Prepared for

Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, Arizona 85007

FEASIBILITY STUDY

EAST CENTRAL PHOENIX
32nd STREET AND INDIAN SCHOOL ROAD
WATER QUALITY ASSURANCE REVOLVING FUND SITE
PHOENIX, ARIZONA

Prepared by

Geosyntec consultants

engineers | scientists | innovators

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Project Number: SP0158E

September 2019

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
1,1-DCE	1,1-dichloroethene
AAC	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
ARS	Arizona Revised Statutes
AS	air sparge
AWQS	Aquifer Water Quality Standard
CAB	Community Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COCs	constituents of concern
COP	City of Phoenix
CSM	Conceptual Site Model
CVOCs	chlorinated volatile organic compounds
DEUR	Declaration of Environmental Use Restriction
ECP	East Central Phoenix
ERA	Early Response Action
ERD	enhanced reductive dechlorination
FASA	Fairmont Avenue Study Area
Former Maroney's	Former Maroney's Cleaners & Laundry
FS	Feasibility Study
ft	feet
ft bgs	feet below ground surface
ft/day	feet per day
Geosyntec	Geosyntec Consultants, Inc.
GETS	groundwater extraction and treatment system
GPCs	groundwater protective concentrations
GPLs	groundwater protection levels
HPCs	heath protective concentrations
ISCO	*in situ* chemical oxidation
ISCR	*in situ* chemical reduction
ITRC	Interstate Technology and Research Council
LAU	Lower Alluvial Unit
LGAC	liquid-phase granular activated carbon
MAU	Middle Alluvial Unit
MNA	monitored natural attenuation

NPV	net present value
O&M	operations and maintenance
P&T	pump and treat
PCE	tetrachloroethylene
PRAP	Proposed Remedial Action Plan
RI	Remedial Investigation
ROI	radius of influence
ROs	Remedial Objectives
SRL	Soil Remediation Level
SRP	Salt River Project
SVE	soil vapor extraction
SVP	soil vapor probe
TCE	trichloroethene
TFG	The Fehling Group, LLC
the site	East Central Phoenix 32nd Street and Indian School Road Water Quality Assurance Revolving Fund Site
trans-1,2-DCE	trans-1,2-dichloroethene
UAU	Upper Alluvial Unit
VC	vinyl chloride
VGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
WQARF	Water Quality Assurance Revolving Fund
WSRV	West Salt River Valley
ZVI	zero valent iron

1. INTRODUCTION

1.1 Purpose and Scope of the Feasibility Study Report

The East Central Phoenix (ECP) 32nd Street and Indian School Road Water Quality Assurance Revolving Fund (WQARF) Site (the site), located in Phoenix, Arizona, is one of six WQARF sites collectively included in the ECP area. The site is in the 3200 block of East Indian School Road and it is bounded approximately by Indian School Road to the north, Interstate 10 to the south, 32nd Street to the east, and 7th Street to the west (Figure 1 and 2).

This Feasibility Study (FS) Report was prepared by Geosyntec Consultants, Inc. (Geosyntec) for the Arizona Department of Environmental Quality (ADEQ) in accordance with Arizona Administrative Code (AAC) Title 18, Environmental Quality, Chapter 16, Department of Environmental Quality WQARF Program, Article 4, Remedy Selection (R18-16), and is based on the data and findings of previous investigations, including the Remedial Investigation (RI) Report, prepared by Geosyntec (2019). This FS Report was prepared in accordance with the FS Work Plan prepared by ADEQ (2018).

The objectives of this FS are as follows:

1. Identify remedial options and alternatives that will achieve the Remedial Objectives (ROs) as outlined in the Remedial Objectives Report (ADEQ, 2019); and
2. Evaluate the identified remedies, recommend alternatives, and comply with the requirements of Arizona Revised Statutes (ARS) §49-282.06.

Based on the objectives stated above, this FS presents recommendations for a preferred remedy that:

1. Assures the protection of public health, welfare, and the environment;
2. To the extent practicable, provides for the control, management, or cleanup of hazardous substances to allow for the maximum beneficial use of waters of the state;
3. Is reasonable, necessary, cost-effective, and technically feasible; and
4. Addresses groundwater wells used for municipal, domestic, industrial, irrigation, or agricultural purposes that could produce water that would not be fit for its current or reasonably foreseeable end use without treatment.

1.2 Report Organization

The remainder of this FS Report is organized as follows:

- Section 2, “Site Background,” presents a summary of the site description, physiographic setting, nature and extent of impacts, and a risk evaluation summary;
- Section 3, “Feasibility Study Scoping,” presents the regulatory requirements presented in statute and rule, delineates the remedial areas, and presents the ROs identified in the RI;
- Section 4, “Identification and Screening of Remediation Technologies,” presents the evaluation and screening of various remedial measures and strategies related to the impacts in the vadose zone and groundwater, and lists the technologies that have been retained for evaluation as part of the reference and alternative remedies pursuant to AAC R18-16-407 (E) and (F);
- Section 5, “Development of Reference Remedy and Alternative Remedies,” presents the selected Reference Remedy, a More Aggressive Alternative Remedy, a Less Aggressive Alternative Remedy, and discussions of the associated remedial measures and remedial strategies pursuant to AAC R18-16407 (E);
- Section 6, “Comparison of Remedies,” compares the remedies to each other based on the comparison criteria of practicability, cost, risk, and benefit. Uncertainties associated with the remedies and comparison criteria are discussed pursuant to AAC R18-16-407 (H);
- Section 7, “Proposed Remedy,” presents the proposed remedy as required in AAC R18 16 407 (I), and discusses how it will achieve the ROs, how the comparison criteria were considered, and how the proposed remedy will meet the requirements of ARS §49-282.06;
- Section 8, “Community Involvement,” documents the community involvement activities conducted in association with the FS; and
- Section 9, “References,” provides a list of references cited in this FS.

2. SITE BACKGROUND

This section presents a summary of the site background, physiographic setting, the nature and extent of impacts, and a risk evaluation. A detailed background and chronology are included in the RI Report (Geosyntec, 2019).

2.1 Site Description

The site has historically contained dry-cleaning and automobile service station facilities since the early 1960s. After several years of investigations, tetrachloroethylene (PCE) source areas that resulted in chlorinated volatile organic compound (CVOC) impacts to soil and groundwater were determined to be located at two dry-cleaning facilities (the Former Maroney's Cleaners & Laundry [Former Maroney's] and the Former Viking Cleaners). These facilities historically operated at locations near the intersection of 32nd Street and Indian School Road. The purpose of the RI was to determine the nature and extent of impacts at the site. The RI also identified present and reasonably foreseeable uses of land and waters of the state that have been or are threatened to be impacted by site constituents of concern (COCs).

2.2 Site Physiography

A detailed description of the site physiography is provided in the RI Report (Geosyntec, 2019). Briefly, the site is located in the West Salt River Valley (WSRV) Sub-basin of the Phoenix Active Management Area (AMA), which is a broad alluvial valley filled with layers of unconsolidated sand, gravel, silt, and clay. Total depth to bedrock is unknown, but it is estimated to be at least 1,500 feet below ground surface (ft bgs). The site hydrogeology is typical for the WSRV, consisting of three alluvial units:

- Upper Alluvial Unit (UAU) – The UAU consists of unconsolidated sands and gravels deposited by flowing drainages and is the most permeable unit. According to the Arizona Department of Water Resources (ADWR), the UAU is typically 300 to 400 feet (ft) thick in the WSRV. Where thick saturated sections of the UAU are present, the groundwater production rates are the highest in the region;
- Middle Alluvial Unit (MAU) – The MAU is composed primarily of silt, clay, mudstone, and gypsiferous mudstone, interbedded with silty sand and gravel. As is the case with the UAU and Lower Alluvial Unit (LAU), coarser-grained sediments predominate near the basin margins, where the MAU is indistinguishable from the overlying or underlying units; and
- LAU – The LAU consists mainly of conglomerate and gravel near the margins of the Salt River Valley. It grades into finer grained mudstone, gypsiferous and anhydritic mudstone, and anhydrite toward the center of the basin. Parts of the

WSRV also contain some interbedded lava flows. The LAU overlies crystalline and volcanic bedrock.

The hydrostratigraphic units have been defined based on review and evaluation of data generated during groundwater assessments at the ECP WQARF sites. The hydrogeology has been investigated to a maximum depth of approximately 407 ft bgs within the UAU. The base of the UAU has not been encountered during drilling activities to date; the UAU ranges in thickness from approximately 125 to more than 300 ft in the ECP WQARF sites region (Geosyntec, 2019).

Groundwater elevations in the UAU have been monitored since April 1996. Monitoring wells installed at the site are screened across both shallow (water table) and deeper intervals within the UAU. Water levels in collocated shallow and deeper screened monitoring wells are generally nearly identical. During the period of record for source area monitoring wells at the site, the depth to water has ranged from approximately 43 ft bgs in 2002 to approximately 55 ft bgs in 2017. In 2018, groundwater at the distal end of the PCE plume was reported at approximately 106 ft bgs (Geosyntec, 2019).

The direction of groundwater flow historically has been to the west-southwest with gradients ranging from approximately 0 to 0.007 feet per foot. Vertical gradients between the shallow and deeper zones of the UAU monitored at the site are generally negligible. The estimated horizontal hydraulic conductivity of the UAU is variable due to the heterogeneity of the UAU but it is estimated to range from 1 to 250 ft per day (ft/day). The highest estimates of hydraulic conductivity in the WSRV are found near the Salt River (Corkhill *et al*., 1993; Freihoefer *et al*., 2009).

