
Draft Report

**Engineering Evaluation/Cost Analysis for
Perchlorate Treatment
Phoenix-Goodyear Airport North Superfund Site
Goodyear, Arizona
EPA Contract No. 68-W-98-225
EPA Work Assignment No. 238-NSEE-09ES**

Prepared for
**U.S. Environmental Protection Agency
Region 9
75 Hawthorne Street
San Francisco, CA 94105**

August 2007



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Acronyms

AAC	Arizona Administrative Code
ADHS	Arizona Department of Health Services
ARAR	applicable or relevant and appropriate requirement
ARS	Arizona Revised Statutes
ATSDR	Agency for Toxic Substances and Disease Registry
AWQS	Aquifer Water Quality Standards
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
DQO	data quality objective
DWEL	Drinking Water Equivalent Level
°F	degrees Fahrenheit
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
ESDs	Explanation of Significant Differences
FBR	fluidized-bed reactor
FEMA	Federal Emergency Management Agency
ft/day	feet per day
GAC	granular activated carbon
gpm	gallons per minute
HBGL	health-based guidance level

HQ	Hazard Quotient
IRIS	Integrated Risk Information System
LAU	Lower Alluvial Unit
LGAC	liquid-phase granular activated carbon
MAU	Middle Alluvial Unit
MCL	maximum contaminant level
mg/kg	milligram per kilogram
MTS	Main Treatment System
NAS	National Academy of Science
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	operations and maintenance
PGA North	Phoenix-Goodyear Airport North
PRG	preliminary remediation goal
PRP	potentially responsible party
PSDW	Park Shadow Domestic Well
RAO	removal action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
RID	Roosevelt Irrigation District
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SRE	streamlined risk evaluation
SVE	soil vapor extraction

TBC	to-be-considered
TCE	trichloroethene
Site	Phoenix-Goodyear Airport North
UAU	Upper Alluvial Unit
UCL	upper confidence level
µg/L	micrograms per liter
UPI	Unidynamics Phoenix, Inc.
U.S.C.	United States Code
VOC	volatile organic compound
WSRV	West Salt River Valley
WWTP	Wastewater Treatment Plant

Executive Summary

ES.1 Overview

This report summarizes the results of an Engineering Evaluation/Cost Analysis (EE/CA) for the Phoenix-Goodyear Airport North Superfund Site (PGA North or the Site). The primary contaminants of concern (COCs) associated with the Site are volatile organic compounds (VOCs), particularly trichloroethene (TCE) and perchlorate, which were used during former manufacturing and testing operations by Unidynamics Phoenix, Inc. (UPI). This EE/CA report addresses only perchlorate because remediation of TCE is addressed by the 1989 Record of Decision (ROD). The United States Environmental Protection Agency (EPA) developed the EE/CA report as the first step in a non-time-critical removal action to address perchlorate contamination in extracted groundwater at the Site. Full characterization of perchlorate contamination in the aquifer and selection of an in situ remedy will be done in an amendment to the ROD, not in this removal action.

The EE/CA considers four removal action alternatives for cleanup at PGA North and identifies Alternative 2 as the *preferred* alternative. Following a public review and comment period on the EE/CA, EPA will document the *selected* removal action alternative for PGA North in an Action Memorandum.

ES.2 Site Information

The Site includes the source area and a plume of groundwater contamination that extends approximately 2 miles north of the source in Maricopa County, Arizona, approximately 17 miles west of downtown Phoenix, Arizona. The Site source area is the former UPI facility, which is located on approximately 58 acres in the City of Goodyear. The physical boundaries of the UPI property are Van Buren Street to the north, Litchfield Road to the east, a vacant field to the south, and Union Pacific Railroad tracks to the west. The Site lies within the West Salt River Valley (WSRV) (CH2M HILL, 2006).

UPI operated the facility as a research, design, development, testing, assembly, and manufacturing plant from 1963 through 1994. The manufacturing operations included machining and assembling mechanical and electrical components, manufacturing of rocket propellant, and heat power blending. Perchlorate is the primary ingredient of solid rocket propellant. As a result of historical waste disposal practices at the facility, the groundwater is contaminated with VOCs and perchlorate. VOCs at the Site consist primarily of TCE, which is being addressed pursuant to a 1989 ROD and five subsequent Explanations of

Significant Differences (ESDs) (EPA; 1989, 1991a, 1993a, 1995, 1998, and 2002). The remedy is being implemented by Crane Co., the parent corporation of UPI, which is the potentially responsible party (PRP) at the Site pursuant to a 2006 Consent Decree between EPA and Crane Co. (EPA, 2006a). As part of current (2007) efforts, Crane Co. is implementing two additional groundwater extraction and treatment systems and is beginning the second year of a 3-year groundwater investigation program.

ES.3 Approach for Engineering Evaluation/Cost Analysis and Removal Action

EPA based the EE/CA on existing Site characterization data. A Streamlined Risk Evaluation (SRE), completed as part of this EE/CA, concluded that an actual or potential threat to the public health or welfare of the environment supports a removal action at the Site.

Potential health risks and hazards at the Site exceed levels considered protective of human health. The SRE estimated a health hazard quotient (HQ) greater than 1 for potential human exposures to perchlorate in groundwater. The removal action objectives (RAOs) for the Site are as follows.

- Remove perchlorate contamination from extracted groundwater at the Site to prevent exposure to drinking water users.
- Remove perchlorate contamination from extracted groundwater at the Site prior to reinjection or other uses to prevent further impacts to groundwater or surface waters.

At the Main Treatment System (MTS) for the Site, the RAOs currently are being achieved by treatment of elevated perchlorate levels using an ion exchange resin system.

ES.4 Summary and Comparison of Removal Action Alternatives

EPA considered the following four removal action alternatives.

- Alternative 1 - No Action
- Alternative 2 - Ion Exchange (*Preferred Alternative*)
- Alternative 3 - Tailored Liquid-Phase Granular Activated Carbon (LGAC)
- Alternative 4 - Ex Situ Biotreatment

Table ES-1 presents an analysis of the four removal action alternatives, comparing the relative benefits of the alternatives based on effectiveness, implementability, and cost. EPA used relative scores for the alternatives to identify the preferred removal action alternative.

ES.5 Preferred Removal Action Alternative

Based on a favorable balance of performance against the criteria evaluated, EPA recommends implementation of Alternative 2 to address the RAOs. Compared to the other three alternatives considered, Alternative 2 provides the following advantages.

- Proven technology to reduce perchlorate contamination to nondetectable concentrations.
- Part of existing MTS.
- Commercially available and broadly accepted technology.
- Lowest overall cost to address perchlorate contamination at MTS.

1. Introduction and Recommendation

1.1 Regulatory Framework

This Engineering Evaluation/Cost Analysis (EE/CA) Report documents the evaluation of removal action alternatives and identifies the preferred alternative to address perchlorate contamination in groundwater extracted at the Phoenix-Goodyear Airport North Superfund Site (PGA North or the Site) located in Goodyear, Maricopa County, Arizona, in accordance with the guidelines provided in the document titled *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA, 1993b). The Site source area is the former Unidynamics Phoenix, Inc. (UPI) facility that occupies approximately 58 acres. The physical boundaries of the UPI property are Van Buren Street to the north, Litchfield Road to the east, vacant field to the south, and Union Pacific Railroad tracks to the west. The Site includes the source area and the trichloroethene (TCE)-contaminated groundwater plume that spreads approximately 2 miles to the north of the former UPI facility. The primary contaminants of concern (COCs) associated with the Site are TCE and perchlorate, which were used during former manufacturing and testing operations. This EE/CA Report address only perchlorate because remediation of TCE is being addressed by the 1989 Record of Decision (ROD).

Similar to a focused feasibility study, an EE/CA provides summary information about the nature and extent of contamination and the related risks. The document then provides an evaluation of removal alternatives that address Site contamination and reduce associated risks. All removal action alternatives are evaluated; however, no initial screening of alternatives is conducted as is done with a typical feasibility study.

The guidance document by the United States Environmental Protection Agency (EPA) states that the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its implementing regulations found in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) define removal actions to include the following:

. . . the cleanup or removal of released hazardous substances from the environment, such actions as may be necessary taken in the event of the threat of release of hazardous substance into the environment, such action as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances, the disposal of removed material, or the taking of such other actions as may be

necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release.

As stated in the Code of Federal Regulations (CFR), Title 40, Section 300.415(b)(2), the NCP lists the following factors for EPA to consider in determining whether a removal action is appropriate.

- (i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants;*
- (ii) Actual or potential contamination of drinking water supplies or sensitive ecosystems;*
- (iii) Hazardous substances, pollutants, or contaminants in drums, barrels, tanks, or other bulk storage containers, which might pose a threat of release;*
- (iv) High levels of hazardous substances, pollutants, or contaminants in soils that are largely at or near the surface and might migrate;*
- (v) Weather conditions that could cause hazardous substances, pollutants, or contaminants to migrate or be released;*
- (vi) Threat of fire or explosion;*
- (vii) Availability of other appropriate federal or state response mechanisms to respond to the release; and*
- (viii) Other situations or factors that could pose threats to public health or welfare or to the environment.*

Perchlorate in Site groundwater justifies institution of a removal action because of potential exposure through area drinking water. This justification implies the two following factors.

- Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants; and
- Actual or potential contamination of drinking water supplies or sensitive ecosystems.

At the Site, humans are potentially exposed to perchlorate through the area public water supplies. Drinking water supplies have had actual impacts in the past, and action is necessary to ensure that potential future impacts do not occur. Perchlorate is in the Site groundwater that serves as the primary drinking water source for residents of the City of Goodyear, the City of Avondale, and the City of Litchfield Park. Perchlorate attributed to the Site has been detected in several drinking water supply wells in the City of Goodyear and continues to pose a risk to other area drinking water supply wells.

EPA generally defines three classes of removal actions, based on the time period allowable for initiating on-site activity: emergency, time critical, and non-time critical. Emergency and time-critical removal activities do not require completion of an EE/CA; whereas, a non-time-critical removal action does require an EE/CA. EPA has determined that a non-time-critical removal action is appropriate to address the extraction of perchlorate-contaminated groundwater at the Site because it is an immediate threat; however, the planning process for this action has taken over 6 months. Immediate exposure is being addressed by a treatability study that mitigates elevated perchlorate levels at the Main Treatment System (MTS) using an ion exchange resin system; therefore, a full removal alternative analysis could be conducted.

1.2 Non-Time-Critical Removal Action Process and EE/CA Organization

The general process that EPA follows for non-time-critical removal actions involves the following steps.

1. Developing an EE/CA to:
 - Evaluate subject contamination at the Site;
 - Assess the potential risks to human health and the environment posed by subject contamination at the Site; and
 - Identify potential cleanup strategies or “removal action alternatives” to address subject contamination at the Site.
2. Holding a public comment period for the EE/CA report.
3. Developing an action memorandum to document the removal action alternative that EPA selected, including a response to public comments on the EE/CA report.
4. Implementing the selected removal action alternative.

EPA will perform Steps 1, 2, and 3 listed above for the removal action process at the Site. EPA then will direct the potentially responsible party (PRP) (that is, Crane Co.) to perform Step 4, implementing the selected removal action alternative.

This EE/CA is organized into eight main sections.

- **Executive Summary** – Provides an overview of the EE/CA, Site information, approach, summary, and comparison of removal alternatives, and identifies the preferred alternative.

- **Section 1 – (Introduction)** – Presents the scope and objectives of this document and a brief history of the regulatory framework and Site.
- **Section 2 – (Site Characterization)** – Presents a description of the Site and a summary of Site characterization information.
- **Section 3 – (Identification of Removal Action Scope and Objectives)** – Describes the scope and objectives of the removal action and identifies the potentially applicable or relevant and applicable requirements (ARARs).
- **Section 4 – (Identification and Evaluation of Removal Action Alternatives)** – Presents the removal action alternatives.
- **Section 5 – (Comparative Analysis of Removal Alternatives)** – Provides a relative evaluation of removal action alternatives.
- **Section 6 – (Conclusions and Recommendations)** – Presents conclusions and recommendations.
- **Section 7 – (References)** – Presents a list of references used in preparation of this EE/CA.

1.3 Site History

The Site consists of an area of contaminated groundwater that encompasses approximately 2 square miles and originates at the former UPI facility. Active operations took place at the facility from 1963 to 1994, which included manufacturing and testing mechanical and electrical components used in defense and aerospace applications. The primary operations at the plant included manufacturing rocket propellant, processing and blending powder, assembling ordnance, machining, testing explosives and ballistics, and related functions. Perchlorate is the primary chemical ingredient of solid rocket propellant. Historical records indicate that potassium perchlorate and ammonium perchlorate were associated with specific buildings and with wastes disposed at the UPI facility.

In 1981, the Arizona Department of Health Services (ADHS) discovered that groundwater in the Site area was contaminated with TCE and other volatile organic compounds (VOCs) from the manufacturing operations at UPI. As a result, EPA added the overall Phoenix-Goodyear Airport Site to the National Priorities List (NPL) in September 1983 as the Litchfield Airport Area Superfund Site. After the airport property was transferred to the City of Phoenix, the Site was renamed the Phoenix-Goodyear Airport Area Superfund Site. Later, the Site was divided into two parts representing two different source areas: Phoenix-Goodyear Airport North and Phoenix-Goodyear Airport South. Because Phoenix-Goodyear

Airport South does not have elevated levels of perchlorate, that site is not addressed in this document. The PRPs for PGA North are UPI and its parent company, Crane Co. (CH2M HILL, 2006).

In 1984, UPI began a subsurface investigation at the former UPI facility, which identified the primary source of contamination to be four dry wells located west of the UPI main building. These dry wells were used for disposal of the solvents that were used at the former UPI facility from 1963 through 1980. A more thorough Remedial Investigation (RI) conducted from 1985 through 1987 revealed that the groundwater plume extended more than 1 mile north of the former UPI facility. EPA conducted an additional investigation to complete the Remedial Investigation/Feasibility Study (RI/FS) for the Site, as described in the *Remedial Investigation/Feasibility Study Phoenix-Goodyear Airport, Goodyear, Arizona*. (CH2M HILL, 1989).

Pursuant to the remedy selected in the 1989 ROD, groundwater throughout the aquifer including Subunit A, and Subunits B and C (hereafter referred to as Subunit C), must meet Site-specific cleanup levels that are listed in Table 2-5 of the ROD. Subunit C and the Middle Alluvial Unit (MAU) are public water supply sources for the area and, therefore, must meet maximum contaminant levels (MCLs). Although Subunit A is not the primary aquifer used for many potable supply wells, some supply wells are open either directly or indirectly to Subunit A because it is considered a potential source of drinking water; however, pursuant to Arizona state law, cleanup must achieve the maximum protection of drinking water (EPA, 1989). Also, several older, unused production wells might be partly screened in Subunit A and acting as conduits for contamination to travel from Subunit A into the deeper, drinking water aquifers.

Groundwater treatment to remove VOCs began at the Site in 1994. Treatment systems include the MTS for groundwater of Subunit A. Treatment of groundwater in Subunit C was added to the MTS in 2002. Groundwater is treated for VOC removal at the MTS using air stripping. Standard treatment processes used to remove VOCs from groundwater, such as air stripping and standard granular activated carbon (GAC), are not effective at removing perchlorate. Therefore, water that had been treated for VOCs and reinjected into clean portions of the aquifer was contaminated with perchlorate because the MTS was not designed to address that contaminant.

In 2003, Crane Co. ceased reinjection of the perchlorate-contaminated water and began sending the VOC-treated groundwater to the City of Goodyear Wastewater Treatment Plant (WWTP) for nitrate treatment as part of a 2-year treatability study. In 2005, the WWTP treatability study ended, and a second treatability study using ion exchange was added to

the MTS. Since April 2005, when the ion exchange system was brought online, the treated groundwater again has been reinjected into the Subunit A aquifer (CH2M HILL, 2006).

About 2 miles north of the former UPI facility is Well 33A, which has a VOC treatment system that treats Subunit A groundwater. The wellhead treatment system at Well 33A uses liquid-phase GAC for VOC removal.

Now that the water no longer is diverted to the WWTP, all treated water from the MTS is injected into Subunit A by means of a network of six injection wells. Treated groundwater from the wellhead treatment system at Well 33A was delivered to an off-site pond at a nearby golf course for irrigation until May 2006, when the treated groundwater was directed to the adjacent Roosevelt Irrigation District (RID) canal for downstream irrigation use (CH2M HILL, 2006).

Since 1998, when laboratory analytical methods detected perchlorate at low levels, perchlorate has been found in Site groundwater. In wells screened in Subunits A and C located on the UPI property, perchlorate concentrations have been as high as 45 micrograms per liter ($\mu\text{g}/\text{L}$). Historically, the highest concentrations being extracted were in the Park Shadows Domestic Well (PSDW), a potable public water supply well screened in Subunit C, with levels as high as 130 $\mu\text{g}/\text{L}$ in 2002 when the well was taken out of service. During the Phase II groundwater investigation completed in 2003, perchlorate concentrations in groundwater samples from depth-specific intervals at the source area were as high as 200 $\mu\text{g}/\text{L}$ (CH2M HILL, 2004).

Currently, no national drinking water standard exists for perchlorate, although EPA has adopted a reference dose with a drinking water equivalent of 24.5 $\mu\text{g}/\text{L}$ (EPA, 2006b), and the state has established guidance levels. Arizona has a Health-Based Guidance Level (HBGL) for perchlorate of 14 $\mu\text{g}/\text{L}$ published by the ADHS (ADHS, 2000). The HBGL is calculated to limit excess lifetime cancer risk to one-in-one million (10^{-6}) for known human carcinogens and one-to-one-hundred-thousand (10^{-5}) for possible and probable human carcinogens. The HBGL is designed to protect human health over a lifetime but might not necessarily represent a health hazard when exceeded.

Over the past several years, the extraction and treatment systems at the Site apparently are not sufficient to contain the VOC and perchlorate groundwater plume. Several conduit wells appear to have drawn contamination into the lower aquifers, and the extraction systems as currently designed do not adequately address the influence of changed pumping in the area. Additionally, these systems were initially developed to address VOC contamination and not necessarily to treat contaminants like perchlorate. These conduit wells are one pathway for contamination to migrate to the lower aquifers, and other

potential pathways are being evaluated as part of the ongoing supplemental remedial investigation of the Site. Currently, a supplemental remedial investigation is being conducted to fully characterize the extent of contamination, both vertically and horizontally, to optimize the Subunit A treatment systems, to develop a treatment system for Subunit C, and to determine a Site-wide remedy for perchlorate. This supplemental characterization investigation is expected to result in additional and differently distributed extraction wells and treatment systems onsite (CH2M HILL, 2006).

EPA is the lead agency for implementation and oversight of response actions to releases of hazardous substances at this Site, with support from the Arizona Department of Environmental Quality. At the direction of EPA, Crane Co. is conducting ongoing investigation and remediation activities resulting from the presence of VOCs and perchlorate (CH2M HILL, 2006). As part of current (2007) efforts, Crane Co. is implementing two additional groundwater extraction and treatment systems and is beginning the second year of a 3-year groundwater investigation program.

This EE/CA evaluates the implementability, effectiveness, and cost of addressing perchlorate-contaminated groundwater that is extracted from wells at the Site. Also, this document identifies the potential regulatory requirements for these actions.

2. Site Characterization

2.1 Site Description and Background

2.1.1 Location

As shown in Figure 2-1, the former UPI facility is located on approximately 58 acres in Goodyear, Maricopa County, Arizona, approximately 17 miles west of downtown Phoenix, Arizona. The physical boundaries of the UPI facility are Van Buren Street to the north, Litchfield Road to the east, a vacant field to the south, and Union Pacific Railroad tracks to the west. The Site lies in the West Basin of the Salt River Valley.

The former UPI facility is delineated on the United States Geological Survey Tolleson 7.5-minute topographic map. The following coordinates define the approximate latitude and longitude of the Site.

Latitude: 33°26'45" North

Longitude: 112°21'33" West

2.1.2 Type of Facility and Operational Status

The Site includes the source area and the TCE-contaminated groundwater plume that spreads approximately 2 miles to the north of the former UPI facility. The perchlorate plume above the Arizona HBGL is within the TCE plume area but is mostly limited to the UPI facility, as shown in Figure 2-2. Active operations took place at the former UPI facility from 1963 to 1994.

Currently, two remedial systems are on the former UPI facility. The MTS, located at the southern end of the Site, provides groundwater treatment for Subunits A and C. The MTS consists of a series of air-stripping columns for VOC removal, vapor-phase GAC for removal of VOCs from the offgas, and an ion-exchange process unit for perchlorate removal. Contaminated groundwater is collected from a series of extraction wells, and the treated groundwater is reinjected through a series of injection wells.

Near the north-central portion of the former UPI facility is a soil vapor extraction (SVE) system that consists of several SVE wells from which subsurface soil vapors are collected, along with a vapor-phase GAC unit for removal of VOCs from the airstream. An additional downgradient groundwater remedial system is located about 2 miles north of the former UPI facility. This system extracts Subunit A groundwater from Well 33A, treats VOC

contamination by means of liquid-phase GAC, and discharges the treated effluent to the RID canal.

2.1.3 Structures and Topography

The former UPI facility consists of 24 abandoned buildings and other structures, such as former storage bunkers. The facility is fenced and gated. The topography is generally flat and mostly unpaved. The elevation is approximately 981 feet above mean sea level. The Site falls within Zone X, which includes areas of 500-year floodplain and areas of 100-year floodplain with average depths of less than 1 foot, or with drainage areas of less than 1 square mile or areas protected by levees from the 100-year flood, as shown in the Federal Emergency Management Agency (FEMA) Map 04013C2080H (FEMA, 2001).

2.1.4 Geology and Soil Types

2.1.4.1 Regional Geology and Hydrogeology

Regionally, the geology and hydrogeology of the area consists of alluvial fill materials of the Basin and Range Physiographic Province. Generally, the Basin and Range Province is characterized by deep alluvial basins of the West Salt River Valley (WSRV) separated by north-to-northwest-trending mountain ranges. Locally, the WSRV alluvial deposits are present and represent the regional water supply resource (CH2M HILL, 2006).

2.1.4.2 Site-Specific Geology and Hydrogeology

Underlying the study area are three WSRV hydrogeological units, namely the Upper Alluvial Unit (UAU), the previously mentioned MAU, and the Lower Alluvial Unit (LAU). The UAU consists of three subunits. Subunit A is an unconfined layer of silty sands extending from the surface to about 160 feet below ground surface (bgs) with an average hydraulic conductivity of 60 feet per day (ft/day). The uppermost groundwater is located within Subunit A at approximately 90 feet bgs. Subunit B, composed primarily of sandy silt with clay, extends from about 160 to 230 feet bgs and acts as a partial aquitard between Subunits A and C. Subunit C, composed primarily of silt, sand, and gravel, extends from about 230 to 360 feet bgs with an average hydraulic conductivity of 108 ft/day (CH2M HILL, 2004).

The UAU grades into the MAU, which consists primarily of clayey silt, mudstone, and gypsiferous mudstone with interbedded sand and gravel deposits. The MAU, along with Subunit C from the UAU, are the major sources of water production in the area. The MAU thicknesses are up to 1,600 feet with hydraulic conductivity ranges of 5 to 50 ft/day (CH2M HILL, 2004). The LAU consists of conglomerate, gravel, and mudstone with

hydraulic conductivities ranging from 5 to 60 ft/day (CH2M HILL, 2004). Area drinking water wells are not deep enough to penetrate the LAU.

2.1.5 Surrounding Land Uses

Surrounding land uses of the Site include a mix of residential, agricultural, commercial, and industrial. Commercial, residential, and industrial properties lie to the north and south of the former Site, agricultural land is to the west, and residential and commercial property is across Litchfield Road to the east. The study area is a rapidly growing suburban area. According to the Arizona Department of Economic Security, the population of the City of Goodyear in 2005 was 46,213, an increase of 638 percent from 1990. The population is projected to grow at an annual rate of 18 percent (GPEC, 2007).

2.1.6 Meteorology

The climate in Maricopa County is semiarid with moderate temperatures that rarely drop below freezing. Highest temperatures generally occur during the months of July, August, and September. Temperatures in the vicinity of the Site range from lows of 37 to highs of 108 degrees Fahrenheit (°F), and wind speeds average 5 to 7 miles per hour. Rainfall averages approximately 8 inches annually, and the greatest precipitation generally occurs in February.

2.1.7 Sensitive Ecosystems

The Site is located in a largely urban or suburban area, with little natural habitat. The Agua Fria River is about 1 mile east of the Site; however, the river flows only in response to storm events or from treated effluent discharges from sources other than groundwater from the PGA North plume. Generally, the Agua Fria River does not receive shallow groundwater recharge. Potential end uses of the extracted groundwater from the Site, other than reinjection and domestic water use, are discharge to the RID canal or to Litchfield Lake and/or turf irrigation. No ecosystem risk work has been done for the Site. However, the 2006 Consent Decree calls for a screening-level ecosystem risk assessment, which will be completed as part of the Supplemental RI/FS by 2009.

2.2 Previous Response Actions

Table 2-1 summarizes the chronology of the Site, including previous investigations, remedial actions, removal actions, and regulatory oversight.

2.3 Data Analysis

Appendix A provides historical perchlorate analytical data for groundwater samples collected at, and in the vicinity of, the Site. EPA assessed the suitability and usability of the data set for the EE/CA by conducting an independent data validation of a data subset. Based on the information reviewed, the perchlorate results along with the data review and validation findings presented by ARCADIS indicate that the data are usable to support environmental decisions. No major analytical deficiencies were noted during this evaluation other than those specifically discussed in the memorandum provided in Appendix B.

The Data Quality Objective (DQO) process is a seven-step iterative planning approach used to prepare plans for environmental data collection activities. The process provides a systematic approach for defining the criteria that a data collection design should satisfy, including when, where, and how to collect samples or measurements, determination of tolerable decision error rates, and the number of samples or measurements that should be collected. Table 2-2 presents the DQOs for the EE/CA.

2.3.1 Contamination in Soil

Soil contamination from VOCs is being addressed pursuant to the existing 1989 ROD. This removal action is to address perchlorate in groundwater that is being extracted for VOC treatment, not to establish a cleanup level for perchlorate in soil. Therefore, soil data were not reviewed. However, a soil investigation for perchlorate and other compounds was begun in May 2007.

2.3.2 Contamination in Soil Vapor

Soil vapor at the Site exhibits elevated VOCs concentrations, which are being addressed by the existing 1989 ROD. Perchlorate is a soluble salt with a very low vapor pressure so that soil vapor concerns are nonexistent. This removal action is to address perchlorate in groundwater that is being extracted for VOC containment, not to establish a cleanup level for perchlorate in soil vapor. Therefore, soil gas data were not reviewed.

2.3.3 Contamination in Groundwater

Perchlorate was first detected at the Site in August 1998, and Site-wide sampling was conducted. In 2001, when elevated perchlorate levels were found in a PSDW water supply well nearby (see Appendix C, Figures C-1 and C-2), more extensive perchlorate monitoring began at the Site. This section of the EE/CA addresses groundwater quality data from the four quarterly groundwater-sampling events conducted in 2006. Perchlorate concentrations by quarter in 2006 are summarized in Tables 2-3 through 2-6. As discussed in Section 1.3,

Arizona has an HBGL for perchlorate of 14 µg/L. Section 3.4 provides the analysis for using the Arizona HBGL as a benchmark at this Site.

During the fourth quarter 2006, as shown in Figure 2-2, perchlorate was detected in 35 wells in Subunit A at concentrations up to the 45 µg/L found at MW-27 (ARCADIS, 2007). Also during the fourth quarter 2006, six wells completed in Subunit A exceeded the Arizona HBGL of 14 µg/L for perchlorate (MW-02, MW-07, MW-09, MW-27, EA-1, and PZ-01). Appendix A provides a complete summary of the historical perchlorate data.

For Subunit C and the MAU, as shown in Figure 2-3, perchlorate concentrations ranged from non-detect in several wells to 22 µg/L at EB-01 during fourth quarter 2006 (ARCADIS, 2007). The only well not located on the former UPI facility that exceeded the Arizona HBGL in the past 3 years was the PSDW, which contained levels as high as 130 µg/L in 2002 and had a value of 16.4 µg/L in January 2005. Since that time, perchlorate levels in PSDW generally have been at 2 and 3 µg/L.

2.4 Source, Nature, and Extent of Contamination

The source of perchlorate in Site groundwater is attributed to historical manufacturing and testing operations at the UPI facility. Although perchlorate might accumulate in the subsoil in arid regions, groundwater monitoring data at the Site show that the perchlorate outside the contaminant plume boundaries is below reporting limit concentrations. Further investigation into the nature and extent of perchlorate in soil at the former UPI facility started in May 2007.

Perchlorate contamination in the groundwater has been detected in Subunits A and C of the UAU and in the MAU. The highest perchlorate concentrations in Subunit A groundwater have been detected beneath the source area and to the north and southeast. The lateral extent of perchlorate concentrations greater than 14 µg/L in Subunit A groundwater extends approximately within 0.25 mile north and east of the former UPI facility, although several additional monitoring wells outside that boundary contain perchlorate at detectable levels that are lower than 14 µg/L. Perchlorate has been detected as far out as Well MW-24, which is about 2 miles northwest of the former UPI facility (ARCADIS, 2007).

Perchlorate concentrations in Subunit C are highest directly beneath the facility and at MW-20, which is located near the north end of the former UPI facility (ARCADIS, 2007). Currently, the insufficient network of monitoring wells in all aquifer subunits fails to accurately define the source and full extent of perchlorate contamination. Additional investigation is being completed to define the full extent of perchlorate contamination as part of the supplemental RI/FS at the Site.

Some of the vertical and lateral spreading of perchlorate likely was caused prior to 2002 by reinjection of groundwater from the MTS that was treating VOC contamination but not perchlorate contamination. Once this problem was identified, reinjection stopped, and the VOC-treated groundwater was piped, via the municipal sewer system, to the City of Goodyear WWTP for nitrate treatment as part of a pilot-testing program. The WWTP uses an anoxic process for denitrification; literature and field data suggested that this process can successfully remove perchlorate.

Crane Co. submitted a work plan to determine the efficacy of biological denitrification (a process step at the Goodyear WWTP) to remove perchlorate from the VOC-treated effluent. Pilot-scale and bench-scale tests conducted from January 2004 to April 2005 suggested that perchlorate in groundwater at the concentrations observed during the pilot study can be successfully treated using biological denitrification in this manner. The perchlorate concentration entering the WWTP ranged from 25 to 30 $\mu\text{g}/\text{L}$, and the concentration in treatment plant effluent was routinely below the detection limit of 2 $\mu\text{g}/\text{L}$ (ARCADIS, 2005b).

Use of the WWTP to remove perchlorate from groundwater was replaced with an ion exchange system in April 2005 due to capacity concerns at the WWTP and the cost-effectiveness of having an ion exchange system onsite. Thus, in April 2005, the ion exchange system was added to the MTS at the Site to remove perchlorate from groundwater prior to reinjection to the Subunit A aquifer (CH2M HILL, 2006).

2.5 Streamlined Risk Evaluation

The goal of the Streamlined Risk Evaluation (SRE) is to determine if hazards to human health from possible exposure to perchlorate-contaminated groundwater extracted from Subunits A and C of the UAU warrant removal action based on risk. The potential human health hazard considered in this SRE is based on the domestic use of perchlorate-contaminated groundwater. TCE contamination is already addressed in the 1989 ROD and is not included in this SRE. The report *Groundwater Monitoring, Fourth Quarter 2006 and 2006 Annual Report, Phoenix-Goodyear Airport-North Superfund Site* presents the most recent overview of VOC-impacted groundwater characterization studies and remedial activities, including similar efforts for perchlorate, conducted for the Site and also references related EPA activities and documents (ARCADIS, 2007).

In this SRE, groundwater perchlorate concentrations in Subunits A, B, and C of the UAU are compared against two risk-based groundwater-screening levels, which were developed by EPA and the State of Arizona. Results of this SRE indicate that current perchlorate levels in groundwater present a potential for significant noncancer health hazards associated with

consumption of perchlorate-contaminated groundwater at the Site (Table 2-7), which is discussed in detail in Section 2.5.4 and Section 2.5.5. Based on this outcome, the EE/CA evaluates removal actions to protect the groundwater resource and addresses potential future health hazards from perchlorate in the groundwater at the Site.

The SRE results will help EPA to: a) justify initiating a removal action for the Site; b) determine whether taking additional cleanup actions at the Site is necessary; and c) identify and document current or future potential exposures that warrant mitigation. The following discussion summarizes the SRE, which is presented in full in Appendix C.

2.5.1 Approach Used for Streamlined Risk Evaluation

The SRE for the Site compares recent available groundwater monitoring well data for perchlorate contamination to human-health-risk-based screening values to determine the nature of the potential threat to public health or welfare. For perchlorate in untreated groundwater used as drinking water, the SRE provides an estimate of how, and to what extent, people might be exposed to perchlorate and assesses the potential health effects associated with perchlorate in groundwater at the Site. The SRE also estimates the potential for adverse health effects if no further cleanup action is taken.

An evaluation of potential threats to human health is conducted by comparing contaminant concentrations in groundwater to selected risk-based screening values (Table 2-8). These screening levels are potentially to be considered for this action.

Currently, no single approach for deriving a screening level for perchlorate in groundwater has been agreed upon. The debate tends to focus on two issues: 1) whether children could have a higher exposure to perchlorate than adults because they drink more water per pound of body weight; and, 2) whether additional exposure to perchlorate from food and other sources should be taken into account when estimating a screening level for perchlorate in groundwater. These different approaches lead to somewhat different screening criteria. At the time of the SRE, this debate has not been resolved. Therefore, a range of screening levels published in the literature were selected, incorporating the different approaches.

The screening levels selected for comparison are:

- 1) The EPA preliminary cleanup goal of 24.5 µg/L (January 26, 2006). The EPA preliminary groundwater cleanup goal is based on adult exposures, assuming 100 percent contribution from ingestion of tap water.
- 2) The ADHS drinking water HBGL of 14 µg/L (May 2000). The ADHS drinking water HBGL is based on exposure in children.

2.5.2 Contaminants Considered in the SRE

For Subunits A and B, the perchlorate concentration used for risk screening is based on Site-wide data collected from August 2005 through September 2006. For Subunit C, perchlorate in groundwater collected in 2002 from the PSDW, located in the far southeast of the Site, was used for risk-screening comparisons. The maximum concentration detected in the PSDW (130 µg/L on November 13, 2002) is far higher than any concentration detected in Subunit C in that well from August 2005 through September 2006 (8.8 µg/L), but the levels from the highest detection are being used for this risk analysis.

The SRE compares the 95 percent upper confidence limit (UCL) concentrations of perchlorate in groundwater in Subunits A and B and the maximum concentration in Subunit C to risk-based screening values from EPA and ADHS. These exposure point concentrations (EPCs) of perchlorate in Subunits A, B, and C are presented in Table 2-9. Each of these values exceeds the two risk-based screening values presented in Table 2-8.

2.5.3 Conceptual Site Model, Exposure Assessment, and Risk Characterization

A human health conceptual Site model diagram was developed and used to plan the approach for the exposure assessment and risk characterization for the SRE. These elements are further described in this section.

2.5.3.1 Human Health Conceptual Site Model Diagram

Figure 2-4 presents a schematic diagram of the human health conceptual Site model. The model depicts the connections between chemical releases and transport of the releases through environmental media to potential human receptors in a presentation that includes:

- Primary sources (Site historic operations);
- Release mechanisms (e.g., spills, disposal, or leaks);
- Secondary sources (e.g., contaminated soil);
- Secondary release mechanisms (e.g., infiltration or percolation to groundwater);
- Exposure routes and potentially exposed receptors (e.g., residents).

Although the Site currently contains a mix of residential, commercial, industrial, and agricultural uses, the SRE focuses on potential health impacts to existing and future residents using groundwater through tap water. Impacts from perchlorate contamination from other pathways are beyond the scope of this SRE.

2.5.3.2 Approach to Evaluation of Exposure Risks from Perchlorate-Contaminated Groundwater

The potential exposure pathways for perchlorate in groundwater and the potential human populations that could be exposed to these chemicals, either now or in the future, are considered to be part of the SRE. The SRE evaluates the risks to potential residential

receptors that might use perchlorate-contaminated groundwater through tap water; this considers both supply wells and irrigation wells as potential supply wells. Potential exposures to industrial and commercial workers also require consideration. Residential exposures were selected for the quantitative risk evaluation because residents represent the maximally exposed population.

The pathways and exposure routes of groundwater at the Site considered in this SRE include ingestion, inhalation, and dermal contact with contaminants in tap water. Perchlorate is nonvolatile and is unlikely to be absorbed through dermal contact (EPA, 2004). Therefore, the inhalation and dermal contact exposure routes are not considered significant, and EPA and ADHS did not include those exposure routes in the calculation of the groundwater screening values. The two screening levels used for comparison are based on ingestion exposure only.

2.5.4 Noncancer Health Hazards

The SRE estimates potential future perchlorate exposures and associated health hazards from the public use of groundwater from the Site. Potential health effects can vary depending upon assumptions relating to the receptors selected for evaluation. Perchlorate is not associated with carcinogenic human health risks; therefore, a cancer risk evaluation was not conducted.

The groundwater screening levels developed by EPA and ADHS were calculated to a corresponding noncancer hazard quotient (HQ) of 1. For noncancer health effects, an HQ greater than 1 indicates the potential for adverse noncancer health effects associated with exposure to the chemical (EPA, 1991b and 2004). Because perchlorate is the only chemical for which hazards are considered in the SRE, the HQ is evaluated separately for each subunit, using the groundwater screening levels presented in Table 2-9.

For perchlorate-contaminated groundwater, the SRE estimates human noncancer health hazards using the risk ratio approach, as described in the User's Guide for EPA Region 9 Preliminary Remediation Goals (PRG) (EPA, 2004). The EPC of perchlorate in groundwater was divided by each of the groundwater screening concentrations. The resulting value is the HQ relative to that perchlorate groundwater screening level.

2.5.5 Conclusions of the Streamlined Risk Evaluation

The SRE conducted to support the EE/CA for this Site evaluates the potential exposure pathways for current and future residential receptors through groundwater ingestion from tap water. Results of the groundwater investigations at the Site suggest that perchlorate

contamination found in groundwater in Subunits A, B, and C present potential human health hazards at existing concentrations.

The potential noncancer chronic health hazards estimated from domestic use of perchlorate-contaminated groundwater from the Site vary depending on the specific EPA or ADHS drinking water screening value used for calculation of the human health hazard. For Subunit A, the HQs based on EPA and ADHS values (shown in Table 2-7 and rounded to whole numbers) are 2 and 3, respectively. For Subunit B, the HQs are 2 and 3, respectively. For Subunit C, the HQs are 5 and 9, respectively. Each of these HQ values exceeds 1, indicating the potential for adverse noncancer health effects associated with exposure to perchlorate in groundwater at the Site.

The SRE results indicate that a potential exists for adverse noncancer health effects associated with perchlorate contamination at the Site. Estimates of health hazards suggest that, if no further cleanup action is taken, restriction of groundwater use located downgradient off-site is needed to prevent potential future human exposures.

This evaluation of potential health hazards from perchlorate in groundwater will help EPA to evaluate the proposed removal actions and address potential future health hazards from perchlorate at the Site. Perchlorate monitoring will continue; therefore, changes in perchlorate concentrations could trigger further risk evaluation of the Site.

3. Identification of Removal Action Scope and Objectives

3.1 Removal Action Scope and Objectives

The non-time-critical removal action for PGA North seeks to address the perchlorate contamination from extracted groundwater at the Site. The removal action objectives (RAOs) for this action are to remove perchlorate contamination from extracted groundwater at the Site to prevent exposure to drinking water users, and prior to reinjection or other use, to prevent further impacts to groundwater or surface waters (see Table 3-1). As determined by the SRE summarized in Section 2.5 and presented in Appendix C, Site investigation data indicate an unacceptable risk to humans from perchlorate-contaminated Site groundwater.

3.2 Potential Applicable or Relevant and Appropriate Requirements

The NCP requires that removal actions conducted at sites pursuant to CERCLA must comply with (or justify the waiver of) legally applicable or relevant and appropriate requirements, standards, criteria, or limitations (collectively known as ARARs) of federal and state environmental laws and regulations.

This analysis represents the initial step to identify potential ARARs from the universe of environmental regulations, requirements, guidance, or a combination of standards that could pertain to the non-time-critical removal action for the Site. The identification of ARARs is an iterative process, and the Removal Action Memorandum for this action will present the final determination of ARARs.

Table 3-2 contains a summary of the potential ARARs and To-Be-Considered (TBC) documents for this action. Section 3.2.1 provides explanations of ARARs and TBC documents.

3.2.1 Summary of CERCLA and NCP Requirements

Pursuant to the NCP in CFR Title 40, Section 300.415(j), to the extent practicable considering the exigencies of the situation, removal actions shall obtain (or justify the waiver of) ARARs under federal or state environmental or facility siting laws. In determining whether compliance with ARARs is practicable, the lead agency could consider appropriate factors,

including: (1) the urgency of the situation and (2) the scope of the removal action to be conducted.

Federal ARARs could include requirements under any federal environmental laws. State ARARs include promulgated, enforceable environmental or facility-siting laws that are more stringent or broader in scope than federal requirements and are identified by the state in a timely manner.

An ARAR is either “applicable” or “relevant and appropriate,” but not both. If no specific federal or state ARAR for a particular chemical or remedial action exists, or if the existing ARARs are considered insufficiently protective, then risk-based guidance or criteria could be identified and used as TBCs to ensure the protection of public health and the environment. The NCP in CFR Title 40, Part 300 defines “applicable,” “relevant and appropriate,” and “to-be-considered” as follows:

- **Applicable requirements** are defined in Section 300.5 of the NCP as those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility-siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements can be applicable.
- **Relevant and appropriate requirements** are defined Section 300.5 of the NCP as those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility-siting laws that, while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only state standards that are identified in a timely manner and that are more stringent than federal requirements can be ARARs.
- **TBCs** are defined in Section 300.415(j) as other federal and state advisories, criteria, or guidances that, as EPA deems appropriate, could be considered in formulating the removal action.

CERCLA Section 121(e) and the NCP at CFR Title 40, Section 300.400(e), provide that no federal, state, or local permits are required for those portions of a CERCLA cleanup that are conducted onsite. Therefore, only substantive requirements of such permits may be considered as possible ARARs (for example, discharge limits or pretreatment requirements). Administrative requirements such as approval by administrative bodies, issuance of

permits, documentation, reporting, record keeping, and enforcement are not ARARs for the CERCLA response actions conducted onsite.

The three general categories of ARARs are summarized as follows.

- **Chemical-specific ARARs** are health-based or risk-based concentration limits, numerical values, or methodologies for various environmental media (that is, groundwater, surface water, air, and soil), which are established for a specific chemical that might be present in a specific media at the site, or that might be discharged to the site during removal activities. These ARARs set limits on concentrations of specific hazardous substances, pollutants, and contaminants in the environment. Examples of this type of ARAR include state and federal standards for drinking water.
- **Location-specific ARARs** set restrictions on certain types of activities based on site characteristics. Federal and state location-specific ARARs are restrictions placed on the concentration of a contaminant or on the activities to be conducted because the activities occur in a specific location or in the presence of contaminants in a specific location. Examples of special locations possibly requiring ARARs include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.
- **Action-specific ARARs** are technology-based or activity-based requirements that are triggered by the type of removal activities under consideration. Examples are Resource Conservation and Recovery Act (RCRA) regulations for waste treatment, storage, or disposal.

3.2.2 Identification of Potential ARARs

Listed herein are many of the ARARs for this EE/CA. The full list of potential ARARs for this action are in Table 3-2.

3.2.2.1 Chemical-Specific ARARs

In the case of perchlorate in drinking water, no standards are promulgated by either the federal government or by the State of Arizona. EPA has not yet established an MCL for perchlorate, and the State of Arizona has no standard but has adopted a guidance level called an HBGL.

Maximum contaminant levels (CFR Title 40, Part 141) are developed under the Safe Drinking Water Act (United States Code [U.S.C.] Title 42, Sections 300f-j) to protect public health from contaminants that might be found in drinking water sources. MCLs are applicable for tap water that is delivered directly to 25 or more people or to 15 or more service connections.

Although an MCL has not been established yet for perchlorate, any treated groundwater delivered into a public water supply must conform to all applicable federal, state, and local drinking water standards in existence at the time the water is served, including any permit requirements, because EPA considers the service of water to the public to be an off-site activity.

Where no ARAR exists for a particular contaminant, EPA looks to other guidance and criteria to develop cleanup levels for that contaminant. In this case, EPA looks to the guidance discussed in this EE/CA in Section 3.2.3 (To-Be-Considered Documents).

3.2.2.2 Location-Specific ARARs

Any of the removal alternatives discussed in this EE/CA could involve the construction and operation of groundwater treatment systems, extraction systems, injection systems, pipelines, and other methods of transport of the treated water. For any of these constructed remedies, certain requirements are based on the location of those activities.

Facilities located within a 100-year floodplain must be capable of withstanding a 100-year flood as specified in CFR Title 40, Section 264.18 (a) and (b). These standards are potentially applicable to the construction of any new groundwater extraction and treatment facility used as part of this removal action.

Arizona Revised Statutes (ARS) Section 49-224 states that all aquifers in Arizona are classified for drinking water protected use.

ARS Section 45-454.01 exempts new wells installed for a CERCLA remedial action from requirements of ARS Title 45, Chapter 2 if water is withdrawn, treated, and reinjected onsite, but wells must still meet the requirements of ARS Sections 45-594, 45-595, and 45-596.

ARS Section 49-241 requires that discharges of treated water must comply with Aquifer Protection Permit substantive requirements. In aquifers where standards have been exceeded, no further degradation is permitted.

