 years, 4.9% bonding rate
Operating Cost ($)/AF	**$149**	
Total Annualized Cost ($)/AF	**$277**	
Ammortized Capital Cost ($)/kilogram of perchlorate treated	**$103**	
Operating Cost ($)/kilogram of perchlorate treated	**$121**	
Total Cost ($)/kilogram of perchlorate treated	**$224**	

Table 7.4 IX full-scale treatment system cost at 1000 gpm* and CLO_4= 50 µg/L.



Cost Estimate for 1,000 gpm IX System **O_2 = 6 mg/L, NO_3 = 28 mg/L, CLO_4 = 50 µg/L** **Sulfate = 20 mg/L, TDS = 300 mg/L**	**Cost**	**Notes**
Process Equipment Purchased Cost		
Capital Equipment Cost	$500,000	
Spare parts allowance	$0	No spare parts
Equipment Off Loading and Setting Allowance	$0	Assume in contractors time below
Freight Allowance	$0	
Subtotal Adjusted Purchased Equipment Cost	**$500,000**	
Contractor Installation Costs by Discipline		
Installation Disciplines		
Concrete	$2,500	
Above Ground Piping	$12,000	Site dependant
Instrumentation and Controls	$1,500	Included in original pricing
Subtotal Contractor Installation Direct Costs	**$16,000**	
Home Office Costs		
Engineering, Fabrication Assist, Project Mgmt.	$2,000	Included in purchased cost
Installation, Construct Mgmt, Project Mgmt.	$2,800	
Subtotal Home Office Costs	**$4,800**	
Total Equipment Costs	**$500,000**	
Total Contractor Costs	**$16,000**	
Total Home Office Costs	**$4,800**	
Total Installed 1,000 gpm Cost	**$520,800**	
Capital Cost Amortization ($/yr)	**$33,494**	30 yr, 4.9% bonding rate
Operating Costs		Use Perchlorate Selective Resin
Electricity ($/yr)		$0.10 kW/hr
Resin Changeout ($/yr)	$135,000	***See Note below**
Resin Disposal ($/yr)		Included in Resin Changeout
Resin Changeout Labor ($/yr)		Included in Resin Changeout
Maintenance ($/yr)		Generally Provided by Customer
Subtotal Operating Costs ($/yr)	**$135,000**	
Amortized Capital Cost ($)/AF	**$34**	
Operating Cost ($)/AF	**$136**	
Total Annualized Cost ($)/AF	**$169**	
Ammortized Capital Cost ($)/kilogram of perchlorate treated	**$27**	
Operating Cost ($)/kilogram of perchlorate treated	**$110**	
Total Cost ($)/kilogram of perchlorate treated	**$137**	
***Note: System assumed operation of 18 hours/ day 300 days/year (994.3 AF/yr)**		

Table 7.5 FBR full-scale treatment system cost at 1000 gpm, CLO_4= 270 µg/L.



Cost Estimate for 1,000 gpm FBR System **O_2 = 6 mg/L, NO_3 = 28 mg/L, CLO_4 = 270 µg/L** **Sulfate = 20 mg/L, TDS = 300 mg/L**	**Cost**	**Notes**
Process Equipment Purchased Cost		
Capital Equipment Cost	$1,900,000	
Spare parts allowance	$0	No spare parts
Equipment Off Loading and Setting Allowance	$0	Assume in contractors time below
Freight Allowance	$66,000	
Subtotal Adjusted Purchased Equipment Cost	**$1,966,000**	
Contractor Installation Costs by Discipline		
Installation Disciplines		
Concrete	$78,640	
Above Ground Piping	$393,200	
Instrumentation and Controls	$98,300	
Subtotal Contractor Installation Direct Costs	**$570,140**	
Home Office Costs		
Engineering, Fabrication Assist, Project Mgmt.	$550,000	Design of system, fabrication
Engineering, Construct Mgmt, Project Mgmt.	$114,000	Oversight of installation, construction
Subtotal Home Office Costs	**$664,000**	
Total Equipment Costs	**$1,966,000**	
Total Contractor Costs	**$570,140**	
Total Home Office Costs	**$664,000**	
Total Installed 1,000 gpm Capital Cost	**$3,200,140**	
Capital Cost Amortization ($/yr)	**$205,807**	30 yr, 4.9% bonding rate
Operating Costs		
Electricity ($/yr)	$87,600	$0.10 kW/hr for 100 kW
Chemicals ($/yr)	$134,101	Acetic and phosphoric acid, ALUM, polymer
Maintenance ($/yr)	$20,000	8 hours/week, one operator
Subtotal Operating Costs ($/yr)	**$241,701**	
Amortized Capital Cost ($)/AF	**$128**	30 years, 4.9% bonding rate
Operating Cost ($)/AF	**$150**	
Total Annualized Cost ($)/AF	**$277**	
Ammortized Capital Cost ($)/kilogram of perchlorate treated	**$103**	
Operating Cost ($)/kilogram of perchlorate treated	**$121**	
Total Cost ($)/kilogram of perchlorate treated	**$225**	

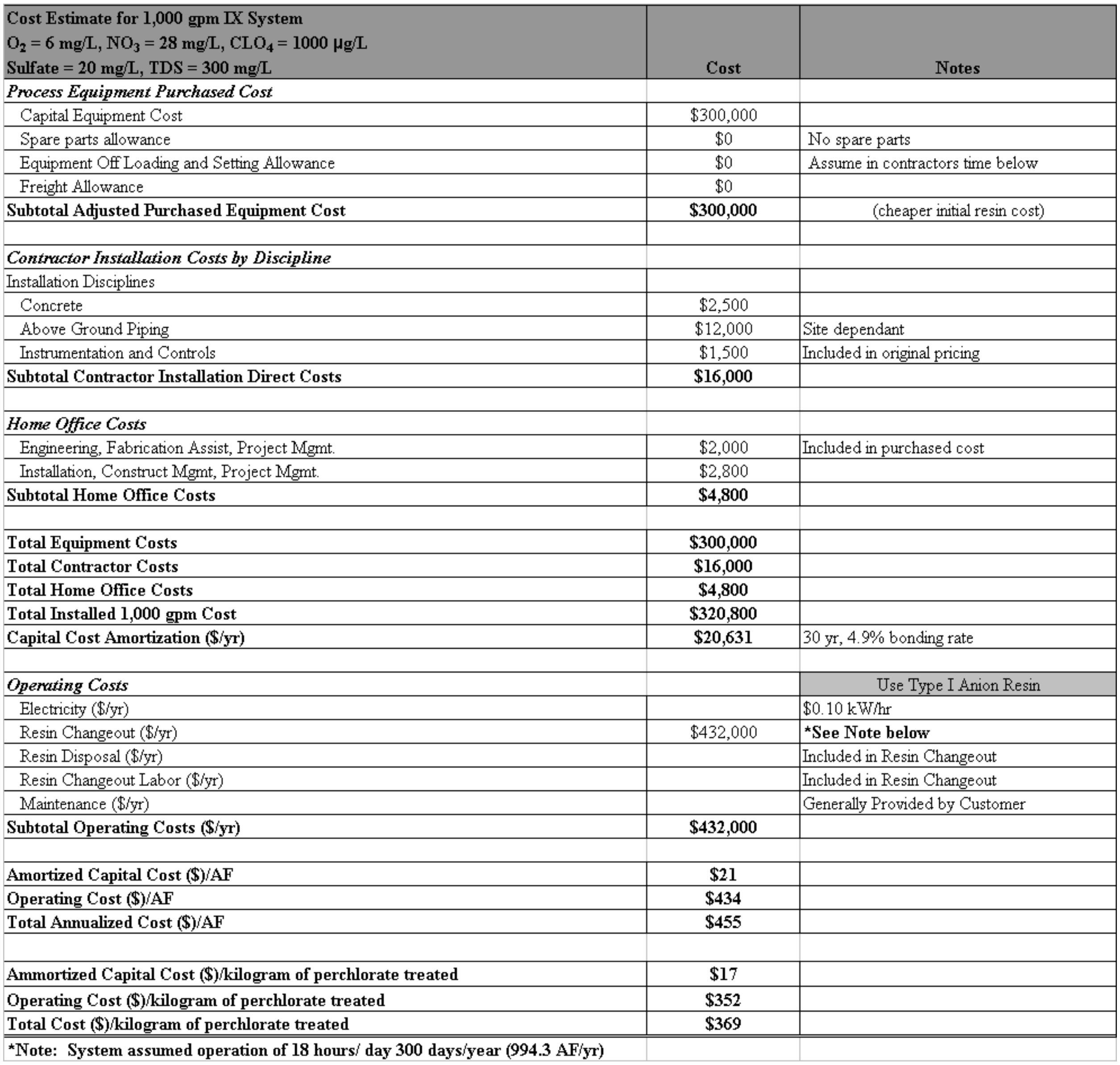
Table 7.6 IX full-scale treatment system cost at 1000 gpm, CLO_4= 270 µg/L.

Cost Estimate for 1,000 gpm IX System **O_2 = 6 mg/L, NO_3 = 28 mg/L, CLO_4 = 270 µg/L** **Sulfate = 20 mg/L, TDS = 300 mg/L**	**Cost**	**Notes**
Process Equipment Purchased Cost		
Capital Equipment Cost	$500,000	
Spare parts allowance	$0	No spare parts
Equipment Off Loading and Setting Allowance	$0	Assume in contractors time below
Freight Allowance	$0	
Subtotal Adjusted Purchased Equipment Cost	**$500,000**	
Contractor Installation Costs by Discipline		
Installation Disciplines		
Concrete	$2,500	
Above Ground Piping	$12,000	Site dependant
Instrumentation and Controls	$1,500	Included in original pricing
Subtotal Contractor Installation Direct Costs	**$16,000**	
Home Office Costs		
Engineering, Fabrication Assist, Project Mgmt.	$2,000	Included in purchased cost
Installation, Construct Mgmt, Project Mgmt.	$2,800	
Subtotal Home Office Costs	**$4,800**	
Total Equipment Costs	**$500,000**	
Total Contractor Costs	**$16,000**	
Total Home Office Costs	**$4,800**	
Total Installed 1,000 gpm Cost	**$520,800**	
Capital Cost Amortization ($/yr)	**$33,494**	30 yr, 4.9% bonding rate
Operating Costs		Use Perchlorate Selective Resin
Electricity ($/yr)		$0.10 kW/hr
Resin Changeout ($/yr)	$253,800	***See Note below**
Resin Disposal ($/yr)		Included in Resin Changeout
Resin Changeout Labor ($/yr)		Included in Resin Changeout
Maintenance ($/yr)		Generally Provided by Customer
Subtotal Operating Costs ($/yr)	**$253,800**	
Amortized Capital Cost ($)/AF	**$34**	
Operating Cost ($)/AF	**$255**	
Total Annualized Cost ($)/AF	**$289**	
Ammortized Capital Cost ($)/kilogram of perchlorate treated	**$27**	
Operating Cost ($)/kilogram of perchlorate treated	**$207**	
Total Cost ($)/kilogram of perchlorate treated	**$234**	
***Note: System assumed operation of 18 hours/ day 300 days/year (994.3 AF/yr)**		

Table 7.7 FBR full-scale treatment system cost at 1000 gpm, CLO_4= 1000 µg/L.

Cost Estimate for 1,000 gpm FBR System **O_2 = 6 mg/L, NO_3 = 28 mg/L, CLO_4 = 1000 µg/L** **Sulfate = 20 mg/L, TDS = 300 mg/L**	**Cost**	**Notes**
Process Equipment Purchased Cost		
Capital Equipment Cost	$1,900,000	
Spare parts allowance	$0	No spare parts
Equipment Off Loading and Setting Allowance	$0	Assume in contractors time below
Freight Allowance	$66,000	
Subtotal Adjusted Purchased Equipment Cost	**$1,966,000**	
Contractor Installation Costs by Discipline		
Installation Disciplines		
Concrete	$78,640	
Above Ground Piping	$393,200	
Instrumentation and Controls	$98,300	
Subtotal Contractor Installation Direct Costs	**$570,140**	
Home Office Costs		
Engineering, Fabrication Assist, Project Mgmt.	$550,000	Design of system, fabrication
Engineering, Construct Mgmt, Project Mgmt.	$114,000	Oversight of installation, construction
Subtotal Home Office Costs	**$664,000**	
Total Equipment Costs	**$1,966,000**	
Total Contractor Costs	**$570,140**	
Total Home Office Costs	**$664,000**	
Total Installed 1,000 gpm Capital Cost	**$3,200,140**	
Capital Cost Amortization ($/yr)	**$205,807**	30 yr, 4.9% bonding rate
Operating Costs		
Electricity ($/yr)	$87,600	$0.10 kW/hr for 100 kW
Chemicals ($/yr)	$135,977	Acetic and phosphoric acid, ALUM, polymer
Maintenance ($/yr)	$20,000	8 hours/week, one operator
Subtotal Operating Costs ($/yr)	**$243,577**	
Amortized Capital Cost ($)/AF	**$128**	30 years, 4.9% bonding rate
Operating Cost ($)/AF	**$151**	
Total Annualized Cost ($)/AF	**$279**	
Ammortized Capital Cost ($)/kilogram of perchlorate treated	**$103**	
Operating Cost ($)/kilogram of perchlorate treated	**$122**	
Total Cost ($)/kilogram of perchlorate treated	**$226**	

Table 7.8 IX full-scale treatment system cost at 1000 gpm* and CLO_4= 1000 µg/L.



Cost Estimate for 1,000 gpm IX System **O_2 = 6 mg/L, NO_3 = 28 mg/L, CLO_4 = 1000 µg/L** **Sulfate = 20 mg/L, TDS = 300 mg/L**	**Cost**	**Notes**
Process Equipment Purchased Cost		
Capital Equipment Cost	$300,000	
Spare parts allowance	$0	No spare parts
Equipment Off Loading and Setting Allowance	$0	Assume in contractors time below
Freight Allowance	$0	
Subtotal Adjusted Purchased Equipment Cost	**$300,000**	(cheaper initial resin cost)
Contractor Installation Costs by Discipline		
Installation Disciplines		
Concrete	$2,500	
Above Ground Piping	$12,000	Site dependant
Instrumentation and Controls	$1,500	Included in original pricing
Subtotal Contractor Installation Direct Costs	**$16,000**	
Home Office Costs		
Engineering, Fabrication Assist, Project Mgmt.	$2,000	Included in purchased cost
Installation, Construct Mgmt, Project Mgmt.	$2,800	
Subtotal Home Office Costs	**$4,800**	
Total Equipment Costs	**$300,000**	
Total Contractor Costs	**$16,000**	
Total Home Office Costs	**$4,800**	
Total Installed 1,000 gpm Cost	**$320,800**	
Capital Cost Amortization ($/yr)	**$20,631**	30 yr, 4.9% bonding rate
Operating Costs		Use Type I Anion Resin
Electricity ($/yr)		$0.10 kW/hr
Resin Changeout ($/yr)	$432,000	***See Note below**
Resin Disposal ($/yr)		Included in Resin Changeout
Resin Changeout Labor ($/yr)		Included in Resin Changeout
Maintenance ($/yr)		Generally Provided by Customer
Subtotal Operating Costs ($/yr)	**$432,000**	
Amortized Capital Cost ($)/AF	**$21**	
Operating Cost ($)/AF	**$434**	
Total Annualized Cost ($)/AF	**$455**	
Ammortized Capital Cost ($)/kilogram of perchlorate treated	**$17**	
Operating Cost ($)/kilogram of perchlorate treated	**$352**	
Total Cost ($)/kilogram of perchlorate treated	**$369**	
***Note: System assumed operation of 18 hours/ day 300 days/year (994.3 AF/yr)**		

7.3.1 FBR System

A complete FBR treatment system to meet all CCR Title 22 requirements is detailed. For all perchlorate conditions (50 µg/L, 270 µg/L, and 1000 µg/L), the same full-scale FBR treatment system is utilized. The plant consists of two full-scale fluidized bed bioreactors, 11.5 feet in diameter and 24 feet tall, constructed with welded, 304 stainless steel to API-650, including sidewall anchor chairs, open top design and full stainless steel flat floor plate with access ladder, and a deck grating and handrail on roof. Included with each FBR is a fluidization pump, an influent distribution system, and effluent/biomass collection system, two biomass separators, 31,000 pounds of carbon media (coconut based), and a chemical feed system. Provided for the entire plant is a systems controls package that includes a NEMA 4 control panel, with system motor controls, Allen-Bradley SLC Series PLC with operator interface, and any required transformers or power supply. Online perchlorate and nitrate analysis with feed forward control of electron donor is provided. Reuse of the instruments and the sampling system from the demonstration plant will occur.

Following the FBR, the first-stage of the surface water treatment plant equipment consists of one post aeration vessel, aeration grid, and blowers that will be provided to increase the oxygen content of the anoxic water. The post-aeration vessel is 14 feet diameter, 24 feet tall, open top, and constructed of welded 304 stainless steel to API-650. The vessel contains an influent aeration system that includes aeration distributors. The aeration blower is a rotary lobe positive displacement blower capable of 66 scfm @12 psig.

After the post-aeration vessel, the next stage consists of two Siemens Trident Multimedia Filters operating in parallel and capable of each treating 500 gpm of forward flow. One filter feed pump, with inverter duty motor with variable frequency drive, rated for 1400 gpm at 30 feet of total discharge head (TDH) is supplied. A complete chemical feed system for coagulant and polymer addition is also being included. Coordinated operation between the FBR and Trident Filter is programmed through the main PLC. Water from the multimedia filters is delivered by gravity to a 45,000 gallon concrete filter effluent tank (provided by others during installation). This concrete filter effluent tank provides clean multimedia filter backwash water via a centrifugal pump rated at 2380 GPM @ 80 feet TDH. Forward feed from the filter effluent sump is provided by an effluent pump rated for 1400 GPM @ 120 feet TDH. Backwash water from the multimedia filter drains by gravity to a 45,000 gallon concrete dirty backwash tank (provided by others during installation). A centrifugal backwash pump, rated at 140 gpm @ 58 feet TDH, l supplies solids-laden water to a solids separator tank for eventual disposal.

Forward feed from the filter effluent tank proceeds to a UV disinfection reactor provided by Calgon, Trojan, Inc., or an equivalent. The UV system design will meet a three log reduction of *Cryptosporidium* using three medium pressure 4 kW lamps/unit. The system comes equipped with a PLC controller with touch-screen HMI and automatic cleaning system. From the UV system, the water is ready for recharge or chlorination for distribution as potable water.

For the implementation of such a treatment plant, the documentation for the project includes:

(1) Process description
(2) Process flow diagrams
(3) Material balance
(4) Piping and instrumentation diagrams
(5) Utility requirements
(6) Equipment and instrument cut sheets for Basin Water supplied equipment/instruments
(7) General layout diagrams
(8) Detailed layouts for skidded equipment and vessels
(9) Electrical design drawings for the control panels
(10) Functional control specification and detailed process specification
(11) Equipment and instrument cut sheets
(12) Project schedule for Basin Water, Inc. scope

The provided costs reflect all project administration, reporting, oversight of subcontracted services, preparation of Operating and Maintenance Manuals and progress reports, installation supervision of major equipment, attendance at all project meetings, system mechanical shakedown and hydraulic testing, process startup, and initial operational training. In addition, an estimate of system installation costs that will be required at a particular site are also provided. These costs include both in-house and subcontractor work.

7.3.2 Ion Exchange Treatment System

Two different ion exchange (IX) systems were quoted by Siemens Water Technologies Corporation to treat the three perchlorate condition streams (50 µg/L, 270 µg/L, and 1000 µg/L). Both systems utilize throw away ion exchange resins. The complete turn-key system treating either 50 or 270 µg/L of perchlorate consists of two 12-foot High-Flow vessels in a lead/lag configuration, containing a perchlorate selective resin. The complete turn-key system treating 1000 µg/L of perchlorate consists of a lead/lag train of two 12 foot diameter HP® 1220 adsorbers, constructed of carbon steel. The resin utilized for this higher perchlorate concentration is a Type I anion resin. Siemens Water Technologies Corporation provided an estimate for the higher perchlorate condition, but placed the caveat that they would not recommend this technology for such an application. No further detailed information about the systems was provided. A typical ion exchange vessel configuration and set-up is shown in Figure 7.1.

For the ion exchange scenarios presented, minimal installation and construction management oversight costs were provided. No maintenance costs were provided.

Figure 7.1 Typical ion exchange technology set-up with a lead/lag vessel configuration (Photo courtesy of Siemens Water Technologies Corporation).

7.3.3 Cost Comparison of FBR versus IX

Difficulties arise in comparing any technology costs for applications where all costs are not accounted equally. Three main issues must be addressed when comparing the data provided in Tables 7.3-7.8:

- The FBR system was quoted as a continually operating system at 1000 gpm (1613 acre·feet/yr). For the IX cost estimates, the systems were quoted at 1000 gpm with 62% operational time (18 hours/day, 300 days per year). This assumption produces 994.3 acre·feet/yr. The technology cost estimates take this difference in acre·feet/yr into account when normalizing the data for $cost/AF and $cost/kg of perchlorate treated.
- The provided FBR treatment system costs detail substantial installation, construction oversight, and maintenance costs. For IX, such costs are not included in the estimates.
- IX quoted costs assumed wellhead pumping, site preparation, site improvements, structural steel, underground piping and electrical, above ground electrical, insulation, painting, paving, construction equipment, overhead, and fees were the responsibility of the client and were not provided as part of the equipment package. Hence, in order to provide as close a cost comparison for the FBR and the IX technology, these costs were not included in the evaluation of either technology and assumed to be similar.

For these reasons, all of the costs provided in Tables 7.3-7.8 must not be construed as directly comparable. However, a general analysis of the costs can be undertaken and trends discovered as they relate to different perchlorate concentrations:

- Capital costs for IX are lower compared to the FBR treatment system regardless of the perchlorate concentration treated ($17-27/kg of perchlorate treated compared with $103/kg of perchlorate treated).
- Operating costs are comparable at the lower perchlorate concentration of 50 µg/L (FBR: $121/kg of perchlorate treated, IX: $110/kg of perchlorate treated).
- At a perchlorate concentration of 50 µg/L, the IX technology has lower capital costs ($27/kg of perchlorate treated) making the IX technology overall more cost effective than the FBR (total cost IX: $137/kg of perchlorate treated, total cost FBR: $224/kg of perchlorate treated).
- Minimal FBR treatment system operating cost changes occur when treating either 50 µg/L, 270 µg/L or 1000 µg/L perchlorate concentration (operating cost difference is less than $2/kg of perchlorate treated between 50 and 1000 µg/L). Capital costs remain the same.
- At a perchlorate concentration of 270 µg/L, the FBR treatment system operating costs ($121/kg of perchlorate treated) are significantly lower than the IX operating costs ($207/kg of perchlorate treated). This tips the overall economics of total cost for treatment slightly in favor of the FBR treatment system ($225/kg of perchlorate treated) compared to the IX system ($234/kg of perchlorate treated). Based on this finding, a rough estimate of the crossover where the FBR total treatment costs are less than IX is 200-250 µg/L of perchlorate. This assumption is based on the specific nitrate conditions presented (28 mg/L). If this nitrate value increases, the perchlorate treatment concentration at which the FBR total treatment costs will be more economical than IX will be less than 200 µg/L of perchlorate.
- At a perchlorate concentration of 1000 µg/L, the FBR treatment system operating costs ($122/kg of perchlorate treated) are significantly lower than the IX operating costs ($352/kg of perchlorate treated). This tips the overall economics of total cost for treatment strongly in favor of the FBR treatment system ($226/kg of perchlorate treated) compared to the IX system ($369/kg of perchlorate treated).
- All costs provided for the FBR treatment system were not provided in the IX quotes (maintenance, construction management, etc.). If such costs were fully developed for the IX cost, the overall IX total costs would be higher than the values provided.

The provided costs in Tables 7.3-7.8 are for a given set of conditions and the general trends are only comparable for the specific site conditions quoted. An increase in nitrate, sulfate, and/or TDS concentrations will affect both the FBR treatment and IX system operating costs. For the FBR, more chemical costs will be required. For the IX system, it is possible that a different, more expensive resin will be required and more resin will be used.

8.0 Implementation Issues

For this demonstration study, the implementation of the FBR treatment system to treat contaminated groundwater to drinking water has been shown to be possible and effective. Future implementation of the technology requires that the necessary permitting regulations are met, end user concerns are addressed, and lessons learned during the demonstration are implemented at the next scaled-up level.

8.1 Regulations

For all drinking water systems installed in the United States, the Environmental Protection Agency has established regulations under the United States Safe Drinking Water Act that must be complied. Under the National Primary Drinking Water Regulations (40 CFR part 141), these regulations include, but are not limited to:

- Surface Water Treatment Rule
- Interim, Long Term 1, and 2 Enhanced Surface Water Treatment Rules
- Stage 1 and 2 Disinfection By-Product Rule
- Total Coliform Rule
- Groundwater Rule
- Lead and Copper Rule

All new and/or existing drinking water production plants are required to comply with these regulations. Under certain circumstances, statewide regulatory agencies are provided primacy to implement these regulations. In the event that regulations do not exist for a particular contaminant or a state determines that a more restrictive regulation is required, such authority to develop new or more stringent regulations is provided to each individual state by the federal government. The CADPH serves as the primacy agent within the State of California. In some cases, compared to the federal limits, the State of California has more stringent primary and secondary MCLs established under the Title 22 California Code of Regulations. Hence, any implementation of a drinking water production plant in the State of California will require that all Title 22 regulations are met.

In addition to meeting all of the regulatory requirements of Title 22, the CADPH has imposed a number of conditions on the FBR treatment technology as a means to produce potable drinking water. Appendix B lists these conditions. The focus of this demonstration study was to evaluate these key conditions imposed by the CADPH such that implementation at the next level would be facilitated more easily (performance objectives of Section 3.0). This demonstration study provided the necessary data to establish the technologies effectiveness to succeed at the next level: a full-scale FBR treatment plant.

In implementing a full-scale FBR treatment plant in the Rialto-Colton basin, the CADPH will require that a domestic water supply permit is submitted and approved. This permit submittal will require a formal application and a technical report with sufficient information to demonstrate that the new drinking water plant can provide consistent, quality potable water. Portions of this report generated for this demonstration study can be utilized to meet the requirements of the technical report submittal to the CADPH. From such a submittal, the CADPH will prepare an engineering evaluation report that will detail the water source, extent of contamination, contaminant migration, and effect on the aquifer. From this report, recommendations are developed for the domestic water supply permit that describe the treatment train, the specific operating regimes, and required monitoring program.

In the State of California, an additional safeguard for utilizing the best source of available water for any drinking water plant has been established under the DPH Memorandum 97-005 Policy Guidance for Direct Domestic Use of Extremely Impaired Sources. For the Rialto-Colton Basin, where multiple contaminants potentially exist (i.e., nitrate, perchlorate, TCE, etc.), this permitting policy may be required if the groundwater meets one or more of the following criteria:

- Exceeds 10 times an MCL or notification level (NL) based on chronic health effects
- Exceeds 3 times an MCL or NL based on acute health effects
- 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

Other states may have comparable policies. The DPH 97-005 policy defines a 12 step procedure that must be followed before a domestic water supply permit may be issued:

- Source water assessment performed
- Raw water quality characterization performed
- Source protection program developed
- Effective monitoring and treatment developed
- Develop health risks with proposed treatment failure
- Alternative source identification and comparison of potential health risks
- Completion of California Environmental Quality Act review
- Permit application completion
- Public hearing
- DPH evaluation
- DPH approval requirement
- Issuance or denial of permit

At a minimum, any technology chosen to be utilized in treating an impaired resource must be approved by the CADPH. In establishing the MCL for perchlorate in drinking water, the CADPH was required to establish those technologies that were considered Best Available Control Technology (BACT) for treating perchlorate-contaminated water to drinking water. For the State of California, the FBR technology is one of only two treatment technologies listed within the California Code of Regulations as a BACT for treating perchlorate-contaminated water to drinking water (CCR, Title 22, Chapter 15, Section 64447.2). Hence, the FBR treatment plant will be a technology that can meet the requirements of the DPH Memorandum 97-005 for a domestic water supply permit.

Under a new addition to the Title 22 California Code of Regulations, permitting of a new drinking water plant requires that NSF approval of all chemical additives and equipment be conducted. All chemical additives utilized throughout the demonstration project were NSF-60 approved. The majority of the equipment demonstrated was NSF-61 certified or constructed of materials that are NSF-61 certified. Basin Water, Inc.'s design approach for the full-scale FBR treatment plant is to build the process from NSF-61 certified components to the fullest extent possible. Basin Water, Inc. is actively pursuing an application with NSF to certify the internal components of the biological FBR for use in drinking water systems. For unit operations that are not listed with the NSF, Basin Water, Inc. is requiring that stainless steel be used for wetted surfaces. This requirement was chosen because NSF normally does not require toxicological tests for stainless steel components.

Finally, additional permits that will be required in the implementation of the plant will include a publicly owned treatment works discharge permit, a National Pollution Discharge Elimination System (NPDES) permit if water is discharged to the surface for any period of time, and typical construction permits with the local municipalities.

8.2 End User Concerns

The primary end-users of this technology are expected to be municipalities that provide drinking water to its constituents. Additional stakeholders with interest in this FBR technology demonstration include the California Department of Public Health, the California Regional Water Quality Control Board, the Environmental Protection Agency, and the Department of Defense. The general concerns for all of the end users include: (1) technology performance; (2) technology cost; (3) ease of operation; (4) technology robustness; and the (5) effluent water quality. These issues, with guidance from the City of Rialto and CADPH, were effectively addressed and demonstrated throughout the study. The concerns are reflected in the performance objectives that are described in Sections 3.0 and 6.0.

Considerable process development has been implemented to ensure that the FBR treatment plant supplies a consistent supply of potable water. Using only NSF-60 compliant additives, constant on-line instrumentation to ensure contaminant removal, and a sophisticated model to adequately monitor and respond to process changes/requirements, the FBR treatment system is proven to be a robust, dependable treatment technology for perchlorate treatment. The use of biological reactors in the United States is a novel concept, but not without precedent (Evans et al., 2008). With recent developments of indirect potable water reuse occurring throughout the United States, the concept of biological treatment at wastewater treatment plants to eventually produce potable water is gaining continual acceptance (Athavaley, 2008).

The FBR treatment system technology is a custom built system and is not considered a commercially-off-the-shelf technology. However, numerous systems of varying size have been previously built and installed elsewhere treating more than 9 million gallons of perchlorate contaminated water to non-detect every day. Thus, the future procurement of an expanded system should not be considered problematic and a typical environmental/civil engineering firm will be able to scale-up and apply this technology in the field. The FBR treatment technology is not considered proprietary. However, specific components of the FBR are considered proprietary or are patented by Basin Water, Inc. These components include the FBR vessel distribution headers, the biomass removal system, the on-line water sampling system used in conjunction with the perchlorate analyzer, and the control logic for the electron donor addition by the PLC. Other system components of the overall FBR treatment system (i.e., SIEMENS Trimite multimedia System) are considered proprietary or patented by others.

In implementing the full-scale FBR treatment system, a number of typical project issues will need to be addressed by those stakeholders involved in the implementation of this drinking water production process. These include:

- Land acquisition for the site of plant
- Site surveying and soil analysis
- Project civil, electrical, and mechanical engineering for plant fabrication/installation
- Preparation of sub-contractor bidding documents for fabrication/installation
- Project management and engineering during fabrication/installation
- Fabrication/installation labor, equipment, and materials
- Geotechnical engineering for production/reinjection well installation
- Preparation of well and water conveyance subcontractor bidding documents
- Drilling/installation of production and or reinjection wells (as necessary)
- Engineering design for water conveyance to/from the plant
- Water conveyance system (piping, booster pumps, labor, etc.)
- Drinking water permitting (possibly DPH 97-005 Permit)
- Other permitting required for installation and water conveyance
- Addition of a TCE removal system (if necessary)
- Chlorination system for treated effluent water prior to distribution
- Operation and maintenance of plant

The implementation of such a “first-of-its-kind” technology to treat contaminated groundwater, rather than simply rely on phase transfer, to drinking water standards can serve as a new paradigm of water treatment for significantly impaired resources. With quality supplies of water rapidly declining throughout the United States, and existing supplies often hindered by multiple contaminants, the implementation of such a biological treatment plant can be effectively used for multiple contaminant removal to drinking water standards.

8.3 Lessons Learned

Over the course of the demonstration project that entailed eight months of design, three months of installation, and one year of operation, a number of lessons were learned in implementing the technology for the next level. Many of these issues are addressed in detail throughout prior sections of the report.

In summary, the design/equipment lessons include:

- The nitrate analyzer system should be refined in its design. Only one nitrate analyzer should be required on line. A solenoid that can be turned on for feed or on for effluent sample analysis should be implemented. This can be programmed into the system to allow the operator to switch which line will be sampled. Based on the demonstration study results, the influent nitrate values do not change drastically enough to effect removal performance. Hence, only periodic analysis of the feed nitrate is required. At all other times, the one nitrate analyzer can measure the effluent water. Also, it is best to have one back-up instrument available at all times.

- A pre-filter is required prior to the Collins Filter for perchlorate analysis of the FBR effluent and Trimite multimedia filter effluent. These pre-filter(s) should be easily accessible and allow for a quick removal and clean-out operation.

- A pre-filter is required prior to the nitrate analyzer to prevent excessive biomass growth within the analyzer. This pre-filter should be easily accessible and allow for a quick removal and clean-out operation.

- Depending on the feed oxygen conditions, multiple eductors will be required for the full-scale unit. Potentially, multiple biomass separators will be required as well. The biomass separator was found to be more effective in the control of the fluidized bed height.

- Remote access of both the system PLC program and of the Dionex instrument interface should be available. This dual access will allow cross reference between both systems in case a false positive alarm is generated (i.e., perchlorate exceeded).

- For all additives, the suction to the pumps should be at the base of the additive tank. Replace diaphragm pumps with electric metering pumps for reliability. Loss in prime occurred too frequently with diaphragm pumps. Also, the diaphragm pumps lost volumetric consistency/capacity over time. Dual metering pumps for all chemical additives should be implemented to ensure that a stoppage of chemical additives does not occur.

- Per discussions with CADPH, the availability of NSF 61 analyzer equipment for the FBR treatment system does not exist (i.e., pH and ORP probes, nitrate analyzers, etc.). Hence, until a manufacturer establishes such NSF approved probes, non-NSF approved probes can and will be utilized within the system.

- The nitrate analyzer should discharge into the perchlorate sump tank. The water could possibly be returned to the front of the system, as long as no chemicals are added to the water. If it is returned to the process directly, a pressure regulator will be needed to prevent pressurizing the nitrate analyzer (which is what occurred at the demonstration scale).

- Post-aeration blower should be isolated away from any buildings and be surrounded by a soundproof box.

- Further design is needed with the programming to prevent the unintentional release of adsorbed perchlorate (from the Trimite multimedia filter) into the effluent of the plant. Logic is needed to test both the FBR effluent and Trimite effluent before the system is brought out of System Recycle to Run Mode. This will be important during start-up and any upset conditions.

- Manufacturer support of the on-line instrumentation (nitrate and Dionex analyzers) is warranted as a preventive maintenance measure.

In summary, the operational/process lessons include:

- Groundwater hydrology is essential to characterize and understand for the particular well that that water is being extracted. The City of Rialto Well #2 was characterized before a new submersible extraction pump was placed within the wellhead casing. However, oxygen concentrations increased significantly compared with prior characterized data from this well because of the cone of influence and location of the submersible pump. Such characterization is critical in sizing additional equipment (i.e, load equalization tanks, conveyance pumps, etc.) for effective treatment by an FBR treatment plant.

- The interruption of forward feed flow to the plant is more detrimental to the system performance in the early stages of bed biofilm maturation. In general, plant interruptions should be kept at a minimum in the first sixty days of operation in order to maximize perchlorate removal performance.

- If the oxygen concentrations are near saturation, the control of bed height using both the in-bed eductor and the biomass separator is required. Under such conditions, the amount of biological solids generated from the FBR effluent of the plant is sufficiently high enough that the addition of a coagulating and flocculating agent are required.

- For 50 gpm flow at a FBR HRT of 12.2 minutes, the electron donor requirements were established at 14.5 mL/min of 50% acetic acid (16.2 mg/L as Carbon) for the treatment of 6.1 mg/L of nitrate-nitrogen, 8.1 mg/L of oxygen, and 50 µg/L of perchlorate. This quantity of electron donor incorporated 20-25% excess beyond stoichiometric requirements to account for abiotic loss and microbial biomass incorporation. A minimal DOC and orthophosphate-phosphorus FBR effluent residual should be maintained at 2 mg/L and 1 mg/L, respectively.

- The formation of pathogenic microorganisms across the FBR and multimedia filter were not observed during the demonstration. A CT of 4 mg/L·min or a UV contact time of 6 seconds via a low-intensity (40 mJ/cm^2) lamp was required to effectively disinfect the FBR treatment system water.

9.0 References

Aerojet. 2003. Personal Communication.

Athavaley, Anjali. 2008. *The Wall Street Journal*, May 23, 2008.

Brown, J., R. Anderson, J. Min, L. Boulos, D. Prasifka, G. Juby, and S. McLean. 2004. *The 2004 Perchlorate in California's Groundwater GRA Symposium*. Glendale, CA.

Brown, J.C., Anderson, R.D., Min, J.H., Boulos, L., Prasifka, D., and G.J.G. Juby, 2005. *Jour. AWWA*, 97:9:70.

California EPA, Department of Toxic Substances Control. 2004. *Perchlorate Contaminant Treatment Alternatives-Draft*. Version 1.01.

Coates, J. D. and L.A. Achenbach. 2004. *Nature Rev. Microbiol*. 2: 569-580.

Coates, J. D., U. Michaelidou, R.A. Bruce, S.M. O'Conner, J.N. Crespi, and L.A. Achenbach. 1999. *Applied and Environmental Microbiology*. 65: 5234-5241.

Delvecchio, M., A.P. Togna, and T.S. Webster. 2005. *Proceedings of the 78th Annual Water Environment Federation's Technical Exhibition and Conference*. Washington D.C.

Evans, P.J., Dodrill, D., Schulz, C., Opitz, E., Blaha, F., and J. Albert. 2008. *2008 Battelle Conference on the Remediation of Chlorinated and Recalcitrant Compounds*, Monterey, CA.

GeoLogic Associates. 1997. *Phase II Off-Site Evaluation Monitoring Program and Engineering Feasibility Study, Mid-Valley Sanitary Landfill, November.*

GeoLogic Associates. 2003. *Evaluation of Perchlorate Impacts to Soils and Groundwater Near Former Bunker Area, Rialto, California, Volumes I-III, October*.

GeoLogic Associates. 2005. *Groundwater Monitoring Well Installation Report, Rialto Airport GWTS, San Bernardino County, California, November.*

Geosyntec Consultants. 2007. *Goodrich Corporation Progress Report for the Month of September, 2007, 160-Acre Parcel, Rialto, California.*

Hatzinger, P. 2005. *Environmental Science and Technology*. 39(11): 239A-247A.

Kengen, S. W. M., G.B. Rikken, W.R. Hagen, C.G. van Ginkel, and A.J.M. Stams. 1999. *J. Bacteriol.* 181: 6706-6711.

Massachusetts DEP. 2006. Website at http://www.mass.gov/dep/public/press/pchl0706.htm. Accessed August, 2006.

OMB (Office of Management and Budget), 2008. Website at www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html.

Song, Y, and B.E. Logan. 2004. *Water Resources*. 38: 1626-1632.

Sutton, P. M. and P.N. Mishra. 1994. *Water Science & Technology*. 29: 309-317.

Togna, A.P., W.J. Guarini, S. Frisch, M. Del Vecchio, J. Polk, C. Murray, D.E. Tolbert. 2001. In A. Leeson (ed.), *Bioremediation of Inorganic Compounds (The Sixth International In Situ and On-Site Bioremediation Symposium, San Diego, CA)*. 6(9): 281-288. Battelle Press, Columbus, OH.

Univar, Personal Communication. 2008.

U.S. Environmental Protection Agency, Office of Research and Development. 1993. *Nitrogen Control Manual*. EPA/625/R-93/010. Washington, D. C.