2.3 Nature and Extent of Impacts

The results of the RI indicate the occurrence of one plume of impacted groundwater within the report focus area. This plume is herein referred to as the site plume. Prior Conceptual Site Models (CSMs) had presumed that the site plume was commingled with the ECP 24th Street and Grand Canal WQARF site plume (Figure 3). As reported in the RI, there appears to be an interaction (overlap) of the PCE plumes associated with the Former Viking Cleaners and Former Maroney's facilities, and the PCE impacts to groundwater associated with the ECP 24th Street and Grand Canal WQARF site. The two plumes, however, are in fact largely discrete, separate plumes, travelling alongside each other and at different vertical elevations, with the plume associated with the ECP 24th and Grand Canal WQARF site being shallower and located to the southeast. The independence of these plumes is shown in Figures 15 through 18 in the RI Report (Geosyntec, 2019). The focus of this FS is the site plume. The ECP 24th Street and Grand Canal WQARF site plume is being addressed in a separate FS.

The RI Report concluded that the Former Viking Cleaners and Former Maroney's dry-cleaning establishments appear to be the sources of most volatile organic compound (VOC) impacts to the site. The site plume appears to have become detached from the two primary suspected residual source areas and is centered southwest of the intersection of 32nd Street and Indian School Road, at the property owned by 32nd Indian School Investors LLC (Assessor's Parcel Number 119-01-380), locally known as the Arcadia Fiesta Shopping Center.

Although the site plume consists primarily of PCE-impacted groundwater, due to the nature of the potential release from the two dry-cleaning establishments, their historical presence, and/or their potential to be generated through biological transformations, the following compounds are also considered COCs:

- Trichloroethene (TCE);
- cis-1,2-Dichloroethene (cis-1,2-DCE);
- trans-1,2-Dichloroethene (trans-1,2-DCE); and
- Vinyl chloride (VC).

2.4 Site History

The following site chronology is summarized from the RI Report (Geosyntec, 2019).

1983: VOCs were detected in Salt River Project (SRP) production well 17E-8N, and PCE was detected above its Arizona Aquifer Water Quality Standard (AWQS) of 5 micrograms per liter (µg/L).

1984 – 2006: Due to these PCE detections, several properties in the ECP region were investigated to locate potential sources. Assessments and field investigations commenced in 1989 at the Former Maroney's and in 1984 at the Former Viking Cleaners.

1987 – 2001: In 1987, ADEQ established the ECP area as a WQARF Priority List site. Subsequently in 1998, the ECP WQARF Priority List site was divided into six WQARF Registry sites, among which was included the 32nd Street and Indian School Road site. In 2000, the 32nd Street and Indian School Road site was placed on the WQARF Registry List with a score of 29 out of a possible 120.

2003 – 2015: Soil vapor and/or indoor air investigations were performed site-wide, at the two dry-cleaning facilities, and at surrounding commercial and residential properties.

2003: The Arizona Department of Health Services (ADHS) evaluated the 2003 indoor air monitoring results from the Former Viking Cleaners facility and provided ADEQ with a health consultation. ADHS advised there was no unacceptable risk to workers inside the building under current exposure scenarios.

2004: Early Response Action (ERA) commenced at the Former Viking Cleaners with construction and operation of an air sparge and soil vapor extraction (AS/SVE) system to reduce VOC concentrations in soil vapor.

2007: In June 2007, ADEQ sent out notices in accordance with ARS §49 287.03 initiating the RI for the site. RI activities were conducted through October 2018.

2008 – 2013: The Fairmount Avenue Study Area (FASA) was established as an investigation area in 2008 due to its location immediately south/southwest and downgradient of the Former Maroney's and Former Viking Cleaners facilities. The FASA was investigated through 2013 for potential impacts from the Former Viking Cleaners and Former Maroney's facility.

2011: ERA commenced at the Former Maroney's with construction and operation of an SVE system. SVE pilot testing activities occurred at the FASA. The objectives of both ERAs were to reduce VOC concentrations in soil vapor.

2011 – 2019: Site soil vapor investigations were performed. The extent of PCE impacts were horizontally and vertically delineated. Impacts were observed to be limited to shallow depths.

2008 – 2019: Groundwater monitoring, sampling, and well installations occurred between April 2008 and April 2019.

2015: Health- and groundwater-protective soil vapor concentrations (HPCs and GPCs, respectively) were developed by risk assessors for the Former Maroney's and Former Viking Cleaners facilities.

2016: ADHS evaluated health concerns associated with potential vapor intrusion of PCE and TCE to residential and commercial buildings located at the site. ADHS concluded that site soil vapor impacts do not pose an unacceptable risk to public health by this exposure pathway.

2018: The Viking Cleaners ERA was completed.

2019: The RI Report prepared by Geosyntec for ADEQ (Geosyntec, 2019) was issued summarizing activities to date, describing the nature and extent of residual impacts at the site, risk analyses, and proposed ROs.

2.5 Risk Evaluation Summary

The risk evaluation in the RI Report provided the following:

- An assessment of the COCs and relevant human receptors;
- An evaluation of potential exposures and pathways present at the site; and
- A characterization of human health concerns associated with the site-related COCs through a comparison to the relevant Arizona standards for groundwater and soil impacts and risk-based screening levels for soil vapor.

The soil, soil vapor, and groundwater monitoring results from the site were included in the evaluation. This section provides a summary of the relevant sections of the RI Report.

An evaluation of current land and water use was performed for the site. Land uses include commercial, industrial, and residential occupancy. Potential receptors therefore include residents and commercial/industrial workers. Impacted media at the site include groundwater, soil, and soil vapor. Because no natural points of discharge of groundwater to surface water exist in the vicinity of the site, the RI Report concluded that no risk characterization for surface water was necessary.

The identification of potentially complete exposure pathways is based on four components, which include:

- A source and mechanism of release;
- Retention or transport media;
- An exposure point (e.g., a setting where contact with impacted media occurs); and
- A route of exposure (e.g., ingestion).

2.5.1 Soil

Investigative activities described in the RI include extensive soil borings during the initial phases of site characterization, including exploratory borings and installation of monitoring wells. Soil samples have not been collected during recent years of site investigation; instead site assessments have focused on soil vapor, which typically provides better indication of the broad/regional subsurface conditions than soil results, which generally provide more discrete/localized conditions. However, potential residual soil concentrations for both the Former Viking Cleaners and Former Maroney's sites were estimated by calculating theoretical equilibrium concentrations with the measured soil vapor concentrations. The resulting concentrations for both sites were below soil cleanup levels, including below default State of Arizona Soil Remediation Levels (SRLs). As such, no additional remedial actions are warranted at either site based on observed soil concentrations and associated cleanup criteria.

2.5.2 Soil Vapor and Indoor Air

As part of the RI, Geosyntec reviewed results of prior indoor air and soil vapor investigations performed at the site to evaluate the vapor intrusion pathway. The RI Report concluded that transport of vapor-phase COCs to outdoor and indoor air with subsequent inhalation exposure has historically been a potentially complete exposure pathway at both sites. While inhalation exposure from outdoor air would be negligible due to atmospheric mixing, vapor intrusion into buildings and subsequent inhalation exposure is of potential concern. Findings and conclusions regarding the risk and vapor pathway as presented in the RI are summarized below (Geosyntec, 2019).

The Fehling Group, LLC (TFG) developed facility- and depth-specific HPCs and utilized GPCs to establish shutdown criteria for the two operating SVE systems. The methodologies and specific screening levels used are described in detail in the RI Report (Geosyntec, 2019).

For both the Former Maroney's and Former Viking Cleaner's facilities, HPCs were developed for two categories of potential receptors: commercial/industrial workers and potential future residents. HPCs were calculated for VOCs detected in soil vapor for three sample depths (5, 15, and 45 ft bgs) and for both receptor categories. ADEQ's minimum groundwater protection levels (GPLs) established in September 1996 were converted to soil vapor equivalent concentrations and used as the GPCs for the VOCs evaluated. The calculated HPCs and GPCs are identical for both dry-cleaning facilities, and are as follows:

- PCE:
  - HPC-RES5 (residential receptor, 5 ft bgs): 11,000 micrograms per cubic meter ($\mu g/m^3$)
  - HPC-RES15 (residential receptor, 15 ft bgs): 20,000 $\mu g/m^3$
  - GPC: 1,460,000 $\mu g/m^3$
- TCE:
  - HPC-RES5: 54,000 $\mu g/m^3$
  - HPC-RES15: 96,000 $\mu g/m^3$

- GPC: 570,000 µg/m^3

Since the HPCs were generally one or more orders of magnitude lower (more conservative) than the GPCs, the HPCs are considered to be the cleanup goals for the vadose zone for both sites.

2.5.2.1 Former Maroney's Current Soil Vapor Condition

The SVE system located at the Former Maroney's facility was shut down in February 2018 for a rebound evaluation. Samples collected approximately five weeks later did not contain detected concentrations above the HPCs. Continued rebound assessments in 2018 and early 2019 show detected PCE concentrations have rebounded in the shallow vadose zone within localized areas above the site-specific HPCs. As such, additional remedy or mitigation implementation is warranted for the shallow vadose zone at the Former Maroney's site. Thus, the vadose zone remedies that are evaluated later in this FS report are intended specifically to address the residual VOC impacts that exceed site-specific cleanup criteria in the localized areas of the Former Maroney's site.