Arizona Administrative Code (AAC) Sections R18-4-501 and 502 require that new treatment units include appropriate siting.

ARS Section 49-223 requires that recharged or reinjected groundwater must meet Arizona Aquifer Water Quality Standards (AWQS).

3.2.2.3 Action-Specific ARARs

Each of the removal alternatives being considered to address perchlorate at the Site has certain action-specific ARARs that pertain to the activity. For instance, for the removal

activities wherein water would be reinjected into the aquifer following treatment, certain aquifer protection regulations would be ARARs; whereas, in the instance of treated water being transported to publicly owned treatment works, certain other requirements might need to be considered. Potential action-specific ARARs for this removal action could include any of the following statutes.

CFR Title 40, Section 262.34 regulates the temporary accumulation of hazardous waste onsite and specifies procedures for accumulation of hazardous wastes onsite for limited quantities of hazardous waste and for limited time periods under generator status.

CFR Title 40, Sections 264.600-603 provide requirements for operation of treatment, storage, and disposal facilities. These facilities must meet performance standards for protection of groundwater, surface water, and air quality.

CFR Title 40, Section 264.1 sets the requirements for waste management sites, specifically waste analysis, inspection requirements, personnel training requirements, as well as contingency and emergency plans.

CFR Title 40, Sections 264.170-178 regulate the storage containers for RCRA-hazardous waste.

CFR Title 40, Part 264, Subpart J, except Section 264.192(a), provides the tank requirements used to store or treat hazardous waste including design and installation, containment and detection of releases, operating requirements, inspections, responses to leaks or spills and closure and postclosure requirements.

CFR Title 40, Part 261 establishes procedures and numeric limits for identification and management of characteristic hazardous wastes, listed hazardous wastes, and state-only (non-RCRA) hazardous wastes.

CFR Title 40, Part 262.11 requires waste generators to determine whether wastes are hazardous wastes, and establishes procedures for such determinations.

The Clean Water Act in CFR Title 40, Sections 402 and 405-471 establishes the National Pollutant Elimination Discharge System (NPDES) permit program, which regulates discharges into surface water through treatment and monitoring requirements for such discharges.

ARS Section 49-282.06(A)(2) requires that CERCLA-response actions provide for the control, management, or cleanup of hazardous substances to allow the maximum beneficial use of the waters of the state.

ARS Section 49-221 states that discharges from treatment systems must comply with AWQS when treated water is discharged to surface water.

ARS Section 49-222 provides standards to assure water quality for protection of public health and takes into consideration its use and value for public water supplies, propagation of fish and wildlife, recreation, agricultural, industrial, and other purposes, including navigation.

The Safe Drinking Water Act found in CFR Title 40, Sections 144.12 through 144.16, regulates the reinjection of groundwater through establishment of criteria and standards for the Underground Injection Control Program.

AAC Sections R18-11-405(a) and (c) provide the AWQS requiring: 1) that a discharge not cause a pollutant to be present in an aquifer classified for a drinking water protected use in a concentration that endangers human health; and 2) that a discharge not cause a pollutant to be present in an aquifer if the pollutant impairs existing or reasonably foreseeable uses of water in an aquifer.

ARS Section 49-241 requires that discharges of treatment water meet Aquifer Protection Permit requirements.

ARS Section 49-243 prohibits discharges that cause or contribute to a violation of the AWQS. In aquifers where standards have been exceeded, no further degradation is permitted.

ARS Section 49-223 requires that recharged or reinjected groundwater must meet AWQS.

CFR Title 40, Section 403.5 provides pretreatment requirements for discharges to publicly owned treatment works.

ARS Sections 45-594-596 and 600 state the requirements and standards for well construction, notice for drilling, and filing of drilling logs.

AAC Sections R18-4-701-704 and 706 require annual consumer confidence reports for community notification of water quality.

3.2.3 To-Be-Considered Documents

Because no chemical-specific ARARs exist for perchlorate, EPA is considering various TBCs to determine the appropriate cleanup level to ensure protection of health and the environment. The TBCs listed in this section are being considered for this removal action. A more in-depth discussion regarding determination of Site-specific cleanup levels is presented in Section 3.4.

- ADHS Heath-Based Guidance Level

- HBGLs are risk-based levels developed by ADHS to represent concentrations of contaminants in drinking water that are protective of public health during long-term exposure. The ADHS process for determining HBGLs accounts for exposure to children. The Arizona HBGL for perchlorate is 14 µg/L.
- EPA PRGs
 - PRGs are risk-based screening levels used to identify sites that might require additional investigation and possible remediation. PRGs combine current EPA toxicity values with standard exposure factors to estimate contaminant concentrations in environmental media. PRGs are considered protective of humans over a lifetime. The EPA PRG for perchlorate is 24.5 µg/L.
- EPA and National Academy of Science (NAS) Suggested No-Observed-Adverse-Response Levels
 - EPA and the NAS publish risk values for toxicity-based factors other than cancer or incremental cancer risk estimates, including the risk estimates for perchlorate. These risk values are posted on the EPA Integrated Risk Information System (IRIS) in the form of Reference Doses (RfDs), which indicate a daily oral exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime. The current RfD for perchlorate on IRIS is 0.0007 mg/kg per day.

3.3 ARAR Waivers

In some circumstances, the ARARs for an action can be waived; specifically, in a removal action, ARARs must be complied with “to the extent practicable” (per CFR Title 40, Section 300.415[j]). EPA expects that the ARARs outlined for these alternatives are attainable and will not need to be waived.

3.4 Analysis of Perchlorate Cleanup Levels

Where MCLs are promulgated under the Safe Drinking Water Act, those standards generally are used as cleanup levels for contaminants in groundwater. The MCLs protect the public from contaminants that might be found in drinking water, and the NCP defines MCLs as relevant and appropriate for groundwater that is a potential source of drinking water. Where available, MCLs generally are selected as cleanup levels for water to be served as drinking water. Because perchlorate has no MCL, determination of a perchlorate cleanup level for this removal action is based on TBC requirements that might be found in federal or state guidance or other publications but that officially have not been promulgated.

Two TBC values are to be taken into account in developing a site-specific cleanup level for perchlorate at this site. The first is from federal guidance. In January 2005, the NAS National Research Council reviewed the toxicity of perchlorate and issued a report that prompted EPA to adopt an RfD for perchlorate of 0.0007 mg/kg per day. The RfD is a TBC for a perchlorate cleanup level. The EPA January 26, 2006, Assessment Guidance for Perchlorate (2006 Guidance) stated that this RfD leads to a Drinking Water Equivalent Level (DWEL) of 24.5 µg/L, which is currently EPA's perchlorate PRG. Second, the State of Arizona has adopted an HBGL for perchlorate of 14 µg/L. HBGLs are risk-based advisory levels developed by the ADHS that represent a maximum concentration of a contaminant in drinking water that can be consumed without resulting in adverse health effects from long-term exposure. HBGLs are calculated by ADHS using a human health-based approach that is generally consistent with risk assessment methodologies recommended by EPA and the Agency for Toxic Substances and Disease Registry (ATSDR). The HBGL is the cleanup level for perchlorate that was selected by EPA at the Apache Powder Superfund site in Arizona.

The 2006 Guidance explains that EPA's PRGs "should be modified, as necessary, as more information becomes available in the RI/FS" (CFR Title 40, Section 300.430[e][2][i]). Factors affecting the PRGs could include physical characteristics of the site, actual and potential exposure pathways, and actual and potential exposure routes (CFR Title 40, Section 300.430[d]). The 2006 Guidance indicates that exposure to perchlorate from multiple pathways should be considered in determining a site-specific remediation goal.

The RI/FS to address perchlorate contamination at this Site is currently underway but has not been completed; thus, a complete analysis has not been performed for relative source contribution of perchlorate at this Site, including perchlorate ingested through food. Therefore, to be protective in this action, to account for the uncertainty of non-water sources of perchlorate, and to remain consistent with other Arizona sites, EPA is selecting the ADHS HBGL of 14 µg/L of perchlorate as the Site-specific cleanup level.

4. Identification and Evaluation of Removal Action Alternatives

This section describes the removal action alternatives and provides an independent evaluation of the alternatives. All removal action alternatives considered technologies that are potentially applicable to Site conditions at PGA North.

The evaluation of the alternatives generally conforms to the guidelines provided in the EPA document titled *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA, 1993b). In addition, EPA consulted portions of the its document titled *Conducting Remedial Investigations and Feasibility Studies (RI/FS) Under CERCLA* (EPA, 1988), as appropriate. Section 5 presents a comparative analysis of the removal action alternatives discussed in Section 4.

4.1 Identification of Removal Alternatives

4.1.1 Initial Screening of Removal Technologies

The general approach EPA used for identifying removal action alternatives for PGA North included the steps summarized below. Tables 4-1, 4-2, and 4-3 provide supporting information regarding the process that EPA used to identify removal action alternatives.

- **Develop a Comprehensive List of Potential Technologies** – EPA initially screened potential technologies from a complete summary of technologies that could be applied to groundwater removal actions for the Site. Table 4-1 presents the list of technologies originally screened and provides brief descriptions of the technologies.
- **Eliminate Unsuitable Technologies Based on Initial Criteria** – EPA then eliminated potential alternatives from further consideration based on likely concerns with effectiveness, implementability, cost, or a combination of these criteria. Table 4-2 provides a summary of the technologies that EPA eliminated from further evaluation.¹
- **Develop Alternatives Based on Technologies Retained** – Table 4-3 presents the final technologies used to develop the removal action alternatives discussed in Section 4.1.2.

¹ Table 4-2 lists the “No Action” alternative although EPA retained this alternative for consideration in the evaluation of alternatives. The No Action alternative provides a baseline for comparing all active removal alternatives.

4.1.2 Description of Removal Technologies

From the initial technology screening, EPA retained and is considering three technologies to treat perchlorate in groundwater. This section provides general information about the technologies, which EPA then further screened to develop four removal action alternatives for consideration in the EE/CA. The technologies considered involve both physical processes (ion exchange and tailored liquid-phase GAC) and a biological process (ex situ biotreatment).

- **Ion exchange** is a reversible physical-chemical reaction wherein an ion from solution is exchanged for a similarly charged ion attached to an immobile solid. During ion exchange, the perchlorate in groundwater, which is a negatively charged ion, is exchanged with an ion provided in resin, typically chloride. In other words, the perchlorate ion switches places with the chloride ion. The perchlorate then binds to the resin, leaving the groundwater uncontaminated.

Ion-exchange materials used for perchlorate treatment resemble small beads, and typically consist of resins made from synthetic, inorganic, or natural polymeric materials that contain ionic functional groups to which exchangeable ions are attached. Ion-exchange resins usually are packed in a column, and, as contaminated water passes through the column, contaminated ions are exchanged for other ions such as chlorides in the resin. Due to the relative concentration difference of the two ions in the resin, the perchlorate switches places with the other ion, which is now released into the water. When the resin reaches an equilibrium concentration where no more perchlorate can be extracted from the water, the resin is regenerated or disposed of properly.

- **Tailored liquid-phase GAC (LGAC)** is a physical process in which a tailored carbon-based product is used as adsorption media. Perchlorate-contaminated groundwater is allowed to pass through the tailored LGAC vessels, and thereby the perchlorate gets adsorbed to the surface of the LGAC. The carbon adsorption media is coated with a monomer that provides for perchlorate treatment. This technology is considered developmental and is undergoing bench-scale testing at other sites, but the technology could be particularly useful at sites like this one where both perchlorate and VOCs can be treated with carbon.

As with ion exchange resin, tailored LGAC usually is packed in a column, in which contaminated water is passed through the column at a rate that allows a long enough residence time for the perchlorate adsorption to take place. Tailored LGAC reaches an equilibrium concentration where no more perchlorate can be extracted from the water, at which time the LGAC is replaced with a new adsorption media.

- **Ex Situ biotreatment** is a biological process in which perchlorate-contaminated groundwater is extracted from wells and allowed to pass through bioreactors that consist of either GAC or sand media where perchlorate is reduced to chloride and oxygen under anaerobic conditions. In some cases, electron donors or nutrients are added to increase the microbial activity. Different types of reactors such as fluidized-bed, packed-bed, or fixed-film reactors could be utilized for this remediation.

The fluidized-bed reactor (FBR) is the most common form of ex situ biotreatment, and incorporates a fixed-film reactor column that fosters the growth of microorganisms on a hydraulically fluidized bed of media, usually sand or activated carbon. The fluidized media provides an extremely large surface area on which microorganisms can grow, thus producing a large inventory of biomass in a small reactor volume. The microorganisms destroy the perchlorate to chloride ions and oxygen (final products) by using the chemicals for their own growth and reproduction. Influent groundwater is combined with the effluent recycle and pumped into the bottom of the FBR through the distribution system at a constant reactor flow, fluidizing the media contained in the reactor. Microorganisms need essential nutrients (mostly nitrogen and phosphorous) to thrive. These nutrients are pumped continually into the reactor flow, supporting biomass growth, along with a carbon source, as an electron donor promoting nitrate and perchlorate reduction in the FBR. Excess biomass film that is formed during the treatment will need to be removed to maintain optimum microbial growth conditions.

4.1.3 Development of Removal Action Alternatives

Table 4-3 contains a summary of the technologies for treatment of perchlorate in extracted groundwater that EPA retained from the initial screening. EPA developed the following four removal action alternatives, based on the evaluation of the nature and extent of contamination at the Site and on the RAOs presented in Table 3-1.

- Alternative 1 – No Action
- Alternative 2 – Ion Exchange (*Preferred Alternative*)
- Alternative 3 – Tailored LGAC
- Alternative 4 – Ex Situ Biotreatment

4.1.4 Alternative 1 – No Action

Alternative 1 is the “no-action alternative.” In this case, no further activity or monitoring would occur. The Site would remain in its current condition, and perchlorate contamination in groundwater would remain unmitigated.

4.1.5 Alternative 2 – Ion Exchange

The following list provides details about ion exchange technology used to treat perchlorate-contaminated groundwater. Currently, an ion exchange system is used as a treatment process unit within the MTS to treat perchlorate in extracted groundwater. Ion exchange materials used for perchlorate treatment typically consist of resins that contain ionic functional groups to which exchangeable ions are attached. As contaminated groundwater passes through the resin column, contaminated ions are exchanged for other ions such as chlorides in the resin. Due to the relative concentration difference of the two ions in the resin, the perchlorate switches places with the other ion, which is then released into the water.

Ion Exchange System

- Affected Aquifer Area, plan view (square feet): 3,200,000*
- Extraction Wells: 5
- Injection Wells: 6
- Maximum Perchlorate Concentration ($\mu\text{g}/\text{L}$), based on 2006 data: 45
- Maximum Design Flow Rate (gallons per minute [gpm]), at MTS: 400
- Estimated Treatment Period (years): 30
- Number of resin canisters and change-out period: Two 10,000-pound canisters, each filled with approximately 424 cubic feet of ion exchange resin, with change out every 3 to 6 months

*This area is shown in Figure 2-2 and encompasses the area where perchlorate concentrations exceed 14 $\mu\text{g}/\text{L}$

Additional details on the ion exchange system design currently in use can be found in the *Final Remedial Design Workplan for the Perchlorate Treatment Unit* (ARCADIS, 2005a).

4.1.6 Alternative 3 – Tailored Liquid-Phase Granular Activated Carbon

The following list provides details about the Tailored LGAC system to treat perchlorate-contaminated groundwater extracted at the Site. Tailored LGAC is GAC preloaded with cationic surfactants, usually a quaternary ammonium monomer. Perchlorate-contaminated groundwater is allowed to pass through the tailored LGAC vessels, and thereby the perchlorate adsorbs to the surface of the LGAC.

Tailored LGAC System

- Affected Aquifer Area, plan view (square feet): 3,200,000*
- Extraction Wells: 5
- Injection Wells: 6
- Maximum Perchlorate Concentration ($\mu\text{g}/\text{L}$): 45
- Maximum Design Flow Rate (gpm) at MTS: 400
- Estimated Treatment Period (years) : 30
- Number of carbon canisters and change-out period: Two 10,000-pound canisters, with change out every 2 to 3 months

*This area is shown in Figure 2-2 and encompasses the area where perchlorate concentrations exceed 14 $\mu\text{g}/\text{L}$

4.1.7 Alternative 4 – Ex Situ Biotreatment

The following list provides details about the ex situ biotreatment system to treat perchlorate-contaminated groundwater extracted at the Site. Ex situ biotreatment is similar to the Goodyear WWTP process in that it fosters microorganism growth on a hydraulically fluidized bed of media, usually sand or activated carbon (ARCADIS, 2005b). The fluidized media provides an extremely large surface area on which microorganisms can grow. The microorganisms destroy the perchlorate to chloride ions and oxygen (final products) by using the chemicals for their own growth and reproduction. Microorganisms need essential nutrients (mostly nitrogen and phosphorous) to thrive. These nutrients are pumped continually, supporting biomass growth, along with a carbon source as an electron donor, promoting nitrate and perchlorate reduction. Excess biomass film that is formed during the treatment will need to be removed to maintain optimum microbial growth conditions.

Ex Situ Biotreatment System

- Affected Aquifer Area, plan view (square feet): 3,200,000*
- Extraction Wells: 5
- Injection Wells: 6
- Maximum Perchlorate Concentration ($\mu\text{g}/\text{L}$): 45
- Maximum Design Flow Rate (gpm) at MTS: 400
- Estimated Treatment Period (years) : 30
- Number of bioreactors : 1

*This area is shown in Figure 2-2 and encompasses the area where perchlorate concentrations exceed 14 $\mu\text{g}/\text{L}$

4.2 Evaluation Criteria

This EE/CA evaluates the four removal action alternatives that EPA developed, based on the following criteria to identify a preferred removal action alternative.

1. Effectiveness

- **Overall Protection of Human Health and the Environment** – This evaluation criterion considers whether the alternatives will adequately protect human health and the environment, in the short-term and long-term, from unacceptable risks posed by contaminants present at the Site by eliminating, reducing, or controlling exposure to levels that would achieve RAOs.

This criterion incorporates assessment of several other factors, including long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs, as described next. This evaluation addresses specifically how each removal action alternative achieves protection over time and reduces Site risks.

- **Compliance with Applicable or Relevant and Appropriate Requirements** – This evaluation criterion considers how each alternative complies with ARARs identified for the Site in Section 3.2. The chemical-specific and location-specific ARARs for each alternative will remain the same. This evaluation considers action-specific ARARs for each removal action alternative based on the technologies used to meet the RAOs.
- **Long-Term Effectiveness and Permanence** – This evaluation criterion considers the results of a removal action in terms of the risk remaining at the Site after RAOs are achieved. This evaluation focuses on the extent and effectiveness of the controls that could be required to manage the risk posed by treatment residuals or untreated wastes, or both within the scope of the removal action. The following aspects of this criterion are considered for each alternative:
 - Magnitude of risk remaining after cleanup
 - Adequacy of controls
 - Reliability of controls
- **Short-Term Effectiveness** – This evaluation criterion considers the effects of the removal action during the construction and implementation phase until the RAOs are achieved. This criterion evaluates the effects of each alternative on human health and the environment during implementation of the removal action. The following aspects of this criterion are considered for each alternative:
 - Protection of community health during the removal actions
 - Protection of workers' health during the removal actions
 - Time until RAOs are achieved

- Environmental impacts (adverse impacts to the environment as a result of removal activity and reliability of mitigation measures in preventing or reducing the potential impacts)
- **Reduction of Toxicity, Mobility, or Volume** – This evaluation criterion considers the effectiveness of the removal action in reducing the toxicity, mobility, or the volume of hazardous substances left at the Site. This criterion is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of the total volume of contaminated media. The following aspects of this criterion are considered for each alternative:
 - Treatment processes to be used and materials to be treated
 - Amount of hazardous materials to be treated
 - Estimated degree of expected reduction in toxicity, mobility, or volume
 - Degree to which the treatment is irreversible
 - Type and quantity of treatment residuals expected to remain after treatment
 - Preference of the alternative for treatment

2. Implementability

- This evaluation criterion considers the technical feasibility with regard to feasibility of construction and operation of the alternative, adaptation of the alternative to the environmental conditions at the Site, the reliability of the technologies involved, the ease of undertaking additional removal action (if any), and the ability to monitor the effectiveness of the remedy.

This EE/CA focuses on the treatment of perchlorate-contaminated groundwater that currently is extracted from groundwater wells and is reinjected into Subunit A. In the future, this water may be found in drinking water wells. Other potential end uses for treated groundwater in the future include turf irrigation, and/or discharge to the RID canal or Litchfield Lake. Additionally, wellhead treatment could be the appropriate action to be taken if a public supply well goes down due to perchlorate contamination. Each technology will be evaluated with regard to the feasibility to use the technology for wellhead treatment on extraction wells at the Site.

- This evaluation criterion considers the administrative feasibility, such as operating permits (not required for an onsite response action under CERCLA) or approvals, and ability to implement institutional controls.

- This criterion considers availability of services and materials, including the availability of personnel and technology; availability of off-site treatment, storage and disposal capacity and services; and availability of necessary services, equipment, materials, and specialists.
- This criterion considers state acceptance. Coordination with the State of Arizona is an ongoing part of the non-time-critical removal action process. EPA determines state acceptance of the preferred removal action alternative identified in the EE/CA through the coordination and review process.
- This criterion also considers community acceptance. EPA will address community acceptance of a removal action alternative following regulatory agency and public review of this EE/CA.

3. Cost

- The cost criterion evaluates removal action alternatives based on economic considerations, which primarily consist of cost estimates derived for each alternative. The cost estimates include capital cost and annual operations and maintenance (O&M) cost. The accuracy of cost estimates for the removal action alternatives generally fall within -30 percent to +50 percent of the final project cost.
- Tables 4-4 through 4-6 are summaries of the estimated costs for each alternative. Appendix D provides detailed cost spreadsheets and summaries of the assumptions for the costs. Estimates of capital cost for each alternative consist of direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for the equipment, labor, and materials necessary to perform removal actions. EPA derived the capital cost for each removal alternative from literature sources, vendor quotes, and previous studies. Indirect costs include engineering expenses such as engineering design, construction supervision, contingency allowances, and other services that are not part of the actual removal activities but are required to complete the removal action. Indirect costs also include expenses related to ensuring that the response action complies with the substantive requirements of local permits.
- Annual O&M costs are the costs necessary to ensure the continued effectiveness of the removal action. Annual costs include operating labor costs, maintenance expenses, auxiliary materials and utilities, disposal of any residuals, and monitoring and support costs.

4.3 Evaluation of Alternatives

The discussion in this section evaluates each alternative independently based on the criteria described. This evaluation encompasses at the current scenario at the MTS, as well as the potential for future wellhead treatment in other areas of the Site. Section 5 provides a comparative evaluation of the four alternatives considered.

4.3.1 Alternative 1 – No Action

This section provides an analysis of the effectiveness, implementability, and costs associated with a no-action alternative. The no-action alternative serves as a baseline for comparison of the other alternatives.

4.3.1.1 Effectiveness

Overall Protection of Human Health and the Environment. Because no action would be taken in Alternative 1, groundwater contaminated with perchlorate would continue to be extracted without treatment and would be a continuing source of potential exposure to humans. Therefore, this alternative is not protective of human health and the environment.

Compliance with ARARs. Because no removal action would be conducted on extracted groundwater, perchlorate would continue to exceed action levels and thus would not comply with ARARs regarding end use of groundwater. Without any treatment, no activity-specific ARARs would be implicated.

Long-Term Effectiveness and Permanence. Alternative 1 would provide no effective or permanent solution. Contaminated groundwater would continue to be extracted and would provide a continuing potential source of exposure to human receptors.

Reduction of Toxicity, Mobility, and Volume through Treatment. Because no action would be taken, material would be neither destroyed nor treated. Alternative 1 fails to provide any reduction in toxicity, mobility, or volume of contamination, and to satisfy the statutory preference for treatment.

Short-Term Effectiveness. Alternative 1 would have short-term effects in that it would allow continued degradation of the environment and continued potential exposure to human receptors because perchlorate-contaminated groundwater extracted from the aquifer would not be treated prior to reinjection or serving. Because no action would be implemented, Alternative 1 would involve no short-term effects or risks to remedial workers.

4.3.1.2 Implementability

Technical Feasibility. Alternative 1 includes no treatment or monitoring and, therefore, involves no technical difficulties to overcome in implementation.

Administrative Feasibility. Alternative 1 includes no treatment or action of any kind and, therefore, involves no coordination with regulatory or other agencies regarding response requirements.

Availability of Services and Materials. This criterion is not applicable; implementing Alternative 1 would involve no services or materials.

State Acceptance. EPA will determine the state acceptance of a removal action alternative identified in the EE/CA after the state reviews the document during the stakeholder review period and public comment period. This information will be provided in the Final EE/CA.

Community Acceptance. The public comment period will allow the community to review the EE/CA. EPA will address community acceptance of the removal action alternative at the close of the comment period. This information will be provided in the Final EE/CA.

4.3.1.3 Cost

The net present worth of Alternative 1 (No Action) is \$0.

4.3.2 Alternative 2 – Ion Exchange

4.3.2.1 Effectiveness

Overall Protection of Human Health and the Environment. Alternative 2 would protect human health and the environment by removing contaminant mass from extracted groundwater, thereby preventing exposure as well as limiting contamination migration to downgradient areas.

Compliance with ARARs. Alternative 2 would comply with ARARs. Action-specific ARARs identified in Section 3 that apply to the reinjection of groundwater and surface disposal would be implicated. Additionally, Alternative 2 would comply with the Arizona HBGL of 14 µg/L for serving the groundwater. Alternative 2 treatment would provide cleanup to nondetectable levels, based on proven performance of the existing ion exchange system at the Site.

Long-Term Effectiveness and Permanence. Alternative 2 would remove significant contaminant mass from groundwater as it is extracted.

Reduction of Toxicity, Mobility, or Volume through Treatment. The ion exchange treatment would remove perchlorate contamination from the extracted groundwater and, over time, would reduce the volume of contaminated groundwater in the aquifer.

Short-Term Effectiveness. Alternative 2 would provide effective short-term contaminant reduction. Because an ion exchange system is already in place at the MTS, no additional treatment systems or piping would be installed at this time, thus reducing any risk associated with construction of the alternative. However, if additional extraction wells are required, adherence to common construction safety procedures and construction oversight typically would mitigate risks. A site-specific health and safety plan would be developed for the installation of any additional treatment systems

4.3.2.2 Implementability

Technical Feasibility. Alternative 2 technically is feasible based on the utilization of treatment units that are proven and easily constructed using standard construction practices. Ion exchange is feasible to use for wellhead treatment because the system requirements are scaleable based on the pumping rate. The system can be easily modified to accommodate LGAC for VOC treatment.

Administrative Feasibility. Implementing Alternative 2 would involve some administrative considerations. The response action would need to comply with the substantive requirements of applicable permitting rules. Specifically, the construction of additional treatment systems and the reinjection of treated groundwater could trigger substantive requirements. Coordination with the appropriate state and local entities, including local water management agencies, would be necessary.

Availability of Services and Materials. The services and materials necessary to implement Alternative 2 are readily available.

State Acceptance. EPA will determine the state acceptance of a removal action alternative identified in the EE/CA after the state reviews the document during the stakeholder review period and public comment period. This information will be provided in the Final EE/CA.

Community Acceptance. The public comment period will allow the community to review the EE/CA. EPA will address community acceptance of the removal action alternative at the close of the comment period. This information will be provided in the Final EE/CA.

4.3.2.3 Cost

Alternative 2 could be costly depending on how often the exchange media is changed or regenerated. Resin usage could be higher if groundwater contains sulfates and nitrates that will use up the resin. Also, disposal of resin for one-pass ion resins or disposal of brine

solution from regenerative resins could increase the cost depending on the frequency of change out or regeneration. All costs are based on assumptions presented in this EE/CA. The net present worth of Alternative 2 (Ion Exchange) is \$1.54 million. Table 4-4 presents the cost estimates for Alternative 2 based on a conceptual-level design. Appendix D presents complete cost details.

For future wellhead treatment, the costs range from \$2.0 million at 575 gpm to \$2.94 million at 1,000 gpm. Appendix E presents the wellhead treatment cost details.

4.3.3 Alternative 3 – Tailored Liquid-Phase Granular Activated Carbon

4.3.3.1 Effectiveness

Overall Protection of Human Health and the Environment. Alternative 3 would protect human health and the environment by removing contaminant mass from extracted groundwater, thereby preventing exposure and limiting migration of contaminants downgradient areas.

Compliance with ARARs. Alternative 3 would comply with ARARs. Action-specific ARARs identified in Section 3 that apply to the reinjection of groundwater and surface disposal would be implicated. Additionally, Alternative 3 would comply with the HBGL of 14 µg/L for serving the groundwater.

Long-Term Effectiveness and Permanence. Alternative 3 would remove significant contaminant mass from groundwater at the Site as it is extracted. Because LGAC media lose effectiveness relatively fast when used for perchlorate removal, this technology is disadvantaged with low treatment capacities.

Reduction of Toxicity, Mobility, or Volume through Treatment. The tailored LGAC system would remove perchlorate contamination from the extracted groundwater and would, over time, reduce the volume of contaminated groundwater in the aquifer.

Short-Term Effectiveness. Alternative 3 would provide effective short-term contaminant reduction. Selection of this alternative would require construction of a treatment system. Because the extraction wells and piping are already in place, no additional wells or piping would necessarily need to be installed. However, if additional extraction wells are required, adherence to common construction safety procedures and construction oversight typically would mitigate risks. A site-specific health and safety plan would be developed for the installation of additional systems.

4.3.3.2 Implementability

Technical Feasibility. The technical feasibility of tailored LGAC is still under evaluation through various pilot studies at other sites. Because tailored LGAC remains under

evaluation, the technical feasibility for wellhead treatment is also under evaluation. However, an LGAC system could be easily modified to accommodate GAC for VOC treatment, which is currently used in the treatment system of Well 33A on the Site to address the TCE contamination.

Administrative Feasibility. Implementing Alternative 3 would involve some administrative considerations. The response action would need to comply with the substantive requirements of applicable permitting rules. Specifically, the construction of treatment systems and the reinjection of treated groundwater could trigger substantive requirements. Coordination with the appropriate state and local entities, including local water management agencies, would be necessary.

Availability of Services and Materials. The services and materials necessary to implement Alternative 3 are readily available.

State Acceptance. EPA will determine the state acceptance of a removal action alternative identified in the EE/CA after the state reviews the document during the stakeholder review period and public comment period. This information will be provided in the Final EE/CA.

Community Acceptance. The public comment period will allow the community to review the EE/CA. EPA will address community acceptance of the removal action alternative at the close of the comment period. This information will be provided in the Final EE/CA.

4.3.3.3 Cost

Alternative 3 has low capital cost but potentially very high operating costs. The low adsorption capacity of perchlorate on GAC would result in frequent GAC change outs. All costs are based on assumptions presented in this EE/CA. The net present worth of Alternative 3 (LGAC) is \$1.58 million. Table 4-5 presents the cost estimates for Alternative 3 based on a conceptual-level design. Appendix D presents complete cost details and assumptions.

For future wellhead treatment, the costs range from \$1.75 million at 575 gpm to \$2.73 million at 1,000 gpm. Appendix E presents the wellhead treatment cost details.

4.3.4 Alternative 4 – Ex Situ Biotreatment

4.3.4.1 Effectiveness

Overall Protection of Human Health and the Environment. Alternative 4 would protect human health and the environment by removing contaminant mass from groundwater, thereby limiting migration of contaminants to downgradient areas.

Compliance with ARARs. Alternative 4 would comply with ARARs. Action-specific ARARs identified in Section 3 that apply to the reinjection of groundwater and surface disposal would be implicated. Additionally, Alternative 4 would comply with the HBGL of 14 µg/L for serving the groundwater.

Long-Term Effectiveness and Permanence. Alternative 4 would remove significant contaminant mass from groundwater at the Site as it is extracted.

Reduction of Toxicity, Mobility, or Volume through Treatment. The ex situ biotreatment system would destroy perchlorate from the extracted groundwater because microorganisms would use the perchlorate as a food source and, over time, would reduce the volume of contaminated groundwater in the aquifer.

Short-Term Effectiveness. Alternative 4 would provide effective short-term contaminant reduction. Significant construction of the treatment process unit would be required, triggering the need for a site-specific health and safety plan. Adherence to common construction safety procedures and construction oversight would mitigate risks from construction. Because the extraction wells and piping are already in place, no additional extraction wells or piping would be installed, thus reducing any risk associated with that construction.

4.3.4.2 Implementability

Technical Feasibility. Alternative 4 technically is feasible based on the use of treatment units that are proven and easily constructed using standard construction practices. Pilot-scale and bench-scale testing at the Goodyear WWTP show that this technology is effective in removing perchlorate. However, the system requires a large area for various system components. Other feasibility considerations include the many steps required to maintain microbial growth and the disposal of treatment sludge. The size requirement for the system makes this technology infeasible for wellhead treatment because treatment would be conducted in residential areas and the available area for treatment might be limited.

Administrative Feasibility. Implementing Alternative 4 would involve some administrative considerations. The response action would need to comply with the substantive requirements of applicable permitting rules. Specifically, the construction of treatment systems, and the reinjection of treated groundwater might trigger substantive requirements. Coordination with the appropriate state and local entities, including local water management agencies, would be necessary.

Availability of Services and Materials. The services and materials necessary to implement Alternative 4 are readily available.

State Acceptance. EPA will determine the state acceptance of a removal action alternative identified in the EE/CA after the state reviews the document during the stakeholder review period and public comment period. This information will be provided in the Final EE/CA.

Community Acceptance. The public comment period will allow the community to review the EE/CA. The EPA will address community acceptance of the removal action alternative at the close of the comment period. This information will be provided in the Final EE/CA.

4.3.4.3 Cost

The capital cost and O&M costs would be high for Alternative 4. Biosolids handling including sludge dewatering and offsite sludge disposal costs can add significantly to operating cost. All costs are based on assumptions presented in this EE/CA. The net present worth of Alternative 4 (Ex Situ Biotreatment) is \$4.74 million. Table 4-6 presents the cost estimates for Alternative 4 based on a conceptual-level design. Appendix D presents complete cost details and assumptions.

For future wellhead treatment, the costs range from \$5.39 million at 575 gpm to \$6.0 million at 1,000 gpm. Appendix E presents the wellhead treatment cost details.

5. Comparative Analysis of Removal Action Alternatives

This section compares the four removal action alternatives based on *relative* performance against each evaluation criterion and recommends Alternative 2 based on the comparison. Table 1-1 contains a summary of the comparative evaluation of removal action alternatives considered in this EE/CA.

5.1 Effectiveness

5.1.1 Overall Protection of Human Health and the Environment

Alternative 1 provides no protection because no action would be taken to reduce the contaminant mass. Alternatives 2, 3, and 4 provide overall protection of human health and the environment by reducing contaminant mass from extracted groundwater. Alternative 3 (Tailored LGAC) is still considered a developmental technology and likely would rate lower than Alternatives 2 and 4 in this category.

5.1.2 Compliance with ARARs

Alternatives 2, 3, and 4 would comply with the ARARs identified in Section 3. Alternative 1 fails to comply with ARARs.

5.1.3 Long-Term Effectiveness and Permanence

Alternative 2 would provide the highest level of effectiveness in the long term because it is a proven technology for perchlorate removal. Alternative 3 is an innovative/developmental approach that appears to be able to reduce perchlorate concentrations to nondetectable levels, but it still in the developmental phase. Because LGAC media lose effectiveness relatively fast when used for perchlorate removal, Alternative 3 is disadvantaged with low treatment capacities. Alternative 1 would provide no permanent reduction of the contaminant mass.

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 2, 3, and 4 would reduce the toxicity, mobility, and volume of contamination through treatment. Alternative 4 actually destroys the perchlorate because microorganisms would use the perchlorate as a food source, while Alternatives 2 and 3 transfer the

perchlorate to either resin or tailored carbon, which would require disposal. Alternative 1 would fail to reduce the toxicity, mobility, or volume of contamination through treatment.

5.1.5 Short-Term Effectiveness

Alternatives 2, 3, and 4 would not introduce short-term environmental impacts associated with the construction of treatment systems and the installation of extraction wells because each alternative takes advantage of the existing treatment piping and extraction wells. However, if additional extraction wells and/or treatment system process units were required, implementing standard safety protocols during construction readily would mitigate short-term environmental impacts. Alternative 4 actually destroys the perchlorate, while Alternatives 2 and 3 transfer the perchlorate to either resin or tailored carbon, which would require disposal. Although no short-term risks would be associated with construction of Alternative 1, the alternative would fail to attain RAOs and, therefore, would prove least effective in the short term.

5.2 Implementability

5.2.1 Technical Feasibility

The technical feasibility of implementing Alternatives 2, 3, and 4 generally is comparable because the three alternatives involve physical or biological technologies and reinjection of the treated groundwater. Both methods in Alternatives 2 and 4 have been pilot tested at this Site. The methods in Alternatives 2 and 4 are proven technologies, which have been successfully implemented at many sites with similar conditions. Alternative 3 is considered an innovative approach that remains in the developmental phase, and real demonstration data are limited. The existing ion exchange treatment system (Alternative 2) is successfully removing perchlorate to nondetectable concentrations at the MTS for the Site. Alternative 4 is more complicated from a design and O&M perspective, due to the increased area needed for treatment equipment, and the numerous steps required to maintain the best conditions for microbial growth.

For wellhead treatment, Alternatives 2 and 3 are more feasible based on size requirements for the treatment system, but Alternative 2 rates as the most feasible because the ion exchange system is a more proven technology.

5.2.2 Administrative Feasibility

Implementing Alternatives 2, 3, and 4 would involve some administrative considerations. All response actions would need to comply with the substantive requirements of applicable permitting rules. Specifically, the construction of treatment systems, and the discharge of

treated groundwater might trigger substantive requirements. EPA will coordinate with the appropriate state and local entities, including local water management agencies.

5.3 Cost

Table 5-1 provides a summary of the cost estimates for the four removal action alternatives. The cost estimates of O&M and net present value (using a 7 percent discount rate) are lowest for Alternative 2. Alternative 4 is approximately three times more expensive than Alternatives 2 and 3.

For wellhead treatment, Alternative 3 rates as the most cost effective because the cost of tailored LGAC is less expensive than ion exchange (Alternative 2) or ex situ bioremediation (Alternative 4). Additionally, for future systems, LGAC has the potential to treat both perchlorate and VOCs, thus it could be more cost effective overall. The wellhead treatment costs are provided in Appendix E.

6. Conclusions and Recommendations

The EPA guidance document titled *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* states the following (EPA, 1993b):

The EE/CA should identify the action that best satisfies the evaluation based on the comparative analysis. This description should briefly describe the evaluation process used to develop the recommended action.

This EE/CA considers the four removal action alternatives. Based on a favorable balance of the evaluation criteria presented in Sections 4 and 5, EPA prefers the implementation of Alternative 2. Table 1-1 presents a summary of the removal action alternatives and the evaluation criteria.

6.1 Removal Action Alternatives Considered

- Alternative 1 – No Action
- Alternative 2 – Ion Exchange – (*Preferred Alternative*)
- Alternative 3 – Tailored Liquid-Phase Granular Activated Carbon (LGAC)
- Alternative 4 – Ex Situ Biotreatment

6.1.1 Effectiveness

Alternatives 2, 3, and 4 rate significantly higher for reduction of contaminant mobility and overall protection of human health and the environment than Alternative 1 because they provide treatment to reduce contaminant concentrations, thereby reducing contaminant mobility. Alternatives 2, 3, and 4 would comply with ARARs. Alternative 1 fails to comply with ARARS.

Alternative 2 would provide the highest level of effectiveness in the long term, as it is a proven technology for perchlorate removal, and is already being used successfully at the Site. Alternative 3 is an innovative/developmental approach that appears to be able to reduce perchlorate concentrations to nondetectable levels, but it still in the developmental phase. However, it would potentially provide the advantage of treating both perchlorate and VOCs. Alternative 4 destroys the perchlorate, but requires considerably more area and many process steps to maintain the optimum conditions for microbial growth. Alternative 1 would provide no permanent reduction of the contaminant mass.

6.1.2 Implementability

The technical feasibility of implementing Alternatives 2 and 3 generally is comparable because the alternatives involve physical technologies and reinjection of the treated groundwater. The methods in Alternatives 2 and 4 are proven technologies, successfully implemented at many sites with similar conditions. Alternative 3, considered an innovative approach, is still in the developmental phase, and real data are limited. The existing ion exchange treatment system, Alternative 2, is successfully removing perchlorate to nondetectable concentrations at the Site. Alternative 4 is more complicated from an O&M perspective due to the numerous steps required to maintain the best conditions for microbial growth, and it requires a larger treatment system area. For wellhead treatment, Alternative 2 is the most feasible of the alternatives because ion exchange is proven to remove perchlorate and can fit into smaller areas for treatment. However, tailored LGAC is less expensive to construct and operate than Alternatives 2 and 4 and can fit onto a smaller system.

Implementing Alternatives 2, 3, and 4 would involve some administrative considerations. All response actions would need to comply with the substantive requirements of applicable permitting rules. Specifically, the installation of extraction wells, the construction of treatment systems, and the discharge of treated groundwater could trigger substantive requirements. Coordination with the appropriate state and local entities, including local water management agencies, would be necessary.

EPA will determine the state and community acceptance of a removal action alternative identified in the EE/CA after the state reviews the document during the stakeholder review period and public comment period. This information will be provided in the Final EE/CA.

6.1.3 Costs

The cost estimates of O&M and net present value (using a 7 percent discount rate) are lowest for Alternative 2. Alternative 4 is approximately three times more expensive than Alternatives 2 and 3.

For wellhead treatment, Alternative 3 appears to rate as the most cost-effective because the cost of tailored LGAC is less expensive than ion exchange (Alternative 2) and ex-situ bioremediation (Alternative 4), and it potentially can be combined with VOC treatment.

6.2 Preferred Alternative

Based on a favorable balance of performance against the criteria evaluated, EPA recommends implementation of Alternative 2 to address the RAOs. Compared to the other three alternatives considered, Alternative 2 provides the following advantages.

- Proven technology to reduce perchlorate contamination to nondetectable concentrations.
- Part of existing MTS.
- Commercially available and broadly accepted technology.
- Lowest overall cost to address perchlorate contamination at MTS.

7. References

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Tables

TABLE 2-1
 Chronology of Events
 PGA North Site-Goodyear, Arizona

Event	Date
Unidynamics Phoenix, Inc. (UPI) established a research, development and manufacturing plant for defense and aerospace equipment in Goodyear, Arizona.	1963
Arizona Department of Health Services (ADHS) discovered that groundwater in the Goodyear area was contaminated with solvents and chromium.	1981
EPA added the PGA Site (originally listed as the "Litchfield Airport Area Superfund Site") to the National Priorities List (NPL).	September 1983
EPA issued first of several orders to UPI "to conduct a comprehensive sampling and analysis program to support subsequent remedial actions." (Resource Conservation and Recovery Act [RCRA] Administrative Order (Docket No. 84-03).	April 1984
Phase I Remedial Investigations began on the entire PGA area.	October 1984
Phase II Remedial Investigations on the PGA North property.	1986
EPA published a Remedial Investigation/Feasibility Study (RI/FS) that identified two areas of noncontiguous contamination (PGA North and PGA South).	June 1989
EPA issued a ROD that applied to both the PGA North and PGA South Sites. For PGA North, the main ROD requirements were groundwater remediation of volatile organic compound (VOC) contamination in Subunits A and B/C using extraction and treatment, and soil remediation using soil vapor extraction (SVE) with granular activated carbon (GAC).	September 1989
Groundwater extraction and treatment system for Subunit A groundwater implemented at PGA South (trigger for five-year review for PGA South and PGA North).	1990
EPA issued an Amended Administrative Order (Docket No. 90-20) to UPI for Remedial Design and Remedial Action to implement the PGA North ROD remedy.	October 1990
EPA issued Explanation of Significant Difference (ESD) #1 to the 1989 ROD.	January 1991
EPA issued ESD #2.	May 1993
UPI facility manufacturing operations ceased.	1994
Full-scale SVE operations began at PGA North.	June 1994
Phase I groundwater treatment system for VOCs, with onsite re-injection back into the Subunit A aquifer, began at PGA North.	September 1994
Phase II / III groundwater treatment system began operation at PGA North.	October 1996
Perchlorate first detected in area monitoring wells.	August 1998
UPI shut down SVE system due to operational difficulties.	October 1998
TCE and perchlorate detected in several domestic supply wells southeast of the UPI facility.	2001
TCE detected above the maximum contaminant level (MCL) for the first time in Subunit C monitor well MW-20 (located north of the main manufacturing area). Concentrations continue to increase over time.	May 2001
MW-20 converted to a temporary extraction well connected to the Phase II / III groundwater treatment system for Subunit C groundwater treatment.	March 2002
EPA issued ESD #5.	September 2002

TABLE 2-1
Chronology of Events
PGA North Site-Goodyear, Arizona

Event	Date
EPA issued a Unilateral Administrative Order (Docket No. CERCLA 9-2003-0001) to restart the SVE system with a GAC treatment unit.	January 2003
TCE concentrations in City of Goodyear production well City of Goodyear (COG)-02, located about ¼ mile east of the UPI facility, increase above MCL forcing closure of that well.	May 2003
Elevated soil gas and groundwater concentrations found north of the UPI manufacturing buildings (boring B-4 (CH2M HILL, 2004) triggering collection and analysis of indoor air samples from buildings in vicinity of the elevated levels.	September 2003 and February 2005
Reinjection stopped at the Main Treatment System (MTS) due to lack of perchlorate treatment. TCE-treated water discharged to Waste Water Treatment Plant for perchlorate treatability study.	October 2003
EPA conducts Phase II Source Area Groundwater Investigation that identified TCE and perchlorate in deeper aquifer, Subunits B and C in source area (perchlorate up to 200 parts per billion [ppb]) (CH2M HILL, 2004).	2003
SVE system restarted using GAC treatment.	April 2004
Scope of Work (SOW) developed to comprehensively address the soil, soil gas, and groundwater impacts attributed to the Site, including investigation of main dry wells area.	2005
TCE concentrations in production well COG-10, located about one mile north of the UPI facility, increase above MCL, forcing closure of that well.	April 2005
Perchlorate treatment using ion exchange technology added to the MTS. Treated effluent re-injected into Subunit A groundwater.	April 2005
Partial Consent Decree (CD) between the U.S. and Crane/UPI entered by U.S. District Court of the District of Arizona. CD requires Crane/UPI to implement SOW.	June 2006
Five-Year Report issued for PGA North Site.	September 2006

TABLE 2-2
Data Quality Objectives Summary
PGA North Site-Goodyear, Arizona

Step	Process	Response
1	State the problem.	Past activities at the former Unidynamics Phoenix, Inc. (UPI) facility within the Phoenix-Goodyear Airport-North (PGA-North) site resulted in the release of chemicals of concern (COCs) including trichloroethene (TCE), other volatiles organic compounds (VOCs) and perchlorate. TCE and perchlorate are present in groundwater at the site at concentrations exceeding site-specific cleanup levels and performance standards. Consequently, the United States Environmental Protection Agency (EPA) requires that an Engineering Evaluation/Cost Analysis (EE/CA) be completed for perchlorate. TCE has been covered by the Record of Decision (ROD). Perchlorate was identified as a COC after the ROD was signed.
2	Identify the decision(s) questions.	What is the most appropriate non-time-critical perchlorate removal action alternative for the site?
3	Identify inputs that affect the decision.	<ul style="list-style-type: none"> • Existing site data and data gap analysis • Applicable or relevant and appropriate requirements (ARARs) • Streamlined Risk Evaluation (SRE) • Removal Action Goals and Objectives • List of Action/Technologies • Selection Criteria <ul style="list-style-type: none"> – Effectiveness <ul style="list-style-type: none"> • Overall protection of human health and the environment (based on outcome of risk evaluation) • Compliance with ARARs • Long-term effectiveness • Reduction of toxicity, mobility, and volume through treatment • Short-term effectiveness – Implementability – Cost – Public Input
4	What are the boundaries of the study?	<ul style="list-style-type: none"> • Media to be evaluated: Groundwater throughout the areal extent of the perchlorate plume as defined by the monitoring network. • Spatial and Temporal Boundaries: Spatial boundaries are defined by the extent of the perchlorate-contaminated plume. Temporal boundaries are defined by the schedule for completion of the EE/CA and Action Memorandum (September 2007).
5	Identify decision rules.	If EPA selects an appropriate removal alternative, then protection of human health and the environment will be facilitated.
6	Limits on decision errors.	<p>Decision errors occur when the data obtained are misleading or are improperly interpreted and resultant actions are taken that are not based on true site conditions or characteristics. The following measure will be implemented to ensure that decisions errors are minimized:</p> <ul style="list-style-type: none"> • Evaluate data spatially and temporally within the plume so that an evaluation of the heterogeneous nature of site geology has been accounted for and can be factored into the remediation and management of the contaminant plume.
7	Optimize the design.	Implement the removal action.