U.S. Environmental Protection Agency, Office of Research and Development. 2002. *Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization*. External Review Draft. NCEA-1-0503.

Wagner, N., and C. Drewry. 2000. Proceedings from the Perchlorate Technology Workshop, August 22 – 24, 2000, San Antonio, TX.

Webster, T.S., W.J. Guarini, and S. McLean. 2004. *2004 Battelle Conference on the Remediation of Chlorinated and Recalcitrant Compounds*, Monterey, CA.

West Valley Water District, 2008. Personal Communication.

Woolfenden, L.R., and Kadhim, D. 1997. *Geohydrology and Water Chemistry in the Rialto-Colton Basin, San Bernardino County, California United States Geological Survey Water Resources Investigation Report 97-4012.*

Wu, J., R.F. Unz, H. Zhang, and B.E. Logan. 2001. *Bioremediation Journal*. 5: 119-130.

Zhang, H., M.A. Bruns, and B.E. Logan. 2002. *Environmental Microbiology*. 4: 570-576.

APPENDICES

Appendix A: Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone/Fax/email	Role in Project
Todd S. Webster	Basin Water, Inc. 4777 Winona Avenue San Diego, CA 92101	P: 619-286-2587 F: 619-286-2587 Twebster@basinwater.com	Co-Principal Investigator/Field Project Manager
A. Paul Togna	Basin Water, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5375 F: 609-895-1858 Atogna@basinwater.com	Co-Principal Investigator
Mike. Delvecchio	Basin Water, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5346 F: 609-895-1858 mdelvecchio@basinwater.com	Chief Engineer
Douglas Watt	Basin Water, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5377 F: 609-895-1858 dwatt@basinwater.com	Lead Process Engineer
Sam Wong	Shaw Environmental, Inc.	P: 626-497-5076 sam.wong@shawgrp.com	Field Engineer

Todd S. Webster

1-19-09

Signature

Date

Appendix B. CADPH Conditional Acceptance Letter of FBR Technology

State of California—Health and Human Services Agency

Department of Health Services

California
Department of
Health Services

DIANA M. BONTÁ, R.N., Dr. P.H.
Director

GRAY DAVIS

April 2, 2002

Mr. Donald E. Vanderkar
Director, Environmental Restoration Programs
Aerojet
P.O. Box 13222
Sacramento CA 95813-6000

Dear Mr. Vanderkar:

CONDITIONAL ACCEPTANCE OF BIOLOGICAL TREATMENT (FLUIDIZED BED REACTORS) FOR THE REMOVAL OF PERCHLORATE DURING DRINKING WATER PRODUCTION

The Water Treatment Committee (WTC) of the Drinking Water Program in the California Department of Health Services has reviewed the following documents submitted with your request to gain acceptance of biological treatment (fluidized bed reactors) as a means of removing perchlorate from source waters for distribution as part of the public water supply.

"Final Phase 2 Treatability Study Report Aerojet GET E/F Treatment Facility Sacramento, California," April 2001, prepared by Harding ESE, Denver, CO.

"Review of Phase 2 Treatability Study Aerojet Facility Rancho Cordova, California," July 2001, by Robert Clark, Ph.D., P.E.; Michael Kavanaugh, Ph.D., P.E; Prof. Perry McCarty, Ph.D., P.E.; R. Rhodes Trussell, Ph.D., P.E.; Jerome B. Gilbert, P.E

The WTC concurs with the recommendations and findings of the Aerojet Expert Panel (AEP). The Department finds that the biological process using a fluidized bed of granular activated carbon for perchlorate removal can be a stable means of removing or reducing perchlorate in source waters provided the perchlorate feed concentration, feed flow, and ethanol feed are carefully monitored and controlled. The system, when operated under stable flow and perchlorate concentration, can produce water that contains nondectable levels of perchlorate. As with any treatment process, reducing contaminants to below a detectable concentration may not be the same as providing absolute removal of the contaminant. Nevertheless, the AEP is clear that they consider

---

Drinking Water Technical Operations Branch, 2151 Berkeley Way, Room 458, Berkeley, CA 94704-1011
(510) 540-2158 FAX (510) 540-2152

the biological process to be capable of perchlorate removal with several important caveats that have been incorporated into the conditions presented below.

Based on the findings of the AEP the WTC recommends conditional acceptance of biological treatment to remove or reduce perchlorate from source water(s) that might be used for potable supply with the following conditions:

1. The system is operated in a manner that minimizes changes in production flow rates (e.g., a plant operated 24 hours a day, 7 days a week, 365 days a year to provide a minimum production of water (base loading)).

2. If variability in flow and composition for extended periods of time cannot be controlled and minimized, then product water should be stored to allow analysis before releasing the water to the distribution system.

3. Site-specific tests are required to determine the impact of seasonal and temporal variations in water quality (temperature, available micro and macro nutrients, etc.) on process performance. For example, it is anticipated the exogenous carbon requirement will vary as a function of source water quality, so the impact(s) of variable nitrate concentrations (in time and magnitude) on finished water quality needs to be evaluated.

4. Source of the microbiological seed must be identified and characterized as not containing human pathogens.

5. All chemicals used in the system must be NSF standard 60 certified by an ANSI accredited laboratory.

6. It is recommended that all components used in the manufacture of the reactor vessel that come into direct contact with the source water be NSF standard 61 certified by an ANSI accredited laboratory.

7. It is also recommended that development continue on a reliable ethanol control system that would allow feed-forward control of the ethanol dose based on measured changes in composition and flow.

8. Treatment following biological perchlorate removal, at a minimum, should meet the pertinent requirements of the Surface Water Treatment Rule (Title 22 of the California Code of Regulations, Div. 4, Chapter 17.

9. On-line monitoring systems for perchlorate and nitrate should be incorporated into process design for improving process control.

10. When appropriate, additional organics removal (e.g., advanced oxidation (UV/H_2O_2) and/or granular activated carbon) can be added at an appropriate location downstream of the FBR as an independent unit treatment process.

11. The WTC extends the conditional acceptance to include the Envirogen fluidized bed reactor (FBR) designed, built, and operated identically to the FBR described in the previously cited reports.

Any modifications proposed to any feature, chemical, part, or product used in this demonstration study of the biological treatment system should be reported (in writing) to the Department in advance of making the changes to any production version of the system sold in California. The detail of your written notification will be reviewed to determine if additional performance testing will be required. The written notice should provide sufficient detail (negative and positive results) to allow the reviewing body to decide whether or not additional studies will be required.

Should additional testing be required, the WTC must review and accept all study protocols before accepting the final report documenting the results of the additional testing. The WTC will also review the final report and, if appropriate, accept and modify any future changes to the design criteria.

Review and formal approval for any proposed design using this technology for individual water systems will be handled on a case-by-case basis by the Drinking Water Program's individual District offices. The individual district offices based on specific site requirements may specify additional unit treatment processes. Approval for the use of your technology in any drinking water application is granted through the domestic water supply permitting process.

An operations plan that includes a protocol for shutdown and cleaning of the FBRs will need to be submitted as part of the drinking water permit application process. Such a protocol should provide documentation (evidence) that the proposed procedure results in the removal of all cleaning chemicals from the FBR and its components before the unit is reassembled or otherwise prepared to return to production.

You are also requested to notify the Department of any changes in the tradename, ownership, or licensing activities of the conditionally accepted FBR. Furthermore, this letter and the conditions of acceptance for the FBR cannot be transferred until the Department receives written notification of any of these activities.

We would like to thank you and your colleagues for working with us during the development and testing of this technology. Having access to your expert panel for discussions during the testing of this technology was also beneficial to improving our understanding of the intricacies of this technology. Should you have any questions regarding the content of this letter, please free to contact me at (510) 849-5050.

Very truly yours,

Original signed by

Richard H. Sakaji, PhD, PE
Senior Sanitary Engineer

cc: WT Committee
chron

Mr. Casey Whittier
Product Manager FBR Systems
Envirex Products
PO Box 1604
1901 South Prairie Ave.
Waukesha, WI 53189

Dr. Todd S. Webster,
Envirogen, Inc.
4777 Winona Ave.
San Diego, CA 92115

Appendix C: Chlorination Disinfection Study Protocol

The following protocol was used to demonstrate the effectiveness of disinfection of finished water from the FBR treatment system. The required level of disinfection is a 4.0-log inactivation of viruses; however, inactivation of other microorganisms potentially present will also be verified. The objectives of the disinfection protocol was to demonstrate:

- The effectiveness of several CT (chlorine concentration multiplied by the contact time) values on the inactivation of microorganisms to achieve disinfection
- Impacts of any variability in finished water quality on disinfection
- The potential for formation of disinfection byproducts (total trihalomethanes [TTHMs] and haloacetic acids [HAA5]).

METHODOLOGY

The testing protocol was completed during three individual testing events:

- After the Feed Shutdown Experiment #2 on the LGAC effluent water (Day 69)
- During steady-state operation on the Trimite effluent water (Day 77)
- After the Electrical Shutdown #1 Experiment (Day 89)

Background Water Quality

The background water quality was established at four locations in the treatment train during each testing event:

1. Raw feedwater
2. Effluent from the FBR
3. Effluent from the Trident multi-media filter
4. Finished water from the liquid GAC reactor

The results of these analyses allowed observations to be made regarding the presence and fate of microorganisms through the FBR treatment train.

Sample quantities were collected and preserved in accordance with approved procedures and as directed by the certified testing laboratory of choice. Each of the samples was tested at an off-site laboratory for presence and quantity of total coliforms, *E.coli*, and heterotrophic plate count (HPC). On-site measurements involved temperature, pH, and turbidity. In addition, the finished water sample from the multimedia filter was analyzed for disinfection byproduct formation potential. Samples were collected and analyzed using the methods provided in Table 1.

Table 1. Analytical Methods

Parameter	Method
Total Coliform	MMO/MUG Quanti-Tray 2000- SM 9223 B
E.Coli	MMO/MUG Quanti-Tray 2000- SM 9223 B
HPC	SM 9215B
TTHM Formation Potential	SM 524.2
HAA5 Formation Potential	SM 6251B
Temperature	On-site hand-held instruments
pH	On-site hand-held instruments
Turbidity	In-line instrument

Virus Inactivation

CT values for viruses were developed as part of the USEPA SWTR Guidance Manual. CT values for 4.0-log inactivation of viruses are listed in Table 2 below as cited from the *Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources* issued by the American Water Works Association (AWWA) in 1991. The required CT is expected to be approximately 4, as determined from Table 2 based on the pH and temperature of the water leaving the City of Rialto Well #2.

Table 2. CT Values for 4.0 Log Inactivation of Viruses by Free Chlorine

	pH	
	6-9	**10**
Temperature (degrees Celsius)	**CT (min-mg/L)**	
0.5	12	90
5	8	60
10	6	45
15	4	30
20	3	22
25	2	15

Bench-Scale Testing

Bench-scale testing was performed to evaluate inactivation of HPC, total coliforms, and *E.coli* over a range of experimental CTs. For each testing event, the final treated water from the Well #2 FBR treatment system (either the LGAC or the Trimite Multimedia Filter effluent) reacted with varying chlorine concentrations in conjunction with varying time periods. The chosen concentrations for chlorine and associated contact times varied after each experimental run depending on witnessed results. For the first experiment, the dosage and reaction times are provided in Table 3. Samples were placed in an incubator at the desired temperature of 15ºC until either the desired temperature was reached or the sample testing began.

Table 3. Chlorine Dosages and Reaction Times

Chlorine Dosage, mg/L	Reaction Time, minutes
0.0 (control)	A control will be used in each of the below concentrations
0.5	0, 4, 10, 30, 100
1.0	0, 4, 10, 30, 100
2.0	0, 4, 10, 30

Per baseline microbiological analysis, it was determined that HPC provided a better indicator of chlorine effectiveness. Hence, total coliform and *E.Coli* were not measured for the bench-scale tests unless noted. Each of the resulting samples of water reacted with chlorine were analyzed for HPC, temperature, pH, turbidity, and free and total chlorine.

Materials

Required materials for each bench-scale test were:

- 10 liter sample volume of final treated water from the Raub-2 FBR treatment system
- A B-KER jar tester 6 two liter beakers
- 5 – one liter amber glass bottles with caps
- stopwatch
- 12.5 percent sodium hypochlorite (NaOCl)
- glass pipettes
- incubator with capability to store bottles at 15ºC-25 ºC (12-140E Incubator, Quincy Lab, Inc., Chicago, IL)
- pH probe with temperature adjustment (HACH SensION, Loveland, CO)
- thermometer (HACH SensION, Loveland, CO)
- In-line turbidimeter (HACH 1720E Low Range Turbidimeter, Loveland, CA)
- Sodium Thiosulfate quenching agent

Procedure

Experiment 1 (LGAC Effluent Water on Day 69)

For Experiment 1, ten liters were acquired from the effluent of the LGAC reactor. The turbidity at the Trimite filter was noted. One liter of sample was placed in each of the six 2-liter beakers for the jar tester. The initial pH and temperature were measured and recorded. An example log sheet for each experiment is provided in Table 4. The sample in beaker 1 was prepared for testing or tested for the parameters of HPC, temperature, pH, turbidity, and free and total chlorine.

Table 4. Sample Log Sheet

Sample	**Time minutes**	**Date**	**Initial pH**	**Temp. °C**	**Final pH**	**Start Time**	**End Time**
1	0						
2	4						
3	10						
4	30						
5	100						
6 (control)	100						
Sample	**Time minutes**	**Turbidity**	**Total Coliform**	**Fecal Coliform**	**HPC CFU/mL**	**Free Chlorine mg/L**	**Total Chlorine mg/L**
1	0						
2	4						
3	10						
4	30						
5	100						
6 (control)	100						

For the 0.5 mg/L chlorine dosage, 4 mL of a 0.0125% NaOCl solution was added to each beaker. The time when the chlorine solution was added was recorded for each beaker. The motor for the jar tester was turned on to 100 rpm for 1 minute and then shut off. At the end of mixing, each sample was transferred to a 1 liter amber glass bottle and capped, headspace-free, and placed into the incubator at 16.6 degrees Celsius to 24.6 degrees Celsius until the required reaction time had been reached. At that point, at least 2.13 mg of sodium thiosulfate ($Na_2S_2O_3$) was added to each bottle to stop the chlorine reaction immediately at the end of each bottle's test time period. The required amount of sodium thiosulfate was calculated based on the highest concentration of chlorine used to ensure that all chlorine was quenched for each test. The final time was recorded. The sample in each beaker was prepared for testing or tested for the parameters of HPC, temperature, pH, turbidity, and free and total chlorine.

Beaker 6 served as a control for each set of tests. It was mixed for 1 minute with no addition of chlorine solution, added to a 1 liter amber glass bottle, and allowed to incubate for a total of 100 minutes. After the 100 minutes has been completed, the chlorine quenching agent was added to maintain consistency with the other beakers.

The above procedure was repeated for chlorine concentrations of 1.0 mg/L and 2.0 mg/L at the reaction times provided in Table 3. For 1.0 mg/L and 2.0 mg/L chlorine concentrations, 8 mL and 16 mL of a 0.0125% NaOCl were added to each beaker, respectively. Fro each amber jar for chlorine concentrations of 1.0 mg/L and 2.0 mg/L, 4.26 and 8.52 mg of sodium thiosulfate ($Na_2S_2O_3$) was added to each bottle to stop the chlorine reaction immediately at the end of each bottle's test time period.

Experiment 2 (Trimite Effluent Water on Day 77)

For Experiment 2, ten liters were acquired from the effluent of the Trimite filter. The procedure was slightly altered from Experiment 1 as it was determined that lower CT's were necessary to achieve sufficient log removal. Hence, only two chlorine concentrations, 0.25 mg/L and 0.5 mg/L, were tested at the reaction times shown in Table 3. For the 0.5 mg/L chlorine concentration, the same amount of sodium hypochlorite and sodium thiosulfate was used as in Experiment 1. For the 0.25 mg/L chlorine concentration, these amounts were linearly cut in half. All other protocol for Experiment 2 followed Experiment 1.

Experiment 3 (Trimite Effluent Water on Day 89)

For Experiment 2, ten liters were acquired from the effluent of the Trimite filter. Based on results determined from Experiment's 1 and 2, Experiment 3 tested all of the parameters in Table 3 with the exception of 1.0 mg/L chlorine dose at 100 minute reaction time. All other protocol for Experiment 3 followed Experiment 1. For both 0.5 mg/L and 1.0 mg/L at 10 minute reaction times, total coliform and *E.Coli* analyses were conducted.

CT Determination

Once the bench tests were completed and analytical results obtained, a plot of the initial concentration over the final concentration of HPC versus CT for each sample in all the experiments (0.5 mg/L, 1.0 mg/L, and 2.0 mg/L) was constructed (where Cl is the concentration of HOCl present determined from the recorded pH) and fit to determine a rate of removal. A resulting CT value was chosen based upon desired contact time and chlorine concentration addition to achieve an acceptable log removal of the chosen parameter (HPC) based on an engineering evaluation of the data.

CT Implementation

The CT values determined from bench testing were compared with that established for 4.0-log inactivation of viruses. The larger CT between the two was chosen for full-scale application. The necessary chlorine dosage was determined for the appropriate temperature and pH based on the available contact time (provided either in the distribution system prior to the first user, or in separate tankage).

BIBLIOGRAPHY

AWWA. *Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*. Denver, CO. 1991.

Appendix D: UV Disinfection Study Protocol

The following protocol was used to demonstrate the effectiveness of UV disinfection of finished water from the FBR treatment system. As with the chlorination study, the required level of disinfection was a 4-log inactivation of viruses and 4-5 log inactivations of bacteria. Typically, UV disinfection can effectively operate at lower UV dosages for *Giardia sp.* and *Cryptosporidium sp.* and increased doses are required for viruses. Hence, a low-pressure, high-intensity lamp should be sufficient to treat the FBR treatment system effluent water. The objectives of the UV disinfection protocol were to demonstrate:

- The effectiveness of the UV system at various UV dosages on the inactivation of microorganisms to achieve suitable disinfection
- The impacts of any variability in the finished water quality on UV disinfection
- The potential for formation of disinfection byproducts (treatment of TCE)
- The necessary maintenance requirements of the technology
- The cost-effectiveness of the technology

TESTING PROTOCOL

UV disinfection occurs through the inactivation of microorganisms by UV radiation. The UV dose is calculated as:

$$\text{Dose} = \text{Intensity (mW/cm}^2\text{) x Exposure Time (s)}$$

By varying either the intensity of electrical energy or the exposure time, the UV dose can be modified. For the Trojan SWIFT™ SC A02 UV pilot reactor utilized in this study, the ability to vary the intensity was not available. The ability to alter the exposure time was utilized to modify the UV dosage. The upper limit for the UV dosage was 40 mJ/cm2.

The testing of the UV reactor was completed from Days 96 to Days 152, after the FBR treatment system had matured. To establish the technology performance versus UV dosage (time of exposure), seven experiments were conducted for the flow through the UV reactor from both the Trimite multimedia filter and LGAC systems. Flowrates of 15, 20, and 25 gpm were tested. The UV technology was also tested when significant unsteady-state conditions occurred within the FBR treatment system (i.e., during multimedia backflushes). Conducted experiments are listed in Table 1.

Table 1. UV Experiments Conducted

UV Experiments	Conditions
1	Steady-State After Trimite (15 gpm)
2	Steady-State After Trimite (25 gpm)
3	Steady-State After Trimite (20 gpm)
4	Before/After Backwash After Trimite (25 gpm)
5	Steady-State After LGAC (25 gpm)
6	Steady-State After LGAC (15/20/25 gpm)
7	Before/After Backwash After Trimite (10/20/25 gpm)

For each testing event, water samples were obtained for the finished water from the effluent of the Trimite multimedia filter or the LGAC unit and effluent of the UV disinfection system. A bypass line was set-up from the Trimite filter, around the LGAC unit, to the UV reactor so that a portion of the FBR treatment plant flow could go through the UV reactor and the LGAC unit, or directly from the LGAC to the UV reactor. Because of limitations of the pilot-scale UV equipment communicating with the FBR treatment plant, the UV system was not operated continuously. Instead, flow was initiated through the UV reactor and the unit was turned on 20-30 minutes prior to sample acquisition. This period of time allowed for suitable warm-up of the UV unit. During this warm-up period, the flowrate through the UV reactor was adjusted according to the experimental conditions being tested. At 15, 20, and 25 gpm through the UV reactor, corresponding residence times through the unit were 8.10, 6.08, 4.86 seconds.

Sample quantities were collected and preserved in accordance with approved procedures and as directed by the certified testing laboratory. Each of the samples was tested for presence and quantity of total coliforms and *E.Coli*, heterotrophic plate count (HPC), temperature, pH, and turbidity. In addition, the finished water samples of UV Experiments 1-3 were analyzed for disinfection byproduct formation potential. Samples were collected and analyzed using the methods provided in Table 2.

Table 2. Analytical Methods

Parameter	**Method**
Total Coliform	MMO/MUG Quanti-Tray 2000- SM 9223 B
E.Coli	MMO/MUG Quanti-Tray 2000- SM 9223 B
HPC	SM 9215B
TTHM Formation Potential	SM 524.2
HAA5 Formation Potential	SM 6251B
Temperature	On-site hand-held instruments
pH	On-site hand-held instruments
Turbidity	In-line instrument

RESULTS

From the results obtained from the off-site certified laboratory, correlations to be developed between the log inactivation of the bacteria and the UV dose. Over the course of the three months of UV reactor operation, maintenance logs were maintained. Required lamp cleaning, lamp replacement, and manpower to monitor were documented. Such data provides potential operating costs for a full-scale system that will be included in the Final Cost Report.

BIBLIOGRAPHY

U.S. Environmental Protection Agency. 1999. *Guidance Manual for Alternative Disinfectants and Oxidants. Document #* 815R99014.
U.S. Environmental Protection Agency. 2006 Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Surface Enhanced Treatment Rule. Document #815R06007.

Appendix E: Quality Assurance Project Plan (QAPP)

E.1 Purpose and Scope

This section presents the project-specific Quality Assurance Project Plan (QAPP) for ESTCP Project #200543, Demonstration of a Full-Scale Fluidized Bed Bioreactor for the Treatment of Perchlorate at Low Concentrations in Groundwater. This QAPP specifies the procedures that were followed for the demonstration to ensure it generated analytical data of known quality. These procedures were integral to the demonstration and complement the sampling procedures presented in Section 5.6.

Both laboratory analytical and field screening methods were used to measure parameters indicative of the FBR treatment system performance. This QAPP provided guidelines to ensure that: (1) data generated during the course of the demonstration was of an acceptable and verifiable quality (*i.e.*, quality assurance); and (2) a sufficient number of control measurements were taken for proper data evaluation (*i.e.*, quality control).

E.2 Quality Assurance Responsibilities

Key QA personnel for the project and their responsibilities are outlined below.

Todd S. Webster, Ph.D., P.E. is a Co-Principal Investigator for the demonstration and has overall project QA responsibility. Dr. Webster served as the Project Manager/QA officer for this demonstration, as well as the Field Project Manager for this study. Dr. Webster coordinated all field sampling activities, implemented procedures so that all field sampling was completed in accordance with the demonstration plan requirements, and coordinated all laboratory data analysis and review.

A. Paul Togna, Ph.D., is a Co-Principal Investigator for the demonstration, and assisted Dr. Webster with the QA review.

Mr. Hang Sau (Sam) Wong, is the FBR treatment Field Technician. Mr. Wong performed all recordkeeping, monitoring, data analysis, and sample acquisition for the FBR treatment system on site. He assisted with the coordination of field activities, including all groundwater sampling. Mr. Wong had day-to-day QA responsibility for field sampling and field analysis and reported directly to Dr. Webster.

Ms. Ann Lewis, is the EMAX QA Laboratory Manager and oversaw the quality assurance of all data analyzed and reported to Basin Water, Inc. Ms. Lewis Reported to Dr. Webster.

Ms. Humaira Saleem, is the E.S. Babcock & Sons, Inc. Laboratory Project Manager and oversaw the quality assurance of all data analyzed and reported to Basin Water, Inc. (through EMAX Laboratories, Inc.). Ms. Saleem Reported to Dr. Webster.

E.3 Data Quality Parameters

This section describes the measurements that were made to achieve the project's objectives.

The laboratory program for the FBR perchlorate treatment demonstration included measuring the concentrations of perchlorate, nitrate, and an array of parameters for typical drinking water applications from the groundwater and treated system effluent. These measurements are outlined in Table 5.4 and were conducted using three sources of evaluation: (1) On-site laboratory; (2) On-line instrumentation; and (3) Off-site laboratory. These three sources served as means to validate and corroborate key data from each respective source. The on-site laboratory analysis, using U.S. EPA approved methodologies, was used for a number of the analytes. This on-site analysis corroborated the on-line measurements (i.e., nitrate) and off-site laboratory measurements (i.e., nitrate and perchlorate). The on-site laboratory was also used to generate analytical data used to implement daily modifications or refinements needed in the system operation. The off-site laboratory was EMAX Laboratories (Torrance, CA) and was utilized for routine off-site analysis of these parameters. A subcontracted laboratory that was also used was E.S. Babcock & Sons, Inc. (Riverside, CA). For all groundwater and treated effluent analyses, standard U.S. EPA methods were used, as outlined in *U.S. EPA Methods for Analysis of Water and Wastes* (EPA-600/4-79-020, 1979) and the *Manual for the Certification of Laboratories Analyzing Drinking Water, Revision 4, EPA 815-B-97-001*.

Additional groundwater and treated effluent parameters were screened in the field using electronic meters. These parameters were measured using methods approved or accepted by the U.S. EPA for reporting purposes. Field-measured parameters included oxidation reduction potential (ORP), pH, dissolved oxygen (DO), sulfide, turbidity, temperature, and bed height.

E.4 Quality Control Checks, Calibration Procedures and Corrective Action

E.4.1 Quality Control Objectives

The goal of the FBR treatment system demonstration was to accomplish the following: (1) Evaluate the efficacy of the FBR technology with respect to nitrate and perchlorate degradation under both steady-state and unsteady-state operating conditions; (2) Evaluate the downstream FBR treatment train components for their ability to produce drinking water quality effluent; (3) Develop the design criteria and protocol necessary for full-scale application of the technology; and (4) Evaluate the cost-effectiveness of the technology compared to existing perchlorate treatment technologies. As such, the project data quality objectives (Project DQOs) were:

- collect data of sufficient quantity and quality to determine destruction efficiencies and biodegradation rates of nitrate and perchlorate within the FBR as a function of electron donor addition;

- collect data of sufficient quantity and quality to assess robustness of the FBR technology as a function of the self-seeding, spike loadings, and system upsets (short-term feed and electrical shutdowns);

- collect data of sufficient quantity and quality to assess the performance of the downstream equipment in treating the FBR effluent to drinking water quality

- determine the extent of operator attention required for the entire FBR treatment system (including downstream equipment and on-line instrumentation)

- collect data suitable for use in designing a full-scale FBR treatment system; and

- collect data suitable for preparing a cost comparison analysis.

To meet the Project DQOs stated above, individual measurements were required to meet particular quantitative QA objectives for precision, accuracy, method detection limits, and completeness, as well as qualitative QA objectives for comparability and representativeness. This section describes the quality assurance objectives for the FBR treatment system demonstration in order to meet the specific Project DQOs stated above.

The specific data QA objectives were as follows:

- establish sample collection and preparation techniques that yield results representative of the media and conditions analyzed;
- collect and analyze a sufficient number of field blanks to evaluate the potential for contamination from ambient conditions or sample collection techniques;
- collect and analyze a sufficient number of field duplicates to assess the homogeneity of samples received by the laboratory as well as the homogeneity of contaminants in the matrix; and
- analyze method blanks, laboratory duplicates, matrix spikes, matrix spike duplicates, and surrogate spikes as required by the specific analytical methodology to determine if QA goals established for precision and accuracy were met for off-site laboratory analyses.

The data generated during the demonstration was used primarily for assessing the efficacy of the FBR treatment system for the removal of nitrate and perchlorate from the contaminated groundwater to a final effluent of drinking water quality. In an effort to produce data that was useful for this assessment, definitions of data usage, data types, data acquisition, and data quality level have been made for this demonstration and were based on the generalized DQOs presented in *U.S. EPA QA/G5: Guidance on Quality Assurance Project Plans, EPA/600/R-98/018, February, 1998*. Due to the variation in the types of monitoring throughout the demonstration, data quality objective Levels I and III were used. Several feed groundwater chemical parameters, such as pH, temperature, ORP, and DO were determined in the field with immediate response required for process control (Level I). In addition, all on-site laboratory data generated was produced using data quality Level I. All off-site analytical laboratory measurements were performed using Level III criteria for production of validated data.

Quality assurance objectives were established to evaluate the criteria of precision, accuracy, and completeness. The evaluation of these criteria for validated (Level III) off-site laboratory analyses were based upon sample duplicates, matrix spikes, matrix spike duplicates, and surrogates, as described in Section E.4.3. The criteria for precision, accuracy, and completeness for all validated data followed the guidelines established in Section E.6.1.

E.4.2 Analytical Procedures and Calibration

Analytical Procedures. All laboratory analyses were performed according to the established U.S. EPA Methods (see Table 5.4).

Sampling Procedures. Prior to sampling, the sampling port was identified and recorded, along with the date and time, in the field logbook. All samples were collected for analysis directly from the sampling ports by manually opening the respective sampling port valve. At least two volumes of water was flushed through the line before the actual sample acquired.

Calibration Procedures and Frequency. Calibration refers to the checking of physical measurements of both field and laboratory instruments against accepted standards. It also refers to determining the response function for an analytical instrument, which is the measured net signal as a function of the given analyte concentration. These determinations have a significant impact on data quality and will be performed regularly. In addition, preventative maintenance is important to the efficient collection of data. The calibration policies and procedures set forth apply to all test and measuring equipment.

All field and laboratory instruments were calibrated according to manufacturers' specifications. All laboratory instruments were calibrated in accordance with established Standard Operating Procedures. Calibration was performed prior to initial use and after periods of non-use. A record of calibration was made in the field logbook each time a field instrument or on-site laboratory instrument was calibrated. The off-site laboratory followed standard procedures in the calibration of their equipment and instrumentation. This information was documented and available to the Project Manager/QA officer upon request.

Process and Field Measurements. The portable instruments used to measure field parameters (*e.g.*, temperature, pH, ORP, sulfide, DO, etc.) were calibrated in accordance with manufacturer's instructions on a weekly basis. Flow measuring devices were not calibrated if calibration requires the instruments to be sent back to the manufacturer. All other manufacturer-recommended checks of the field instruments were performed.

Laboratory Measurements. The calibration procedures for all off-site analyses followed the established U.S. EPA guidelines for the specific method and the guidelines established by the off-site laboratory. Certified standards were used for all calibrations and calibration check measurements. The frequency and acceptance criteria for all off-site analyses followed the guidelines established by the off-site laboratory. The analysis of a calibration check standard was required prior to analysis of any samples. If the results of the calibration check standard were not acceptable, immediate re-analysis of the calibration check standard was performed. If the results of the re-analysis still exceeded the limits of acceptability, the system was considered to have failed calibration. Sample analysis was halted and did not resume until successful completion of the initial calibration. Corrective actions taken to restore initial calibration were documented in the analyst's notebook. Any deviations from the standard practices were documented by the laboratory and reported to the Project Manager/QA officer immediately.

Calibration Check Standards. Calibration check standards were analyzed during each calibration. The calibration check standard contained all analytes of interest for the method in question at a concentration as required by the method. Results of the calibration check standards were required to fall within the limits of acceptability as described below:

Case 1 - A certified check standard was available from the U.S. EPA or some other source with both the true value and limits of acceptability specified by the supplier. The results were required to fall within the limits specified by the supplier, or ± 20% for inorganics and ± 15% for organics, whichever is less.

Case 2 - A certified check standard was available from the U.S. EPA or some other source with a true value specified but without limits of acceptability. The results were required to fall within ± 20% for inorganics and within ± 15% for organics.

Case 3 - If no certified check standard was available, the laboratory prepared a check standard using a second source of reference material. This standard was prepared by a different analyst than the one who prepared the calibration standard. If weighing of the material was required, a different balance was used, if possible. The results must fall within ± 20% for inorganics and within ± 15% for organics.

Case 4 - If there was only one source of reference material available, then the calibration and calibration check standards were prepared from the same source. The standards were prepared by different analysts. If weighing was required, different balances were used, if possible. The results were required to fall within ± 20% for inorganics and within ± 15% for organics.

For all cases listed above, after the seventh acceptable check standard, the limits of acceptability were required to be ± two standard deviations, as determined from the first seven points.

E.4.3 Internal Quality Control Checks

Quality Control Samples. Internal QC data provides information for identifying and defining qualitative and quantitative limitations associated with measurement data. Analysis of the following types of QC samples provided the primary basis for quantitative evaluation of analytical measurement data quality:

Field QC Samples

- equipment blanks to evaluate the potential for contamination from ambient conditions, sampling equipment, or sample collection techniques;
- trip blanks to evaluate the presence of contamination from handling errors or cross-contamination during transport;

- field blanks to evaluate the level of background contamination at the site; and
- field-split/collection duplicates to assess the homogeneity of samples received by the laboratory as well as the homogeneity of contaminants in the matrix, respectively.

Laboratory QC Samples

- method blanks, laboratory duplicates, matrix spikes, and matrix spike duplicates to determine if QA goals established for precision and accuracy are met by the analytical laboratory.

The number, type, and frequency of laboratory QC samples was dictated by the validated U.S. EPA Methods used by Shaw E&I on-site laboratory or the off-site EMAX laboratory. The U.S. EPA Methods shown in Table 5.4 specify the number and types of laboratory QC samples required during routine analysis. This information was supplied with the data package provided by the laboratory.

In addition to the internal QC samples described above, the off-site laboratories provided, at a minimum, additional internal QC checks as follows:

- use of standard analytical reference materials for traceability of independent stock solutions prepared for calibration stocks, control spike stocks, and reference stock solutions;
- verification of initial calibration curves with independent reference stock solutions
- verification of initial calibration curves with daily calibration standards
- verification of continued calibration control by analysis of calibration standards to document calibration drift;
- analysis of control spikes to document method performance and control with respect to recent performance.

An attempt was made to analyze all samples within the calibrated range of the analytical method. Dilution of a sample extract with extracting solvent, or of the original sample matrix with distilled/de-ionized water, was performed if the concentration of an analyte was greater than the calibrated range of the method.

Blank Samples

Blanks are artificial samples designed to detect the introduction of contamination or other artifacts into the sampling, handling, and analytical process. Blanks are the primary QC check of measurements for trace-level concentrations. Each blank sample was run at a frequency of at least 5 percent of the total number of environmental samples.

Equipment Blanks. Equipment blanks are used to assess the level of contamination of sampling devices. No special sampling devices were used for this demonstration. Hence, equipment blanks will not be provided.

Trip Blanks. Trip blanks were prepared by the analytical laboratory with purified water for groundwater and treated effluent samples. The trip blanks were delivered to the site in the same containers to be used for collection of the groundwater and treated effluent samples and returned to the off-site laboratory with these collected samples.

Field Blanks. Field blanks are used to assess the background level of contamination at the site. The off-site laboratory provided the site deionized/distilled water. At the site during a sampling procedure, the Field Technician filled one sample bottle with sample water and another bottle with the supplied deionized/distilled water. Each sample was submitted separately, with the field blank appropriately labeled.

Method Blanks. Method blanks are prepared by the off-site laboratories to evaluate the impact of the analytical process on detected concentrations of contaminants. Method blanks were prepared for each batch of samples run for a given method of analysis. The method blanks were processed through the entire preparation and analytical procedure in the same manner as field samples. The method blanks provided data to assess potential systematic contamination of the measurement system.

Field Duplicate Samples. Duplicate samples are analyzed to evaluate the accuracy of the analytical process. Duplicate samples were analyzed as described below: Each duplicate was run at a frequency of at least 5 percent of the total number of environmental samples. A comparison of the detected concentrations in the duplicate samples was performed to evaluate precision. The evaluation was conducted using Equation E.2 for Relative Percent Difference (RPD) as described in Section E.6.1.

Collection Duplicates. The purpose of the collection duplicate is to assess the homogeneity of the contaminants in the matrix. The collection duplicate was obtained by collecting a second discrete sample from the same sample location and submitting the collections as discrete samples to the laboratory.

Field Split Duplicates. The purpose of the field split duplicate is to assess the homogeneity of the samples received by the laboratory. This duplicate was obtained by collecting one sample from the same sample location, splitting it between two sample containers in the field, and submitting each split sample as a discrete sample to the laboratory.

Blind Samples. At least 5 percent of the duplicate samples were submitted to the laboratory as “blind samples,” so that the laboratory does not know the location from which the sample was taken.

Laboratory Control Samples. Laboratory control samples were used by the laboratory to assess analytical performance under a given set of standard conditions. These samples were specifically prepared to contain some or all of the analytes of interest at known concentrations. The samples were prepared independently of the calibration standards. Types of laboratory control samples that were used included laboratory duplicates, matrix spikes, matrix spike duplicates, and surrogate spikes. Analysis of laboratory control samples were used to estimate the analytical bias and accuracy by comparing measured results obtained during analysis to theoretical concentrations. This comparison was measured using Equation E.1 as presented in Section E.6.0. The matrix spike/matrix spike duplicate samples were used to evaluate precision according to Equation E.2. Stock solutions used to spike QC samples were prepared independently of stocks used for calibration as required by appropriate EPA methods. Validation of spiked solutions was performed on a regular basis before the solution was used.

E.4.4 Sample Documentation

The on-site Field Technician coordinated with the off-site laboratories for shipment and receipt of sample bottles, coolers, icepacks, and chain-of-custody (COC) forms. An important consideration for the collection of environmental data is the ability to demonstrate that the analytical samples have been obtained from predetermined locations and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented to accomplish this. Documentation was accomplished through a COC Record that recorded each sample and the names of the individuals responsible for sample collection, transport, and receipt. Upon completion of sampling, the COC was filled out and returned with the samples to the laboratory. A sample was considered in custody if it was:

- in a person's actual possession;
- in view after being in physical possession;
- sealed so that no one can tamper with it after having been in physical custody; or
- in a secured area, restricted to authorized personnel.

Sample custody was initiated by field personnel upon collection of samples. As discussed in Section 5.6.1 Sample Collection, samples were packaged to prevent breakage or leakage during transport, and shipped to the laboratory via commercial carrier, or transported via car or truck.

Sample Identification. A discrete sample identification number was assigned to each sample. These discrete sample numbers were placed on each bottle and were recorded, along with other pertinent data in a field notebook dedicated to the project. For blind samples, the sample location was recorded in the field notebook along with a note indicating that the sample was submitted to the laboratory as a blind sample. The sample identification number designated the sample location ("AP-" for specific analysis port, and "B" for blind samples) and date collected. For example, a sample collected from the AP-100 sample port collected on January 10, 2007 was identified AP100-011007. For a blind sample, the identification was AP-B-011007.

Chain-of Custody Forms. The independent laboratories supplied their own COCs with sample bottles that were shipped to the site. All samples collected for off-site analysis were physically inspected by the Field Technician prior to shipment.

Each individual who had the sample in their possession signed the COC Record. Preparation of the COC Record was as follows:

- The COC Record was initiated in the field by the person collecting the sample, for every sample. Every sample was assigned a unique identification number that was entered on the COC Record.
- The record was completed in the field to indicate project, sampling person, etc.
- If the person collecting the samples did not transport the samples to the laboratory or ship the samples directly, the first block for "Relinquished By ______, Received By ________" was completed in the field.
- The person transporting the samples to the laboratory or delivering them for shipment signed the record for as "Relinquished By ________".
- The original COC Record was sealed in a watertight container, taped to the top (inside) of the shipping container, and the shipping container sealed prior to being given to the commercial carrier. A copy of the COC Record was kept on-site.
- If shipping by commercial carrier, the waybill served as an extension of the COC Record between the final field custodian and receipt by the off-site laboratory.
- Upon receipt by the off-site laboratory, the laboratory QC Coordinator, or designated representative, opened the shipping container(s), compared the contents with the COC Record, and signed and dated the record. Any discrepancies were noted on the COC Record.
- The COC Record was completed after sample disposal.
- COC Records were maintained with the records for the project, and became part of the data package.