2.5.2.2 Former Viking Cleaner's Current Soil Vapor Condition

Results of soil vapor rebound analyses conducted in 2019 indicate that the vadose zone at the Former Viking Cleaners site has been effectively remediated by the historical SVE and AS ERAs. Soil vapor rebound monitoring data for samples collected after the SVE system was shut down were below the site-specific HPCs. As such, no additional remedial actions are required for soils at the Former Viking Cleaners site.

2.5.2.3 Offsite Soil Vapor Conditions

ADHS evaluated health concerns associated with potential vapor intrusion of PCE and TCE to residential and commercial buildings located at the site. ADHS concluded that vapor intrusion of PCE-impacted soil vapor into site buildings did not pose unacceptable risk to public health by this exposure pathway (ADHS, 2016).

2.5.3 Groundwater

The RI Report states that possible exposure routes for VOC-impacted groundwater include direct ingestion, inhalation, or dermal contact. General population inhalation exposures to VOCs could occur from volatilization from water during activities such as showering, bathing, or washing. However, site groundwater is currently not used as a water supply. Potable use of groundwater is therefore not currently a complete pathway at the site. Several water supply wells that produce from the deeper portion of the aquifer are present in and adjacent to the site. If these supply wells are utilized in the future for water supply, this exposure pathway would require re-evaluation.

The transport mechanism for a groundwater pathway is advection/dispersion and off-gassing/vapor intrusion; the secondary impacted media is indoor air (Geosyntec, 2019). Since nearby production wells are currently inactive, the exposure pathway would only become potentially complete for the three receptors (commercial/industrial workers, construction workers, and residential occupants) if pumping is resumed. The indoor air inhalation exposure route presents a potentially complete exposure pathway from COCs off-gassing from groundwater, both on and off site, and associated vapor intrusion into indoor air; however, the risk is likely negligible and either has been or is currently being mitigated.

3. FEASIBILITY STUDY SCOPING

The following presents the regulatory requirements of pertinent statutes and rules, delineation of the remediation areas, and the ROs identified by ADEQ.

3.1 Regulatory Requirements

Per ARS §49-282.06, the following factors must be considered for selecting remedial actions:

- Population, environmental, and welfare concerns at risk;
- Routes of exposure;
- Amount, concentration, hazardous properties, environmental fate, such as the ability to bio-accumulate, persistence and probability of reaching the waters of the state, and the form of the substance present;
- Physical factors affecting environmental exposure, such as hydrogeology, climate, and the extent of previous and expected migration;
- The extent to which the amount of water available for beneficial use will be preserved by a particular type of remedial action;
- The technical practicability and cost-effectiveness of alternative remedial actions applicable to a site; and
- The availability of other appropriate federal or state remedial action and enforcement mechanisms, including, to the extent consistent with this article, funding sources established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to respond to the release.

The Remedy Selection Rule, AAC R18-16-407, states that an FS is a process by which to identify a Reference Remedy and alternative remedies that appear to be capable of achieving ROs and to evaluate the remedies based on the comparison criteria to select an approach that complies with ARS §49-282.06.

3.2 Delineation of Remediation Areas

The following subsections discuss the delineation of impacts to the vadose zone and groundwater at the site, as well as the uncertainties associated with the delineations.

3.2.1 Vadose Zone

Historical site characterization associated with the RI, as well as Preliminary Investigations, Preliminary Assessments, and Environmental Site Assessments, have demonstrated that the vadose zone was significantly impacted at the Former Viking Cleaners and Former Maroney's properties. Soil and soil vapor VOC impacts, primarily from PCE, have been observed from the shallow subsurface to groundwater at both the Former Maroney's and Former Viking Cleaners' properties. Historical investigations and numerous sampling events using temporary borings and a network of dedicated soil vapor probes (SVPs) and extraction wells have provided requisite delineation of the VOC vadose zone impacts. Soil and soil vapor VOC impacts, primarily from PCE, have been observed from the shallow subsurface throughout the vadose zone to groundwater at both the Former Viking Cleaners and Former Maroney's properties. The investigations have defined both the lateral and vertical extent of the impacts, with no vadose zone characterization data gaps noted. Details related to investigations, SVE pilot tests, and SVE remediation for both facilities are detailed in the RI Report (Geosyntec, 2019).

3.2.2 Groundwater

The following is a summary of VOC source areas and distribution trends in groundwater, further discussed in the RI Report (Geosyntec, 2019). The COC suspected source concentrations begin within generally lower permeability material at the Former Viking Cleaners and Former Maroney's facilities. As the COCs migrate with the general flow direction of groundwater to the southwest, they slowly travel downward from groundwater surface near 60 ft bgs, until they encounter a sand and gravel horizon in the vicinity of VCMW-06B (at a depth of approximately 80 ft bgs). At this point, the COCs migrate downward until reaching a relatively stable mid-plume depth of approximately 240 ft bgs in the vicinity of VCMW-20 and continue to travel downgradient in the same southwesterly direction, creating a 2.5-mile-long and relatively narrow plume bounded by the 5 µg/L PCE isoconcentration contour (Figure 3). Near the intersection of Thomas Road and 24th Street, located approximately 1.5 miles southwest and downgradient of the site source areas, the site is associated with the 24th Street and Grand Canal WQARF site PCE plume. Based on modeling of the local hydrogeology and PCE results in groundwater, these two plumes are largely discrete, separate plumes, travelling alongside each other. The 24th Street and Grand Canal WQARF site plume is being addressed in a separate FS. Further downgradient, and southwest of the Grand Canal, the site plume appears to extend as far as the intersection of 16th Street and Oak Street.

Investigation data suggest that PCE, TCE, and cis-1,2-DCE impacts to groundwater associated with the Former Viking Cleaners and Former Maroney's facilities have been naturally attenuating over time. The remaining site COCs (trans-1,2,-DCE and VC) have not been detected in groundwater above their respective AWQS. The highest CVOC concentrations during recent monitoring have been located immediately downgradient from these areas along the southern sections of the FASA. Groundwater COC impacts, primarily PCE, at concentrations above 100 µg/L are downgradient of the former source areas, suggesting that the groundwater plume is disconnected from the former sources at the Former Viking Cleaners and Former Maroney's facility, extending downgradient approximately 1,000 ft in a southwesterly direction. These results demonstrate that implementation of SVE beneath the former dry-cleaner facilities has effectively remediated vadose zone impacts in these areas and the plume has detached from these source areas; groundwater impacted from ongoing vadose zone sources has advected hydraulically downgradient with unimpacted groundwater now migrating into the footprint beneath the previous vadose zone impacts. This observation serves as an additional line of evidence that ERA implementation in the vadose zone of both facilities has been broadly effective for addressing ongoing impacts to groundwater, with downgradient concentrations trends recently observed to be either stable or declining.

Furthermore, due to the generally recalcitrant nature of PCE in the saturated zone, it is expected that the extent of the groundwater PCE plume will continue to migrate and expand unless remedial action to address groundwater impacts is implemented. Plume expansion may also be accelerated in future years if SRP and City of Phoenix (COP) further develop their groundwater extraction well network and pumping capacities in the region. Based on the relative proximity of SRP and COP groundwater wells to impacted groundwater within the site, it would be expected that increased groundwater extraction would likely necessitate the need for wellhead treatment at the source of extraction.

3.2.3 Areas of Uncertainty

The following data gaps were identified as part of the RI (Geosyntec, 2019):

- Petroleum hydrocarbon impacts that were identified during the completion of the ERA (SVE) at the site should be delineated back to their original source area. These impacts are not associated with the Former Viking and Former Maroney's dry-cleaning facilities. Residual petroleum-related VOCs, such as benzene, ethylbenzene, toluene and xylenes (BTEX), have been historically detected in groundwater on-site. However, BTEX compounds have not been detectedc during recent groundwater monitor events, and are therefore not expected during the implementation of the groundwater remedy outlined in the FS;
- The extent of the plume has been estimated based on available data and expected plume behavior. Additional monitoring wells should be installed to allow for remedy performance monitoring in the future.

3.3 Remedial Objectives

The ROs for the site were developed by ADEQ pursuant to AAC R18-16-406 of the Remedy Selection Rule. ROs are established for the current and reasonably foreseeable uses of land and waters of the state that have been or are threatened to be affected by a release of a hazardous substance. Pursuant to AAC R18-16-406 (D), it is specified that reasonably foreseeable uses of land are those likely to occur at the site and the reasonably foreseeable uses of water are those likely to occur within one hundred years, unless site-specific information suggests a longer time period is more appropriate.

Reasonably foreseeable uses are those likely to occur, based on information provided by water providers, well owners, land owners, government agencies, and others. The ROs are based on land and water use study questionnaires collected in October 2017. Public comments on the proposed ROs were solicited as part of finalizing the RI Report in 2019 (Geosyntec, 2019). The land and water use questionnaires are included in Appendix E of the 2019 RI Report.

The ROs are stated in the following terms: (1) protection against the loss or impairment of each use; (2) restoration, replacement, or otherwise providing for each use; (3) when action is needed, protection or providing for the use; and (4) how long action is needed to protect or provide for the use.