Table 2-3

Perchlorate Analytical Results (First Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Monitoring Wells				
Chevron MW-08	A	N	2/3/2006	<5
Chevron MW-09	A	N	2/3/2006	<1
Chevron MW-09	A	FD	2/3/2006	<1
EMW-29A	A	N	2/9/2006	<1
MW-01	A	N	2/6/2006	10.4
MW-02	A	N	2/8/2006	25.4
MW-03	A	N	2/7/2006	20.1
MW-04	A	N	2/7/2006	18.8
MW-07	A	N	2/8/2006	33.5
MW-08	A	N	2/6/2006	10.5
MW-09	A	N	2/6/2006	16.1
MW-11	A	N	2/1/2006	2.3
MW-12	A	N	2/8/2006	9.9
MW-13	A	N	2/1/2006	<2
MW-15	A	N	2/6/2006	2.4
MW-16	A	N	2/7/2006	3.1
MW-17	A	N	2/1/2006	1.5
MW-18	A	N	1/20/2006	3.8
MW-18	A	N	2/7/2006	3.4
MW-18	A	FD	2/7/2006	3.9
MW-19	A	N	2/7/2006	<2
MW-22	A	N	2/1/2006	1.7
MW-24	A	N	2/3/2006	<2
MW-25	A	N	1/19/2006	4.9
MW-25	A	N	2/8/2006	6.4
MW-27	A	N	2/7/2006	44.7
PZ-01	A/B	N	2/8/2006	40.9
PZ-01	A/B	FD	2/8/2006	40.8
OW-B	B	N	2/9/2006	17
MW-06	C	N	2/6/2006	2.7
MW-06	C	FD	2/6/2006	3.7
MW-10	C	N	2/1/2006	1.5
MW-14	C	N	2/1/2006	1.2
MW-21	C	N	2/2/2006	2.7
MW-23	C	N	2/3/2006	3.1
MW-26	C	N	2/3/2006	<1
MW-28	C	N	2/2/2006	4
MW-29	C	N	2/2/2006	3.2
OW-C	C	N	2/1/2006	<1
OW-C	C	N	2/3/2006	<1
Production Wells, Irrigation				
AE1W	B/C	N	2/2/2006	4.9
SunCor-34B	B/C/M	N	2/10/2006	<2
PSDW	C	N	1/19/2006	3.4
PSDW	C	N	2/2/2006	3.1
PSDW	C	FD	2/2/2006	3.7

Table 2-3

Perchlorate Analytical Results (First Quarter 2006)
 PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Production Wells, Domestic				
COG-01	C	N	1/19/2006	3.3
GOG-01	C	N	2/9/2006	3.7
COG-03	C	N	2/9/2006	1.3
COA-01	C/M	N	2/3/2006	1.5
COG-06	C/M	N	2/9/2006	1.6
COG-06	C/M	FD	2/9/2006	1.6
COG-11	C/M	N	2/9/2006	1.9
COG-18A	C/M	N	2/9/2006	1.2
COA-15	L	N	2/3/2006	1.3
COA-18	L	N	2/3/2006	<1
Tank (COG-11)		N	1/19/2006	2
Tank (COG-11)		N	2/9/2006	1.7
Remediation Wells, Water				
EA-01	A	N	2/8/2006	34
EA-02	A	N	2/6/2006	3
EA-03	A/B	N	2/7/2006	8.9
33A	A/B/C	N	1/19/2006	4.1
33A	A/B/C	N	2/7/2006	5
EB-01	B	N	2/7/2006	22.2
MW-20	C	N	1/19/2006	4.9
MW-20	C	FD	1/19/2006	4.9
MW-20	C	N	2/7/2006	6.1
Treatment System, Water				
IX-EFF		N	1/19/2006	<2
IX-EFF		N	2/9/2006	<1
IX-EFF		FD	2/9/2006	<1
IX-INF		N	1/19/2006	11.7
IX-INF		N	2/9/2006	12
Performance Evaluation Samples				
MW-30		PE	2/3/2006	4.8
MW-31		PE	2/3/2006	4.8
MW-32		PE	2/3/2006	4.9

Notes:

Shaded area indicates concentrations that exceed the HBGL of 14 µg/L

N = Normal sample, analyzed by Aerotech Environmental Laboratories

FD = Field duplicate sample, analyzed by Aerotech Environmental Laboratories

PE = Performance Evaluation provided by EPA, analyzed by Aerotech Environmental Laboratories.

A = Subunit A of the Upper Alluvial Unit

B = Subunit B of the Upper Alluvial Unit

C = Subunit C of the Upper Alluvial Unit

M = Middle Alluvial Unit

L = Lower Alluvial Unit

Table 2-4

Perchlorate Analytical Results (Second Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Monitoring Wells				
Chevron MW-08	A	N	5/6/2006	<4 R
Chevron MW-09	A	N	5/6/2006	<4 R
EMW-29A	A	N	5/3/2006	<4
MW-01	A	N	5/8/2006	5
MW-01	A	FD	5/8/2006	5.6
MW-02	A	N	5/10/2006	24.4
MW-03	A	N	5/10/2006	13.6
MW-04	A	N	5/9/2006	13.9
MW-07	A	N	5/11/2006	21.3
MW-08	A	N	5/8/2006	7.8
MW-09	A	N	5/8/2006	11.2
MW-11	A	N	5/2/2006	<4
MW-11	A	FD	5/2/2006	<2
MW-12	A	N	5/11/2006	15.5
MW-13	A	N	5/2/2006	<2
MW-15	A	N	5/8/2006	<4
MW-16	A	N	5/9/2006	3.2
MW-17	A	N	5/4/2006	<2
MW-18	A	N	3/7/2006	4.2 J
MW-18	A	FD	3/7/2006	4.1 J
MW-18	A	N	4/6/2006	2
MW-18	A	N	5/9/2006	3.3
MW-18	A	FD	5/9/2006	3.8
MW-19	A	N	5/9/2006	2.1
MW-22	A	N	5/3/2006	<4
MW-25	A	N	3/7/2006	6.5 J
MW-25	A	N	4/6/2006	8
MW-25	A	N	5/10/2006	4.2
MW-25	A	FD	5/10/2006	4.5
MW-27	A	N	3/7/2006	45
MW-27	A	N	4/6/2006	44.4
MW-27	A	N	5/10/2006	45.1
PZ-01	A/B	N	5/11/2006	13.9
OW-B	B	N	5/8/2006	33.6
MW-06	C	N	5/8/2006	2.1
MW-10	C	N	5/2/2006	<2
MW-14	C	N	5/2/2006	3.1
MW-21	C	N	5/5/2006	2.6
MW-23	C	N	5/4/2006	<2
MW-26	C	N	5/3/2006	<2
MW-28	C	N	5/4/2006	3.1
MW-29	C	N	5/5/2006	<4
OW-C	C	N	5/2/2006	<2
MW-1M	M	N	5/2/2006	<4
MW-1M	M	FD	5/2/2006	2.2

Table 2-4

Perchlorate Analytical Results (Second Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Production Wells, Irrigation				
SunCor-3B	A/B/C/M	N	5/5/2006	<2
AE1W	B/C	N	5/4/2006	4.1
SunCor-34B	B/C/M	N	3/9/2006	<2.0
SunCor-34B	B/C/M	N	4/7/2006	<2
SunCor-34B	B/C/M	N	5/5/2006	<4
PSDW	C	N	3/7/2006	<4.0 J
PSDW	C	N	4/6/2006	3.2
PSDW	C	N	5/9/2006	3
Production Wells, Domestic				
COG-01	C	N	3/8/2006	5.2
GOG-01	C	N	4/6/2006	4.3
COG-01	C	N	5/3/2006	3.7
COG-01	C	FD	5/3/2006	3.7
COG-03	C	N	4/6/2006	<2
COG-03	C	N	5/3/2006	<2
COA-01	C/M	N	5/4/2006	<2
COG-06	C/M	N	5/3/2006	<2
COG-11	C/M	N	5/3/2006	<2
COG-18A	C/M	N	5/3/2006	<2
COA-15	L	N	5/4/2006	<2
COA-18	L	N	5/4/2006	<2
COG-18B	M	N	5/3/2006	<2
Tank (COG-11)		N	3/8/2006	<4.0
Tank (COG-11)		N	4/6/2006	<2
Tank (COG-11)		N	5/3/2006	<2
Remediation Wells, Water				
EA-01	A	N	5/10/2006	35.4
EA-02	A	N	5/8/2006	2.8
EA-03	A/B	N	5/10/2006	13.1
EB-01	B	N	5/10/2006	20.1
MW-20	C	N	3/7/2006	8.7 J
MW-20	C	N	3/13/2006	<10 J
MW-20	C	N	4/6/2006	5.5
MW-20	C	FD	4/6/2006	6.1
MW-20	C	N	4/20/2006	6
MW-20	C	N	5/9/2006	5.7
COG-10	M	N	5/6/2006	<2 R
COG-10	M	N	5/18/2006	<2
Treatment System, Water				
IX-EFF		N	3/8/2006	3.1 J
IX-EFF		FD	3/8/2006	<3.0
IX-EFF		N	4/7/2006	<2
IX-EFF		N	5/11/2006	<4
IX-INF		N	3/8/2006	15
IX-INF		N	4/7/2006	14
IX-INF		N	5/11/2006	14.3

Table 2-4

Perchlorate Analytical Results (Second Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Performance Evaluation Samples				
MW-30		PE	5/5/2006	95.6
MW-31		PE	5/5/2006	4.3

Notes

Shaded area indicates concentrations that exceed the HBGL of 14 µg/L

N = Normal sample, analyzed by Aerotech Environmental Laboratories

FD = Field duplicate sample, analyzed by Aerotech Environmental Laboratories

PE = Performance Evaluation provided by EPA, analyzed by Aerotech Environmental Laboratories.

J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample

R = Sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. Therefore, the presence or absence of the analyte in the samples in this sample delivery group cannot be verified.

A = Subunit A of the Upper Alluvial Unit

B = Subunit B of the Upper Alluvial Unit

C = Subunit C of the Upper Alluvial Unit

M = Middle Alluvial Unit

L = Lower Alluvial Unit

Table 2-5

Perchlorate Analytical Results (Third Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Monitoring Wells				
Chevron MW-08	A	N	8/4/2006	3.5
Chevron MW-09	A	N	8/14/2006	2.3
EMW-29A	A	N	8/7/2006	2.0
EPA MW-10A	A	N	8/14/2006	1.9
MW-01	A	N	8/9/2006	4.3
MW-02	A	N	8/10/2006	24
MW-03	A	N	8/10/2006	8.3
MW-04	A	N	8/10/2006	7.3
MW-07	A	N	8/10/2006	20
MW-08	A	N	8/9/2006	8.2
MW-09	A	N	8/10/2006	16
MW-11	A	N	8/8/2006	2.3
MW-12	A	N	8/2/2006	14
MW-13	A	N	8/8/2006	<2
MW-13	A	FD	8/8/2006	2.2
MW-15	A	N	8/8/2006	<2
MW-16	A	N	8/3/2006	4.1
MW-18	A	N	6/8/2006	4
MW-18	A	FD	6/8/2006	3.7
MW-18	A	N	7/6/2006	3.5
MW-18	A	N	8/3/2006	5.0
MW-19	A	N	8/9/2006	2.5
MW-22	A	N	8/8/2006	2.6
MW-24	A	N	8/3/2006	5.1
MW-25	A	N	6/7/2006	4.4
MW-25	A	N	7/6/2006	3.5
MW-25	A	FD	7/6/2006	3.4
MW-25	A	N	8/3/2006	4.4
MW-25	A	FD	8/3/2006	4.4
MW-27	A	N	6/7/2006	44.2
MW-27	A	N	7/6/2006	43.5
MW-27	A	N	8/2/2006	41
PZ-01	A/B	N	8/10/2006	16
OW-B	B	N	8/10/2006	40
EPA MW-9C	C	N	8/14/2006	3.1
MW-06	C	N	8/9/2006	5.0
MW-10	C	N	8/9/2006	2.5
MW-14	C	N	8/8/2006	3.5
MW-21	C	N	8/7/2006	3.2
MW-21	C	FD	8/7/2006	2.8
MW-23	C	N	8/9/2006	3.7
MW-26	C	N	6/7/2006	<2
MW-26	C	N	7/6/2006	<2
MW-26	C	N	8/9/2006	<2.0
MW-28	C	N	8/8/2006	4.1
MW-29	C	N	6/7/2006	5.4
MW-29	C	N	7/6/2006	7.5
MW-29	C	N	8/2/2006	5.9
OW-C	C	N	8/9/2006	1.6
OW-C	C	N	8/9/2006	2.1

Table 2-5

Perchlorate Analytical Results (Third Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Production Wells, Irrigation				
SunCor-3B	A/B/C/M	N	6/7/2006	1.7 J
SunCor-3B	A/B/C/M	N	8/3/2006	2.1
AE1W	B/C	N	8/9/2006	4.6
SunCor-27A	B/C/M	N	6/9/2006	2.4
SunCor-27A	B/C/M	N	6/20/2006	2.7
SunCor-27A	B/C/M	FD	6/20/2006	2.2
SunCor-34B	B/C/M	N	8/4/2006	2.7
SunCor-34B	B/C/M	N	8/14/2006	2.7
SunCor-34B	B/C/M	FD	8/14/2006	2.5
PSDW	C	N	6/8/2006	3.2
PSDW	C	N	7/7/2006	3.2
PSDW	C	N	8/9/2006	3.2
Production Wells, Domestic				
COG-01	C	N	6/8/2006	5.2
GOG-01	C	N	7/7/2006	3.7
COG-01	C	N	8/7/2006	4.3
COG-03	C	N	7/7/2006	1.2 J
COG-03	C	N	8/7/2006	1.6 J
COA-01	C/M	N	8/10/2006	2.2
COG-06	C/M	N	8/7/2006	1.9 J
COG-11	C/M	N	8/7/2006	2.2
COG-18A	C/M	N	8/7/2006	1.7 J
Tank (COG-11)	C/M	N	6/8/2006	1.4
Tank (COG-11)	C/M	N	7/7/2006	1.1 J
Tank (COG-11)	C/M	N	8/7/2006	1.7 J
COA-15	L	N	8/10/2006	<2
COA-18	L	N	8/10/2006	1.2
COG-18B	M	N	8/7/2006	<2.0
Remediation Wells, Water				
EA-01	A	N	8/10/2006	33
EA-02	A	N	8/10/2006	3.5
EA-02	A	FD	8/10/2006	3.8
EA-03	A/B	N	8/10/2006	10
EB-01	B	N	8/10/2006	20
EB-01	B	FD	8/10/2006	20
MW-20	C	N	6/7/2006	8.8
MW-20	C	N	7/6/2006	6.9
MW-20	C	N	8/10/2006	6
COG-10	M	N	6/7/2006	1.3 J
COG-10	M	N	7/7/2006	<2
COG-10	M	FD	7/7/2006	0.78
COG-10	M	N	8/3/2006	2.4

Table 2-5

Perchlorate Analytical Results (Third Quarter 2006)

PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Performance Evaluation Samples				
MW-30		PE	8/30/2006	4.9
MW-31		PE	8/30/2006	190

Notes

Shaded area indicates concentrations that exceed the HBGL of 14 µg/L

N = Normal sample, analyzed by Aerotech Environmental Laboratories

FD = Field duplicate sample, analyzed by Aerotech Environmental Laboratories

PE = Performance Evaluation provided by EPA, analyzed by Aerotech Environmental Laboratories.

J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample

A = Subunit A of the Upper Alluvial Unit

B = Subunit B of the Upper Alluvial Unit

C = Subunit C of the Upper Alluvial Unit

M = Middle Alluvial Unit

L = Lower Alluvial Unit

Table 2-6
Perchlorate Analytical Results (Fourth Quarter 2006)
PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Monitoring Wells				
APS	A	N	11/9/2006	<2.0
APS	A	N	12/18/2006	<0.36
CK MW-1	A	N	10/6/2006	1.9 J
Chevron MW-08	A	N	11/10/2006	<2.0
Chevron MW-09	A	N	11/10/2006	4.1
EMW-29A	A	N	11/9/2006	<2.0
EMW-29A	A	FD	11/9/2006	<2.0
EPA MW-10A	A	N	10/5/2006	1.8 J
EPA MW-10A	A	FD	10/5/2006	1.9 J
EPA MW-10A	A	N	11/8/2006	1.8 J
EPA MW-10A	A	N	12/15/2006	1.8 J
EPA MW-10A	A	FD	12/15/2006	2
EPA MW-16A	A	N	9/1/2006	3.9
EPA MW-16A	A	N	11/8/2006	4.9
EPA MW-16A	A	FD	11/8/2006	4.6
EPA MW-16A	A	N	12/18/2006	5.8
EPA MW-17A	A	N	12/1/2006	<2.0
EPA MW-17A	A	FD	12/1/2006	<4.0
EPA MW-17A	A	N	12/18/2006	4.8
EPA MW-17A	A	FD	12/18/2006	3.5 J
EPA MW-18A	A	N	9/1/2006	<2.0
EPA MW-18A	A	N	10/5/2006	<2.0
EPA MW-18A	A	N	11/8/2006	<2.0
EPA MW-18A	A	N	12/15/2006	1.1 J
EPA MW-20A	A	N	9/1/2006	4.2
EPA MW-20A	A	N	11/8/2006	4.0
EPA MW-20A	A	N	12/15/2006	0.89 J
MW-01	A	N	11/2/2006	1.6 J
MW-02	A	N	11/7/2006	32
MW-03	A	N	11/6/2006	7.1
MW-04	A	N	11/6/2006	4.3
MW-04	A	FD	11/6/2006	4.4
MW-07	A	N	11/7/2006	22
MW-08	A	N	11/3/2006	6.3
MW-09	A	N	11/3/2006	18
MW-11	A	N	11/1/2006	2.3
MW-12	A	N	11/7/2006	13
MW-13	A	N	11/1/2006	2.0 J
MW-15	A	N	11/3/2006	1.9 J
MW-16	A	N	11/2/2006	3.5
MW-17	A	N	11/7/2006	1.8 J
MW-18	A	N	9/7/2006	4.3
MW-18	A	N	10/6/2006	3.9
MW-18	A	N	11/7/2006	3.4
MW-18	A	N	12/13/2006	4.2
MW-19	A	N	11/3/2006	2.1
MW-22	A	N	11/2/2006	2.5

Table 2-6
Perchlorate Analytical Results (Fourth Quarter 2006)
PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Monitoring Wells (continued)				
MW-24	A	N	11/3/2006	2.0
MW-25	A	N	9/7/2006	4.2
MW-25	A	N	10/6/2006	4.2
MW-25	A	N	11/7/2006	3.5 J
MW-25	A	N	12/13/2006	3.9
MW-27	A	N	9/7/2006	43
MW-27	A	N	10/6/2006	44
MW-27	A	N	11/7/2006	42
MW-27	A	N	12/13/2006	45
PZ-01	A/B	N	11/7/2006	18
EPA MW-6C	C	N	11/9/2006	<2.0
EPA MW-6C	C	N	12/14/2006	5.2
EPA MW-9C	C	N	10/5/2006	3.2
EPA MW-9C	C	N	11/8/2006	3.1
EPA MW-9C	C	N	12/14/2006	3.6
MW-06	C	N	11/6/2006	4.1
MW-10	C	N	11/2/2006	2.0
MW-14	C	N	11/1/2006	3.2
MW-14	C	FD	11/1/2006	3.1
MW-21	C	N	11/2/2006	2.5
MW-23	C	N	11/3/2006	3.4
MW-26	C	N	9/7/2006	<2.0
MW-26	C	FD	9/7/2006	<2.0
MW-26	C	N	10/4/2006	<2.0
MW-26	C	N	11/2/2006	<2.0
MW-26	C	N	12/12/2006	<2.0
MW-26	C	FD	12/12/2006	<2.0
MW-28	C	N	11/2/2006	3.7
MW-29	C	N	9/8/2006	6.7
MW-29	C	N	10/4/2006	7.3
MW-29	C	N	11/6/2006	6.5
MW-29	C	N	12/12/2006	8.5
OW-C	C	N	11/2/2006	1.3 J
OW-C	C	FD	11/2/2006	1.7 J
EPA MW-1M	M	N	9/7/2006	4.2
EPA MW-1M	M	N	10/6/2006	3.2
EPA MW-1M	M	N	11/10/2006	<2.0
EPA MW-1M	M	N	12/14/2006	3.4 J
EPA MW-28M	M	N	9/6/2006	<2.0
EPA MW-28M	M	N	11/10/2006	<2.0
EPA MW-28M	M	N	12/14/2006	<2.0 UJ

Table 2-6
Perchlorate Analytical Results (Fourth Quarter 2006)
PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Production Wells, Irrigation				
SunCor-3B	A/B/C/M	N	10/9/2006	2.1
SunCor-3B	A/B/C/M	N	11/16/2006	<2.0
SunCor-3B	A/B/C/M	FD	11/16/2006	<2.0
SunCor-3B	A/B/C/M	N	12/22/2006	1.8 J
AE1W	B/C	N	11/6/2006	4.7
SunCor-27A	B/C/M	N	9/5/2006	3.0
SunCor-27A	B/C/M	N	11/9/2006	<2.0
SunCor-34B	B/C/M	N	9/1/2006	<2.0
SunCor-34B	B/C/M	FD	9/1/2006	<2.0
SunCor-34B	B/C/M	N	10/5/2006	2.6
SunCor-34B	B/C/M	N	11/13/2006	<2.0
SunCor-34B	B/C/M	FD	11/13/2006	<2.0
SunCor-34B	B/C/M	N	12/18/2006	1.1 J
PSDW	C	N	9/7/2006	3.4
PSDW	C	N	11/6/2006	3
Production Wells, Domestic				
COG-01	C	N	9/8/2006	4.3
GOG-01	C	N	10/4/2006	4.6
COG-01	C	N	11/9/2006	4.7
COG-01	C	N	12/13/2006	5.2
COG-03	C	N	10/13/2006	1.7 J
COG-03	C	N	11/29/2006	<2.0
COG-03	C	N	12/22/2006	0.78 J
COA-01	C/M	N	11/8/2006	2 J
COG-06	C/M	N	12/22/2006	1.7 J
COG-11	C/M	N	11/9/2006	<2.0
COG-18A	C/M	N	11/9/2006	<2.0
COA-15	L	N	11/8/2006	2.5
COA-18	L	N	11/8/2006	<2.0
COG+A120-18B	M	N	11/9/2006	<2.0
LPW-894	C	N	12/1/2006	<2.0
LPW-894	C	FD	12/1/2006	<2.0
LPW-894	C	N	12/15/2006	1.1 J
Tank (COG-11)	C/M	N	9/8/2006	2.3
Tank (COG-11)	C/M	N	10/4/2006	2.4
Tank (COG-11)	C/M	N	11/9/2006	<2.0

Table 2-6
 Perchlorate Analytical Results (Fourth Quarter 2006)
 PGA North Site-Goodyear, Arizona

Well ID	Subunit	Type	Date	Perchlorate (µg/L)
Remediation Wells, Water				
EA-01	A	N	11/8/2006	34
EA-02	A	N	11/6/2006	3.8
EA-03	A/B	N	11/7/2006	7.9
33A	A/B/C	N	9/11/2006	5.7
33A	A/B/C	N	10/4/2006	6.0
33A	A/B/C	N	11/1/2006	6.2
33A	A/B/C	N	12/12/2006	5.4
EB-01	B	N	11/6/2006	22
EC-01	C	FD	11/10/2006	<2.0
MW-20	C	N	9/7/2006	6.9
MW-20	C	N	10/4/2006	7.1
MW-20	C	N	11/7/2006	5.9
MW-20	C	FD	11/7/2006	6.4
COG-10	M	N	10/6/2006	2.2
COG-10	M	FD	10/6/2006	2.0
COG-10	M	N	11/1/2006	1.6 J
COG-10	M	N	12/1/2006	<2.0
COG-10	M	N	12/15/2006	1.5 J

Notes

Shaded area indicates concentrations that exceed the HBGL of 14 µg/L

N = Normal sample, analyzed by Aerotech Environmental Laboratories

FD = Field duplicate sample, analyzed by Aerotech Environmental Laboratories

J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample

UJ = Analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

A = Subunit A of the Upper Alluvial Unit

B = Subunit B of the Upper Alluvial Unit

C = Subunit C of the Upper Alluvial Unit

M = Middle Alluvial Unit

L = Lower Alluvial Unit

Table 2-7
Summary of Hazard Quotients from Exposure to Groundwater Used as Domestic Tap Water
 Streamlined Risk Evaluation
 PGA North Site-Goodyear, Arizona

Subunit (Well)	EPC basis	Hazard Quotients	
		EPA	ADHS
Subunit A (MW-27)	95% UCL	2	3
Subunit B (OW-B)	95% UCL	2	3
Subunit C (PSDW)	Maximum	5	9

Notes

MW = Monitoring Well

OW = Observation Well

PSDW = Park Shadows Domestic Well

EPC = Exposure Point Concentration

EPA = U.S. Environmental Protection Agency

ADHS = Arizona Department of Health Services

95% UCL = 95th percentile of upper confidence limit on the mean

Table 2-8
Perchlorate Screening Levels for Groundwater Used as Domestic Tap Water
 Streamlined Risk Evaluation
 PGA North Site-Goodyear, Arizona

Regulatory Agency Source	Health-based screening level ($\mu\text{g/L}$)	Receptor	Basis
EPA, 2005	24.5	Adult	100% contribution from tap water ingestion
ADHS, 2000	14	Child	100% contribution from tap water ingestion
Notes EPA = U.S. Environmental Protection Agency ADHS = Arizona Department of Health Services $\mu\text{g/L}$ = micrograms per liter			

Table 2-9
Groundwater Concentrations of Perchlorate - Subunits A, B, and C
 Streamlined Risk Evaluation
 PGA North Site-Goodyear, Arizona

Subunit (Well)	EPC basis	Groundwater Concentration (µg/L)
Subunit A (MW-27)	95% UCL	45
Subunit B (OW-B)	95% UCL	37
Subunit C (PSDW)	Maximum	130

Notes

MW = Monitoring Well

OW = Observation Well

PSDW = Park Shadows Domestic Well

EPC = Exposure Point Concentration

95% UCL = 95th percentile of upper confidence limit on the mean

µg/L = micrograms per liter

TABLE 3-1
 Removal Action Objectives and Removal Objective Goals
PGA North

Removal Action Objective (RAO)	Removal Objective Endpoints/Goals
Remove perchlorate contamination from extracted groundwater at the Site to prevent exposure	<ul style="list-style-type: none"> • Conduct effluent monitoring at a determined frequency prior to use for domestic purposes/reinjection or other use to ensure against exposure. • Monitor extraction wells to ensure perchlorate contamination not in exceedence of cleanup standard. • Demonstration of removal of contaminant mass in groundwater through collecting data at a determined frequency and calculating mass removed (by comparing mass remaining to baseline mass). • Documentation of successful treatment system operations through effective mass removal and adequate system monitoring. • Operation of groundwater treatment system(s) to attain health protective levels through sufficient contaminant mass reduction and operation of system until limits of system effectiveness are reached, as demonstrated by insufficient ongoing mass removal to warrant continued operations.
Remove perchlorate contamination from extracted groundwater at the Site prior to reinjection or other use to prevent further impacts to groundwater or surface waters	<ul style="list-style-type: none"> • Conduct effluent monitoring at a determined frequency prior to use for domestic purposes/reinjection or other use to ensure against exposure. • Monitor extraction wells to ensure perchlorate contamination not in exceedence of cleanup standard. • Demonstration of removal of contaminant mass in groundwater through collecting data at a determined frequency and calculating mass removed (by comparing mass remaining to baseline mass). • Documentation of successful treatment system operations through effective mass removal and adequate system monitoring.

TABLE 3-2
 Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Documents
 PGA North

Requirements	Description	Media	Applicable or Relevant and Appropriate
Chemical-Specific ARARs			
National Drinking Water Regulations Title 42 United States Code (U.S.C.) Sections (§§)300g-l Title 40 Code of Federal Regulations (CFR) Part 141	Federal primary maximum contaminant levels (MCLs) under the Safe Drinking Water Act protect the public from contaminants that may be found in drinking water. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) defines MCLs as relevant and appropriate for groundwater that is a potential source of drinking water. Because there is no MCL for perchlorate, until an MCL is determined, the perchlorate cleanup level for this removal action is based on risk using TBC standards below.	Groundwater	Relevant and Appropriate
Location-Specific ARARs			
Resource Conservation and Recovery Act (RCRA) Title 42 U.S.C. Section (§)6901 <i>et seq.</i> ; Arizona Revised Statutes (ARS) §49-921 <i>et seq.</i> ; Title 40 CFR §§264.18(a) and (b); Arizona Administrative Code (AAC) §§18-8-264.18(a) and (b) Title 40 CFR §141.5b	Design, construction, operation, and maintenance requirements for new facilities and expansion of old facilities to prevent damage due to earthquakes or washout of any hazardous waste by a 100-year flood.	Groundwater	Relevant and Appropriate
ARS §49-224	All aquifers in the State of Arizona identified under §49-222(A) and any other aquifers subsequently discovered are classified for drinking water protected use. The aquifers at the PGA-North Site have been identified as drinking water sources.	Groundwater	Applicable
ARS §45-454.01	Exempts Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) response actions from requirements of ARS §45-401 <i>et. seq</i> if water is withdrawn, treated, and reinjected onsite. Provides certain well drilling and construction standards.	Groundwater	Relevant and Appropriate
ARS, Article 3 §49-241	Discharges of treated water must meet substantive requirements of Aquifer Protection Permit.	Groundwater	Applicable
AAC §§R18-4-501 and 502	Requirements for new treatment units including appropriate siting.	Groundwater	Applicable
ARS §49-223	Recharged or reinjected groundwater must meet Arizona Aquifer Water Quality Standards. A discharge shall not cause a pollutant to be present in an aquifer classified as protected for drinking water in a concentration which endangers human health, or if it could impair existing or reasonably foreseeable uses of water in an aquifer.	Groundwater	Applicable

TABLE 3-2
 Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Documents
 PGA North

Requirements	Description	Media	Applicable or Relevant and Appropriate
Action-Specific ARARs			
Hazardous Waste Regulations Accumulation Time Title 40 CFR §262.34	Regulates temporary accumulation of hazardous waste on site. Specifies procedures for accumulation of hazardous wastes onsite for limited quantities of hazardous waste and for limited time periods under generator status. The substantive requirements of this section are relevant and appropriate to management of waste materials generated as a result of operation of any of the groundwater treatment plants where the waste material generated is hazardous waste.	Groundwater	Relevant and Appropriate
RCRA 40 CFR 264 (Subpart X): §§264.600, 264.601, 264.602, 264.603 AAC §R18-8-264	Requirements for operation of treatment, storage, and disposal facilities. Miscellaneous treatment units must satisfy environmental performance standards by protection of groundwater, surface water, and air quality, and by limiting surface and subsurface migration.	Groundwater	Relevant and Appropriate
RCRA Subtitle C ARS §49-921 <i>et seq.</i> 40 CFR 264.1(j)(2-6, 10-12) AAC §R18-8-264.1(j)(2-6, 10-12)	Requirements for waste management sites, specifically waste analysis, inspection requirements, personnel training requirements, and contingency and emergency plans.	Groundwater	Relevant and Appropriate
RCRA Subtitle C ARS §49-921 <i>et seq.</i> 40 CFR 264 Subpart I §§264.170-178 AAC §§R18-8-264 (170-178)	Requirements for containers holding RCRA hazardous waste for treatment, storage or disposal including condition, management, and inspection of containers, container compatibility with wastes and design and operation of container storage areas. Substantive provisions apply.	Groundwater	Relevant and Appropriate
RCRA Subtitle C ARS §49-921 <i>et seq.</i> 40 CFR 264 Subpart J, except §264.192(a) AAC §§R18-8-264.190 <i>et seq.</i> , except §R-18-264.192(a).	Requirements for tank systems used to store or treat hazardous waste, including design and installation, containment and detection of releases, operating requirements, inspections, responses to leaks or spills and closure and post-closure. Substantive provisions apply.	Groundwater	Relevant and Appropriate
40 CFR Part 261 AAC §R18-8-261	Establishes procedures and numeric limits for identification and management of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes. These requirements are relevant to management of waste materials generated as a result of construction and operation of the selected response action.	Groundwater	Relevant and Appropriate

TABLE 3-2
 Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Documents
 PGA North

Requirements	Description	Media	Applicable or Relevant and Appropriate
40 CFR Part 262.11 AAC §R18-8-262	Requires waste generators to determine whether wastes are hazardous wastes, and establishes procedures for such determinations. Requirements for management of waste materials generated as a result of construction of the selected action or operation of any groundwater treatment units.	Groundwater	Relevant and Appropriate
Clean Water Act 33 U.S.C. §§1311-1387	Establishes Water Quality Criteria for surface waters. The Water Quality Criteria are designed to protect both marine and freshwater aquatic life. The standards are expressed on the basis of acute and chronic toxicity levels. Any treated groundwater that is discharged into a surface water body must meet the Criteria.	Groundwater	Relevant and Appropriate
Clean Water Act 40 CFR §§402 and 405-471 40 CFR Parts 125	Establishes National Pollutant Elimination Discharge System (NPDES) Permit Program which regulates discharges into surface water through treatment and monitoring requirements for such discharge.	Groundwater	Relevant and Appropriate
ARS §49-282.06(A)(2)	To the extent practicable, CERCLA response actions shall provide for the control, management, or cleanup of hazardous substances in order to allow the maximum beneficial use of the waters of the state.	Groundwater	Applicable
ARS §49-221 AAC §§ R18-11-101 et seq	Discharge from treatment systems must comply with Arizona State Water Quality Standards when treated water is discharged to surface water	Groundwater	Applicable
ARS §49-222	Standards to assure water quality for protection of public health and takes into consideration its use and value for public water supplies, propagation of fish and wildlife, recreation, agricultural, industrial and other purposes, including navigation.	Groundwater	Applicable
Safe Drinking Water Act 42 U.S.C. §300f et seq. Title 40 CFR §§144.12 - 144.16	Regulates the reinjection of groundwater through establishment of criteria and standards for the Underground Injection Control Program. These criteria include current and future use, yield and water quality characteristics and are applicable for determining exempt aquifers. Sets forth design construction, operation, and maintenance requirements for injection wells.	Groundwater	Applicable
Aquifer Water Quality Standards AAC §§R18-11-405 (a) and (c)	Narrative Aquifer Water Quality Standards (AWQS) requiring that 1) a discharge not cause a pollutant to be present in an aquifer classified for a drinking water protected use in a concentration which endangers human health; and 2) a discharge not cause a pollutant to be present in an aquifer which impairs existing or reasonably foreseeable uses of water in an aquifer.	Groundwater	Applicable

TABLE 3-2
 Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Documents
 PGA North

Requirements	Description	Media	Applicable or Relevant and Appropriate
Aquifer Protection Requirements ARS §49-241	Requires discharges of treatment water to meet Aquifer Protection Permit requirements. Individual permit requirements include use of best available control technology and showing that discharge would not cause AWQS to be violated at a point of compliance as a result of discharge from the facility. Where aquifer already exceeds the AWQS, the aquifer must not be further degraded.	Groundwater	Relevant and Appropriate
Anti-Degradation ARS §49-243	Prohibits discharges that cause or contribute to a violation of AWQS. In aquifers where standards have been exceeded, no further degradation is permitted.	Groundwater	Applicable
Reinjection Standards ARS §49-223	Recharged or reinjected groundwater must meet AWQS.	Groundwater	Applicable
Pretreatment requirements Title 40 CFR Section 403.5	Provides pretreatment requirements for discharges to a publicly owned treatment works.	Groundwater	Applicable
ARS §§45-594-596 and 600	Requirements and standards for well construction, notice for drilling, and filing of drilling logs.	Groundwater	Applicable
AAC §§R18-4-701 to R18-4-704 and §R18-4-706	Requires annual consumer confidence reports for community notification of water quality.	Groundwater	Applicable
To-Be-Considered Documents			
Arizona Department of Health Services (ADHS) Perchlorate Health-based Guidance Level	Health-Based Guidance Levels (HBGLs) are risk-based levels developed by ADHS to represent concentrations of contaminants in drinking water that are protective of public health during long-term exposure. The ADHS process for determining HBGLs accounts for exposure to children. Arizona's HBGL for perchlorate is 14 parts per billion (ppb).	Groundwater	To Be Considered
United States Environmental Protection Agency (EPA) Region 9 Preliminary Remediation Goals (PRGs)	PRGs are risk-based levels used to screen sites that may require additional investigation and possible remediation. PRGs may also be considered in setting groundwater cleanup standards in the absence of promulgated MCLs for contaminants. EPA Region 9's PRG range for perchlorate is 24.5 ppb.	Groundwater	To Be Considered
EPA and National Academy of Science (NAS) Suggested No Observed Adverse Effects Levels	EPA and the NAS publish risk values for toxicity-based factors other than cancer or incremental cancer risk estimates, including the risk estimates for perchlorate. These risk values are posted on EPA's Integrated Risk Information System (IRIS) in the form of Reference Doses (RfDs), which indicate a daily oral exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD for perchlorate on IRIS is 0.0007 milligrams per kilogram (mg/kg) per day.	Groundwater	To Be Considered

TABLE 4-1
Perchlorate Removal Technology Screening
PGA North Site-Goodyear, Arizona

Removal Technology	Description	Effectiveness	Implementability	Relative Cost Range
Physical Processes				
Ion Exchange	Ion exchange is a reversible physical-chemical reaction wherein an ion from solution is exchanged for a similarly charged ion attached to an immobile solid. During ion exchange, perchlorate which is a negatively charged ion is exchanged with another anion, typically chloride.	High. Has shown be to highly effective at various sites. However, effectiveness could be affected by the high levels of sulfates or nitrate ions. Use of perchlorate selective resins can reduce the negative impact of these competing ions.	Medium to High. Several full scale systems operational; Will require extraction wells and ion exchange resins, which could be regenerative or removed for off-site disposal.	Low to Medium. Can be costly depending on how often is changed or regenerated. Resin usage could be higher if groundwater contains sulfates and nitrates which will use up the resin. Also, disposal of resin for one-pass ion resins or disposal of brine solution from regenerative resins could increase the cost depending on the frequency of change out or regeneration.
Tailored Liquid-phase carbon adsorption	Tailored granular activated carbon (GAC) is used as the adsorption media and perchlorate-contaminated groundwater is allowed to pass through the GAC vessels and thereby the perchlorate gets adsorbed to the surface of the GAC.	Low to Medium. Because GAC media lose effectiveness relatively fast when used for perchlorate removal, this technology is disadvantaged with low treatment capacities. Water-soluble contaminants with high polarity can not be effectively removed by GAC. Also, the presence of suspended solids can plug the GAC causing less removal efficiency unless pre-filtration is included.	Low to Medium. Limited number of full scale installations-has not been widely used for perchlorate; more applicable to lower perchlorate concentrations; development of more effective tailored GAC is underway.	Medium to High. Low capital cost but potentially very high operating costs. The low adsorption capacity of perchlorate on GAC will result in frequent GAC change outs.
Reverse Osmosis (RO)	In reverse osmosis high pressure is applied to one side of a semi-permeable membrane to reverse the osmosis process and force water molecules to pass through the semi-permeable membrane out of the perchlorate-contaminated water. This leaves the perchlorate and most other dissolved salts behind in a concentrated waste stream (up to 30% of the inlet water becomes waste) that must be treated or disposed.	Medium to High. RO has been shown to be effective in removing perchlorate at various sites and studies. However, the presence of organic matter, microorganisms, alkaline earth metals (calcium, magnesium, beryllium etc) could cause membrane fouling causing damage to it. This in turn could reduce the effectiveness of perchlorate removal.	Unknown. Although studies indicate high perchlorate removal rate, only limited bench scale testing has been done to date.	High. High capital cost and moderate to high annual operation cost which includes utility cost, pump and membrane maintenance cost, membrane replacement cost, disposal or treatment of concentrated wastewater stream (up to 30% of total flow) and potential need to pretreat the RO feedwater to prevent fouling.

TABLE 4-1
Perchlorate Removal Technology Screening
PGA North Site-Goodyear, Arizona

Removal Technology	Description	Effectiveness	Implementability	Relative Cost Range
Physical Processes (continued)				
Nanofiltration	Perchlorate-contaminated water is pumped through membranes using high pressure. The membranes act like a shield, preventing particles of a defined size or larger from passing through.	Unknown. Untested for perchlorate removal.	Unknown. Untested for perchlorate removal.	Unknown. Requires high energy and produces brine approximately 20% of the volume of water treated. The brine which contains total dissolved solids and perchlorate needs disposal and could be expensive.
Electrodialysis	Water is passed through alternating permeable-semipermeable membranes, which are selective of anion and cations, while electric current is applied across the membranes. Anionic perchlorate ions accumulate at the cationic-selective membrane and are collected as concentrate or salty water.	Unknown. Pilot studies are still ongoing for this technology.	Unknown. Pilot studies are still ongoing for this technology.	Unknown. Capital and operation and maintenance costs not known; concentrated waste stream would also require further treatment or disposal.
Chemical Processes				
Nano-scale Zero Valent Iron (ZVI)	This method involves contacting the groundwater with iron media that has been manufactured to a particle size of approximately 100 nanometers. Nano-scale iron facilitates the chemical reduction of perchlorate. This method can be used for in-situ treatment by injecting the non-scale iron and also for ex-situ treatment by use of reactors or application through system piping.	Unknown. Untested for perchlorate removal. The in-situ treatment would be limited by low-permeability aquifer and lack of information on specific source areas.	Unknown. Untested in field for perchlorate removal.	High. Cost of nano-scale zero valent iron is relatively high and may not be cost effective for large plumes. For in-situ applications, may require multiple injections, depending on perchlorate concentration, and may need specialized equipment for mixing and injecting the nano-scale zero valent iron.
ZVI Reduction with Ultraviolet Light	Perchlorate-contaminated water is reduced by iron (FeO) under anoxic conditions and ultraviolet light is utilized to accelerate the reaction rate.	Medium to High. A study conducted by San Diego State University demonstrated high effectiveness. However, the study also showed that accumulation of ferrous iron could be detrimental to the reaction rate.	Unknown. Developmental stage.	Unknown. Developmental stage.