Laboratory Sample Receipt. Following sample receipt, the Laboratory Manager was tasked to:

- Examine all samples and determine if proper temperature has been maintained during transport. If samples have been damaged during transport, the remaining samples were carefully examined to determine whether they were affected. Any samples affected were be considered damaged. It was noted on the COC Record that specific samples were damaged and that the samples were removed from the sampling program. Field personnel were instructed to re-sample, if appropriate.
- Compare samples received against those listed on the COC Record.
- Verify that sample holding times had not been exceeded.
- Sign and date the COC Record, attaching the waybill if samples were shipped for off-site analysis.
- Denote the samples in the laboratory sample log-in book which contained, at a minimum, the following information:

    - Project Identification Number
    - Sample numbers
    - Type of samples
    - Date and time received

- Place the completed COC Record in the project file.

The date and time the samples were logged in by the sample custodian or designee should agree with the date and time recorded by the person relinquishing the samples. Any nonconformance to the stated procedures that may affect the cost or data quality was reported to the Project Manager/QA Officer.

Other Documentation. Following sample receipt at the laboratory, the Laboratory Manager or sample custodian clearly documented the processing steps that were applied to the sample. The analytical data from laboratory QC samples were identified with each batch of related samples. The laboratory log book included the time, date, and name of the person who logged each sample into the laboratory system. This documentation was thorough enough to allow tracking of the sample analytical history without aid from the analyst. At a minimum, laboratory documentation procedures provided:

- Recording in a clear, comprehensive manner using indelible ink;
- Corrections to data and logbooks made by drawing a single line through the error and initialing and dating the correction;
- Consistency before release of analytical results by assembling and cross-checking the information on the sample tags, custody records, bench sheets, personal and instrument logs, and other relevant data to verify that data pertaining to each sample were consistent throughout the record;
- Observations and results identified with the project number, date, and analyst and reviewer signatures on each line, page, or book as appropriate;
- Data recorded in bound books or sheaf of numbered pages, instrument tracings or hard copy, or computer hard copy; and,
- Data tracking through document consolidation and project inventory of accountable documents: sample logbook, analysis data book, daily journal, instrument logbook, narrative and numerical final reports, etc.

E.4.5 Data Reduction, Validation, and Reporting

This section describes procedures employed for reducing, validating, and reporting data. All validated analytical data generated within the off-site laboratories was extensively checked for accuracy and completeness by laboratory and project personnel. Records were kept throughout the analytical process, during data generation, and during reporting so that adequate documentation to support all measurements was available. Recordkeeping, data reduction, validation, and reporting procedures are discussed in this section.

Data Reduction. Data reduction followed the requirements contained in the U.S. EPA analytical methods cited previously. Reduction involves the reformatting of data to present the desired end-product, *i.e.*, the concentrations of the contaminants. Reformatting involved the process of performing calculations on the raw data and presenting all values in appropriate units. The information generated by the data reduction step was used in the interpretation of the data qualifiers.

The responsibility for data acquisition and reduction of raw data resided with the analysts who performed the analysis. Raw data for the quantitative analysis procedures used during this project consisted of peak areas for surrogates, standards, and target compounds. Analytical results were reduced to concentration units appropriate for the medium being analyzed (i.e. either milligrams or micrograms per liter (µg/L) for aqueous samples).

Data Validation. Data validation involved a review of the QC data and the raw data in order to identify any qualitative, unreliable, or invalid measurements. As a result, it was possible to determine which samples, if any, were related to out-of-control QC samples. Laboratory data was screened for inclusion of and frequency of the necessary QC supporting information, such as detection limit verification, initial calibration, continuing calibration, duplicates, matrix spikes, surrogate spikes, and the method and preparation blanks. QC supporting information was screened to determine whether any datum was outside established control limits. If out-of-control data were discovered, appropriate corrective action was determined based upon QC criteria for precision, accuracy, and completeness. Any out-of-control data without appropriate corrective action was cause to qualify the affected measurement data.

Levels of data validation for the demonstration are defined below:

- **Level I.** For Level I field screening data quality, a data "package" including the results from sample blanks, method blanks, and supporting calibration information, was recorded in the field logbook and on log sheets maintained within a folder on-site. The extent of contamination and the achievement of detection limits was determined from this information. The sample results and QC parameters were routinely evaluated by site personnel, and 10% of the analytical raw data results were reviewed by the Project Manager/QA Officer to verify sample identity, instrument calibration, quantification limits, numerical computation, accuracy of transcriptions, and calculations.

- **Level III.** For Level III validated data quality, a CLP-like data package was provided, including case narrative, Form I results, CLP-like form III QC summaries, initial calibration, daily calibration, and analysis and extraction logs. The chromatograms of calibration standards, matrix spikes, or matrix spike duplicates were not be included. Sample results were evaluated according to the current version of the U.S. EPA functional guidelines for organic and inorganic analyses for selected QA/QC parameters, and 10% of the analytical raw data results were reviewed to verify sample identity, instrument calibration, detection limits, numerical computation, accuracy of transcriptions, and calculations.

The Laboratory Manager or designee performed the data review and validation. Each data package was reviewed and the data validated prior to submission. Checklists were used to demonstrate that the data review was accomplished.

The data review included, but were not limited to, the following subjects:

- Completeness of laboratory data;
- Evaluation of data with respect to reporting limits;

- Evaluation of data with respect to control limits;
- Review of holding time data;
- Review of sample handling;
- Correlation of laboratory data from related laboratory tests;
- Comparison of the quality of the data generated with DQOs as stated in this Work Plan (on a daily basis, during routine analyses, and during internal laboratory audits); and
- QC chart review, performed weekly, following receipt of control charts for analyses performed the previous week. Review shall consist of assessing trends, cycles, patterns, etc. This review also assessed whether control corrective actions had been implemented.

The elements of data validation included, but were not limited to, the following items:

- Examination of COC records to assess whether custody was properly maintained;
- Comparison of data on instrument printouts with data recorded on worksheets or in notebooks;
- Comparison of calibration and analysis dates and assessment of whether the same calibration was used for all samples within a lot;
- Examination of chromatographic outputs for manual integrations, and documentation of the reasons for any manual integrations;
- Comparison of standard, sample preparation, and injection records with instrument output to assess whether each output was associated with the correct sample;
- Examination of calibration requirements, as specified in the methods;
- Use of a hand-held calculator to perform all calculations on selected samples to assess the correctness of results; and
- Examination of all papers and notebooks to ensure that all pages were signed and dated, that all changes were initialed, dated, have sufficient explanation for the change, and that all items were legible.

Required record-keeping following a laboratory audit documented that all lots were reviewed in the audit report. The audit report also identified any deficiencies that were noted. A copy of the audit report was placed in the applicable installation audit folder.

Data Reporting. Data and information generated during the demonstration was summarized in a Technology Application Final Report, to be submitted at the completion of the project. QA/QC analysis reports were generated by laboratory personnel as a product of validation procedures described above. All off-site Level III analyses were accompanied by QA/QC data packages as described in the previous section. The summary QA/QC reports have not been included in the Technology Application Final Report, but have been made available upon request. The ultimate data set produced for project use consisted of all values reported in appropriate units flagged with respective data qualifiers for entry into the project database as described below. Analytical results were reduced to concentration units appropriate for the medium being analyzed as either “µg/L” or “mg/L”, depending on analyte and method, for aqueous samples.

The results for each analyte in spiked QC samples was determined using the same acceptable calibration curve that is used for environmental samples in the lot. Values above the practical quantitation limit (PQL) or reporting limit (RL) were reported as the found value. Raw values that fall below the method detection limit (MDL) were reported as “less than” the PQL or RL. Values above the method detection limit (MDL) and less than the PQL were reported and flagged with a “J.” Results for QC samples were not corrected, except as described below. Data will be reported using the correct number of significant figures.

Each day of analysis, the analyst quantified each analyte in the method blank and spiked QC samples. A new lot of samples were introduced into the analytical instrument until results for QC samples in the previous lot had been calculated, plotted on control charts as necessary, and the entire analytical method shown to be in control. If time was a constraint, the calculation of associated environmental sample results were postponed until a later date

Data from the method blank was reported, usually as less than the MDL for each analyte. Any values above the MDL were reported as the found value. Corrections to the QC samples, necessitated by background levels in the method blank, were performed using instrument response values and not the found values calculated from the linear calibration curve. Reported entries were in terms of concentration. The importance attached to finding measurable concentrations in the method blank was dependent on analyte and method. Identification of measurable concentrations in the method blanks were reported in writing to the Project Manager/QC Officer for possible corrective actions.

The following additional data reporting procedures were followed.

All data was reported, and numerical results reported in terms of concentration in the environmental sample. Resultant found concentrations were adjusted for dilution, etc. before being reported, and both the raw data and correction factors (*e.g.*, percent moisture, and dilution factor) were recorded in the data package submitted. Laboratory comments on the usability of the data was also included.

In reporting results, rounding to the correct number of significant figures occurred only after all calculations and manipulations had been completed. As many figures as were warranted by each analytical technique were used in pre-reporting calculations. Rounding was accomplished using the following rules:

<u>Rule 1</u> - In expressing an experimental quantity, retain no digits beyond the second uncertain one.

<u>Rule 2</u> - In rounding numbers (*i.e.*, in dropping superfluous digits):

- Increase the last retained digit by one if the first uncertain digit is larger than 5;
- Retain the last digit unchanged if the first uncertain digit is less than 5;

- Retain the last digit unchanged if even, or increase it by one if odd, if the first uncertain digit is 5 and the second uncertain digit is 0;
- Increase the last retained digit by one if the first uncertain digit is 5 and the second uncertain digit is greater than 0.

The correct number of reported significant figures, by validation type, is 3 significant figures. The number of allowable significant figures was reduced when added uncertainties were included in the analysis, *i.e.*, the results for samples diluted into the validated range allow one less significant figure due to the uncertainty added by the dilution process.

E.4.6 Corrective Action Plan

If routine procedures (*e.g.*, equipment calibration), QC sample analysis, or performance and system audits indicated that sampling or analysis systems were unsatisfactory, a corrective action was implemented. During performance audits, if performance evaluation (PE) samples did not meet the QA criteria for accuracy and precision specified in Section E.6.0, analytical work was stopped until the problems were identified and resolved. Before work resumed, another blind PE sample was analyzed, and results were required to meet the acceptance criteria. Results of all PE samples have been included in the Technology Application Final Report. If previously reported data were effected by the situation requiring correction or if the corrective action impacted the project budget or schedule, the action directly involved the Project Manager/QA Officer.

Corrective actions were of two kinds:

1. Immediate, to correct or repair non-conforming equipment and systems. The need for such an action was most frequently identified by the analyst or technician as a result of calibration checks and QC sample analyses. Immediate corrective actions addressed problems peculiar to a single measurement or lot of samples. Immediate corrective action included:

    - Re-run of analyses if sample holding times had not been exceeded;
    - Instrument re-calibration using freshly prepared standards;
    - Replacement of reagents or solvents that give unacceptable blank values;
    - Examination of data calculation errors; and
    - Replacement of reference standards that have been degraded.

If corrective action indicates that non-conformance was due to problems with laboratory equipment, procedures, and/or calibration, once the problem was resolved, the non-conforming samples were re-analyzed if holding times had not been exceeded. If holding times had been exceeded, new samples were collected if the completeness criteria specified in Section E.6.0 required that these samples be collected. If corrective action indicated that non-conformance of duplicate samples was due to sampling technique, once the problem was corrected, new samples were collected if the completeness criteria specified in Section E.6.0 required that these samples be collected.

2. Long-term, to eliminate causes of non-conformance. The need for such actions were identified by audits. Long-term corrective actions addressed procedural deficiencies or unsatisfactory trends or cycles in data that affected multiple lots of samples. Examples of long-term corrective action included:

- Staff training in technical skills or in implementing the QAPP;
- Rescheduling of laboratory routine to ensure analysis within allowed holding times;
- Identifying alternate vendors to supply reagents of sufficient purity; and
- Revision of the QAPP.

For either immediate or long-term corrective action, steps comprising a closed-loop corrective action system were implemented:

- Define the problem;
- Assign responsibility for investigating the problem;
- Investigate and determine the cause of the problem;
- Determine a corrective action to eliminate the problem;
- Assign responsibility for implementing the corrective action; and
- Verify that the corrective action has eliminated the problem.

Unsatisfactory items or situations were identified by anyone involved with the project, particularly the analysts, field engineers, technicians, or QA personnel. Depending on the nature of the problem, the corrective action employed was either formal or informal.

To enhance the timeliness of corrective action and thereby reduce the generation of unacceptable data, problems identified by assessment procedures were resolved at the lowest possible management level. Problems that were not resolved at this level were reported to the Project Manager/QA Officer. The Project Manager/QA Officer determined the management level at which the problem was best resolved, and notified the appropriate manager. Monthly progress reports from the on-site Field Technician detailed all problems and subsequent resolutions.

In all cases, the occurrence of the problem, the corrective action(s) employed, and verification that the problem was eliminated was effectively documented. In addition, if the corrective action resulted in the preparation of a new standard or calibration solution(s), then a comparison of the new versus the old standard or solution was performed, and the results supplied with a full QC report as verification that the problem had been eliminated. Corrective action reports that relate to a particular lot analysis were included in the data package for that lot.

E.5 Demonstration Procedures

Prior to the operation of the FBR treatment system at the site, all system components, including pumps, flow meters, pressure gauges, actuators, valves, the PLC, and in-line analytical instruments were tested by the Field Technician and Field Project Manager for operability and accuracy per the manufacturer's recommendations. All in-line analytical instruments and portable field instruments were calibrated per the manufacturer's specifications. Malfunctioning equipment was immediately reported to the Field Project Manager and documented in the field logbook. Based on the cause of the malfunction, the Field Project Manager determined whether the equipment should be returned to the manufacturer for repair, replaced by the manufacturer, or serviced on-site by the manufacturer or their service representative.

During the demonstration, routine maintenance and calibration of equipment was required. This maintenance is detailed in Section 5.5.3. As during start-up, any equipment failures or instrument calibration errors were documented in the field logbook. Upon review by the Field Project Manager/QC Officer, a decision was rendered as to how to proceed with the repair or replacement of the effected equipment.

If any malfunction of equipment created a delay to the study or hindered the ability for DQOs to be met, the Field Project Manager/QA Officer notified ESTCP.

E.6 Calculation of Data Quality Indicators

E.6.1 Quantitative QA Objectives: Accuracy, Precision, Completeness, and Method-Detection Limit

Accuracy: Accuracy indicates the degree of bias in a measurement system, and is the degree of agreement of a measurement with an accepted reference value. Sample measurement uses laboratory equipment. The percent recovery of matrix spike/matrix spike duplicate samples measures the accuracy of the laboratory equipment, calculated according to the following equation:

$$\% R = (C_I - C_o)/ C_t * 100 \qquad \text{(Equation E.1)}$$

Where: $\% R$ = percent recovery
C_I = measured concentration; spiked sample aliquot
C_o = measured concentration, unspiked sample aliquot
C_t = actual concentration of spike added

Precision: Precision is the reproducibility of measurements under a given set of conditions. For large data sets, precision is expressed as the variability of a group of measurements compared to their average value. Variability may be attributable to field practices or chemical analyses. Precision is expressed as relative percentage difference, determined using Equation E.2 below.

Precision is measured by calculating the Relative Percent Difference (RPD) of laboratory duplicates, matrix spike/matrix spike duplicate sample pairs, surrogate spikes, and field duplicate samples (collection and split).

RPD = $(C_1 - C_2)$ *100/ $((C_1 + C_2)/2)$ (Equation E.2)

Where: RPD = relative percent difference
C_1 = the larger of the two observed values
C_2 = the smaller of the two observed values

Completeness: Completeness is defined as the qualified and estimated results, and represents the results usable for data interpretation and decision making. Results qualified as rejected or unusable, or that were not reported because of sample loss, breakage, or analytical error, negatively influence completeness and are subtracted from the total number of results to calculate completeness. Percent completeness is determined by using the following equation:

% Completeness = (VDP/ TDP) * 100 (Equation E.3)

Where: VDP = number of valid data points
TDP = number of total samples obtained

Completeness was calculated for each method and matrix during the demonstration. The completeness objective for all validated data was 95 percent.

Method-Detection Limits. Method detection limits (MDLs) and practical quantitation limits (PQLs) or reporting limits (RL) must be distinguished for proper understanding and data use. The MDL is the minimum analyte concentration that can be measured and reported with a 99% confidence that the concentration is greater than zero. The PQL/RL represents the concentration of an analyte that can be routinely measured in the sampled matrix with “reasonable” confidence in both identification and quantitation. PQLs/RLs are often based on analytical judgment and experience, and should be verifiable by having the lowest non-zero calibration standard or calibration check sample concentration at or near the PQL/RL. MDLs may be higher, particularly in contaminant mixtures, due to dilution limits required for analysis. Concentrations detected below the PQL/RL were appropriately flagged. These flagged concentrations were considered below the practical quantification limits/reporting limits of the analytical method used, but did not negatively impact completeness.

Method quantification limits and detection limits were reported for each sample set of validated data. The calculated MDL was equal to or less than the Required Detection Level (RDL). If the calculated MDL was lower than the level the laboratory deemed practical, the calculated MDL was raised to a higher level. In no instance was the reported MDL below the calculated level. The method documentation included both the calculated MDL and the request for an increased reportable MDL. Raising the reportable MDL to a higher level was contingent upon approval by Basin Water’s Project Manager/QA Officer.

E.6.2 Qualitative QA Objectives: Comparability and Representativeness

Comparability refers to the confidence with which one data set can be compared to another. Comparability is essential for the evaluation of technology performance compared to that of similar technologies. Comparable data was generated by following standard U.S. EPA protocols for all laboratory analyses, and manufacturers' instructions for all on-site test kits and meters.

Representativeness is a measure of the degree to which data accurately and precisely represent the conditions of the parameter represented by the data. Collected samples must be representative of the matrix characteristics and contamination concentrations. Representativeness is affected by errors introduced through the sampling process, field contamination, preservation, handling, sample preparation, and analysis.

Representativeness was ensured through the following practices:

- selecting the necessary number of samples, sample locations, and sampling procedures that depicted as accurately and precisely as possible the matrix and conditions measured;
- developing protocols for storage, preservation, and transport that preserved the representativeness of the collected samples;
- using documentation methods to ensure that protocols were followed and that samples were properly identified to maintain integrity and traceability; and
- using standard, well-documented analytical procedures to ensure consistent, representative data.

While none of these practices were quantified as a measure of representativeness, QC samples were collected to indicate factors that may affect representativeness. The QC samples to be used for this purpose were:

- field duplicates (field split samples and collection duplicates) to indicate variations caused by sampling techniques;
- trip blanks to indicate contamination of samples during transport; and
- field blanks to indicate contamination introduced through background, ambient conditions.

E.7 Performance System Audits

On site system and performance audits were conducted monthly between the Field Project Manager/QC Officer and the site Field Technician. During these on-site audits, the Field Project Manager confirmed:

- all field instruments were calibrated correctly per the manufacturer's recommendations;
- all on-site laboratory measurements were conducted per the manufacturer's recommendations. The on-site measurements were reviewed and any discrepancies were documented in the field logbook. Additional training occurred when necessary;

- confirmation of all field measurements by comparing recent field logs with data observed at the time of the audit;
- confirmation that all field equipment was operating correctly per the manufacturer's recommendations. Any discrepancies were documented in the field logbook;
- provided an overview and a review safety procedures as required by internal Basin Water, Inc. policy. Any safety violations and the means to correct them were noted in the field logbook.

E.8 Quality Assurance Reports

To gather information on the performance of the QA program for this project, the Project Manager/QA officer met with the off-site EMAX laboratory QA Manager via teleconference call on a monthly basis to review quality control data summary, documentation, and other pertinent information.

E.9 Data Format

All field activities and observations were documented in the field logbook, along with the date, time, and collector's initials, in legible ink. Any entries that were considered erroneous were lined out with a single line, initialed, and dated by the individual correcting the error. If further explanation for the correction was warranted, supplemental notes were included along side the correction.

Data collected at the site by the Field Technician was formatted and inputted from the field logs into a spreadsheet format for review and graphing. All data collected automatically was stored within the PLC that was password protected. This data was downloaded to the spreadsheets by the Field Technician as well. The spreadsheets were reviewed by the Field Technician for changes in data between day to day operations or any other unexpected data occurrences. In the event that unexpected data surfaces, the data was sent to the Field Project Manager/QA Officer for immediate review. Otherwise, these spreadsheets were electronically supplied to the Field Project Manager/QA Officer on a weekly basis. Any discrepancies or unforeseen data was reviewed by the Field Project Manager/QA Officer and discussed with the Field Technician. Any changes made were noted in the notes section on the spreadsheet before the final data was confirmed and the weekly data stored.

E.10 Data Storage and Archiving Procedures

All raw data, documentation, records, test plans, analyses, reports and correspondence generated as a result of this demonstration were properly stored and archived in paper and electronic file formats as appropriate. Project data and analyses were stored in an organized fashion to facilitate retrieval in an expedient fashion. Field logbooks were retained on site during the demonstration and surrendered to the Field Project Manager at the demonstration completion. Electronic data was stored on-site weekly in spreadsheets and transferred off-site at the end of the week. Off-site laboratory results were stored off-site. Paper files were maintained and stored so as to minimize deterioration during and after the project was complete. Electronic files associated with the project were automatically backed-up on a monthly basis during the active phase of the project. Electronic files have been archived on Basin Water, Inc. system network drives upon completion of the project to ensure data integrity.

Appendix F: Field Monitoring Data

Version 2 3/15/2007

MONITORING LOGSHEET FOR RIALTO DRINKING WATER PLANT

Date	Time	Days Elapsed	Feed Flow FIT-20	System Feed Pressure PI-20	Pump 100 Discharge Pressure PI-100	System pH AIT-105	System Temperature AIT-105	Fluidization Flow FI-110	FBR Influent FluidizationPress. PI-110	FBR Bed Height	System ORP AIT-110	Blower Discharge Pressure PI-200	Blower Discharge Temp. (deg F)	Aeration Tank Height LIT-210	Pump 210 Discharge Pressure PI-210	Trimite Absorption Clarifier Pressure PI-310	Trimite Mixed Media Pressure PI-320	Trimite Flow FI-310	Trimite Effluent Turbidity AIT-310	Trimite Blower B-310 Discharge Pressure PI-330	Holding Tank Level LIT-340	GAC Pressure In PI-501	GAC Pressure Out PI-501	Nitrate-N Feed AE-650	Nitrate-N Effluent AE-660	Perchlorate Feed AI 761	Perchlorate Effluent AI 762	Electron Donor Tank 430 Volume
d/m/y	hh:mm	# days	gpm	psig	psig	0-14	Deg F	gpm	psig	inches	mV	psig	Deg F	inches	0 to 2	psig	ft H_2O	gpm	NTU	psig	inches	psig	psig	mg/l	mg/l	µg/l	µg/l	gallons
																								4-10		4-10		
Avg.			40.0	5.6	22.2	7.41	18.5	91.7	8.7	132.0	-190.0	9.6	206.2	93.1	15.2	0.8	4.4	44.2	0.105	0.6	159.0	1.4	1.1	6.1	0.5	346.6	4.5	22.1
Std.			13.6	0.2	1.7	0.31	0.6	6.5	1.2	18.7	320.1	4.8	17.3	20.7	2.1	0.4	1.9	19.0	0.097	1.2	19.2	1.6	1.4	1.0	1.2	768.7	9.8	11.4
Max.			72.9	6.0	26.0	8.93	23.1	112.0	11.0	170.0	499.0	13.0	240.0	146.0	20.5	2.1	8.0	90.0	0.759	3.0	166.0	8.0	6.5	7.6	6.2	4029.0	86.6	55.0
Min.			0.0	5.0	19.5	6.79	13.9	74.5	6.0	0.0	-497.0	0.0	90.0	8.0	11.0	0.0	-3.5	0.0	0.015	0.0	19.0	0.0	0.0	0.1	0.0	32.2	0.0	0.0
13-Feb-07		-30																										
14-Feb-07		-29																										
15-Feb-07	10:24	-28	35.1	6.0	25.0	8.93	17.9	99.6	7.50	117	277	12	178	63	18.0	0.20	0	0		0	163	0	0	6.4	1.8		0.0000	
16-Feb-07	09:00	-27	21.4	5.5	24.0	8.67	18.3	99.6	8.00	114	342	12	175	57	18.0	0.10	0	0		0	163	0	0	6.8	3.5		0.0000	
17-Feb-07		-26																										
18-Feb-07		-25																										
19-Feb-07	10:00	-24	21.3	5.0	24.0	8.38	17.4	98.2	8.50	114	338	12	180	57	18.5	0.10	0	0		0	161	0	0	7.1	4.1		0.0000	
20-Feb-07	9:00	-23	21.5	5.0	24.5	8.62	16.6	98.2	9.00	114	376	12	150	62	19.0	0.10	0	0		0	161	0	0	6.8	4.5		0.0000	
21-Feb-07	9:20	-22	20.7	5.0	24.5	8.55	17.4	98.2	8.75	114	374	12	170	58	19.0	0.10	0	0		0	161	0	0	6.8	4.9		0.0000	
22-Feb-07	13:40	-21	50.0	5.5	24.5	8.43	17.7	98.2	9.25	114	359	12	185	71	17.5	0.35	0	0		0	161	0	0	6.7	5.2	42.1986	3.9362	
23-Feb-07	14:50	-20	0		24.5	7.93	15.9	101	9.00	114	405	0		54		0	0	0		0	164	0	0					
24-Feb-07		-19																										
25-Feb-07		-18																										
26-Feb-07	11:40	-17	0		24.0	7.98	17.0	98.2	9.00	114	388	0		52		0	0	0		0	163	0	0					
27-Feb-07	11:00	-16	0		23.5	7.95	13.9	96.7	8.75	114	386	0		52		0	0	0		0	163	0	0					
28-Feb-07	16:05	-15	40.0	5.5	24.0	7.85	17.9	98.2	9.00	114	418	12	185	74	17.5	0.1	-0.1		0.208	0	84	0	0	6.2	1.3			49
1-Mar-07	13:30	-14	40.0	5.5	24.0	7.67	18.2		7.50	114	449	13	190	90	16.5	0.1	-3.0		0.378		19	0	0	6.1	0.5	38.1	0.0	46
2-Mar-07	13:30	-13	39.3	5.5	24.0	7.43	18.2	96.7	7.75	114	424	13	190	83	16.5	0.1	-3.5		0.660		84	0	0	6.1	1.5		4.4	34
3-Mar-07		-12																										
4-Mar-07		-11																										
5-Mar-07	15:30	-10	0		22.0	7.51	23.1	96.7	7.75	144	283			77					0.429		104	0	0	5.8	0.5			29
6-Mar-07	13:00	-9	39.5	5.5	23.0	8.02	18.3	96.7	7.25	150	379	12	215	73	14.0	0.1	-3.0	40	0.268		162	0	0	6.0	0.7			33
7-Mar-07	10:30	-8	0		23.5	7.98	19.9	96.7	8.00	138											84							
8-Mar-07	15:00	-7	40.0	5.5	23.0	8.21	21.4	96.7	8.75	138	374	12	205	134	17.5	0.15	-0.1	40	0.144		164	1	0	5.9	4.0			33
9-Mar-07	8:30	-6	40.0	5.5	24.0	8.10	18.1	96.7	9.50	135	399		185	79	16.5	0.20	-0.3	40	0.091		164	2	1.5	5.6	5.4			33
10-Mar-07		-5																										
11-Mar-07		-4																										
12-Mar-07	15:00	-3	40.0	5.0				103	6.00	122				64							163	0	0					
13-Mar-07	12:30	-2	40.0	5.5	23.0	8.33	18.6	101	6.25	117	386		205	76	14.5	0.70					163	0	0	5.7	4.4			
14-Mar-07	16:00	-1	40.2	5.5	23.0	8.51	18.3	101	7.75	116	399		200	79	14.5	0.60					163	0	0	5.7	6.1	39.7	30.2	33
15-Mar-07	9:30	0	20.0	5.0	23.5	8.16	18.6	99.6	8.00	112	404		190	66	17.0	0.20					162	0	0	5.7	6.1			33
16-Mar-07	10:30	1	19.9	5.5	23.0	7.47	19.0	96.7	7.25	115	499		205	66	17.0	0.25					162	0	0	6.3	3.5	39.0	21.8	31
17-Mar-07		2																										
18-Mar-07		3																										
19-Mar-07	12:00	4	20	5.0	24.0	7.53	18.3	95.1	9.50	116	439		180	70	18.0	0.55					161	0	0	6.3	2.5	38.1	21.8	29
20-Mar-07	9:30	5	20	5.0	24.0	7.47	18.2	95.1	9.75	120	487		185	64	18.0	0.60					160	0	0	6.3	2.8	35.8	23.6	27
21-Mar-07	11:00	6	20	5.0	24.5	7.37	18.3	96.7	10.00	120	467		185	67	18.0	1.30					160	0	0	6.3	1.6	39.2	18.5	26
22-Mar-07	9:00	7	30	5.5	24.0	7.32	18.5	90.4	8.00	123	477		200	71	16.5	0.30					84	0	0	6.3	1.6	36.9	15.0	23
23-Mar-07	11:00	8	30	5.5	24.0	7.32	18.3	90.4	8.50	129	433		190	69	16.0	0.50					83	0	0	6.4	1.6	38.1	15.6	20
24-Mar-07		9																										
25-Mar-07		10																										
26-Mar-07	13:15	11	31	5.5	24.0	7.32	18.3	95.1	9.50	135	476		190	71	17.5	0.20					83	0	0	6.4	0.5	38.1	0	16
27-Mar-07	9:30	12	30	5.5	24.0	7.15	18.1	95.1	10.00	138	319		180	73	18.0	0.25					83	0	0	6.4	0.5	37.7	0	12
28-Mar-07	10:30	13	40	5.5	24.5	7.21	18.3	95.1	8.00	148	-32		190	60	16.0	0.10	4.0	40	0.455		84	0	0	6.8	0.2	38.2	0.3	9
29-Mar-07	11:00	14	40	5.5	24.0	7.08	18.3	93.6	8.00	156	-32		185	67	16.0	0.15			0.430		161	0	0	6.8	1.5	35.7	10.5	5
30-Mar-07	9:00	15	40	5.5	23.5	7.03	18.3	95.1	8.00	140	-32		190	67	15.0	0.10					161	0	0	6.8	0.9	36.8	12.1	49
31-Mar-07		16																										
1-Apr-07		17																										
2-Apr-07		18																										38
3-Apr-07	15:30	19	20	5.0	24.0	8.07	18.8	112	8.50	151	-31		205	67	15.0	0.20					160	0	0	6.6	5.5	35.8	15.3	38
4-Apr-07	12:00	20	50	5.5	26.0	8.01	18.3	108	6.50	135	289		215	108	15.0	0.20					84	0	0	6.5	6.2	34.9	16.1	38
5-Apr-07	11:00	21	50	5.5	22.0	7.49	18.3	107	7.50	129	321		200	74	13.5	0.20	2.0	50	0.219	2.5	164	0	0	7.3	1.5	35.0	11.3	34
6-Apr-07	9:30	22	50	5.5	23.0	7.83	18.1	83.7	9.75	139	346		185	72	14.0	0.20	2.5	50	0.180		166	4.0	3.5	7.4	0.4	36.5	8.1	29
7-Apr-07		23								138																		
8-Apr-07		24								135																		
9-Apr-07	9:30	25	50	5.5	23.5	7.86	18.1	93.6	9.50	134	299		190	72	15.0	0.20	4.0	50	0.171		165	4.0	4.0	7.2	1.3	36.7	22.6	14
10-Apr-07		26	51	5.5	23.0	7.83				146	283		200	75	13.0	0.20	5.0	50	0.088		164	2.0	2.0	7.6	0.2	35.0	23.4	11
11-Apr-07	11:00	27	50	5.5	22.5	7.26	18.3	90.4	7.50	144	273		195	74	13.5	0.20	6.0	55	0.129		164	4.0	3.5	7.3	0.1	35.2	0.0	6/10
12-Apr-07	10:00	28	50	5.5	24.0	7.19	18.3	85.4	9.00	141	217		185	75	14.0	0.25	4.0	50	0.156	3.0	164	8.0	6.5	6.3	0.1	37.0	0.0	5/11
13-Apr-07	15:30	29	42+8	5.5	23.0	7.17	18.3	82.0	8.00	146	135		205	75	12.5	0.20	3.5	50	0.150		164	2.0	2.0	6.0	0.1	40.3	6.5	5/55
14-Apr-07	8:00	30								158																		
15-Apr-07	13:00	31								170																		
16-Apr-07	17:00	32	51	5.75	20.5	7.21	18.3	90.4	8.75	146 / 96	-156		195	76	14.0	0.20	3.5	55	0.173		165	4.0	4.0	6.0	0.5	35.7	5.4	40
17-Apr-07	9:00	33	50	6.00	21.5	7.32	18.3	90.4	8.50	102	-68		185	76	14.5	0.20	5.0	55	0.050		164	4.0	4.0	6.0	0.1	35.4	ND<1.8	38
18-Apr-07	12:30	34	50	5.75	22.5	7.26	18.3	83.7	9.00	114 /116	-114		190	80	14.0	0.20	3.5	45	0.059		165	4.0	4.0	6.0	0.1	35.9	3.0(grab)	32
19-Apr-07	14:30	35	50	5.75	22.0	7.47	18.3	80.2	8.75	142 / 129	-72		210	78	13.0	0.25	6.0	50	0.110		165	3.5	2.5	6.0	0.1	35.9	6.0	26
20-Apr-07	10:00	36	50	5.75	23.5	7.08	18.1	80.2	10.25	152 / 135	-99		180	79	14.5	0.20	3.5	50	0.188		164	4.5	4.5	5.9	0.1	36.0	4.9	21
21-Apr-07		37																										
22-Apr-07		38																										
23-Apr-07		39																										

Version 2 **3/15/2007**

Date	Time	Electron Donor Pump 430 Stoke	Electron Donor Pump 430 Speed	Electron Donor Pump 430 Proportionality Constant	Nutrient Tank 410 Volume	Nutrient Pump 410 Stoke	Nutrient Pump 410 Speed	Nutrient Pump 410 Proportionality Constant	Dissolved Oxygen Feed (V-106)	Oxidation Reduction Potential Feed (V-106)	pH Feed (V-106)	Temperature Feed (V-106)	Nitrate-N Feed (V-106)	Nitrite-N Feed (V-106)	Dissolved Oxygen Effluent (V-1143)	Oxidation Reduction Potential Effluent (V-1143)	pH Effluent (V-1143)	Temperature Effluent (V-1143)	Nitrate-N Effluent (V-1143)	Nitrite-N Effluent (V-1143)	Total Organic Carbon Effluent (V-1143)	Ortho-Phosphate P Effluent (V-1143)	Trimite Effluent Turbidity	Post Aeration Dissolved Oxygen
d/m/y	hh:mm	0-100	0-100	0-1	gallons	0-100	0-100	0-1	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mg/l	NTU	mg/l
									5.5-8.0	>0	6 -8	15-20	4-10	<1	5.5-8.0	<0	6-8	20-35	<1	<1	<100	9-30	<1	5.0-9.0
Avg.		100.0	29.4	0.65	23.3	100.0	23.1	0.67	8.10	74.9	8.0	19.3	4.5	0.0	0.83	28.7	7.40	19.7	0.7	0.147	2.2	1.3	0.19	7.4
Std.		0.0	9.9	0.02	9.0	0.0	10.3	0.28	0.87	88.9	0.3	0.9	0.7	0.0	1.14	130.9	0.45	0.9	1.1	0.560	2.4	0.9	0.16	1.1
Max.		100.0	46.0	0.71	44.0	100.0	64.0	2.00	9.76	317.9	8.8	22.7	5.8	0.1	5.78	346.1	8.74	22.8	4.6	3.100	15.6	4.93	0.78	9.4
Min.		100.0	0.0	0.60	0.0	100.0	0.0	0.00	5.98	-31.7	7.5	0.0	2.7	0.0	0.01	-207.1	6.84	17.3	0.0	0.000	-2.0	0.00	0.07	3.6
13-Feb-07																								
14-Feb-07																								
15-Feb-07	10:24																							
16-Feb-07	09:00								6.17	215.0	7.75	21.3	4.0	0	3.88	229.4	8.38	19.7	3.0	0				
17-Feb-07																								
18-Feb-07																								
19-Feb-07	10:00								6.12	236.8	8.40	19.9	5.0	0.021	3.70	208.6	8.42	19.4	3.7	0.005		3.8		
20-Feb-07	9:00								6.94	230.1	8.54	17.5			4.95	220.9	8.72	19.7						
21-Feb-07	9:20										8.84	17.9												
22-Feb-07	13:40																							
23-Feb-07	14:50																							
24-Feb-07																								
25-Feb-07																								
26-Feb-07	11:40																							
27-Feb-07	11:00																							
28-Feb-07	16:05	100	25	0.65		100	17	0.55																
1-Mar-07	13:30	100	26	0.65	39	100	18	0.55	7.27	170.1	7.88	19.4	4	0	0.88	244.1	7.44	17.3	0.6	0.004	-2.0	1.81	0.69	
2-Mar-07	13:30	100	26	0.65	38	100	18	0.55	7.47	125.0	7.72	19.2	4	0	0.59	98.5	7.35	19.2	1.0	0	-0.4	1.08	0.78	
3-Mar-07																								
4-Mar-07																								
5-Mar-07	15:30	100	0	0.65	32	100	0	0.55							0.05	31.7		20.9	0.5	0				
6-Mar-07	13:00	100	0	0.65	32	100	0	0.55	6.64	207.0		19.8			0.16	171.5		19.5	0.5	0				
7-Mar-07	10:30	100	0	0.65	32	100	0	0.55																
8-Mar-07	15:00	100	0	0.65	32	100	0	0.55																
9-Mar-07	8:30	100	0	0.65	32	100	0	0.55																
10-Mar-07																								
11-Mar-07																								
12-Mar-07	15:00																							
13-Mar-07	12:30														1.59	145.6								
14-Mar-07	16:00	100	0	0.65	31	100	0	0.55	6.04	201.7	8.61	20.2	4.6	0	5.13	228.7	8.74	21.5	3.7	0				
15-Mar-07	9:30	100	12	0.65	31	100	8	0.55	6.16	199.1	8.83	19.1	4.7	0.004	5.78	218.4	8.74	19.7	4.6	0.002		0.18		
16-Mar-07	10:30	100	11	0.65	31	100	7	0.52	7.02	244.9	7.76	21.2	4	0	0.84	245.7	7.50	22.1	2	0		0.14		
17-Mar-07																								
18-Mar-07																								
19-Mar-07	12:00	100	11	0.65	30	100	10	0.70	6.56	103.5	7.95	18.4	3.8	0.001	0.85	86.0	7.25	18.2	1.4	0.020		0.14		
20-Mar-07	9:30	100	11	0.65	27	100	13	1.00	5.98	114.3	8.18	18.4	3.8	0.003	1.17	4.3	7.30	18.7	1.9	0.023	0.7	1.05		
21-Mar-07	11:00	100	13	0.65	23	100	32	2.00	6.91	148.4	8.03	18.9	5.6	0.003	0.32	0.4	7.31	18.4	1.2	0.028	0.9	2.06		
22-Mar-07	9:00	100	18	0.65	16	100	45	2.00	6.85	152.1					0.80	49.7		18.1						
23-Mar-07	11:00	100	21	0.65	8	100	53	2.00	7.12	182.8	7.81	19.3	5.1		0.68	35.6	7.37	19.7	0.6		3.5	2.13		
24-Mar-07																								
25-Mar-07																								
26-Mar-07	13:15	100	30	0.65	33	100	54	2.00	9.20	73.4	8.18	19.0	4.1		0.55	64.1	7.29	19.3	0.9			2.60		
27-Mar-07	9:30	100	30	0.65	27	100	39	1.50	9.22	53.4		18.3			0.26	65.8		18.5			5.9	1.76		
28-Mar-07	10:30	100	25	0.65	20	100	47	1.50	9.15	28.3	8.44	18.6	2.7	0.001	0.35	33.4	7.86	19.5	0.3	0.010	1.6	1.42	0.67	
29-Mar-07	11:00	100	26	0.65	13	100	48	1.50	9.10	33.4	8.56	19.0	5.0	0.003	0.10	75.5	7.68	18.5	1.1	0.012	1.0	1.46		
30-Mar-07	9:00	100	26	0.65	7	100	47	1.50	8.90	22.1		19.3			0.09	66.4		19.5						8.09
31-Mar-07																								
1-Apr-07																								
2-Apr-07		100	0	0.65	32	100	0	1.50																
3-Apr-07	15:30	100	0	0.65	32	100	0	1.50																
4-Apr-07	12:00	100	31	0.65	32	100	57	1.50	8.63	19.4	7.89	19.2	5.3	0.016	0.10	346.1	7.52	19.8	2.9	0.035		1.17		9.03
5-Apr-07	11:00	100	34	0.65	29	100	63	1.50	8.90	39.4	7.92	19.8	4.9	0.024	0.37	110.6	7.31	19.4	1.3	0.048	1.2	0.40	0.23	9.09
6-Apr-07	9:30	100	35	0.65	21	100	64	1.50	9.76	39.1	7.94	19.3	4.4		0.57	59.6	7.68	19.5	0.3		1.0	1.80	0.45	9.39
7-Apr-07								1.30																
8-Apr-07								1.30																
9-Apr-07	9:30	100	35	0.65	17	100	56	1.30	9.24	17.4	8.18	18.2	3.6		1.85	59.6	7.55	19.0	0.4		0.9	1.53	0.18	8.58
10-Apr-07		100	38	0.65	13/40	100	57	1.20													1.6	0.12		
11-Apr-07	11:00	100	38	0.65	32	100	57	1.20	9.09	44.3	7.99	19.5	4.8	0.004	1.41	48.7	7.46	18.8	0.2	0.005	4.3	1.53	0.23	8.63
12-Apr-07	10:00	100	37	0.65	23	100	55	1.20	8.91	20.1	8.30	19.2	4.3	0.002	0.25	34.4	7.95	19.7	0.3	0.004	2.7	0.38	0.29	8.48
13-Apr-07	15:30	100	46	0.65	16/40	100	55/26	1.20/0.55														2.49		
14-Apr-07	8:00																							
15-Apr-07	13:00																							
16-Apr-07	17:00	100	35	0.65	30	100	23	0.55															0.28	
17-Apr-07	9:00	100	35	0.65	28	100	23	0.55	8.72	15.8		19.0	3.9	0.004	0.92	14.6		19.2	0.3	0.024	0.9	1.39	0.17	8.01
18-Apr-07	12:30	100	36	0.65	24	100	24	0.55					4.0	0.002					0.2	0.005	0.5	1.25	0.08	
19-Apr-07	14:30	100	40	0.65	20.5	100	27	0.55																
20-Apr-07	10:00	100	36	0.65	18	100	24	0.55	9.07	51.0	7.84	18.0			1.71	27.9	7.33	18.6	0.3	0.002	1.1	1.02		9.22
21-Apr-07																								
22-Apr-07																								
23-Apr-07																								

Version 2 **3/15/2007**

MONITORING LOGSHEET FOR RIALTO DRINKING WATER PLANT

Shaw Shaw Environmental & Infrastructure, Inc.