3.3.1 Remedial Objectives for Land Use

PCE concentrations at the site have exceeded SRLs at the source properties and PCE and TCE concentrations have exceeded site-specific risk-based levels for soil gas at the source properties and beneath residential properties. The greatest impacts to the soil have occurred within the source areas, where current and reasonably foreseeable use is commercial/non-residential. Based on this information, the RO for soil is:

> *Protect against the loss or impairment of land threatened by contaminants of concern at the 32nd Street and Indian School Road WQARF site and restore land that has been impaired by contaminants of concern at the 32nd Street and Indian School Road WQARF site to below applicable remediation levels. Action is needed for the present time and for as long as necessary to ensure that the level of contamination in the soil associated with the Site no longer exceeds applicable remediation levels.*

3.3.2 Remedial Objectives for Groundwater Use

PCE concentrations exceed the AWQS in groundwater at the site. Currently, groundwater within the site is used only for irrigation. However, reasonably foreseeable future groundwater use at this site includes both irrigation and potable supply. Therefore, the ROs for groundwater use at the site are as follows:

The RO for irrigation use at the site is:

> *Protect against the loss or impairment of irrigation water threatened by contaminants of concern at the 32nd Street and Indian School Road WQARF site.*

Where protection cannot be achieved in a reasonable, necessary or cost-effective manner; restore, replace, or otherwise provide for irrigation water that is lost or impaired by contaminants of concern at the 32nd Street and Indian School Road WQARF site. Action is needed for as long as necessary to ensure that, while the water exists and the resource remains available, the contamination associated with Site does not prohibit or limit the designated use of groundwater.

The RO for potable use at the site is:

Protect against the loss or impairment of potable water threatened by contaminants of concern at the 32nd Street and Indian School Road WQARF site. Where protection cannot be achieved in a reasonable, necessary or cost-effective manner; restore, replace, or otherwise provide for potable water that is lost or impaired by contaminants of concern at the 32nd Street and Indian School Road WQARF site. Action is needed for as long as necessary to ensure that, while the water exists and the resource remains available, the contamination associated with Site does not prohibit or limit the designated use of groundwater.

3.3.3 Remedial Objectives for Surface Water Use

Current surface water use in the area of the site is irrigation from man-made canals containing pumped groundwater. The projected future use of the canal water includes drinking water. However, ROs for surface water use are not necessary, as ROs for groundwater pumped into the canal address protection of this use.

4. IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

This section presents the evaluation and screening of various remedial strategies and measures related to the impacts in soil and groundwater and lists the technologies that have been retained for evaluation as part of the reference and alternative remedies. A detailed discussion of the remediation technologies evaluated for potential implementation at the site is provided.

4.1 Remedial Strategies

The Remedy Selection Rule, AAC R18-16-407 (Feasibility Study), prescribes six remedial strategies to be developed, incorporating one or more remediation technologies or methodologies. These strategies are:

1. Plume remediation, a strategy to achieve water quality standards for COCs in waters of the state throughout the site;
2. Physical containment, a strategy to contain impacts within definite boundaries;
3. Controlled migration, a strategy to control the direction or rate of migration but not necessarily to contain migration of the impacts;
4. Source control, a strategy to eliminate or mitigate a continuing source of impacts;
5. Monitoring, a strategy to observe and evaluate the impacts at the site through the collection of data; and
6. No action, a strategy that consists of no action at the site.

4.2 Remedial Measures and Technologies Screening Assumptions

This section defines and describes the general assumptions about the site that were used during the identification and screening of remedial technologies.

Remediation technologies that would meet site ROs and comply with requirements of AAC R18-16-407 and ARS §49-282.06 were identified and screened according to the following criteria:

- Contaminant treatment effectiveness;
- Constructability;
- Flexibility/expandability;
- Operations and maintenance (O&M) requirements;
- Operational hazards; and

- Cost-effectiveness.

The remediation technologies that passed screening were retained for use in development of the Reference Remedy and alternative remedies that are described in Section 5. The following were assumed during the identification and screening of remedial technologies:

4.2.1 Concentrations of COCs in Vadose Zone and Groundwater

Conservative COC concentrations were assumed as follows based on August 2018 maximums (Geosyntec, 2019):

- Maximum PCE concentration of 480 µg/L in groundwater;
- Maximum TCE concentration of 1.1 µg/L in groundwater; and
- Maximum cis-1,2-DCE concentration of 2.4 µg/L in groundwater.

PCE soil vapor concentrations in the vicinity of the Former Viking Cleaners site have been remediated to below applicable standards. PCE soil vapor concentrations in the vicinity of the Former Maroney's site in the unsaturated subsurface are of very low magnitude, with mass removal rates that are a fraction of a pound per day by SVE remediation.

4.2.2 Groundwater Natural Attenuation Conditions

Groundwater velocity at the site was assumed to be ranging between 0.01 and 25 ft/day to the southwest. Aquifer performance testing has not been conducted on site to date. No significant non-remedial pumping was expected to occur. Data collected during groundwater monitoring suggest aquifer conditions to be generally aerobic, with insignificant organic carbon availability for biotic attenuation of the COCs by native biota. In the absence of an engineered intervention, attenuation of the COCs is expected to be driven primarily by dilution, dispersion, and phase separation.

4.2.3 Flow Rates and Dosage Rates

Flow rates and dosage rates for active remedies depend on the remedial strategy. For injection-based technologies, the actual flow rates that can be achieved will depend on the lithology in the areas to be extracted from or injected into. Results from the RI and ERA activities were used to generate estimates of flow rates and radii of influence (ROI) for groundwater and SVE. During implementation of the ERA at the Former Maroney's facility, vacuum ROI from the highest vacuum step extraction was estimated to range from 50 to over 100 ft (H+A, 2014). Methodology and results of operations and testing of the SVE system are described in detail in the referenced report and the RI Report.

4.3 Screening of Remedial Measures

Technologies described below are commonly used for remediation of chlorinated hydrocarbons. The basic treatment mechanisms and the suitability and limitations of the technologies are also discussed. An initial screening is presented below for each technology for applicability to site conditions, plume extent, and VOC concentrations. Those technologies that are potentially applicable were then evaluated in detail using the technology screening criteria discussed above. The results of the initial technology screening are summarized in Table 1.

4.3.1 No Action

The No Action Alternative assumes that no remediation efforts would be implemented for the site, and that current conditions would continue in the Project Area. The vadose zone soil would not be remediated, resulting in a continued source of chlorinated solvents to groundwater, and the dilute groundwater plume could potentially propagate further downgradient. As a result, under the No Action Alternative, the ROs for the site would not be met and the alternative is not retained.

4.3.2 Institutional Controls

Institutional controls such as a land use restriction are commonly utilized for sites where residual soil impacts may exist and the future use of a property is likely to be commercial or industrial. Institutional controls can consist of items such as a deed restriction limiting the use of a property to non-residential development and/or the utilization of an engineering control. ARS §49-152 allows for the use of an institutional control consisting of a deed restriction through the implementation of a Declaration of Environmental Use Restriction (DEUR) for facilities that have residual impacts above the Residential SRLs but below the Non-Residential SRLs. If soil impacts were to remain in place above Non-Residential SRLs, an engineering control would also need to be implemented.

4.3.3 Groundwater Extraction and Treatment

Groundwater extraction and treatment systems (GETS), also commonly referred to as pump-and-treat (P&T), is a technology for groundwater that can be effective for hydraulic containment and/or migration control for sites impacted by VOCs and soluble metals such as hexavalent chromium. GETS typically utilize submersible pumps in extraction wells to extract groundwater and transfer it via conveyance piping into an aboveground treatment system. The post-treatment water is subsequently discharged to a municipal sewer, a canal or other surface water, or an infiltration basin; or re-injected into the subsurface with an injection well. These systems can control the subsurface flow of impacted groundwater, mitigating migration and/or reducing the footprint of the impacts.

Liquid-phase granular activated carbon (LGAC) is typically employed for VOC removal via adsorption onto the media surface, while ion exchange resin is commonly employed for the removal of soluble metals.

The primary limitation for GETS is typically long cleanup times when used as the primary remedial measure in heterogeneous formations where diffusion from fine-grained layers provides a secondary source. As a dissolved-phase plume treatment alternative, GETS is not typically cost effective for large, dilute plumes. However, GETS is a widely implemented and proven component for source control and mitigation of localized, high-concentration groundwater impacts. This measure is implementable with respect to both the design and operation of a treatment system and is amenable to the hydrostratigraphy of the site. However, because of the extensive size of the plume, and the expected length of remediation required for GETS at the site, GETS was not retained as a remedial measure for additional evaluation.

4.3.4 *In Situ* Chemical Oxidation

In situ chemical oxidation (ISCO) relies on injection of a chemical agent to oxidize VOCs. Several oxidants are available and have been proven effective for chlorinated VOCs, including potassium permanganate, sodium persulfate, hydrogen peroxide, and ozone. These oxidants are considered effective for oxidizing PCE and its biological degradation products, TCE, cis-1,2-DCE, and VC (Interstate Technology and Research Council [ITRC], 2005). The oxidant is generally delivered to the site in concentrated formulations or as solids, mixed in the field, and then injected through injection wells or temporary injection points. For the case of ozone, a mobile ozone generation and sparge system can be mobilized and injected as a gas through sparge wells.