TABLE 4-1
Perchlorate Removal Technology Screening
PGA North Site-Goodyear, Arizona

Removal Technology	Description	Effectiveness	Implementability	Relative Cost Range
Chemical Processes (continued)				
Electrochemical Reduction	The system involves a two chambered reactor consisting of cathodic and anodic compartments separated by an ion exchange membrane and electrodes consisting of titanium coated with thin film of titanium dioxide particles.	Low to Medium. A bench scale study conducted by Clarkson University showed limited effectiveness due to competition among anions for active sites on the electrode surface, with perchlorate being less strongly adsorbed than both sulfate and chloride.	Unknown to Low. Limited bench scale testing underway; the time required for ions in the water to travel to the electrode surface restricts its full scale implementation. Electrode corrosion, surface passivation, and natural organic matter adsorption to the surface present technological difficulties.	High. Precious metal titanium is expensive.
Capacitive Deionization	Perchlorate-contaminated water is allowed to pass through a stack of high surface area electrodes. Ions and charged particles are attracted to the electrodes, anions are attracted to positive electrode and cations are attracted to the negative electrode and purified water leaves the space between the electrodes.	Unknown. Details unknown	Unknown. Details unknown; developmental stage.	High. High capital cost.
Titanium+3 Chemical Reduction	Titanium+3 ions are used to reduce perchlorate ions to chloride ions.	Unknown. Untested for perchlorate removal.	Unknown. Untested for perchlorate removal.	Unknown. Likely to be high.
Biological Processes				
In-situ Bioremediation	Amendments (electron donors such as acetate, corn syrup, ethanol, edible oils, etc) are injected in to the contaminated aquifer which promotes the growth of perchlorate-degrading microorganisms. These microorganisms reduce perchlorate to chloride and oxygen under anaerobic conditions. Nutrients are also added in some cases. Injection wells or permeable reactive barriers could be used for bringing electron donors into contact with contaminated groundwater.	Low to High (variable). Effectiveness depends on the type of the amendments and the zone of influence obtained by the amendments which in turn depends on the heterogeneity or homogeneity of the aquifer. This may be limited by low-permeability aquifer and lack of information on specific source areas. Presence of other competing electron acceptors (other than perchlorate) could impede the rate of degradation.	Medium to High. Several full scale facilities in operation; Will require adequate number of injection/extraction wells to obtain overlapping of zone of influence for the amendments. Depending on depth to groundwater, specific amendment injection methods should be utilized.	Low to Medium. This will depend on the amount of amendments, number of injection/extraction wells needed, and the number of amendment applications needed.

TABLE 4-1
Perchlorate Removal Technology Screening
PGA North Site-Goodyear, Arizona

Removal Technology	Description	Effectiveness	Implementability	Relative Cost Range
Biological Processes (continued)				
Ex-situ Biotreatment	Perchlorate-contaminated groundwater is extracted from wells and is allowed to pass through reactors which consist of either GAC or sand media where perchlorate is reduced to chloride and oxygen under anaerobic conditions. In some cases electron donors or nutrients are also added to increase the microbial activity. Different types of reactors such as Fluidized Bed, Packed Bed, or Fixed Film reactors could be utilized for this remediation.	Medium to High. Several full-scale operations in place; effectiveness could be affected by the high presence of nitrate or sulfate ions in the influent and also the adequate and consistent dosage of electron donor and nutrients.	Medium to High. Several full scale facilities are in operation.	High. The capital cost and O&M costs are approximately 4 to 5 times higher than that of ion exchange resins. Biosolids handling including sludge dewatering and offsite sludge disposal costs can add significantly to operating cost.
<p>Notes:</p> <p>The following were the references used for preparing this screening table.</p> <p>* Urbansky E.T and M.R. Schock, 1996, <i>Issues in managing risks associated with perchlorate in drinking water</i>, <i>Journal of Environmental Management</i>, (1999) 56, pages 79–95.</p> <p>* United States Environmental Protection Agency, 2005, <i>Perchlorate Treatment Technology Update</i>, EPA 542-R-05 015, May 2005</p> <p>* The Interstate Technology & Regulatory Council Perchlorate Team, 2005, <i>Perchlorate: Overview of Issues, Status, and Remedial Options</i>, September 2005</p> <p>Websites:</p> <p>http://www.ert2.org/nzvii/tool.aspx</p> <p>http://www.perchlorateinfo.com/perchlorate-case-55.html</p>				

TABLE 4-2
Eliminated Perchlorate Removal Technologies
PGA North Site-Goodyear, Arizona

Removal Technologies	Site-Specific Limitations
Physical Processes	
No action	Fails to protect human health and environment. Will not attain Removal Action Objectives (RAOs) within a reasonable time frame.
Reverse Osmosis (RO)	Could be cost prohibitive. Only limited bench-scale testing has been completed.
Nanofiltration	High energy requirement. Process is untested for perchlorate.
Electrodialysis	Pilot studies ongoing. Effectiveness and cost details unknown
Chemical Processes	
Nano-scale Zero Valent Iron (ZVI)	Cost of ZVI is high and would require multiple injections. May be limited by low-permeability aquifer and lack of information on specific source areas.
ZVI Reduction with Ultraviolet Light	Process still in developmental stages. Iron could accumulate in the subsurface.
Electrochemical Reduction	Limited bench-scale testing. Titanium would be expensive.
Capacitive Deionization	High capital costs. Effectiveness details unknown.
Titanium+3 Chemical Reduction	High capital costs. Effectiveness details unknown.
Biological Processes	
In-situ Bioremediation	May be limited by low-permeability aquifer and lack of information on specific source areas. Will require adequate number of injection/extraction wells to obtain overlapping of zone of influence for the amendments

TABLE 4-3
Selected Perchlorate Removal Technologies
PGA North Site-Goodyear, Arizona

Removal Technology	Description	Effectiveness	Implementability	Relative Cost Range
Ion Exchange	Ion exchange is a reversible physical-chemical reaction wherein an ion from solution is exchanged for a similarly charged ion attached to an immobile solid. During ion exchange, perchlorate which is a negatively charged ion is exchanged with another anion, typically chloride.	High. Has shown be to highly effective at various sites. However, effectiveness could be affected by the high levels of sulfates or nitrate ions. Use of perchlorate selective resins can reduce the negative impact of these competing ions.	Medium to High. Several full scale systems operational; Will require extraction wells and ion exchange resins, which could be regenerative or removed for off-site disposal.	Low to Medium. Can be costly depending on how often is changed or regenerated. Resin usage could be higher if groundwater contains sulfates and nitrates which will use up the resin. Also, disposal of resin for one-pass ion resins or disposal of brine solution from regenerative resins could increase the cost depending on the frequency of change out or regeneration.
Tailored Liquid-phase carbon adsorption	Tailored granular activated carbon (GAC) is used as the adsorption media and perchlorate-contaminated groundwater is allowed to pass through the GAC vessels and thereby the perchlorate gets adsorbed to the surface of the GAC.	Low to Medium. Because GAC media lose effectiveness relatively fast when used for perchlorate removal, this technology is disadvantaged with low treatment capacities. Water-soluble contaminants with high polarity can not be effectively removed by GAC. Also, the presence of suspended solids can plug the GAC causing less removal efficiency unless pre-filtration is included.	Low to Medium. Limited number of full scale installations-has not been widely used for perchlorate; more applicable to lower perchlorate concentrations; development of more effective tailored GAC is underway.	Medium to High. Low capital cost but potentially very high operating costs. The low adsorption capacity of perchlorate on GAC will result in frequent GAC change outs.

TABLE 4-3
Selected Perchlorate Removal Technologies
PGA North Site-Goodyear, Arizona

Removal Technology	Description	Effectiveness	Implementability	Relative Cost Range
Ex-situ Biotreatment	Perchlorate-contaminated groundwater is extracted from wells and is allowed to pass through reactors which consist of either GAC or sand media where perchlorate is reduced to chloride and oxygen under anaerobic conditions. In some cases electron donors or nutrients are also added to increase the microbial activity. Different types of reactors such as Fluidized Bed, Packed Bed, or Fixed Film reactors could be utilized for this remediation.	Medium to High. Several full-scale operations in place; effectiveness could be affected by the high presence of nitrate or sulfate ions in the influent and also the adequate and consistent dosage of electron donor and nutrients.	Medium to High. Several full scale facilities are in operation.	High. The capital cost and O&M costs are approximately 4 to 5 times higher than that of ion exchange resins. Biosolids handling including sludge dewatering and offsite sludge disposal costs can add significantly to operating cost.

Notes:

The following were the references used for preparing this screening table.

* Urbansky E.T and M.R. Schock, 1996, *Issues in managing risks associated with perchlorate in drinking water*, *Journal of Environmental Management*, (1999) 56, pages 79–95.

* United States Environmental Protection Agency, 2005, *Perchlorate Treatment Technology Update*, EPA 542-R-05 015, May 2005

* The Interstate Technology & Regulatory Council Perchlorate Team, 2005, *Perchlorate: Overview of Issues, Status, and Remedial Options*, September 2005

Websites:

<http://www.ert2.org/nzvit/tool.aspx>

<http://www.perchlorateinfo.com/perchlorate-case-55.html>

Table 4-4

Cost Estimate for Alternative 2
PGA North Site-Goodyear, Arizona

Ion Exchange	Cost	Comments
Capital Cost ¹	\$ 446,290	Existing equipment and wells utilized. Therefore, limited capital cost
Operation and Maintenance Cost	\$ 1,095,723	Adjusted for net present value
Total Cost (Net Present Value)	\$ 1,542,013	

¹Capital cost is provided for completeness. Site already has Ion Exchange system. Therefore, this cost will be deducted from the total cost. The capital costs are provided for completeness.

Net Present value calculated based on 7% discount rate.

Table 4-5

Cost Estimate for Alternative 3

PGA North Site-Goodyear, Arizona

Tailored LGAC	Cost	Comments
Capital Cost	\$ 484,697	Existing extraction wells utilized.
Operation and Maintenance Cost	\$ 1,104,365	Adjusted for net present value
Total Cost (Net Present Value)	\$ 1,589,062	

Net Present value calculated based on 7% discount rate.

O&M Cost is for 30 years on an annual basis.

Table 4-6

Cost Estimate for Alternative 4
PGA North Site-Goodyear, Arizona

Ex-Situ Bioremediation	Cost	Comments
Capital Cost	\$ 2,595,154	Existing extraction wells utilized
Operation and Maintenance Cost	\$ 2,145,214	Adjusted for net present value
Total Cost (Net Present Value)	\$ 4,740,368	

Net Present value calculated based on 7% discount rate.
O&M Cost is for 30 years on an annual basis.

Table 5-1
 Cost Estimates for Removal Alternatives
 PGA North Site-Goodyear, Arizona

Alternative 1 - No Action	Cost	Comments
Capital Cost	\$ -	
Operation and Maintenance Cost	\$ -	
Total Cost (Net Present Value)	\$ -	
Alternative 2 - Ion Exchange		
Capital Cost	\$ 446,290	Existing equipment and wells utilized. Therefore, limited capital cost
Operation and Maintenance Cost	\$ 1,095,723	Adjusted for net present value
Total Cost (Net Present Value)	\$ 1,542,013	
Alternative 3 - Tailored LGAC		
Capital Cost	\$ 484,697	Existing extraction wells utilized.
Operation and Maintenance Cost	\$ 1,104,365	Adjusted for net present value
Total Cost (Net Present Value)	\$ 1,589,062	
Alternative 4 - Ex-Situ Bioremediation		
Capital Cost	\$ 2,595,154	Existing extraction wells utilized
Operation and Maintenance Cost	\$ 2,145,214	Adjusted for net present value
Total Cost (Net Present Value)	\$ 4,740,368	

Net Present value calculated based on 7% discount rate.
 O&M Cost is for 30 years on an annual basis.

Figures

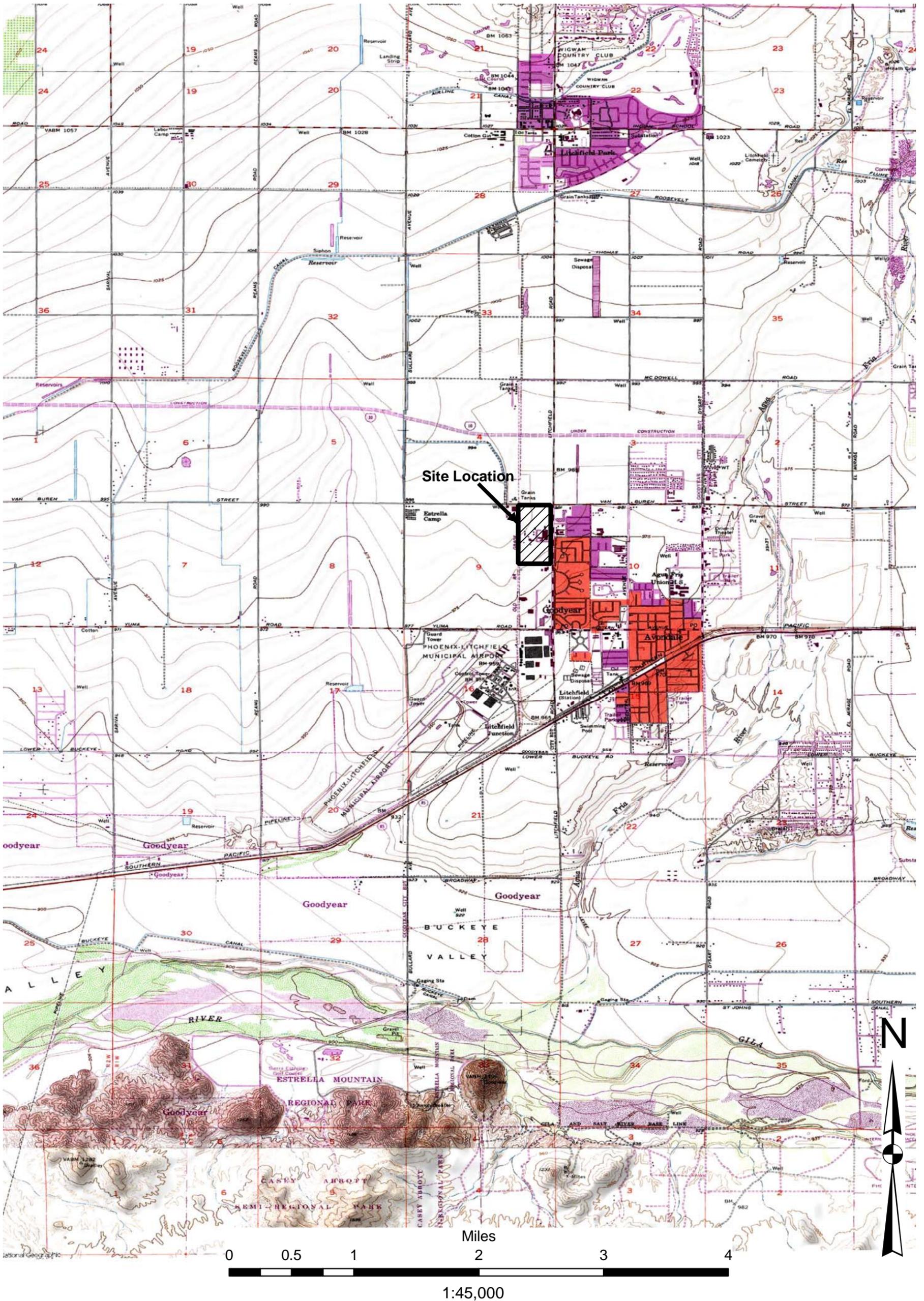
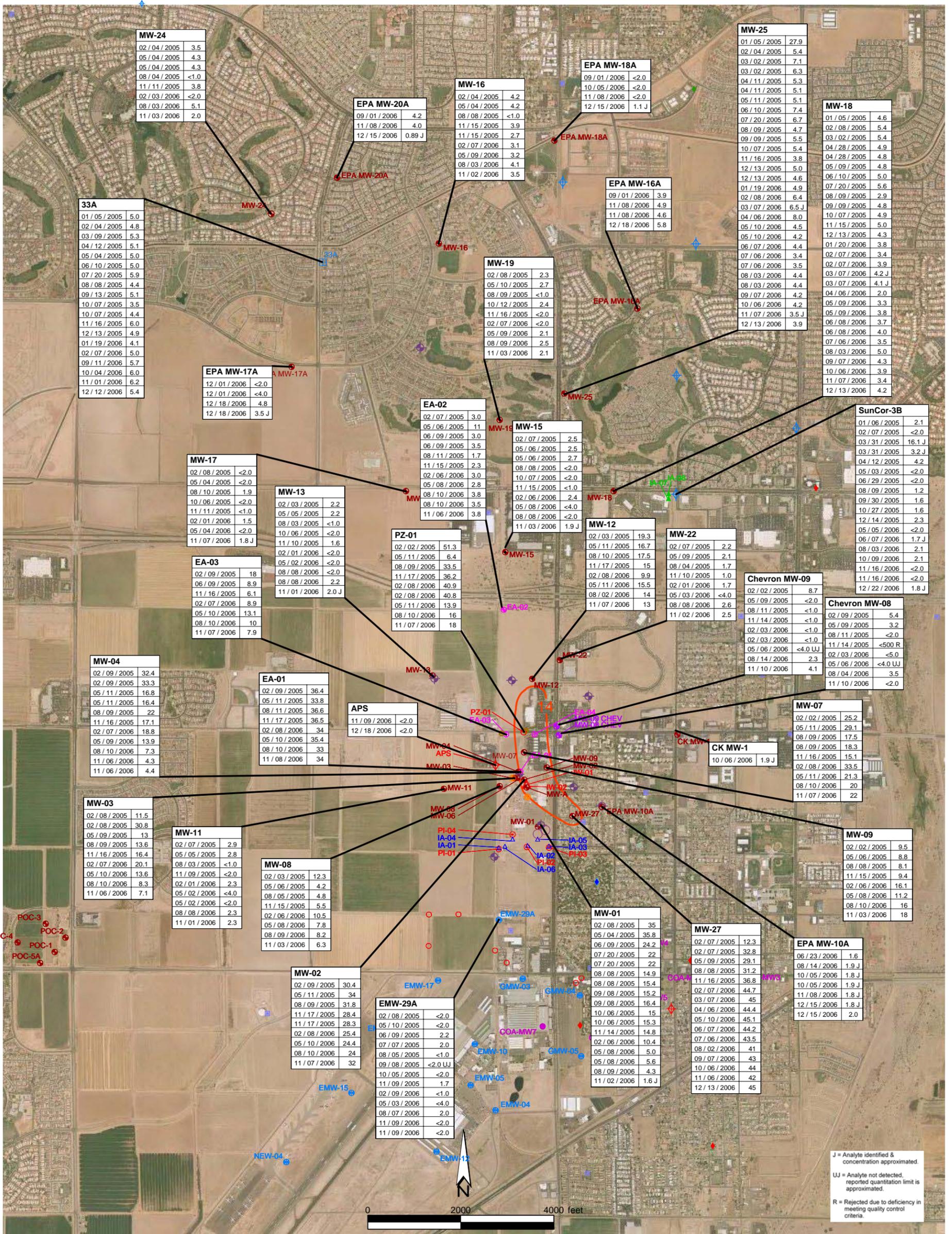
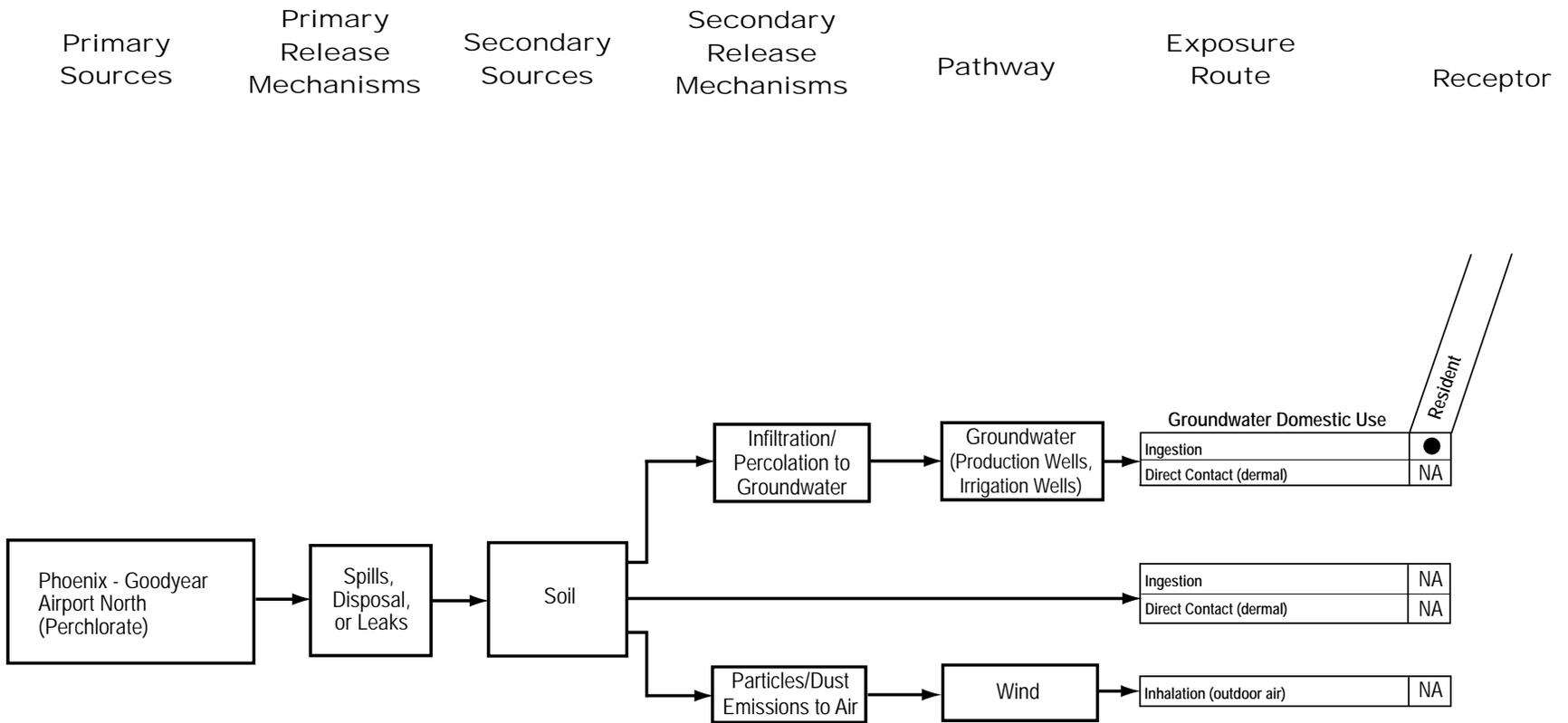


FIGURE 2-1
Property Location Map
PGA North





LEGEND:

- = Potentially Complete Pathway Evaluated in Streamlined Risk Evaluation
- NA = Beyond Scope of Current EE/CA

Figure 2-4
Draft Human Health Conceptual Site Model Diagram
 Phoenix - Goodyear Airport North Superfund Site EE/CA for Perchlorate