Date	Time	Days Elapsed	Feed Flow FIT-20	System Feed Pressure PI-20	Pump 100 Discharge Pressure PI-100	System pH AIT-105	System Temperature AIT-105	Fluidization Flow FI-110	FBR Influent FluidizationPress. PI-110	FBR Bed Height	System ORP AIT-110	Blower Discharge Pressure PI-200	Blower Discharge Temp. (deg F)	Aeration Tank Height LIT-210	Pump 210 Discharge Pressure PI-210	Trimite Absorption Clarifier Pressure PI-310	Trimite Mixed Media Pressure PI-320	Trimite Flow FI-310	Trimite Effluent Turbidity AIT-310	Trimite Blower B-310 Discharge Pressure PI-330	Holding Tank Level LIT-340	GAC Pressure In PI-501	GAC Pressure Out PI-501	Nitrate-N Feed AE-650	Nitrate-N Effluent AE-660	Perchlorate Feed AI 761	Perchlorate Effluent AI 762	Electron Donor Tank 430 Volume
d/m/y	hh:mm	# days	gpm	psig	psig	0-14	Deg F	gpm	psig	inches	mV	psig	Deg F	inches	0 to 2	psig	ft H_2O	gpm	NTU	psig	inches	psig	psig	mg/l	mg/l	µg/l	µg/l	gallons
																								4-10		4-10		
Avg.			40.0	5.6	22.2	7.41	18.5	91.7	8.7	132.0	-190.0	9.6	206.2	93.1	15.2	0.8	4.4	44.2	0.105	0.6	159.0	1.4	1.1	6.1	0.5	346.6	4.5	22.1
Std.			13.6	0.2	1.7	0.31	0.6	6.5	1.2	18.7	320.1	4.8	17.3	20.7	2.1	0.4	1.9	19.0	0.097	1.2	19.2	1.6	1.4	1.0	1.2	768.7	9.8	11.4
Max.			72.9	6.0	26.0	8.93	23.1	112.0	11.0	170.0	499.0	13.0	240.0	146.0	20.5	2.1	8.0	90.0	0.759	3.0	166.0	8.0	6.5	7.6	6.2	4029.0	86.6	55.0
Min.			0.0	5.0	19.5	6.79	13.9	74.5	6.0	0.0	-497.0	0.0	90.0	8.0	11.0	0.0	-3.5	0.0	0.015	0.0	19.0	0.0	0.0	0.1	0.0	32.2	0.0	0.0
24-Apr-07		40																										
25-Apr-07		41																										
26-Apr-07	17:00	42	50	5.75	20.0	7.39	18.3	74.5	8.00	133	40		210	79	13.0	0.35	3.0	55	0.524		117			6.0	0.1	37.2	5.7	21 / 23
27-Apr-07	10:30	43	50	5.75	21.0	7.29	18.3	76.4	6.50	129 / 126	79		215	81	13.0	0.20	3.0	50	0.220	2.6	164	3.0	3.0	6.0	0.1	35.6	2.6	19 / 55
28-Apr-07		44																										
29-Apr-07		45																										
30-Apr-07	13:15	46	50	5.75	20.0	7.20	18.3	78.3	7.75	105	140		215	83	13.0	0.30	4.0	55	0.212		165	3.0	2.5	6.0	0.2	36.4	4	41
1-May-07	10:15	47	50	5.75	22.5	7.14	18.3	82.0	9.50	119	165		200	81	14.0	0.20	4.0	50	0.200		165	4.0	4.0	6.0	0.1	40.4	0	36
2-May-07	12:00	48	50	5.75	20.0	7.22	18.4	85.4	7.50	96	200		200	83	13.0	0.65	8.0	55	0.367		164	5.0	4.0	6.0	0.6	39.6	0	33
3-May-07	10:30	49	50	5.75	21.0	7.20	18.3	80.2	8.00	95	167		205	108	13.5	0.30	5.0	55	0.759		101			6.1	0.3	36.7	4.3	32 / 44
4-May-07	10:30	50	50	5.75	22.0	7.08	18.3	96.7	9.00	102	-34		190	78	14.0	0.35	3.5	60	0.169		164	4.0	4.0	6.1	0.1	35.9	0	39
5-May-07		51																										
6-May-07		52																										
7-May-07	16:00	53	50	5.75	20.5	7.21	18.3	74.5	7.50	104	-361		215	82	17.0	0.50					162			6.1	0.1	37.7	0	
8-May-07	14:15	54	50	5.75	21.0	7.05	18.3	85.4	7.50	103	-139			80	14.0	0.50	4.0	50	0.105		164			6.1	0.2	37.9	4.2	20
9-May-07	11:30	55	50	5.75	21.5	7.04	18.3	82.0	7.50	96	-13		225	104	12.0	0.30	4.0	50	0.200		164	3.0	2.0	6.1	0.1	36.0	0	14 / 16
10-May-07	10:30	56	50	5.75	21.5	6.79	18.3	76.4	7.50	105	-345		215	86	12.0	0.50	5.0	50	0.096		164	4.0	4.0	6.1	0.1	38.0	0	11
11-May-07	11:30	57	50	5.75	22.0	6.84	18.3	80.2	7.50	108	-190		210	87	12.5	1.00	4.0	55	0.084		164	3.0	3.0	6.1	0.1	37.8	0	5 / 55
12-May-07		58																										
13-May-07		59																										
14-May-07	16:00	60	50	5.75	21.0	7.20	18.3	85.4	8.50	132	19		220	146	19.5						163			6.2	0.1	36.3	0	35
15-May-07	12:30	61	50	5.75	21.5	7.29	18.3	85.4	8.50	120	-128		215	146	20.0						163			6.2	0.1	35.7	0	30
16-May-07	12:15	62	50	5.75	22.0	7.29	18.3	88.8	8.50	114	-114		215	146	20.5						163			6.2	0.1	35.9	0	25 / 41
17-May-07	09:00	63	50	5.75	23.0	7.30	18.3	87.1	10.00	113	-433		190	91	14.0	2.00	4.5	65	0.024		164	5.0	4.0	6.2	0.1	35.5	0	36
18-May-07	09:45	64	50	5.75	22.0	7.35	18.3	90.4	9.00	99	-435		200	89	13.5	2.10	5.5	55	0.015		164	3.0	3.0	6.2	0.1	34.9	0	30
19-May-07		65																										
20-May-07		66																										
21-May-07		67																										
22-May-07		68																										
23-May-07	11:45	69	50	5.75	20.5	8.2	18.3	90.4	7.50	96	-369		220	120	14.0	1.70	4.5	65	0.082		164	2.0	1.5	6.2	0.8	34.5	0	24
24-May-07	10:00	70	50	5.75	21.0	7.4	18.3	92.0	7.00	105	-413		220	103	12.5	0.80	7.0	70	0.209		164	2.0	2.0	6.2	0.1	32.2	0	18
25-May-07	11:15	71	50	5.75	21.0	7.4	18.3	88.8	7.50	120	-433		215	123	14.0	1.50	6.5	90	0.062		164	2.0	2.0	6.2	0.2	35.1	0	13 / 44
26-May-07		72																										
27-May-07		73																										
28-May-07	12:30	74	50	5.75	21.5	7.78	18.3	90.4	8.25	115	19		220	88	13.0	1.00	5.0		0.070		164	2.0	2.0	6.2	0.2	36.3	0	26
29-May-07	10:30	75	50	5.75	22.0	7.52	18.3	82.0	9.00	114	-17		205	98	14.0	1.35	5.0		0.072		164	2.0	2.0	6.2	0.2	35.4	0	20 / 29
30-May-07		76																										
31-May-07	13:30	77	50	5.75	21.0	7.29	18.3	87.1	8.50	115	-208		225	140	14.0	0.80	5.0		0.073		164	3.0	2.0	6.2	0.2	37.2	0	18
1-Jun-07	10:00	78	50	5.75	21.5	7.54	18.3	85.4	9.00	116	-264		210	124	14.0	1.00	7.5		0.065		164	3.5	3.0	6.3	0.2	35.3	0	55
2-Jun-07		79																										
3-Jun-07		80																										
4-Jun-07	15:00	81	50	5.75	20.5	7.40	18.3	80.2	8.00	119	-84		235	125	12.5	1.00	6.5		0.057		164	2.0	2.0	6.3	0.2	39.1	0	35
5-Jun-07	11:30	82	50	5.75	21.5	7.39	18.3	78.3	8.75	119	38		220	123	14.0	1.00	4.0		0.053		164	1.5	1.0	6.3	0.2	36.2	0	32
6-Jun-07	08:00	83	50	5.75	22.0	7.42	18.3	78.3	10.00	120	-57		195	117	15.0	1.50	5.0		0.051		164	2.0	1.0	6.3	0.2	36.8	0	39
7-Jun-07	10:45	84	50	5.75	21.5	7.49	18.3	76.4	8.00	122	-348		215	136	14.5	2.00			0.052		164			6.3	0.2	35.8	0	34
8-Jun-07		85																										
9-Jun-07		86																										
10-Jun-07		87																										
11-Jun-07		88																										
12-Jun-07	12:20	89	50	5.75	19.5	7.80	18.3	82.0	6.75	110	4	10	225	78	12.0	1.25	3.0	65	0.059		164	1.0	0.5	5.8	0.2	37.0	0	32
13-Jun-07	12:00	90	50	5.75	19.5	7.56	18.5	87.1	7.00	135	60	10	225	81	12.0	0.90	3.5	55	0.069		164	0	0	5.8	0.2	37.6	0	27
14-Jun-07	13:00	91	50	5.75	20.0	7.80	18.5	90.4	8.00	147	83		235	80	12.0	1.35	4.5	60	0.074		164	0	0	5.8	0.2	37.8	7.2	22 / 50
15-Jun-07		92																										
16-Jun-07		93																										
17-Jun-07		94																										
18-Jun-07	13:15	95	50	5.75	20.0	7.63	18.3	98.2	7.75	99	132		225	82	12.5	1.10	4.5		0.055		164	0	0	5.9	0.2	35.0	0	30
19-Jun-07	12:35	96	50	5.75	20.0	7.30	18.3	98.2	7.00	108	155		225	87	12.5	1.30	5.5		0.053		164	1.0	1.0	5.9	0.2	39.0	3.9	25
20-Jun-07	14:15	97	50	5.75	20.0	7.20	18.5	98.2	7.50	129	153		235	124	13.0	2.00	6.0		0.094		164	1.0	1.0	5.9	0.2	35.2	0	20 / 40
21-Jun-07	08:00	98	50	5.75	21.0	7.24	18.3	98.2	9.25	123	160		205	81	14.0	1.00	5.0		0.060		164	1.0	1.0	5.9	0.2	35.4	0	36
22-Jun-07		99																										
23-Jun-07		100																										
24-Jun-07		101																										
25-Jun-07	16:20	102	50	5.75	20.0	7.37	19.0	85.4	7.50	136	179		220	81	12.5	1.10	3.0		0.070		164	1.0	1.0	5.9	0.1	36.1		13
26-Jun-07	15:20	103	50	5.75	20.0	7.56	18.7	80.2	7.50	150	35		220	77	12.5	0.90	4.5		0.129		164	0.5	0.5	6.0	0.1	36.2	0	9 / 57
27-Jun-07	11:00	104	50	5.75	20.0	7.48	18.5	80.2	6.50	132	89		210	84	13.5	0.80	4.0		0.069		164	1.0	1.0	6.0	0.1	35.9	0	50
28-Jun-07	10:30	105	50	5.75	20.0	7.18	18.8	82.0	7.00	123	143		210	94	13.5	1.80	5.0	80	0.051		164	0.5	0.5	6.0	0.1	35.1	0	48
29-Jun-07		106																										
30-Jun-07		107																										
1-Jul-07		108																										
2-Jul-07	16:15	109	50	5.75	20.0	7.47	18.6	90.4	7.00	162	100		220	144							163			6.0	0.2	36.6	0	27

Version 2 **3/15/2007**

Date	Time	Electron Donor Pump 430 Stoke	Electron Donor Pump 430 Speed	Electron Donor Pump 430 Proportionality Constant	Nutrient Tank 410 Volume	Nutrient Pump 410 Stoke	Nutrient Pump 410 Speed	Nutrient Pump 410 Proportionality Constant	Dissolved Oxygen Feed (V-106)	Oxidation Reduction Potential Feed (V-106)	pH Feed (V-106)	Temperature Feed (V-106)	Nitrate-N Feed (V-106)	Nitrite-N Feed (V-106)	Dissolved Oxygen Effluent (V-1143)	Oxidation Reduction Potential Effluent (V-1143)	pH Effluent (V-1143)	Temperature Effluent (V-1143)	Nitrate-N Effluent (V-1143)	Nitrite-N Effluent (V-1143)	Total Organic Carbon Effluent (V-1143)	Ortho-Phosphate P Effluent (V-1143)	Trimite Effluent Turbidity	Post Aeration Dissolved Oxygen
d/m/y	hh:mm	0-100	0-100	0-1	gallons	0-100	0-100	0-1	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mg/l	NTU	mg/l
									5.5-8.0	>0	6 -8	15-20	4-10	<1	5.5-8.0	<0	6-8	20-35	<1	<1	<100	9-30	<1	5.0-9.0
Avg.		100.0	29.4	0.65	23.3	100.0	23.1	0.67	8.10	74.9	8.0	19.3	4.5	0.0	0.83	28.7	7.40	19.7	0.7	0.147	2.2	1.3	0.19	7.4
Std.		0.0	9.9	0.02	9.0	0.0	10.3	0.28	0.87	88.9	0.3	0.9	0.7	0.0	1.14	130.9	0.45	0.9	1.1	0.560	2.4	0.9	0.16	1.1
Max.		100.0	46.0	0.71	44.0	100.0	64.0	2.00	9.76	317.9	8.8	22.7	5.8	0.1	5.78	346.1	8.74	22.8	4.6	3.100	15.6	4.93	0.78	9.4
Min.		100.0	0.0	0.60	0.0	100.0	0.0	0.00	5.98	-31.7	7.5	0.0	2.7	0.0	0.01	-207.1	6.84	17.3	0.0	0.000	-2.0	0.00	0.07	3.6
24-Apr-07																								
25-Apr-07																								
26-Apr-07	17:00	100	37	0.65	16	100	25	0.55																
27-Apr-07	10:30	100	36	0.65	14 / 40	100	25	0.55	9.06	15.6	8.58	19.3	4.9	0.007	1.32	-42.7	7.85	19.8	0.3	0.004	1.1	0.93	0.26	8.97
28-Apr-07																								
29-Apr-07																								
30-Apr-07	13:15	100	37	0.65	32.5	100	25	0.55	8.55	104.2	8.60	19.6			0.98	103.2	8.19	19.5					0.42	8.40
1-May-07	10:15	100	37	0.65	29.5	100	25	0.55	9.12	54.6	8.43	.18.9	5.3	0.004	1.30	60.3	8.32	19.2	0.1	0.004	2.6	1.03	0.30	8.36
2-May-07	12:00	100	37	0.65	27.5	100	25	0.55																
3-May-07	10:30	100	37	0.65	25.0	100	25	0.55	8.43	23.1	8.26	19.2			1.38	33.2	7.43	19.4	1.1			1.30	0.31	7.87
4-May-07	10:30	100	40	0.60	21.5	100	25	0.55													2.7		0.23	
5-May-07																								
6-May-07																								
7-May-07	16:00	100	39	0.60	14 / 40	100	25	0.55																
8-May-07	14:15	100	39	0.60	36	100	25	0.55		14.1	8.34	19.8				-33.1	6.84	19.8			1.9		0.23	
9-May-07	11:30	100	39	0.60	32.5	100	24	0.55															0.25	
10-May-07	10:30	100	39	0.60	29	100	23	0.52		208.0	8.23	19.6	5.4	0.002		206.5	6.95	19.8	0	0		1.53	0.22	
11-May-07	11:30	100	40	0.60	26	100	22	0.50	8.84	317.9	7.69	19.2			0.78	324.9	6.98	20.6				0.92	0.18	8.26
12-May-07																								
13-May-07																								
14-May-07	16:00	100	39	0.60	16	100	22	0.50					5.3	0.004					0	0		0.61		
15-May-07	12:30	100	40	0.60	14	100	23	0.50		140.4	7.75	21.8				153.1	7.05	21.7			3.3	0.62		
16-May-07	12:15	100	39	0.60	12	100	22	0.50																
17-May-07	09:00	100	39	0.60	9	100	22	0.50		30.3	7.70	19.6				-18.6	6.99	19.5				0.65	0.12	
18-May-07	09:45	100	40	0.60	7	100	22	0.50	7.75	48.4	7.97	19.2			0.01	23.4	7.20	19.4					0.13	7.48
19-May-07																								
20-May-07																								
21-May-07																								
22-May-07																								
23-May-07	11:45	100	40	0.60	27	100	24	0.53																
24-May-07	10:00	100	39	0.60	23	100	23	0.53			7.95	19.0	5.4	0.004			7.31	19.2	0.3	0.002	5.8	1.49	0.25	
25-May-07	11:15	100	39	0.60	20	100	22	0.50	8.24	3.3	7.60	19.4			0.24	-55.8	7.03	20.0			1.7	1.39	0.07	6.80
26-May-07																								
27-May-07																								
28-May-07	12:30	100	40	0.60	12	100	23	0.50	8.52	280.5	7.93	19.9	5.0	0.014	0.30	259.7	7.12	20.0	0	0.006		0.50	0.08	7.37
29-May-07	10:30	100	40	0.60	8.5 / 35	100	23	0.50	8.30	45.3	8.20	19.1			0.36	39.3	7.62	20.0			3.2	0.54	0.07	7.58
30-May-07																								
31-May-07	13:30	100	40	0.60	28	100	23	0.50															0.08	
1-Jun-07	10:00	100	40 / 38	0.60	26	100	23 / 22	0.50	7.57	1.6	8.05	19.2			0.49	-17.7	7.34	19.5				0.96	0.07	6.36
2-Jun-07																								
3-Jun-07																								
4-Jun-07	15:00	100	38 /34	0.60	17	100	21	0.50										22.8	0	3.1	3.1	0.60	0.08	
5-Jun-07	11:30	100	34	0.65	15	100	21	0.50	8.75	1.2	7.51	22.2	4.9				6.98	19.7		1.9	1.9	0.45	0.10	7.01
6-Jun-07	08:00	100	36	0.65	12	100	22	0.50				20.4			0.44	-15.2								
7-Jun-07	10:45	100	36	0.65	9	100	22	0.50																
8-Jun-07																								
9-Jun-07																								
10-Jun-07																								
11-Jun-07																								
12-Jun-07	12:20	100	34	0.65	8	100	21	0.50																
13-Jun-07	12:00	100	34	0.65	5 / 31	100	21	0.50	8.58	-17.5	8.01	22.7	4.2		0.25	-79.4	7.20	21.0	0.3			1.73	0.09	7.17
14-Jun-07	13:00	100	32	0.71	27.5	100	21	0.50													0.9	1.78		
15-Jun-07																								
16-Jun-07																								
17-Jun-07																								
18-Jun-07	13:15	100	32	0.71	15	100	21	0.50	8.50	-31.7	8.10	19.9			0.15	-102.6	7.31	21.5						
19-Jun-07	12:35	100	33	0.71	13	100	22	0.50																
20-Jun-07	14:15	100	32	0.71	10 / 40	100	22	0.50					4.0	0.040					0	0.020	1.1	0.52		
21-Jun-07	08:00	100	38	0.65	37.5	100	23	0.50	8.15													0.72		
22-Jun-07												22.1			0.75			21.3					0.09	7.13
23-Jun-07																								
24-Jun-07																								
25-Jun-07	16:20	100	35	0.65	24	100	22	0.50																
26-Jun-07	15:20	100	35	0.65	22	100	22	0.50	8.23	281.1	7.78	21.4	4.4	0.009	0.07	230.8	7.24	19.9	0.2	0	2.8	0.77	0.15	6.34
27-Jun-07	11:00	100	34	0.65	20	100	21	0.50														0.83	0.10	7.58
28-Jun-07	10:30	100	35	0.65	17.5	100	21	0.50														0.58		6.73
29-Jun-07																								
30-Jun-07																								
1-Jul-07																								
2-Jul-07	16:15	100	34	0.65	7 / 35	100	21	0.50																

Version 2 3/15/2007

MONITORING LOGSHEET FOR RIALTO DRINKING WATER PLANT

Date	Time	Days Elapsed	Feed Flow FIT-20	System Feed Pressure PI-20	Pump 100 Discharge Pressure PI-100	System pH AIT-105	System Temperature AIT-105	Fluidization Flow FI-110	FBR Influent FluidizationPress. PI-110	FBR Bed Height	System ORP AIT-110	Blower Discharge Pressure PI-200	Blower Discharge Temp. (deg F)	Aeration Tank Height LIT-210	Pump 210 Discharge Pressure PI-210	Trimite Absorption Clarifier Pressure PI-310	Trimite Mixed Media Pressure PI-320	Trimite Flow FI-310	Trimite Effluent Turbidity AIT-310	Trimite Blower B-310 Discharge Pressure PI-330	Holding Tank Level LIT-340	GAC Pressure In PI-501	GAC Pressure Out PI-501	Nitrate-N Feed AE-650	Nitrate-N Effluent AE-660	Perchlorate Feed AI 761	Perchlorate Effluent AI 762	Electron Donor Tank 430 Volume
d/m/y	hh:mm	# days	gpm	psig	psig	0-14	Deg F	gpm	psig	inches	mV	psig	Deg F	inches	0 to 2	psig	ft H_2O	gpm	NTU	psig	inches	psig	psig	mg/l	mg/l	µg/l	µg/l	gallons
																								4-10		4-10		
Avg.			40.0	5.6	22.2	7.41	18.5	91.7	8.7	132.0	-190.0	9.6	206.2	93.1	15.2	0.8	4.4	44.2	0.105	0.6	159.0	1.4	1.1	6.1	0.5	346.6	4.5	22.1
Std.			13.6	0.2	1.7	0.31	0.6	6.5	1.2	18.7	320.1	4.8	17.3	20.7	2.1	0.4	1.9	19.0	0.097	1.2	19.2	1.6	1.4	1.0	1.2	768.7	9.8	11.4
Max.			72.9	6.0	26.0	8.93	23.1	112.0	11.0	170.0	499.0	13.0	240.0	146.0	20.5	2.1	8.0	90.0	0.759	3.0	166.0	8.0	6.5	7.6	6.2	4029.0	86.6	55.0
Min.			0.0	5.0	19.5	6.79	13.9	74.5	6.0	0.0	-497.0	0.0	90.0	8.0	11.0	0.0	-3.5	0.0	0.015	0.0	19.0	0.0	0.0	0.1	0.0	32.2	0.0	0.0
3-Jul-07	11:30	110	62	6.00	20.0	7.24	18.6	95.1	6.50	150	130		225	146							163			6.0	0.1	38.8	0	22
4-Jul-07	10:15	111	61	6.00	20.0	7.16	18.3	90.4	6.50	150	152		220	146							162			6.0	0.1	36.3	0	16
5-Jul-07	10:00	112	61	5.75	20.5	7.20	18.3	95.1	7.00	158	132		225	146							162			6.0	0.2	36.2	0	9
6-Jul-07	10:00	113	62	5.75	20.5	7.19	18.3	98.2	7.00	150	5		220	146							161			6.0	0.2	37.6	0	47
7-Jul-07		114																										
8-Jul-07		115																										
9-Jul-07	15:30	116	50	5.75	19.5	7.50	18.5	96.7	7.50	168	5		220	146							159			6.1	0.7	40.3	11.1	33
10-Jul-07	15:30	117	50	5.75	19.5	7.22	18.5	95.1	8.50	159	125		215	146							159			6.1	0.1	38.1	11.9	28
11-Jul-07	16:00	118	50	5.75	20.5	7.17	18.5	92.0	8.50	158	144		215	146							158			6.1	0.1	38.6	3.3	23
12-Jul-07	14:00	119	50	5.75	20.5	7.16	18.5	90.4	8.00	140	23		225	90	13.0	1.00	4.0	50	0.064		164			6.1	0.1	38.4	0	18 / 25
13-Jul-07		120																										
14-Jul-07																												
15-Jul-07		122																										
16-Jul-07	17:00	123	50	5.75	19.5	7.46	18.5	88.8	7.00	144	-26		215	126	13.0	0.75	3.5	50	0.072		131			6.3	0.1			20
17-Jul-07	15:45	124	50	5.75	19.5	7.37	18.5	87.1	7.50	90	28		210	82	13.0	0.70	5.0	50	0.056		164			6.2	0.5			17
18-Jul-07	10:45	125	50	5.75	20.5	7.24	18.5	87.1	7.50	96	29		200	92	14.0	0.90	6.0	50	0.049		163			6.2	0.1	48.0	0	13
19-Jul-07	12:00	126	50	5.75	21.0	7.25	18.5	92.0	7.00	117	112.0		205	92	14.5	0.85	6.0	50	0.260		164	0	0	6.2	0.2	48.2	0	6 / 55
20-Jul-07	09:00	127	50	5.75	21.5	7.23	18.5	87.1	8.50	119	168.0		205.0	87.0	14.5	1.20	4.5	50	0.056		164	0.5	0	6.2	0.4	50.4	16.3	48
21-Jul-07		128																										
22-Jul-07		129																										
23-Jul-07	14:30	130	50	5.75	20.0	7.35	18.5	96.7	7.50	150	-42		210	88	13.5	1.10	4.0	50	0.073		164	0	0	6.2	0.2	46.3	0	34
24-Jul-07	12:15	131	50	5.75	20.0	7.36	18.5	90.4	7.00	144	102		225	137	14.0	1.60	4.0	50	0.074		86			6.2	0.2	47.5	0	30
25-Jul-07	13:00	132	50	5.75	20.0	7.18	18.5	93.6	7.50	144	-224		225	90	13.0	1.30	6.5	50	0.063		164	0	0	6.2	0.2	48.3	0	24
26-Jul-07	09:30	133	51	5.75	21.0	7.17	18.5	92.0	7.00	144	-260		215	94	14.0	1.50	7.0	55	0.066		164	0.5	0.5	6.2	0.2	47.6	0	19
27-Jul-07	10:00	134	50	5.75	20.0	7.34	18.5	87.1	7.00	111	-136		215	87	14.0	0.90	5.0	50	0.078		164	1.0	0.5	6.2	0.2	41.4	0	15 / 55
28-Jul-07		135																										
29-Jul-07		136																										
30-Jul-07	12:15	137	50	5.75	20.0	7.18	18.5	90.4	7.00	144	-436		220	92	13.5	0.95	5.00	40	0.066		164	0.5	0.5	6.1	0.2	46.3	0	38
31-Jul-07	09:45	138	50	5.75	21.0	7.23	18.3	88.8	9.00	144	-438		205	92	13.0	0.90	5.00	40	0.071		164	0.5	0.5	6.2	0.2	46.3	0	31
1-Aug-07	12:00	139	50	5.75	21.0	7.23	18.4	90.4	8.50	144	-356		215	95	13.5	1.20	4.00	50	0.079		164	0.5	0.5	6.1	0.3	46.7	14.0	27
2-Aug-07	12:00	140	50	5.75	20.0	7.22	18.5	87.1	7.50	144	-200		230	117	14.0	1.30	4.00	50	0.177		156	1.0	0.0	6.2	0.3	47.5	4.0	23 / 34
3-Aug-07	10:45	141	50	5.75	20.5	7.15	18.5	92.0	7.00	140	-449		225	116	14.0	1.50	4.00	50	0.117		164	0.5	0.5	6.2	0.3	46.8	0	28
4-Aug-07		142																										
5-Aug-07		143																										
6-Aug-07	12:00	144	50	5.75	21.0	7.17	18.5	88.8	8.50	141	-228		230	86	14.0	0.80	6.50	50	0.071		164	0.5	0.5	6.3	0.1	47.7	0	12
7-Aug-07	13:00	145	50	5.75	20.5	7.28	18.6	83.7	8.00	140	-91		210	88	14.0	1.10	4.00	55	0.069		164	1.0	0.5	6.3	0.1	45.7	0	8 / 55
8-Aug-07	09:15	146	50	5.75	21.0	7.23	18.5	92.0	8.00	136	-230		215	96	14.0	0.90	3.50	55	0.072		164	2.0	1.0	6.3	0.2	45.7	0	51
9-Aug-07	10:45	147	50	5.75	21.0	7.18	18.5	93.6	7.50	135	-185		215	86	13.5	1.00			0.067		164			6.3	0.2	46.0	0	44
10-Aug-07	10:30	148	50	5.75	21.0	7.14	18.5	90.4	7.50	139	-456		215	113	14.5				0.068		164			6.3	0.1	47.3	2.6	39
11-Aug-07		149																										
12-Aug-07		150																										
13-Aug-07	14:30	151	50	5.75	20.0	7.23	18.6	87.1	7.50	139	-381		235	88	12.0	1.10	4.00		0.068		164	0.0	0	6.3	0.2	48.1	2.8	23
14-Aug-07	10:30	152	50	5.75	20.5	7.17	18.8	87.1	6.50	140	-400		225	89	12.5	0.85			0.068		164	1.0	1.0	6.3	0.2	48.2		16 / 52
15-Aug-07	13:15	153	50	5.75	20.0	7.16	18.5	90.4	7.00	132	-472		240	146					0.069		164			6.3	0.1	48.4	5.3	47
16-Aug-07		154																										
17-Aug-07		155																										
18-Aug-07		156																										
19-Aug-07		157																										
20-Aug-07	11:30	158	50	5.75	20.5	7.17	18.8	95.1	7.75	90	-468		230	93	12.0	0.80	5.50		0.063		164	2.0	1.0	6.4	0.7	48.4	12.3	18
21-Aug-07	11:00	159	50	5.75	20.5	7.18	18.5	96.7	8.00	92	-56		230	94	12.5	0.90	4.00		0.124		164	2.0	1.5	6.4	0.2	48.8	0	13
22-Aug-07	10:00	160	50	5.75	21.0	7.22	18.5	87.1	6.50	96	-156		220	96	13.0	0.90	4.00	45	0.093		164	2.0	1.0	6.4	0.2	48.2	3.7	8
23-Aug-07	10:00	161	50	5.75	21.0	7.20	18.5	96.7	8.00	103	-376		210	114	13.0	0.80	4.00		0.140		164	3.0	1.0	6.4	0.3	46.9	0	22
24-Aug-07	09:30	162	50	5.75	21.0	7.19	18.5	96.7	8.00	115	-448		210	94	13.0	0.90	4.00		0.116		164	2.0	1.5	6.4	0.2	44.2	0	16 / 55
25-Aug-07		163																										
26-Aug-07		164																										
27-Aug-07	13:30	165	50	5.75	20.5	7.23	18.6	83.7	8.00	90	-393		235	88	11.5	0.90	4.00		0.085		164	2.0	1.0	6.4		43.9	15.4	35
28-Aug-07	12:00	166	50	5.75	20.0	7.24	18.6	93.6	7.00	90	-344		235	92	12.0	1.00	4.00	40	0.092		164	1.0	0.0	6.4		43.6	5.1	30
29-Aug-07	10:30	167	50	5.75	20.5	7.22	18.8	90.4	7.00	96	-204		225	87	12.0	0.80	4.00	40	0.061		164	0.5	0.5			44.1	4.3	24
30-Aug-07	09:45	168	50	5.75	20.5	7.22	18.5	92.0	7.50	103	-371		235	94	12.0	0.80	4.00	40	0.055		164	0.5	0.5			44.1	3.8	19
31-Aug-07	09:00	169	50	5.75	21.0	7.23	18.5	92.0	8.00	120	-435		225	98	12.0	0.80	3.50		0.103		164	2.0	1.0			44.3	1.8	14 / 55
1-Sep-07		170																										
2-Sep-07		171																										
3-Sep-07		172																										
4-Sep-07	15:00	173	50	5.75	20.0	7.21	18.5	93.6	8.00	87	-469		235	97	12.0	0.90	4.00		0.060		164	0.5	0.0			44.2	16.8	28
5-Sep-07	14:15	174	50	5.75	20.5	7.19	18.6	90.4	9.00	90	-471		230	97	12.0	1.00	4.00		0.066		164	0.5	0.5				3.3	23 / 14
6-Sep-07	10:30	175	50	5.75	21.0	7.17	18.5	87.1	7.00	92	-440		210	96	13.0	1.10	7.00	40	0.069		164	1.0	0.5			44.1	8.3	7 / 16
7-Sep-07	10:15	176	50	5.75	21.5	7.20	18.5	90.4	9.50	96	-336		200	105	13.5	1.10	6.00	40	0.073		164	3.0	1.0		0.2	44.0	5.0	9 / 23
8-Sep-07		177																										
9-Sep-07		178																										
10-Sep-07	14:30	179	50	5.75	21.0	7.19	18.5	93.6	9.00	144	-438		225	106	13.0				0.076		164				0.4	43.1	0	5 / 11

Version 2 **3/15/2007**

Date	Time	Electron Donor Pump 430 Stoke	Electron Donor Pump 430 Speed	Electron Donor Pump 430 Proportionality Constant	Nutrient Tank 410 Volume	Nutrient Pump 410 Stoke	Nutrient Pump 410 Speed	Nutrient Pump 410 Proportionality Constant	Dissolved Oxygen Feed (V-106)	Oxidation Reduction Potential Feed (V-106)	pH Feed (V-106)	Temperature Feed (V-106)	Nitrate-N Feed (V-106)	Nitrite-N Feed (V-106)	Dissolved Oxygen Effluent (V-1143)	Oxidation Reduction Potential Effluent (V-1143)	pH Effluent (V-1143)	Temperature Effluent (V-1143)	Nitrate-N Effluent (V-1143)	Nitrite-N Effluent (V-1143)	Total Organic Carbon Effluent (V-1143)	Ortho-Phosphate P Effluent (V-1143)	Trimite Effluent Turbidity	Post Aeration Dissolved Oxygen
d/m/y	hh:mm	0-100	0-100	0-1	gallons	0-100	0-100	0-1	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mg/l	NTU	mg/l
									5.5-8.0	>0	6 -8	15-20	4-10	<1	5.5-8.0	<0	6-8	20-35	<1	<1	<100	9-30	<1	5.0-9.0
Avg.		100.0	29.4	0.65	23.3	100.0	23.1	0.67	8.10	74.9	8.0	19.3	4.5	0.0	0.83	28.7	7.40	19.7	0.7	0.147	2.2	1.3	0.19	7.4
Std.		0.0	9.9	0.02	9.0	0.0	10.3	0.28	0.87	88.9	0.3	0.9	0.7	0.0	1.14	130.9	0.45	0.9	1.1	0.560	2.4	0.9	0.16	1.1
Max.		100.0	46.0	0.71	44.0	100.0	64.0	2.00	9.76	317.9	8.8	22.7	5.8	0.1	5.78	346.1	8.74	22.8	4.6	3.100	15.6	4.93	0.78	9.4
Min.		100.0	0.0	0.60	0.0	100.0	0.0	0.00	5.98	-31.7	7.5	0.0	2.7	0.0	0.01	-207.1	6.84	17.3	0.0	0.000	-2.0	0.00	0.07	3.6
3-Jul-07	11:30	100	43	0.65	33	100	26	0.50													1.8	1.56		
4-Jul-07	10:15	100	43	0.65	30	100	26	0.50	7.95	27.1	8.01	19.7	4.4	0.005	0.28	-76.0	7.41	20.8	0	0.011		1.21		4.60
5-Jul-07	10:00	100	43	0.65	26	100	26	0.50														1.11		
6-Jul-07	10:00	100	43	0.65	25	100	26	0.50	7.84	0.5	8.10	19.6			0.77	-66.1	7.33	19.1			0.2			3.60
7-Jul-07																								
8-Jul-07																								
9-Jul-07	15:30	100	30	0.65	13	100	19	0.50																
10-Jul-07	15:30	100	31	0.65	10.5	100	19	0.50													0.4			
11-Jul-07	16:00	100	32	0.65	8	100	19	0.50					4.3	0.006					0	0.009	0.9	0.38		
12-Jul-07	14:00	100	33	0.65	5.5 / 30	100	26	0.55	7.81	1.5	7.95	20.3			0.50	-50.2	7.28	20.9			1.6	0.44	0.09	6.06
13-Jul-07																								
14-Jul-07																								
15-Jul-07																								
16-Jul-07	17:00	100	36	0.65	27.5	100	26	0.60																
17-Jul-07	15:45	100	37	0.65	25.5	100	27	0.60																
18-Jul-07	10:45	100	37	0.65	23	100	27	0.60	7.15	-5.0	7.81	19.4	5.4	0.024	0.24	-149.0	7.28	20.4	0	0.011	2.9	1.21	0.09	6.18
19-Jul-07	12:00	100	35	0.65	19	100	26	0.60																
20-Jul-07	09:00	100	35	0.65	19	100	0	0							0.28	-124.0		19.8						
21-Jul-07																								
22-Jul-07																								
23-Jul-07	14:30	100	35	0.65	10	100	26	0.60	8.82	-13.1	7.89	19.9			0.34	-159.4	7.23	19.8					0.08	7.57
24-Jul-07	12:15	100	36	0.65	8	100	26	0.60																
25-Jul-07	13:00	100	36	0.65	5 / 35	100	26	0.60					5.4	0.009					0	0.015	1.7	0.80		
26-Jul-07	09:30	100	35	0.65	32	100	26	0.60	8.83	-5.5	7.62	19.7			0.41	-133.1	7.03	19.7					0.11	7.56
27-Jul-07	10:00	100	36	0.65	29.5	100	26	0.60																
28-Jul-07																								
29-Jul-07																								
30-Jul-07	12:15	100	35	0.65	18	100	26	0.60	8.53	-10.4	7.74	19.7			0.36	-190.2	7.04	19.8				0.09		7.32
31-Jul-07	09:45	100	32	0.65	15	100	23	0.60					5.8	0.029					0.2	0.13	1.0			
1-Aug-07	12:00	100	30	0.65	12	100	22	0.60	8.6	-5.3	7.8	19.9			0.45	-124.1	7.11	19.9				0.10		7.51
2-Aug-07	12:00	100	35	0.65	9 / 40	100	26	0.60																
3-Aug-07	10:45	100	35	0.65	37	100	26	0.60																
4-Aug-07																								
5-Aug-07																								
6-Aug-07	12:00	100	35	0.65	25	100	26	0.60																
7-Aug-07	13:00	100	35	0.65	23	100	26	0.60	8.54	-10.9	7.76	19.7			0.25	-145.0	7.14	19.8				0.09		
8-Aug-07	09:15	100	36	0.65	20	100	26	0.60					5.6						0	1.7	1.48			
9-Aug-07	10:45	100	36	0.65	16.5	100	26	0.60																
10-Aug-07	10:30	100	36	0.65	13 / 45	100	26	0.60																
11-Aug-07																								
12-Aug-07																								
13-Aug-07	14:30	100	38	0.65	34	100	28	0.60					5.2	0.059					0.2	0.005	1.4	1.06		
14-Aug-07	10:30	100	38	0.65	30	100	28	0.60													4.1	3.47	0.09	
15-Aug-07	13:15	100	36	0.65	25	100	27	0.60	8.20	7.4	7.72	19.7			0.31	-82.7	7.03	20.3						6.81
16-Aug-07																								
17-Aug-07																								
18-Aug-07																								
19-Aug-07																								
20-Aug-07	11:30	100	36	0.65	8 / 40	100	27	0.60													3.6	0.88		
21-Aug-07	11:00	100	36	0.65	36	100	28	0.62	8.46													1.78		
22-Aug-07	10:00	100	36	0.65	32	100	27	0.62	7.92	-15.4	7.56	19.9	4.7	0.027	0.25	-118.5	7.03	20.7	0.3	0.002		1.43	0.11	7.13
23-Aug-07	10:00	100	37	0.65	28	100	28	0.62																
24-Aug-07	09:30	100	37	0.65	24	100	28	0.62																
25-Aug-07																								
26-Aug-07																								
27-Aug-07	13:30	100	36	0.65	11.5	100	28	0.62																
28-Aug-07	12:00	100	37	0.65	8 / 40	100	28	0.62																
29-Aug-07	10:30	100	36	0.65	36.5	100	28	0.62					3.8	0.012					0.2	0.006		2.75	0.11	
30-Aug-07	09:45	100	36	0.65	32.5	100	27	0.62	8.16	19.1	7.75	19.5			0.30	-113.0	7.08	19.7				0.95		7.11
31-Aug-07	09:00	100	36	0.65	28	100	27	0.62																
1-Sep-07																								
2-Sep-07																								
3-Sep-07																								
4-Sep-07	15:00	100	36	0.65	12	100	28	0.62																
5-Sep-07	14:15	100	36	0.65	9 / 45	100	26	0.62																
6-Sep-07	10:30	100	37	0.65	41.5	100	28	0.62	7.80	51.7	7.75	19.3	3.8	0.020	0.30	32.7	7.06	19.3	0.2	0.013		2.63	0.09	6.84
7-Sep-07	10:15	100	36	0.65		100	28	0.62																
8-Sep-07																								
9-Sep-07																								
10-Sep-07	14:30	100	36	0.65	25	100	27	0.62																

Version 2 3/15/2007

MONITORING LOGSHEET FOR RIALTO DRINKING WATER PLANT

Shaw Environmental & Infrastructure, Inc.