These highly reactive amendments oxidize the COCs to produce innocuous byproducts. Catalysts may be included or required to promote reactions for some amendments, such as sodium persulfate or potassium permanganate. ISCO, as with other *in situ* methods, typically includes higher capital costs than *ex situ* methods such as GETS, but may provide significant savings through long-term O&M cost reductions and reduced time to closure. It is capable of rapidly reducing high concentration VOCs and well suited for targeted remediation of small source areas. However, these oxidants require robust safety considerations for safe handling and, if applied at too high of concentrations, can potentially result in unintended changes to aquifer geochemistry. For example, persulfate may result in an increase in groundwater sulfate (SO_{4-2}) concentrations, whereas permanganate may result in increasing manganese dioxide (MnO_2) concentrations in groundwater. Additionally, because of the presence of naturally occurring chromium in site sediments, ISCO remedies such as alkaline activated sodium persulfate and excessive amounts of potassium permanganate have the potential to react with the site mineralogy and have the potential to result in the conversion of stable and innocuous chromium-III (trivalent chromium) into chromium-VI (hexavalent chromium), a relatively mobile and acutely toxic substance. Unlike other oxidizing agents, the processes involving ozonation are unlikely to lead to any persistent changes in aquifer geochemistry.

Ozone sparge pilot testing was performed at the 7th and Missouri WQARF site, located approximately 5 miles northwest of the site, as part of an ozone injection pilot study. Similar to the site, the 7th and Missouri WQARF site is characterized by the same COCs (CVOCs released from a former dry-cleaner), mode of transport, lithology, and hydrogeologic properties. At the 7th and Missouri WQARF site, groundwater laboratory results and field observations indicate that VOC results suggest positive remedial effect associated with the ozone treatment in areas downgradient of the source area. In the vicinity of the source area, VOC reductions have been modest, likely due to continued source addition attributed to continued dissolution of PCE into the local area groundwater. Based on the results of this ozone pilot study indicating successful oxidation of VOCs, the large ROI, and the lack of insoluble trivalent chromium conversion to soluble hexavalent chromium, ozone sparge is considered also capable of achieving the applicable ROs for the site.

As stated above, ISCO will require relatively large capital costs associated with installation of additional injection wells, trenching, and ozone sparge system; however, ozone will be effective as a treatment at targeted areas with elevated VOC concentrations. Therefore, ISCO is retained as a potential remedial alternative.

4.3.5 *In Situ* Chemical Reduction

In situ chemical reduction (ISCR) can abiotically reduce VOC concentrations by chemically breaking the bonds within the VOC molecules using chemical reductants such as zero valent iron (ZVI). ZVI can also be combined with an electron donor to promote concurrent biotic and abiotic reduction of VOCs. Because groundwater at the site is typically aerobic or moderately chemically oxidizing, a large quantity of the injectate would be consumed in reactions associated with ambient groundwater general chemistry as opposed to reduction of target COCs. Given the thickness of the impacted groundwater zone, and the depth to groundwater, installation, and the expected large volume of injectate that would be necessary, ISCR would be both technically and economically infeasible. Based on these limitations, this technology was not retained for further consideration.

4.3.6 Enhanced Reductive Dechlorination

Enhanced reductive dechlorination (ERD) involves stimulation or augmentation of naturally occurring microbial populations to expedite the anaerobic biodegradation (reductive dechlorination) of chlorinated VOCs through injections of electron donor (e.g., sodium lactate or emulsified vegetable oil). In the presence of sufficient electron donor, natural microbial activity will produce the required anaerobic conditions conducive to reductive dechlorination. If a sufficient population of bacteria capable of completely degrading PCE and its daughter products is not naturally present, the natural bacterial population can be augmented with a commercially available and regulatorily approved consortium of bacteria capable of completely degrading PCE and its daughter products.

Successful implementation of ERD includes adequate spatial distribution of the electron donor to achieve strongly reducing conditions; a microbial community capable of complete reductive dechlorination; groundwater pH greater than 5.5 and less than 9.0; sufficient concentration of chlorinated VOCs to support the growth of the microbial culture (typically a minimum of 100 µg/L); absence of high concentrations of inhibitory constituents; and low concentrations of competing electron acceptors, such as sulfate and nitrate. If these conditions are not initially present in an aquifer, measures must be taken to alter conditions to become conducive to active reductive dechlorination. Although reduction can be ultimately stimulated in most aquifers, the greater the initial deviation from these ideal conditions, the more difficult and costlier ERD will be to implement.

The natural groundwater condition at the site is generally aerobic and would require significant amounts of electron donor to become sufficiently reducing. Given the size of the plume and the site geochemical conditions, significant amounts of bacterial culture would be required to establish the necessary bacterial population for successful ERD at the site.

Although ERD is potentially capable of achieving the applicable ROs for the site, there are challenges posed by the predominantly aerobic groundwater conditions, the low PCE concentrations in the downgradient dissolved plume, the depth to groundwater, and the size of the plume. The successful implementation of ERD would be prohibitively costly as a treatment alternative for the overall plume; however, ERD may be effective as a treatment for targeted areas in combination with other treatment methodologies. Therefore, ERD is retained as a potential contingent remedial alternative should conducive future conditions warrant.

4.3.7 Air Sparge

AS systems introduce compressed atmospheric air below the water table through injection wells, where the air expands and travels upward through the saturated zone to the unsaturated zone. VOCs partition from impacted groundwater into the introduced bubbles or air channels and are removed by advection to the vadose zone. Air sparging can enhance SVE remediation by increasing contaminant mass removal from the saturated zone. As a complimentary system to SVE, air sparging would provide groundwater treatment while the SVE system provides overlying soil vapor mitigation.

AS promotes aerobic biological activity and degradation of some VOCs that are known to degrade under aerobic conditions. PCE, the primary COC at the site, is not expected to be degradable under aerobic conditions. Furthermore, AS is impractical for the treatment of large dilute plumes. Based on these factors, air sparging has been eliminated from further consideration.

4.3.8 Monitored Natural Attenuation

Monitored natural attenuation (MNA) is a widely-applied remedial measure when natural processes are expected to reduce COC concentrations over time. Such natural processes include dilution, dispersion, sorption, volatilization, and chemical or biological stabilization or transformation. For chlorinated VOCs, such as PCE, TCE, and 1,1-dichloroethene (1,1-DCE), natural reductive dechlorination (via biological and/or abiotic degradation processes) is usually the most significant degradation process when conditions are favorable (i.e., anaerobic environment with available organic carbon). Application of MNA requires the identification of the most likely attenuation processes and an estimation of the time required for these processes to meet the remedial objectives. MNA also includes implementation of a plan to observe the progress of the remedy to monitor that natural attenuation proceeds and that unexpected migration of impacts does not occur.

For large and very dilute plumes, such as the site plume, MNA is often the only technically feasible solution. MNA is frequently included as a component in a larger remedial strategy, sometimes coupled with more active remediation at source areas. Thus, MNA is retained as a feasible remedial measure for additional evaluation.

5. DEVELOPMENT OF REFERENCE REMEDY AND ALTERNATIVE REMEDIES

This section presents the selected Reference Remedy, a More Aggressive Alternative Remedy, and a Less Aggressive Alternative Remedy for residual impact at the site. Evaluations of the alternatives include a discussion of the associated remedial measures and strategies pursuant to AAC R18-16-407 (E). The reference and alternative remedies for the impacts are summarized in Table 2.

The Reference Remedy and alternative remedies consist of combinations of remedial strategies and their associated remedial measures, selected to achieve the ROs for the site. The remedies also include contingent remedial strategies (contingencies) to address reasonable uncertainties regarding the achievement of ROs, or uncertain timeframes in which ROs will be achieved. Where remedial measures are necessary to achieve ROs, such remedial measures will remain in effect as long as required for continued achievement of those objectives.

5.1 Reference Remedy

The remedial strategies for the Reference Remedy are:

- Source control to eliminate or mitigate a continuing source of contamination;
- Plume remediation to achieve water quality standards for COCs in waters of the state throughout the site;
- Monitoring to observe and evaluate the contamination at the site through the collection of data; and
- Contingency remedial measures to address potential uncertainties.

5.1.1 Source Control and Plume Remediation

Under the Reference Remedy, source control will be achieved through a combination of SVE (implemented to mitigate VOC impacts to the vadose zone at the Former Maroney's facility) and ISCO (implemented to mitigate impacts to groundwater). The ISCO implementation will provide plume remediation for elevated concentration groundwater impacts; dilute groundwater impacts will be mitigated by natural attenuation.

5.1.1.1 Reference Remedy – SVE

Implementation of SVE for the Reference Remedy will comprise the following:

- Restart of the SVE system with existing extraction wells and infrastructure at the Former Maroney facility; and
- Continued operational monitoring to assess remedial progress and system performance.

Resumed operation of the SVE system will provide source control through the removal of VOC mass in the vadose zone at the source area within the Former Maroney's facility. This activity will mitigate the remaining residual VOCs in the vadose zone below the onsite structure, mitigating the potential for vapor intrusion. The remaining VOCs in the vadose zone are shallow in nature and they are likely not an ongoing source to groundwater. The SVE ERA performance and capacity will be evaluated, and upgrades will be recommended as part of the forthcoming Proposed Remedial Action Plan (PRAP) for the site, if warranted. The system will be operated with the existing SVE wells and it will continue until rebound VOC concentrations are below site-specific HPCs, which is anticipated to occur within one year. SVE system optimization will be conducted throughout the remediation period, which includes a contingency for expansion of the system (Section 5.1.3), and operational schedules may be adjusted to enhance VOC removal. After SVE system shutdown, VOCs will be monitored for rebound for a period of three months, after which confirmation soil vapor samples will be collected to assess achieving the ROs and support discontinued SVE operations.