Appendix A

Historical Perchlorate Analytical Data

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
OLD COG-02	10/23/2003	<2	
COG-01	6/14/2001	4.1	
COG-01	7/17/2001	2.13	
COG-01	10/16/2001	<2	
COG-01	11/21/2001	<2	
COG-01	12/13/2001	<2	
COG-01	1/17/2002	<2	
COG-01	3/29/2002	2.1	
COG-01	6/6/2002	<2	
COG-01	9/18/2002	<2	
COG-01	12/4/2002	<2	
COG-01	3/12/2003	<2	
COG-01	6/4/2003	2.3	
COG-01	9/4/2003	3.3	
COG-01	12/11/2003	3.3	
COG-01	2/25/2004	4.3	
COG-01	4/14/2004	4.6	
COG-01	5/6/2004	4	
COG-01	6/9/2004	4.5	
COG-01	7/7/2004	4.4	
COG-01	8/3/2004	5.8	
COG-01	9/1/2004	4	
COG-01	10/6/2004	3.8	
COG-01	11/10/2004	4.7	
COG-01	12/1/2004	4	
COG-01	1/5/2005	2.8	
COG-01	2/3/2005	4	
COG-01	3/9/2005	4	
COG-01	4/28/2005	4.0	
COG-01	5/10/2005	4.1	
COG-01	6/9/2005	4.8	
COG-01	7/6/2005	3.9	
COG-01	8/5/2005	3.2	
COG-01	9/26/2005	4.1	
COG-01	10/5/2005	4.1	
COG-01	11/9/2005	3.9	
COG-01	12/14/2005	3.8	
COG-01	1/19/2006	3.3	
COG-01	2/9/2006	3.7	
COG-01	3/8/2006	5.2	
COG-01	4/6/2006	4.3	
COG-01	5/3/2006	3.7	
COG-01	6/8/2006	5.2	
COG-01	7/7/2006	3.7	
COG-01	8/7/2006	4.3	
COG-02	6/14/2001	2.5	
COG-02	7/17/2001	1.9	
COG-02	9/6/2001	2.4	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
COG-02	10/16/2001	<2	
COG-02	11/21/2001	<2	
COG-02	12/13/2001	<2	
COG-02	1/17/2002	<2	
COG-02	3/8/2002	2	
COG-02	3/29/2002	2.6	
COG-02	4/22/2002	2.2	
COG-02	5/17/2002	2.3	
COG-02	6/6/2002	<2	
COG-02	7/24/2002	2.9	
COG-02	8/14/2002	2.8	
COG-02	9/18/2002	2.1	
COG-02	10/9/2002	2.8	
COG-02	11/22/2002	2.5	
COG-02	12/4/2002	2.3	
COG-02	12/11/2002	2.4	
COG-02	12/18/2002	2.5	
COG-02	12/23/2002	3.6	
COG-02	1/2/2003	2.3	
COG-02	1/8/2003	2.7	
COG-02	1/15/2003	3.1	
COG-02	2/5/2003	2.5	
COG-02	2/11/2003	2.7	
COG-02	2/19/2003	2.7	
COG-02	2/26/2003	2.9	
COG-02	3/12/2003	2.5	
COG-02	3/19/2003	3.1	
COG-02	3/26/2003	2.8	
COG-02	4/2/2003	3.1	
COG-02	4/9/2003	3.3	
COG-02	4/17/2003	3.1	
COG-02	4/23/2003	2.9	
COG-02	5/1/2003	2.8	
COG-02	5/22/2003	3.4	
COG-02	5/27/2003	3.3	
COG-02	6/3/2003	3.8	
COG-02	6/10/2003	3.3	
COG-02	6/18/2003	3.5	
COG-02	6/25/2003	3.4	
COG-02	7/2/2003	3.4	
COG-02	7/8/2003	3.1	
COG-02	5/17/2004	3.7	
COG-02	5/18/2004	4	
COG-02	5/19/2004	4.1	
COG-02	5/20/2004	3.6	
COG-02	6/1/2004	3.9	
COG-02	6/2/2004	4	
COG-02	6/3/2004	3.7	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
COG-02	6/7/2004	3.8	
COG-02	6/9/2004	3.6	
COG-02	6/11/2004	3	
COG-02	6/14/2004	3.3	
COG-02	6/15/2004	3.6	
COG-02	6/21/2004	3.6	
COG-02	6/10/2005	<2	
COG-03	6/14/2001	<2.5	
COG-03	9/6/2001	<2	
COG-03	10/16/2001	<2	
COG-03	11/21/2001	<2	
COG-03	12/13/2001	<2	
COG-03	3/29/2002	<2	
COG-03	6/6/2002	<2	
COG-03	9/18/2002	<2	
COG-03	12/4/2002	<2	
COG-03	3/12/2003	<2	
COG-03	6/4/2003	<2	
COG-03	9/4/2003	<2	
COG-03	12/11/2003	<2	
COG-03	2/25/2004	<2	
COG-03	5/6/2004	<2	
COG-03	8/3/2004	<2	
COG-03	12/21/2004	10.6	
COG-03	2/3/2005	<2.0	
COG-03	4/28/2005	<2.0	
COG-03	5/10/2005	<2	
COG-03	6/9/2005	<2	
COG-03	7/6/2005	<2	
COG-03	8/5/2005	<1	
COG-03	9/8/2005	<1	
COG-03	11/9/2005	2.1	
COG-03	2/9/2006	1.3	
COG-03	4/6/2006	<2	
COG-03	5/3/2006	<2	
COG-03	7/7/2006	1.2	
COG-03	8/7/2006	1.6	
COG-05	11/21/2001	<2	
COG-05	1/23/2002	<2	
COG-06	11/21/2001	<2	
COG-06	6/6/2002	2	
COG-06	7/24/2002	2.4	
COG-06	8/14/2002	2	
COG-06	9/18/2002	2.4	
COG-06	12/4/2002	<2	
COG-06	3/12/2003	<2	
COG-06	6/4/2003	2.1	
COG-06	9/4/2003	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
COG-06	12/11/2003	<2	
COG-06	2/25/2004	2.5	
COG-06	5/6/2004	<2	
COG-06	8/5/2004	<2	
COG-06	11/10/2004	<2	
COG-06	2/3/2005	2.2	
COG-06	5/10/2005	<2	
COG-06	8/5/2005	1.8	
COG-06	11/9/2005	1.9	
COG-06	2/9/2006	1.6	
COG-06	5/3/2006	<2	
COG-06	8/7/2006	1.9	
COG-10	6/14/2001	<2.5	
COG-10	9/6/2001	<2	
COG-10	10/16/2001	<2	
COG-10	11/21/2001	<2	
COG-10	12/13/2001	<2	
COG-10	1/17/2002	<2	
COG-10	2/14/2002	<2	
COG-10	3/8/2002	<2	
COG-10	3/29/2002	<2	
COG-10	4/22/2002	<2	
COG-10	5/17/2002	<2	
COG-10	6/6/2002	<2	
COG-10	7/24/2002	<2	
COG-10	8/14/2002	<2	
COG-10	9/18/2002	<2	
COG-10	10/9/2002	2.2	
COG-10	11/22/2002	<2	
COG-10	12/4/2002	<2	
COG-10	1/15/2003	<2	
COG-10	2/19/2003	<2	
COG-10	3/12/2003	<2	
COG-10	4/9/2003	<2	
COG-10	5/19/2003	<2	
COG-10	6/4/2003	<2	
COG-10	7/16/2003	<2	
COG-10	8/27/2003	<2	
COG-10	9/4/2003	<2	
COG-10	10/15/2003	<2	
COG-10	11/13/2003	<2	
COG-10	12/11/2003	<2	
COG-10	1/14/2004	<2	
COG-10	2/11/2004	<2	
COG-10	2/25/2004	<2	
COG-10	4/14/2004	<2	
COG-10	5/6/2004	<2	
COG-10	6/3/2004	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
COG-10	7/7/2004	<2	
COG-10	8/5/2004	<2	
COG-10	9/1/2004	<2	
COG-10	10/6/2004	<2	
COG-10	11/10/2004	<2	
COG-10	12/1/2004	<2	
COG-10	1/5/2005	2.9	
COG-10	2/3/2005	<2	
COG-10	3/2/2005	<2	
COG-10	4/28/2005	2.3	
COG-10	5/10/2005	<2.0	
COG-10	9/29/2005	2.1	
COG-10	9/30/2005	2.6	
COG-10	12/22/2005	1.2	
COG-10	12/22/2005	1	
COG-10	5/6/2006	<2	
COG-10	5/18/2006	<2	
COG-10	6/7/2006	1.3	
COG-10	7/7/2006	<2	
COG-10	7/7/2006	0.78	
COG-10	7/7/2006	0.91	
COG-10	8/3/2006	2.4	
COG-11	8/10/2004	<2	
COG-11	11/10/2004	<2	
COG-11	2/4/2005	<2	
COG-11	5/10/2005	2.2	
COG-11	7/6/2005	<2	
COG-11	8/5/2005	1.8	
COG-11	11/9/2005	1.8	
COG-11	2/9/2006	1.9	
COG-11	5/3/2006	<2	
COG-11	8/7/2006	2.2	
COG-18A	11/21/2001	<2	
COG-18A	6/6/2002	<2	
COG-18A	8/5/2004	<2	
COG-18A	11/10/2004	<2	
COG-18A	2/3/2005	<2	
COG-18A	5/10/2005	<2	
COG-18A	2/9/2006	1.2	
COG-18A	5/3/2006	<2	
COG-18A	8/7/2006	1.7	
COG-18B	6/6/2002	<2	
COG-18B	8/5/2004	<2	
COG-18B	11/10/2004	<2	
COG-18B	2/3/2005	<2	
COG-18B	5/10/2005	<2	
COG-18B	11/9/2005	<1	
COG-18B	5/3/2006	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
COG-18B	8/7/2006	<2.0	
Tank (COG-10)	5/23/2005	2.1	
Tank (COG-11)	5/23/2005	3.4	
Tank (COG-11)	6/9/2005	2.9	
Tank (COG-11)	8/5/2005	<1	
Tank (COG-11)	9/8/2005	<1	UJ
Tank (COG-11)	10/5/2005	1.7	
Tank (COG-11)	11/9/2005	1.9	
Tank (COG-11)	12/14/2005	1.8	
Tank (COG-11)	1/19/2006	2	
Tank (COG-11)	2/9/2006	1.7	
Tank (COG-11)	3/8/2006	<4.0	
Tank (COG-11)	4/6/2006	<2	
Tank (COG-11)	5/3/2006	<2	
Tank (COG-11)	6/8/2006	1.4	
Tank (COG-11)	7/7/2006	1.1	J
Tank (COG-11)	8/7/2006	1.7	J
Tank (COG-18)	8/5/2005	<1	
COA-01	8/13/2004	2.8	
COA-01	11/17/2004	<2	
COA-01	2/2/2005	<2.0	
COA-01	5/10/2005	<2	
COA-01	8/10/2005	<1	
COA-01	11/10/2005	2	
COA-01	2/3/2006	1.5	
COA-01	5/4/2006	<2	
COA-01	8/10/2006	2.2	
COA-15	8/13/2004	<2	
COA-15	11/17/2004	<2	
COA-15	2/2/2005	<2.0	
COA-15	5/10/2005	<2	
COA-15	8/10/2005	1.5	
COA-15	11/10/2005	1.5	
COA-15	2/3/2006	1.3	
COA-15	5/4/2006	<2	
COA-15	8/10/2006	<2	
COA-18	8/13/2004	<2	
COA-18	11/17/2004	<2	
COA-18	2/2/2005	<2.0	
COA-18	5/10/2005	<2	
COA-18	8/10/2005	<1	
COA-18	11/10/2005	<1	
COA-18	2/3/2006	<1	
COA-18	5/4/2006	<2	
COA-18	8/10/2006	1.2	J
PSDW	11/1/2000	<4	
PSDW	5/24/2001	<4	
PSDW	7/17/2001	2.84	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
PSDW	9/6/2001	3.1	
PSDW	10/16/2001	2.7	
PSDW	11/20/2001	<2	
PSDW	12/13/2001	<2	
PSDW	1/17/2002	<2	
PSDW	2/14/2002	2.3	
PSDW	3/8/2002	2.3	
PSDW	3/29/2002	3	
PSDW	4/22/2002	2.8	
PSDW	5/17/2002	2.2	
PSDW	7/18/2002	2.3	
PSDW	8/14/2002	3.3	
PSDW	8/28/2002	3.8	
PSDW	9/16/2002	2.9	
PSDW	9/30/2002	3.7	
PSDW	10/7/2002	6.5	
PSDW	10/23/2002	<2	
PSDW	11/13/2002	53	
PSDW	11/26/2002	22.6	
PSDW	11/27/2002	22.6	
PSDW	12/2/2002	30.4	
PSDW	12/5/2002	4.3	
PSDW	12/11/2002	2.9	
PSDW	12/18/2002	3.7	
PSDW	12/26/2002	3	
PSDW	1/2/2003	3.6	
PSDW	1/8/2003	3.5	
PSDW	1/15/2003	2.9	
PSDW	1/22/2003	3.3	
PSDW	1/29/2003	2.3	
PSDW	2/5/2003	2.9	
PSDW	2/11/2003	2.6	
PSDW	4/9/2003	3.3	
PSDW	4/17/2003	3.1	
PSDW	4/23/2003	3.1	
PSDW	5/1/2003	2.9	
PSDW	5/7/2003	3	
PSDW	5/14/2003	2.9	
PSDW	5/19/2003	3	
PSDW	5/28/2003	3.4	
PSDW	6/5/2003	2.8	
PSDW	6/11/2003	2.7	
PSDW	6/18/2003	2.9	
PSDW	6/25/2003	2.7	
PSDW	7/2/2003	3.3	
PSDW	7/8/2003	2.9	
PSDW	7/16/2003	2.7	
PSDW	7/23/2003	3.1	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
PSDW	7/30/2003	2.9	
PSDW	8/6/2003	3.1	
PSDW	8/13/2003	2.7	
PSDW	8/20/2003	3	
PSDW	8/27/2003	2.7	
PSDW	9/3/2003	2.4	
PSDW	9/10/2003	2.9	
PSDW	9/17/2003	2.8	
PSDW	9/24/2003	3	
PSDW	10/1/2003	2.9	
PSDW	10/8/2003	2.8	
PSDW	10/15/2003	2.7	
PSDW	10/22/2003	2.6	
PSDW	10/29/2003	2.8	
PSDW	11/5/2003	2.5	
PSDW	11/13/2003	2.7	
PSDW	11/19/2003	2.5	
PSDW	11/25/2003	2.7	
PSDW	12/3/2003	2.4	
PSDW	12/10/2003	3.1	
PSDW	12/17/2003	2.5	
PSDW	12/23/2003	2.1	
PSDW	12/30/2003	2.5	
PSDW	1/7/2004	3.1	
PSDW	1/14/2004	3.3	
PSDW	1/21/2004	3	
PSDW	1/28/2004	2.6	
PSDW	2/4/2004	3.2	
PSDW	2/11/2004	3.2	
PSDW	2/18/2004	3	
PSDW	2/26/2004	3.2	
PSDW	3/3/2004	3.1	
PSDW	3/10/2004	2.9	
PSDW	3/17/2004	3.3	
PSDW	3/24/2004	3	
PSDW	3/31/2004	3	
PSDW	4/7/2004	3	
PSDW	4/14/2004	3.7	
PSDW	4/21/2004	3.2	
PSDW	4/28/2004	2.9	
PSDW	5/5/2004	3	
PSDW	5/12/2004	3.3	
PSDW	5/19/2004	3.4	
PSDW	5/26/2004	3.1	
PSDW	6/2/2004	3.2	
PSDW	6/9/2004	3.1	
PSDW	6/16/2004	3.2	
PSDW	6/23/2004	2.8	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
PSDW	6/29/2004	3.3	
PSDW	7/7/2004	2.8	
PSDW	7/14/2004	2.5	
PSDW	7/21/2004	3.3	
PSDW	8/4/2004	2.5	
PSDW	9/1/2004	2.5	
PSDW	10/6/2004	2.8	
PSDW	11/4/2004	2.9	
PSDW	12/1/2004	3.4	
PSDW	1/5/2005	16.4	
PSDW	2/2/2005	4.8	
PSDW	3/2/2005	2.9	
PSDW	4/28/2005	3.0	
PSDW	5/9/2005	3.1	
PSDW	6/9/2005	3.1	
PSDW	7/20/2005	3.4	
PSDW	8/10/2005	2.2	
PSDW	9/8/2005	2.2	
PSDW	10/6/2005	2.9	
PSDW	11/10/2005	3.1	
PSDW	12/13/2005	2.9	
PSDW	1/19/2006	3.4	
PSDW	2/2/2006	3.7	
PSDW	3/7/2006	<4.0	J
PSDW	4/6/2006	3.2	
PSDW	5/9/2006	3	
PSDW	6/8/2006	3.2	
PSDW	7/7/2006	3.2	
PSDW	8/9/2006	3.2	
PSDW	9/7/2006	3.4	
GWWTP	3/31/2005	<2.0	
GWWTP	4/28/2005	<2.0	
GWWTP-EFF	10/9/2003	<2	
GWWTP-EFF	11/18/2003	7.9	
GWWTP-EFF	12/9/2003	11	
GWWTP-EFF	1/13/2004	<2	
GWWTP-EFF	2/19/2004	<2	
GWWTP-EFF	3/24/2004	<2	
GWWTP-EFF	4/20/2004	<2	
GWWTP-EFF	5/19/2004	<2	
GWWTP-EFF	6/16/2004	<2	
GWWTP-EFF	7/21/2004	<2	
GWWTP-EFF	8/19/2004	<2	
GWWTP-EFF	9/16/2004	<2	
GWWTP-EFF	10/21/2004	<2	
GWWTP-EFF	11/23/2004	<2	
GWWTP-EFF	12/21/2004	<2	
GWWTP-EFF	1/26/2005	<2.0	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
GWWTP-EFF	2/23/2005	<2.0	
AEIW	3/28/2002	<2	
AEIW	3/25/2003	<2	
AEIW	11/16/2005	4.2	
AEIW	12/13/2005	3.9	
AEIW	2/2/2006	4.9	
AEIW	5/4/2006	4.1	
AEIW	8/9/2006	4.6	
G-01	5/30/2001	<4	
G-01	11/20/2001	<2	
G-01	6/4/2002	<2	
G-01	12/3/2002	3.3	
G-02	11/1/2000	<4	
G-02	11/20/2001	<2	
G-02	6/4/2002	<2	
G-02	12/3/2002	2.7	
G-03	11/20/2001	<2	
G-04	5/30/2001	<4	
G-04	11/20/2001	<2	
G-04	9/18/2002	2.8	
G-04	12/3/2002	2.8	
GDW	11/1/2000	<4	
GDW	11/1/2000	<4	
GDW	9/6/2001	<2	
GDW	9/6/2001	<2	
GDW	11/21/2001	<2	
GDW	12/13/2001	<2	
GDW	3/8/2002	<2	
GDW	6/13/2002	<2	
GDW	7/18/2002	<2	
GDW	8/14/2002	<2	
GDW	9/11/2002	3.5	
GDW	10/9/2002	<2	
GDW	11/22/2002	<2	
GDW	12/4/2002	<2	
GDW	12/4/2002	<2	
GDW	1/15/2003	<2	
GDW	2/19/2003	<2	
GDW	3/12/2003	<2	
GDW	4/9/2003	<2	
GDW	5/19/2003	<2	
GDW	6/5/2003	<2	
GDW	7/16/2003	<2	
GDW	8/27/2003	<2	
SunCor-27A	6/9/2006	2.4	
SunCor-27A	6/20/2006	2.7	
SunCor-27A	9/5/2006	3.0	
SunCor-29A	4/2/2002	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
SunCor-33B	11/21/2001	<2	
SunCor-33B	9/18/2002	4.8	
SunCor-34B	11/4/2004	2.1	
SunCor-34B	2/14/2005	3.6	
SunCor-34B	2/10/2006	<2	
SunCor-34B	3/9/2006	<2.0	
SunCor-34B	4/7/2006	<2	
SunCor-34B	5/5/2006	<4	
SunCor-34B	8/4/2006	2.7	
SunCor-34B	8/14/2006	2.5	
SunCor-34B	9/1/2006	<2.0	
SunCor-3B	4/2/2002	<2	
SunCor-3B	9/5/2003	<2	
SunCor-3B	5/6/2004	<2	
SunCor-3B	8/27/2004	<2	
SunCor-3B	11/12/2004	<2	
SunCor-3B	12/9/2004	<2	
SunCor-3B	1/6/2005	2.1	
SunCor-3B	2/7/2005	<2	
SunCor-3B	3/31/2005	3.2	
SunCor-3B	4/12/2005	4.2	
SunCor-3B	5/3/2005	<2	
SunCor-3B	6/29/2005	<2	
SunCor-3B	8/9/2005	1.2	
SunCor-3B	9/2/2005	<2	
SunCor-3B	9/2/2005	<1	
SunCor-3B	9/30/2005	1.6	
SunCor-3B	10/27/2005	1.6	
SunCor-3B	12/14/2005	2.3	
SunCor-3B	5/5/2006	<2	
SunCor-3B	6/7/2006	1.7	
SunCor-3B	8/3/2006	2.1	
PSIW	11/1/2000	8.4	
PSIW	5/24/2001	10.3	
PSIW	7/17/2001	10.5	
PSIW	9/6/2001	12	
PSIW	10/16/2001	10	
PSIW	11/20/2001	8.4	
PSIW	12/13/2001	8.2	
PSIW	1/17/2002	7.7	
PSIW	2/14/2002	9.1	
PSIW	3/8/2002	11	
PSIW	3/29/2002	8.3	
PSIW	4/22/2002	10	
PSIW	5/17/2002	10	
PSIW	7/18/2002	11	
PSIW	8/14/2002	12	
33A	11/1/2000	<7	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
33A	11/21/2001	<10	
33A	12/13/2001	<2	
33A	4/5/2002	6.3	
33A	5/22/2002	4.2	
33A	6/13/2002	6.7	
33A	7/24/2002	6.5	
33A	8/14/2002	6.7	
33A	9/25/2002	7.9	
33A	10/9/2002	7.8	
33A	11/22/2002	5.4	
33A	12/4/2002	5.9	
33A	1/15/2003	5.1	
33A	2/19/2003	5.2	
33A	3/7/2003	4.3	
33A	4/23/2003	5.6	
33A	5/6/2003	6	
33A	6/5/2003	6.3	
33A	7/16/2003	6.4	
33A	8/27/2003	5.5	
33A	9/10/2003	5.4	
33A	10/8/2003	4.9	
33A	11/13/2003	5.2	
33A	12/3/2003	4.4	
33A	12/10/2003	4.3	
33A	1/14/2004	5.4	
33A	2/11/2004	6.1	
33A	3/3/2004	5.7	
33A	4/14/2004	5.8	
33A	5/5/2004	4.9	
33A	6/2/2004	5.7	
33A	7/7/2004	5.3	
33A	8/4/2004	5.3	
33A	9/1/2004	5.4	
33A	10/6/2004	5.4	
33A	11/3/2004	5.1	
33A	12/1/2004	5.1	
33A	1/5/2005	5	
33A	2/4/2005	4.8	
33A	3/9/2005	5.3	
33A	4/12/2005	5.1	
33A	5/4/2005	5	
33A	6/10/2005	5	
33A	7/20/2005	5.9	
33A	8/8/2005	4.4	
33A	9/13/2005	5.1	
33A	10/7/2005	3.5	
33A	11/16/2005	6	
33A	12/13/2005	4.9	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
33A	1/19/2006	4.1	
33A	2/7/2006	5	
33A-EFF	5/8/2006	<4	
EA-01	9/6/2001	80	
EA-01	11/20/2001	64	
EA-01	3/26/2002	70	
EA-01	6/4/2002	61	
EA-01	9/17/2002	65	
EA-01	12/4/2002	63	
EA-01	3/12/2003	58	
EA-01	6/5/2003	60	
EA-01	9/3/2003	49	
EA-01	12/3/2003	53	
EA-01	2/24/2004	51	
EA-01	5/4/2004	46	
EA-01	8/4/2004	40.8	
EA-01	11/9/2004	37.9	
EA-01	2/9/2005	36.4	
EA-01	5/11/2005	33.8	
EA-01	8/11/2005	36.6	
EA-01	11/17/2005	36.5	
EA-01	2/8/2006	34	
EA-01	5/10/2006	35.4	
EA-01	8/10/2006	33	
EA-02	10/31/2001	<2	
EA-02	11/20/2001	<2	
EA-02	3/26/2002	4.5	
EA-02	6/4/2002	3.1	
EA-02	9/17/2002	3.1	
EA-02	12/4/2002	4.3	
EA-02	3/11/2003	4.1	
EA-02	6/6/2003	4.9	
EA-02	9/3/2003	4.3	
EA-02	12/3/2003	3.6	
EA-02	3/17/2004	3.5	
EA-02	5/4/2004	2.9	
EA-02	8/3/2004	2.5	
EA-02	11/5/2004	2.7	
EA-02	2/7/2005	3	
EA-02	5/6/2005	11	
EA-02	6/9/2005	3.5	
EA-02	8/11/2005	1.7	
EA-02	11/15/2005	2.3	
EA-02	2/6/2006	3	
EA-02	5/8/2006	2.8	
EA-02	8/10/2006	3.5	
EA-03	9/6/2001	48	
EA-03	11/20/2001	35	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
EA-03	3/26/2002	40	
EA-03	6/4/2002	32	
EA-03	9/17/2002	31	
EA-03	12/23/2002	11	
EA-03	3/12/2003	33	
EA-03	6/6/2003	20	
EA-03	9/3/2003	18	
EA-03	12/9/2003	18	
EA-03	2/24/2004	25	
EA-03	5/4/2004	19	
EA-03	8/4/2004	17.8	
EA-03	11/5/2004	16.5	
EA-03	2/9/2005	18	
EA-03	6/9/2005	8.9	
EA-03	11/16/2005	6.1	
EA-03	2/7/2006	8.9	
EA-03	5/10/2006	13.1	
EA-03	8/10/2006	10	
EB-01	5/24/2001	<8	
EB-01	9/6/2001	11	
EB-01	11/20/2001	6.8	
EB-01	3/26/2002	12	
EB-01	6/4/2002	8.8	
EB-01	9/17/2002	15	
EB-01	12/4/2002	14	
EB-01	3/12/2003	13	
EB-01	6/5/2003	15	
EB-01	9/3/2003	14	
EB-01	12/3/2003	14	
EB-01	2/24/2004	15	
EB-01	5/4/2004	14	
EB-01	8/4/2004	17.5	
EB-01	11/9/2004	17.7	
EB-01	2/8/2005	18.9	
EB-01	6/9/2005	10	
EB-01	8/11/2005	16.9	
EB-01	11/16/2005	21.4	
EB-01	2/7/2006	22.2	
EB-01	5/10/2006	20.1	
EB-01	8/10/2006	20	
EB-02	2/1/2002	<2	
CHEVRON MW-08	5/29/2001	<8	
CHEVRON MW-08	11/14/2001	<2	
CHEVRON MW-08	7/3/2002	5.8	
CHEVRON MW-08	9/26/2002	6.6	
CHEVRON MW-08	12/4/2002	6.6	
CHEVRON MW-08	3/13/2003	3.3	
CHEVRON MW-08	6/5/2003	5.9	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
CHEVRON MW-08	9/8/2003	6.5	
CHEVRON MW-08	12/9/2003	5.5	
CHEVRON MW-08	2/24/2004	5.8	
CHEVRON MW-08	5/3/2004	3.8	
CHEVRON MW-08	8/5/2004	4.3	
CHEVRON MW-08	11/10/2004	5.7	
CHEVRON MW-08	2/9/2005	5.4	
CHEVRON MW-08	5/9/2005	3.2	
CHEVRON MW-08	8/11/2005	<2	
CHEVRON MW-08	11/14/2005	<500	R
CHEVRON MW-08	2/3/2006	<5	
CHEVRON MW-08	5/6/2006	<4	R
CHEVRON MW-08	8/4/2006	3.5	
CHEVRON MW-09	3/25/2003	<2	
CHEVRON MW-09	3/3/2004	<2	
CHEVRON MW-09	5/7/2004	<2	
CHEVRON MW-09	8/2/2004	4	
CHEVRON MW-09	11/3/2004	<2	
CHEVRON MW-09	2/2/2005	8.7	
CHEVRON MW-09	5/9/2005	<2	
CHEVRON MW-09	8/11/2005	<1	
CHEVRON MW-09	11/14/2005	<1	
CHEVRON MW-09	2/3/2006	<1	
CHEVRON MW-09	5/6/2006	<4	R
CHEVRON MW-09	8/14/2006	2.3	
COA-MW1	11/23/2004	<2	
COA-MW3	12/7/2004	<2	
COA-MW4	12/7/2004	<2	
COA-MW5	12/7/2004	<2	
COA-MW7	12/7/2004	3	
EMW-22LC	3/28/2002	4.9	
EMW-29A	5/25/2001	<8	
EMW-29A	11/13/2001	<2	
EMW-29A	3/29/2002	<2	
EMW-29A	6/24/2002	<2	
EMW-29A	9/23/2002	<2	
EMW-29A	12/13/2002	<2	
EMW-29A	3/12/2003	<2	
EMW-29A	6/4/2003	<2	
EMW-29A	9/4/2003	<2	
EMW-29A	12/2/2003	<2	
EMW-29A	2/25/2004	<2	
EMW-29A	5/6/2004	<2	
EMW-29A	8/10/2004	<2	
EMW-29A	11/3/2004	<2	
EMW-29A	2/8/2005	<2	
EMW-29A	5/10/2005	<2	
EMW-29A	6/9/2005	2.2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
EMW-29A	7/7/2005	2	
EMW-29A	8/5/2005	<1	
EMW-29A	9/8/2005	<2	UJ
EMW-29A	10/5/2005	<2	
EMW-29A	11/9/2005	1.7	
EMW-29A	2/9/2006	<1	
EMW-29A	5/3/2006	<4	
EMW-29A	8/7/2006	2.0	
EPA MW-10A	6/23/2006	1.6	
EPA MW-10A	8/14/2006	1.9	J
EPA MW-16A	8/17/2006	3.0	
EPA MW-16A	9/1/2006	3.9	
EPA MW-18A	6/14/2006	<2	
EPA MW-18A	6/14/2006	0.82	J
EPA MW-18A	9/1/2006	<2.0	
EPA MW-1M	3/3/2006	42	
EPA MW-1M	3/6/2006	50	
EPA MW-1M	3/22/2006	12	
EPA MW-1M	3/23/2006	5.3	
EPA MW-1M	3/24/2006	6.6	
EPA MW-1M	3/27/2006	<4	
EPA MW-1M	3/28/2006	1.8	
EPA MW-1M	3/29/2006	<1	
EPA MW-1M	5/2/2006	2.2	
EPA MW-1M	9/7/2006	4.2	
EPA MW-20A	8/7/2006	4.7	
EPA MW-20A	9/1/2006	4.2	
EPA MW-28M	6/27/2006	161	
EPA MW-28M	6/28/2006	32.3	
EPA MW-9C	5/17/2006	<2	
EPA MW-9C	5/23/2006	2.1	
EPA MW-9C	5/23/2006	2.4	J
EPA MW-9C	5/24/2006	1.1	J
EPA MW-9C	5/25/2006	0.79	J
EPA MW-9C	6/23/2006	1.4	
EPA MW-9C	8/14/2006	3.1	
GMW-02	2/18/2002	2.6	
GMW-11UC	2/18/2002	2.6	
GMW-13UC	2/18/2002	2.6	
GMW-17LC	3/29/2002	2	
MW-01	11/1/2000	37	
MW-01	11/19/2001	41	
MW-01	3/25/2002	42	
MW-01	6/5/2002	42	
MW-01	9/25/2002	38	
MW-01	12/13/2002	41	
MW-01	3/6/2003	35	
MW-01	6/3/2003	37	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-01	9/5/2003	38	
MW-01	12/8/2003	46	
MW-01	2/27/2004	39	
MW-01	5/7/2004	39	
MW-01	8/9/2004	39.9	
MW-01	11/5/2004	37.7	
MW-01	2/8/2005	35	
MW-01	5/4/2005	35.8	
MW-01	6/9/2005	24.2	
MW-01	7/20/2005	22	
MW-01	8/8/2005	15.4	
MW-01	9/8/2005	16.4	
MW-01	10/6/2005	15	
MW-01	11/14/2005	14.8	
MW-01	2/6/2006	10.4	
MW-01	5/8/2006	5.6	
MW-01	8/9/2006	4.3	
MW-02	9/26/2002	46	
MW-02	3/14/2003	31	
MW-02	6/10/2003	29	
MW-02	9/8/2003	28	
MW-02	12/8/2003	23	
MW-02	2/26/2004	28	
MW-02	5/7/2004	27	
MW-02	8/9/2004	30.3	
MW-02	11/8/2004	84.5	
MW-02	2/9/2005	30.4	
MW-02	5/11/2005	34	
MW-02	8/9/2005	31.8	
MW-02	11/17/2005	28.3	
MW-02	2/8/2006	25.4	
MW-02	5/10/2006	24.4	
MW-02	8/10/2006	24	
MW-03	5/25/2001	48	
MW-03	11/14/2001	37	
MW-03	3/25/2002	47	
MW-03	3/13/2003	27	
MW-03	6/4/2003	28	
MW-03	9/5/2003	29	
MW-03	12/8/2003	22	
MW-03	2/29/2004	20	
MW-03	5/4/2004	17	
MW-03	8/9/2004	16.1	
MW-03	11/9/2004	12.5	
MW-03	2/8/2005	11.5	
MW-03	5/9/2005	13	
MW-03	8/9/2005	13.6	
MW-03	11/16/2005	16.4	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-03	2/7/2006	20.1	
MW-03	5/10/2006	13.6	
MW-03	8/10/2006	8.3	
MW-04	11/1/2000	39	
MW-04	11/16/2001	37	
MW-04	6/4/2002	36	
MW-04	12/10/2002	27	
MW-04	3/5/2003	26	
MW-04	6/4/2003	25	
MW-04	9/4/2003	28	
MW-04	12/8/2003	27	
MW-04	2/29/2004	24	
MW-04	5/7/2004	22	
MW-04	8/9/2004	20.8	
MW-04	11/8/2004	17.1	
MW-04	2/9/2005	33.3	
MW-04	5/11/2005	16.8	
MW-04	8/9/2005	22	
MW-04	11/16/2005	17.1	
MW-04	2/7/2006	18.8	
MW-04	5/9/2006	13.9	
MW-04	8/10/2006	7.3	
MW-06	11/1/2000	<4	
MW-06	9/6/2001	2.5	
MW-06	11/16/2001	<2	
MW-06	3/27/2002	2.6	
MW-06	6/4/2002	<2	
MW-06	9/17/2002	<2	
MW-06	12/6/2002	2.2	
MW-06	3/6/2003	2.4	
MW-06	6/5/2003	3	
MW-06	9/4/2003	3.4	
MW-06	12/8/2003	2.4	
MW-06	2/29/2004	4.1	
MW-06	5/4/2004	2.7	
MW-06	8/9/2004	4.2	
MW-06	11/9/2004	4.5	
MW-06	2/9/2005	5.2	
MW-06	5/9/2005	4.5	
MW-06	8/8/2005	<2	
MW-06	11/15/2005	5.6	
MW-06	2/6/2006	3.7	
MW-06	5/8/2006	2.1	
MW-06	8/9/2006	5.0	
MW-07	5/25/2001	15	
MW-07	11/14/2001	40	
MW-07	6/5/2002	46	
MW-07	9/25/2002	50	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-07	12/13/2002	59	
MW-07	3/7/2003	53	
MW-07	6/3/2003	48	
MW-07	9/3/2003	39	
MW-07	12/4/2003	45	
MW-07	2/26/2004	46	
MW-07	5/7/2004	42	
MW-07	8/6/2004	32.1	
MW-07	11/5/2004	24.4	
MW-07	2/2/2005	25.2	
MW-07	5/11/2005	29.1	
MW-07	8/9/2005	17.5	
MW-07	11/16/2005	15.1	
MW-07	2/8/2006	33.5	
MW-07	5/11/2006	21.3	
MW-07	8/10/2006	20	
MW-08	5/24/2001	52	
MW-08	11/16/2001	28	
MW-08	6/4/2002	38	
MW-08	12/6/2002	25	
MW-08	3/5/2003	19	
MW-08	6/4/2003	13	
MW-08	9/4/2003	7.1	
MW-08	12/2/2003	5.7	
MW-08	2/29/2004	8.6	
MW-08	5/4/2004	5.4	
MW-08	8/9/2004	5.4	
MW-08	11/8/2004	4.9	
MW-08	2/3/2005	12.3	
MW-08	5/6/2005	4.2	
MW-08	8/5/2005	4.8	
MW-08	11/15/2005	5.5	
MW-08	2/6/2006	10.5	
MW-08	5/8/2006	7.8	
MW-08	8/9/2006	8.2	
MW-09	11/1/2000	16	
MW-09	11/16/2001	5	
MW-09	6/4/2002	16	
MW-09	3/7/2003	23	
MW-09	6/3/2003	19	
MW-09	9/3/2003	13	
MW-09	12/4/2003	12	
MW-09	2/26/2004	11	
MW-09	5/7/2004	11	
MW-09	8/6/2004	11.5	
MW-09	11/5/2004	11.8	
MW-09	2/2/2005	9.5	
MW-09	5/6/2005	8.8	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-09	8/8/2005	8.1	
MW-09	11/15/2005	9.4	
MW-09	2/6/2006	16.1	
MW-09	5/8/2006	11.2	
MW-09	8/10/2006	16	
MW-10	9/6/2001	4.5	
MW-10	11/13/2001	<2	
MW-10	3/25/2002	3.5	
MW-10	6/4/2002	2.2	
MW-10	9/17/2002	2.6	
MW-10	12/2/2002	2.6	
MW-10	3/6/2003	<2	
MW-10	6/3/2003	2.4	
MW-10	9/5/2003	2.6	
MW-10	12/8/2003	2.1	
MW-10	2/27/2004	3.7	
MW-10	5/7/2004	2.4	
MW-10	8/10/2004	2.8	
MW-10	11/5/2004	2.7	
MW-10	2/7/2005	2.9	
MW-10	5/4/2005	3	
MW-10	6/9/2005	3.9	
MW-10	7/20/2005	3	
MW-10	8/4/2005	<1	
MW-10	9/8/2005	<1	
MW-10	10/6/2005	<2	
MW-10	11/10/2005	1.1	
MW-10	2/1/2006	1.5	
MW-10	5/2/2006	<2	
MW-10	8/9/2006	2.5	
MW-11	11/1/2000	<4	
MW-11	11/15/2001	<4	
MW-11	6/3/2002	<2	
MW-11	9/16/2002	2.6	
MW-11	12/3/2002	2.2	
MW-11	3/7/2003	<2	
MW-11	6/2/2003	3.3	
MW-11	9/2/2003	<2	
MW-11	12/4/2003	<2	
MW-11	2/27/2004	2.3	
MW-11	5/3/2004	2.1	
MW-11	8/6/2004	2.3	
MW-11	11/5/2004	2.3	
MW-11	12/1/2004	3.7	
MW-11	2/7/2005	2.9	
MW-11	5/5/2005	2.8	
MW-11	8/3/2005	<1	
MW-11	11/9/2005	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-11	2/1/2006	2.3	
MW-11	5/2/2006	<2	
MW-11	8/8/2006	2.3	
MW-12	5/23/2001	<4	
MW-12	11/16/2001	<2	
MW-12	3/28/2002	3.2	
MW-12	6/4/2002	3.3	
MW-12	9/17/2002	6.2	
MW-12	12/10/2002	4.7	
MW-12	3/10/2003	5.8	
MW-12	6/2/2003	8.4	
MW-12	9/2/2003	12	
MW-12	12/2/2003	11	
MW-12	2/27/2004	7.2	
MW-12	5/3/2004	12	
MW-12	8/6/2004	16	
MW-12	11/3/2004	24.1	
MW-12	2/3/2005	19.3	
MW-12	5/11/2005	16.7	
MW-12	8/10/2005	17.5	
MW-12	11/17/2005	15	
MW-12	2/8/2006	9.9	
MW-12	5/11/2006	15.5	
MW-12	8/2/2006	14	
MW-13	11/1/2000	6	
MW-13	11/15/2001	<4	
MW-13	6/3/2002	<2	
MW-13	9/16/2002	3.1	
MW-13	12/3/2002	2.2	
MW-13	3/7/2003	<2	
MW-13	6/2/2003	2.1	
MW-13	9/3/2003	2	
MW-13	12/4/2003	<2	
MW-13	2/27/2004	3	
MW-13	5/3/2004	<2	
MW-13	8/6/2004	2.4	
MW-13	11/4/2004	2.4	
MW-13	2/3/2005	2.2	
MW-13	5/5/2005	2.2	
MW-13	8/3/2005	<1	
MW-13	10/6/2005	<2	
MW-13	11/10/2005	1.6	
MW-13	2/1/2006	<2	
MW-13	5/2/2006	<2	
MW-13	8/8/2006	2.2	
MW-14	9/6/2001	3.5	
MW-14	11/15/2001	<2	
MW-14	3/26/2002	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-14	6/3/2002	<2	
MW-14	9/16/2002	3.2	
MW-14	12/3/2002	2.1	
MW-14	3/7/2003	<2	
MW-14	6/2/2003	3.3	
MW-14	9/3/2003	2.2	
MW-14	12/4/2003	<2	
MW-14	2/27/2004	<2	
MW-14	5/3/2004	2.2	
MW-14	8/6/2004	3.4	
MW-14	11/4/2004	3.4	
MW-14	2/3/2005	6.9	
MW-14	5/5/2005	4	
MW-14	8/3/2005	<1	
MW-14	10/6/2005	3.5	
MW-14	11/10/2005	2.6	
MW-14	2/1/2006	1.2	
MW-14	5/2/2006	3.1	
MW-14	8/8/2006	3.5	
MW-15	11/1/2000	<4	
MW-15	11/20/2001	<2	
MW-15	6/4/2002	<2	
MW-15	12/6/2002	2.3	
MW-15	3/10/2003	3.6	
MW-15	6/3/2003	2.3	
MW-15	9/2/2003	2	
MW-15	12/4/2003	<2	
MW-15	2/26/2004	2.5	
MW-15	5/5/2004	<2	
MW-15	8/6/2004	2.4	
MW-15	11/2/2004	2.4	
MW-15	2/7/2005	2.5	
MW-15	5/6/2005	2.5	
MW-15	8/8/2005	<2	
MW-15	10/7/2005	<2	
MW-15	11/15/2005	<1	
MW-15	2/6/2006	2.4	
MW-15	5/8/2006	<4	
MW-15	8/8/2006	<2	
MW-16	11/1/2000	5	
MW-16	11/14/2001	<10	
MW-16	6/5/2002	4.4	
MW-16	9/25/2002	6.4	
MW-16	12/13/2002	5.8	
MW-16	3/10/2003	5.8	
MW-16	6/2/2003	5.1	
MW-16	9/2/2003	4.8	
MW-16	12/2/2003	4.4	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-16	2/25/2004	4.9	
MW-16	5/5/2004	4.3	
MW-16	8/2/2004	4.2	
MW-16	11/2/2004	4.6	
MW-16	2/4/2005	4.2	
MW-16	5/4/2005	4.2	
MW-16	8/8/2005	<1	
MW-16	11/15/2005	2.7	
MW-16	2/7/2006	3.1	
MW-16	5/9/2006	3.2	
MW-16	8/3/2006	4.1	
MW-17	11/1/2000	<4	
MW-17	11/15/2001	<4	
MW-17	6/3/2002	<2	
MW-17	9/23/2002	2.2	
MW-17	12/5/2002	<2	
MW-17	3/11/2003	2	
MW-17	6/3/2003	2	
MW-17	9/4/2003	<2	
MW-17	12/9/2003	<2	
MW-17	2/29/2004	2.1	
MW-17	5/6/2004	<2	
MW-17	8/2/2004	<2	
MW-17	11/4/2004	<2	
MW-17	2/8/2005	<2	
MW-17	5/4/2005	<2	
MW-17	8/10/2005	1.9	
MW-17	10/6/2005	<2	
MW-17	11/11/2005	<1	
MW-17	2/1/2006	1.5	
MW-17	5/4/2006	<2	
MW-18	11/1/2000	<4	
MW-18	11/15/2001	<2	
MW-18	6/4/2002	<2	
MW-18	9/16/2002	2.7	
MW-18	12/3/2002	2.2	
MW-18	3/11/2003	2.5	
MW-18	6/3/2003	2.6	
MW-18	9/4/2003	<2	
MW-18	12/9/2003	2.1	
MW-18	2/29/2004	3.2	
MW-18	5/6/2004	2.7	
MW-18	8/2/2004	5.5	
MW-18	8/13/2004	5.5	
MW-18	11/4/2004	3.9	
MW-18	12/1/2004	2.3	
MW-18	1/5/2005	4.6	
MW-18	2/8/2005	5.4	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-18	3/2/2005	5.4	
MW-18	4/28/2005	4.9	
MW-18	5/9/2005	4.8	
MW-18	6/10/2005	5	
MW-18	7/20/2005	5.6	
MW-18	8/9/2005	2.9	
MW-18	9/9/2005	4.8	
MW-18	10/7/2005	4.9	
MW-18	11/15/2005	5	
MW-18	12/13/2005	4.3	
MW-18	1/20/2006	3.8	
MW-18	2/7/2006	3.9	
MW-18	3/7/2006	4.1	J
MW-18	4/6/2006	2	
MW-18	5/9/2006	3.8	
MW-18	6/8/2006	3.7	
MW-18	7/6/2006	3.5	
MW-18	8/3/2006	5.0	
MW-18	9/7/2006	4.3	
MW-19	11/1/2000	6.9	
MW-19	11/16/2001	6.4	
MW-19	6/24/2002	4.6	
MW-19	9/24/2002	5.1	
MW-19	12/13/2002	4.4	
MW-19	3/13/2003	4.1	
MW-19	6/3/2003	4	
MW-19	9/2/2003	3.3	
MW-19	12/4/2003	2.5	
MW-19	3/3/2004	3.3	
MW-19	5/6/2004	2.7	
MW-19	8/3/2004	3.1	
MW-19	11/5/2004	3.1	
MW-19	2/8/2005	2.3	
MW-19	5/10/2005	2.7	
MW-19	8/9/2005	<1	
MW-19	10/12/2005	2.4	
MW-19	11/16/2005	<2	
MW-19	2/7/2006	<2	
MW-19	5/9/2006	2.1	
MW-19	8/9/2006	2.5	
MW-20	9/6/2001	8.3	
MW-20	10/29/2001	9.3	
MW-20	11/16/2001	6.6	
MW-20	1/17/2002	<4	
MW-20	2/14/2002	7.8	
MW-20	3/21/2002	12	
MW-20	3/28/2002	6.8	
MW-20	4/4/2002	6.2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-20	4/11/2002	5.9	
MW-20	4/18/2002	6.4	
MW-20	4/25/2002	5.3	
MW-20	5/2/2002	5.7	
MW-20	5/9/2002	5.5	
MW-20	5/13/2002	5	
MW-20	5/20/2002	5.4	
MW-20	5/27/2002	6.7	
MW-20	6/4/2002	7.6	
MW-20	6/13/2002	7.7	
MW-20	6/28/2002	6.6	
MW-20	7/3/2002	6.5	
MW-20	7/10/2002	9.5	
MW-20	7/24/2002	6.1	
MW-20	7/30/2002	7	
MW-20	8/14/2002	7.9	
MW-20	8/21/2002	7.9	
MW-20	8/28/2002	6.6	
MW-20	9/4/2002	7.3	
MW-20	9/11/2002	6.7	
MW-20	9/17/2002	13	
MW-20	9/26/2002	14	
MW-20	10/2/2002	9.4	
MW-20	10/8/2002	13	
MW-20	10/16/2002	7.9	
MW-20	10/23/2002	7.1	
MW-20	11/6/2002	9.8	
MW-20	11/13/2002	6.7	
MW-20	11/20/2002	5.9	
MW-20	11/27/2002	5.9	
MW-20	12/4/2002	6.8	
MW-20	12/11/2002	6.2	
MW-20	12/18/2002	4.4	
MW-20	12/26/2002	2.1	
MW-20	12/30/2002	<2	
MW-20	1/2/2003	<2	
MW-20	1/8/2003	5.6	
MW-20	1/15/2003	5.8	
MW-20	1/22/2003	7.2	
MW-20	2/5/2003	6.7	
MW-20	2/12/2003	5.8	
MW-20	2/19/2003	6	
MW-20	2/26/2003	5.6	
MW-20	3/6/2003	5.6	
MW-20	4/9/2003	7.4	
MW-20	5/19/2003	6.4	
MW-20	6/6/2003	6.5	
MW-20	7/16/2003	6.8	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-20	8/29/2003	6.5	
MW-20	9/3/2003	5.5	
MW-20	10/8/2003	6.2	
MW-20	11/13/2003	5.8	
MW-20	12/3/2003	5.3	
MW-20	1/14/2004	6.4	
MW-20	2/11/2004	5.9	
MW-20	2/26/2004	6.1	
MW-20	4/14/2004	6.4	
MW-20	5/4/2004	5.4	
MW-20	6/2/2004	6.1	
MW-20	7/7/2004	5.9	
MW-20	8/4/2004	5.6	
MW-20	9/1/2004	5.7	
MW-20	10/6/2004	5.8	
MW-20	11/4/2004	5.7	
MW-20	12/1/2004	5.7	
MW-20	1/5/2005	5.9	
MW-20	2/2/2005	7.1	
MW-20	3/2/2005	5.5	
MW-20	3/14/2005	7.9	
MW-20	4/11/2005	4.8	
MW-20	5/6/2005	5.4	
MW-20	6/9/2005	5.6	
MW-20	7/20/2005	6.7	
MW-20	8/10/2005	7.5	
MW-20	9/2/2005	8.8	
MW-20	9/9/2005	4.5	
MW-20	9/13/2005	4.2	
MW-20	9/23/2005	7.1	
MW-20	9/29/2005	6.6	
MW-20	10/14/2005	7	
MW-20	11/16/2005	6	
MW-20	12/13/2005	4.8	
MW-20	12/21/2005	5.8	
MW-20	1/19/2006	4.9	
MW-20	2/7/2006	6.1	
MW-20	3/7/2006	8.7	J
MW-20	3/13/2006	<10	J
MW-20	4/6/2006	6.1	
MW-20	4/20/2006	6	
MW-20	5/9/2006	5.7	
MW-20	6/7/2006	8.8	
MW-20	7/6/2006	6.9	
MW-20	8/10/2006	6	
MW-20	9/7/2006	6.9	
MW-21	9/6/2001	2.4	
MW-21	11/16/2001	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-21	3/27/2002	<2	
MW-21	6/4/2002	<2	
MW-21	9/24/2002	2.2	
MW-21	12/13/2002	2.7	
MW-21	3/10/2003	2	
MW-21	6/3/2003	2.6	
MW-21	9/3/2003	2.3	
MW-21	12/4/2003	<2	
MW-21	2/27/2004	<2	
MW-21	5/5/2004	2.6	
MW-21	8/6/2004	3.3	
MW-21	11/8/2004	3.2	
MW-21	2/7/2005	2.3	
MW-21	8/5/2005	2.1	
MW-21	11/14/2005	2.7	
MW-21	2/2/2006	2.7	
MW-21	5/5/2006	2.6	
MW-21	8/7/2006	2.8	
MW-22	11/1/2000	<4	
MW-22	11/15/2001	<2	
MW-22	6/4/2002	<2	
MW-22	9/16/2002	2.4	
MW-22	12/3/2002	<2	
MW-22	3/12/2003	2.2	
MW-22	6/2/2003	2.2	
MW-22	9/3/2003	2.1	
MW-22	12/4/2003	<2	
MW-22	2/27/2004	2.4	
MW-22	5/6/2004	<2	
MW-22	8/6/2004	2.6	
MW-22	11/3/2004	2.3	
MW-22	2/7/2005	2.2	
MW-22	5/9/2005	2.1	
MW-22	8/4/2005	1.7	
MW-22	11/10/2005	1	
MW-22	2/1/2006	1.7	
MW-22	5/3/2006	<4	
MW-22	8/8/2006	2.6	
MW-23	11/1/2000	<4	
MW-23	9/6/2001	<2	
MW-23	11/16/2001	<2	
MW-23	3/27/2002	2	
MW-23	6/4/2002	<2	
MW-23	9/17/2002	2.5	
MW-23	12/3/2002	<2	
MW-23	3/6/2003	<2	
MW-23	6/5/2003	2.4	
MW-23	9/4/2003	2.2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-23	12/8/2003	<2	
MW-23	2/29/2004	2.8	
MW-23	5/5/2004	<2	
MW-23	8/9/2004	2.7	
MW-23	11/8/2004	2.6	
MW-23	2/9/2005	5.8	
MW-23	5/6/2005	2.9	
MW-23	8/5/2005	<1	
MW-23	11/14/2005	2	
MW-23	2/3/2006	3.1	
MW-23	5/4/2006	<2	
MW-23	8/9/2006	3.7	
MW-24	11/1/2000	<4	
MW-24	11/13/2001	<2	
MW-24	6/5/2002	<2	
MW-24	9/25/2002	3.9	
MW-24	12/13/2002	2.2	
MW-24	3/5/2003	2	
MW-24	6/2/2003	3.1	
MW-24	9/2/2003	3.1	
MW-24	12/2/2003	2.9	
MW-24	2/24/2004	3	
MW-24	5/5/2004	2.9	
MW-24	8/2/2004	3.6	
MW-24	11/2/2004	2.9	
MW-24	2/4/2005	3.5	
MW-24	5/4/2005	4.3	
MW-24	8/4/2005	<1	
MW-24	11/11/2005	3.8	
MW-24	2/3/2006	<2	
MW-24	8/3/2006	5.1	
MW-25	11/1/2000	<4	
MW-25	11/14/2001	<2	
MW-25	6/5/2002	2.1	
MW-25	9/24/2002	<2	
MW-25	12/5/2002	2.6	
MW-25	3/10/2003	3.1	
MW-25	6/2/2003	2.9	
MW-25	9/2/2003	2.5	
MW-25	12/2/2003	2.4	
MW-25	2/24/2004	4.1	
MW-25	5/5/2004	3.4	
MW-25	8/2/2004	3.5	
MW-25	8/13/2004	4	
MW-25	11/2/2004	5.3	
MW-25	12/1/2004	4.8	
MW-25	1/5/2005	27.9	
MW-25	2/4/2005	5.4	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-25	3/2/2005	6.3	
MW-25	4/11/2005	5.1	
MW-25	5/11/2005	5.1	
MW-25	6/10/2005	7.4	
MW-25	7/20/2005	6.7	
MW-25	8/9/2005	4.7	
MW-25	9/9/2005	5.5	
MW-25	10/7/2005	5.4	
MW-25	11/16/2005	3.8	
MW-25	12/13/2005	5	
MW-25	1/19/2006	4.9	
MW-25	2/8/2006	6.4	
MW-25	3/7/2006	6.5	J
MW-25	4/6/2006	8	
MW-25	5/10/2006	4.5	
MW-25	6/7/2006	4.4	
MW-25	7/6/2006	3.4	
MW-25	8/3/2006	4.4	
MW-25	9/7/2006	4.2	
MW-26	11/16/2001	<2	
MW-26	3/29/2002	<2	
MW-26	6/5/2002	<2	
MW-26	9/23/2002	<2	
MW-26	12/5/2002	<2	
MW-26	3/10/2003	2	
MW-26	6/2/2003	<2	
MW-26	9/2/2003	<2	
MW-26	12/2/2003	<2	
MW-26	2/25/2004	<2	
MW-26	5/6/2004	<2	
MW-26	8/2/2004	<2	
MW-26	11/2/2004	<2	
MW-26	2/4/2005	2.8	
MW-26	5/4/2005	<2	
MW-26	8/4/2005	<1	
MW-26	10/6/2005	<1	
MW-26	11/11/2005	<1	
MW-26	2/3/2006	<1	
MW-26	5/3/2006	<2	
MW-26	6/7/2006	<2	
MW-26	7/6/2006	<2	
MW-26	8/9/2006	<2.0	
MW-26	9/7/2006	<2.0	
MW-27	10/29/2001	7.5	
MW-27	11/16/2001	5.8	
MW-27	3/26/2002	11	
MW-27	6/4/2002	17	
MW-27	9/17/2002	21	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-27	12/6/2002	23	
MW-27	3/7/2003	21	
MW-27	6/3/2003	27	
MW-27	9/3/2003	30	
MW-27	12/4/2003	27	
MW-27	2/24/2004	32	
MW-27	5/6/2004	31	
MW-27	8/6/2004	35.3	
MW-27	11/8/2004	33	
MW-27	2/7/2005	32.8	
MW-27	5/9/2005	29.1	
MW-27	8/8/2005	31.2	
MW-27	11/16/2005	36.8	
MW-27	2/7/2006	44.7	
MW-27	3/7/2006	45	
MW-27	4/6/2006	44.4	
MW-27	5/10/2006	45.1	
MW-27	6/7/2006	44.2	
MW-27	7/6/2006	43.5	
MW-27	8/2/2006	41	
MW-27	9/7/2006	43	
MW-28	3/7/2002	3.3	
MW-28	4/24/2002	4.7	
MW-28	6/5/2002	3	
MW-28	7/30/2002	4.2	
MW-28	8/14/2002	4.3	
MW-28	9/24/2002	5.8	
MW-28	10/9/2002	4.9	
MW-28	11/22/2002	4.3	
MW-28	12/5/2002	4	
MW-28	1/15/2003	3.6	
MW-28	2/19/2003	4	
MW-28	3/10/2003	8.4	
MW-28	6/2/2003	3.9	
MW-28	9/3/2003	3.9	
MW-28	12/2/2003	2.4	
MW-28	2/27/2004	4.4	
MW-28	5/6/2004	3.7	
MW-28	8/6/2004	4.3	
MW-28	11/3/2004	3.8	
MW-28	2/7/2005	3.6	
MW-28	5/5/2005	3.8	
MW-28	8/3/2005	3.3	
MW-28	11/11/2005	5.3	
MW-28	2/2/2006	4	
MW-28	5/4/2006	3.1	
MW-28	8/8/2006	4.1	
MW-29	3/7/2002	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-29	6/5/2002	<2	
MW-29	9/23/2002	2.1	
MW-29	12/5/2002	2.5	
MW-29	3/10/2003	2.8	
MW-29	6/2/2003	3	
MW-29	9/2/2003	2.6	
MW-29	12/4/2003	3.7	
MW-29	2/27/2004	2.8	
MW-29	5/3/2004	2.5	
MW-29	8/6/2004	2.2	
MW-29	11/4/2004	3.3	
MW-29	2/3/2005	3.4	
MW-29	5/5/2005	3.1	
MW-29	8/3/2005	<1	
MW-29	10/7/2005	4.4	
MW-29	11/14/2005	4.6	
MW-29	2/2/2006	3.2	
MW-29	5/5/2006	<4	
MW-29	6/7/2006	5.4	
MW-29	7/6/2006	7.5	
MW-29	8/2/2006	5.9	
MW-A	8/17/2005	49.5	
MW-A	8/29/2005	47.9	
MW-A	11/8/2005	52.4	
MW-A	12/30/2005	49.9	
MW-A	1/31/2006	50.4	
MW-A	3/1/2006	53	
MW-B	8/16/2005	46.8	
MW-B	8/30/2005	52.7	
MW-B	11/8/2005	33.1	
MW-B	12/28/2005	38.8	
MW-B	1/6/2006	33.1	
MW-B	1/11/2006	34.6	
MW-B	1/18/2006	25.3	
MW-B	1/31/2006	28.2	
MW-B	3/1/2006	40	
MW-C	8/17/2005	49.7	
MW-C	8/30/2005	48.5	
MW-C	11/8/2005	48.5	
MW-C	12/30/2005	47.3	
MW-C	1/6/2006	48.6	
MW-C	1/11/2006	45.7	
MW-C	1/18/2006	25.2	
MW-C	1/31/2006	55.5	
MW-C	3/2/2006	56	
MW-D	8/17/2005	46.8	
MW-D	8/30/2005	47.9	
MW-D	11/8/2005	45.5	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
MW-D	12/29/2005	42.9	
MW-D	1/31/2006	47.3	
MW-D	3/1/2006	60	
OW-B	3/6/2002	5.2	
OW-B	6/10/2003	11	
OW-B	9/8/2003	14	
OW-B	12/8/2003	14	
OW-B	2/27/2004	15	
OW-B	5/7/2004	16	
OW-B	8/10/2004	21.2	
OW-B	11/5/2004	22.3	
OW-B	2/8/2005	24.6	
OW-B	5/4/2005	28.4	
OW-B	8/4/2005	25.4	
OW-B	11/14/2005	37.3	
OW-B	2/9/2006	17	
OW-B	5/8/2006	33.6	
OW-B	8/10/2006	40	
OW-C	3/6/2002	3.1	
OW-C	6/10/2003	2.6	
OW-C	9/8/2003	3	
OW-C	12/8/2003	<2	
OW-C	2/26/2004	2.2	
OW-C	5/4/2004	<2	
OW-C	8/10/2004	2	
OW-C	11/5/2004	2.3	
OW-C	2/8/2005	<2	
OW-C	5/4/2005	<2	
OW-C	8/4/2005	<1	
OW-C	11/10/2005	<1	
OW-C	2/1/2006	<1	
OW-C	2/3/2006	<1	
OW-C	5/2/2006	<2	
OW-C	8/9/2006	2.1	
OW-C	8/9/2006	1.6	J
PZ-01	11/14/2001	<10	
PZ-01	6/5/2002	68	
PZ-01	9/25/2002	72	
PZ-01	12/5/2002	52	
PZ-01	1/15/2003	<2	
PZ-01	2/19/2003	31	
PZ-01	3/13/2003	43	
PZ-01	6/3/2003	38	
PZ-01	9/3/2003	27	
PZ-01	12/4/2003	49	
PZ-01	2/26/2004	36	
PZ-01	5/7/2004	20	
PZ-01	8/6/2004	17.7	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
PZ-01	11/4/2004	20.2	
PZ-01	2/2/2005	51.3	
PZ-01	5/11/2005	6.4	
PZ-01	8/9/2005	33.5	
PZ-01	11/17/2005	36.2	
PZ-01	2/8/2006	40.8	
PZ-01	5/11/2006	13.9	
PZ-01	8/10/2006	16	
IW-01	8/17/2005	45.1	
IW-01	8/30/2005	61.8	
IW-01	11/8/2005	65	
IW-01	12/30/2005	57.4	
IW-01	1/6/2006	1.3	
IW-01	1/11/2006	<5	
IW-01	1/18/2006	<2	
IW-01	1/31/2006	<5	
IW-01	3/2/2006	11	
IW-02	8/16/2005	61.6	
IW-02	8/29/2005	65.9	
IW-02	11/8/2005	51.2	
IW-02	12/30/2005	47	
IW-02	1/6/2006	<2	
IW-02	1/11/2006	<2	
IW-02	1/18/2006	<2	
IW-02	1/31/2006	<2	
IW-02	3/2/2006	<10	
IX-INF	4/25/2005	18.1	
IX-INF	4/27/2005	15.5	
IX-INF	4/29/2005	12.2	
IX-INF	5/4/2005	12.7	
IX-INF	5/11/2005	12.5	
IX-INF	5/18/2005	13.1	
IX-INF	6/10/2005	7.3	
IX-INF	7/7/2005	13.9	
IX-INF	8/12/2005	13.1	
IX-INF	9/8/2005	12.4	
IX-INF	10/27/2005	17.7	
IX-INF	11/16/2005	12.8	
IX-INF	12/13/2005	11.5	
IX-INF	1/19/2006	11.7	
IX-INF	2/9/2006	12	
IX-INF	3/8/2006	15	
IX-INF	4/7/2006	14	
IX-INF	5/11/2006	14.3	
IX-INF	6/8/2006	13.2	
IX-INF	7/7/2006	10.1	
IX-INF	8/8/2006	13	
IX-V2	1/19/2006	<2	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
IX-V2	2/9/2006	1.5	
IX-V2	3/8/2006	<4.0	
IX-V2	4/7/2006	3.4	
IX-V2	4/24/2006	4.1	
IX-V2	5/11/2006	4.5	
IX-V2	5/22/2006	7.9	
IX-V2	6/8/2006	11.8	
IX-VI	4/21/2005	<2.0	
IX-VI	4/25/2005	<2.0	
IX-VI	4/27/2005	<2.0	
IX-VI	4/29/2005	<2	
IX-VI	5/4/2005	<2.0	
IX-VI	5/11/2005	<2.0	
IX-VI	5/18/2005	<2.0	
IX-VI	6/10/2005	<2	
IX-VI	7/7/2005	2.6	
IX-VI	8/12/2005	3.1	
IX-VI	9/8/2005	5.4	
IX-VI	10/27/2005	5.6	
IX-VI	11/16/2005	6	
IX-VI	12/13/2005	5	
IX-VI	7/7/2006	<2	
IX-VI	8/8/2006	<2	
IX-EFF	4/21/2005	<2.0	
IX-EFF	4/25/2005	<2.0	
IX-EFF	4/27/2005	<2.0	
IX-EFF	4/29/2005	<2	
IX-EFF	5/4/2005	<2.0	
IX-EFF	5/11/2005	<2.0	
IX-EFF	5/18/2005	<2.0	
IX-EFF	6/10/2005	<2	
IX-EFF	7/7/2005	<2	
IX-EFF	8/12/2005	<2	
IX-EFF	9/8/2005	<1	
IX-EFF	10/27/2005	<2	
IX-EFF	11/16/2005	<2	
IX-EFF	12/13/2005	1.3	
IX-EFF	1/19/2006	<2	
IX-EFF	2/9/2006	<1	
IX-EFF	3/8/2006	<3.0	
IX-EFF	3/8/2006	3.1	J
IX-EFF	4/7/2006	<2	
IX-EFF	5/11/2006	<4	
IX-EFF	6/8/2006	2.8	J
IX-EFF	7/7/2006	<2	
IX-EFF	8/8/2006	<2	
PH1-INF	8/23/2001	64	
PH1-INF	2/4/2002	74	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
PH1-INF	2/9/2005	24.8	
PH23-INF	8/23/2001	28	
PH23-INF	2/4/2002	28	
PH23-INF	2/9/2005	10	
PH123-EFF	12/13/2001	40	
PH123-EFF	3/8/2002	46	
PH123-EFF	6/13/2002	48	
PH123-EFF	9/11/2002	42	
PH123-EFF	12/12/2002	45	
PH123-EFF	3/25/2003	45	
PH123-EFF	6/18/2003	19	
PH1-EFF	8/23/2001	65	
PH1-EFF	2/4/2002	73	
PH1-EFF	4/16/2002	69	
PH1-EFF	11/13/2003	38	
PH1-EFF	2/11/2004	36	
PH1-EFF	5/5/2004	34	
PH1-EFF	8/4/2004	30.8	
PH1-EFF	10/6/2004	30.1	
PH1-EFF	2/9/2005	24.1	
PH23-EFF	8/23/2001	32	
PH23-EFF	11/21/2001	41	
PH23-EFF	2/4/2002	30	
PH23-EFF	11/13/2003	14	
PH23-EFF	2/11/2004	16	
PH23-EFF	5/5/2004	10	
PH23-EFF	8/4/2004	10.7	
PH23-EFF	10/6/2004	9.8	
PH23-EFF	2/9/2005	9.7	
SB-09LC	2/18/2002	2.3	
SB-6UC	2/18/2002	2.8	
COG-02	6/14/2001	2.5	
COG-02	7/17/2001	1.9	
COG-02	9/6/2001	2.4	
COG-02	9/6/2001	2.9	
COG-02	10/16/2001	<2	
COG-02	10/16/2001	<2	
COG-02	11/21/2001	<2	
COG-02	12/13/2001	<2	
COG-02	1/17/2002	<2	
COG-02	3/8/2002	2	
COG-02	3/29/2002	2.6	
COG-02	4/22/2002	2.2	
COG-02	5/17/2002	2.3	
COG-02	6/6/2002	<2	
COG-02	7/24/2002	2.9	
COG-02	8/14/2002	2.8	
COG-02	9/18/2002	2.4	

Table A-1 Historic Perchlorate Data

Well Name	Sample_date	Perchlorate (ppb)	Validator_qualifiers
COG-02	9/18/2002	2.1	
COG-02	10/9/2002	2.7	
COG-02	10/9/2002	2.8	
COG-02	11/22/2002	2.5	
COG-02	12/4/2002	2.6	
COG-02	12/4/2002	2.3	
COG-02	12/11/2002	2.4	
COG-02	12/18/2002	2.5	
COG-02	12/23/2002	3.6	
COG-02	1/2/2003	2.3	
COG-02	1/8/2003	2.7	
COG-02	1/15/2003	3.1	
COG-02	1/22/2003	NS	
COG-02	1/29/2003	NS	
COG-02	2/5/2003	2.5	
COG-02	2/11/2003	2.7	
COG-02	2/19/2003	2.7	
COG-02	2/26/2003	2.9	
COG-02	3/5/2003	NS	
COG-02	3/12/2003	2.5	
COG-02	3/12/2003	3.1	
COG-02	3/19/2003	3.1	
COG-02	3/26/2003	2.8	
COG-02	4/2/2003	3.1	

CATEGORY	Well	Sample_date	Perchlorate (ppb)	Validator_qualifiers
	COG-02	6/14/2001	2.5	
	COG-02	7/17/2001	1.9	
	COG-02	9/6/2001	2.4	
	COG-02	9/6/2001	2.9	
	COG-02	10/16/2001	<2	
	COG-02	10/16/2001	<2	
	COG-02	11/21/2001	<2	
	COG-02	12/13/2001	<2	
	COG-02	1/17/2002	<2	
	COG-02	3/8/2002	2	
	COG-02	3/29/2002	2.6	
	COG-02	4/22/2002	2.2	
	COG-02	5/17/2002	2.3	
	COG-02	6/6/2002	<2	
	COG-02	7/24/2002	2.9	
	COG-02	8/14/2002	2.8	
	COG-02	9/18/2002	2.4	
	COG-02	9/18/2002	2.1	
	COG-02	10/9/2002	2.7	
	COG-02	10/9/2002	2.8	
	COG-02	11/22/2002	2.5	
	COG-02	12/4/2002	2.6	
	COG-02	12/4/2002	2.3	
	COG-02	12/11/2002	2.4	
	COG-02	12/18/2002	2.5	
	COG-02	12/23/2002	3.6	
	COG-02	1/2/2003	2.3	
	COG-02	1/8/2003	2.7	
	COG-02	1/15/2003	3.1	
	COG-02	1/22/2003	NS	
	COG-02	1/29/2003	NS	
	COG-02	2/5/2003	2.5	
	COG-02	2/11/2003	2.7	
	COG-02	2/19/2003	2.7	
	COG-02	2/26/2003	2.9	
	COG-02	3/5/2003	NS	
	COG-02	3/12/2003	2.5	
	COG-02	3/12/2003	3.1	
	COG-02	3/19/2003	3.1	
	COG-02	3/26/2003	2.8	
	COG-02	4/2/2003	3.1	

NOTES:

NS - Not Sampled

REFERENCES:

USEPA, Region IX. "Wellhead Treatment Required for City of Goodyear Well COG-2 Phoenix Goodyear Airport North Superfund Site" (2003)

Appendix B

Data Usability Assessment

Draft Evaluation of ARCADIS Data Validation PGA North Site Perchlorate EE/CA Project

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1.0 Introduction

The United States Environmental Protection Agency (EPA) requested that CH2M HILL validate a subset of the perchlorate groundwater data from the second and third quarters of 2006 that has low and high concentration hits. This memorandum presents a discussion of the independent evaluation of laboratory results reports and third party validation reports that were included the quarterly groundwater monitoring reports provided by ARCADIS in 2006. The evaluation was limited to perchlorate results from groundwater samples collected during the second and third quarters 2006 to support the Engineering Evaluation and Cost Analysis (EE/CA) project that is being performed for the Phoenix-Goodyear Airport North (PGA North) site.