Date	Time	Days Elapsed	Feed Flow FIT-20	System Feed Pressure PI-20	Pump 100 Discharge Pressure PI-100	System pH AIT-105	System Temperature AIT-105	Fluidization Flow FI-110	FBR Influent FluidizationPress. PI-110	FBR Bed Height	System ORP AIT-110	Blower Discharge Pressure PI-200	Blower Discharge Temp. (deg F)	Aeration Tank Height LIT-210	Pump 210 Discharge Pressure PI-210	Trimite Absorption Clarifier Pressure PI-310	Trimite Mixed Media Pressure PI-320	Trimite Flow FI-310	Trimite Effluent Turbidity AIT-310	Trimite Blower B-310 Discharge Pressure PI-330	Holding Tank Level LIT-340	GAC Pressure In PI-501	GAC Pressure Out PI-501	Nitrate-N Feed AE-650	Nitrate-N Effluent AE-660	Perchlorate Feed AI 761	Perchlorate Effluent AI 762	Electron Donor Tank 430 Volume
d/m/y	hh:mm	# days	gpm	psig	psig	0-14	Deg F	gpm	psig	inches	mV	psig	Deg F	inches	0 to 2	psig	ft H_2O	gpm	NTU	psig	inches	psig	psig	mg/l	mg/l	µg/l	µg/l	gallons
																								4-10		4-10		
Avg.			40.0	5.6	22.2	7.41	18.5	91.7	8.7	132.0	-190.0	9.6	206.2	93.1	15.2	0.8	4.4	44.2	0.105	0.6	159.0	1.4	1.1	6.1	0.5	346.6	4.5	22.1
Std.			13.6	0.2	1.7	0.31	0.6	6.5	1.2	18.7	320.1	4.8	17.3	20.7	2.1	0.4	1.9	19.0	0.097	1.2	19.2	1.6	1.4	1.0	1.2	768.7	9.8	11.4
Max.			72.9	6.0	26.0	8.93	23.1	112.0	11.0	170.0	499.0	13.0	240.0	146.0	20.5	2.1	8.0	90.0	0.759	3.0	166.0	8.0	6.5	7.6	6.2	4029.0	86.6	55.0
Min.			0.0	5.0	19.5	6.79	13.9	74.5	6.0	0.0	-497.0	0.0	90.0	8.0	11.0	0.0	-3.5	0.0	0.015	0.0	19.0	0.0	0.0	0.1	0.0	32.2	0.0	0.0
11-Sep-07	14:15	180	50	5.75	20.5	7.20	18.8	95.1	8.50	159	-363		235	91	12.0	1.20	4.00		0.079		164	0.0	0.0		0.3	42.7		4 / 16
12-Sep-07	13:00	181	50	5.75	20.5	7.18	18.6	92.0	8.00	129	-306		230	89	12.0	1.40	5.00	40	0.072		164	1.0	0.0		0.2	43.6	3.8	9
13-Sep-07	11:45	182	50	5.75	20.0	7.19	18.6	88.8	8.00	120	-475		230	91	12.0	0.80	4.00		0.063		164	1.0	0.0		0.3	42.2	3.2	2 / 55
14-Sep-07	10:45	183	50	5.75	21.0	7.09	18.5	90.4	9.00	126	-472		225	96	13.0	0.90	4.00	4*	0.066		164	2.0	0.0		0.2	43.8	0	49
15-Sep-07		184																										
16-Sep-07		185																										
17-Sep-07	14:30	186	50	5.75	21.0	7.23	18.5	92.0	9.50	167	-446		225	89	11.0						164				0.1	42.7	0	32
18-Sep-07	15:00	187	50	5.75	21.5	7.26	18.6			147	-451		225	94	13.0				0.070		164				0.1	44.4	0	
19-Sep-07	8:15	188	50	5.75	22.0	7.23	18.3	93.6	11.00	147	-456		195	91	14.0	1.60	7.00		0.072		164				0.3	41.3	0	22
20-Sep-07	11:00	189	50	5.75	22.5	7.26	18.5	93.6	11.00	147	-464		200	85	16.0				0.072		164				0.2	41.2		16
21-Sep-07	10:30	190	50	5.75	22.0	7.26	18.5	90.4	11.00	147	-306		210	85	15.0	1.30	5.00	40	0.063		164			6.0	0.1			11 / 55
22-Sep-07		191																										
23-Sep-07		192																										
24-Sep-07	13:00	193	50	5.75	22.0	7.26	18.5	90.4	11.00	147	-477		215	86	14.0	1.20	6.00	40	0.064		164			6.0	0.1			39 / 11
25-Sep-07	12:15	194	50	5.75	21.5	7.20	18.5	95.1	8.50	149	-478		225	83	14.0	1.10	5.00		0.088		164			6.1	0.1			5 / 39
26-Sep-07	13:15	195	50	5.75	21.0	7.22	18.5	95.1	8.50	147	-481		225	92	14.0	1.70	5.00		0.093		164			6.1	0.1		0	31
27-Sep-07	10:30	196	50	5.75	21.5	7.19	18.5	90.4	9.00	147	-478		215	140	14.0	1.20	4.00		0.089		164			6.1	0.1		0	26 / 28
28-Sep-07	10:45	197	50	5.75	22.5	7.24	18.5	96.7	10.50	147	-477		200	91	16.0	1.60	5.00		0.079		164			6.1	0.1		0	24
29-Sep-07		198																										
30-Sep-07		199																										
1-Oct-07	12:15	200	50	5.75	21.5	7.22	18.5	90.4	9.00	147	-478		210	86	14.0	1.70	5.00		0.076		164			6.0	0.1		0	7 / 9
2-Oct-07	13:30	201	50	5.75	21.0	7.25	18.5	95.1	8.00	147	-483		230	90	14.0	1.20	7.50		0.066		164			6.1	0.1		0	4 / 55
3-Oct-07	13:15	202	50	5.75	21.0	7.21	18.5	90.4	8.50	147	-480		225	85	13.5	1.60	5.00		0.075		164			6.1	0.1		0	48
4-Oct-07	12:15	203	50	5.75	21.5	7.22	18.5	90.4	9.00	147	-484		215	87	14.0	0.90	5.00		0.069		164			6.1	0.1	43.1	0	43
5-Oct-07	9:30	204	50	5.75	22.5	7.21	18.5	90.4	10.50	147	-286		200	84	16.0	1.00	7.00		0.075		164			6.0	0.1	42.2	0	
6-Oct-07		205																										
7-Oct-07		206																										
8-Oct-07	13:45	207	50	5.75	21.0	7.20	18.5	92.0	8.00	147	-289		235	90	13.5	1.00	6.50		0.070		164			6.1	0.1	44.7	0	24
9-Oct-07	11:15	208	50	5.75	21.5	7.34	18.5	95.1	8.75	147	-471		210	82	13.5	0.90	6.00		0.070		164			6.1	0.1	43.8	0	20
10-Oct-07	8:30	209	50	5.75	21.5	7.25	18.5	90.1	10.50	150	-468		190	87	16.0	0.90	6.00		0.072		164			6.1	0.1	44.0	0	15
11-Oct-07	9:30	210	49	5.75	22.0	7.30	18.5	93.6	10.00	149	-464		210	83	14.0	1.10	6.00		0.074		164			6.0	0.1	43.1	0	9
12-Oct-07	9:45	211	50	5.75	22.5	7.26	18.3	95.1	10.50	149	-473		200	87	14.0	1.10	5.00		0.073		164			6.0	0.1	44.2	0	4 / 55
13-Oct-07		212																										
14-Oct-07		213																										
15-Oct-07		214																										
16-Oct-07		215																										
17-Oct-07	11:30	216	50	5.75	22.0	7.36	18.3	92.0	10.00	149	-161		205		16.0	1.40	4.00		0.074		164			6.0	0.1	43.5	0	25
18-Oct-07	12:15	217	50	5.75	22.0	7.28	18.5	96.7	9.00	151	72			86	16.0	1.20	4.00		0.072		164			6.1	0.0	43.7	ND	19
19-Oct-07	11:45	218	50	5.75	21.0	7.39	18.5	90.4	8.75	150	100		215	100	14.0	1.10	5.00		0.071		164			6.1	0.2	43.9	ND<2.5	15 / 55
20-Oct-07		219																										
21-Oct-07		220																										
22-Oct-07	15:45	221	50	5.75	21.5	7.26	18.5	96.7	9.00	150	-478		210	81	14.5	0.80	5.00		0.069		164			6.1	0.2	44.5	0	38
23-Oct-07	14:30	222	50	5.75	21.0	7.36	18.5			152	-404		215	89	15.0	1.00	5.00		0.065		164			6.1	0.1	43.0	0	32
24-Oct-07	15:45	223	50	5.75	21.0	7.36	18.5		8.75	152	-478		215	89	13.5	0.90	6.00		0.089		164			6.1	0.1	43.0	0	27
25-Oct-07	11:15	224	50	5.75	22.0	7.41	18.5	98.2	9.00	159	-471		210	88	14.0	1.10	5.50		0.067		164			6.1	0.1	43.7	0	23
26-Oct-07	8:15	225	50	5.75	23.0	7.44	18.3	98.2	10.00	162	-469		190	83	15.5	0.90	5.50		0.067		164			6.1	0.1	43.9	0	15 / 55
27-Oct-07		226																										
28-Oct-07		227																										
29-Oct-07	16:15	228	50	5.75	22.0	7.35	18.3	93.6	9.50	147	-489		210	87	14.0	1.50	7.50		0.068		164			6.1	0.1	43.5	0	35
30-Oct-07		229																										
31-Oct-07	12:20	230	50	5.75	22.0	7.47	18.3	98.2	8.75	149	-443		205	87	14.5	0.90	4.25							6.1	0.2			
1-Nov-07	16:00	231	50	5.75	22.0	7.40	18.3			149	-453		215	82	14.5	1.40	5.00		0.074		164			6.1	0.2	42.8	0	
2-Nov-07	11:30	232	50	5.75	22.0	7.34	18.5	93.6	8.50	149	-489		215	85	15.0	1.10	6.00		0.055		164			6.1	0.1	45.7	0	31
3-Nov-07		233																										
4-Nov-07		234																										
5-Nov-07	14:00	235	50	5.75	22.0	7.33	18.5	83.7	9.50	156	-487		200	83	15.0	1.20	6.00		0.063		164			6.1	0.1	43.0	0	14
6-Nov-07	14:30	236	50	5.75	21.0	7.35	18.5	99.6	9.00	147	-484		200	84	14.5	0.90	5.00		0.056		164			6.1	0.1	43.0	0	
7-Nov-07	13:10	237	50	5.75	21.0	7.14	18.5	98.2	9.00	151	-465		205	89	14.0	1.20	5.00		0.067		164			6.1	0.2	44.5	7.8	5 / 55
8-Nov-07	10:00	238	50	5.75	22.0	7.34	18.5	96.7	9.50	149	-486		200	85	15.0	1.00	5.50		0.068		164			6.1	0.2	44.7	0	
9-Nov-07	11:00	239	50	5.75	23.0	7.11	18.3	99.6	9.50	149	-57		190	82	15.0	0.90	5.00		0.086		164			6.1	0.2	44.7	0	45
10-Nov-07		240																										
11-Nov-07		241																										
12-Nov-07	15:45	242	25	5.75	22.0	7.16	19.0	96.7	9.50	149	-446		200	91	18.0	1.00	2.50		0.071		164			6.2	0.2	42.2	0	23
13-Nov-07	14:30	243	25	5.75	21.0	7.73	19.0	96.7	9.50	147	-460		215	91	18.0	0.60	2.00		0.069		164			6.2	0.2	43.1	0	18
14-Nov-07	15:30	244	25	5.75	21.0	7.60	19.3	99.6	9.00	144	0		220	89	15.0	0.70	4.00		0.061		164			6.2	0.2	43.0	0	15
15-Nov-07	8:30	245	25	5.50	21.0	7.47	19.0	96.7	9.00	144	-58		200	8	16.0	0.90	3.50		0.065		164			6.2	0.2	43.0	0	14
16-Nov-07	12:30	246	25	5.50	21.0	7.47	19.0	95.1	8.75	141	-45		200	100	17.0	0.60	4.00		0.080		164			6.2	0.3	43.0	0	13 / 55
17-Nov-07		247																										
18-Nov-07		248																										
19-Nov-07	13:45	249	25	5.50	21.0	7.38	19.0	96.7	8.50	141	-54		200	105	16.0	0.90	4.00		0.064		164			6.2	0.1	43.6	0	42 / 12

Version 2 **3/15/2007**

Date	Time	Electron Donor Pump 430 Stoke	Electron Donor Pump 430 Speed	Electron Donor Pump 430 Proportionality Constant	Nutrient Tank 410 Volume	Nutrient Pump 410 Stoke	Nutrient Pump 410 Speed	Nutrient Pump 410 Proportionality Constant	Dissolved Oxygen Feed (V-106)	Oxidation Reduction Potential Feed (V-106)	pH Feed (V-106)	Temperature Feed (V-106)	Nitrate-N Feed (V-106)	Nitrite-N Feed (V-106)	Dissolved Oxygen Effluent (V-1143)	Oxidation Reduction Potential Effluent (V-1143)	pH Effluent (V-1143)	Temperature Effluent (V-1143)	Nitrate-N Effluent (V-1143)	Nitrite-N Effluent (V-1143)	Total Organic Carbon Effluent (V-1143)	Ortho-Phosphate P Effluent (V-1143)	Trimite Effluent Turbidity	Post Aeration Dissolved Oxygen
d/m/y	**hh:mm**	**0-100**	**0-100**	**0-1**	**gallons**	**0-100**	**0-100**	**0-1**	**mg/l**	**mV**		**Deg C**	**mg/l**	**mg/l**	**mg/l**	**mV**		**Deg C**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**NTU**	**mg/l**
									5.5-8.0	**>0**	**6 -8**	**15-20**	**4-10**	**<1**	**5.5-8.0**	**<0**	**6-8**	**20-35**	**<1**	**<1**	**<100**	**9-30**	**<1**	**5.0-9.0**
Avg.		**100.0**	**29.4**	**0.65**	**23.3**	**100.0**	**23.1**	**0.67**	**8.10**	**74.9**	**8.0**	**19.3**	**4.5**	**0.0**	**0.83**	**28.7**	**7.40**	**19.7**	**0.7**	**0.147**	**2.2**	**1.3**	**0.19**	**7.4**
Std.		**0.0**	**9.9**	**0.02**	**9.0**	**0.0**	**10.3**	**0.28**	**0.87**	**88.9**	**0.3**	**0.9**	**0.7**	**0.0**	**1.14**	**130.9**	**0.45**	**0.9**	**1.1**	**0.560**	**2.4**	**0.9**	**0.16**	**1.1**
Max.		**100.0**	**46.0**	**0.71**	**44.0**	**100.0**	**64.0**	**2.00**	**9.76**	**317.9**	**8.8**	**22.7**	**5.8**	**0.1**	**5.78**	**346.1**	**8.74**	**22.8**	**4.6**	**3.100**	**15.6**	**4.93**	**0.78**	**9.4**
Min.		**100.0**	**0.0**	**0.60**	**0.0**	**100.0**	**0.0**	**0.00**	**5.98**	**-31.7**	**7.5**	**0.0**	**2.7**	**0.0**	**0.01**	**-207.1**	**6.84**	**17.3**	**0.0**	**0.000**	**-2.0**	**0.00**	**0.07**	**3.6**
11-Sep-07	14:15	100	37	0.65	21	100	28	0.62																
12-Sep-07	13:00	100	35	0.65		100	27	0.62	8.10	46.3	7.84	19.8	3.9	0.048	0.21	-80.5	7.12	19.9	0.2	0.012	2.6	0.95	0.12	7.08
13-Sep-07	11:45	100	35	0.65	14 / 45	100	27	0.62																
14-Sep-07	10:45	100	35	0.65	42	100	27	0.62																
15-Sep-07																								
16-Sep-07																								
17-Sep-07	14:30	100	36	0.65	30	100	27	0.62																
18-Sep-07	15:00	100	35	0.65		100	27	0.62																
19-Sep-07	8:15	100	35	0.65	22.5	100	27	0.62	8.09	10.8	7.54	19.8	4.2	0.035	0.35	-120.8	7.03	19.8	0.2	0.011	2.1	4.54	0.10	6.92
20-Sep-07	11:00	100	35	0.65	18 / 45	100	27	0.62																
21-Sep-07	10:30	100	35	0.65	42.5	100	27	0.62																
22-Sep-07																								
23-Sep-07																								
24-Sep-07	13:00	100	35	0.65	30	100	26	0.62																
25-Sep-07	12:15	100	35	0.65	26	100	27	0.62																
26-Sep-07	13:15	100	36	0.65	22	100	27	0.62													0.8			
27-Sep-07	10:30	100	35	0.65	19 / 45	100	27	0.62					4.4									1.06	0.10	
28-Sep-07	10:45	100	36	0.65	41	100	27	0.62	8.53	19.3	7.78	19.7												6.91
29-Sep-07																			0.2					
30-Sep-07															0.21	-193.3	7.05	19.7						
1-Oct-07	12:15	100	35	0.65	30	100	27	0.62					3.8	0.025					0.0	0.004		1.10	0.14	
2-Oct-07	13:30	100	36	0.65	26	100	27	0.62																
3-Oct-07	13:15	100	36	0.65	22	100	27	0.62													0.6			
4-Oct-07	12:15	100	35	0.65	19 / 45	100	27	0.62																
5-Oct-07	9:30	100	35	0.65	43	100	27	0.62																
6-Oct-07																								
7-Oct-07																								
8-Oct-07	13:45	100	36	0.65	30	100	27	0.62													1.1	1.54		
9-Oct-07	11:15	100	35	0.65	26	100	27	0.62																
10-Oct-07	8:30	100	35	0.65	23	100	27	0.62																
11-Oct-07	9:30	100	36	0.65	19 / 45	100	27	0.62					4.0	0.012					0	0.008			0.12	
12-Oct-07	9:45	100	36	0.65	42	100	27	0.62																
13-Oct-07																								
14-Oct-07																								
15-Oct-07																								
16-Oct-07																								
17-Oct-07	11:30	100	36	0.65	25	100	27	0.62																
18-Oct-07	12:15	100	36	0.65	19 / 45	100	28	0.62																
19-Oct-07	11:45	100	37	0.65	42.5	100	28	0.62					5.4	0.037					0	0.003	1.9	1.32	0.13	
20-Oct-07																								
21-Oct-07																								
22-Oct-07	15:45	100	37	0.65		100	28	0.62																
23-Oct-07	14:30	100	37	0.65	27.5	100	28	0.62																
24-Oct-07	15:45	100	37	0.65	24.0	100	28	0.62																
25-Oct-07	11:15	100	36	0.65	21 / 45	100	28	0.62																
26-Oct-07	8:15	100	37	0.65	42.5	100	28	0.62																
27-Oct-07																								
28-Oct-07																								
29-Oct-07	16:15	100	37	0.65	29	100	28	0.62																
30-Oct-07																								
31-Oct-07	12:20		38	0.65	23 / 45	100	29	0.62	8.10						1.04							1.60		
1-Nov-07	16:00	100	41	0.65	41	100	31	0.62																
2-Nov-07	11:30	100	40	0.65	37	100	30	0.62																
3-Nov-07																								
4-Nov-07																								
5-Nov-07	14:00	100	40	0.65	24	100	31	0.62																
6-Nov-07	14:30	100	41	0.65		100	31	0.62																
7-Nov-07	13:10	100	40	0.65	18	100	30	0.62					3.3	0.003					0	0.001		1.03		
8-Nov-07	10:00	100	41	0.65	15 / 45	100	30	0.62	8.07	25.4	7.85	19.7			0.55	-207.1	7.22	19.7			1.4		0.10	6.83
9-Nov-07	11:00	100	41	0.65	44	100	31	0.62																
10-Nov-07																								
11-Nov-07																								
12-Nov-07	15:45	100	39	0.65	32	100	16	0.62																
13-Nov-07	14:30	100	21	0.65	29	100	13	0.62	7.99	119.0	7.75	19.5			0.60	107.7	7.36	20.1			15.6		0.15	7.05
14-Nov-07	15:30	100	21	0.65	28	100	13	0.62																
15-Nov-07	8:30	100	21	0.65	27	100	14	0.62																
16-Nov-07	12:30	100	20	0.65	26	100	16	0.62																
17-Nov-07																								
18-Nov-07																								
19-Nov-07	13:45	100	20	0.65	19 / 45	100	16	0.62																

Version 2 3/15/2007

MONITORING LOGSHEET FOR RIALTO DRINKING WATER PLANT

Date	Time	Days Elapsed	Feed Flow FIT-20	System Feed Pressure PI-20	Pump 100 Discharge Pressure PI-100	System pH AIT-105	System Temperature AIT-105	Fluidization Flow FI-110	FBR Influent FluidizationPress. PI-110	FBR Bed Height	System ORP AIT-110	Blower Discharge Pressure PI-200	Blower Discharge Temp. (deg F)	Aeration Tank Height LIT-210	Pump 210 Discharge Pressure PI-210	Trimite Absorption Clarifier Pressure PI-310	Trimite Mixed Media Pressure PI-320	Trimite Flow FI-310	Trimite Effluent Turbidity AIT-310	Trimite Blower B-310 Discharge Pressure PI-330	Holding Tank Level LIT-340	GAC Pressure In PI-501	GAC Pressure Out PI-501	Nitrate-N Feed AE-650	Nitrate-N Effluent AE-660	Perchlorate Feed AI 761	Perchlorate Effluent AI 762	Electron Donor Tank 430 Volume
d/m/y	hh:mm	# days	gpm	psig	psig	0-14	Deg F	gpm	psig	inches	mV	psig	Deg F	inches	0 to 2	psig	ft H_2O	gpm	NTU	psig	inches	psig	psig	mg/l	mg/l	µg/l	µg/l	gallons
																								4-10		4-10		
Avg.			40.0	5.6	22.2	7.41	18.5	91.7	8.7	132.0	-190.0	9.6	206.2	93.1	15.2	0.8	4.4	44.2	0.105	0.6	159.0	1.4	1.1	6.1	0.5	346.6	4.5	22.1
Std.			13.6	0.2	1.7	0.31	0.6	6.5	1.2	18.7	320.1	4.8	17.3	20.7	2.1	0.4	1.9	19.0	0.097	1.2	19.2	1.6	1.4	1.0	1.2	768.7	9.8	11.4
Max.			72.9	6.0	26.0	8.93	23.1	112.0	11.0	170.0	499.0	13.0	240.0	146.0	20.5	2.1	8.0	90.0	0.759	3.0	166.0	8.0	6.5	7.6	6.2	4029.0	86.6	55.0
Min.			0.0	5.0	19.5	6.79	13.9	74.5	6.0	0.0	-497.0	0.0	90.0	8.0	11.0	0.0	-3.5	0.0	0.015	0.0	19.0	0.0	0.0	0.1	0.0	32.2	0.0	0.0
20-Nov-07	13:45	250	25	5.50	21.5	7.34	19.0	99.6	9.00	143	-156		200	101	17.0	0.80	4.00		0.058		164			6.2	0.2	43.6	0	9.15
21-Nov-07	12:30	251	25	5.50	22.0	7.29	19.0	102.6	8.50	146	-458		200	93	17.0	0.90	5.00		0.074		164			6.2	0.1	44.1	0	6 / 42
22-Nov-07		252																										
23-Nov-07		253																										
24-Nov-07		254																										
25-Nov-07		255																										
26-Nov-07	14:15	256	25	5.50	22.0	7.37	18.8	102.6	9.50	144	-469		200	103	18.0	0.80	4.00		0.064		164			6.2	0.1	113	0	27 / 39
27-Nov-07	16:00	257	25	5.50	21.5	7.45	18.8	96.7	9.50	144	-479		185	105	17.0	0.60	4.00		0.068		164			6.3	0.1	41.0	0	36
28-Nov-07	13:45	258	25	5.50	22.0	7.44	18.8	93.6	9.75	146	-390		185	98	17.5	0.70	4.00		0.061		164			6.3	0.1	114.0	0	33
29-Nov-07	14:30	259	25	5.50	21.5	7.41		105.3		146	-427		185	95		0.70	4.00		0.059		164			6.3	0.1	86.1	0	29
30-Nov-07	9:30	260	25	5.50	22.0	7.38	18.3		11.00	146	-474		175	103	17.0	0.90	4.00		0.065		164			6.2	0.1	83.5	0	27
1-Dec-07		261																										
2-Dec-07		262																										
3-Dec-07		263	25	5.25	22.5	7.46	19.0	102.6	8.50	144	-485		180	95	17.0	0.80	5.50		0.060		164			6.3	0.2		0	22
4-Dec-07	14:15	264	25	5.50	22.0	7.40	19.0	102.5	9.50	144	-488		195	103	17.0	0.60	4.00		0.071		164			6.2	0.2	553	9.2	
5-Dec-07	15:15	265	25	5.50	22.0	7.25	19.0	105.3	8.50	144	-490		180	89	17.5	0.80	4.50		0.062		164			6.2	0.1	43.7	0	
6-Dec-07	11:00	266	25	5.50	21.5	7.43	18.8	101.1	9.50	146	-486		180	98	17.0	0.80	4.00		0.061		164			6.3	0.1			8
7-Dec-07	9:30	267	25	5.50	22.5	7.46	18.3	96.7	10.50	146	-489		170	90	18.0	0.60	5.00		0.073		164			6.3	0.1			5 / 55
8-Dec-07		268																										
9-Dec-07		269																										
10-Dec-07		270																										
11-Dec-07		271	25	5.50	22.5	7.47	18.3	102.5	10.00	146	-483		175	91	18.0	0.80	3.00		0.067		164			6.3	0.1			42
12-Dec-07		272	25	5.50	22.0	7.36	18.6	96.7	9.50	146	-480		180	90	17.0	0.60	3.00		0.079		164			6.3	0.1	454	5.6	38
13-Dec-07		273	25	5.50	22.0	7.31	18.5	98.2	10.00	148	-479		175	92	17.0	0.60	5.00				164			6.3	0.1	445	0.0	
14-Dec-07		274																										
15-Dec-07		275																										
16-Dec-07		276																										
17-Dec-07	15:15	277	25	5.50	22.0	7.50	18.6	98.2	10.00	137	-330		200	91	17.0	0.60	5.00				164			6.3	0.1		0.0	31
18-Dec-07	11:45	278	25	5.50	22.5	7.29	18.6	98.2	10.00	147	-462		200	91	18.0	0.80	4.00		0.078		164			6.3	0.1	1013	9.4	28
19-Dec-07	15:00	279	25	5.50	22.0	7.26	18.5	95.1	10.00	146	-476		200	98	17.0	0.60	5.00		0.064		164			6.3	0.1	984	9.7	25
20-Dec-07	10:15	280	25	5.50	22.0	7.31	18.3	95.1	10.50	148	-480		200	135	17.0	0.80	4.00		0.070		164			6.3	0.1	876	8.3	21
21-Dec-07	11:15	281	25	5.50	22.0	7.29	18.5	99.6	10.00	145	-481		200	100	18.0	0.80	4.00		0.065		164			6.3	0.1	43		18
22-Dec-07																												
23-Dec-07																												
24-Dec-07	14:30	284	25	5.50	21.5	7.30	18.6	96.7	10.00	146	-87		200	100	18.0	0.70	4.00		0.068		164			6.4	0.1	1319		7 / 55
25-Dec-07																												
26-Dec-07	15:00	286	25	5.25	21.0	7.50	18.5	93.6	10.00	138	-399		200	86	16.0	0.70	5.00		0.085		164			6.4	0.1	42		
27-Dec-07	15:00	287	25	5.25	25.0	7.80	18.3	87.1	10.00	144	-471		90	96	17.0	0.60	5.00		0.063		164			6.4	0.1	1145	9.6	42
28-Dec-07	11:00	288	25	5.25	25.5	7.23	18.3	90.4	10.50	144	-479		200	87	17.5	0.70	5.00		0.068		164			6.4	0.1			41
29-Dec-07																												
30-Dec-07																												
31-Dec-07	14:45	291	25	5.25	25.0	7.27	18.3	83.7	9.50	146	-486		200	101	17.0	0.80	5.00		0.064		164			6.4	0.1	3921	86.6	29
1-Jan-08																												
2-Jan-08	16:00	293	50	5.50	25.0	7.40	17.7	83.7	9.50	146	-487		200	82	14.0	0.90	7.00		0.148		164			0.1	0.1	35.4	4.7	24
3-Jan-08	12:15	294	25	5.50	25.0	7.28	17.2	88.8	9.25	146	-484		210	101	17.0	0.60	3.00		0.142		164			0.1	0.1			21 / 26
4-Jan-08	14:15	295	25	5.25	25.0	7.24	17.4	88.8	10.00	146	-482		200	87	17.0	0.70	4.00		0.130		164			0.1	0.1			22
5-Jan-08		296																										
6-Jan-08		297																										
7-Jan-08	13:30	298	25	5.25	25.0	7.38		83.7	9.50	146	-486		205	90	17.0													
8-Jan-08	15:15	299	25	5.50	25.0	7.19	18.5	87.1	10.00		-480		205	79	17.0						164			6.4	0.1	1595	18.8	9
9-Jan-08	13:30	300	25	5.50	25.0	7.23	18.5	90.4	10.00	146	-479		200	90	18.0	1.00	3.00				164			6.2	0.1	1422	8.9	6 / 55
10-Jan-08	14:15	301	26	5.50	25.0	7.27	18.8	87.1	9.00	146	-479		210	99	17.0	0.60	3.00		0.084		164			6.2	0.1	1089	10.9	49
11-Jan-08	12:00	302	25	5.50	24.5	7.31	18.8	83.7	8.00	146	-480		210	98	16.0	0.60	4.00		0.156		164			6.4	0.1	45.5	0	46
12-Jan-08		303																										
13-Jan-08		304																										
14-Jan-08	13:15	305	25	5.50	25.0	7.26	18.5	85.4	10.00	146	-486		200	96	17.0	0.60	5.00		0.164		164			6.4	0.1	1820	72.2	36
15-Jan-08	14:00	306	25	5.50	25.0	7.41	18.5	87.1	10.00	146	-485		200	88	19.0						164			0.1	0.1	2145	22.8	32
16-Jan-08	15:30	307	73	6.00	25.0	7.45	17.0	90.4	10.00	146	-490		200	144	16.0	0.90	6.00		0.321		164			0.1	0.1	82	4.3	28
17-Jan-08	16:30	308	25			7.39		87.1	10.50	146	-490		200	100	16.0						164			6.2	0.1	1863		25
18-Jan-08	13:15	309	26	5.25	25.0	7.41	18.5	83.7	10.00	146	-489		200	85	17.0	0.60	8.00		0.079		164			6.2	0.1	42.6	0	23
21-Jan-08	13:50	312	25	5.25	25.5	7.45	18.3	90.4	11.00	146	-489		200	87	18.0				0.075		164			6.2	0.1	1597	12.3	13
22-Jan-08	13:45	313	25	5.25	25.0	7.42	18.5	90.4	10.00	146	-490		210	107	17.5	0.60	6.50		0.091		164			6.2	0.1	1755		9
23-Jan-08	14:00	314	25	5.50	25.0	7.47	18.5	90.4	10.00	146	-490		200	102	17.5	0.60	5.50		0.084		164			6.2	0.1			6 / 55
24-Jan-08	14:15	315	25	5.50	25.5	7.38	18.3	96.7	11.00	146	-486		200	95	19.0	0.80	6.00		0.085		164			6.3	0.1	2030	11.0	51
25-Jan-08	14:00	316	25	5.50	25.0	7.49	18.3	96.7	10.00	146	-487		200	105	19.0				0.070		164				0.1	1933		47
26-Jan-08		317																			164							
27-Jan-08		318																			164							
28-Jan-08	13:00	319	25	5.50	25.5	7.57	18.3		10.50	147	-487		190	95	18.0	0.60	8.00		0.103		164				0.1	1773	11.0	37
29-Jan-08	14:00	320	25	5.50	25.0	7.47	18.5	90.4	10.50	148	-488		200	145	17.0	0.60	5.00		0.090		164				0.1	1845	5.5	33
30-Jan-08	12:00	321	25	5.50	25.0	7.53	18.8	90.4	9.00	148	-488		210	107	17.5	0.70	8.00		0.081		164				0.1	2027	10.5	29

Version 2 **3/15/2007**

Date	Time	Electron Donor Pump 430 Stoke	Electron Donor Pump 430 Speed	Electron Donor Pump 430 Proportionality Constant	Nutrient Tank 410 Volume	Nutrient Pump 410 Stoke	Nutrient Pump 410 Speed	Nutrient Pump 410 Proportionality Constant	Dissolved Oxygen Feed (V-106)	Oxidation Reduction Potential Feed (V-106)	pH Feed (V-106)	Temperature Feed (V-106)	Nitrate-N Feed (V-106)	Nitrite-N Feed (V-106)	Dissolved Oxygen Effluent (V-1143)	Oxidation Reduction Potential Effluent (V-1143)	pH Effluent (V-1143)	Temperature Effluent (V-1143)	Nitrate-N Effluent (V-1143)	Nitrite-N Effluent (V-1143)	Total Organic Carbon Effluent (V-1143)	Ortho-Phosphate P Effluent (V-1143)	Trimite Effluent Turbidity	Post Aeration Dissolved Oxygen
d/m/y	hh:mm	0-100	0-100	0-1	gallons	0-100	0-100	0-1	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mg/l	NTU	mg/l
									5.5-8.0	>0	6 -8	15-20	4-10	<1	5.5-8.0	<0	6-8	20-35	<1	<1	<100	9-30	<1	5.0-9.0
Avg.		100.0	29.4	0.65	23.3	100.0	23.1	0.67	8.10	74.9	8.0	19.3	4.5	0.0	0.83	28.7	7.40	19.7	0.7	0.147	2.2	1.3	0.19	7.4
Std.		0.0	9.9	0.02	9.0	0.0	10.3	0.28	0.87	88.9	0.3	0.9	0.7	0.0	1.14	130.9	0.45	0.9	1.1	0.560	2.4	0.9	0.16	1.1
Max.		100.0	46.0	0.71	44.0	100.0	64.0	2.00	9.76	317.9	8.8	22.7	5.8	0.1	5.78	346.1	8.74	22.8	4.6	3.100	15.6	4.93	0.78	9.4
Min.		100.0	0.0	0.60	0.0	100.0	0.0	0.00	5.98	-31.7	7.5	0.0	2.7	0.0	0.01	-207.1	6.84	17.3	0.0	0.000	-2.0	0.00	0.07	3.6
20-Nov-07	13:45	100	20	0.65	43	100	16	0.62	7.95	19.8	7.82	19.7	3.8	0.020	0.48	-119.2	7.40	20.0	0	0.005		1.92	0.12	7.11
21-Nov-07	12:30	100	20	0.65	41	100	15	0.62																
22-Nov-07																								
23-Nov-07																								
24-Nov-07																								
25-Nov-07																								
26-Nov-07	14:15	100	20	0.65	32	100	15	0.62																
27-Nov-07	16:00	100	21	0.65	30	100	16	0.62																
28-Nov-07	13:45	100	21	0.65	28	100	16	0.62																
29-Nov-07	14:30	100		0.65		100		0.62						0.003						0.002		1.13		
30-Nov-07	9:30	100	20	0.65	25	100	15	0.62																
1-Dec-07																								
2-Dec-07																								
3-Dec-07		100	21	0.65	24	100	16	0.62																
4-Dec-07	14:15	100	22	0.65		100		0.62													3.7	4.93		
5-Dec-07	15:15	100	21	0.65	17.5 / 45	100	6	0.62																
6-Dec-07	11:00	100	21	0.65	40	100	16	0.62																
7-Dec-07	9:30	100	20	0.65	38	100	16	0.62																
8-Dec-07																								
9-Dec-07																								
10-Dec-07																								
11-Dec-07		100	21	0.65	30	100	16	0.62																
12-Dec-07		100	25	0.65	27	100	19	0.62																
13-Dec-07		100	25	0.65	25	100	19	0.62	8.10	190.9	7.80	19.4			0.34	140	7.06	20.2						
14-Dec-07																								
15-Dec-07																								
16-Dec-07																								
17-Dec-07	15:15	100	25	0.65	23	100	19	0.62																8.10
18-Dec-07	11:45	100	27	0.65	20 / 45	100	20	0.62													5.7	1.43		
19-Dec-07	15:00	100	27	0.65	43	100	20	0.62																
20-Dec-07	10:15	100	25	0.65	42	100	19	0.62	8.46	44.5	8.32	19.3			0.49	30	7.38	19.2						7.75
21-Dec-07	11:15	100	24	0.65	38	100	18	0.62																
22-Dec-07																								
23-Dec-07																								
24-Dec-07	14:30	100	26	0.65	32	100	20	0.62																
25-Dec-07																								
26-Dec-07	15:00	100	26	0.65	31	100	19	0.62																
27-Dec-07	15:00	100	26	0.65	30	100	19	0.62	8.02	29.9	8.17	18.3			0.58	37.9	7.78	19.3			5.1	0		8.23
28-Dec-07	11:00	100	21	0.65	28	100	16	0.68														1.10		
29-Dec-07																								
30-Dec-07																								
31-Dec-07	14:45	100	27	0.65	22	100		0.62																
1-Jan-08																								
2-Jan-08	16:00	100	14	0.65	18	100	11	0.62																
3-Jan-08	12:15	100	10	0.65	15 / 44	100		0.62																
4-Jan-08	14:15	100			43	100		0.62																
5-Jan-08																								
6-Jan-08																								
7-Jan-08	13:30																							
8-Jan-08	15:15	100	26	0.65	34	100	20														0.16	1.34		
9-Jan-08	13:30	100	25	0.65	32	100	21																	
10-Jan-08	14:15	100	27	0.65	28	100	23		8.02		7.74	19.0					7.13	19.0			0.80	0.96		7.30
11-Jan-08	12:00	100	21	0.65	26 / 45	100	16																	
12-Jan-08																								
13-Jan-08																								
14-Jan-08	13:15	100	27	0.65	38	100	22																	
15-Jan-08	14:00	100	9	0.65	37	100	7																	
16-Jan-08	15:30	100	21	0.65	35	100	16																	
17-Jan-08	16:30	100	22	0.65	34	100	16																	
18-Jan-08	13:15	100	20	0.65	32	100	15		8.25	34.8	8.03	19.30			0.55	-30.3		19.8						
21-Jan-08	13:50	100	22	0.65	26	100	17	0.62																
22-Jan-08	13:45	100	21	0.65	24	100	17	0.66																
23-Jan-08	14:00	100	19	0.65	22	100	1	0.70																
24-Jan-08	14:15	100	22	0.65	19	100	19	0.70																
25-Jan-08	14:00	100	2	0.65	17 / 45	100	17	0.70	8.20		7.80	18.7			0.55		7.04	19.0						7.10
26-Jan-08		100																						
27-Jan-08		100																						
28-Jan-08	13:00	100	21	0.65	39	100	17	0.70	8.44		7.76	18.9			0.47	-80	6.98	18.4			3.0	1.62		
29-Jan-08	14:00	100	20	0.65	36	100	17	0.70	8.54		7.47	19.4			0.52	-145	7.40	18.7						
30-Jan-08	12:00	100	21	0.65	35	100	18	0.70	7.80			19.7			0.36	-10		19.5						