5.1.1.2 Reference Remedy – ISCO

Implementation of ISCO for the Reference Remedy will comprise of the following:

- Stage 1 – Installation of ozone sparge injection wells and associated ozone sparge system equipment along E Fairmont Avenue (12 dual nested ozone sparge wells assumed for cost estimating purposes);
- Stage 2 – One year after implementation of Stage 1, installation of ozone sparge injection wells and associated ozone sparge system equipment along the northeast side of the Grand Canal, north of E Thomas Road (11 dual nested ozone sparge wells assumed for cost estimating purposes);
- Installation of performance monitoring groundwater wells (five dual nested monitoring wells assumed for cost estimating purposes);
- MNA of the dilute PCE plume downgradient of the Grand Canal; and
- Operation and monitoring to assess remedial progress and system performance.

The Reference Remedy will consist of a staged approach for remediation of the plume. Stage 1 assumes installation of ozone sparge injection wells along E Fairmont Avenue. Each injection well will be connected to conveyance piping running along E Fairmont Avenue, to an ozone sparge system installed near the intersection of E Fairmont Avenue and N 32nd Street.

A second ozone sparge system will be installed along the north side of the Grand Canal, and north of E Thomas Road. This work will be implemented as Stage 2 of remediation, which will consist of ozone sparge injection wells, and an ozone sparge system located near the intersection of the Grand Canal and E Thomas Road. Implementation of Stage 2 will take place after a period of at least one year of monitoring Stage 1 performance and its implementation will be designed based on Stage 1 results.

The indicated injection well configuration would intercept the anticipated path of the plume along the ambient gradient towards the south-southwest. This remedy would treat groundwater where elevated VOC concentrations are encountered at the northern portion of the plume, cut off the dilute plume, and inhibit migration of PCE further downgradient, ultimately mitigating the elevated-concentration impacts, with MNA mitigating the dilute impacts further downgradient south of Grand Canal. For cost estimating purposes, it was assumed that ozone sparge operations will continue for a period of three years at each stage, with three additional years of post-ozone injection MNA (six years of monitoring total were assumed for this FS).

System performance monitor wells will be used to monitor the northwestern and southeastern edges of the plume, and the downgradient toe of the plume.

5.1.1.3 Reference Remedy – MNA

Due to the large area covered by the dilute plume, the application of MNA is appropriate for the peripheral portions of the plume where the COCs may be reasonably anticipated to be attenuated by natural processes (e.g., dilution and dispersion) downgradient of or away from the ozone sparge system. As a result, the ozone sparge system does not need to be designed to capture the entire footprint of the plume as it presently exists. Due to the aerobic conditions in the groundwater, abiotic MNA processes such as dilution, dispersion, volatilization, and sorption are likely to be the dominant mechanisms for concentration reductions in the VOC plume over time.

5.1.2 Monitoring

Implementation of monitoring for the Reference Remedy will comprise of the following:

- Quarterly soil vapor sampling from onsite soil vapor probes and SVE wells;
- Installation of system performance groundwater monitoring wells cross-gradient and downgradient of the plume;
- Continued semiannual sampling of the groundwater monitor well network to evaluate plume stability, VOC concentrations, and natural attenuation parameters; and
- Continued semiannual groundwater elevation measurements to evaluate flow direction and hydraulic gradient.

Semiannual groundwater monitoring will be continued for up to six years for the current monitoring well network (three years during active remediation and three additional years of monitoring post remediation). Up to 27 wells were assumed for cost estimating purposes. If the PCE plume appears to be stable, the groundwater monitoring frequency may be reduced to annual and the number of monitor wells may be decreased.

As part of the Reference Remedy, six additional ozone system performance monitor wells are assumed to be required to monitor the upper and middle portion of the UAU.

Based on the most recent site-wide groundwater data collected in April 2019 (Geosyntec, 2019), the groundwater monitor well network for the Reference Remedy would include (Figure 3):

- Upgradient: MMW-03D, UMW-04R, and one additional proposed well;
- Source areas: MMW-04D, MMW-06-124, MMW-06-160, UMW-01R;
- Downgradient: UMW-06R, VCMW-04A, VCMW-04B, VCMW-05A, VCMW-05B, VCMW-06A, VCMW-07A, VCMW-07B, VCMW-08AR, VCMW-12, VCMW-20, VCMW-26, and two additional proposed system performance monitor wells (between VCMW-12 and VCMW-20, and VCMW-26 and former boring 24MW-12); and
- Cross-gradient: VCMW-17, VCMW-21, VCMW-22, and three additional proposed system performance monitor wells (two along the northwest side of the plume, and one along the southwest).

These wells, along with the newly proposed wells, will define the downgradient and cross-gradient PCE impacts exceeding the AWQS of 5 µg/L.

5.1.3 Contingencies

As mentioned in Section 5.1.1.1, the capacity required for the proposed SVE system will be evaluated as part of the PRAP. However, the following contingency remedial measures have been identified to address potential uncertainty in the achievement of the ROs.

5.1.3.1 Source Area Remediation Contingencies

- If, during SVE monitoring or post-SVE soil vapor probe confirmation sampling, portions of the source area at the Former Maroney's facility do not appear to be fully affected by the extraction process, six additional months of SVE system O&M may be performed; and
- During ozone sparging, an SVE system consisting of a 500 cubic feet per minute blower and vapor-phase granular activated carbon (VGAC) vessels may be considered to reduce the potential for the accumulation of ozone in the subsurface beneath residences and businesses along the FASA area. This contingency assumes that the SVE system will include the blower, conveyance piping, and up to eight proposed SVE wells.

5.1.3.2 Dissolved Plume Remediation Contingencies

- If COC response to ozone sparging is slow, hydrogen peroxide will be injected simultaneously with the ozone as a mist added to all the ozone sparging wells;
- If the PCE concentrations continue to be greater than the AWQS after six years of monitoring, then additional groundwater monitoring will be performed (a contingency of one additional year is assumed for this FS);
- If persistent elevated PCE concentrations are measured farther downgradient from the FASA area, then the FASA area ozone sparge system will be moved to a downgradient area between the FASA and Grand Canal. This ozone sparge system will be connected to additional nested injection wells (10 dual nested wells assumed for cost estimating purposes), and it will be operated for an assumed period of one year. The approximate location of this contingency is shown in Figure 3;
- If PCE concentrations continue to be greater than the AWQS in the areas surrounding either SRP, COP, or other production wells that have the potential to be impinged by COC impacts above AWQS, targeted ozone sparge injection wells and a mobile ozone sparge system may be installed in the vicinity of the extraction wells to restore the surrounding groundwater quality; and
- If SRP, COP, or others resume pumping from extraction wells that are impacted with PCE concentrations above the AWQS, or have any future capacity to be

impacted through use, then wellhead treatment using LGAC or modification of the production well (e.g., sleeving) may be performed to allow groundwater usage. Wellhead treatment with LGAC would be installed at a production well if monitoring results indicate PCE concentrations are greater than the AWQS and SRP requires drinking water quality out of the production well. For the Reference Remedy, additional coordination with SRP would be required for the design and access location of the wellhead treatment system or modification of the production well.

5.1.4 Permits and Agreements

Multiple permits and/or agreements would be necessary to authorize installation and operation of the Reference Remedy, including:

- Pre-construction notifications (i.e., ADWR Notice of Intent to Drill) and post-construction reporting (Driller's Reports) would be prepared for new groundwater injection/monitor wells that are installed;
- Well construction and/or modification work must be conducted by an ADWR-licensed driller. New wells must comply with ADWR standards found in ARS §45-594, 45-595, 45 596, and 45-600 of the Groundwater Code;
- General construction permits and right-of-way construction permits would be required from the COP for the installation of a new injection system and associated conveyance piping. This would require preparation and submittal of design plans and specifications (i.e., civil, plumbing, mechanical, electrical) to COP; and
- Access agreements with private land owners and SRP would be required if the injection system components and/or associated conveyance piping needs to be located on private property.

5.2 More Aggressive Alternative Remedy

The following subsections present the More Aggressive Alternative Remedy that has been developed for the site. The remedial strategies for the More Aggressive Alternative Remedy are:

- Source control to mitigate a continuing source of contamination in the vadose zone (Former Maroney's site);
- Plume remediation to achieve water quality standards for COCs in waters of the state throughout the site;

- Controlled migration to control the direction or rate of migration, but not necessarily to stop migration of contaminants;
- Monitoring to observe and evaluate the contamination at the site through the collection of data; and
- Contingency remedial measures to address potential uncertainties.

The More Aggressive Alternative Remedy includes the measures listed in the Reference Remedy, plus additional remedial strategies and contingencies.

5.2.1 Source Control, Plume Remediation, and Controlled Migration

5.2.1.1 More Aggressive Alternative Remedy – SVE

The remediation approach for the More Aggressive Alternative Remedy for the vadose zone is taken directly from the Reference Remedy; however, the installation of two SVE wells would be implemented in the More Aggressive Alternative Remedy.

5.2.1.2 More Aggressive Alternative Remedy – ISCO

The dissolved plume remedial measures for the More Aggressive Alternative Remedy was taken from the Reference Remedy; however, for the More Aggressive Remedy, Stage 1, Stage 2, and MNA will be conducted simultaneously.

5.2.2 Monitoring

Monitoring measures for the More Aggressive Alternative Remedy are taken from the Reference Remedy and are not changed.

5.2.3 Contingencies

Contingency measures for the More Aggressive Alternative Remedy are taken from the Reference Remedy and are not changed.

5.2.4 Permits and Agreements

The same permits requirements as those specified in Section 5.1.4 would be required for the More Aggressive Alternative Remedy.