The evaluation was focused on verifying that the findings of the validation reports were consistent with the following.

- Corresponding laboratory reports; the ARCADIS Quality Assurance Project Plan (QAPP) (Arcadis, 2006) and associated Standard Operating Procedures (SOPs);
- EPA Region 9 guidance for Tier 1 data review and Tier 3 data validation;
- Applicable method, EPA Method 314.0; and
- General data-flagging procedures presented in the *National Functional Guidelines for Inorganic Data Review* (EPA, 2004).

As a first step in the evaluation, the laboratory reports and validation reports presented in the quarterly report Appendix D and Appendix F, respectively, were inventoried. Both Aerotech Environmental Laboratory (AEL) and Severn Trent Laboratories (STL) performed the sample analyses. The results of this inventory are presented in Table 1.

TABLE 1
Inventory of Laboratory Reports and Data Review/Validation Reports

Collection Date	AEL Sample Delivery Group	STL Sample Delivery Group	Tier 1 Data Review Report	Tier 3 Data Validation Report	Number of Samples Analyzed for Perchlorate
3/7/2006	6030782	NA		x	7
3/8/2006	6030844	NA	x		8
3/13/2006	6031042	NA	x		1
4/6/2006	6040760	G6D140166	x		10
4/7/2006	6040831	G6D140151	x		2
4/7/2006	6040831	G6D140159	x		4
4/20/2006	6041465	G6D220212	x		1
4/24/2006	6041553	G6D260281	x		1
5/2/2006	6050474	G6E030365	x		5
5/2/2006	6050545	G6E040262	x		6
5/3/2006	6050616	G6E060121	x		11
5/4/2006	6050673	G6E060203	x		7
5/5/2006	6050717	G6E090235	x		7
5/6/2006	6050723	G6E090232	x		3
5/8/2006	6050767	G6E100328	x		9
5/9/2006	6050845	G6E110382	x		7
5/10/2006	6050905	G6E130188	x		8
5/11/2006	6050967	G6E130197	x		9
5/18/2006	6051228	G6E190333	x		1
5/22/2006	6051316	G6E240314	x		1
6/7/2006	6060269	G6F100213	x		7
6/8/2006	6060305	G6F100214	x		8
6/9/2006	6060353	G6F13304	x		2
6/20/2006	6060728	G6F220258	x		2
6/23/2006	6060859	G6F240215	x		3
7/6/2006	6070152	G6G080192	x		7
7/7/2006	6070194	G6G110312	x		11
8/2/2006	6080111	NA	x		3
8/3/2006	6080175	NA	x		7
8/4/2006	6080232	NA	x		2

TABLE 1
Inventory of Laboratory Reports and Data Review/Validation Reports

Collection Date	AEL Sample Delivery Group	STL Sample Delivery Group	Tier 1 Data Review Report	Tier 3 Data Validation Report	Number of Samples Analyzed for Perchlorate
8/7/2006	6080273	NA	x		10
8/8/2006	6080340	NA	x		4
8/9/2006	6080393	NA		x	11
8/10/2006	6080463	NA		x	8
8/14/2006	6080544	NA	x		8

NA = Not applicable

The following steps were taken to accomplish the evaluation:

- The analytical and validation procedures were reviewed for consistency with QAPP requirement;
- A number of Tier 1 data review memoranda were selected and the findings verified by comparison with the laboratory results report;
- The findings of all of the Tier 3 data review memoranda were verified by comparison with the laboratory results report and the raw data, and;
- Several laboratory submissions were selected for independent Tier 3 review.

The following sections describe the outcome of the evaluation steps described above.

2.0 Qualified Results

The data validation reports were reviewed, and the qualified perchlorate results and the basis for the qualifications are presented in Table 2.

TABLE 2
Summary of Qualified Results

SDG	Date Collected	Sample ID	Result	Final Qualifier	Reason
Second Quarter 2006					
06030782	6/7/2006	PSDW	3.8	J	Result is reported at a concentration between the Method Detection Limit and the Reporting Limit; the result is estimated because of the increased uncertainty as the limit of detection is approached
06030782	6/7/2006	MW-20	8.7	J	
06030782	6/7/2006	MW_25	6.9	J	
06030782	6/7/2006	MW-18	4	J	
06030782	6/7/2006	MW-18 FD	4	J	

TABLE 2
Summary of Qualified Results

SDG	Date Collected	Sample ID	Result	Final Qualifier	Reason
Second Quarter 2006					
06050723	5/6/2006	MW8	<4	R	Quantitation limits were rejected because the samples arrived at the laboratory at a temperature of 13.6 degrees Celsius.
06050723	5/6/2006	MW9	<4	R	
Third Quarter 2006					
06060269	6/7/2006	COG-10	1.3	J	Result is reported at a concentration between the Method Detection Limit and the Reporting Limit; the result is estimated because of the increased uncertainty as the limit of detection is approached.
06060269	6/7/2006	Sun-Cor-3B	1.7	J	
06070194	6/7/2006	COG-10 dup	0.78	J	
06070194	7/7/2006	COG-03	1.2	J	
06080273	8/7/2006	COG-03	1.6	J	
06080273	8/7/2006	COG-06	1.9	J	
06080273	8/7/2006	COG-18A	1.7	J	
06080393	8/9/2006	OWC	1.6	J	
06080463	8/10/2006	COA-18	1.2	J	
06080544	8/14/2006	EPA-10A	1.9	J	

3.0 Overall Comments on the Laboratory Reports

The laboratory reports, Tier 1 review, and Tier 3 validation reports, as well as the applicable documents listed in Section 1, were reviewed for consistency with the QAPP. In general, requirements of the ARCADIS QAPP, the AEL Standard Operating Procedure 08-039.03, and other applicable documents were followed. Of the 35 sample delivery groups (SDGs) containing perchlorate results, 24 were subcontracted by AEL (the primary laboratory) to STL in West Sacramento, California, an AEL-affiliated laboratory. Based on the summary laboratory reports submitted, STL and AEL used the QAPP requirements for sensitivity, precision, and accuracy.

- No full documentation packages, including raw data, were submitted from STL, and no Tier 3 validation was performed on any STL SDG. This is contrary to the requirements of the QAPP, Section 5.2.1, which states, "...initially, 25 percent of the laboratory analytical results will be subjected to Tier 3 validation."
- Both laboratories reported results to the required perchlorate reporting limit, 2 micrograms per liter ($\mu\text{g}/\text{L}$). Sensitivity is not discussed as part of the Data Quality Indicators, Section 2.5 of the QAPP. However, Section 2.7.2 of the QAPP presents the requirement for reporting results between the reporting limit (RL) and the method detection limit (MDL). The MDL is listed in Table 2 of the QAPP, but the MDL is not

included in the laboratory reports by AEL or STL. The MDL was not included in the results reports. Based on the information submitted, determining if the QAPP MDL requirement was satisfied is not possible.

4.0 Data Review and Validation

4.1 Tier 1 Data Review Reports

A total of 201 perchlorate results were presented. Of these, 175 (or 87 percent) were reviewed at the Tier 1 level. The Tier 1 review included the following elements as presented in the third party validator report:

- Holding Time/Preservation
- Detection Limits/Dilutions
- Blanks
 - Method Blanks/Preparation Blanks
 - Equipment Blanks
- Matrix Spike Percent Recovery
- Matrix Spike Duplicate Percent Recovery and Relative Percent Difference
- Field/Laboratory Duplicate Comparison
- Results Quantitation

The review elements listed above as presented by the third party validator are consistent with the QAPP requirements presented in Section 5.2.1. The perchlorate laboratory results and corresponding validation reports for SDGs 06030844 and 06050616 (STL SDG G6E060121) were reviewed. For SDG 06030844, the Practical Quantitation Limit (PQL) was changed from 2 µg/L to 1 µg/L for three samples. No information was submitted about the reason for this change, either in the laboratory report or the data review report. The QAPP required reporting limit is 2 µg/L. Additionally, because no raw data were provided, determining if the low-point standard was at or below the quantitation limit.

4.2 Tier 3 Validation

Overall, 13 percent of the results received Tier 3 validation based on the total number of STL and AEL analyses contrary to the 25 percent requirement stated in the QAPP from ARCADIS. Full data packages, and Tier 3 validation reports were submitted for second quarter results in SDG 6030782. The Tier 3 report accurately presented the review findings based on the raw data submitted. One deviation from the AEL SOP was noted. The SOP for AEL requires a 6-point curve. The AEL SDG included a 5-point curve. Because the analytical method requires a 3-level initial calibration curve, this deviation is insignificant and does not affect usability. The linearity requirement was satisfied.

Three full-data packages, SDGs 06030782, 06080393, and 06080463, were reviewed independently and compared to the findings of the ARCADIS validation reports.

SDG 06030782

In general, the information presented in the ARCADIS data validation report was consistent with the laboratory report and supporting raw data. The ARCADIS validation reports do

not specifically state that any sample results were recalculated and verified, which should be part of the Tier 3 validation process.

The following issues were noted:

- Raw data were submitted only for the samples analyzed on 3/17/2006 although two samples, MW018 primary and field duplicate, were analyzed on 3/17/2006 and again on 3/31/2006. This finding is consistent with Item 11 in the ARCADIS validation report, which implies that the ion chromatograms for 3/31/2006 were not reviewed:

...All ion chromatograms from the March 17 analyses were reviewed to verify that the sample results reported matched those presented in the raw data...

The associated batch quality control results were provided in the laboratory report for the 3/31/2006 analyses and were within project acceptance criteria. The samples from 3/31/2006 should be considered Tier 1 reviewed because the raw data were not provided.

- The initial analyses of samples MW018 primary and field duplicate were performed on 3/17/2006. No perchlorate was detected in these samples on 3/17/2006. Subsequently, AEL laboratory reanalyzed the samples and resubmitted an amended report dated 4/5/2006. The Reporting Limit for the 3/31/2006 analyses was lowered to 1 µg/L. The low point standard in the calibration curve supplied for the 3/17/2006 analyses was 2 µg/L. Because no raw data were supplied for these samples, determining if the low point calibration standard was at or below the revised 1 µg/L Reporting Limit is not possible. In addition, the laboratory report indicates that both of these samples were analyzed at 10:04 PM. Analyzing two samples at the same time seems unlikely unless the samples were analyzed on different instruments. This issue might be an error in the laboratory report. The raw data are unavailable for verification.
- For the samples analyzed on 3/17/2006, the matrix spike concentration was 125 µg/L and the matrix spike/spike duplicate samples were analyzed at a 5-fold dilution. This is contrary to the Aerotech SOP, which specifies a 25-µg/L spiking level.

SDGs 06080393 and 06080463

In general, the information presented in the ARCADIS data validation report was consistent with the laboratory reports and supporting raw data. Selected results were recalculated and were in agreement with the reported results. No other issues or problems were identified with this data package or the with associated data validation report.

5.0 Overall Assessment

Based on the information reviewed, the perchlorate results along with the data review and validation findings presented by ARCADIS indicate that the data are usable to support environmental decisions. No major analytical deficiencies were noted during this evaluation other than those specifically discussed in this memorandum. Some uncertainties do remain associated with the analyses performed by STL, which did not undergo a Tier 3 review.

Appendix C

Streamlined Risk Evaluation

C. Streamlined Risk Evaluation

C.1 Introduction

Perchlorate in groundwater at the Phoenix-Goodyear Airport North Superfund Site (PGA North or the Site) presents a potential threat to nearby drinking water supplies. Land uses near the Site include a mix of residential, commercial, industrial, and agricultural activities, with associated public drinking water and irrigation use of groundwater.

The hydrogeology of the PGA North study area includes the Upper Alluvial Unit (UAU) and Middle Alluvial Unit (MAU). The UAU is the uppermost water bearing unit and consists of three subunits. Subunit A is composed primarily of silty sands and extends from surface to about 160 feet below ground surface (bgs). Subunit B, composed primarily of sandy silt, extends from about 160 to 230 feet bgs. Subunit C, composed primarily of silt, sand and gravel, extends from about 230 to 360 feet bgs. Where competent, Subunit B acts as an aquitard, impeding the flow of groundwater between Subunit A and Subunit C. Therefore, Subunits A and C are the primary water bearing horizons within the UAU. The UAU grades into the MAU which consists generally of lower permeability silty sands and clay, but is still an important regional water supply unit. Some regional water supply wells, especially older irrigation wells converted into product wells, have screen intakes completed across Subunits A, B and C of the UAU, and extending into the MAU. Based on available data, the highest concentrations of perchlorate are in Subunits A and C of the UAU.

As part of the Engineering Evaluation/Cost Analysis (EE/CA), the goal of the Streamlined Risk Evaluation (SRE) is to determine if hazards to human health from possible exposure to perchlorate-contaminated groundwater contained in the UAU (Subunits A, B, and C) warrant removal action. The potential human health hazard considered in this SRE is based on the domestic use of perchlorate-contaminated groundwater.

Trichloroethene (TCE) contamination is already addressed in the Site Record of Decision (ROD) and is not included in this SRE. The recent report "Groundwater Monitoring, Fourth Quarter 2006 and 2006 Annual Report", Phoenix Goodyear Airport-North Superfund Site (ARCADIS, 2007) presents an overview of volatile organic compound (VOC) groundwater characterization studies and remedial activities including similar efforts for perchlorate conducted for the Site, and also describes related EPA activities and documents.

In this SRE, groundwater perchlorate concentrations within Subunits A, B, and C of the UAU are compared against two risk-based groundwater screening levels, which were developed by the U. S. Environmental Protection Agency (EPA) and the State of Arizona.

Results of this SRE indicate that current perchlorate levels in groundwater present a potential significant health hazard for both groundwater screening levels. A HQ greater than one indicates the potential for adverse health effects. For Subunit A the hazard quotients (HQs) range from 2 to 3 (rounded to whole numbers). For Subunit B the HQs also range from 2 to 3. For Subunit C the HQs range from 5 to 9. The SRE results indicate that there is a potential for significant noncancer health hazards associated with consumption of perchlorate-contaminated groundwater at the Site (Table C-1).

The SRE results will help EPA to justify adoption of current perchlorate treatment as the removal action for the site along with consideration of taking additional cleanup actions. Completion of the EE/CA will ideally result in the potentially responsible parties (PRPs) implementing the selected removal action under EPA's oversight.

C.2 Approach and Methodology Used for SRE

The SRE for the Site compares recent available groundwater monitoring well data for perchlorate contamination to human health risk-based screening values to determine the nature of the potential threat to public health or welfare. For perchlorate in untreated groundwater used as public drinking water, the SRE provides an estimate of how, and to what extent, people might be exposed to perchlorate and assesses the potential health effects associated with perchlorate in groundwater at the Site. It also estimates the potential for adverse health effects, if no further cleanup action is taken.

Therefore, the SRE results help EPA to: a) justify continuation of current perchlorate removal action; b) decide whether taking additional cleanup action at the site is necessary; and c) identify exposures that need to be addressed by the action.

For this EE/CA, the SRE focuses on the specific problem that the removal action is intended to address. For PGA North, the risk evaluation addresses health hazards due to consumption and domestic use of groundwater, contaminated with perchlorate, as tap water.

An evaluation of potential threats to human health is conducted by comparing contaminant concentrations in groundwater to selected risk-based screening values. These screening levels are potential chemical-specific applicable or relevant and appropriate requirements (ARARs) for remedial action. For this SRE, groundwater perchlorate concentrations within Subunits A, B, and C are compared against two risk-based groundwater screening levels

(Table C-2). The site-specific approach for this SRE was developed in coordination with the EPA project toxicologist.

There currently is no single agreed upon approach for deriving a screening level for perchlorate in groundwater. The debate tends to focus on two issues: 1) whether children could have a higher exposure to perchlorate than adults because they drink more water per pound body weight; and, 2) whether additional exposures to perchlorate from food and other sources should be taken into account when estimating a screening level for groundwater. These different approaches lead to somewhat different screening criteria. At the time of this SRE, this debate has not been resolved. Therefore, a range of screening levels published in the literature were selected which incorporate these different approaches. The screening levels selected for comparison are:

- 1) EPA's preliminary cleanup goal of 24.5 µg/liter (µg/L) (January 26, 2006). The EPA preliminary groundwater cleanup goal is based on adult exposures, assuming 100 percent contribution from tap water ingestion.
- 2) Arizona Department of Health Services (ADHS) drinking water health-based guidance level of 14 µg/L (May 2000). The ADHS drinking water health-based guidance is based on child exposures.

This SRE uses methods consistent with EPA risk assessment guidance. Specific guidance documents consulted for this SRE include:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA, 1989).
- The EE/CA guidance document: *Guidance on Conducting Non-time-Critical Removal Actions under CERCLA* (EPA, 1993).
- *Memorandum: Assessment Guidance for Perchlorate* (Office of Solid Waste and Emergency Response, EPA, 2006).
- *Health Based Guidance Level for Perchlorate* (ADHS, Office of Environmental Health, 2000).
- *User's Guide and Background Technical Document for EPA Region 9's Preliminary Remediation Goals Table* (EPA, 2004).

C.3 Contaminants of Concern in Groundwater

Previous site investigations, dating back to 1981, have identified TCE and other VOCs as chemical contaminants in soil and groundwater at the PGA North site. Perchlorate was first

identified in groundwater samples in 1998 and is now considered a Contaminant of Concern (COC) for the PGA North site.

Remedial action objectives established in the 1989 ROD focused on removal of VOCs from soil and groundwater, and did not specifically address perchlorate. Soil vapor extraction (SVE) with vapor phase carbon is the primary remediation technique for soil contamination. Air stripping with containment and treatment is the primary remediation technique for groundwater, and a separate liquid-phase carbon system is also in place for VOC removal. An ion-exchange system was added to the Main Treatment System (MTS) in 2005 to assist with the removal of perchlorate. Treated water is reinjected into the Subunit A aquifer.

The impacts of remediation actions on VOC concentrations are described in other documents. This SRE only evaluates the potential health effects posed by perchlorate in groundwater.

C.3.1 Perchlorate in Groundwater

Perchlorate data collected from groundwater in Subunits A, B and C were evaluated as part of this SRE. For Subunits A and B, the concentration used for risk screening is based on data collected from August 2005 through September 2006. For Subunit C, groundwater collected from the Park Shadows Domestic Well (PSDW) was used for risk screening comparisons. It is important to recognize that background levels in each subunit are below the current detection limit (2 µg/L).

For Subunit A, the evaluation is based on 10 groundwater samples collected from monitoring well MW-27. This monitoring well is located inside the “footprint” of the 14 µg/L perchlorate plume in Subunit A. For Subunit B, the evaluation was based on six groundwater samples collected from observation well OW-B. OW-B is also located inside the “footprint” of the 14 µg/L perchlorate plume in Subunit A. For Subunit C, health hazards were evaluated based on groundwater samples collected in November 2002 from the Park Shadows Domestic Well (PSDW), located offsite. The 130 µg/L perchlorate was the highest concentration detected in PSDW groundwater before it was taken off-line because of the rapidly increasing perchlorate concentrations. Figure C-1 presents the trend line of perchlorate concentrations in the PSDW from 2000 to 2006. The increased perchlorate concentrations observed at the PSDW in November 2002 are presented as a more focused trend line in Figure C-2, which shows a rapid ascent to a peak concentration of 130 µg/L perchlorate followed by a rapid fall to low concentrations after the well ceased production. The maximum concentration detected in 2002 in the PSDW (130 µg/L) exceeds the maximum concentration detected in Subunit C from August 2005 through September 2006

(8.8 µg/L, in MW-20 on June 7, 2006). From August 2005 to September 2006, the concentration at the PSDW ranged from 2.2 µg/L to 3.7 µg/L.

The SRE compares the 95 percent upper confidence limit (UCL) concentrations of perchlorate in groundwater in Subunit A and B, and the maximum concentration in Subunit C to risk-based screening values from EPA and ADHS. The exposure point concentrations of perchlorate in Subunits A, B, and C are presented in Table C-3 (proUCL statistical analysis output files are presented in Attachment 1). Each of these values exceeds the two risk-based screening values presented in Table C-2.

C.4 Conceptual Site Model, Toxicity Values, Exposure Assessment, Risk Characterization

A human health conceptual site model diagram for the Site was developed and used to plan the approach for the exposure assessment and risk characterization for the SRE.

C.4.1 Human Health Conceptual Site Model Diagram

Figure C-3 presents a schematic diagram of the human health conceptual site model. The model depicts the connection between on-site chemical releases and transport through environmental media to potential human receptors in a schematic presentation that includes:

- Primary sources (Site historic operations);
- Release mechanisms (e.g., spills, disposal, or leaks);
- Secondary sources (e.g., contaminated soil);
- Secondary release mechanisms (e.g., infiltration/percolation to groundwater);
- Exposure routes, and potentially exposed receptors (e.g., residents).

Although the Site currently contains a mix of residential, commercial, industrial and agricultural uses, the SRE focuses on potential health impacts to current and future residents using groundwater through tap water. Impacts from perchlorate contamination from other pathways are beyond the scope of this SRE.

C.4.2 Approach to Evaluation of Exposure Risks from Perchlorate-Contaminated Groundwater

The potential exposure pathways for perchlorate in groundwater and the potential human populations that could be exposed to these chemicals, either now or in the future are considered as part of the SRE. The SRE evaluates the risks to potential residential receptors, who may use perchlorate-contaminated onsite groundwater as domestic tap water.

Potential exposures to industrial/commercial workers also require consideration. Residential exposures were selected for the quantitative risk evaluation because residents represent the maximally exposed population.

The pathways and exposure routes considered in this SRE of groundwater at PGA North include ingestion, inhalation and dermal contact with contaminants in tap water. Perchlorate is non-volatile and is unlikely to be absorbed through dermal contact (EPA, 2004). Therefore, the inhalation and dermal contact exposure routes are not considered significant and are also not included by EPA and ADHS in the calculation of the groundwater screening values. The two screening levels used for comparison are based only on the ingestion exposure route.

C.5 Noncancer Health Hazards

The SRE estimates potential future perchlorate exposures and associated health hazards from the public use of groundwater in proximity to the Site. Perchlorate exhibits its primary health effect by interfering with the sodium ion symporter (NIS) of the thyroid hormone. Potential health effects can vary depending upon assumptions relating to the receptors selected for evaluation. Perchlorate is not associated with carcinogenic human health risks; therefore, a cancer risk evaluation is not conducted.

The groundwater screening levels developed by the EPA and ADHS were calculated to correspond to a noncancer hazard quotient of 1. For perchlorate-contaminated groundwater, the SRE estimates human noncancer health hazards using the risk ratio approach, as described in the User's Guide for the EPA Region 9 Preliminary Remediation Goals (PRG) Table (2004). The Exposure Point Concentration (EPC) of perchlorate in groundwater was divided by each of the groundwater screening concentrations. The resulting value is the HQ relative to that perchlorate groundwater screening level.

For noncancer health effects, a HQ greater than 1 indicates the potential for adverse noncancer health effects associated with exposure to the chemical (EPA, 1991, 2004). Since perchlorate is the only chemical for which hazards are considered in the SRE, the hazard quotient is evaluated separately for each subunit, using the groundwater screening levels presented in Table C-2.

C.5.1 Hazard Quotients

The SRE estimates potential future noncarcinogenic chronic hazards for groundwater by a direct comparison to two different risk-based screening levels developed by EPA and ADHS.

- For Subunit A, the HQs (rounded to whole numbers) are 2 and 3, respectively (Table C-4).
- For Subunit B, the HQs are 2 and 3, respectively (Table C-5).
- For Subunit C, the HQs are 5 and 9, respectively (Table C-6).

For Subunits A, B, and C, all of the estimated HQs exceed 1.

C.6 Uncertainties of Streamlined Risk Evaluation

This risk evaluation presents numerical estimates of health hazards; however, it is important to note that these numbers do not predict actual health outcomes. Because of the conservative assumptions used for the risk assessment, these estimates are calculated in a way that tends to overestimate potential risks, and thus any actual risks are likely to be lower than these estimates. Uncertainties associated with this risk assessment are due to uncertainties in the risk assessment process in general, the toxicological database for perchlorate, specific uncertainties in characterizing the site, and uncertainties associated with describing exposures. Some specific uncertainties associated with this site are described below.

- Changes in perchlorate concentrations over time

The SRE assumes that perchlorate concentrations remain constant over the entire exposure duration. However, the concentrations may change over time. The current perchlorate removal technique (ion exchange system) allows for groundwater to be reinjected into the subsurface. If this method proves effective, the concentration of perchlorate in groundwater will decrease over time resulting in a decrease in the health hazard at the site.

Alternatively, the concentration of perchlorate could increase in one or more of the subunits due to migration of perchlorate sources from the site to areas within and outside of the current investigation area.

- Uncertainties in the toxicity values and receptor exposure assumptions used by EPA and ADHS to develop the groundwater screening levels.

Each of the perchlorate groundwater screening levels used in the SRE was developed based on a different toxicity value and receptor:

- The EPA uses the EPA Integrated Risk Information System (IRIS) reference dose (RfD) of 0.0007 milligrams per kilogram per day (mg/kg-day), which is the most current RfD (IRIS, 2005). The EPA Drinking Water Equivalent Level (DWEL) is

- calculated for an adult receptor based on a conservative tap water consumption rate of 2 liters per day.
- The ADHS uses a 1998 EPA provisional oral reference dose of 0.0009 mg/kg-day (EPA, 1998), which is less health protective than the current IRIS value. The drinking water health based guidance level for perchlorate is calculated for a child receptor based on a drinking water consumption rate of 1 liter per day.
 - Changes in the state of the science pertaining to perchlorate

Environmental perchlorate is a popular subject in the scientific literature, and the current proposed guidelines are the result of extensive critical analysis. As additional studies are conducted concerning this compound, the extent of perchlorate knowledge will increase. Recent advances in analytical methodology, for instance, have enabled research demonstrating that perchlorate exposure may be more widespread than previously thought.

Additional uncertainty relates to potential health impacts among the most sensitive individuals, in particular infants of mothers with an iodine deficiency. Attachment 2 provides an analysis of selected recent studies relating to environmental perchlorate exposure. A brief summary of selected recent studies is also provided below.

- Kirk A. B. (2006) provides a review of scientific literature relating to potential adverse neurodevelopment effects among infants and children who consume elevated levels of perchlorate, particularly from breast milk. The importance of considering iodide intake status among mothers is emphasized. Perchlorate exposure in conjunction with iodide deficiency can cause developmental hypothyroidism in children potentially resulting in reduced intelligence, increased risk for attention deficit hyperactivity disorder (ADHD), cerebral palsy, and hearing and language deficits.

The question of, how much perchlorate infants and children are exposed to, is poorly characterized and merits further research. Consideration of the combined intake of perchlorate from all possible sources suggests that the current RfD for water consumption may not be adequately protective of infants and children. Kirk cites another study in which perchlorate in breast milk was measured at levels up to four times greater than the current perchlorate drinking water standard of 24.5 µg/L.

- Blount B. C. et al. (2006a) present an estimation of perchlorate exposure based on urinary excretion data. These data were collected from 2,820 individuals ages 6 and older participating in the National Health and Nutrition Examination Survey (NHANES). Children were found to have higher urine perchlorate concentrations than adults, whereas adult males had higher perchlorate concentrations than females.

The 95 percent UCL estimated dose for adults was 0.234 micrograms per kilogram per day ($\mu\text{g}/\text{kg}\text{-day}$) compared with EPA's current RfD of 0.7 $\mu\text{g}/\text{kg}\text{-day}$. For pregnant women the 95 percent UCL dose was 0.214 $\mu\text{g}/\text{kg}\text{-day}$ (dose for infants and children not estimated). Dose estimates for children and adolescents were not presented due to "limited validation of formulas for these age groups." Potential differences in perchlorate exposure among ethnic groups were also demonstrated with Mexican Americans having higher perchlorate concentrations than non-Hispanics.

In addition, the authors provide a discussion relating to potential perchlorate exposure to infants through consumption of breast milk. Since the human mammary gland expresses the sodium iodine symporter during lactation, the authors state that transfer of perchlorate to human milk is likely. Other investigations have confirmed the presence of perchlorate in human breast milk and discussed potential resulting exposures to infants.

- Another study by Blount, B. C., et. al. (2006b) demonstrates the relationship between perchlorate, iodine intake and thyroid hormone production in women. For women with iodine levels less than 100 $\mu\text{g}/\text{L}$, perchlorate was a negative predictor for total thyroxine (T4) and a positive predictor for thyroid stimulating hormone (TSH); whereas, in women with iodine greater than 100 $\mu\text{g}/\text{L}$ perchlorate was a positive predictor for TSH but not a predictor for T4. EPA's RfD includes a tenfold safety factor to account for sensitive subpopulations such as individuals with iodine deficiencies. However, the impact of iodine deficiency both on the mother and on her offspring remains an area of current uncertainty.
- Houssain, et al. (2006) describes a new analytical method for evaluating perchlorate levels in food and beverages at part per trillion levels. The authors report on the analysis of over 350 samples using this novel method. Analyses were conducted for samples including water, fruits, vegetables, milk, beer and wine. All but four of these samples had positive results for detection of perchlorate. Although the sample size for each individual sample type precludes generalization of results, these data as a whole suggest that perchlorate is widespread in foods throughout the world.
- Baier-Anderson, C. (2006) summarizes many of the current uncertainties relating to the process of risk assessment for perchlorate. Regarding the hazard evaluation, newborn babies may be the most appropriate sensitive population because when born they only have approximately one day's worth of thyroid hormone, and thus require a steady intake of iodine to produce additional thyroid hormone critical for normal development.

Regarding the toxicity assessment, the author points out that although use of data from human studies is generally preferred, studies such as the one upon which the EPA's RfD was based do not allow for the same level of control over chronic exposure conditions as do animal studies. As previously mentioned, the exposure assessment also includes considerable uncertainties such as the widespread presence of perchlorate in many foods including human breast milk and dairy milk. The authors cite another investigation in which individuals without any known perchlorate intake source were found to excrete perchlorate in their urine.

It is unknown whether future additional scientific research will suggest that perchlorate is more or less hazardous than currently thought. Any such changes could impact the calculated hazards presented in the SRE if the assumptions used by EPA or ADHS to calculate the groundwater screening levels are found to be either too stringent or inadequate to be protective of child, adult receptors or receptors not yet identified or evaluated.

C.7 Conclusions of Streamlined Risk Evaluation

The SRE conducted to support the EE/CA for this site evaluates the potential exposure pathways for current and future residential receptors through the groundwater ingestion from tap water. Results of the groundwater investigations at the Site suggest that perchlorate contamination found in groundwater in Subunits A, B, and C present potential human health hazards at current concentrations.

The potential noncancer chronic health hazards estimated from domestic use of perchlorate-contaminated groundwater near PGA North vary depending on the specific EPA or ADHS drinking water screening value used for human health hazard calculation. For Subunit A, the HQs are 2 and 3, respectively. For Subunit B, the HQs are 2 and 3, respectively. For Subunit C, the HQs are 5 and 9, respectively. Each of these HQ values exceeds 1, indicating the potential for adverse noncancer health effects associated with exposure to perchlorate at the Site.

The SRE results indicate that there exists a potential for adverse noncancer health effects associated with perchlorate contamination at PGA North. Estimates of health hazards suggest that, if no further cleanup action is taken, restriction of groundwater use located downgradient of PGA North is needed to prevent potential future human exposures.

This evaluation of potential health hazards from perchlorate in groundwater will help EPA to evaluate current and proposed additional removal actions to protect the groundwater resource and address potential future health hazards from perchlorate at PGA North.

Ongoing perchlorate monitoring will continue and, therefore, a change in perchlorate concentrations may trigger further risk evaluation of the site.

C.8 References

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Tables

Table C-1

Summary of Hazard Quotients from Exposure to Groundwater Used as Domestic Tap Water
Streamlined Risk Evaluation
Phoenix-Goodyear Airport North EE/CA for Perchlorate

Subunit (Well)	EPC basis	Hazard Quotients	
		EPA	ADHS
Subunit A (MW-27)	95% UCL	2	3
Subunit B (OW-B)	95% UCL	2	3
Subunit C (PSDW)	Maximum	5	9

Notes

EE/CA = Engineering Evaluation/Cost Analysis

MW = Monitoring Well

OW = Observation Well

PSDW = Park Shadows Domestic Well

EPC = Exposure Point Concentration

EPA = U.S. Environmental Protection Agency

ADHS = Arizona Department of Health Services

95% UCL = 95th percentile of upper confidence limit on the mean

Table C-2

Perchlorate Screening Levels for Groundwater Used as Domestic Tap Water

Streamlined Risk Evaluation

Phoenix-Goodyear Airport North EE/CA for Perchlorate

Regulatory Agency Source	Health-based screening level (µg/L)	Receptor	Basis
EPA, 2005	24.5	Adult	100% contribution from tap water ingestion
ADHS, 2000	14	Child	100% contribution from tap water ingestion

Notes

EE/CA = Engineering Evaluation/Cost Analysis

EPA = U.S. Environmental Protection Agency

ADHS = Arizona Department of Health Services

µg/L = micrograms per liter

Table C-3
Groundwater Concentrations of Perchlorate - Subunits A, B and C
 Streamlined Risk Evaluation
 Phoenix-Goodyear Airport North EE/CA for Perchlorate

Subunit (Well)	EPC basis	Groundwater Concentration (µg/L)
Subunit A (MW-27)	95% UCL	45
Subunit B (OW-B)	95% UCL	40
Subunit C (PSDW)	Maximum	130

Notes

EE/CA = Engineering Evaluation/Cost Analysis

MW = Monitoring Well

OW = Observation Well

PSDW = Park Shadows Domestic Well

EPC = Exposure Point Concentration

95% UCL = 95th percentile of upper confidence limit on the mean

µg/L = micrograms per liter

Table C-4
Noncancer Health Hazard Calculation Worksheet for Groundwater - Subunit A (MW-27)
 Streamlined Risk Evaluation
 Phoenix-Goodyear Airport North EE/CA for Perchlorate

Hazard Calculations - Subunit A (MW-27)				
Source of Screening Level	Health-based screening level (µg/L)	Groundwater EPC basis	EPC Value (µg/L)	Hazard Quotient
EPA, 2005	24.5	95% UCL	45	1.8
ADHS, 2000	14	95% UCL	45	3.2

Notes

EE/CA = Engineering Evaluation/Cost Analysis

MW = Monitoring Well

EPA = U.S. Environmental Protection Agency

ADHS = Arizona Department of Health Services

EPC = Exposure Point Concentration

µg/L = micrograms per liter

95% UCL = 95th percentile of upper confidence limit on the mean

Table C-5

Noncancer Health Hazard Calculation Worksheet for Groundwater - Subunit B (OW-B)

Streamlined Risk Evaluation

Phoenix-Goodyear Airport North EE/CA for Perchlorate

Hazard Calculations - Subunit B (OW-B)				
Source of Screening Level	Health-based screening level (µg/L)	Groundwater EPC basis	EPC Value (µg/L)	Hazard Quotient
EPA, 2005	24.5	95% UCL	40	1.6
ADHS, 2000	14	95% UCL	40	2.8

Notes

EE/CA = Engineering Evaluation/Cost Analysis

OW = Observation Well

EPA = U.S. Environmental Protection Agency

ADHS = Arizona Department of Health Services

EPC = Exposure Point Concentration

µg/L = micrograms per liter

95% UCL = 95th percentile of upper confidence limit on the mean

Table C-6

Noncancer Health Hazard Calculation Worksheet for Groundwater - Subunit C (PSDW)

Streamlined Risk Evaluation

Phoenix-Goodyear Airport North EE/CA for Perchlorate

Hazard Calculations - Subunit C (PSDW)				
Source of Screening Level	Health-based screening level (µg/L)	Groundwater EPC basis	EPC Value (µg/L)	Hazard Quotient
EPA, 2005	24.5	Maximum	130	5.3
ADHS, 2000	14	Maximum	130	9.3

Notes

EE/CA = Engineering Evaluation/Cost Analysis

PSDW = Park Shadows Domestic Well

EPA = U.S. Environmental Protection Agency

ADHS = Arizona Department of Health Services

µg/L = micrograms per liter

EPC = Exposure Point Concentration

Figures

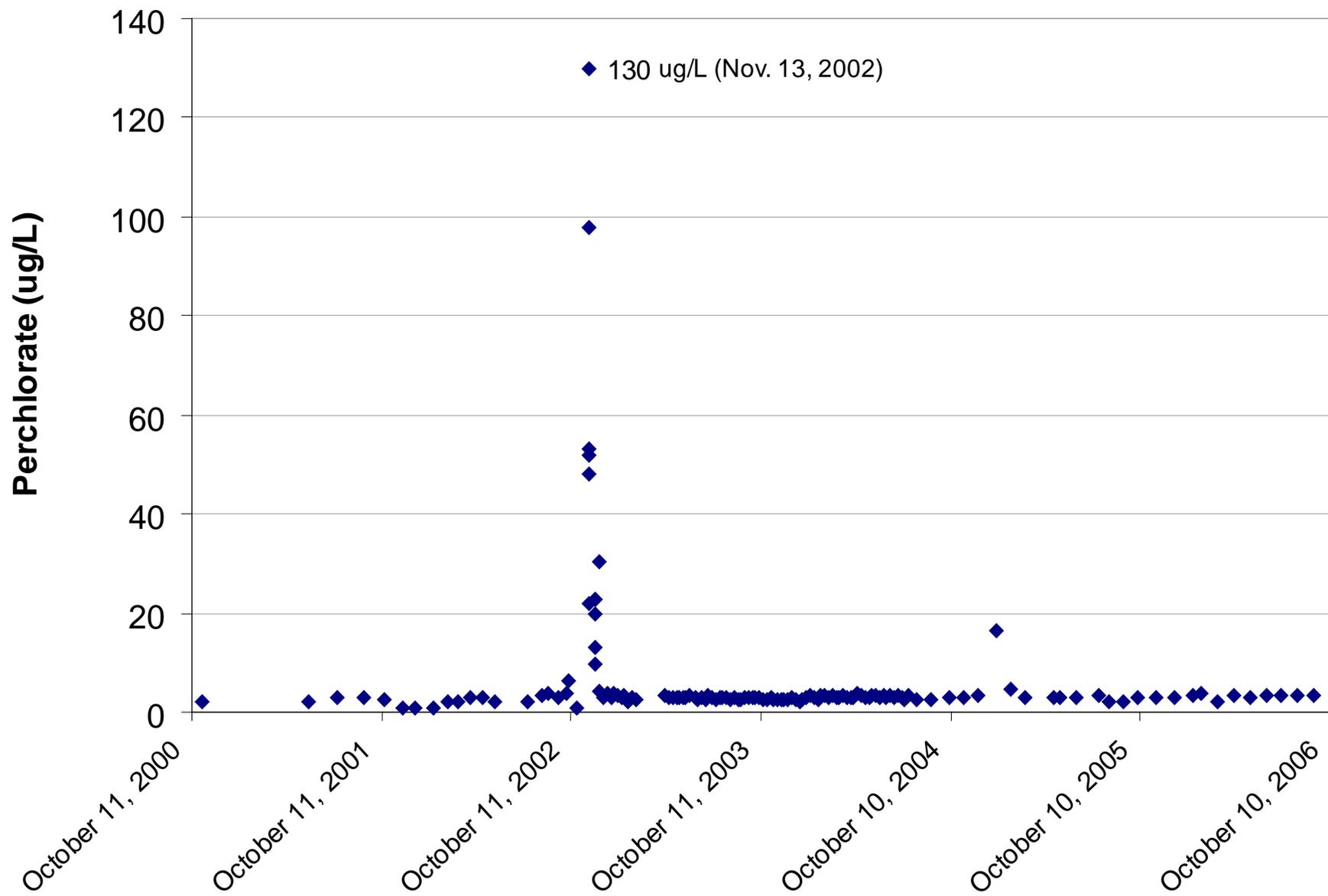


Figure C-1
Park Shadow Domestic Well Perchlorate Concentrations in Groundwater
 Phoenix - Goodyear Airport North Superfund Site EE/CA for Perchlorate