Version 2 3/15/2007

MONITORING LOGSHEET FOR RIALTO DRINKING WATER PLANT

Date	Time	Days Elapsed	Feed Flow FIT-20	System Feed Pressure PI-20	Pump 100 Discharge Pressure PI-100	System pH AIT-105	System Temperature AIT-105	Fluidization Flow FI-110	FBR Influent FluidizationPress. PI-110	FBR Bed Height	System ORP AIT-110	Blower Discharge Pressure PI-200	Blower Discharge Temp. (deg F)	Aeration Tank Height LIT-210	Pump 210 Discharge Pressure PI-210	Trimite Absorption Clarifier Pressure PI-310	Trimite Mixed Media Pressure PI-320	Trimite Flow FI-310	Trimite Effluent Turbidity AIT-310	Trimite Blower B-310 Discharge Pressure PI-330	Holding Tank Level LIT-340	GAC Pressure In PI-501	GAC Pressure Out PI-501	Nitrate-N Feed AE-650	Nitrate-N Effluent AE-660	Perchlorate Feed AI 761	Perchlorate Effluent AI 762	Electron Donor Tank 430 Volume
d/m/y	hh:mm	# days	gpm	psig	psig	0-14	Deg F	gpm	psig	inches	mV	psig	Deg F	inches	0 to 2	psig	ft H_2O	gpm	NTU	psig	inches	psig	psig	mg/l	mg/l	µg/l	µg/l	gallons
																								4-10		4-10		
Avg.			**40.0**	**5.6**	**22.2**	**7.41**	**18.5**	**91.7**	**8.7**	**132.0**	**-190.0**	**9.6**	**206.2**	**93.1**	**15.2**	**0.8**	**4.4**	**44.2**	**0.105**	**0.6**	**159.0**	**1.4**	**1.1**	**6.1**	**0.5**	**346.6**	**4.5**	**22.1**
Std.			**13.6**	**0.2**	**1.7**	**0.31**	**0.6**	**6.5**	**1.2**	**18.7**	**320.1**	**4.8**	**17.3**	**20.7**	**2.1**	**0.4**	**1.9**	**19.0**	**0.097**	**1.2**	**19.2**	**1.6**	**1.4**	**1.0**	**1.2**	**768.7**	**9.8**	**11.4**
Max.			**72.9**	**6.0**	**26.0**	**8.93**	**23.1**	**112.0**	**11.0**	**170.0**	**499.0**	**13.0**	**240.0**	**146.0**	**20.5**	**2.1**	**8.0**	**90.0**	**0.759**	**3.0**	**166.0**	**8.0**	**6.5**	**7.6**	**6.2**	**4029.0**	**86.6**	**55.0**
Min.			**0.0**	**5.0**	**19.5**	**6.79**	**13.9**	**74.5**	**6.0**	**0.0**	**-497.0**	**0.0**	**90.0**	**8.0**	**11.0**	**0.0**	**-3.5**	**0.0**	**0.015**	**0.0**	**19.0**	**0.0**	**0.0**	**0.1**	**0.0**	**32.2**	**0.0**	**0.0**
31-Jan-08	15:30	322	25	5.50	25.0	7.43	18.5	90.4	10.00	148	-490		210	101	18.0	0.70	4.00		0.070		164				0.1	1060	11.5	36
1-Feb-08	14:45	323	25	5.50	25.0	7.43	18.5	90.4	10.00	148	-487		205	91	17.5	0.70	6.50		0.066		164				0.1	1975	6.3	32
2-Feb-08		324																			164							
3-Feb-08		325																			164							
4-Feb-08	14:00	326	26	5.50	25.0	7.46	18.3	90.4	10.00	148	-484		200	92	17.5	0.60			0.066		164				0.1	1144	2.8	22
5-Feb-08	16:00	327	25	5.50	25.0	7.45	18.5	83.7	10.00	146	-484		200	96	18.5	0.70	6.00		0.065		164			6.1	0.1	1184	0	19
6-Feb-08	16:00	328	25	5.50	25.0	7.57	18.5	90.4	10.00	146	-484		200	101	18.5	0.70	6.00		0.064		164			6.1	0.1	1802	0	16
7-Feb-08	15:15	329	25	5.50	24.5	7.47	19.0	93.6	9.00	148	-486		200	104	17.5	0.70	5.50		0.062		164			6.1	0.1	2300	1.8	13
8-Feb-08	12:45	330	25	5.50	24.0	7.46	19.2	87.1	8.00	148	-493		220	87	16.0	0.70	6.50		0.068		164			6.1	0.1	3031	7.7	10
9-Feb-08	13:00	331	25	5.50	24.0	7.48	19.0	90.4	8.00	148	-495		225	103	17.0	0.60	6.50		0.098		164			6.1	0.1	3470		7 / 55
10-Feb-08		332																										
11-Feb-08	15:00	333	25	5.50	24.0	7.66	19.6	90.4	8.50	148	-497		225	96	17.0	0.60	5.00		0.067		164			6.0	0.1	4029	8.9	47
12-Feb-08	15:15	334	25	5.50	24.0	7.63	19.0	83.7	8.50	148	-495		225	97	17.0	0.60	5.00		0.062		164			6.0	0.1	3329		43
13-Feb-08	8:15	335	25	5.50	25.5	7.43	18.6	90.4	10.00	148	-492		200	96	18.0	0.60	5.00		0.148		164			6.0	0.1	3058	19.0	40
14-Feb-08	14:00	336	25	5.50	25.0	7.53	18.3	87.1	10.50	148	-492		200	106	18.0	0.80	5.00		0.068		164			6.0	0.1	1354	17.7	36
15-Feb-08	13:15	337	26	5.50	24.5	7.55	18.6	87.1	10.00	148	-493		200	99	18.0	0.60	7.00		0.063		164			6.0	0.1	58.8	0.0	33
16-Feb-08		338																										
17-Feb-08		339																										
18-Feb-08	11:00	340	25	5.50	25.0	7.50	18.6	90.4	10.00	151	-490		200	105	18.0	0.60	5.00		0.070		164			6.0	0.1		0.5	25
19-Feb-08	13:00	341	25	5.50	25.5	7.47	18.5	83.7	10.50	152	-493		200	89	17.5	0.60	8.00		0.067		164			6.0	0.1			24
20-Feb-08		342																										
21-Feb-08		343																										
22-Feb-08	14:45	344	24	5.50	25.0	7.52	18.3	80.2	10.00	148	-492		200	104	18.0	0.60	8.00		0.070		164			6.0	0.1			15
23-Feb-08		345																										
24-Feb-08		346																										
25-Feb-08	12:15	347	24	5.50	24.5	7.49	19.0	90.4	8.50	148	-495		215	113	17.5	0.60	5.00		0.088		164			6.1	0.1			
26-Feb-08	15:30	348	25	5.50	24.5	7.89	19.0	90.4	8.50		5		200	82	18.5	0.60	5.00		0.162		164			6.0	0.1			11

Version 2 3/15/2007

Date	Time	Electron Donor Pump 430 Stoke	Electron Donor Pump 430 Speed	Electron Donor Pump 430 Proportionality Constant	Nutrient Tank 410 Volume	Nutrient Pump 410 Stoke	Nutrient Pump 410 Speed	Nutrient Pump 410 Proportionality Constant	Dissolved Oxygen Feed (V-106)	Oxidation Reduction Potential Feed (V-106)	pH Feed (V-106)	Temperature Feed (V-106)	Nitrate-N Feed (V-106)	Nitrite-N Feed (V-106)	Dissolved Oxygen Effluent (V-1143)	Oxidation Reduction Potential Effluent (V-1143)	pH Effluent (V-1143)	Temperature Effluent (V-1143)	Nitrate-N Effluent (V-1143)	Nitrite-N Effluent (V-1143)	Total Organic Carbon Effluent (V-1143)	Ortho-Phosphate P Effluent (V-1143)	Trimite Effluent Turbidity	Post Aeration Dissolved Oxygen
d/m/y	hh:mm	0-100	0-100	0-1	gallons	0-100	0-100	0-1	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mV		Deg C	mg/l	mg/l	mg/l	mg/l	NTU	mg/l
									5.5-8.0	>0	6 -8	15-20	4-10	<1	5.5-8.0	<0	6-8	20-35	<1	<1	<100	9-30	<1	5.0-9.0
Avg.		100.0	29.4	0.65	23.3	100.0	23.1	0.67	8.10	74.9	8.0	19.3	4.5	0.0	0.83	28.7	7.40	19.7	0.7	0.147	2.2	1.3	0.19	7.4
Std.		0.0	9.9	0.02	9.0	0.0	10.3	0.28	0.87	88.9	0.3	0.9	0.7	0.0	1.14	130.9	0.45	0.9	1.1	0.560	2.4	0.9	0.16	1.1
Max.		100.0	46.0	0.71	44.0	100.0	64.0	2.00	9.76	317.9	8.8	22.7	5.8	0.1	5.78	346.1	8.74	22.8	4.6	3.100	15.6	4.93	0.78	9.4
Min.		100.0	0.0	0.60	0.0	100.0	0.0	0.00	5.98	-31.7	7.5	0.0	2.7	0.0	0.01	-207.1	6.84	17.3	0.0	0.000	-2.0	0.00	0.07	3.6
31-Jan-08	15:30	100	21	0.65	33	100	18	0.70																
1-Feb-08	14:45	100	21	0.65	30	100	18	0.70																
2-Feb-08		100		0.65																				
3-Feb-08		100		0.65				0.70																
4-Feb-08	14:00	100	20	0.65	24	100	17	0.70																
5-Feb-08	16:00	100	21	0.65	21	100	18	0.70													3.3			
6-Feb-08	16:00	100	21	0.65	19 / 45	100	18	0.70																
7-Feb-08	15:15	100	22	0.65	43	100	19	0.70																
8-Feb-08	12:45	100	21	0.65	41	100	17	0.70																
9-Feb-08	13:00	100	21	0.65	38	100	18	0.70																
10-Feb-08																								
11-Feb-08	15:00	100	22	0.65	34	100	18	0.70																
12-Feb-08	15:15	100	22	0.65	31	100	19	0.70																
13-Feb-08	8:15	100	21	0.65	30 / 45	100	18	0.70														1.37		
14-Feb-08	14:00	100	20	0.65	42	100	17	0.70																
15-Feb-08	13:15	100	19	0.65	40	100	16	0.70																
16-Feb-08																								
17-Feb-08																								
18-Feb-08	11:00	100	20	0.65	35	100	17	0.70							0.42									
19-Feb-08	13:00	100		0.65	31	100	17	0.70																
20-Feb-08																								
21-Feb-08																								
22-Feb-08	14:45	100	20	0.65	26	100	17	0.70																
23-Feb-08																								
24-Feb-08																								
25-Feb-08	12:15	100	20	0.65	19	100	18	0.70																
26-Feb-08	15:30	100	20	0.65		100	17	0.70																

Appendix G: Off-site Laboratory Data

Rialto Lab Data Date	2/14/2007	2/20/2007	3/20/2007	3/21/2007	3/22/2007	3/26/2007	3/28/2007	3/29/2007	4/5/2007	4/9/07	4/11/07	4/12/07	4/17/07	4/18/07	4/19/07	5/1/2007	5/3/2007	5/9/2007	5/15/2007	5/17/2007	5/23/2007	5/24/2007	5/29/2007
Days Elapsed	**-29**	**-23**	**5**	**6**	**7**	**11**	**13**	**14**	**21**	**25**	**27**	**28**	**33**	**34**	**35**	**47**	**49**	**55**	**61**	**63**	**69**	**70**	**75**
Feed Water																							
Feed Perchlorate (µg/L)	90.50		54.80	56.60	52.20	50.00	51.30	51.50	45.70	50.20	50.10	52.20	51.70	50.50	53.80	54.3	53.2	54.1	56.4	53.1	51.7	50.5	50.1
Dionex Feed CLO4 (µg/L)			38.0920	39.2340	38.9583	38.0659	33.2528	35.7418	35.8554	36.0401	36.4587	36.5643	35.5578	35.9200	35.8803	31.8830	36.6804	36.0426	37.2251	35.068	34.4862	34.8814	36.8032
Feed Nitrate-N (mg/L)	7.72		6.22	6.01	6.28	6.41	5.89	5.85	5.85	5.84	5.87	5.77	5.87	5.82	5.86	5.77	5.74	5.76		5.98	5.85		
HACH Feed NO3-N (mg/L)			6.2600	6.2978	6.3467	6.4024	6.8446	6.8287	7.2289	7.0606	7.3255	6.2660	6.3000	6.3000	6.3*	6.0375	6.067	6.0784		6.2091	6.1875		
Chlorate (µg/L)		ND																					
Chlorite (µg/L)		ND																					
Barium (mg/L)	0.0291																						
Cadmium (mg/L)	ND																						
Chromium (mg/L)	ND																						
Iron (mg/L)	0.0673J																						
Lead (mg/L)	ND																						
Manganese (mg/L)	0.00327J																						
Nickel (mg/L)	ND																						
Zinc (mg/L)	0.00726J																						
Mercury (µg/L)	ND																						
Feed Color (CPU)	ND			ND			ND		ND		2.50			ND									
Feed pH	7.46			7.78			7.73		7.63		7.83												
Feed TDS (mg/L)	325.00			260.00			270.00		220.00		310.00			310									
Feed TSS (mg/L)	ND																						
Feed Chloride (mg/L)	27.80			20.40			19.60		19.50		20.20			19.8									
Feed Nitrite (mg/L)	ND			ND			ND		ND		ND			ND									
Feed Orthophosphate-P (mg/L)	ND													ND									
Feed Sulfate (mg/L)	22.10			19.40			17.90		17.70		18.80			18.6									
Ammonia (mg/L)	0.24																						
TOC (mg/L)	ND																						
Carbonate (mg/l)														ND						ND			
Bicarbonate (mg/l)														160						163			
Hydroxide Alkalinity (mg/l)														ND						ND			
Calcium (mg/l)														69.5						63.5			
Magnesium (mg/l)														11.1						10.8			
Sodium (mg/l)														12.9						11.9			
Total Hardness (mg/l)														219						203			
VOC (µg/L)																							
FBR Effluent Water																							
Effluent Perchlorate (µg/L)			34.10	28.50	32.00	<0.5 MDL	2.03	11.70	15.60	31.60	<0.5 MDL	<0.5 MDL	3.28	<0.5 MDL	9.8000	<0.5 MDL	10.3000	<0.5 MDL	<0.5 MDL	<0.5 MDL	2.2	<0.5 MDL	<0.5 MDL
Dionex Eff. CLO4 (µg/L)			23.7938	14.5667	26.3099	0.0350	0.0350	14.8122	13.1483	16.0335	0.0350	0.0350	2.3427	0.0350	8.2960	0.0000	4.8270	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Effluent Nitrate-N (mg/L)			2.34	1.10	1.04	<0.05 MDL	<0.05 MDL	1.37	1.14	0.53	<0.05 MDL	<0.05 MDL	<0.05 MDL	<0.05 MDL	<0.05 MDL	<0.05 MDL	0.312	<0.05 MDL		<0.05 MDL	<0.05 MDL		
HACH Eff. NO3-N (mg/L)			2.3111	1.6176	1.5631	0.5536	0.2137	1.4835	1.5153	0.9674	0.1114	0.1261	0.1000	0.1000	0.1011	0.1011	0.4047	0.1000		0.1227	0.1432		
Effluent Color (CPU)				ND			ND		ND		2.50			ND						ND	ND		
Effluent pH				7.23			7.20		7.05		7.36												
Effluent TDS (mg/L)				270.00			280.00		225.00		300.00			300									
FBR Eff. TSS (mg/L)							ND		ND		ND					ND				ND	ND		
Effluent Chloride (mg/L)				20.20			19.60		18.60		19.80			19.8									
Effluent Nitrite (mg/L)				ND			ND		ND		ND			ND									
Effluent Orthophosphate-P (mg/L)				0.87										0.502									
Effluent Sulfate (mg/L)				18.40			17.80		16.20		18.80			18.4									
Barium (mg/L)																							
Cadmium (mg/L)																							
Calcium (mg/l)																							
Chromium (mg/L)																							
Iron (mg/L)																							
Lead (mg/L)																							
Magnesium (mg/l)																							
Manganese (mg/L)																							
Nickel (mg/L)																							
Sodium (mg/l)																							
Zinc (mg/L)																							
Carbonate (mg/l)														ND						ND	ND		
Bicarbonate (mg/l)														185						185	183		
Hydroxide Alkalinity (mg/l)														ND						ND	ND		
Calcium (mg/l)														69.3						65.9	66.6		
Magnesium (mg/l)														11						11.2	11.3		
Sodium (mg/l)														12.8						12.4	12.5		
Total Hardness (mg/l)														218						241	213		
VOC (µg/L)																							
Post Aeration																							
VOC (µg/L)																							

Date	2/14/2007	2/20/2007	3/20/2007	3/21/2007	3/22/2007	3/26/2007	3/28/2007	3/29/2007	4/5/2007	4/9/07	4/11/07	4/12/07	4/17/07	4/18/07	4/19/07	5/1/2007	5/3/2007	5/9/2007	5/15/2007	5/17/2007	5/23/2007	5/24/2007	5/29/2007
Days Elapsed	-29	-23	5	6	7	11	13	14	21	25	27	28	33	34	35	47	49	55	61	63	69	70	75
Trimite Effluent Water																							
Effluent Perchlorate (µg/L)																							
Dionex Eff. CLO4 (µg/L)																							
Filter TSS (mg/L)							ND		ND		ND					ND				ND	ND		
Barium (mg/L)																0.0286				0.0274	0.0278		
Cadmium (mg/L)																ND				ND	ND		
Calcium (mg/l)																				63.3	66.3		
Chromium (mg/L)																ND				ND	ND		
Iron (mg/L)																ND				ND	ND		
Lead (mg/L)																ND				ND	ND		
Magnesium (mg/l)																				11.1	11.3		
Manganese (mg/L)																ND				ND	ND		
Nickel (mg/L)																ND				ND	ND		
Sodium (mg/l)																				12.7	12.4		
Zinc (mg/L)																0.0580				0.012	0.00598J		
Mercury (µg/L)																ND				ND	ND		
Carbonate (mg/l)																				ND	ND		
Bicarbonate (mg/l)																				185	183		
Hydroxide Alkalinity (mg/l)																				ND	ND		
Total Hardness (mg/l)																				204	212		
VOCs (µg/L)																							
Potassium (mg/L)																							
Total Cations (me/L)																							
Total Alkalinity (mg/L)																							
Chloride (mg/L)																							
Sulfate (mg/L)																							
Fluoride (mg/L)																							
Nitrate (mg/L)																							
Total Anions (mg/L)																							
pH																							
Specific Conductance (µmhos/cm)																							
Temperature (degrees C)																							
Aggressive Index																							
Langlier Index at 25 C																							
Color (CPU)																							
Odor (TON)																							
Turbidity (NTU)																							
TDS (mg/L)																							
MBAS (mg/L)																							
Cyanide (mg/L)																							
Perchlorate (mg/L)																							
Nitrite (mg/L as N)																							
Aluminum (mg/L)																							
Antimony (mg/L)																							
Arsenic (mg/L)																							
Beryllium (mg/L)																							
Copper (mg/L)																							
Selenium (mg/L)																							
Silver (mg/L)																							
Thallium (mg/L)																							
Total Trihalomethanes (µg/L)														**13.00**							**9.9**		
Bromodichloromethanes (µg/L)														4.20							3.2		
Bromoform (µg/L)														0.93							1.4		
Chloroform (µg/L)														5.00							2.4		
Dibromochloromethane (µg/L)														3.30							2.9		
HAA5 FP (µg/L)														**22.00**							**18**		
Monochloroacetic Acid FP (µg/L)														14.00							12		
Dichloroacetic Acid FP (µg/L)														3.50							1.9		
Trichloroacetic Acid FP (µg/L)														2.00							1.5		
Monobromoacetic Acid FP (µg/L)														1.30							1.4		
Dibromoacetic Acid FP (µg/L)														ND (<1.0)							ND (<1.0)		
NDMA (µg/L)																							
BOD AC(forward flush intitial, mg/l)																					44.9		
BOD AC(forward flush middle, mg/l)																					22.4		
BOD AC(forward flush end, mg/l)																					17.1		
BOD MMF(back flush intitial, mg/l)																					23.1		
BOD MMF(back flush middle, mg/l)																					4.94		
BOD MMF(back flush end, mg/l)																					3.37		
COD AC(forward flush intitial, mg/l)																					851		
COD AC(forward flush middle, mg/l)																					79.9		
COD AC(forward flush end, mg/l)																					39.3		
COD MMF(back flush intitial, mg/l)																					277		

Date	2/14/2007	2/20/2007	3/20/2007	3/21/2007	3/22/2007	3/26/2007	3/28/2007	3/29/2007	4/5/2007	4/9/07	4/11/07	4/12/07	4/17/07	4/18/07	4/19/07	5/1/2007	5/3/2007	5/9/2007	5/15/2007	5/17/2007	5/23/2007	5/24/2007	5/29/2007
Days Elapsed	-29	-23	5	6	7	11	13	14	21	25	27	28	33	34	35	47	49	55	61	63	69	70	75
Trimite Effluent Water																							
COD MMF(back flush middle, mg/l)																					25		
COD MMF(back flush end, mg/l)																					10.8		
TSS AC(forward flush intitial, mg/l)																							
TSS AC(forward flush near end, mg/l)																							
TSS AC(rinse to waste begin, mg/l)																							
TSS AC(rinse to waste middle, mg/l)																							
TSS AC(rinse to waste end, mg/l)																							
TSS MMF(back flush intitial, mg/l)																							
TSS MMF(back flush middle, mg/l)																							
TSS MMF(back flush end, mg/l)																							
UV																							
VOCs (µg/L)																							

NOTES

(1) QA/QC Results

3/26/2007	Feed Perchlorate Laboratory Collection Duplicate (µg/L)	51.8
3/28/2007	Effluent Perchlorate Collection Duplicate (µg/L)	2.17
	Effluent Perchlorate Field Split Duplicate (µg/L)	2.58
	Trip Blank Perchlorate (µg/L)	<0.5 MDL
	Field Blank Perchlorate (µg/L)	<0.5 MDL
6/5/2007	Effluent Perchlorate Collection Duplicate (µg/L)	<0.5 MDL
	Effluent Perchlorate Field Split Duplicate (µg/L)	<0.5 MDL
	Trip Blank Perchlorate (µg/L)	<0.5 MDL
	Field Blank Perchlorate (µg/L)	<0.5 MDL
2/14/2008	Feed Blind Perchlorate Collection Duplicate (µg/L)	2860
	Feed Blind Perchlorate Field Split Duplicate (µg/L)	2880
	Trip Blank Perchlorate (µg/L)	<0.5 MDL
	Field Blank Perchlorate (µg/L)	<0.5 MDL
2/26/2008	Feed Perchlorate Collection Duplicate (µg/L)	61.1
	Feed Perchlorate Field Split Duplicate (µg/L)	62.7
	Trip Blank Perchlorate (µg/L)	<0.5 MDL
	Field Blank Perchlorate (µg/L)	<0.5 MDL

(2) Reporting Limits

Feed Chlorate (µg/L)	RL = 20 ppb	Feed Nitrite (mg/L)	RL=0.1, MDL=0.05
Feed Chlorite (µg/L)	RL = 20 ppb	Effluent Nitrite (mg/L)	RL=0.1, MDL=0.05
Barium (mg/L)	RL=0.01, MDL=0.002	Nitrate-N (mg/L)	Rl= 0.2, MDL=0.1
Cadmium (mg/L)	RL=0.01, MDL=0.001	Feed Orthophosphate-P (mg/L)	RL=0.5, MDL=0.25
Chromium (mg/L)	RL=0.01, MDL=0.0025	Effluent Orthophosphate-P (mg/L)	RL=0.5, MDL=0.25
Iron (mg/L)	RL=0.2 , MDL=0.04	Feed Sulfate (mg/L)	RL=1.0, MDL=0.50
Lead (mg/L)	RL=0.01, MDL=0.003	Effluent Sulfate (mg/L)	RL=0.5, MDL=0.25
Manganese (mg/L)	RL=0.01, MDL=0.003	Ammonia (mg/L)	RL=0.1, MDL=0.03
Nickel (mg/L)	RL=0.01, MDL=0.0025	TOC (mg/L)	RL=1.0, MDL=0.50
Zinc (mg/L)	RL=0.01, MDL=0.005	Carbonate (mg/l)	RL=5.0, MDL=1
Mercury (µg/L)	RL=0.5, MDL=0.1	Bicarbonate (mg/l)	RL=5.0, MDL=1
Feed Color (CPU)	RL=5.0, MDL=2.5	Hydroxide Alkalinity (mg/l)	RL=5.0, MDL=1
Effluent Color (CPU)	RL=5.0, MDL=2.5	Total Hardness (mg/l)	RL=10.0, MDL=5.0
Odor (TON)	MDL=1.0	MBAS	RL=0.10
Feed TDS (mg/L)	RL=10.0, MDL=5.0	Calcium (mg/l)	RL=1.0, MDL=0.10
Effluent TDS (mg/L)	RL=10.0, MDL=5.0	Magnesium (mg/l)	RL=1.0, MDL=0.10
Feed TSS (mg/L)	RL=10.0, MDL=5.0	Sodium (mg/l)	RL=1.0, MDL=0.25
FBR Eff. TSS (mg/L)	RL=10.0, MDL=5.0	BOD (mg/l)	RL=2.0, MDL=1.0
Filter TSS (mg/L)	RL=10.0, MDL=5.0	COD (mg/l)	RL=10.0, MDL=5.0
Feed Chloride (mg/L)	RL=0.4, MDL=0.2	Feed perchlorate	RL=10.0, MDL=2.5
Effluent Chloride (mg/L)	RL=0.4, MDL=0.2	Effluent perchlorate	RL=2.0, MDL=0.5
Turbidity (NTU)	MDL=0.2	NDMA (µg/L)	MDL=0.004

(3) * Indicates that the feed Nitrate-N value was frozen at this value while the instrument was repaired. Effluent analyzer temporarily swtiched to demonstrate this feed value.

(4) Originally, results for 4/11/07 and 4/12/07 for feed perchlorate were reported as 10.3 and 6.91, respectively.

(5) Split samples for perchlorate for 4/17/07 were reported by UCR lab to be 48.2186, 50.3539 at the feed and 3.0479, 3.0222 at the effluent.

(6) For 5/09/07, check standard as measured by EMAX was 53.019 ppb for a 50 ppb standard (Dionex measured 44.5 ppb)

(7) 5/1/07 Dionex perchlorate data may not be comparable to lab result as the next sample was at 40.3876 ppb.

(8) 4/19/07 EMAX perchlorate effluent originally reported as ND, then changed to 9.8 ppb.

(9) 5/28/07 Feed sample for Shaw lab read 37.4 ppb and 42.7 without/with pretreatment. The 50 ppb standard read 47.5 and 47.7 ppb without/with pretreatment.

(10) 5/10/07 sample not analyzed due to over temperature range upon receipt.

(11) COD/Metals Analyses bottles were unpreserved for 5/31/07

(12) Metal analyses bottle was unpreserved on 6/19/07

(13) 10/17/07, Feed CLO4 sample for Shaw lab read 37.8. 37.0, and 40.5 ppb. Effluent CLO4 <0.5 ppb.

(14) 10/18/07, Dionex effluent sample reads 0, but next sample read 2.7549 ppb. Low acetic acid addition rate.

(15) 10/30/07, Dionex effluent sample reads 0. Low acetic acid addition rate.

(16) 11/28/07 Effluent sample read 85.1584 ppb and 48.7324 ppb before and after the 114.123 ppb reading.

(17) 11/29/07 Effluent sample read 89.0895 ppb and 82.5286 ppb before and after the 35.588 ppb reading.

(18) 12/12/07 Effluent sample read 6.1284 ppb after the 0 ppb reading.

(19) 1/10/08 Effluent sample read 8.2827 ppb, but a minute later it read 10.8785. Color, Odor, and Turbidity out of holding time.

(20) 2/7/08 Filter Effluent by Dionex 10 minutes after sample collected read 6.42 ppb.

(21) 2/13/08 Nitrate-N effluent value may be off due to nitrate analyzer influent clog.

Rialto Lab Data Date	5/31/2007	6/5/2007	6/12/2007	6/14/2007	6/19/2007	6/21/2007	6/26/2007	6/28/2007	7/5/2007	7/12/2007	7/18/2007	7/19/2007	7/24/2007	7/25/2007	7/30/2007	8/2/2007	8/7/2007	8/9/2007	8/14/2007	8/21/2007	8/22/2007	8/30/2007	9/6/2007	9/11/2007	9/13/2007
Days Elapsed	**77**	**82**	**89**	**91**	**96**	**98**	**103**	**105**	**112**	**119**	**125**	**126**	**131**	**132**	**137**	**140**	**145**	**147**	**152**	**159**	**160**	**168**	**175**	**180**	**182**
Feed Water																									
Feed Perchlorate (µg/L)	51.5	52.9	50.6	52.5	53.1	51.3	51	52.1	52.3	51.4	54.6	56.6	56.0	56.4	56.0	51.5	55.0	55.3	53.8	54.6	54	52.7	50.5	52.3	51.2
Dionex Feed CLO4 (µg/L)	37.2091	37.1715	37.0343	36.9057	39.0161	35.3938	36.1515	36.8594	35.3048	38.4462	48.0431	46.9924	47.5366	48.3034	46.3274	47.4604	47.7005	45.6963	NA	48.7749	48.1849	44.1236	44.0529	42.7069	42.193
Feed Nitrate-N (mg/L)	5.72	5.8	5.86		5.75		5.47	5.56	5.88	5.85	5.85		5.94		6.05		6.01		5.76	6.11		6.22	5.86	6.54	
HACH Feed NO3-N (mg/L)	6.2649	6.2876	5.809		5.9147		5.9727	5.9863	6.05	6.1262	6.1773		6.1796		6.1478		6.2819		6.3183	6.4126		N/A	N/A	N/A	
Chlorate (µg/L)																									
Chlorite (µg/L)																									
Barium (mg/L)																									
Cadmium (mg/L)																									
Chromium (mg/L)																									
Iron (mg/L)																									
Lead (mg/L)																									
Manganese (mg/L)																									
Nickel (mg/L)																									
Zinc (mg/L)																									
Mercury (µg/L)																									
Feed Color (CPU)																									
Feed pH																									
Feed TDS (mg/L)																									
Feed TSS (mg/L)																									
Feed Chloride (mg/L)																									
Feed Nitrite (mg/L)																									
Feed Orthophosphate-P (mg/L)																									
Feed Sulfate (mg/L)																									
Ammonia (mg/L)																									
TOC (mg/L)																									
Carbonate (mg/l)																									
Bicarbonate (mg/l)																									
Hydroxide Alkalinity (mg/l)																									
Calcium (mg/l)																									
Magnesium (mg/l)																									
Sodium (mg/l)																									
Total Hardness (mg/l)																									
VOC (µg/L)															ND (TCE=4.4)										
FBR Effluent Water																									
Effluent Perchlorate (µg/L)	<0.5 MDL	<0.5 MDL	<0.5 MDL	1.42J	9.8100	<0.5 MDL	<0.5 MDL	<0.5 MDL	<0.5 MDL	5.86	2.12	<0.5 MDL	<0.5 MDL	<0.5 MDL	<0.5 MDL	5.35	4.12	4.86	8.71	9.77	6.7	5.72	12.9	6.08	5.28
Dionex Eff. CLO4 (µg/L)	0.0000	0.0000	0.0000	0.0000	3.9487	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	7.4575	0.0000	0.0000	3.848	0.0000	3.6888	2.9152	8.3279	3.5188	3.1783
Effluent Nitrate-N (mg/L)	<0.05 MDL	<0.05 MDL	<0.05 MDL		.0881J		<0.05 MDL	<0.05 MDL	<0.05 MDL	<0.05 MDL	<0.05 MDL		<0.05 MDL		<0.05 MDL		<0.05 MDL		0.0792J	<0.05 MDL		<0.05 MDL	<0.05 MDL	0.136	
HACH Eff. NO3-N (mg/L)	0.1716	0.1955	0.1409		0.1		0.108	0.1	0.1557	0.1341	0.1045		0.2125		0.1648		0.1045		0.1705	0.1421		N/A	N/A	0.2842	
Effluent Color (CPU)			ND																						
Effluent pH																									
Effluent TDS (mg/L)																									
FBR Eff. TSS (mg/L)	ND		ND																						
Effluent Chloride (mg/L)																									
Effluent Nitrite (mg/L)																									
Effluent Orthophosphate-P (mg/L)																									
Effluent Sulfate (mg/L)																									
Barium (mg/L)			0.0258																						
Cadmium (mg/L)			ND																						
Calcium (mg/l)			60.9																						
Chromium (mg/L)			ND																						
Iron (mg/L)			0.0447J																						
Lead (mg/L)			ND																						
Magnesium (mg/l)			10.8																						
Manganese (mg/L)			ND																						
Nickel (mg/L)			ND																						
Sodium (mg/l)			12.9																						
Zinc (mg/L)			0.0113																						
Carbonate (mg/l)			ND																						
Bicarbonate (mg/l)			180																						
Hydroxide Alkalinity (mg/l)			ND																						
Calcium (mg/l)			60.9																						
Magnesium (mg/l)			10.8																						
Sodium (mg/l)			12.9																						
Total Hardness (mg/l)			197																						
VOC (µg/L)																									
Post Aeration																									
VOC (µg/L)																									

Date	**5/31/2007**	**6/5/2007**	**6/12/2007**	**6/14/2007**	**6/19/2007**	**6/21/2007**	**6/26/2007**	**6/28/2007**	**7/5/2007**	**7/12/2007**	**7/18/2007**	**7/19/2007**	**7/24/2007**	**7/25/2007**	**7/30/2007**	**8/2/2007**	**8/7/2007**	**8/9/2007**	**8/14/2007**	**8/21/2007**	**8/22/2007**	**8/30/2007**	**9/6/2007**	**9/11/2007**	**9/13/2007**
Days Elapsed	**77**	**82**	**89**	**91**	**96**	**98**	**103**	**105**	**112**	**119**	**125**	**126**	**131**	**132**	**137**	**140**	**145**	**147**	**152**	**159**	**160**	**168**	**175**	**180**	**182**
Trimite Effluent Water																									
Effluent Perchlorate (µg/L)																		3.97	11.5	10.1		5.76	13.7	6.84	
Dionex Eff. CLO4 (µg/L)																		0.0000	5.8372	8.0832		3.7399		3.9829	
Filter TSS (mg/L)	ND		ND																						
Barium (mg/L)	0.0283		0.0252		0.0276		0.0265	0.0275		0.0262	0.0258				<0.1										
Cadmium (mg/L)	ND		ND		ND		ND	ND		ND	ND				<0.001										
Calcium (mg/l)	65.8		60.3												54										
Chromium (mg/L)	ND		ND		.00268J		ND	ND		ND	ND				0.0039										
Iron (mg/L)	ND		ND		ND		ND	ND		ND	ND				<.1										
Lead (mg/L)	ND		ND		ND		ND	ND		ND	ND				<.005										
Magnesium (mg/l)	11.3		10.6												9.7										
Manganese (mg/L)	.00309J		ND		ND		ND	0.00784J		ND	ND				<0.02										
Nickel (mg/L)	ND		ND		ND		ND	ND		ND	ND				<0.01										
Sodium (mg/l)	11.6		12.9												11										
Zinc (mg/L)	.00702J		.00811J		0.0132		0.0117	0.0124		0.0137	0.0199				<0.05										
Mercury (µg/L)	ND		ND		ND		ND	ND		0.136J	ND				<0.001										
Carbonate (mg/l)	ND		ND												ND										
Bicarbonate (mg/l)	180		175												220										
Hydroxide Alkalinity (mg/l)	ND		ND												ND										
Total Hardness (mg/l)	211		194												170										
VOCs (µg/L)													ND		ND										
Potassium (mg/L)															1.7										
Total Cations (me/L)															4										
Total Alkalinity (mg/L)															180										
Chloride (mg/L)															15										
Sulfate (mg/L)															16										
Fluoride (mg/L)															0.3										
Nitrate (mg/L)															ND										
Total Anions (mg/L)															4.37										
pH															7.6										
Specific Conductance (µmhos/cm)															430										
Temperature (degrees C)															25										
Aggressive Index															12										
Langlier Index at 25 C															0.2										
Color (CPU)															ND										
Odor (TON)															ND										
Turbidity (NTU)															ND										
TDS (mg/L)															250										
MBAS (mg/L)															ND										
Cyanide (mg/L)															<0.1										
Perchlorate (mg/L)																									
Nitrite (mg/L as N)															<0.1										
Aluminum (mg/L)															0.053										
Antimony (mg/L)															<0.006										
Arsenic (mg/L)															<0.002										
Beryllium (mg/L)															<0.001										
Copper (mg/L)															<0.05										
Selenium (mg/L)															<0.005										
Silver (mg/L)															<0.01										
Thallium (mg/L)															<0.001										
Total Trihalomethanes (µg/L)	**6.2**		**8.5**		**5.7**																				
Bromodichloromethanes (µg/L)	2.2		2.7		1.8																				
Bromoform (µg/L)	0.64		ND (<0.5)		ND (<0.5)																				
Chloroform (µg/L)	1.7		2.4		1.9																				
Dibromochloromethane (µg/L)	1.6		2.9		1.9																				
HAA5 FP (µg/L)	**7.5**		**10**		**ND (<5.0)**																				
Monochloroacetic Acid FP (µg/L)	ND (<2.0)		2.9		ND(<2.0)																				
Dichloroacetic Acid FP (µg/L)	3.0		3.1		1.90																				
Trichloroacetic Acid FP (µg/L)	1.7		2.2		ND (<1.0)																				
Monobromoacetic Acid FP (µg/L)	ND (<1.0)		ND (<1.0)		ND (<1.0)																				
Dibromoacetic Acid FP (µg/L)	1.1		1.4		ND (<1.0)																				
NDMA (µg/L)																									
BOD AC(forward flush intitial, mg/l)	57.5		22																						
BOD AC(forward flush middle, mg/l)	18.8		ND																						
BOD AC(forward flush end, mg/l)	ND		ND																						
BOD MMF(back flush intitial, mg/l)	5.93		ND																						
BOD MMF(back flush middle, mg/l)	ND		ND																						
BOD MMF(back flush end, mg/l)	ND		2.35																						
COD AC(forward flush intitial, mg/l)	1000		789																						
COD AC(forward flush middle, mg/l)	356		180																						
COD AC(forward flush end, mg/l)	ND		ND																						
COD MMF(back flush intitial, mg/l)	137		124																						