5.3 Less Aggressive Alternative Remedy

The following subsections present the Less Aggressive Alternative Remedy that has been developed for the plume. The remedial strategies for the Less Aggressive Alternative Remedy are:

- Source control to mitigate a continuing source of contamination;
- Plume remediation to achieve water quality standards for COCs in waters of the state throughout the site;
- Monitoring to observe and evaluate the contamination at the site through the collection of data; and
- Contingency remedial measures to address potential uncertainties.

The Less Aggressive Alternative Remedy includes a subset of the measures listed in the Reference Remedy.

5.3.1 Source Control and Plume Remediation

The vadose zone and dissolved plume remedial measures for the Less Aggressive Alternative Remedy are limited to MNA. This remedy will include the installation of five performance monitoring wells.

5.3.2 Monitoring

Monitoring measures for the Less Aggressive Alternative Remedy are taken from the Reference Remedy and are not changed. For cost evaluation purposes, it was assumed that monitoring would be semiannual for 30 years. However, as part of this remedy, a groundwater flow and transport model and a natural attenuation model would be completed to estimate the extent of PCE impacts over time. The groundwater model will be updated every five years to reevaluate the timeline for PCE natural attenuation to concentrations below AWQS.

5.3.3 Contingencies

Contingencies for the Less Aggressive Alternative Remedy are limited to the following:

5.3.3.1 Source Area Remediation Contingencies

- If during MNA soil vapor probe confirmation sampling of the source area at the Former Maroney's facility indicates that there may be a significant occupancy concern related to indoor air, the SVE will be restarted with existing infrastructure (a period of one year assumed for cost estimating purposes).

5.3.3.2 Dissolved Plume Remediation Contingencies

- If PCE concentrations continue to be greater than the AWQS in the areas surrounding either SRP, COP, or other production wells that have the potential to be impinged by COC impacts above AWQS, targeted ozone sparge injection wells and a mobile ozone sparge system may be installed in the vicinity of the extraction wells to restore the surrounding groundwater quality; and

- If SRP, COP, or others resume pumping from extraction wells that are impacted with PCE concentrations above the AWQS, or have any future capacity to be impacted through use, then wellhead treatment using LGAC or modification of the production well (e.g., sleeving) may be performed to allow groundwater usage. Wellhead treatment with LGAC would be installed at a production well if monitoring results indicate PCE concentrations are greater than the AWQS and SRP requires drinking water quality out of the production well. For the Reference Remedy, additional coordination with SRP would be required for the design and access location of the wellhead treatment system or modification of the production well.

5.3.4 Permits and Agreements

Permits and agreements for the Less Aggressive Alternative Remedy are taken from the Reference Remedy and are not changed, as they relate to installation of an additional monitoring well.

6. COMPARISON OF REMEDIES

The following section compares the reference and alternative remedies to criteria described in AAC R18-16-407H.3.

6.1 Comparison Criteria

In accordance with AAC R18-16-407E.3, the FS has been completed to (1) identify a Reference Remedy and alternative remedies that are potentially capable of achieving ROs; and to (2) evaluate the remedies based on the comparison criteria to select a remedy that complies with ARS §49-282.06. AAC R18-16-407H specifies that practicability, risks, costs, and benefits are the primary remedy evaluation criteria.

Practicability includes the assessment of feasibility, short- and long-term effectiveness, and the reliability of the remedial alternative. The risk criteria include assessment of the overall protectiveness of public health and the environment in terms of fate and transport of the COCs, current and future land and water uses, exposure pathways and durations of potential exposure, changes in risk during remediation, and residual risk at the end of remediation. The cost analysis includes capital, operating, maintenance, and life cycle costs. Evaluation of benefits includes the assessment of lowered risk, reduced COC concentration or volume, decrease in liability, and preservation of existing and future uses.

Table 2 presents a detailed evaluation of the remedies for VOCs impacts in the vadose zone and groundwater with respect to the comparison criteria. The following subsections detail how the remedies perform against these criteria.

For cost analyses, the estimates are conceptual and assumed to have similar margins of error between +50% and –30% (i.e., the actual costs are expected to be between 30% less than and 50% more than the estimated costs).

6.1.1 Reference Remedy

6.1.1.1 Practicability

The groundwater Reference Remedies involve technologies that are known and reliable remediation technologies (SVE and ozone sparge). For the remaining vadose zone VOC impacts at the Former Maroney’s facility, the SVE system infrastructure will be reevaluated and used for additional remediation near the source area; as such, it is considered highly practicable. SVE is a known effective and reliable remedy for VOC impacts in the vadose zone, and it resulted in remediation of the vadose zone at the Former Viking Cleaners facility.

For the groundwater Reference Remedy, ozone injection is a well-established technology that can be highly effective in the short-term. Ozone sparge systems are comprised of generally compact equipment, requiring minimal storage requirements. Although initial capital improvements may be high in order to install injection wells and the associated piping, the effectiveness of ozone at remediating groundwater VOC plumes results in a significant decrease in costs and risk associated with MNA over a long period of time.

6.1.1.2 Protectiveness (Risk)

The groundwater Reference Remedy is protective in that it provides active remediation of PCE impacts at the northeast extent of the plume where concentrations are highest, which will ultimately enhance natural attenuation further downgradient. Additionally, the Reference Remedy provides continued monitoring of the dissolved-phase contaminant plume and nearby SRP production wells with the contingency of wellhead treatment.

6.1.1.3 Cost

The cost of the Reference Remedy is presented in Table 3, and detailed costs are presented in Appendix A. The Reference Remedy costs include operation, maintenance, and monitoring of the ozone sparge system at the FASA area, and a downgradient segment along Grand Canal. The costs were developed based on the assumptions detailed in Section 5.1.

From Table 3, there are no estimated capital costs associated with the SVE remedy. A total of $3.9 million (M) would be required for ozone sparge system installation ($2.4M for Stage 1 and $1.5M for Stage 2). Total estimated O&M costs (excluding contingencies) are approximately $1M (accounting for a net present value [NPV] discounted at 5%), based on the estimation that SVE O&M would be conducted for one year and groundwater monitoring activities would be conducted for six years after the capital improvements are installed (three years during ozone sparging and up to three years post-injection). Total estimated contingency costs are approximately $4.8M based on the assumptions included in Appendix A. Contingencies assumed for cost estimating are summarized in Section 5.1.3. The total cost for the Reference Remedy, including contingency, is approximately $9.6M, with a margin of error between $6.8M (-30%) and $14.5M (+50%).

6.1.1.4 Benefit

The groundwater Reference Remedy is considered beneficial by providing immediate decrease of PCE concentrations at the FASA area and the dilute downgradient plume, and continued monitoring of the PCE plume as a means of evaluating the effectiveness of remediation.

6.1.2 More Aggressive Alternative Remedy

The practicability, risk, cost, and benefits for implementation of the More Aggressive Alternative Remedy are discussed in the following subsections.

6.1.2.1 Practicability

The More Aggressive Alternative Remedy for the vadose zone includes two additional SVE wells. It is considered a practical approach, since the infrastructure for SVE is already in place at the Former Maroney's facility, and the addition of one more well is not a significant scope increase to that proposed in the Reference Remedy.

The More Aggressive Alternative Remedy for the dilute plume takes the Reference Remedy staged approach for ozone sparge and proposes to implement the stages simultaneously. As in the Reference Remedy, the ozone injection is a well-established technology for remediation of VOCs impacted groundwater. The simultaneous implementation of Stage 1 and Stage 2 will aggressively remediate impacted groundwater. The scope of work will result in some impact to the community during drilling activities, resulting from parking lane closures and traffic control, but the impacts are temporary; therefore, the approach is deemed practical.

6.1.2.2 Protectiveness (Risk)

The More Aggressive Alternative Remedy for the plume is comparably protective of human health and the environment with the Reference Remedy.

6.1.2.3 Cost

Costs for the More Aggressive Alternative Remedy are presented in Table 3; detailed costs are presented in Appendix A. Capital costs for the vadose zone remedy are slightly higher, but the dilute plume remedy costs are similar to those of the Reference Remedy because the general scope of work is the same; however, the More Aggressive Alternative Remedy would result in more capital costs earlier in the remediation process since both stages of remediation are implemented simultaneously. Capital costs are estimated to be approximately \$3.9M, and O&M costs are estimated to be approximately \$5.0M. The total cost for the More Aggressive Alternative Remedy including contingency is approximately \$9.9M, with a margin of error between \$6.9M (-30%) and \$14.8M (+50%).

6.1.2.4 Benefit

The More Aggressive Alternative Remedy for the plume expands treatment of the plume and is less reliant upon MNA compared to the Reference Remedy. Additionally, it is expected to decrease the timing required for remediation of the highest VOC concentrations in groundwater; however, for cost estimating purposes, a conservative remediation period of three years has been retained, as in the Reference Remedy.

6.1.3 Less Aggressive Alternative Remedy

The practicability, risk, cost, and benefit of the Less Aggressive Alternative Remedy for the plume are discussed in the following subsections.

6.1.3.1 Practicability

The Less Aggressive Alternative Remedy for the plume consists of MNA, a well-established remedial measure that has been demonstrated to have long-term effectiveness. MNA does not provide short-term effectiveness, but does enable the implementation of contingencies that would have short-term effectiveness. No significant technological or hydrogeological barriers to application are anticipated. This remedy is considered to be feasible.