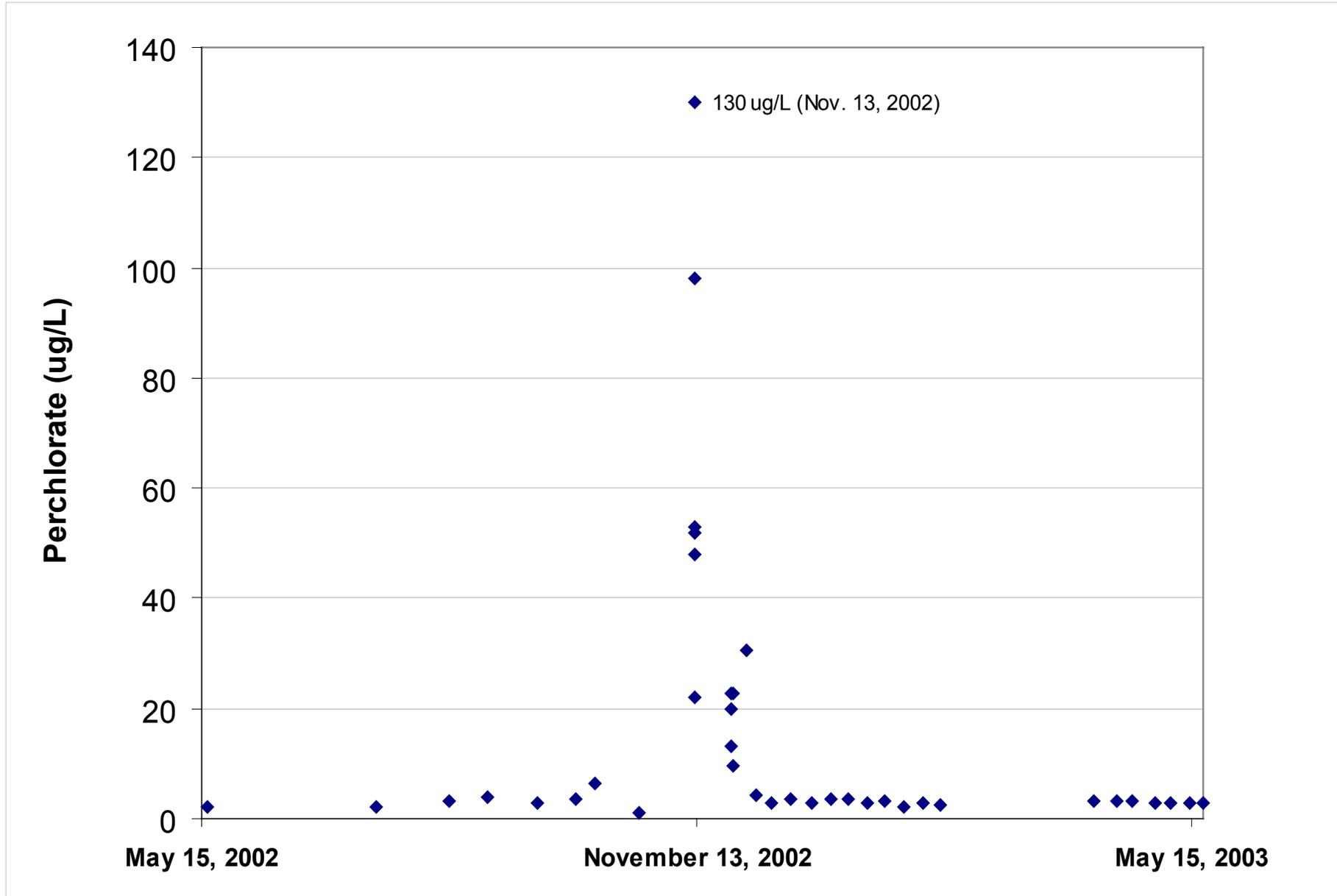
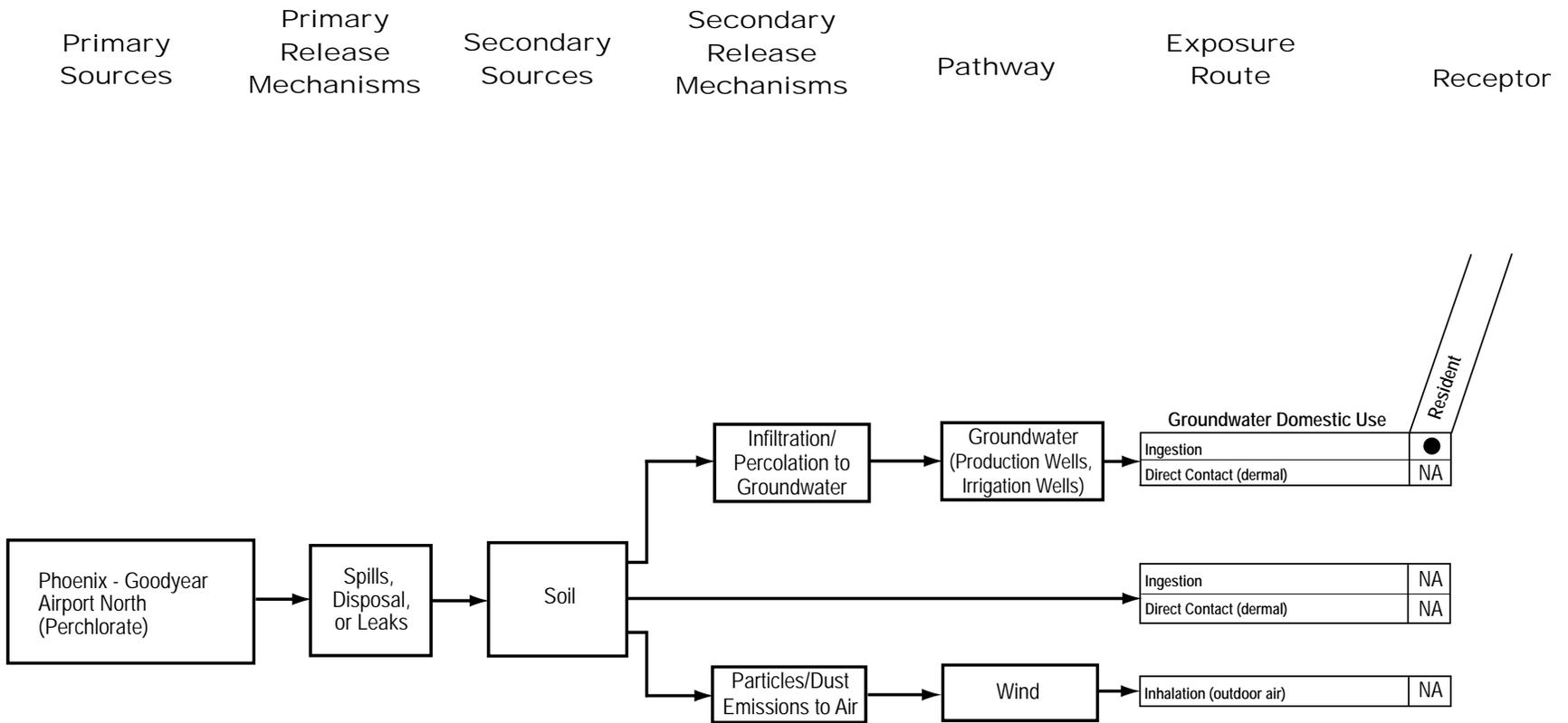


Figure C-2
 Park Shadow Domestic Well Perchlorate Concentrations in Groundwater (2002 - 2003)
 Phoenix - Goodyear Airport North Superfund Site EE/CA for Perchlorate



LEGEND:

● = Potentially Complete Pathway Evaluated in Streamlined Risk Evaluation

NA = Beyond Scope of Current EE/CA

Figure C-3

Draft Human Health Conceptual Site Model Diagram

Phoenix - Goodyear Airport North Superfund Site EE/CA for Perchlorate

Attachment 1
proUCL Statistical Analysis Output Files

ProUCL Output

Data File				Variable:	MW-27		
Raw Statistics			Normal Distribution Test				
Number of Valid Samples	10	Shapiro-Wilk Test Statistic		0.686905			
Number of Unique Samples	10	Shapiro-Wilk 5% Critical Value		0.842			
Minimum	13.5	Data not normal at 5% significance level					
Maximum	45.1						
Mean	38.89	95% UCL (Assuming Normal Distribution)					
Median	43.6	Student's-t UCL		44.67943			
Standard Deviation	9.987264						
Variance	99.74544	Gamma Distribution Test					
Coefficient of Variation	0.256808	A-D Test Statistic		1.614876			
Skewness	-2.198957	A-D 5% Critical Value		0.725038			
Gamma Statistics		K-S Test Statistic		0.308408			
		K-S 5% Critical Value		0.26661			
k hat	10.44116	Data do not follow gamma distribution					
k star (bias corrected)	7.375476	at 5% significance level					
Theta hat	3.724683						
Theta star	5.27288	95% UCLs (Assuming Gamma Distribution)					
nu hat	208.8231	Approximate Gamma UCL		47.63318			
nu star	147.5095	Adjusted Gamma UCL		49.37528			
Approx.Chi Square Value (.05)	120.4338						
Adjusted Level of Significance	0.0267	Lognormal Distribution Test					
Adjusted Chi Square Value	116.1846	Shapiro-Wilk Test Statistic		0.59567			
		Shapiro-Wilk 5% Critical Value		0.842			
Log-transformed Statistics		Data not lognormal at 5% significance level					
Minimum of log data	2.60269						
Maximum of log data	3.808882	95% UCLs (Assuming Lognormal Distribution)					
Mean of log data	3.612086	95% H-UCL		51.32943			
Standard Deviation of log data	0.373696	95% Chebyshev (MVUE) UCL		59.95874			
Variance of log data	0.139649	97.5% Chebyshev (MVUE) UCL		68.84075			
		99% Chebyshev (MVUE) UCL		86.28774			
		95% Non-parametric UCLs					
		CLT UCL		44.08486			
		Adj-CLT UCL (Adjusted for skewness)		41.73823			
		Mod-t U		44.3134			
		Jackknife UCL		44.67943			
		Standard Bootstrap UCL		43.72391			
		Bootstrap-t UCL		43.21539			
		Hall's Bootstrap UCL		42.34928			
		Percentile Bootstrap UCL		43.14			
		BCA Bootstrap UCL		42.46			
		Use Student's-t UCL		95% Chebyshev (Mean, Sd) UCL		52.65649	
		or Modified-t UCL		97.5% Chebyshev (Mean, Sd) UCL		58.61327	
				99% Chebyshev (Mean, Sd) UCL		70.31419	

ProUCL Output

Data File				Variable:	OW-B		
Raw Statistics			Normal Distribution Test				
Number of Valid Samples	5	Shapiro-Wilk Test Statistic		0.930708			
Number of Unique Samples	5	Shapiro-Wilk 5% Critical Value		0.762			
Minimum	17	Data are normal at 5% significance level					
Maximum	40						
Mean	30.66	95% UCL (Assuming Normal Distribution)					
Median	33.6	Student's-t UCL		39.63191			
Standard Deviation	9.410526						
Variance	88.558	Gamma Distribution Test					
Coefficient of Variation	0.306932	A-D Test Statistic		0.351091			
Skewness	-0.780699	A-D 5% Critical Value		0.678855			
		K-S Test Statistic		0.259541			
Gamma Statistics		K-S 5% Critical Value		0.357534			
k hat	11.3033	Data follow gamma distribution					
k star (bias corrected)	4.654654	at 5% significance level					
Theta hat	2.712482						
Theta star	6.586956	95% UCLs (Assuming Gamma Distribution)					
nu hat	113.033	Approximate Gamma UCL		44.75261			
nu star	46.54654	Adjusted Gamma UCL		53.45714			
Approx.Chi Square Value (.05)	31.88902						
Adjusted Level of Significance	0.0086	Lognormal Distribution Test					
Adjusted Chi Square Value	26.69647	Shapiro-Wilk Test Statistic		0.891508			
		Shapiro-Wilk 5% Critical Value		0.762			
Log-transformed Statistics		Data are lognormal at 5% significance level					
Minimum of log data	2.833213						
Maximum of log data	3.688879	95% UCLs (Assuming Lognormal Distribution)					
Mean of log data	3.378072	95% H-UCL		48.47119			
Standard Deviation of log data	0.350242	95% Chebyshev (MVUE) UCL		51.699			
Variance of log data	0.122669	97.5% Chebyshev (MVUE) UCL		60.75226			
		99% Chebyshev (MVUE) UCL		78.53565			
		95% Non-parametric UCLs					
		CLT UCL		37.58239			
		Adj-CLT UCL (Adjusted for skewness)		36.01236			
		Mod-t UCL (Adjusted for skewness)		39.38701			
		Jackknife UCL		39.63191			
		Standard Bootstrap UCL		36.8745			
		Bootstrap-t UCL		37.92578			
		Hall's Bootstrap UCL		35.39497			
RECOMMENDATION		Percentile Bootstrap UCL		36.16			
Data are normal (0.05)		BCA Bootstrap UCL		35.8			
Use Student's-t UCL		95% Chebyshev (Mean, Sd) UCL		49.00449			
		97.5% Chebyshev (Mean, Sd) UCL		56.94217			
		99% Chebyshev (Mean, Sd) UCL		72.5342			

Attachment 2

**Summary of Recent Perchlorate Publications Relevant to the
PGA North SRE for Perchlorate in Groundwater**

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Stanford Smucker/EPA

PREPARED BY: Golan Kedan/CH2M HILL
Richard Braun/CH2M HILL

DATE: August 2007

Summary of Recent Perchlorate Publications Relevant to the Phoenix-Goodyear Airport North (PGA North) Engineering Evaluation/Cost Analysis (EE/CA) Streamlined Risk Evaluation (SRE) for Perchlorate in Groundwater

The following is a review of several recent perchlorate publications relevant to the SRE developed to support the EE/CA for the PGA North Superfund Site. Information applicable to the SRE is included in the Uncertainties section.

1) Kirk, A. B. 2006. Environmental Perchlorate: Why it Matters. *Analytica Chimica Acta* 567: 4-12.

The only known mechanism of toxicity for perchlorate is interference with iodide uptake. This review article focuses on potential adverse neurodevelopmental effects among infants and children who consume elevated levels of perchlorate, particularly from breast milk. The importance of considering iodide intake status is highlighted with regards to evaluation of potential perchlorate health effects.

The introduction provides background on the chemical properties of perchlorate, as well as the basic function of the thyroid gland and the role of the sodium-iodide symporter. The authors present a developmental timeline illustrating that fetuses rely on maternal thyroid throughout their development. A flow chart also illustrates general effects of perchlorate on the "mother-fetus/infant system." Perchlorate exposure in conjunction with iodide deficiency can cause developmental hypothyroidism in children. The physiological manifestation of this condition is a decreased brain weight with densely packed neurons. Adverse health effects associated with thyroid hormone deficiency include:

- Reduced intelligence
- Increased risk for Attention Deficit Hyperactivity Disorder (ADHD)
- Cerebral palsy
- Hearing and language deficits

The question of, to how much perchlorate infants and children are exposed, is poorly characterized and merits further research, according to the authors. Consideration of the combined intake of perchlorate from all possible sources suggests that the current Reference Dose (RfD) for water consumption may not be adequately protective for infants and children.

For instance, perchlorate levels in breast milk were measured at levels up to four times greater than the current perchlorate drinking water standard of 24.5 micrograms per liter ($\mu\text{g}/\text{L}$). In addition, perchlorate levels in fruits and vegetables should be considered as part of a total perchlorate dose evaluation. Perchlorate can be spread to these food sources through irrigation using contaminated water (e.g. Colorado River in the southwest) and through use of fertilizers containing perchlorate (e.g. Chilean saltpeter spray used on citrus crops). Furthermore, certain crops have the ability to bioconcentrate perchlorate (e.g. bioconcentration factors for wheat and alfalfa are greater than 200 and 300, respectively).

Adding to this burden is the fact that iodine deficiency is relatively common among pregnant women. Aside from developing infants, the authors report that Hispanic and Asian populations might be more susceptible to health risks from perchlorate due to relatively higher rates of congenital hypothyroidism.

2) Dasgupta, P.K., Dyke, J.V., Kirk, A.B., Jackson, W.A. 2006. "Perchlorate in the United States. Analysis of Relative Source Contributions to the Food Chain". *Environ Sci Technol* 40(21):6608-14.

This review article focuses on relative source contributions for perchlorate within the United States. The authors identify three general sources of perchlorate and present an estimation of relative source strength for each of these as presented below (in gigagrams per year):

- Use as oxidizer (10.6)
- Use of Chilean nutrient fertilizer [(CNF), (0.75)]
- Natural sources (0.13 - 0.64)

Actual perchlorate quantities as an oxidizer (rocket propellant) are difficult to verify because much of it has been used for military purposes and this information is not readily available. When used as a rocket propellant evidence suggests that perchlorate is efficiently consumed resulting in chloride as a byproduct. As an oxidizer, perchlorate has a limited effective lifespan after which time it is discarded. Recycling and reuse of unused perchlorate does not occur according to the authors. The process of washing out unused perchlorate creates high concentrations of localized contaminated wastewater. Other non-military uses of perchlorate include use in road flares and fireworks. The overall contribution from these sources was not presented.

Although, use as an oxidizer is far greater than the other sources, the authors suggest that the use of CNF may have a similar overall impact on exposure due to its direct application to food sources. CNF has been used in the U.S. for over 100 years although the quantities used have decreased significantly since about 1970 corresponding with an increase in industrial production of fixed nitrogen products. A variety of plants can take up perchlorate in some cases resulting in bacterial-mediated degradation.

In consideration of potential health implications associated with perchlorate, the authors report that iodine intake appears to have decreased over the past 30 years based on levels excreted in urine. Of particular concern is a study of 100 pregnant women in Boston in which 49 percent were found to have iodine levels below the recommended daily allowance (RDA).

3) **Blount, B. C., Valentin-Blasini, L., Osterloh, J.D., Mauldin, J.P., Pirkle, J.L. 2006.**
“Perchlorate Exposure of the U.S. Population, 2001-2002”. *J Expo Sci Environ Epidemiol.* 2006 Oct 18; [Epub ahead of print].

The authors of this study present an estimation of perchlorate exposure based on urinary excretion data. These data were collected from 2,820 individuals ages 6 and older participating in the National Health and Nutrition Examination Survey (NHANES).

Perchlorate was identified in all urine samples analyzed ranging in concentration from 0.19 to 160 µg/L. The urinary perchlorate data analyzed in this study were distributed lognormally with a median of 3.6 µg/L. Differences in perchlorate urine data included the following:

- Children ages 6-11 years (geometric mean = 4.9) had higher urine perchlorate concentrations than adults
- Males (geometric mean = 4.2) had higher perchlorate concentrations than females (geo mean = 3.0)
- Mexican Americans (geometric mean = 4.0) had higher perchlorate concentrations than non-Hispanics (geo mean = 3.5).

Perchlorate dose was estimated by accounting for pharmacokinetic properties of perchlorate and correcting for creatinine concentration in urine. Previous investigations have shown that perchlorate has a half life of approximately 8 hours and that 70 to 95 percent of perchlorate is excreted unchanged in urine.

The following list summarizes some of the findings relating to the authors’ dose estimates:

- 95 percent UCL estimated dose in adults was 0.234 micrograms per kilogram per day (µg/kg-day) compared with the current RfD of 0.7 µg/kg-day.
- For pregnant women the 95 percent UCL dose was 0.214 µg /kg-day.
- Dose estimates for children and adolescents were not presented due to “limited validation of formulas for these age groups.”

In addition, the authors provide a discussion relating to potential exposure to infants through consumption of breast milk. Since the human mammary gland expresses the sodium iodine symporter during lactation, the authors state that transfer of perchlorate to human milk is likely.

Other investigations have confirmed the presence of perchlorate in human breast milk and discussed potential resulting exposures to infants. Dairy cattle have also been shown to excrete perchlorate through milk in a manner similar to humans.

4) **Blount, B.C., Pirkle, J.L., Osterloh, J.D., Valentin-Blasini, L., Caldwell, K.L. 2006.**
“Urinary Perchlorate and Thyroid Hormone Levels in Adolescent and Adult Men and Women Living in the United States”. *Environmental Health Perspectives* 114, Number 12.

The authors of this study examined the potential relationship between perchlorate in urine and markers of thyroid hormone function. Data for this study was collected from

2,299 subjects participating in the NHANES program from 2001 – 2002. Multiple regression analysis was used to evaluate potential relationships between urinary perchlorate, and serum thyroxine (T4) and thyroid-stimulating hormone (TSH) levels.

Among the key findings were that perchlorate was a significant predictor of T4 and TSH levels in women but not in men. The relationship between perchlorate and thyroid hormones in women was shown to be impacted by dietary iodine levels. In women with iodine less than 100 µg/L perchlorate was a negative predictor for T4 and a positive predictor for TSH; whereas, in women with iodine greater than 100 µg/L perchlorate was a positive predictor for TSH but not for T4.

Urinary data were based on three samples collected from each subject; and thyroid hormone data were corrected for known confounders. Individuals taking medications known to affect thyroid hormone levels were excluded from the data set. The 100 µg/L cut off point for evaluation of iodine intake is from World Health Organization criteria related to development of goiter.

According to the authors, the results for women with iodine levels less than 100 µg/L are consistent with competitive inhibition of iodide uptake presumably by perchlorate. The gender effect seen in this study is consistent with other research demonstrating that women are more susceptible to goiter than men.

Characterization of perchlorate levels was based on an evaluation of the study population as a whole using levels corresponding to the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles. The geometric mean for urine perchlorate was 2.84 µg/L. An estimation of dose required to reach this level was not presented.

A potential uncertainty identified by the authors is that perchlorate could be a surrogate for some other determinant of thyroid function.

5) Sanchez, C. A., Krieger, R. I., Khandaker, N. R., Valentin-Blasini, L., Blount, B. C. 2006. "Potential Perchlorate Exposure from Citrus sp Irrigated with Contaminated Water." *Analytica Chimica Acta* 567: 33-38.

The authors report on perchlorate concentrations measured in citrus species from locations within the Southwestern United States. Irrigation sources include both the Colorado River and irrigation wells. Concentrations in these sources ranged from below detection to 18 µg/L. Perchlorate levels were measured both in the fruit as well as other parts of the citrus plants.

Perchlorate was found to accumulate at higher levels in leaves compared with fruit. The lowest levels of perchlorate accumulation occurred in roots, trunks and branches. Within fruit pulp perchlorate concentration ranged from below detection to 38 micrograms per kilogram (µg/kg) fresh weight.

A dose estimation is presented for hypothetical adult and child populations using the perchlorate levels measured in citrus fruit (lemons, grapefruit and oranges). The estimated values for adults and children are presented below in micrograms per persons per day (µg/person/day).

These dose estimates are well below the EPA's current RfD of 0.7 µg/kg-BW/day; therefore, the authors conclude that the "potential perchlorate exposures from citrus in the southwestern United States are negligible relative to the reference dose recommended by the NAS."

Receptor	Orange	Grapefruit	Lemon
Child	0.51	0.03	0.005
Adult	1.2	0.24	0.009

6) El Aribi, H., Le Blanc, Y.J.C., Antonsen, S., Sakuma, T. 2006. "Analysis of Perchlorate in Foods and Beverages by Ion Chromatography Coupled with Tandem Mass Spectrometry (IC-ESI-MS/MS)." *Analytica Chimica Acta*, 567: 39-47.

The authors describe a new analytical method for the analysis of perchlorate in food, water, beer and wine samples with detection limits at the parts per trillion (ng/L) level. The authors report on the analysis of over 350 samples using this novel method. All but four of these samples had positive results for detection of perchlorate.

Results from some of these analyses are presented. For instance, tap water and bottle samples from different parts of the world are compared. Results for produce, wine and beer are presented. Because the sample size for each individual sample type is relatively small, it is not appropriate to generalize from these data; however these data as a whole suggest that perchlorate is widespread throughout the world.

Among the types of foods analyzed, the following results were presented:

- Drinking water (tap and bottled)
 - Tap water in Las Vegas had the highest perchlorate concentrations reported (~ 3 µg/L)
 - Filtration and use of reverse osmosis are effective at reducing perchlorate levels in tap water
- Fruits and vegetables
 - Green lettuce samples from California had a reported perchlorate concentration of 6.6 µg/kg
 - The Colorado River is reported to irrigate an estimated 1.4 million acres of cropland in the Southwestern US.
 - Perchlorate survived cooking in an asparagus sample (decreased from ~40 to 24 µg/kg)
- Wines, beers and other beverages
 - A high degree of variation was observed in results both between and within regions.
 - Wines from Chile had the highest perchlorate concentrations.
 - Sample results were found to vary considerably likely due to practice of blending juices.

-
- Milk: (1 percent) 4.8 µg/L
 - Samples from CA evaluated in another study ranged in levels from 4 to 8.3 µg/L
 - Baby formula (milk): 1.2 µg/L

7) **Baier-Anderson, C. 2006. "Risk Assessment, Remedial Decisions and the Challenge to Protect Public Health: The Perchlorate Case Study". *Analytica Chimica Acta*, 67:13-19.**

The authors present a case study relating to risk evaluation and subsequent remediation strategy of groundwater contaminated with perchlorate. The site described is a U. S. Army garrison located in Aberdeen, Maryland.

The authors provide background on the various current health based standards relating to perchlorate in drinking water. The drinking water standards discussed include the EPA Drinking Water Equivalent Level (DWEL) (i.e. 24.5 µg/L) which assumes that the total perchlorate dose contribution comes from drinking water ingestion.

The authors describe several uncertainties of the risk assessment process for this case. For instance, the hazard identification includes uncertainties regarding the population identified as the most susceptible to potential health impacts from perchlorate exposure. According to the authors, the National Academy of Science (NAS) identifies infants of mothers having insufficient thyroid hormone during pregnancy as the most at risk receptor. Others have suggested that a more appropriate population are newborn babies because after birth they only have approximately one day's worth of thyroid hormone and thus require a steady intake of iodine to produce additional thyroid hormone.

Regarding the toxicity assessment, the authors point out that the NAS relies on a study of twenty four healthy human adults as the basis for its RfD derivation. Although there are clear advantages to using data on adults, such a study does not allow for the level of control over chronic exposure conditions as could an animal study.

The exposure assessment also includes considerable uncertainties. While the recent RfD assumes that drinking water is the primary source of perchlorate exposure, perchlorate has been shown to have a widespread presence in many foods including human breast milk and dairy milk. The authors cite another investigation in which individuals without any known perchlorate intake source were found to excrete perchlorate in their urine. Based on the current state of knowledge, additional research regarding both perchlorate exposure levels and the effects of iodine levels are merited in support of the establishment of a Maximum Contaminant Levels (MCL), which would take into account other possible sources aside from drinking water.

Issues relating to the risk characterization raised by the authors include questions regarding the interpretation of the endpoint selected by NAS, as well as, the relevance of the exposure period for selected human study with respect to potential perchlorate exposure among infants of mothers with iodine deficiency.

In addition to discussing uncertainties relating to the risk assessment in this perchlorate case, the authors discuss the difficult challenges in risk management and remediation in the face of scientific uncertainties and the potential for delays in remediation and subsequent prolonged exposure to health hazards while the health assessment is carried out.

8) Dasgupta, P.K. 2006. "Perchlorate: an Enigma for the New Millennium". *Analytica Chimica Acta*, 567:1-3.

This editorial lays out the topics discussed in this journal issue, which is devoted entirely to perchlorate. The author states that the debate regarding the significance of environmental perchlorate is highly controversial and heated, to the extent that it can "bear little resemblance with how you usually practice science..." The author does acknowledge that, to date, no studies have clearly established adverse human health impacts at environmentally relevant levels.

In the meantime, analytical chemists are developing methods to detect perchlorate at increasingly low levels in a variety of different media including both environmental and biological samples. The result of these advances has been to confirm that perchlorate is widely present in the environment at low levels throughout the world.

This information raises the question of source contribution, in particular how much of the environmental perchlorate is natural and how much is from anthropogenic sources.

Clearly, a major source of anthropogenic perchlorate is the handling of unused product. Contamination of the lower Colorado River for instance, is attributable to seepage of perchlorate from storage areas. The amount of perchlorate that is naturally produced is identified as an uncertainty.

References

Baier-Anderson, C. 2006. Risk Assessment, Remedial Decisions and the Challenge to Protect Public Health: The Perchlorate Case Study. *Analytica Chimica Acta*, 567:13-19

Blount, B.C., Valentin-Blasini, L., Osterloh, J.D., Mauldin, J.P., Pirkle, J.L. 2006. Perchlorate Exposure of the US Population, 2001-2002. *J Expo Sci Environ Epidemiol*. 2006 Oct 18; [Epub ahead of print]

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El Aribi, H., Le Blanc, Y.J.C., Antonsen, S., Sakuma, T. 2006. Analysis of Perchlorate in Foods and Beverages by Ion Chromatography Coupled with Tandem Mass Spectrometry (IC-ESI-MS/MS). *Analytica Chimica Acta*, 567: 39-47

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Sanchez, C.A., Krieger, R.I., Khandaker, N.R., Valentin-Blasini, L., Blount, B.C. 2006. Potential Perchlorate Exposure from Citrus sp. Irrigated with Contaminated Water. *Analytica Chimica Acta* 567: 33-38

Appendix D

Cost Analysis

Table D-1
 Cost Estimate Summary
 PGA North Site-Goodyear, Arizona

Technology	Costs	Comments
Ion Exchange Resin		
Capital Cost	\$446,290	Existing equipment and wells utilized. Therefore, limited capital cost
Operation and Maintenance Cost	\$1,095,723	Adjusted for net present value
Total Net Present Cost	\$1,542,014	
Tailored GAC		
Capital Cost	\$484,697	Existing extraction wells utilized.
Operation and Maintenance Cost	\$1,104,365	Adjusted for net present value
Total Net Present Cost	\$1,589,062	
Ex-situ Bioremediation		
Capital Cost	\$2,595,154	Existing extraction wells utilized
Operation and Maintenance Cost	\$2,145,214	Adjusted for net present value
Total Net Present Cost	\$4,740,368	

Prepared By: Soomodh Abraham, Mike Grigorieff
 Checked By: Greg Mah-Hing

Table D-2

Cost Estimate - Ion Exchange Resin
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
 SITE: PGA North
 ALTERNATIVE: Groundwater
 DESCRIPTION: Ion Exchange Resin
 PREPARED BY: Soomodh Abraham/Mike Grigorieff
 PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Existing extraction wells EA-01, EB-01, EA-03, EA-02, and MW-20 are used as extraction wells and no new wells are required.
3. Existing remediation compound and equipment are utilized
4. Perchlorate concentration used is 45 ppb, which was the highest concentration detected at Subunit A during Fourth Qtr 2007 groundwater monitoring.
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Ion Exchange Resin					
Site Details			Assumptions		
Length of treatment area	ft		3200		Approximate: Based on 14 ppb perchlorate isoconcentration contour as shown in in 4Q06 groundwater report
Width of treatment area	ft		1000		Approximate: Based on 14 ppb perchlorate isoconcentration contour as shown in in 4Q06 groundwater report
Approximate thickness of saturated zone	ft		230		Apprx. combined saturated thickness of subunit A, B, and C
Porosity			0.3		
Effective ROI of extraction wells	ft		NA		Assuming existing extraction wells are sufficient.
Number of wells			0		Assuming existing extraction wells are sufficient.
Pumping Rate	gpm		400 gpm		Average pumping rate assumed based on historical data
Capital Costs					
	Unit	Unit Cost	Qty	Cost	Assumptions
Ion Exchange Resin					
Ion exchange adsorbers	per acre foot	\$128	1276	\$163,328	2-10000 lbs resin. Assuming, existing ion exchange adsorbers are sufficient.
ASME Code vessels	each		0		Included above
Valve nest	each		0		Included above
Vessel internals	each		0		Included above
Piping inside valve nest			0		Included above
Control Panel	each		0		Included above
Discharge pumps	each	\$2,000	0	\$0	Assuming utilizing existing discharge pump
Dual Bag Filter Units	each	\$14,000	2	\$28,000	400 gpm, Dual bag 20 micron. Calgon Carbon Quote, 2006
Surge Tank	each	\$5,000	0	\$0	Assuming utilizing existing surge tank
Transfer Pump	each	\$2,000	0	\$0	Assuming utilizing existing transfer pump
Well Head Completions (electrical and mechanical)	each	\$10,000	0	\$0	Assuming utilizing existing well heads
Drawings, O&M Manuals	LS	\$10,000	0	\$0	Includes process and instrumentation diagram, misc. drawings, and O&M guidance document
Capital Cost-Subtotal A				\$191,328	
Additional Costs-1					
Additional Site Misc Equipment/Valves			10%	\$19,133	Page Plant Cost Guide
Additional Site Piping Costs			8.0%	\$15,306	Use existing plant
Additional Site Electrical Installation Costs			8.9%	\$17,074	Based on 1992 EPRI document cost analysis performed for a similar site
Additional Site Instrumentation and Control Costs			6.4%	\$12,241	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$255,081	Sum of Subtotal A and Additional Costs-1
Additional Costs-2					
Contractors Overhead				\$51,016	Approximately 20% of capital cost
Contractors Profit				\$24,488	Approximately 8% of capital cost
Construction Management				\$26,447	8% of capital cost
Construction and Material Contingency				\$89,258	25% of capital and additional costs
Total Capital Costs				\$446,290	

Table D-2
 Cost Estimate - Ion Exchange Resin
 PGA North Site-Goodyear, Arizona

Operation and Maintenance Costs	Unit	Unit Cost	Qty	Cost	Assumptions
O&M - Cost A					
Electrical Power	\$/Kw-hr	\$0.12	150,000	\$18,000	Estimate based on requirements at similar sites
Miscellaneous Permits	LS	\$8,000	0	\$0	Assuming existing permits are sufficient.
Ion Exchange Resin Replacement	per vessel	\$10,000	4	\$40,000	Resin replacement assuming one vessel change every three months for the whole duration. Based on approximate existing replacement duration and \$1/lb replacement cost.
Dual Bag Filter Replacement	each	\$200	12	\$2,400	Assuming replacement once a month
Waste Disposal	per event	\$10,000	4	\$40,000	Include bag filters, used GAC and misc. Quarterly assumed.
Total O&M - Cost A				\$100,400	
Labor					
Operating	\$/hr	60	1,095	\$65,700	Assumed
Maintenance	\$/hr	70	365	\$25,550	Assumed
Supervisory	\$/hr	90	150	\$13,500	Assumed
Clerical	\$/hr	40	100	\$4,000	Assumed
Total Labor Cost				\$108,750	
Parts/Equipment					
Parts (2% of capital)				\$8,926	
Equipment Replacement (10% of capital)				\$47,629	Existing plant is 10-12 years old
O&M Cost				\$265,705	
O&M Cost for 30 years (Net present value)				\$1,047,408	Adjusted for net present value
Groundwater Monitoring					
Groundwater Monitoring	per event	\$10,000	3	\$30,000	Monthly first 3 months and quarterly thereafter; includes subcontractor and supervision and equipment rentals. Assuming approximately 5 days of sampling (17 wells within and adjacent to perchlorate plume) and quarterly monitoring as part of current GW monitoring
Reporting	per event	\$5,000	3	\$15,000	Each month for 3 months and quarterly thereafter. Quarterly reporting as part of current GW reporting
Laboratory Sampling Cost	per sample	\$65	51	\$3,315	Monthly first 3 months and quarterly thereafter and quarterly monitoring as part of current GW monitoring plan. Analysis for perchlorate only. Calscience Quote, 2007
Total Monitoring Cost				\$48,315	
Total O&M Cost¹				\$1,095,723	
Discount Rate	7%				
NPV Factor			0.1314		For 30 years at 7% rate
Total Costs				\$1,542,014	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost, excluding total analytical costs
 Analytical cost is only calculated for first three months of operation. Net present value is not calculated for this section.

Table D-3

Cost Estimate - Tailored Liquid-phase Carbon
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT:	PGA North
SITE:	PGA North
ALTERNATIVE:	Groundwater
DESCRIPTION:	Tailored Liquid Carbon Treatment
PREPARED BY:	Soomodh Abraham/Mike Grigorieff
PROJECT NUMBER:	

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Existing extraction wells EA-01, EB-01, EA-03, EA-02, and MW-20 are used as extraction wells and no new wells are required.
3. Existing remediation compound and equipment are utilized
4. Perchlorate concentration used is 45 ppb, which was the highest concentration detected at Subunit A during Fourth Qtr 2007 groundwater monitoring.
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Tailored Liquid-phase Carbon					
Site Details			Assumptions		
Length of treatment area	ft	3200	Approximate: Based on 14 ppb perchlorate isoconcentration contour as shown in in 4Q06 groundwater report		
Width of treatment area	ft	1000	Approximate: Based on 14 ppb perchlorate isoconcentration contour as shown in in 4Q06 groundwater report		
Approximate thickness of saturated zone	ft	230	Apprx. combined saturated thickness of subunit A, B, and C		
Porosity		0.3			
Effective ROI of extraction wells	ft	NA	Assuming existing extraction wells are sufficient.		
Number of wells		0	Assuming existing extraction wells are sufficient.		
Pumping Rate	gpm	400 gpm	Average pumping rate assumed based on historical data		
Capital Costs					
	Unit	Unit Cost	Qty	Cost	Assumptions
Tailored GAC Installation					
Discharge pumps	each	\$2,000	0	\$0	Assuming utilizing existing discharge pump
Tailored GAC	each	\$180,000	1	\$180,000	2 liquid carbon vessels and 2-10,000 lbs tailored GAC. Siemens quote for tailored GAC (email correspondence).
Dual Bag Filter Units	each	\$14,000	2	\$28,000	400 gpm, Dual bag 20 micron. Calgon Carbon Quote, 2006
Surge Tank	each	\$5,000	0	\$0	Assuming utilizing existing surge tank
Transfer Pump	each	\$2,000	0	\$0	Assuming utilizing existing transfer pump
Well Head Completions (electrical and mechanical)	each	\$10,000	0	\$0	Assuming utilizing existing well heads
Drawings, O&M Manuals	LS	\$10,000	0	\$0	Includes process and instrumentation diagram, misc. drawings, and O&M guidance document
Capital Cost-Subtotal A				\$208,000	
Additional Costs-1					
Additional Site Misc Equipment/Valves			10%	\$20,800	Page Plant Cost Guide
Additional Site Piping Costs			8.0%	\$16,640	Use existing plant
Additional Site Electrical Installation Costs			8.8%	\$18,380	Based on 1992 EPRI document cost analysis performed for a similar site
Additional Site Instrumentation and Control Costs			6.4%	\$13,213	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$277,033	Sum of Subtotal A and Additional Costs-1
Additional Costs-2					
Contractors Overhead				\$55,407	Approximately 20% of capital cost
Contractors Profit				\$26,595	Approximately 8% of capital cost
Construction Management				\$28,723	8% of capital cost
Construction and Material Contingency				\$96,939	25% of capital and additional costs
Total Capital Costs				\$484,697	Sum of Subtotal B and Additional Cost-2

Table D-3

Cost Estimate - Tailored Liquid-phase Carbon
 PGA North Site-Goodyear, Arizona

Operation and Maintenance Costs	Unit	Unit Cost	Qty	Cost	Assumptions
O&M - Cost A					
Electrical Power	\$/Kw-hr	\$0.12	150,000	\$18,000	Estimate based on requirements at similar sites
Miscellaneous Permits	LS	\$8,000	1	\$8,000	Permits for injection and misc
Tailored GAC Replacement	per vessel	\$80,000	1	\$80,000	Carbon recharge assuming one vessel change every six months for the whole duration. Based on approx. estimate provided by Siemens.
Dual Bag Filter Replacement	each	\$200	12	\$2,400	Assuming replacement once a month
Waste Disposal	per event	\$10,000	2	\$20,000	Include bag filters, used GAC and misc- average. Disposal once every 6 months.
Total O&M - Cost A				\$128,400	
Labor					
Operating	\$/hr	60	730	\$43,800	Assumed
Maintenance	\$/hr	70	243	\$17,033	Assumed
Supervisory	\$/hr	90	150	\$13,500	Assumed
Clerical	\$/hr	40	100	\$4,000	Assumed
Total Labor Cost				\$78,333	
Parts/Equipment					
Parts (2% of capital)				\$9,694	
Equipment Replacement (10% of capital)				\$51,470	Existing plant is 10-12 years old
O&M Cost				\$267,897	Total of all above O&M costs (excluding GW monitoring)
O&M Cost for 30 years (Net present value)				\$1,056,050	Adjusted for net present value
Groundwater Monitoring					
Groundwater Monitoring	per event	\$10,000	3	\$30,000	Monthly first 3 months and quarterly thereafter; includes subcontractor and supervision and equipment rentals. Assuming approximately 5 days of sampling (17 wells within and adjacent to perchlorate plume) and quarterly monitoring thereafter as part of current GW monitoring plan.
Reporting	per event	\$5,000	3	\$15,000	Each month for 3 months and quarterly thereafter. Quarterly reporting as part of current GW reporting.
Laboratory Sampling Cost	per sample	\$65	51	\$3,315	Monthly first 3 months and quarterly thereafter and quarterly monitoring as part of current GW monitoring plan. Analysis for perchlorate only. Calscience Quote, 2007
Total Monitoring Cost				\$48,315	
Total O&M Cost¹				\$1,104,365	
Discount Rate	7%				
NPV Factor			0.1314		For 30 years at 7% rate
Total Costs				\$1,589,062	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost, excluding total analytical costs
 Analytical cost is only calculated for first three months of operation. Net present value is not calculated for this section.

Table D-4
 Cost Estimate - Ex-situ Bioremediation
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
 SITE: PGA North
 ALTERNATIVE: Groundwater
 DESCRIPTION: Ex-situ Bioremediation-Fluidized Bed Reactor
 PREPARED BY: Soomodh Abraham/Mike Grigorieff
 PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Existing extraction wells EA-01, EB-01, EA-03, EA-02, and MW-20 are used as extraction wells and no new wells are required.
3. Existing remediation compound and equipment are utilized
4. Perchlorate concentration used is 45 ppb, which was the highest concentration detected at Subunit A during Fourth Qtr 2007 groundwater monitoring.
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation for remediation

Ex-situ Bioremediation - Fluidized Bed Reactor				
Site Details			Assumptions	
Length of treatment area	ft	3,200	Approximate: Based on 14 ppb perchlorate isoconcentration contour as shown in 4Q06 groundwater report	
Width of treatment area	ft	1,000	Approximate: Based on 14 ppb perchlorate isoconcentration contour as shown in 4Q06 groundwater report	
Approximate thickness of saturated zone	ft	230	Apprx. combined saturated thickness of subunit A, B, and C	
Porosity		0.3		
Effective ROI of extraction wells	ft	NA	Assuming existing extraction wells are sufficient	
Number of wells		0	Assuming existing extraction wells are sufficient	
Pumping Rate	gpm	400 gpm	Average pumping rate assumed based on historical data	
Capital Costs			Assumptions	
Exsitu Biological Anoxic Treatment System	Unit	Unit Cost	Qty	Cost
Fluidized Bed Treatment System				
Fluidized Bed Tanks	each	\$440,000	1	\$440,000
Tank Internals	each	0	0	\$0
Biomass Control Unit	each	0	0	\$0
Fluidization Pumps	each	0	0	\$0
Flow indicating totalizer	each	\$4,000	1	\$4,000
Instruments and Control Panel	each	0	0	\$0
Alcohol and nutrient feed pumps	each	0	0	\$0
Aeration tank	each	0	0	\$0
Total Fluidized Bed Treatment Costs				\$444,000
Acetate/Alcohol Feed System				
Slant bottom holding tank	each	\$24,000	1	\$24,000
Acetate/Alcohol Feed System Package	LS	\$35,000	1	\$35,000
Total Acetate Feed System Cost				\$59,000
Nutrient Feed System				
Nutrient Feed System Package	LS	\$35,000	1	\$35,000
Total Nutrient Feed System Cost				\$35,000
Backwater and Rinse Recovery				
Stopped bottom holding tank	each	\$40,000	1	\$40,000
Diaphragm-type sludge pump	each	\$3,000	2	\$6,000
Polymer package	LS	\$35,000	1	\$35,000
Backwash recirculation pump	each	\$5,000	1	\$5,000
Plate and frame filter press	each	\$121,740	1	\$121,740
Tank level switch	each	\$1,500	1	\$1,500
Total Backwater and Rinse Recovery Cost				\$209,240

Table D-4
 Cost Estimate - Ex-situ Bioremediation
 PGA North Site-Goodyear, Arizona

Pump Station					
Bioreactor overflow tank	each	\$35,000	1	\$35,000	20,000 gallon fiberglass reinforced plastic. Adjusted from a 1993 Ershigs quote for a 25,000 gallon tank
Tank level switch	each	\$1,500	1	\$1,500	Assumed
Multimedia filter feed pump	each	\$20,000	1	\$20,000	400 gpm@70'. Adjusted from a 1998 Gierlich-Mitchell Quote for a 1,400 gpm pump.
Total Pump Station Cost				\$56,500	
Polymer Feed System					
Make down system package	each	\$30,000	1	\$30,000	Assumed
Static Mixer	each	\$5,000	1	\$5,000	Assumed
Total Polymer Feed System Cost				\$35,000	
Multimedia Filter System					
Multimedia filter vessels and media	per unit	\$26,000	3	\$78,000	Appr. 300 gpm, CS-epoxy coated, (2 operating + 1 backwashing). Yardney phone quote, 2007
Differential pressure switch	each	\$300	1	\$300	0-30 psig epoxy coated aluminum body
Modulating valve	each	\$4,500	1	\$4,500	Assumed
Backwash pump and auxiliary	each	\$10,000	1	\$10,000	Assumed
Air scour System	each	\$20,000	1	\$20,000	Assumed
Total Multimedia Filter System Cost				\$112,800	
Bag Filter System					
Dual Bag filters	each	\$14,000	2	\$28,000	400 gpm, Dual bag 20 micron. Calgon Carbon Quote, 2006
Differential pressure switch	each		0		Included in the above estimate
Total Bag Filter System Cost				\$28,000	
pH Adjustment & Pump for Treated Water					
Treated Water Tank	each	\$23,000	1	\$23,000	10,000 gallon fiberglass reinforced plastic. Ershigs quote, 2007
Tank Level Switch	each	\$500	1	\$500	
pH adjustment package	LS	\$35,000	1	\$35,000	Include acid tote, metering pump and pulsation dampner, pH probe, and static mixer.
Booster pump	each	\$3,000	1	\$3,000	400 gpm, 60' head, 10hp stainless steel. Based on Grainger Quote, 2007.
Total pH Adjustment & Treated Water Booster Pump Cost				\$61,500	
Water Disinfection					
Hydrogen Peroxide Holding Tank	each	\$12,000	1	\$12,000	5,000 gallon fiberglass reinforced plastic. Approx. based on Ershigs 1993 cost for a 10,000 gallon tank
Tank Level Switch	each	\$500	1	\$500	Assumed
Metering Pump	each	\$7,640	1	\$7,640	0.5 gpm, CH2M HILL files, escalate from 2003
Pulsation Dampners	each	\$700	1	\$800	CH2M HILL files, escalate from 2003
Injection pump	each	\$15,000	1	\$15,000	PD pump, apprx. 180 gpm
Total Waster Disinfection Cost				\$35,940	
Capital Cost-Subtotal A				\$1,076,980	
Additional Costs-1					
Additional Site Misc Equipment/Valves			10%	\$107,698	Page Plant Cost Guide
Additional Site Piping Costs			11%	\$122,379	Based on 1992 EPRI document cost analysis performed for a similar site
Additional Site Electrical Installation Costs			9%	\$95,888	Based on 1992 EPRI document cost analysis performed for a similar site
Additional Site Instrumentation and Control Costs			7.5%	\$80,340	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$1,483,284	Sum of Subtotal A and Additional Costs-1
Additional Costs-2					
Contractors Overhead				\$296,657	Approximately 20% of capital cost
Contractors Profit				\$142,395	Approximately 8% of capital cost
Construction Management				\$153,787	8% of capital cost
Construction and Material Contingency				\$519,031	25% of capital and additional costs
Total Capital Cost				\$2,595,154	Sum of Subtotal B and Additional Cost-2

Table D-4
 Cost Estimate - Ex-situ Bioremediation
 PGA North Site-Goodyear, Arizona

Operation and Maintenance Costs	Unit	Unit Cost	Qty	Cost	Assumptions
Electrical Power					
Bioreactor - Fluidized Pumps	kW-hr/year	\$0.12	73,400	\$8,808	15 hp each. Based on Environgen 2007 estimate
Bioreactor - Biomass Pumps	kW-hr			\$0	Included above
Bioreactor- Pump Station	kW-hr			\$0	Included above
Ethanol Metering Pumps	kW-hr			\$0	Included above
Nutrient Metering Pumps	kW-hr			\$0	Included above
Polymer Metering Pumps	kW-hr	\$0.12	682	\$82	0.5 hp each, 50% time
Polymer Tank Mixer	kW-hr	\$0.12	56	\$7	1 hp, 10% time
Backwash Decant Pump	kW-hr	\$0.12	85	\$10	200 gpm @ 30', 10% time
Misc. Controls/Lights	kW-hr	\$0.12	5,489	\$659	1500 W
Total Electrical Power Costs				\$9,566	
Carbon Make-up					
Bioreactor LGAC	lbs per year	\$1.5	1,000	\$1,500	Replacement carbon 1,000 lbs per year. Environgen estimate, 2007
Total Bioreactor LGAC Make-up Cost				\$1,500	
Chemicals/Materials					
Acetic Acid (31.5 gallons per day of 50% acetic acid = 31.5 X 365 = 11,497 gallons per year)	per gallon	\$1.5	11,497	\$17,246	Consumption per Environgen, 2007
Phosphoric Acid/Urea (1.6 gallons per day X 3 years =584 gallons/yr)	per lb	\$0.25	584	\$146	Consumption per Environgen, 2007
Polymer	per lb	\$3	1,296	\$3,888	20 lb/dry ton
Sodium Hydroxide	per lb	\$0.11	48,219	\$5,304	10 ppm as CaCO3. Assumed
Hydrogen Peroxide	per lb	\$1	72,328	\$72,328	15 ppm dosage
Total Chemicals/Materials Cost				\$98,912	
Waste Disposal					
Bioreactor Sludge	per ton	\$114	200	\$22,800	20 ppm at 30% solid assumed. Cost from a similar site adjusted for inflation
Total Waste Disposal Cost				\$22,800	
Labor					
Operating	\$/hr	60	2,190	\$131,400	Assumed
Maintenance	\$/hr	70	730	\$51,100	Assumed
Supervisory	\$/hr	90	300	\$27,000	Assumed
Clerical	\$/hr	40	200	\$8,000	Assumed
Total Labor Cost				\$217,500	
Parts/Equipment					
Parts (2% of capital)				\$51,903	
Equipment Replacement (5% of capital)				\$129,758	
O&M Costs				\$531,938	Total of all above O&M costs (excluding GW monitoring)
O&M Cost for 30 years (Net present value)				\$2,096,899	Adjusted for net present value
Groundwater Monitoring					
Groundwater Monitoring	per event	\$10,000	3	\$30,000	Monthly first 3 months and quarterly thereafter; includes subcontractor and supervision and equipment rentals. Assuming approximately 5 days of sampling (17 wells within and adjacent to perchlorate plume) and quarterly monitoring as part of current GW monitoring plan
Reporting	per event	\$5,000	3	\$15,000	Each month for 3 months and quarterly thereafter. Quarterly reporting as part of current GW reporting
Laboratory Sampling Cost	per sample	\$65	51	\$3,315	Monthly first 3 months and quarterly thereafter and quarterly monitoring as part of current GW monitoring plan. Analysis for perchlorate only. Calscience Quote, 2007
Total Monitoring Cost				\$48,315	
Total O&M Cost¹				\$2,145,214	Calculated for net present value
Discount Rate		7%			
NPV Factor			0.1314		For 30 years at 7% rate
Grand Total				\$4,740,368	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost, excluding total analytical costs
 Analytical cost is only calculated for first three months of operation. Net present value is not calculated for this section.