Date	**5/31/2007**	**6/5/2007**	**6/12/2007**	**6/14/2007**	**6/19/2007**	**6/21/2007**	**6/26/2007**	**6/28/2007**	**7/5/2007**	**7/12/2007**	**7/18/2007**	**7/19/2007**	**7/24/2007**	**7/25/2007**	**7/30/2007**	**8/2/2007**	**8/7/2007**	**8/9/2007**	**8/14/2007**	**8/21/2007**	**8/22/2007**	**8/30/2007**	**9/6/2007**	**9/11/2007**	**9/13/2007**
Days Elapsed	**77**	**82**	**89**	**91**	**96**	**98**	**103**	**105**	**112**	**119**	**125**	**126**	**131**	**132**	**137**	**140**	**145**	**147**	**152**	**159**	**160**	**168**	**175**	**180**	**182**
Trimite Effluent Water																									
COD MMF(back flush middle, mg/l)	45.4		52.5																						
COD MMF(back flush end, mg/l)	18.9		ND																						
TSS AC(forward flush intitial, mg/l)																									
TSS AC(forward flush near end, mg/l)																									
TSS AC(rinse to waste begin, mg/l)																									
TSS AC(rinse to waste middle, mg/l)																									
TSS AC(rinse to waste end, mg/l)																									
TSS MMF(back flush intitial, mg/l)																									
TSS MMF(back flush middle, mg/l)																									
TSS MMF(back flush end, mg/l)																									
UV																									
VOCs (µg/L)													ND												

Rialto Lab Data																		**Spiking of 100 ppb**		**Spiking of 500 ppb**		**Spiking of 1000 ppb**	
Date	**9/18/2007**	**9/20/2007**	**9/25/2007**	**9/27/2007**	**10/3/2007**	**10/4/2007**	**10/9/2007**	**10/11/2007**	**10/17/2007**	**10/18/2007**	**10/23/2007**	**10/25/2007**	**10/30/2007**	**11/6/2007**	**11/8/2007**	**11/13/2007**	**11/20/2007**	**11/28/2007**	**11/29/2007**	**12/12/2007**	**12/13/2007**	**12/18/2007**	**12/20/2007**
Days Elapsed	**187**	**189**	**194**	**196**	**202**	**203**	**208**	**210**	**216**	**217**	**222**	**224**	**229**	**236**	**238**	**243**	**250**	**258**	**259**	**272**	**273**	**278**	**280**
Feed Water																							
Feed Perchlorate (µg/L)	52.5	52.5	50.6	50.6	50.4	51.5	50.4	51.3	49.5	50.2	53.2	54.7	51.4	54.80	53.60	51.70	64.40	68.00	106.00	547	607.00	1020.00	859
Dionex Feed CLO4 (µg/L)	44.3685	41.2255	N/A	N/A	N/A	43.1489	43.8254	43.066	43.5328	43.7105	43.0288	43.7258	43.9458	43.0303	44.6950	43.4549	43.5504	114.1230	35.5880	454.7431	521.5685	1013.6500	876.1500
Feed Nitrate-N (mg/L)	5.89		5.91		5.900		5.4600		5.76		5.86		5.9	5.7900		5.5500	5.9600	5.95		5.82		5.79	
HACH Feed NO3-N (mg/L)	6.0621		6		6.0591		6.0545		6.0523		6.1296		6.1353	6.1398		6.1387	6.1819	6.2489		6.3012		6.33	
Chlorate (µg/L)																							
Chlorite (µg/L)																							
Barium (mg/L)																							
Cadmium (mg/L)																							
Chromium (mg/L)																							
Iron (mg/L)																							
Lead (mg/L)																							
Manganese (mg/L)																							
Nickel (mg/L)																							
Zinc (mg/L)																							
Mercury (µg/L)																							
Feed Color (CPU)																							
Feed pH																							
Feed TDS (mg/L)																							
Feed TSS (mg/L)																							
Feed Chloride (mg/L)																							
Feed Nitrite (mg/L)																							
Feed Orthophosphate-P (mg/L)																							
Feed Sulfate (mg/L)																							
Ammonia (mg/L)																							
TOC (mg/L)																							
Carbonate (mg/l)																							
Bicarbonate (mg/l)																							
Hydroxide Alkalinity (mg/l)																							
Calcium (mg/l)																							
Magnesium (mg/l)																							
Sodium (mg/l)																							
Total Hardness (mg/l)																							
VOC (µg/L)																							
FBR Effluent Water																							
Effluent Perchlorate (µg/L)	3.31	16.3	21.4	7.8	3.71	2.73	2.01	2.2	<0.5 MDL	4.5	<0.5 MDL	1.9J	2.42	3.33	2.91	1.77J	2.67	<0.5 MDL	<0.5 MDL	17.0	20.1000	22.1000	22.9000
Dionex Eff. CLO4 (µg/L)	0.0000	10.4311	N/A	N/A	N/A	2.8859	0.0000	0.0000	0.0000	0*	0.0000	0.0000	0*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	8.9763	8.3
Effluent Nitrate-N (mg/L)	<0.05 MDL		0.0939J		0.0893J		<0.05 MDL		<0.05 MDL		<0.05 MDL		<0.05 MDL	<0.05 MDL		<0.05 MDL	<0.05 MDL	<0.05 MDL		<0.05 MDL		<0.05 MDL	
HACH Eff. NO3-N (mg/L)	0.1068		0.1432		0.1296		0.1023		0.1045		0.1		0.1227	0.1		0.2125	0.1875	0.1011		0.1		0.1	
Effluent Color (CPU)																							
Effluent pH																							
Effluent TDS (mg/L)																							
FBR Eff. TSS (mg/L)																							
Effluent Chloride (mg/L)																							
Effluent Nitrite (mg/L)																							
Effluent Orthophosphate-P (mg/L)																							
Effluent Sulfate (mg/L)																							
Barium (mg/L)																							
Cadmium (mg/L)																							
Calcium (mg/l)																							
Chromium (mg/L)																							
Iron (mg/L)																							
Lead (mg/L)																							
Magnesium (mg/l)																							
Manganese (mg/L)																							
Nickel (mg/L)																							
Sodium (mg/l)																							
Zinc (mg/L)																							
Carbonate (mg/l)																							
Bicarbonate (mg/l)																							
Hydroxide Alkalinity (mg/l)																							
Calcium (mg/l)																							
Magnesium (mg/l)																							
Sodium (mg/l)																							
Total Hardness (mg/l)																							
VOC (µg/L)																							
Post Aeration																							
VOC (µg/L)																							

																		Spiking of 100 ppb		Spiking of 500 ppb		Spiking of 1000 ppb	
Date	**9/18/2007**	**9/20/2007**	**9/25/2007**	**9/27/2007**	**10/3/2007**	**10/4/2007**	**10/9/2007**	**10/11/2007**	**10/17/2007**	**10/18/2007**	**10/23/2007**	**10/25/2007**	**10/30/2007**	**11/6/2007**	**11/8/2007**	**11/13/2007**	**11/20/2007**	**11/28/2007**	**11/29/2007**	**12/12/2007**	**12/13/2007**	**12/18/2007**	**12/20/2007**
Days Elapsed	**187**	**189**	**194**	**196**	**202**	**203**	**208**	**210**	**216**	**217**	**222**	**224**	**229**	**236**	**238**	**243**	**250**	**258**	**259**	**272**	**273**	**278**	**280**
Trimite Effluent Water																							
Effluent Perchlorate (µg/L)	2.71		22.1		3.23		2.17		<0.5 MDL		<0.5 MDL		2.23	4.00		<0.5 MDL	3.2	3.16		17.9		34.5	
Dionex Eff. CLO4 (µg/L)									0														
Filter TSS (mg/L)																							
Barium (mg/L)																							
Cadmium (mg/L)																							
Calcium (mg/l)																							
Chromium (mg/L)																							
Iron (mg/L)																							
Lead (mg/L)																							
Magnesium (mg/l)																							
Manganese (mg/L)																							
Nickel (mg/L)																							
Sodium (mg/l)																							
Zinc (mg/L)																							
Mercury (µg/L)																							
Carbonate (mg/l)																							
Bicarbonate (mg/l)																							
Hydroxide Alkalinity (mg/l)																							
Total Hardness (mg/l)																							
VOCs (µg/L)																							
Potassium (mg/L)																							
Total Cations (me/L)																							
Total Alkalinity (mg/L)																							
Chloride (mg/L)																							
Sulfate (mg/L)																							
Fluoride (mg/L)																							
Nitrate (mg/L)																							
Total Anions (mg/L)																							
pH																							
Specific Conductance (µmhos/cm)																							
Temperature (degrees C)																							
Aggressive Index																							
Langlier Index at 25 C																							
Color (CPU)																							
Odor (TON)																							
Turbidity (NTU)																							
TDS (mg/L)																							
MBAS (mg/L)																							
Cyanide (mg/L)																							
Perchlorate (mg/L)																							
Nitrite (mg/L as N)																							
Aluminum (mg/L)																							
Antimony (mg/L)																							
Arsenic (mg/L)																							
Beryllium (mg/L)																							
Copper (mg/L)																							
Selenium (mg/L)																							
Silver (mg/L)																							
Thallium (mg/L)																							
Total Trihalomethanes (µg/L)																							
Bromodichloromethanes (µg/L)																							
Bromoform (µg/L)																							
Chloroform (µg/L)																							
Dibromochloromethane (µg/L)																							
HAA5 FP (µg/L)																							
Monochloroacetic Acid FP (µg/L)																							
Dichloroacetic Acid FP (µg/L)																							
Trichloroacetic Acid FP (µg/L)																							
Monobromoacetic Acid FP (µg/L)																							
Dibromoacetic Acid FP (µg/L)																							
NDMA (µg/L)																							
BOD AC(forward flush intitial, mg/l)																							
BOD AC(forward flush middle, mg/l)																							
BOD AC(forward flush end, mg/l)																							
BOD MMF(back flush intitial, mg/l)																							
BOD MMF(back flush middle, mg/l)																							
BOD MMF(back flush end, mg/l)																							
COD AC(forward flush intitial, mg/l)																							
COD AC(forward flush middle, mg/l)																							
COD AC(forward flush end, mg/l)																							
COD MMF(back flush intitial, mg/l)																							

																		Spiking of 100 ppb		Spiking of 500 ppb		Spiking of 1000 ppb	
Date	**9/18/2007**	**9/20/2007**	**9/25/2007**	**9/27/2007**	**10/3/2007**	**10/4/2007**	**10/9/2007**	**10/11/2007**	**10/17/2007**	**10/18/2007**	**10/23/2007**	**10/25/2007**	**10/30/2007**	**11/6/2007**	**11/8/2007**	**11/13/2007**	**11/20/2007**	**11/28/2007**	**11/29/2007**	**12/12/2007**	**12/13/2007**	**12/18/2007**	**12/20/2007**
Days Elapsed	**187**	**189**	**194**	**196**	**202**	**203**	**208**	**210**	**216**	**217**	**222**	**224**	**229**	**236**	**238**	**243**	**250**	**258**	**259**	**272**	**273**	**278**	**280**
Trimite Effluent Water																							
COD MMF(back flush middle, mg/l)																							
COD MMF(back flush end, mg/l)																							
TSS AC(forward flush intitial, mg/l)																							640
TSS AC(forward flush near end, mg/l)																							350
TSS AC(rinse to waste begin, mg/l)																							154
TSS AC(rinse to waste middle, mg/l)																							<5
TSS AC(rinse to waste end, mg/l)																							<5
TSS MMF(back flush intitial, mg/l)																							280
TSS MMF(back flush middle, mg/l)																							54.0
TSS MMF(back flush end, mg/l)																							59.0
UV																							
VOCs (µg/L)																							

Rialto Lab Data	**1000 ppb**	**2000 ppb**	**2000 ppb w/recy.**	**1500 ppb**	**1000 ppb**	**Ramped to 2000 ppb Sample taken at 600 ppb**	**1000 ppb**	**2000 ppb**	**2000 ppb**	**1000 ppb**	**2000 ppb**	**2500 ppb**	**3200 ppb**			
Date	**12/27/2007**	**1/2/2008**	**1/3/2008**	**1/9/2008**	**1/10/2008**	**1/17/2008**	**1/23/2008**	**1/24/2008**	**1/29/2008**	**2/5/2008**	**2/7/2008**	**2/13/2008**	**2/14/2008**	**2/25/2008**	**2/26/2008**	**2/27/2008**
Days Elapsed	**287**	**293**	**294**	**300**	**301**	**308**	**314**	**315**	**320**	**327**	**329**	**335**	**336**	**347**	**348**	**349**
Feed Water																
Feed Perchlorate (µg/L)	1080	2150	1790	1340	1090	605	1140	2050	1630	1290	1940	2090	2990		63.5	64.1
Dionex Feed CLO4 (µg/L)	1051.4890	2115.745	1987.858	1422.791	1075.988	613.394	0	1958.747	1826.204	1232.169	2066.79	2490.809	3284.216 (2969.48)		56.0704	56.6836
Feed Nitrate-N (mg/L)	5.74	5.93		5.92		5.89	5.95		5.89	6.04		5.93			5.93	
HACH Feed NO3-N (mg/L)	6.3876	6.4195		6.4		6.2398	6.2444		6.1*	6.1*		6.0125			6.0466	
Chlorate (µg/L)																
Chlorite (µg/L)																
Barium (mg/L)																
Cadmium (mg/L)																
Chromium (mg/L)																
Iron (mg/L)																
Lead (mg/L)																
Manganese (mg/L)																
Nickel (mg/L)																
Zinc (mg/L)																
Mercury (µg/L)																
Feed Color (CPU)																
Feed pH																
Feed TDS (mg/L)																
Feed TSS (mg/L)																
Feed Chloride (mg/L)																
Feed Nitrite (mg/L)																
Feed Orthophosphate-P (mg/L)																
Feed Sulfate (mg/L)																
Ammonia (mg/L)																
TOC (mg/L)																
Carbonate (mg/l)																
Bicarbonate (mg/l)																
Hydroxide Alkalinity (mg/l)																
Calcium (mg/l)																
Magnesium (mg/l)																
Sodium (mg/l)																
Total Hardness (mg/l)																
VOC (µg/L)											ND (TCE=3.1)					
FBR Effluent Water																
Effluent Perchlorate (µg/L)	22.6000	57.1	37.4	15.1	22.1	<2.5 MDL	12.3	21.6	9.65	3.36	8.42	17.9	29.5			1.86J
Dionex Eff. CLO4 (µg/L)	6.9727	45.1982	41.4205	8.8	8.2827	5.5635	7.2615	11.039	5.7685	0	0	8.5305 (5.2)	12.9892			0
Effluent Nitrate-N (mg/L)	<0.05 MDL	<0.05 MDL		<0.05 MDL		<0.05 MDL	<0.05 MDL		<0.05 MDL	<0.05 MDL		<0.05 MDL				
HACH Eff. NO3-N (mg/L)	0.1011	0.1		0.1		0.1011	0.1		0.1011	0.1		0.1341*				
Effluent Color (CPU)																
Effluent pH																
Effluent TDS (mg/L)																
FBR Eff. TSS (mg/L)																
Effluent Chloride (mg/L)																
Effluent Nitrite (mg/L)																
Effluent Orthophosphate-P (mg/L)																
Effluent Sulfate (mg/L)																
Barium (mg/L)																
Cadmium (mg/L)																
Calcium (mg/l)																
Chromium (mg/L)																
Iron (mg/L)																
Lead (mg/L)																
Magnesium (mg/l)																
Manganese (mg/L)																
Nickel (mg/L)																
Sodium (mg/l)																
Zinc (mg/L)																
Carbonate (mg/l)																
Bicarbonate (mg/l)																
Hydroxide Alkalinity (mg/l)																
Calcium (mg/l)																
Magnesium (mg/l)																
Sodium (mg/l)																
Total Hardness (mg/l)																
VOC (µg/L)											ND					
Post Aeration																
VOC (µg/L)											ND					

	1000 ppb	2000 ppb	2000 ppb w/recy.	1500 ppb	1000 ppb	Sample taken at 600 ppb	1000 ppb	2000 ppb	2000 ppb	1000 ppb	2000 ppb	2500 ppb	3200 ppb			
Date	**12/27/2007**	**1/2/2008**	**1/3/2008**	**1/9/2008**	**1/10/2008**	**1/17/2008**	**1/23/2008**	**1/24/2008**	**1/29/2008**	**2/5/2008**	**2/7/2008**	**2/13/2008**	**2/14/2008**	**2/25/2008**	**2/26/2008**	**2/27/2008**
Days Elapsed	**287**	**293**	**294**	**300**	**301**	**308**	**314**	**315**	**320**	**327**	**329**	**335**	**336**	**347**	**348**	**349**
Trimite Effluent Water																
														Clarifier Flush Water		
Effluent Perchlorate (µg/L)	21.4	56.5		15.7		<2.5 MDL	16.2		11.0	7.69	6.65*	16.6	19.6	<4.0		1.75J
Dionex Eff. CLO4 (µg/L)																
Filter TSS (mg/L)																
Barium (mg/L)					<0.1					<0.1	<0.1	<0.1		<0.1		
Cadmium (mg/L)					<0.001					<0.001	<0.001	<0.001		<0.001		
Calcium (mg/l)					61					60	61	61		62		
Chromium (mg/L)					0.0033					0.003	0.0019	0.0024		0.02		
Iron (mg/L)					<.1					<.1	<.1	<.1		0.110		
Lead (mg/L)					<.005					<.005	<.005	<.005		<.005		
Magnesium (mg/l)					10					10	10	11		12		
Manganese (mg/L)					<0.02					<0.02	<0.02	<0.02		<0.02		
Nickel (mg/L)					<0.01					<0.01	<0.01	<0.01		<0.01		
Sodium (mg/l)					12					12	12	12		13		
Zinc (mg/L)					<0.05					<0.05	<0.05	<0.05		<0.05		
Mercury (µg/L)					<0.001					<0.001	<0.001	<0.001		<0.001		
Carbonate (mg/l)					ND < 3.0					ND < 3.0	ND < 3.0	ND < 3.0		ND < 3.0		
Bicarbonate (mg/l)					220					210	220	210		220		
Hydroxide Alkalinity (mg/l)					ND < 3.0					ND < 3.0	ND < 3.0	ND < 3.0		ND < 3.0		
Total Hardness (mg/l)					200					190	200	200		200		
VOCs (µg/L)					ND						ND					
Potassium (mg/L)					2.4					2.4	2.5	2.7		3.2		
Total Cations (me/L)					4.5					4.5	4.5	4.5		4.7		
Total Alkalinity (mg/L)					180					170	180	180		180		
Chloride (mg/L)					16					16	16	16		16		
Sulfate (mg/L)					17					17	16	17		17		
Fluoride (mg/L)					0.3					0.3	0.3	0.3		0.3		
Nitrate (mg/L)					ND <1.0					ND <1.0	ND <1.0	ND <1.0		ND <1.0		
Total Anions (mg/L)					4.42					4.22	4.4	4.42		4.42		
pH					7.7					7.7	7.7	7.7		7.4		
Specific Conductance (µmhos/cm)					410					420	420	430		430		
Temperature (degrees C)										25	25	25		25		
Aggressive Index					12.2					12.1	12.2	12.2		11.7		
Langlier Index at 25 C					0.35					0.26	0.32	0.32		0.02		
Color (CPU)					ND<3.0*					ND<3.0	ND<3.0	ND<3.0		3.0		
Odor (TON)					ND<1.0*					ND<1.0	ND<1.0	ND<1.0		ND<1.0		
Turbidity (NTU)					ND<0.2*					ND<0.2	ND<0.2	ND<0.2		180		
TDS (mg/L)					230					290	300	280		280		
MBAS (mg/L)					ND < 0.05					ND < 0.05	ND < 0.05	ND < 0.05		0.16		
Cyanide (mg/L)					ND < 0.1					ND < 0.1	ND < 0.1	ND < 0.1		ND < 0.1		
Perchlorate (mg/L)														<.004		
Nitrite (mg/L as N)					ND < 0.1					ND < 0.1	ND < 0.1	ND < 0.1		ND < 0.1		
Aluminum (mg/L)					0.064					0.056	0.062	0.076		3.5		
Antimony (mg/L)					<0.006					<0.006	<0.006	<0.006		<0.006		
Arsenic (mg/L)					<0.002					<0.002	<0.002	<0.002		<0.002		
Beryllium (mg/L)					<0.001					<0.001	<0.001	<0.001		<0.001		
Copper (mg/L)					<0.05					<0.05	<0.05	<0.05		<0.05		
Selenium (mg/L)					<0.005					<0.005	<0.005	<0.005		0.0068		
Silver (mg/L)					<0.01					<0.01	<0.01	<0.01		<0.01		
Thallium (mg/L)					<0.001					<0.001	<0.001	<0.001		<0.001		
Total Trihalomethanes (µg/L)					14					9.6						
Bromodichloromethanes (µg/L)					3.8					3						
Bromoform (µg/L)					2.8					<0.5						
Chloroform (µg/L)					2.2					4.6						
Dibromochloromethane (µg/L)					4.8					1.6						
HAA5 FP (µg/L)					18					19						
Monochloroacetic Acid FP (µg/L)					8.7					13						
Dichloroacetic Acid FP (µg/L)					2.6					3.3						
Trichloroacetic Acid FP (µg/L)					2.7					1.5						
Monobromoacetic Acid FP (µg/L)					2.4					<1.0						
Dibromoacetic Acid FP (µg/L)					1.5					<1.0						
NDMA (µg/L)					<.004											
BOD AC(forward flush intitial, mg/l)																
BOD AC(forward flush middle, mg/l)																
BOD AC(forward flush end, mg/l)																
BOD MMF(back flush intitial, mg/l)																
BOD MMF(back flush middle, mg/l)																
BOD MMF(back flush end, mg/l)																
COD AC(forward flush intitial, mg/l)																
COD AC(forward flush middle, mg/l)																
COD AC(forward flush end, mg/l)																
COD MMF(back flush intitial, mg/l)																

	1000 ppb	2000 ppb	2000 ppb w/recy.	1500 ppb	1000 ppb	Sample taken at 600 ppb	1000 ppb	2000 ppb	2000 ppb	1000 ppb	2000 ppb	2500 ppb	3200 ppb			
Date	12/27/2007	1/2/2008	1/3/2008	1/9/2008	1/10/2008	1/17/2008	1/23/2008	1/24/2008	1/29/2008	2/5/2008	2/7/2008	2/13/2008	2/14/2008	2/25/2008	2/26/2008	2/27/2008
Days Elapsed	287	293	294	300	301	308	314	315	320	327	329	335	336	347	348	349
Trimite Effluent Water																
COD MMF(back flush middle, mg/l)																
COD MMF(back flush end, mg/l)																
TSS AC(forward flush intitial, mg/l)																
TSS AC(forward flush near end, mg/l)																
TSS AC(rinse to waste begin, mg/l)																
TSS AC(rinse to waste middle, mg/l)																
TSS AC(rinse to waste end, mg/l)																
TSS MMF(back flush intitial, mg/l)																
TSS MMF(back flush middle, mg/l)																
TSS MMF(back flush end, mg/l)																
UV																
VOCs (µg/L)																

Date	Steady-State	Steady-State	Restart After Feed Shutdown	Steady-State	Steady-State	Restart After Plant Shutdown	Steady-State, UV =15 gpm	Steady-State, UV =25 gpm	Steady-State, UV =20 gpm	Steady-State	Steady-State UV at 25 gpm Post Trimite before/after Backwash	Steady-State UV at 25 gpm Post LGAC	Steady-State	Steady-State UV at 15/20/25 gpm Post LGAC	Steady-State UV at 15/20/25 gpm Post Trimite before/after Backwash	Steady-State	Steady-State	Steady-State	Steady-State	Steady-State	Steady-State	Steady-State, 100 ppb	Steady-State, 500 ppb	Steady-State, 1000 ppb	Steady-State, 1000 ppb	Steady-State, 1000 ppb	Steady-State, 2000 ppb	Steady-State, 1000 ppb	Steady-State, 2000 ppb	Steady-State, 2500 ppb
	4/18/2007	5/17/2007	5/23/2007	5/31/2007	6/5/2007	6/12/2007	6/19/2007	6/27/2007	6/28/2007	7/19/2007	7/24/2007	7/25/2007	7/30/2007	8/9/2007	8/14/2007	8/22/2007	9/6/2007	9/27/2007	10/11/2007	10/31/2007	11/20/2007	11/29/2007	12/13/2007	12/20/2007	12/27/2007	1/10/2008	1/24/2008	2/5/2008	2/7/2008	2/13/2008
Days Elapsed	**34**	**63**	**69**	**77**	**82**	**89**	**96**	**104**	**105**	**126**	**131**	**132**	**137**	**147**	**152**	**160**	**175**	**196**	**210**	**230**	**250**	**259**	**273**	**280**	**287**	**301**	**315**	**327**	**329**	**335**
Feed Water																														
Total Trihalomethanes (µg/L)	**5.20**						**3.5**																							
Bromodichloromethanes	1.30						1.1																							
Bromoform	ND (<0.5)						ND (<0.5)																							
Chloroform	2.30						1.1																							
Dibromochloromethane	1.20						1.3																							
HAA5 (µg/L)	**21.00**						**ND (<5.0)**																							
Monochloroacetic acid	18.00						ND(<2.0)																							
Dichloroacetic acid	ND (<1.0)						ND (<1.0)																							
Trichloroacetic acid	ND (<1.0)						ND (<1.0)																							
Monobromoacetic acid	ND (<1.0)						ND (<1.0)																							
Dibromoacetic acid	ND (<1.0)						ND (<1.0)																							
Total Coliform (MPN/100 ml)	1.00	<1	<1	<1	<1	1	2	<1	<1	<1	1700		16	2		3.1	1	3.1	<1.0	<1.0	<1.0	<1.0	1.0	6.3	<1.0	4.1	<1.0	1	<1.0	2.0
E. Coli (MPN/100 ml)	<1.00	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1		<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heterotrophic Plate Counts (cfu/ml)	190.00	34		110	>5700	1300	65	1100	150	670	1100		43	47		71	37	43	92	90	120	NA	150	200	240	310	92	160	430	34
Heterotrophic Plate Counts (cfu/ml)-Dilution		25	12000																											
FBR Effluent Water																														
Total Trihalomethanes (µg/L)	**83.00**						**54**																							
Bromodichloromethanes	27.00						18																							
Bromoform	1.90						3.2																							
Chloroform	42.00						19																							
Dibromochloromethane	13.00						**14**																							
HAA5 (µg/L)	**55.00**						32																							
Monochloroacetic acid	4.30						ND(<2.0)																							
Dichloroacetic acid	22.00						11																							
Trichloroacetic acid	23.00						14																							
Monobromoacetic acid	3.30						1.7																							
Dibromoacetic acid	3.30						4.3																							
Total Coliform (MPN/100 ml)	1.00	76	12	210	18	290	5.2	17	28	650	130		180	49		4.1	52	100	3.1	83	2	57	32	230	27	<100	62	19	32	25
E. Coli (MPN/100 ml)	<1.00	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1		<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<100	<1.0	<1.0	<1.0	<1.0
Heterotrophic Plate Counts (cfu/ml)	>5700	>5700																												
Heterotrophic Plate Counts (cfu/ml)-Dilution		400000	>570000	>570000	>570000	33000	2000000	1300000	1600000	1700000	240000		3200000	1000000		700000	>570,000	1400000	460000	>570000	80000	160000	1500000	1700000	320000	600000	940000	1500000	990000	710000
Trimite Effluent Water																														
Total Trihalomethanes (µg/L)	**13.00**		**9.9**	**6.2**		**8.5**	**5.7**																			**14**		**9.6**		
Bromodichloromethanes	4.20		3.2	2.2		2.7	1.8																			3.8		3		
Bromoform	0.93		1.4	0.64		ND (<0.5)	ND (<0.5)																			2.8		<0.5		
Chloroform	5.00		2.4	1.7		2.4	1.9																			2.2		4.6		
Dibromochloromethane	3.30		2.9	1.6		2.9	1.9																			4.8		1.6		
HAA5 (µg/L)	**22.00**		**18**	**7.5**		**10**	**ND (<5.0)**																			**18**		**19**		
Monochloroacetic acid	14.00		12	ND (<2.0)		2.9	ND(<2.0)																			8.7		13		
Dichloroacetic acid	3.50		1.9	3.0		3.1	1.90																			2.6		3.3		
Trichloroacetic acid	2.00		1.5	1.7		2.2	ND (<1.0)																			2.7		1.5		
Monobromoacetic acid	1.30		1.4	ND (<1.0)		ND (<1.0)	ND (<1.0)																			2.4		<1.0		
Dibromoacetic acid	ND (<1.0)		ND (<1.0)	1.1		1.4	ND (<1.0)																			1.5		<1.0		
Total Coliform (MPN/100 ml)	22.00	29	12	6.3	<1	130	2	43	14	17	12		310	<1	<1.0/<1.0/3.1/3.1	<1	5.2	<1.0	<1.0	5.1	28	390	390	180	690	<100	>2400	170	170	110
E. Coli (MPN/100 ml)	<1.00	<1.00	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1.0/<1.0/<1.0/<1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<100	<1.0	<1.0	<1.0	<1.0
Heterotrophic Plate Counts (cfu/ml)	>5700	>5700																												
Heterotrophic Plate Counts (cfu/ml)-Dilution		150000	8300	13000	10000	85000	330	11000	1400	>570000	26000		3200	6000	6700/4300/34000/23000	18000	41000	3200	1000	38000	200	300	3900	5000	5400	4100	100000	5000	3200	660
UV																														
Total Trihalomethanes (µg/L)							**6.1**	**7.4**	**5.8**																					
Bromodichloromethanes							1.9	2.5	1.9																					
Bromoform							ND (<0.5)	0.85	0.73																					
Chloroform							2.2	2.1	1.6																					
Dibromochloromethane							1.9	2	1.5																					
HAA5 (µg/L)							**ND (<5.0)**	**7.4**	**12**																					
Monochloroacetic acid							ND(<2.0)	11	6.5																					
Dichloroacetic acid							1.80	5.1	2																					
Trichloroacetic acid							ND (<1.0)	2.4	1.6																					
Monobromoacetic acid							ND (<1.0)	1.8	ND (<1.0)																					
Dibromoacetic acid							ND (<1.0)	1	ND (<1.0)																					
Total Coliform (MPN/100 ml)							<1	<1	<1		<1/<1	<1		4.0/<1.0/<1.0	<1.0/<1.0/<1.0/<1.0/<1.0/<1.0															
E. Coli (MPN/100 ml)							<1	<1	<1		<1/<1	<1		<1.0/<1.0/<1.0	<1.0/<1.0/<1.0/<1.0/<1.0/<1.0															
Heterotrophic Plate Counts (cfu/ml)							3	32	11		400/99	550		20/20/15	9.0/4.0/1.0/2.0/2.0/11.0															
Heterotrophic Plate Counts (cfu/ml)-Dilution																														
LGAC Effluent Water																														
Total Trihalomethanes (µg/L)	**9.20**		**7.3**				**5.6**																							
Bromodichloromethanes	2.70		2.4				1.7																							
Bromoform	0.62		0.97				ND (<0.5)																							
Chloroform	4.00		1.8				2																							
Dibromochloromethane	2.20		2.2				1.8																							
HAA5 (µg/L)	**28.00**		**16**				**ND (<5.0)**																							
Monochloroacetic acid	21.00		11				2.1																							
Dichloroacetic acid	2.40		1.4				1.60																							
Trichloroacetic acid	1.50		1.3				ND (<1.0)																							
Monobromoacetic acid	1.60		1.4				ND (<1.0)																							
Dibromoacetic acid	ND (<1.0)		ND (<1.0)				ND (<1.0)																							
Total Coliform (MPN/100 ml)	4.10	24	3	3.1	<1	200	1	14	7.4	23	30	1		1.0/<1.0/<1.0		<1.0	1													
E. Coli (MPN/100 ml)	<1.00	<1.00	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1.0/<1.0/<1.0		<1.0	<1.0													
Heterotrophic Plate Counts (cfu/ml)	>5700	>5700																												
Heterotrophic Plate Counts (cfu/ml)-Dilution		29000	3700	2700	8300	93000	1000	7100	1400	400000	22000	2500		3800/2900/3400		4500	15000													

Title 22 limits:
TTHM = 80 µg/L
HAA5 = 60 µg/L
Total Coliform= <1 MPN/100 ml
E. Coli = <1 MPN/100 ml
Heterotrophic Plate Counts = < 500 cfu/ml

QA/QC Notes:
11/29/07 sample for feed HPC NA due to lab error
1/10/2008 Total Coliform/E. Coli improperly diluted. Procedure does not call for such a dilution.

	Restart After Feed Shutdown	**Steady-State**	**Restart After Plant Shutdown**
Date	**5/23/2007**	**5/31/2007**	**6/12/2007**
Days Elapsed	**69**	**77**	**89**
Trimite Effluent Water	**HPC (CFUs/ml)**	**HPC (CFUs/ml)**	**HPC (CFUs/ml)**
0.25 mg/l- 0 minutes-Control			
0.25 mg/l- 4 minutes		85	
0.25 mg/l- 10 minutes		86	
0.25 mg/l- 30 minutes			
0.25 mg/l- 100 minutes			
0.5 mg/l- 0 minutes-Control		9200	81000
0.5 mg/l- 4 minutes		69	34
0.5 mg/l- 10 minutes		110	24
0.5 mg/l- 30 minutes		18	10
0.5 mg/l- 100 minutes		13	14
0.5 mg/l- 100 minutes-Control		10000	28000
1.0 mg/l- 4 minutes			8
1.0 mg/l- 10 minutes			16
1.0 mg/l- 30 minutes			23
1.0 mg/l- 100 minutes			
1.0 mg/l- 100 minutes-Control			37000
2.0 mg/l- 4 minutes			25
2.0 mg/l- 10 minutes			24
2.0 mg/l- 30 minutes			18
2.0 mg/l- 100 minutes-Control			37000
0.5 mg/l- 10 minutes (Total Coliform)			<1.0
0.5 mg/l- 10 minutes (E. Coli)			<1.0
1.0 mg/l- 10 minutes (Total Coliform)			<1.0
1.0 mg/l- 10 minutes (E.Coli)			<1.0
LGAC Effluent Water	**HPC (CFUs/ml)**		
0.5 mg/l- 0 minutes-Control	18000		
0.5 mg/l- 4 minutes	3		
0.5 mg/l- 10 minutes	3		
0.5 mg/l- 30 minutes	3		
0.5 mg/l- 100 minutes	2		
0.5 mg/l- 100 minutes-Control	15000		
1.0 mg/l- 4 minutes	2		
1.0 mg/l- 10 minutes	4		
1.0 mg/l- 30 minutes	2		
1.0 mg/l- 100 minutes	2		
1.0 mg/l- 100 minutes-Control	16000		
2.0 mg/l- 4 minutes	1		
2.0 mg/l- 10 minutes	1		
2.0 mg/l- 30 minutes	2		
2.0 mg/l- 30 minutes-Control	7400		

Notes:
(1) 5/23/07 chlorination study conducted after a system feed shutdown for five days.
(2) 5/31/07 chlorination study conducted for steady-state operation

Appendix H: Daily System Modifications Report

Date	Time	Change to System/Maintenance	Outcome/Result
4/18/2007		Cleaned FBR Effluent filter element	
4/19/2007	A.M.	Run eductor for 1.5 hours at 11.5 psi	Bed level decreased from 142" to 124"
		Increased Emax to 25%	
	P.M.	Increased Emax to 30%	
		Increased Emax to 35%	
		Replaced FBR Effluent filter element (swiched with Filter Effluent filter)	
		Decreased Emax to 20%	
4/20/2007	A.M.	Forward flush and backwash trimite filter	
		Run trimite filter	
		Run eductor at 11.5 psi	increasing turbidity
	P.M.	Opened waste trough (bypass trimite mixed media filter)	
		Stopped eductor after 3 hours of run time	Bed level decreased from 152" to 135" bed stablized
		System in recycle mode	
4/26/2007	A.M.	Restarted system to forward feed	Bed level at 125"
		Initiate manual trimite flush and backwash	
	P.M.	Run eductor at 10.5 psi	Bypass mixed media filter
		Stopped eductor after 1.5 hours of run time	started mixed media filter
		Bed level stabilized at 135"	Run eductor continuously starting18:00
4/27/2007	A.M.	Stopped eductor at 09:00	Bed level at 126"
		Backwash mixed media filter	
		Started mixed media filter	
		Cleaned Feed and FBR effluent filter elements	
		Changed trimite backwash frequency to 720 minutes	
		Changed trimite forward flush frequency to 180 minutes	
4/30/2007	A.M.	Manually initate trimite forward flush and backwash twice each	
		Cleaned FBR Effluent filter element	
	P.M.	Lanced reactor	
		System shutdown in recycle mode due to repetitive backwash cycle at trimite filter	
5/1/2007	A.M.	Cleaned Feed and FBR Effluent filter element	
	P.M.	Turned off eductor at 12:00	
		Lanced reactor	
		Changed Emax to 26%	
		Started eductor at 14:00	
5/2/2007	A.M.	System in recycle mode	
		Lanced reactor	
		Turned off eductor	
		Diverted water stream to trimite waste trough	
		Set turbidity setpoint to 0.80 NTU	
	P.M.	Cleaned Feed and FBR Effluent filter element	
		Cleaned nitrate analyzers	
		Manually initiate trimite forward flush and backwash	
		Changed Emax to 28%	
		Started eductor at 14:45	
		Restarted mixed media filter	
5/3/2007	A.M.	System in recycle mode due to repetitive backwash of trimite	
		Cleaned nitrate analyzers	
		Checked E.D. pump span flow	span flow =0.60 gph (last measurement was 0.65 gph)
		Restarted system bypass trimite mixed media filter (eductor remained off after system shutdown to recycle mode)	
		Manually initiate trimite forward flush and backwash	
		Restarted mixed media filter	
	P.M.	Backwash trimite filter 4 times	
		Increased Emax to 32% at 13:30	
5/4/2007	A.M.	Lanced reactor	
		Cleaned nitrate analzyers' sampling lines	
		Set trimite forward flush cycle time to 1440 minutes	
		Backwash trimite filter	
	P.M.	Started eductor at 14:30	
		Bypass mixed media filter at 15:30	
5/7/2007	A.M.	System in recycle mode due to low E.D. flow (triggered by sensor)	
		Restarted system	
	P.M.	System in recycle mode due to low E.D. flow (triggered by sensor)	Disabled E.D. flow sensor
		Continue to bypass mixed media filter	
5/8/2007	A.M.	System in continuous feed mode	
		Eductor running at 10 psi	
		Started feeding alum at ~10 ml/min	Low turbidity at effluent but high headloss at MMF
		Bed level decreased to 93" at 12:00	Adjusted eductor pressure to 7 psi
	P.M.	Shutoff eductor at 16:30	
		Shutoff polymer and alum feed to trimite	
		Cleaned Feed and FBR effluent Collins Filter	
		Bypass mixed media filter at ~17:00	
5/9/2007	A.M.	Bed level at 96"	Lanced reactor
		Backwashed MMF 4 times	
		Cleaned FBR Effluent filter element	
	P.M.	Prepared Dionex standard for onsite and off site analysis	
		Eductor not running	
		Run water through MMF	
5/10/2007	A.M.	Bed level at 105" with eductor off	
		Restarted eductor at 09:30 at 7 psi of pressure	Biosolids removed
		Feed polymer and alum to trimite	
	P.M.	Tested different alum and polymer feed rate	
		Final alum feed rate at 1ml/min and polymer feed rate at 5 ml/min	
		Changed flush cycle to 480 minutes	
		Changed Backwash cycle to 2880 minutes	
5/11/2007	A.M.	Eductor running at 7 psi	
		Bed level = 108"	
	P.M.	Tested different alum and polymer feed rate	
		Final alum feed rate at 1ml/min and polymer feed rate at 5 ml/min	
5/14/2007	A.M.	Bed level = 134"	
		eductor off	
		Trimite blower motor failed	
	P.M.	Started eductor at 10 psi	
		bypass trimite filter (AC and MMF)	
5/15/2007	A.M.	Bed level = 120"	
		Adjusted eductor pressure to 8 psi	
	P.M.	Check trimite PSH	
		Replaced trimite panel fuse	
		Adjusted eductor pressure to 7.5 psi	
5/16/2007	A.M.	Refilled Dionex DI water	
		Cleaned FBR Effluent filter element	
		Removed trimite blower assembly	
	P.M.	Replaced trimite blower	
		Cleared AC by forcing blower and automated valve to turn on	
		Check trimite PSH	
		Backwash MMF	
		Adjusted eductor pressure to 7.0 psi (Bed level = 114")	
		Alum feed rate at 0.5 ml/min and polymer feed at 4.0 ml/min	
		Changed flush cycle to 360 minutes	

Date	Time	Change to System/Maintenance	Outcome/Result
		Changed backwash cycle to 1440 minutes	
5/17/2007	A.M.	Bed level = 113"	
		Eductor running at 7.5 psi	
		Adjusted polymer feed to 3.0 ml/min	
	P.M.	Adjusted polymer feed to 4.0 ml/min	
		Adjusted flush cycle to 300 minutes	
5/18/2007	A.M.	Stopped alum feed for 1.5 hours	breakthrough of floc; increase of MMF headloss
		Shutoff eductor (Bed level = 99")	Increase of nitrate-N at FBR effluent stream
		Shutoff FBR to recycle mode at 11:30	
	P.M.	Changed Collins Filter element for FBR effluent	
		Changed trimite PSHH	
		Restarted FBR at 14:00	
		Adjusted Knut to 0.53 from home at ~19:00	
5/19/2007	A.M.	Feed shutdown by T.W. at 8:00	
5/21/2007	A.M.	System in Shutdown Mode at ~09:00	
	P.M.	System restarted to FBR Recycle Mode at ~15:00	
5/23/2007	A.M.	Restarted system to Feed Mode at 06:40	
		Eductor remained off	
		Forward flush AC twice and backwash MMF once	
		Temporarily increase alum feed to 4 ml/min	
	P.M.	Adjusted alum feed back to 2 ml/min	
5/24/2007	A.M.	Trimite turbidity increase to ~0.2 NTU due to low polymer tank level	Polymer feed pump lost primed
	P.M.	Prepared polymer solution (0.8%)	Decrease of turbidity at trimite MMF effluent
		Took samples for Shaw NJ lab	
5/25/2007	A.M.	Turned on eductor at ~11:00 at 6.5 psi	increase of nitrate-n concentration at FBR effluent
		temporarily increase alum feed to 3 ml/min for 30 minutes	No noticeable difference
	P.M.	Adjusted eductor pressure to 5 psi at ~12:30	
		Adjusted eductor pressure to 6.0 psi at 13:30	
5/28/2007	A.M.	Dionex sampling line disconnected (blown by water pressure)	Restarted RSView and Chromeleon
		Decreased eductor pressure to 5 psi at 10:00	
	P.M.	Adjusted LCV210 setting (100% opened at 90" aeration tank height)	
		Adjusted polymer feed to 4 ml/min	
5/31/2007	A.M.	Adjusted polymer feed to 5 ml/min	
6/1/2007	A.M.	Set Flush preset to 100% (PID setting)	
		Changed EMAX to 20% at 9:30 (0.230 gph req'd at 50 gpm)	
6/4/2007	A.M.	Polymer pump lost primed	Refill polymer solution
		Dionex eluent pump lost primed	reprimed pump; no samples since 6/2/2007 13:07
	P.M.	Checked span flow for E.D. pump	
		Adjusted eductor pressure to 5.5 psi	
6/5/2007	A.M.	Adjusted Emax to 20% from 15% (Emax adjusted at night through pcAnywhere)	
	P.M.	Adjusted eductor pressure to 6 psi	
6/6/2007	A.M.	Adjusted eductor pressure to 5.5 psi	
	P.M.	Adjusted eductor pressure to 6 psi	
6/7/2007	A.M.	Shutdown FBR to shutdown mode at 11:00 am	
		Close suction valve	
		Close post aeration tank feed valve	
		Close System recycle line	
		Turnt off eductor	
	P.M.	Installed UV system piping	
6/11/2007		Cleared Trimite feed pipe	
		Installed electrical for UV system	
6/12/2007	A.M.	Started FBR to FBR recycle mode at 6:45 am	
		Started forward feed at 7:00 am	
		Started Chlorination study at 10:45 am	
6/13/2007	A.M.	Started eductor at 9 psi at 10:00 am	
	P.M.	Changed span flow for E.D. pump to 0.71 gph	
		Changed Emax to 25%	
		Temporarily adjusted alum flow to 0.5 ml/min	
		Alum pump lost primed	Reprimed alum pump
		Adjusted eductor pressure to 7 psi at 15:00	
6/14/2007	A.M.	Adjusted eductor pressure to 9 psi	Bed level decreased from 147" to 128"
		Shutoff E.D. feed at 9:00	
		Restarted E.D. feed at 10:30	
		Shutoff E.D. feed at 11:00	
	P.M.	Invalid Dionex sample at ~12:30 due to blown sampling line	
		Restarted E.D. feed at 13:00	
		Adjusted eductor pressure to 8 psi	
6/18/2007	A.M.	Eductor pressure at 8.5 psi	Bed level too low at 99"
		Shutoff eductor at 09:30	
		Dionex sampling line disconnected (blown by water pressure) since 6/16/07 9:00 am	
	P.M.	Restarted eductor at 5.5 psi at 16:00	
6/19/2007	A.M.	Shutoff eductor	
		Run UV	
6/20/2007	A.M.	Change EMAX to give E.D. pump 36 spm	
	P.M.	Started eductor at 7.5 psi at 13:00	
6/21/2007	P.M.	System in recycle mode from 14:00 to 15:30	
		Siemens positioner LCV-210 malfunctioned	
		Run system with Trimite filter bypassed	
		Adusted eductor pressure to 5.5 psi	
6/25/2007	A.M.	Bed level at 168"	Increase eductor pressure to 10 psi
		Reinitialize Siemens positioner	
		Change PID setting: max open from 100% to 90%	
		Dionex in alarm state since 06/21/07 at ~17:00	
	P.M.	Adusted eductor pressure to 9.5 psi	
6/26/2007	A.M.	Dionex leakage, last valid sample on 06/25/07 14:38	
		Next valid sample on 06/26/07 10:58	
6/27/2007	A.M.	System in FBR recycle mode due to low aeration pressure	
		Restarted system	
		Change PID setting: max open 90% at 110"; flust preset to 85%	
		Run UV	
		Restarted eductor at 10 psi	
6/28/2007	A.M.	Adjusted eductor pressure to 7 psi	
		Run UV from 09:00 to 09:40 at 20 gpm	
	P.M.	Changed Emax to 21%	
		Changed Dionex sampling freqency to 210 (+17min)	
7/2/2007	A.M.	LCV-210 malfunctioned	Bypass trimite/LGAC
		Increased eductor pressure to 9.5 psi	
7/3/2007	A.M.	System shutdown for ~ 5 to 10 minutes (electrical for UCR)	
		Increase flow to 61 to 62 gpm at 9:45 am	
		Dionex offline from ~8:00 am to 11:00 am due to electrical shutdown	
7/4/2007		no significant changes	
7/5/2007	A.M.	Replaced Dionex main and guard colum at 11:00 am	
		Dionex manual feed update at ~12:00	
7/6/2007		no significant changes	
7/9/2007	A.M.	Changed EMAX from 18% to 15% to 1%	
	P.M.	Shutoff E.D. feed at 12:30 pm	
		Restarted E.D. feed to 5% at 15:15	
		Changed Emax to 2% at 15:45	
7/10/2007	A.M.	Changed Emax to 7% at 09:30 am	

Date	Time	Change to System/Maintenance	Outcome/Result
	P.M.	Changed Emax to 9% at 15:00	
		Installed biomass separator	
		Started separator at 14:30	
		Turned off separator at 15:45	
7/11/2007	A.M.	Turned on biomass separator	
		Changed Emax to 12%	
7/12/2007	A.M.	Increased Emax to 15%	
	P.M.	Started trimite filter	
7/16/2007	A.M.	System in recycle mode due to low aeration pressure (LCV-210 not closed)	
		Recalibrated/readjusted LCV-210	
		Dionex offline with Mike Doyle troubleshooting instrument	
	P.M.	Restarted feed at 15:00	
		Dionex back online at 17:00	
7/17/2007	A.M.	System in recycle mode due to low aeration pressure (LCV-210 not leaking but aeration vessel drained)	
		Readjusted LCV-210	
		Changed PID setup max open 90% from 110" to 120"	
		Changed Flush preset from 75% to 65%	
	P.M.	Dionex troubleshooting completed at 15:00	
		Changed Emax to 28%	
7/18/2007	A.M.	Changed Emax to 21%	
7/19/2007	A.M.	Turned on eductor at 6.5 psi	
	P.M.	Turned off phosphric acid at 12:00 pm / Knut = 0	
7/20/2007	A.M.	Adjusted eductor pressure to 7 psi	
		Nitrate analyzers in hold mode since 07/19/07 P.M.	
		Reset analyzers to normal mode, FBR eff nitrate-n = 0.4 ppm	
		Turned on phosphric acid at 9:00 am (Knut = 0.65)	
		Adjusted Knut = 0.60 at 09:30 am	
7/22/2007	A.M.	System in FBR recycle mode due to high turbidity at trimite	
		Restarted unit	
		System in feed mode for 1/2 hour with high turbidity	
		Diluted polymer solution expired/refilled polymer solution	
		Adjusted eductor pressure to 7.5 psi	
7/23/2007	A.M.	Adjusted eductor pressure to 10 psi	
	P.M.	Started biomass separator at 25 scfh	
		Adjusted eductor pressure to 8.5 psi	
		Initiate manual trimite backwash at 14:30	
7/24/2007		no significant changes	
7/25/2007	A.M.	Dionex offline (cartridge replacement)	
7/26/2007	A.M.	Dionex back online at 11:00 am	
7/27/2007	A.M.	System in Shutdown Mode at 12:00 am (test)	
		Restarted to feed mode at 8:30 am	
		Turned off eductor and biomass separator	
		Increased Alum and Polymer dosage by 100% temporarily	
		Bypass trimite A.C.	
		Restarted eductor (7.5 psi) and biomass separator (25 scfh) at 9:45 am	
		Readjusted Alum (1ml/min) and Polymer (5ml/min) dosage	
7/30/2007	A.M.	no significant changes	
7/31/2007	A.M.	Feed AGEFLOC polymer to trimite filter	
		Restarted RSView	
		Changed Emax to 5% at 09:30 am	
8/1/2007	A.M.	E% was adjusting to 4.3% automatically	
		Adjusted E% back to Emax	
8/2/2007	A.M.	Trimite forward flush 8 times since 08/01/07; short filter runs	
		Replaced polymer (from Roemer Plant)	
		Emax adjusted to 20.4% automatically	
8/3/2007	A.M.	no significant changes	
8/6/2007	A.M.	Feed polymer blend (SW8807) to trimite filter	
		Invalid Dionex samples (due to high TOC?)	
8/7/2007	A.M.	System in FBR recycle mode (high turbidity caused by polymer pump losing prime); restarted to feed mode	
		Turned off eductor and biomass separator	
		Took manual Dionex samples from Trimite Effluent, Trimite AC and Post Aeration: All ND	
	P.M.	Switched Polymer and Alum feed to trimite from polymer blend (SW8807)	
		Restarted eductor (8 psi) and biomass separator (25 scfh) at 13:45	
8/8/2007	A.M.	System in FBR recycle mode since 06:45 am	
		Restarted feed at 8:00 am	
8/9/2007	A.M.	Run UV test	
8/10/2007	A.M.	no significant changes	
8/11/2007	P.M.	Emax adjusted to 24% by TW	
8/13/2007	P.M.	Emax adjusted to 28% (38 spm)	
8/14/2007	P.M.	Replaced Acetic Acid feed (new drum/same lot)	
8/15/2007	A.M.	Turned off eductor and biomass separator	
		Replaced Acetic Acid feed (leftover from previous drum)	
	P.M.	System shutdown to FBR recycle mode due to faulty reading of FBR effluent perchlorate reading of 103 ppb (interupted run/analysis by operator)	
		Restarted eductor at 7 psi and biomass separator at 25 scfh	
8/20/2007	A.M.	Bed level decreased to 90"	
		Turned off biomass separator and eductor	
8/21/2007	P.M.	Adjusted alum feed to 0.5 ml/min	
8/22/2007	A.M.	Changed Emax to 22% from 21%; changed Emin to 21% from 1%	
8/23/2007	A.M.	FBR in recycle mode since 06:40	
		Restarted system in feed mode	
		Adjusted alum and polymer feed to 2 ml/min and 10 ml/min, respectively	
		Change feed flow to 30 gpm at 10:00	
		Adjusted PID setup; max open % at 120" from 90% to 65%; flush preset from 65% to 40%	
		Adjust alum and plymer feed to 0.5 ml/min and 6 ml/min, respectively	
	P.M.	Adjusted feed flow to 50 gpm	
8/24/2007	A.M.	Started eductor at 6.5 psi and biomass separator at 10 scfh	
8/27/2007	A.M.	Turned off biomass separator and eductor	
8/28/2007	A.M.	FBR effluent nitrate analyzer not functioning	
		Adjusted polumer feed to 4 ml/min	
8/29/2007	A.M.	Feed nitrate analyzer not functioning	
		Inaccurate Dionex reading of FBR effluent sample at 0 ppb (bypass valve closed); subsequent correct reading at 4.3 ppb	
8/30/2007	A.M.	Faulty dionex readings of perchlorate at 300s and 0 ppb due to operator interruptions	
8/31/2007	A.M.	Turned on eductor at 11:30 at 6.5 psi	
		Ajdusted feed of alum to 1 ml/min and polymer to 6 ml/min	
9/4/2007	A.M.	Turned off eductor	
		Inaccurate Dionex feed readings from 09/2/07 2:53 to 09/04/07 13:30	
		Inaccurate Dionex FBR effuent readings on 09/04/7 from 10:30 to 11:40	
		Inaccurate Dionex Filter effluent readings on 09/04/07 from 16:10 to 16:50	
9/5/2007		no significant changes	
9/6/2007	A.M.	Run manual standards to Dionex: 25 ppb vs. 24.4 ppb	
	P.M.	Inaccurate Dionex readings if FBR and Filter effluent perchlorate = 0 ppbs (multiple peaks in chromatograms)	
		Feed Nitrate analyzer repaired by HACH representative; switched to read FBR effluent stream temporarily	
9/7/2007	A.M.	Calibrated nitrate analyzer	
9/10/2007	A.M.	Turned on biomass separator at 15 scfh at 10:00	
	P.M.	Increased biomass separator flow to 20 scfh at 14:00	

Date	Time	Change to System/Maintenance	Outcome/Result
9/11/2007	A.M.	Turned off biomass separator at 9:30	
		Turned on eductor at 5.5 psi at 9:30	
	P.M.	Bed level declined to 150" at 14:30; turned on biomass separator at 25 scfh	
9/12/2007	A.M.	Replaced AE-660 (effluent stream nitrate analyzer)	
		Cleaned AE-650 (feed stream nitrate analyzer) with HCl	
9/13/2007	A.M.	Turned off biomass separator and eductor	
	P.M.	Repaired Dionex leakage	
9/14/2007	A.M.	Turned on biomass separator at 25 scfh	
		Cleaned AE-660 (effluent stream nitrate analyzer) with HCl	Nitrate reading decreased from 0.5 to 0.1 ppm
9/17/2007	A.M.	Lanced bed; bed level at 167"	Increased biomass separator flow to 45 scfh
		Cleaned AE-660 (effluent stream nitrate analyzer) with HCl	
		AE-660 (effluent stream nitrate analyzer) wiper not wiping	Inaccurate effluent nitrate readings (if nitrate reading > 0.2 ppm)
		Turned on eductor at 11:30 at 5 psi	
	P.M.	Turned off eductor at 14:00	
		Increased biomass separator flow to 55 scfh	
9/18/2007	A.M.	Dionex eluent pump lost primed since 17:00 on 09/17/07; high pressure alarm	
9/19/2007	A.M.	Turned on eductor for 15 minutes at 5 psi due to high recycle pump discharge pressure	
		Removed GAC; reconnect trimite discharge piping	
9/20/2007	A.M.	Dionex eluent pump high pressure alarm	Shortened back pressure restrictor
		Run 25 ppb standards to Dionex: ~26 ppb	
	P.M.	Replaced FBR Effluent filter element	
		Run manual sample of FBR effluent water to Dionex: ND	
		Run manual sample of Filter effluent water to Dionex: 3.1 ppb	
9/21/2007	A.M.	Run manual sample of FBR effluent water to Dionex: ND at~ 2.2 ppb	
9/24/2007	P.M.	Replaced Dionex guard column	
9/25/2007	A.M.	Received new water tank	
	P.M.	Replaced FBR effluent sampling lines/Dionex internal sampling lines; sampled FBR effluent stream: presence of peak at chromatogram	
9/26/2007	A.M.	Run manual samples to Dionex unit	
	P.M.	ND at water stream prior to sampling pump	
		ND at FBR effluent sampling port	
		ND at Collin's filter inlet	
		ND at Collin's filter discharge (to analytical sump)	
		ND at Collin's filter chamber	
		Presence of peak in chromatogram from Filtered discharge	
		Presence of peak in chromatogram after removed Collin's filter base element and resampled	
9/27/2007	A.M.	Removed Feed and Trimite sampling connection from multiport sampling system; run FBR effluent samples: presence of peak detected.	
	P.M.	Run manual FBR effluent sample: ND	
9/28/2007	A.M.	Bypass multiport sampling system; removed all check standard/standard connections to Dionex	
9/29/2007	A.M.	Restarted RSView and Chromeleon; no samples taken from 09/28/07 11:30 pm to 09/29/07 10:30 am	
10/1/2007	A.M.	Run manual FBR effluent sample: ND	
10/2/2007	A.M.	E.D. pump lost primed	Increase of nitrate reading to 0.3 ppm
	P.M.	Run manual FBR effluent sample: ND	
10/3/2007	A.M.	Run manual FBR effluent sample: ND	
10/4/2007	A.M.	RSView not recording perchlorate data since 10/03/07 09:40am to 10/04/07 09:00 am	
		Run manual FBR effluent sample: ND	
		Run manual Trimite effluent sample: ND	
		Replaced E.D. pump suction line	
10/5/2007	A.M.	Run 25 ppb standards to Dionex: ~24 ppb	
		Fixed leakage at multiport sampling valve	
		Took Dionex Feed and FBR effluent samples on 09:30 am	
10/8/2007	A.M.	Cleared all lines in Dionex multiport sampling valve with compressed air.	
		FBR effluent filter base and element destroyed/replaced	
		Cleared all sampling lines for Dionex unit with compressed air	
		Invalid samples from 10/05/07 12:00 to 10/08/07 11:00 am	
		Turned off biomass separator for 0.5 hour; measured bed level: 147"	
10/9/2007	A.M.	Dionex did not take sample from 10/08/07 13:00 to 10/09/07 08:15 due to incorrect sampling timer setpoint	
		Received materials from harrington's plastics	
		Received Stancor pump	
10/11/2007	A.M.	Run 5 ppb (prepared by SW with 25 ppb standard prepared by Shaw) standard to Dionex unit: 4.8 ppb	
	P.M.	Check bed level with cup-string method; result agreed with sludge gun measurement	
10/12/2007	A.M.	Took split samples for EMAX and Shaw NJ lab	
	P.M.	Replaced Collins Filter supporting pad for FBR effluent filter	
10/13/2007	A.M.	Replaced FBR Effluent Collins Filter element	
10/18/2007	A.M.	HACH representative on site to troubleshoot Nitratax	
		Changed nitrate measurement interval from 1 per minute to 1 per 5 minutes	
	P.M.	Increased EMAX from 24% to 25 % and Emin from 23% to 24% at approximately 13:00	
10/19/2007	A.M.	Measured Acetic Acid feed rate: 14 ml/min	
		Adjusted Emax from 25% to 27% and Emin from 24% to 26% at approximately 11:00 am; acetic acid feed rate measured to be ~16 ml/min	
10/21/2007	A.M.	System in shutdown mode since 1:17 am due to power outage; restarted at 12:06 pm	
10/22/2007	A.M.	Dionex unit offline due to high pressure alarm; no samples were taken since 10/20/07 ~11:45 pm til 10/22/07 11:37 am	
10/23/2007	A.M.	Installed FBR effluent holding tank (Baker Tanks)	
	P.M.	FBR in recycle mode from ~1:30 pm to 6:00 pm due to piping installation	
10/25/2007	A.M.	Electrical Installations for spiking experiment	
		Polymer pump and coagulent pump was off for approximately 0.5 hours, causing turbidity to rise from 9:00 to 10:00	
10/30/2007	A.M.	Completed electrical Installations for spiking experiment	
10/31/2007	A.M.	Presence of perchlorate in FBR effluent samples overnight; checked E.D. pump; E.D. feed was at 14 ml/min (normal feed was at approximately 15 to 16 ml/min)	
		Increased Emax to 30% and Emin to 29%; E.D. pump was at approximately 15 ml/min	
	P.M.	Absolute Automation uploaded new program to PLC; system in shutdown mode for approximately 1 min	
11/1/2007	A.M.	Increased Emax to 39% and Emin to 38%; E.D. pump was at 17 ml/min (higher E.D. usage related to bed level?)	
	P.M.	Tested Holding Tank flow;	
		Run in-bed eductor for approximately 1 hour from 14:30 to 15:30; bed declined approximately 6"	
11/2/2007	A.M.	Checked E.D. flow: 17 ml/min	
11/5/2007	P.M.	Checked level switches; did not work in Run Start Mode	
11/6/2007	A.M.	System in FBR Recycle Mode due to switch delays	
	P.M.	Tested Trimite FF and BW flow to DWT	
		Adjusted Trimite BW flow rate to ensure no backflow of dirty water	
11/7/2007	A.M.	Tested system at 25 gpm feed for approximately 3 hours	
		Feed sample was not valid overnight if = 0 due to sampling pump not able to reach pumping pressure	
	P.M.	LCV-210 settings changed from MAXOPEN 90% to 58% at 120" and Flush Preset from 65% TO 45% when system feed changed from 50 gpm to 25 gpm	
		Invalid FBR effluent sample at 9999 ppb	
11/8/2007	P.M.	System in recycle mode for piping repairs	
11/9/2007	A.M.	Restarted system in Run Mode	
11/12/2007	P.M.	Started running system at 25 gpm at 12:30	
11/13/2007	P.M.	Changed Emax from 39% to 21% and Emin from 38% to 20% due to high TOC level (SPM of E.D. pump not adjusting correctly according to Load)	
11/15/2007	A.M.	Changed Emax from 21% to 39% and Emin from 20% to 38% after verifying system programming has been modified	
11/16/2007	A.M.	Tested LMI pump for spiking experiment	
11/26/2007	A.M.	Dionex did no take samples from 11/21/07 14:09 to 11/26/07 10:31 (system communication issues?)	
		Dissolved 40g of KClO4 in ~10 gallons of water for spiking experiment	
		Started perchlorate pump (30 strength/30speed) at 10:15am	
		Adjusted perchlorate pump (30 strength/22 speed)	

Date	Time	Change to System/Maintenance	Outcome/Result
11/27/2007	A.M.	Took manual samples from Filter Effluent, FBR Effluent, DWT, Trimite BW and FF for onsite perchlorate analysis: ND	
	P.M.	Discover cross-contamination in sampling container, causing a faulty perchlorate concentration in HTA and HTB samples	
		Stopped perchlorate pump until 16:45 and have system runing in "retreating" mode due to contaminated samples of HTA and HTB	
		Rechecked HTA and HTB: ND	
		Restarted perchlorate spiking experiment at 16:45	
11/28/2007	P.M.	Perchlorate pump lost primed temporarily	
12/3/2007	A.M.	Started spiking experiment	
	P.M.	Manual sample collected from HTA at 13:30 indicated ClO4 concentration at 5.2 ppb; drained HTA	
12/4/2007	A.M.	Perchlorate pump lost primed overnight; reprimed	
		manual samples collected from HTA and HTB indicated ND ClO4	
	P.M.	Manual sample collected from HTA at 13:30 indicated ClO4 concentration at 7.2 ppb; drained HTA	
12/5/2007	A.M.	Manual sample collected from HTA at 8:00 inidcated ClO4 concentration at 23 ppb; DID NOT DRAIN HTA	
		Manual sample collected from HTB at 9:00 inidcated ClO4 concentration at 15 ppb; DID NOT DRAIN HTB	
		Stopped perchlorate pump; recycled HTA and HTB water to system for retreatment of residual ClO4	
	P.M.	Sampled HTA and HTB at ~13:00; ND and 17 ppb of ClO4 in HTA and HTB, respectively; Drained HTA and HTB	
		Restarted perchlorate spiking experiment at ~ 300 ppb	
12/6/2007	A.M.	Dionex unit offline due to high pressure alarm	
		Stopped perchlorate pump; operate system in normal run mode with water to drain	
		Replaced I.C. column	
12/7/2007	A.M.	Run calibration for Dionex unit	
		Replaced Feed Collins Filter	
12/10/2007		Recalibrated Dionex; calibration curve still not accurate; used old calibration curve (for old column)	
12/11/2007		Run modified calibration program; calibration curve accurate	
		Started perchlorate spking at 300 ppb	
		Sampled HTA at 13:30: ND	
		E.D pump running at 9 ml/min (24 spm)	
12/12/2007		Dionex lost primed upon arrival; no sample from 12/11/07 ~11:00 am to 12/12/07 11:00 am	
		Run perchlorate spiking to 450 ppb	
		Increased EMAX from 69% and Emin to 68%	
		E.D. pump at 10 ml/min (25 spm)	
12/13/2007		Manual sample of HTA and HTB inidcated ClO4 concentration at ND and 14 ppb, respectively; drained HTA and HTB	
		Manual sample of HTA at 14:00 inidcated ClO4 concentration at 9 ppb; drained HTA	
12/14/2007	A.M.	System in FBR Recycle Mode	
		Blower Overload Alarm due to broken vanes	
		Manual samples of HTA and HTB indicated ClO4 concentration at ND and 9 ppb, respectively; drained HTA and HTB	
12/17/2007	A.M.	Repaired Aeration Blower B-200	
		Restarted system at 11:30 am	
	P.M.	Started spiking experiment at 15:00 at 1000 ppb	
12/18/2007	A.M.	Manual samples of HTA indicated ClO4 concentration at 20 ppb; drained HTA	
		Manual samples of HTB indicated ClO4 concentration at ~200 ppb; recycle water to system; stopped perchlorate pump	
	P.M.	Due to possible cross contamination of glass containers, retake HTB manual samples: 26.6ppb; drained HTB	
		Restarted spiking experiment	
12/19/2007	A.M.	Manual samples of HTA and HTB indicated ClO4 concentration at 18 and 19 ppb, respectively; drained HTA and HTB	
	P.M.	Manual sample of HTA at 13:30 inidcated ClO4 concentration at 20 ppb; drained HTA	
		Tested syringe filter (nylon 0.45 micron) for ClO4 capacity	
12/20/2007	A.M.	Inaccurate Dionex data from ~12/19/07 22:00 to ~12/20/07 11:30 resulting from delayed retention time.	
		Manual samples of HTA and HTB indicated ClO4 concentration at 25 and 15 ppb, respectively; drained HTA and HTB	
	P.M.	Manual sample of HTA at 13:30 inidcated ClO4 concentration at 19 ppb; drained HTA	
12/21/2007	A.M.	Perchlorate pump lost primed upon arrival	
		Manual samples of HTA and HTB indicated ClO4 concentration at 12 and 14 ppb, respectively; drained HTA and HTB	
12/24/2007	A.M.	Started spiking experiment at ~1500 ppb	
	P.M.	Operate system back in normal feed mode	
12/26/2007	A.M.	System in FBR Recycle Mode upon arrival; restarted system	
	P.M.	Started spiking experiment at ~1500 ppb	
12/27/2007	A.M.	Manual samples of HTA and HTB indicated ClO4 concentration at 29.5 and 21.9 ppb, respectively; drained HTA and HTB	
	P.M.	Turned off biomass separator from 12:00 to 15:00	
		Decrease System recycle flow rate	
		Manual sample of HTA at 13:30 inidcated ClO4 concentration at 22.6 ppb; drained HTA	
12/28/2007	A.M.	Biomass separator shot GAC out from reactor; loss of carbon ~ 5 gallons	
		Repaired biomass separator	
		Manual samples of HTA and HTB indicated ClO4 concentration at 25.7 and 20.7 ppb, respectively; drained HTA and HTB	
12/31/2007	A.M.	Started spking experiment at ~ 4000 ppb	
	P.M.	Did not drain HTA due to high FBR effluent perchlorate concentration	
		Operate system back in normal feed mode	
1/2/2008	A.M.	Started spiking experiment at ~2000 ppb	
		Manual sample of HTA at 13:00 inidcated ClO4 concentration at 59 ppb; recycle HTA water until 17:30	
	P.M.	Manual sample of HTA at 17A:30 inidcated ClO4 concentration at 21ppb; Drain HTA; restarted spiking experiment	
1/3/2008	A.M.	Manual sample of HTA at 08:00 inidcated ClO4 concentration at 51.6 ppb; recycled HTA and HTB water until 16:00	
1/4/2008	A.M.	Manuals samples of HTA and HTB indicated ClO4 concentration at 53 ppb and 25 ppb, respectively; isolated HTB and recycle HTA water back to system for further treatment.	
	P.M.	Manual sample of HTA at 13:00 inidcated ClO4 concentration at 27 ppb	
		Drained HTB	
1/7/2008	A.M.	Signs of unauthorized entry into site	
	P.M.	Restarted spiking to 1500 ppb at 13:45	
1/8/2008	A.M.	Manual samples of HTA and HTB indicated ClO4 concentration at 12.5 and 12.9 ppb, respectively; drained HTA and HTB	
		E.D. flow at 12 ml/min	
	P.M.	Manual sample of HTA at 13:30 inidcated ClO4 concentration at 16 ppb; Drained HTA	
1/9/2008	A.M.	Manual samples of HTA and HTB indicated ClO4 concentration at 23 and 18 ppb, respectively; drained HTA and HTB	
		Perchlorate pump lost primed; reprimed pump	
		Changed Emax to increase E.D. flow to ~13.5 ml/min	
		Increased Knut to 0.66 from 0.62	
	P.M.	Replaced Phosphoric acid feed line	
		Manual sample of HTA at 13:30 inidcated ClO4 concentration at 20 ppb; Drained HTA	
1/10/2008	A.M.	Checked TOC at trimite effluent water stream: 0.8 ppm	
		Changed Emax to decrease E.D. flow from 13.5 ml/min to 12.5 ml/min	
		Manual samples of HTA and HTB indicated ClO4 concentration at 13 and 26 ppb, respectively; drained HTA and HTB	
	P.M.	Manual sample of HTA at 13:30 inidcated ClO4 concentration at 21 ppb; Drained HTA	
1/11/2008	A.M.	Perchlorate solution was all consumed overnight; feed perchlorate concentration decrease back to ~45 ppb	
		Manual samples of HTA and HTB indicated ClO4 concentration at 19 and 20 ppb, respectively; drained HTA and HTB	
		Stopped spiking and back to normal feed mode	

Date	Time	Change to System/Maintenance	Outcome/Result
1/14/2008	A.M.	Operate system in System Recycle Mode; not recommended due to low process flow to system at 25 gpm	
		Started spiking experiment at 2000 ppb and decrease concentration to 1500 ppb	
	P.M.	Manual sample of HTB at 14:30 inidcated ClO4 concentration at 47 ppb; recycle water back to system for further treatment	
		Drained HTB when manual sample of HTB inidcated ClO4 concentration at 19.4 ppb	
		Restarted spiking	
1/15/2008	A.M.	Manual samples of HTA and HTB indicated ClO4 concentration at 35 and 34 ppb, respectively; recycled HTA water for further treatment and with spiking	
	P.M.	Stopped spiking and run system in forward feed mode with feed groundwater; checked Filter effluent water at 27.3 ppb	
1/16/2008	A.M.	Started spiking of recycled water from HTA and HTB to 2000 ppb	
	P.M.	Manual sample of HTB at 14:00 inidcated ClO4 concentration at 41 ppb; recycle water back to system for further treatment without spiking until 17:30	
		Operate system in Run Mode with feed groundwater without spiking overnigh	
1/17/2008	A.M.	Recycle HTA water to system for further treatment	
		Manual samples of HTA and HTB indicated ClO4 concentration at 16 and 14 ppb, respectively; drained HTA and HTB	
	P.M.	Started spiking of feed water to ~1500 ppb at 13:00	
		Decrease spiking level of feed water to ~500 ppb at 14:45	
		Manual sample of HTA at 15:00 inidcated ClO4 concentration at 3.5 ppb; drained HTA	
		Increase spiking level of feed water to ~2000 ppb overnight	
1/18/2008	A.M.	Measure E.D. flow: 10.5 ml/min with Emax = 38%	
		Manual samples of HTA and HTB indicated ClO4 concentration at 11 and 10 ppb, respectively; drained HTA and HTB	
1/21/2008	A.M.	Started spiking experiment at ~1500 ppb	
		Changed Emax to 44% (12 ml/min at 22 spm)	
	P.M.	Increased spiking concentration to ~2000 ppb	
1/22/2008	A.M.	Emax was adjusted back to 39% on 01/21/08 21:00	
		Adjusted Emax to 28% at 10:00	
	P.M.	Adjusted Emax to 38% at 13:00	
		Decreased spiking concentration to ~1500 ppb	
1/23/2008	A.M.	Perchlorate pump lost primed at ~3:30	
		Restarted spiking ot ~ 1200 ppb	
		E.D. flow at 10 ml/min	
	P.M.	Increased spiking concentration to ~2000 ppb	
1/24/2008	A.M.	Perchlorate pump lost primed	
		Restarted spiking at ~2000 ppb	
		Emax at 38% / E.D. feed at 10 ml/min	
1/25/2008	A.M.	Perchlorate pump lost primed	
		Restarted spiking at ~2000 ppb	
		Temporarily adjusted Emax to 44%	
	P.M.	Adjusted Emax to 30% (20 spm E.D. at 10 ml/min)	
1/26/2008	A.M.	Obstruction in holding tank	
		System operated in feed mode at 50 ppb	
1/27/2008	P.M.	Restarted spiking to 2000 ppb	
		Adjusted Emax to 38%	
1/29/2008	A.M.	Adjusted Emax to 36%	
1/30/2008	A.M.	Perchlorate pump lost primed	
		Restarted spiking at ~2000 ppb	
1/31/2008	A.M.	Perchlorate pump lost primed; reprimed pump	
		Restarted spiking at ~2000 ppb	
	P.M.	Decreased spiking concentration to ~ 1000 ppb	
		Increased spiking concentration to ~1500 ppb	
2/1/2008	P.M.	Increased spiking concntration to ~ 2000 ppb at 13:00	
		E.D. feed at ~ 11 ml/min at 21 spm	
2/2/2008	A.M.	Dionex unit offline on 02/01/08	
		Perchlorate pump lost primed	
	P.M.	Restarted spiking to ~2000 ppb	
		Reduced E.D. feed to 20 spm	
2/3/2008	A.M.	Perchlorate pump lost primed	
		Restarted spiking at ~2000 ppb	
2/4/2008	A.M.	Continued spiking at ~2000 ppb	
2/5/2008	A.M.	Decreased spiking to ~1500 ppb	
		Continued to decrease spiking to ~1000 ppb	
	P.M.	Collected sampled for Babcock labs	
		Increased spiking back to ~2000 ppb	
		E.D. feed at 11 ml/min	
2/6/2008	A.M.	Perchlorate feed decreased to ~ 1000 ppb	
		Increased perchlorate feed to ~2000 ppb	
	P.M.	Run Dionex standard: 26 ppb vs. 25 ppb	
2/7/2008	A.M.	Perchlorate pump lost primed due to accumulated solids in pump feed line; repair feed line	
		Increased perchlorate feed to ~2000 ppb	
	P.M.	Increased perchlorate feed to 2500 ppb	
2/8/2008	A.M.	Increased perchlorate feed to ~3000 ppb	
2/9/2008	A.M.	Increased perchlorate feed to ~ 3500 ppb	
2/10/2008	A.M.	Continued perchlorate feed at ~ 3500 ppb	
		Polymer pump lost primed; reprimed	
2/11/2008	A.M.	Perchlorate pump lost primed; reprimed pump	
		Increased perchlorate feed to 4000 ppb	
	P.M.	Replaced malfunctioned nitratax	
2/12/2008	A.M.	System did not take feed samples overnight	
		Faulty dionex readings of perchlorate at FBR effluent stream	
		Decreased perchlorate feed to 3500 ppb	
2/13/2008	A.M.	Decreased perchlorate feed to 2500 ppb	
2/14/2008	A.M.	Increased perchlorate feed to 3500 ppb	
		Refill perchlorate drum with water only	
	P.M.	Perchlorate feed was at 1000 ppb	
2/15/2008	A.M.	Cleaned perchlorate container; combined all rinsate in one drum (245 ppm perchlorate solution)	
		Rinse DWT	
		Feed system with 20 spm rinsate temporarily (400 ppb)	
2/18/2008	A.M.	Dionex offline due to emptied D.I. container	
2/19/2008	P.M.	Turned off E.D. feed	
2/21/2008		Tank Cleaning	
2/22/2008	A.M.	Cleaned Tank areas; disconnect level switches	
2/25/2008	A.M.	Recalibrate Dionex	
2/26/2008	A.M.	System in FBR recycle mode due to faulty readings and calibrations	
		Recalibrate Dionex with fresh stock perchlorate solution	
2/27/2008	A.M.	Run TOC experiment	
	P.M.	Run system in System Recycle Mode	
		Feed Perchlorate (drum rinsate) at 40 spm	
2/28/2008	A.M.	Run system in System Recycle Mode without adding in perchlorate	
	P.M.	Feed remaining perchlorate water (~ 5 gallon) with 1.5 L of E.D. and 500 ml of phosphoric acid to system while running system in FBR recycle mode	
2/29/2008	A.M.	Feed 200 ml of E.D. to FBR while keeping running system in FBR recycle mode	