Appendix E

Wellhead Treatment Cost Analysis

Table E-1
 Cost Estimate Summary
 Wellhead Treatment at 575 gallons per minute
 PGA North Site-Goodyear, Arizona

Technology	Costs	Comments
Ion Exchange Resin		
Capital Cost	\$931,227	
Operation and Maintenance Cost	\$1,071,819	Adjusted for net present value
Total Net Present Cost	\$2,003,046	
Tailored GAC		
Capital Cost	\$759,312	
Operation and Maintenance Cost	\$988,854	Adjusted for net present value
Total Net Present Cost	\$1,748,166	
Ex-situ Bioremediation		
Capital Cost	\$3,100,813	
Operation and Maintenance Cost	\$2,291,754	Adjusted for net present value
Total Net Present Cost	\$5,392,567	

Table E-2

Cost Estimate Summary
Wellhead Treatment at 575 gallons per minute
PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
SITE: PGA North
ALTERNATIVE: Groundwater
DESCRIPTION: Ion Exchange Resin
PREPARED BY: Soomodh Abraham/Mike Grigorieff
PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Assuming injection of treated water
4. Perchlorate concentration used is 14 ppb for a worst case scenario
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Ion Exchange Resin					
Site Details					Assumptions
Pumping Rate	gpm		575 gpm		Pumping rate for COG-3 considered for EA-05 also for conservative cost estimates
Capital Costs	Unit	Unit Cost	Qty	Cost	Assumptions
Well Installation and pump					
Site Geophysical Survey	each	\$1,500	0.5	\$750	Assuming a maximum of half a day to conduct geophysical at a well location
Well Installation Permit	each	\$200	1	\$200	Monitoring well installation permit
Drilling and Soil Sampling	per foot	\$70	250	\$17,500	Approximate well installation depth of 250 feet assumed and sampling every 10 feet
Investigation-derived waste disposal	LS	\$5,000	1	\$5,000	Disposal of soil and water originated during well installation
Soil Sample Analyses	per sample	\$65	25	\$1,625	Analyses for perchlorate only and soil sample collected every 10 feet
Extraction pump	each	\$20,000	1	\$20,000	Estimate from a 350 gpm pump price
Total Well Installation Cost				\$45,075	
Remediation Compound					
Concrete containment pad	ft3	\$500	71	\$35,613	Assuming a 55 feet X 35 feet and 1 inch thick concrete pad
Total Remediation Compound Cost				\$35,613	
Ion Exchange Resin					
Ion exchange adsorbers	per acre foot	\$128	1854	\$237,312	2-10000 lbs resins
ASME Code vessels	each		0		Included above
Valve nest	each		0		Included above
Vessel internals	each		0		Included above
Piping inside valve nest			0		Included above
Control Panel	each		0		Included above
Dual Bag Filter Units	each	\$21,000	2	\$42,000	600 gpm, Dual bag 20 micron. Estimated from Calgon Carbon Quote, 2006 for 400 gpm
Well Head Completions (electrical and mechanical)	each	\$10,000	1	\$10,000	
Drawings, O&M Manuals	LS	\$10,000	1	\$10,000	Includes process and instrumentation diagram, misc. drawings, and O&M guidance document
Capital Cost-Subtotal A				\$380,000	
Site Misc Equipment/Valves			10%	\$38,000	Page Plant Cost Guide
Site Piping Costs			13.3%	\$50,486	Based on 1992 EPRI document cost analysis performed for a similar site
Site Electrical Installation Costs			8.2%	\$31,192	Based on 1992 EPRI document cost analysis performed for a similar site
Site Instrumentation and Control Costs			6.0%	\$22,896	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$522,574	
Additional Costs					
Contractors Overhead				\$104,515	Approximately 20% of capital cost
Contractors Profit				\$50,167	Approximately 8% of capital cost
Construction Management				\$67,726	10% of capital cost
Construction and Material Contingency				\$186,245	25% of capital and additional costs
Total Capital Costs				\$931,227	

Table E-2

Cost Estimate Summary
 Wellhead Treatment at 575 gallons per minute
 PGA North Site-Goodyear, Arizona

Operation and Maintenance Costs	Unit	Unit Cost	Qty	Cost	Assumptions
O&M - Cost A					
Electrical Power	\$/Kw-hr	\$0.12	150,000	\$18,000	Estimate based on requirements at similar sites
Miscellaneous Permits	LS	\$8,000	1	\$8,000	Assuming existing permits are sufficient.
Ion Exchange Resin Replacement	per vessel	\$10,000	1	\$10,000	Resin replacement assuming one vessel change every year for the whole duration. Based on approximate existing replacement duration and \$1/lb replacement cost.
Dual Bag Filter Replacement	each	\$200	12	\$2,400	Assuming replacement once a month
Waste Disposal	per event	\$10,000	1	\$10,000	Include bag filters, used GAC and misc . Quarterly assumed.
Total O&M - Cost A				\$48,400	
Labor					
Operating	\$/hr	60	1,095	\$65,700	Assumed
Maintenance	\$/hr	70	365	\$25,550	Assumed
Supervisory	\$/hr	90	150	\$13,500	Assumed
Clerical	\$/hr	40	100	\$4,000	Assumed
Total Labor Cost				\$108,750	
Parts/Equipment					
Parts (2% of capital)				\$18,625	
Equipment Replacement (10% of capital)				\$96,123	
O&M Cost				\$271,897	
O&M Cost for 30 years (Net present value)				\$1,071,819	Adjusted for net present value
Groundwater Monitoring considered as part of site wide monitoring, and therefore no costs involved					
Total O&M Cost¹				\$1,071,819	
Discount Rate	7%				
NPV Factor			0.1314		For 30 years at 7% rate
Total Costs				\$2,003,046	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost

Table E-3

Cost Estimate Summary
Wellhead Treatment at 575 gallons per minute
PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
SITE: PGA North
ALTERNATIVE: Groundwater
DESCRIPTION: Tailored Liquid Carbon Treatment
PREPARED BY: Soomodh Abraham/Mike Grigorieff
PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Assuming injection of treated water
4. Perchlorate concentration used is 14 ppb for a worst case scenario
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Tailored Liquid-phase Carbon					
Site Details				Assumptions	
Pumping Rate	gpm		575 gpm		Pumping rate for COG-3 considered for EA-05 also for conservative cost estimates
Capital Costs					
	Unit	Unit Cost	Qty	Cost	Assumptions
Well Installation and pump					
Site Geophysical Survey	each	\$1,500	0.5	\$750	Assuming a maximum of half a day to conduct geophysical at a well location
Well Installation Permit	each	\$200	1	\$200	Monitoring well installation permit
Drilling and Soil Sampling	per foot	\$70	250	\$17,500	Approximate well installation depth of 250 feet assumed and sampling every 10 feet
Investigation-derived waste disposal	LS	\$5,000	1	\$5,000	Disposal of soil and water originated during well installation
Soil Sample Analyses	per sample	\$65	25	\$1,625	Analyses for perchlorate only and soil sample collected every 10 feet
Extraction pump	each	\$20,000	1	\$20,000	Estimate from a 350 gpm pump price
Total Well Installation Cost				\$45,075	
Remediation Compound					
Concrete containment pad	ft3	\$500	71	\$35,613	Assuming a 55 feet X 35 feet and 1 inch thick concrete pad
Total Remediation Compound Cost				\$35,613	
Tailored GAC Installation					
Tailored GAC	each	\$180,000	1	\$180,000	2 liquid carbon vessels and 2-10,000 lbs tailored GAC. Siemens quote for tailored GAC (email correspondence).
Dual Bag Filter Units	each	\$21,000	2	\$42,000	600 gpm, Dual bag 20 micron. Estimated from Calgon Carbon Quote, 2006 for 400 gpm
Well Head Completions (electrical and mechanical)	each	\$10,000	1	\$10,000	Assuming utilizing existing well heads
Drawings, O&M Manuals	LS	\$10,000	1	\$10,000	Includes process and instrumentation diagram, misc. drawings, and O&M guidance document
Extraction pump	each	\$20,000	1	\$20,000	Estimate from a 350 gpm pump price
Capital Cost-Subtotal A				\$322,688	
Additional Costs-1					
Site Misc Equipment/Valves			10%	\$32,269	Page Plant Cost Guide
Site Piping Costs			10.0%	\$32,269	Based on 1992 EPRI document cost analysis performed for a similar site
Site Electrical Installation Costs			8.4%	\$27,038	Based on 1992 EPRI document cost analysis performed for a similar site
Site Instrumentation and Control Costs			6.1%	\$19,729	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$433,992	
Additional Costs-2					
Contractors Overhead				\$86,798	Approximately 20% of capital cost
Contractors Profit				\$41,663	Approximately 8% of capital cost
Construction Management				\$44,996	8% of capital cost
Construction and Material Contingency				\$151,862	25% of capital and additional costs
Total Capital Costs				\$759,312	Sum of Subtotal B and Additional Cost

Table E-3

Cost Estimate Summary
 Wellhead Treatment at 575 gallons per minute
 PGA North Site-Goodyear, Arizona

Operation and Maintenance Costs	Unit	Unit Cost	Qty	Cost	Assumptions
O&M - Cost A					
Electrical Power	\$/Kw-hr	\$0.12	150,000	\$18,000	Estimate based on requirements at similar sites
Miscellaneous Permits	LS	\$8,000	1	\$8,000	Permits for injection and misc
Tailored GAC Replacement	per vessel	\$40,000	1	\$40,000	Carbon recharge assuming one vessel change every year for the whole duration.
Dual Bag Filter Replacement	each	\$200	12	\$2,400	Assuming replacement once a month
Waste Disposal	per event	\$10,000	1	\$10,000	Include bag filters, used GAC and misc- average. Disposal once every 6 months.
Total O&M - Cost A				\$78,400	
Labor					
Operating	\$/hr	60	730	\$43,800	Assumed
Maintenance	\$/hr	70	243	\$17,033	Assumed
Supervisory	\$/hr	90	150	\$13,500	Assumed
Clerical	\$/hr	40	100	\$4,000	Assumed
Total Labor Cost				\$78,333	
Parts/Equipment					
Parts (2% of capital)				\$15,186	
Equipment Replacement (10% of capital)				\$78,931	
O&M Cost				\$250,851	Total of all above O&M costs (excluding GW monitoring)
O&M Cost for 30 years (Net present value)				\$988,854	Adjusted for net present value
Groundwater Monitoring considered as part of site wide monitoring, and therefore no costs involved					
Total O&M Cost¹				\$988,854	
Discount Rate	7%				
NPV Factor			0.1314		For 30 years at 7% rate
Total Costs				\$1,748,166	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost

Table E-4

Cost Estimate Summary
 Wellhead Treatment at 575 gallons per minute
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
 SITE: PGA North
 ALTERNATIVE: Groundwater
 DESCRIPTION: Ex-situ Bioremediation-Fluidized Bed Reactor
 PREPARED BY: Soomodh Abraham/Mike Grigorieff
 PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Assuming injection of treated water
4. Perchlorate concentration used is 45 ppb, which was the highest concentration detected at Subunit A during Fourth Qtr 2007 groundwater monitoring.
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Ex-situ Bioremediation - Fluidized Bed Reactor					
Site Details				Assumptions	
Pumping Rate	gpm		575 gpm	Pumping rate for COG-3 considered for EA-05 also for conservative cost estimates	
Capital Costs	Unit	Unit Cost	Qty	Cost	
Well Installation and pump					
Site Geophysical Survey	each	\$1,500	0.5	\$750	Assuming a maximum of half a day to conduct geophysical at a well location
Well Installation Permit	each	\$200	1	\$200	Monitoring well installation permit
Drilling and Soil Sampling	per foot	\$70	250	\$17,500	Approximate well installation depth of 250 feet assumed and sampling every 10 feet
Investigation-derived waste disposal	LS	\$5,000	1	\$5,000	Disposal of soil and water originated during well installation
Soil Sample Analyses	per sample	\$65	25	\$1,625	Analyses for perchlorate only and soil sample collected every 10 feet
Extraction pump	each	\$20,000	1	\$20,000	Estimate from a 350 gpm pump price
Total Well Installation Cost				\$45,075	
Remediation Compound					
Concrete containment pad	ft3	\$500	71	\$35,613	Assuming a 55 feet X 35 feet and 1 inch thick concrete pad. CH2M HILL estimate
Total Remediation Compound Cost				\$35,613	
Exsitu Biological Anoxic Treatment System					
Fluidized Bed Treatment System					
Fluidized Bed Tanks	each	\$550,000	1	\$550,000	11.5' X 24' tank. Envirogen Quote, 2007
Tank Internals	each		0	\$0	included
Biomass Control Unit	each		0	\$0	included
Fluidization Pumps	each		0	\$0	included
Flow indicating totalizer	each	\$4,000	1	\$4,000	Price includes power and control wires.
Instruments and Control Panel	each		0	\$0	included
Alcohol and nutrient feed pumps	each		0	\$0	included
Aeration tank	each		0	\$0	included
Total Fluidized Bed Treatment Costs				\$554,000	
Acetate/Alcohol Feed System					
Slant bottom holding tank	each	\$24,000	1	\$24,000	10,000 gallon fiberglass reinforced plastic tank. Ershigs quote, 2007
Acetate/Alcohol Feed System Package	LS	\$35,000	1	\$35,000	Assumed. Package includes 1 gph metering pumps, level switch, and pulsation dampner
Total Acetate Feed System Cost				\$59,000	
Nutrient Feed System					
Nutrient Feed System Package	LS	\$35,000	1	\$35,000	Package include tote bin, tank level switch, 1.5 gph metering pump, and pulsation dampner

Table E-4

Cost Estimate Summary
 Wellhead Treatment at 575 gallons per minute
 PGA North Site-Goodyear, Arizona

Total Nutrient Feed System Cost					\$35,000
Backwater and Rinse Recovery					
Slopped bottom holding tank	each	\$40,000	1	\$40,000	20,000 gallon fiberglass reinforced plastic. Ershings quote, 2007
Diaphragm-type sludge pump	each	\$3,000	2	\$6,000	Assumed
Polymer package	LS	\$35,000	1	\$35,000	Include mixer and feed pump
Backwash recirculation pump	each	\$5,000	1	\$5,000	Carbon Steel casing, stainless steel impeller. 200 gpm @ 30'. 15 cubic feet, PVC. Price from previous quote; verified with U.S.Filter
Plate and frame filter press	each	\$121,740	1	\$121,740	Assumed
Tank level switch	each	\$1,500	1	\$1,500	
Total Backwater and Rinse Recovery Cost					\$209,240
Pump Station					
Bioreactor overflow tank	each	\$35,000	1	\$35,000	20,000 gallon fiberglass reinforced plastic. Adjusted from a 1993 Ershigs quote for a 25,000 gallon tank
Tank level switch	each	\$1,500	1	\$1,500	Assumed
Multimedia filter feed pump	each	\$30,000	1	\$30,000	575 gpm@70'. Adjusted from a 1998 Gierlich-Mitchell Quote for a 1,400 gpm pump.
Total Pump Station Cost					\$66,500
Polymer Feed System					
Make down system package	each	\$30,000	1	\$30,000	Assumed
Static Mixer	each	\$5,000	1	\$5,000	Assumed
Total Polymer Feed System Cost					\$35,000
Multimedia Filter System					
Multimedia filter vessels and media	per unit	\$26,000	3	\$78,000	Appr. 300 gpm, CS-epoxy coated, (2 operating + 1 backwashing). Yardney phone quote, 2007
Differential pressure switch	each	\$300	1	\$300	0-30 psig epoxy coated aluminum body
Modulating valve	each	\$4,500	1	\$4,500	Assumed
Backwash pump and auxiliary	each	\$10,000	1	\$10,000	Assumed
Air scour System	each	\$20,000	1	\$20,000	Assumed
Total Multimedia Filter System Cost					\$112,800
Bag Filter System					
Dual Bag filters	each	\$21,000	2	\$42,000	600 gpm, Dual bag 20 micron. Estimated from Calgon Carbon Quote, 2006
Differential pressure switch	each		0		Included in the above estimate
Total Bag Filter System Cost					\$42,000
pH Adjustment & Pump for Treated Water					
Treated Water Tank	each	\$23,000	1	\$23,000	10,000 gallon fiberglass reinforced plastic. Ershigs quote, 2007
Tank Level Switch	each	\$500	1	\$500	
pH adjustment package	LS	\$35,000	1	\$35,000	Include acid tote, metering pump and pulsation dampner, pH probe, and static mixer.
Booster pump	each	\$4,500	1	\$4,500	600 gpm, 60' head, 10hp stainless steel. Based on Grainger Quote, 2007.
Total pH Adjustment & Treated Water Booster Pump Cost					\$63,000
Water Disinfection					
Hydrogen Peroxide Holding Tank	each	\$12,000	1	\$12,000	5,000 gallon fiberglass reinforced plastic. Approx. based on Ershigs 1993 cost for a 10,000 gallon tank
Tank Level Switch	each	\$500	1	\$500	Assumed
Metering Pump	each	\$7,640	1	\$7,640	0.5 gpm, CH2M HILL files, escalate from 2003
Pulsation Dampners	each	\$700	1	\$800	CH2M HILL files, escalate from 2003
Injection pump	each	\$15,000	1	\$15,000	PD pump, apprx. 180 gpm
Total Waster Disinfection Cost					\$35,940
Capital Cost-Subtotal A					\$1,293,168
Site Misc Equipment/Valves			10%	\$129,317	Page Plant Cost Guide
Site Piping Costs			11%	\$142,578	Based on 1992 EPRI document cost analysis performed for a similar site
Site Electrical Installation Costs			9%	\$112,053	Based on 1992 EPRI document cost analysis performed for a similar site
Site Instrumentation and Control Costs			7.4%	\$95,183	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B					\$1,772,298

Table E-4

Cost Estimate Summary
Wellhead Treatment at 575 gallons per minute
PGA North Site-Goodyear, Arizona

Additional Costs					
Contractors Overhead				\$354,460	Approximately 20% of capital cost
Contractors Profit				\$170,141	Approximately 8% of capital cost
Construction Management				\$183,752	8% of capital cost
Construction and Material Contingency				\$620,163	25% of capital and additional costs
Total Capital Cost				\$3,100,813	Sum of Subtotal B and Additional Cost
Operation and Maintenance Costs					
	Unit	Unit Cost	Qty	Cost	Assumptions
Electrical Power					
Bioreactor - Fluidized Pumps	kW-hr/year	\$0.12	119,784	\$14,374	15 hp each. Based on Environgen 2007 estimate
Bioreactor - Biomass Pumps	kW-hr			\$0	Included above
Bioreactor- Pump Station	kW-hr			\$0	Included above
Ethanol Metering Pumps	kW-hr			\$0	Included above
Nutrient Metering Pumps	kW-hr			\$0	Included above
Polymer Metering Pumps	kW-hr	\$0.12	682	\$82	0.5 hp each, 50% time
Polymer Tank Mixer	kW-hr	\$0.12	56	\$7	1 hp, 10% time
Backwash Decant Pump	kW-hr	\$0.12	85	\$10	200 gpm @ 30', 10% time
Misc. Controls/Lights	kW-hr	\$0.12	5,489	\$659	1500 W
Total Electrical Power Costs				\$15,132	
Carbon Make-up					
Bioreactor LGAC	lbs per year	\$1.5	1,608	\$2,412	Replacement carbon 1,000 lbs per year. Envirogen estimate, 2007
Total Bioreactor LGAC Make-up Cost				\$2,412	
Chemicals/Materials					
Acetic Acid (31.5 gallons per day of 50% acetic acid = 45.2 X 365 = 16,498 gallons per year)	per gallon	\$1.5	16,498	\$24,747	Consumption per Envirogen, 2007
Phosphoric Acid/Urea (2.2 gallons per day X 1 year =24090 gallons/yr)	per lb	\$0.25	803	\$201	Consumption per Envirogen, 2007
Polymer	per lb	\$3	1,296	\$3,888	20 lb/dry ton
Sodium Hydroxide	per lb	\$0.11	48,219	\$5,304	10 ppm as CaCO3. Assumed
Hydrogen Peroxide	per lb	\$1	72,328	\$72,328	15 ppm dosage
Total Chemicals/Materials Cost				\$106,468	
Waste Disposal					
Bioreactor Sludge	per ton	\$114	200	\$22,800	20 ppm at 30% solid assumed. Cost from a similar site adjusted for inflation
Total Waste Disposal Cost				\$22,800	
Labor					
Operating	\$/hr	60	2,190	\$131,400	Assumed
Maintenance	\$/hr	70	730	\$51,100	Assumed
Supervisory	\$/hr	90	300	\$27,000	Assumed
Clerical	\$/hr	40	200	\$8,000	Assumed
Total Labor Cost				\$217,500	
Parts/Equipment					
Parts (2% of capital)				\$62,016	
Equipment Replacement (5% of capital)				\$155,041	
O&M Costs				\$581,368	Total of all above O&M costs (excluding GW monitoring)
O&M Cost for 30 years (Net present value)				\$2,291,754	Adjusted for net present value
Groundwater Monitoring considered as part of site wide monitoring, and therefore no costs involved					
Total O&M Cost¹				\$2,291,754	Calculated for net present value
Discount Rate					
NPV Factor		7%	0.1314		For 30 years at 7% rate
Grand Total				\$5,392,567	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost

Table E-5
 Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

Technology	Costs	Comments
Ion Exchange Resin		
Capital Cost	\$1,491,620	
Operation and Maintenance Cost	\$1,447,283	Adjusted for net present value
Total Net Present Cost	\$2,938,903	
Tailored GAC		
Capital Cost	\$1,270,294	
Operation and Maintenance Cost	\$1,459,205	Adjusted for net present value
Total Net Present Cost	\$2,729,499	
Ex-situ Bioremediation		
Capital Cost	\$3,496,774	
Operation and Maintenance Cost	\$2,505,824	Adjusted for net present value
Total Net Present Cost	\$6,002,599	

Table E-6

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
 SITE: PGA North
 ALTERNATIVE: Groundwater
 DESCRIPTION: Ion Exchange Resin
 PREPARED BY: Soomodh Abraham/Mike Grigorieff
 PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Assuming injection of treated water
4. Perchlorate concentration used is 14 ppb for a worst case scenario
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Ion Exchange Resin					Assumptions
Site Details					
Pumping Rate	gpm		1000 gpm		Pumping rate for EA-06 considered for 33A also for conservative cost estimates
Capital Costs	Unit	Unit Cost	Qty	Cost	Assumptions
Well Installation and pump					
Site Geophysical Survey	each	\$1,500	0.5	\$750	Assuming a maximum of half a day to conduct geophysical at a well location
Well Installation Permit	each	\$200	1	\$200	Monitoring well installation permit
Drilling and Soil Sampling	per foot	\$70	250	\$17,500	Approximate well installation depth of 250 feet assumed and sampling every 10 feet
Investigation-derived waste disposal	LS	\$5,000	1	\$5,000	Disposal of soil and water originated during well installation
Soil Sample Analyses	per sample	\$65	25	\$1,625	Analyses for perchlorate only and soil sample collected every 10 feet
Extraction pump	each	\$40,000	1	\$40,000	Estimated from 350 gpm pump price
Total Well Installation Cost				\$65,075	
Remediation Compound					
Concrete containment pad	ft3	\$500	96	\$48,100	Assuming a 65 X 40 feet and 1 inch thick concrete pad. CH2M HILL estimate
Total Remediation Compound Cost				\$48,100	
Ion Exchange Resin					
Ion exchange adsorbers	per acre foot	\$128	3226	\$412,928	2-20000 lbs resins
ASME Code vessels	each		0		Included above
Valve nest	each		0		Included above
Vessel internals	each		0		Included above
Piping inside valve nest			0		Included above
Control Panel	each		0		Included above
Dual Bag Filter Units	each	\$35,000	2	\$70,000	1000 gpm, Dual bag 20 micron. Estimated from Calgon Carbon Quote, 2006 for 400 gpm
Well Head Completions (electrical and mechanical)	each	\$10,000	1	\$10,000	
Drawings, O&M Manuals	LS	\$10,000	1	\$10,000	Includes process and instrumentation diagram, misc. drawings, and O&M guidance document
Capital Cost-Subtotal A				\$616,103	
Site Misc Equipment/Valves			10%	\$61,610	Page Plant Cost Guide
Site Piping Costs			12.4%	\$76,360	Based on 1992 EPRI document cost analysis performed for a similar site
Site Electrical Installation Costs			7.7%	\$47,470	Based on 1992 EPRI document cost analysis performed for a similar site
Site Instrumentation and Control Costs			5.8%	\$35,506	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$837,048	

Table E-6

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

Additional Costs-2					
Contractors Overhead				\$167,410	Approximately 20% of capital cost
Contractors Profit				\$80,357	Approximately 8% of capital cost
Construction Management				\$108,481	10% of capital cost
Construction and Material Contingency				\$298,324	25% of capital and additional costs
Total Capital Costs				\$1,491,620	
Operation and Maintenance Costs					
	Unit	Unit Cost	Qty	Cost	Assumptions
O&M - Cost A					
Electrical Power	\$/Kw-hr	\$0.12	300,000	\$36,000	Estimate based on requirements at similar sites
Miscellaneous Permits	LS	\$8,000	1	\$8,000	
Ion Exchange Resin Replacement	per vessel	\$20,000	1	\$20,000	Resin replacement assuming one vessel change once a year for the whole duration. Based on approximate existing replacement duration and \$1/lb replacement cost.
Dual Bag Filter Replacement	each	\$200	12	\$2,400	Assuming replacement once a month
Waste Disposal	per event	\$10,000	1	\$10,000	Include bag filters, used GAC and misc . Once a year
Total O&M - Cost A				\$76,400	
Labor					
Operating	\$/hr	60	1,095	\$65,700	Assumed
Maintenance	\$/hr	70	365	\$25,550	Assumed
Supervisory	\$/hr	90	150	\$13,500	Assumed
Clerical	\$/hr	40	100	\$4,000	Assumed
Total Labor Cost				\$108,750	
Parts/Equipment					
Parts (2% of capital)				\$29,832	
Equipment Replacement (10% of capital)				\$152,162	
O&M Cost				\$367,144	
O&M Cost for 30 years (Net present value)				\$1,447,283	Adjusted for net present value
Groundwater Monitoring considered as part of site wide monitoring, and therefore no costs involved					
Total O&M Cost¹				\$1,447,283	
Discount Rate	7%				
NPV Factor			0.1314		For 30 years at 7% rate
Total Costs				\$2,938,903	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost

Table E-7

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
 SITE: PGA North
 ALTERNATIVE: Groundwater
 DESCRIPTION: Tailored Liquid Carbon Treatment
 PREPARED BY: Soomodh Abraham/Mike Grigorieff
 PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Assuming injection of treated water
3. Perchlorate concentration used is 14 ppb for a worst case scenario
4. Perchlorate concentration used is 14 ppb for a worst case scenario
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Tailored Liquid-phase Carbon					
Site Details				Assumptions	
Pumping Rate	gpm		1000 gpm		Pumping rate for EA-06 considered for 33A also for conservative cost estimates
Capital Costs	Unit	Unit Cost	Qty	Cost	Assumptions
Well Installation and pump					
Site Geophysical Survey	each	\$1,500	0.5	\$750	Assuming a maximum of half a day to conduct geophysical at a well location
Well Installation Permit	each	\$200	1	\$200	Monitoring well installation permit
Drilling and Soil Sampling	per foot	\$70	250	\$17,500	Approximate well installation depth of 250 feet assumed and sampling every 10 feet
Investigation-derived waste disposal	LS	\$5,000	1	\$5,000	Disposal of soil and water originated during well installation
Soil Sample Analyses	per sample	\$65	25	\$1,625	Analyses for perchlorate only and soil sample collected every 10 feet
Extraction pump	each	\$20,000	1	\$20,000	Estimate from a 350 gpm pump price
Total Well Installation Cost				\$45,075	
Remediation Compound					
Concrete containment pad	ft3	\$500	96	\$48,100	Assuming a 65 X 40 feet and 1 inch thick concrete pad. CH2M HILL estimate
Total Remediation Compound Cost				\$48,100	
Tailored GAC Installation					
Tailored GAC	each	\$180,000	2	\$360,000	2 liquid carbon vessels and 2-20,000 lbs tailored GAC. Siemens quote for tailored GAC (email correspondence).
Dual Bag Filter Units	each	\$35,000	2	\$70,000	1000 gpm, Dual bag 20 micron. Estimated from Calgon Carbon Quote, 2006 for 400 gpm
Well Head Completions (electrical and mechanical)	each	\$10,000	1	\$10,000	Assuming utilizing existing well heads
Drawings, O&M Manuals	LS	\$10,000	1	\$10,000	Includes process and instrumentation diagram, misc. drawings, and O&M guidance document
Capital Cost-Subtotal A				\$543,175	
Site Misc Equipment/Valves			10%	\$54,318	Page Plant Cost Guide
Site Piping Costs			10%	\$54,318	
Site Electrical Installation Costs			7.8%	\$42,564	Based on 1992 EPRI document cost analysis performed for a similar site
Site Instrumentation and Control Costs			5.8%	\$31,674	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$726,048	Sum of Subtotal A and Additional Costs-1
Additional Costs					
Contractors Overhead				\$145,210	Approximately 20% of capital cost
Contractors Profit				\$69,701	Approximately 8% of capital cost
Construction Management				\$75,277	8% of capital cost
Construction and Material Contingency				\$254,059	25% of capital and additional costs
Total Capital Costs				\$1,270,294	Sum of Subtotal B and Additional Cost

Table E-7

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

Operation and Maintenance Costs	Unit	Unit Cost	Qty	Cost	Assumptions
O&M - Cost A					
Electrical Power	\$/Kw-hr	\$0.12	300,000	\$36,000	Estimate based on requirements at similar sites
Miscellaneous Permits	LS	\$8,000	1	\$8,000	Permits for injection and misc
Tailored GAC Replacement	per vessel	\$80,000	1	\$80,000	Carbon recharge assuming one vessel change once a year for the whole duration.
Dual Bag Filter Replacement	each	\$200	12	\$2,400	Assuming replacement once a month
Waste Disposal	per event	\$10,000	1	\$10,000	Include bag filters, used GAC and misc- average. Disposal once a year
Total O&M - Cost A				\$136,400	
Labor					
Operating	\$/hr	60	730	\$43,800	Assumed
Maintenance	\$/hr	70	243	\$17,033	Assumed
Supervisory	\$/hr	90	150	\$13,500	Assumed
Clerical	\$/hr	40	100	\$4,000	Assumed
Total Labor Cost				\$78,333	
Parts/Equipment					
Parts (2% of capital)				\$25,406	
Equipment Replacement (10% of capital)				\$130,029	
O&M Cost				\$370,169	Total of all above O&M costs (excluding GW monitoring)
O&M Cost for 30 years (Net present value)				\$1,459,205	Adjusted for net present value
Groundwater Monitoring considered as part of site wide monitoring, and therefore no costs involved					
Total O&M Cost¹				\$1,459,205	
Discount Rate	7%				
NPV Factor			0.1314		For 30 years at 7% rate
Total Costs				\$2,729,499	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost

Table E-8

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

SITE DATA AND ALTERNATIVE CONCEPTUAL DESIGN

PROJECT: PGA North
 SITE: PGA North
 ALTERNATIVE: Groundwater
 DESCRIPTION: Ex-situ Bioremediation-Fluidized Bed Reactor
 PREPARED BY: Soomodh Abraham/Mike Grigorieff
 PROJECT NUMBER:

Assumptions

1. Perchlorate is considered to be the primary contaminant and thus focuses on the perchlorate concentrations only.
2. Assuming injection of treated water
4. Perchlorate concentration used is 14 ppb for a worst case scenario
5. Target perchlorate concentration is 2 ppb
6. Assumed 30 years of operation

Ex-situ Bioremediation - Fluidized Bed Reactor					Assumptions
Site Details					
Pumping Rate	gpm		1000 gpm		Pumping rate for EA-06 considered for 33A also for conservative cost estimates
Capital Costs	Unit	Unit Cost	Qty	Cost	Assumptions
Well Installation and pump					
Site Geophysical Survey	each	\$1,500	0.5	\$750	Assuming a maximum of half a day to conduct geophysical at a well location
Well Installation Permit	each	\$200	1	\$200	Monitoring well installation permit
Drilling and Soil Sampling	per foot	\$70	250	\$17,500	Approximate well installation depth of 250 feet assumed and sampling every 10 feet
Investigation-derived waste disposal	LS	\$5,000	1	\$5,000	Disposal of soil and water originated during well installation
Soil Sample Analyses	per sample	\$65	25	\$1,625	Analyses for perchlorate only and soil sample collected every 10 feet
Extraction pump	each	\$20,000	1	\$20,000	Estimate from a 350 gpm pump price
Total Well Installation Cost				\$45,075	
Remediation Compound					
Concrete containment pad	ft3	\$500	71	\$35,613	Assuming a 55 feet X 35 feet and 1 inch thick concrete pad. CH2M HILL estimate
Total Remediation Compound Cost				\$35,613	
Exsitu Biological Anoxic Treatment System					
Fluidized Bed Treatment System					
Fluidized Bed Tanks	each	\$669,000	1	\$669,000	9' X 24' tank. Envirogen Quote, 2007
Tank Internals	each		0	\$0	included
Biomass Control Unit	each		0	\$0	included
Fluidization Pumps	each		0	\$0	included
Flow indicating totalizer	each	\$4,000	1	\$4,000	Price includes power and control wires.
Instruments and Control Panel	each		0	\$0	included
Alcohol and nutrient feed pumps	each		0	\$0	included
Aeration tank	each		0	\$0	included
Total Fluidized Bed Treatment Costs				\$673,000	
Acetate/Alcohol Feed System					
Slant bottom holding tank	each	\$24,000	1	\$24,000	10,000 gallon fiberglass reinforced plastic tank. Ershigs quote, 2007
Acetate/Alcohol Feed System Package	LS	\$35,000	1	\$35,000	Assumed. Package includes 1 gph metering pumps, level switch, and pulsation dampner
Total Acetate Feed System Cost				\$59,000	
Nutrient Feed System					
Nutrient Feed System Package	LS	\$35,000	1	\$35,000	Package include tote bin, tank level switch, 1.5 gph metering pump, and pulsation dampner
Total Nutrient Feed System Cost				\$35,000	

Table E-8

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

Backwater and Rinse Recovery					
Slopped bottom holding tank	each	\$40,000	1	\$40,000	20,000 gallon fiberglass reinforced plastic. Ershings quote, 2007
Diaphragm-type sludge pump	each	\$3,000	2	\$6,000	Assumed
Polymer package	LS	\$35,000	1	\$35,000	Include mixer and feed pump
Backwash recirculation pump	each	\$5,000	1	\$5,000	Carbon Steel casing, stainless steel impeller. 200 gpm @ 30'. 15 cubic feet, PVC. Price from previous quote; verified with U.S.Filter
Plate and frame filter press	each	\$121,740	1	\$121,740	
Tank level switch	each	\$1,500	1	\$1,500	Assumed
Total Backwater and Rinse Recovery Cost				\$209,240	
Pump Station					
Bioreactor overflow tank	each	\$35,000	1	\$35,000	20,000 gallon fiberglass reinforced plastic. Adjusted from a 1993 Ershigs quote for a 25,000 gallon tank
Tank level switch	each	\$1,500	1	\$1,500	Assumed
Multimedia filter feed pump	each	\$50,000	1	\$50,000	1000 gpm@70'. Adjusted from a 1998 Gierlich-Mitchell Quote for a 1,400 gpm pump.
Total Pump Station Cost				\$86,500	
Polymer Feed System					
Make down system package	each	\$30,000	1	\$30,000	Assumed
Static Mixer	each	\$5,000	1	\$5,000	Assumed
Total Polymer Feed System Cost				\$35,000	
Multimedia Filter System					
Multimedia filter vessels and media	per unit	\$26,000	3	\$78,000	Appr. 300 gpm, CS-epoxy coated, (2 operating + 1 backwashing). Yardney phone quote, 2007
Differential pressure switch	each	\$300	1	\$300	0-30 psig epoxy coated aluminum body
Modulating valve	each	\$4,500	1	\$4,500	Assumed
Backwash pump and auxiliary	each	\$10,000	1	\$10,000	Assumed
Air scour System	each	\$20,000	1	\$20,000	Assumed
Total Multimedia Filter System Cost				\$112,800	
Bag Filter System					
Dual Bag filters	each	\$35,000	2	\$70,000	1000 gpm, Dual bag 20 micron. Estimated from Calgon Carbor Quote, 2006
Differential pressure switch	each		0		Included in the above estimate
Total Bag Filter System Cost				\$70,000	
pH Adjustment & Pump for Treated Water					
Treated Water Tank	each	\$23,000	1	\$23,000	10,000 gallon fiberglass reinforced plastic. Ershigs quote, 2007
Tank Level Switch	each	\$500	1	\$500	
pH adjustment package	LS	\$35,000	1	\$35,000	Include acid tote, metering pump and pulsation dampner, pH probe, and static mixer.
Booster pump	each	\$7,500	1	\$7,500	1000 gpm, 60' head, 10hp stainless steel. Estimated from Grainger Quote, 2007.
Total pH Adjustment & Treated Water Booster Pump Cost				\$66,000	
Water Disinfection					
Hydrogen Peroxide Holding Tank	each	\$12,000	1	\$12,000	5,000 gallon fiberglass reinforced plastic. Approx. based on Ershigs 1993 cost for a 10,000 gallon tank
Tank Level Switch	each	\$500	1	\$500	Assumed
Metering Pump	each	\$7,640	1	\$7,640	0.5 gpm, CH2M HILL files, escalate from 2003
Pulsation Dampners	each	\$700	1	\$800	CH2M HILL files, escalate from 2003
Injection pump	each	\$15,000	1	\$15,000	PD pump, apprx. 180 gpm
Total Waster Disinfection Cost				\$35,940	
Capital Cost-Subtotal A				\$1,463,168	
Site Misc Equipment/Valves			10%	\$146,317	Page Plant Cost Guide
Site Piping Costs			11%	\$157,986	Based on 1992 EPRI document cost analysis performed for a similar site
Site Electrical Installation Costs			9%	\$124,429	Based on 1992 EPRI document cost analysis performed for a similar site
Site Instrumentation and Control Costs			7.3%	\$106,714	Based on 1992 EPRI document cost analysis performed for a similar site
Capital Costs- Subtotal B				\$1,998,614	

Table E-8

Cost Estimate Summary
 Wellhead Treatment at 1,000 gallons per minute
 PGA North Site-Goodyear, Arizona

Additional Costs					
Contractors Overhead				\$399,723	Approximately 20% of capital cost
Contractors Profit				\$191,867	Approximately 8% of capital cost
Construction Management				\$207,216	8% of capital cost
Construction and Material Contingency				\$699,355	25% of capital and additional costs
Total Capital Cost				\$3,496,774	Sum of Subtotal B and Additional Cost
Operation and Maintenance Costs					
	Unit	Unit Cost	Qty	Cost	Assumptions
Electrical Power					
Bioreactor - Fluidized Pumps	kW-hr/year	\$0.12	177,524	\$21,303	15 hp each. Based on Environgen 2007 estimate
Bioreactor - Biomass Pumps	kW-hr			\$0	Included above
Bioreactor- Pump Station	kW-hr			\$0	Included above
Ethanol Metering Pumps	kW-hr			\$0	Included above
Nutrient Metering Pumps	kW-hr			\$0	Included above
Polymer Metering Pumps	kW-hr	\$0.12	682	\$82	0.5 hp each, 50% time
Polymer Tank Mixer	kW-hr	\$0.12	56	\$7	1 hp, 10% time
Backwash Decant Pump	kW-hr	\$0.12	85	\$10	200 gpm @ 30', 10% time
Misc. Controls/Lights	kW-hr	\$0.12	5,489	\$659	1500 W
Total Electrical Power Costs				\$22,060	
Carbon Make-up					
Bioreactor LGAC	lbs per year	\$1.5	2,383	\$3,575	Replacement carbon 1,000 lbs per year. Environgen estimate, 2007
Total Bioreactor LGAC Make-up Cost				\$3,575	
Chemicals/Materials					
Acetic Acid (31.5 gallons per day of 50% acetic acid = 78.7 X 365 = 11,497 gallons per year)	per gallon	\$1.5	28,726	\$43,088	Consumption per Environgen, 2007
Phosphoric Acid/Urea (1.6 gallons per day X 3 years =584 gallons/yr)	per lb	\$0.25	1,424	\$356	Consumption per Environgen, 2007
Polymer	per lb	\$3	1,296	\$3,888	20 lb/dry ton
Sodium Hydroxide	per lb	\$0.11	48,219	\$5,304	10 ppm as CaCO3. Assumed
Hydrogen Peroxide	per lb	\$1	72,328	\$72,328	15 ppm dosage
Total Chemicals/Materials Cost				\$124,964	
Waste Disposal					
Bioreactor Sludge	per ton	\$114	200	\$22,800	20 ppm at 30% solid assumed. Cost from a similar site adjusted for inflation
Total Waste Disposal Cost				\$22,800	
Labor					
Operating	\$/hr	60	2,190	\$131,400	Assumed
Maintenance	\$/hr	70	730	\$51,100	Assumed
Supervisory	\$/hr	90	300	\$27,000	Assumed
Clerical	\$/hr	40	200	\$8,000	Assumed
Total Labor Cost				\$217,500	
Parts/Equipment					
Parts (2% of capital)				\$69,935	
Equipment Replacement (5% of capital)				\$174,839	
O&M Costs				\$635,673	Total of all above O&M costs (excluding GW monitoring)
O&M Cost for 30 years (Net present value)				\$2,505,824	Adjusted for net present value
Total O&M Cost¹				\$2,505,824	Calculated for net present value
Discount Rate		7%			
NPV Factor			0.1314		For 30 years at 7% rate
Grand Total				\$6,002,599	

Notes:

¹Total O&M cost is calculated by using net present value of total O&M cost, excluding total analytical costs
 Analytical cost is only calculated for first three months of operation. Net present value is not calculated for this section.