6.1.3.2 Protectiveness (Risk)

No aquatic or terrestrial biota are at risk from the impacts at the plume. The Less Aggressive Alternative Remedy for the site is protective of human health because it mitigates the potential for exposure via the groundwater consumption pathway by monitoring potential plume migration towards potential production wells where an exposure pathway could be completed, including the contingency of applying wellhead treatment for production wells if installed, thereby mitigating exposure.

6.1.3.3 Cost

Costs for the Less Aggressive Alternative Remedy are presented in Table 3; detailed costs are presented in Appendix A. There are no capital costs for the vadose zone, and the capital costs for the groundwater remedy are limited to installation of performance monitor wells. Capital costs are estimated to be approximately $0.7M, and O&M costs are estimated to be approximately $2.6M. The total cost for the Less Aggressive Alternative Remedy including contingency is approximately $6.1M, with a margin of error between $4.3M (-30%) and $9.2M (+50%).

6.1.3.4 Benefits

The Less Aggressive Alternative Remedy for the plume provides less benefit than the Reference or More Aggressive Alternative Remedies for the site because it can be anticipated to leave the impacted groundwater unavailable for beneficial use for the longest period of time.

6.2 Comparison of Remedies

Comparison of the remedies is required under the AAC R18 16-407(H). Table 4 presents a ranking of the comparison criteria for each of the remedies. Each remedy was ranked from zero to five, with five indicating the most relative benefit and zero indicating the least relative or no benefit. The following sections describe the practicability, risk, cost, and benefits comparison for remedies.

6.2.1 Practicability

The groundwater Reference Remedy consists of a phased approach for ozone sparging of the FASA and the Grand Canal area. The More Aggressive Alternative Remedy consists of the two proposed steps in Reference Remedy, completed simultaneously. Both remedies scored high in practicability (13 and 14, respectively); however, the More Aggressive Alternative Remedy is considered more effective in the short/long term since the simultaneous remediation of both the FASA and Grand Canal area would result in a quicker remediation period for the plume. Both remedies are considered feasible and reliable. The Less Aggressive Alternative Remedy scored lowest in practicability (total score of 10). It is moderately reliable, as a future expansion to the monitor well network may be needed should an exceedance of the AWQS be measured further downgradient from wells with current concentrations below AWQS. Additionally, the Less Aggressive Alternative Remedy scored low in short to long-term effectiveness and reliability, since MNA of the plume with no active remediation would result in a significantly extended monitoring period.

6.2.2 Protectiveness (Risk)

The groundwater More Aggressive Alternative Remedy is slightly more protective than the Reference Remedy due to the simultaneous implementation of Stages 1 and 2, though each of the groundwater remedies includes the contingency for one additional year of ozone sparge, well-head treatment and ozone sparge at SRP or COP production wells, and additional ozone sparging at a location south of Grand Canal. The groundwater Less Aggressive Alternative Remedy ranked lowest for protectiveness since it involves no active groundwater remediation.

6.2.3 Cost

The three remedies have varying capital and O&M costs. Including the capital, O&M, and contingency costs, it is estimated that Less Aggressive Alternative Remedy would cost the least ($6.1M), the Reference Remedy cost would be moderate ($9.6M), and the More Aggressive Alternative Remedy would cost the most ($9.9M). Although the Reference Remedy and More Aggressive Alternative Remedy cost nearly the same, the

More Aggressive Alternative Remedy would require a significantly higher initial capital cost to implement both Stage 1 and 2 simultaneously.

6.2.4 Benefits

The groundwater Reference Remedy and More Aggressive Alternative Remedy had similar benefits since they both include active groundwater remediation systems; however, the More Aggressive Alternative Remedy scored higher, since it has the same level of practicability for implementation of the remedy, would require similar O&M requirements, and would likely expedite remediation period. The Less Aggressive Alternative Remedy, implementing MNA with the existing monitor well network, scored lowest since it would result in the potential spread of the plume further downgradient as PCE mass in groundwater further degrades the aquifer, and because the period of MNA monitoring is expected to be at least 30 years.

7. PROPOSED REMEDY

The following presents the proposed remedy for groundwater, as well as the basis for selecting the proposed remedy. Detailed cost information for the remedial alternatives is included in Appendix A.

7.1 Process and Reason for Selection

The Reference Remedy is recommended as the proposed remedy at the site. This recommendation is based on what is considered to be the best combination of remedial effectiveness, practicability, cost, and benefit for restoration and use of groundwater resources. The Reference Remedy scored the highest when ranking in accordance with the comparison criteria specified in AAC R18 16-407H.3.e (Section 6).

7.2 Achievement of Remedial Objectives

The Reference Remedy for VOCs in the vadose zone and groundwater also achieves the ROs for the site (Section 3.3.) The groundwater Reference Remedy will provide active remediation of VOCs in groundwater by ozone sparging, which will result in a decreased number of years required for MNA of the PCE plume concentrations.

7.3 Achievement of Remedial Action Criteria Pursuant to ARS §49-282.06

To meet the remedial action criteria listed in ARS §49-282.06, it is recommended that the Reference Remedy for PCE in groundwater be selected as the Final Remedy for the site. The Reference Remedy will:

- Provide for adequate protection of public health and welfare and the environment;
- Provide a thorough and timely means for continued remediation and monitoring of the existing groundwater impacts, including evaluation of the progress of remediation over time;
- To the extent practicable, provide for the control, management, and cleanup of the COCs in the groundwater;
- Provide for the beneficial use of the groundwater resource by SRP; and
- Be reasonable, cost-effective, and technically feasible.

7.4 Consistency with Water Management and Land Use Plans

The Reference Remedy for groundwater is consistent with water management plans and general land use plans.

7.5 Contingencies

For the groundwater Reference Remedy, an ozone sparge system will be installed within the FASA, and ozone sparge wells and ozone sparge system will be installed along Fairmont Avenue. A contingency of one additional year of ozone sparge system operation has been included for the Reference Remedy. Additionally, the Reference Remedy contingency includes injection of hydrogen peroxide at the FASA area simultaneous to ozone-sparging and installation of additional ozone sparge wells between Stage 1 and 2. If SRP determines that the inactive water production wells at the site are to be reactivated, or that future wells are capable of becoming impacted by PCE, then wellhead treatment using LGAC or modification of the production well may be performed to allow for groundwater usage.

The hypothetical need for and cost of wellhead treatment or well modification of a production well would be well-specific and may vary significantly depending on the well location and the timing of when well treatment or modifications may be needed. Although a cost estimate for wellhead treatment is provided in Appendix A, the actual cost for wellhead treatment would be further evaluated on a well specific basis, if the need arises. If PCE concentrations continue to be greater than the AWQS in the areas surrounding SRP wells, additional ozone sparge injection wells and a mobile ozone sparge system can be installed in the vicinity of these extraction wells, in addition to wellhead treatment, to restore the surrounding groundwater quality prior to extraction. Additional contingencies considered for the Reference Remedy include operation of an SVE system to mitigate potential ozone intrusion into structures.

Contingencies for the Reference Remedy will be presented in further detail in the forthcoming PRAP and subsequent remedial design documents.

8. COMMUNITY INVOLVEMENT

ADEQ will issue a Notice to the Public announcing the availability of FS on ADEQ's website at www.azdeq.gov. The notice may be mailed to the Public Mailing List for the site, water providers, the Community Advisory Board (CAB), and any other interested parties. ADEQ may also present a summary of this FS and the remedial alternatives in a CAB meeting.

Interested parties can also review the FS and other site documents at the ADEQ Main Office located at 1110 West Washington Street, Phoenix, Arizona. With 24-hour notice, an appointment can be made to review related documentation.

9. REFERENCES

Arizona Department of Environmental Quality (ADEQ), 2018. Feasibility Study Work Plan, ECP 32nd Street and Indian School Road WQARF Site, Phoenix, Arizona. November.

ADEQ, 2019. Remedial Objectives Report, ECP Phoenix 32nd Street and Indian School Road WQARF Site, Phoenix, Arizona. 14 June.

Arizona Department of Health Services (ADHS), 2016, Health Consultation: Vapor Intrusion of Tetrachloroethylene (PCE) and Trichloroethylene (TCE) in Residential and Commercial Buildings, Site Location: East Central Phoenix (ECP) – 32nd Street and Indian School Road for ADEQ, Phoenix, Arizona. Prepared by Office of Environmental Health, Environmental Health Consultation Services. 19 December.

Corkhill, E.F., S. Corell, B.M. Hill, and D.A. Carr, 1993. A Regional Groundwater Flow Model of the Salt River Valley—Phase I. Phoenix AMA Hydrogeologic Framework and Basic Data Report, April. http://azgs.arizona.edu/azgeobib/regional-groundwater-flow-model-salt-river-valley-phase-i-phoenix-active-management-area

Freihoefer, A., D. Mason, P. Jahnke, L. Dubas, and K. Hutchinson, 2009. Regional Groundwater Flow Model of the Salt River Valley, Phoenix Active Management Area, Model Update and Calibration. April.

Geosyntec Consultants, Inc., 2019. Remedial Investigation Report, ECP 32nd Street and Indian School Road WQARF Site, Phoenix, Arizona. June.

H+A, 2014. Technical Memorandum, Rev 1: Soil Vapor Extraction Evaluation, East Central Phoenix WQARF Site, 32nd St & Indian School Rd, Maroney's Cleaners, 3192 East Indian School Road. 28 January.

Interstate Technology and Research Council (ITRC), 2005. Technical and Regulatory Guidance for *In Situ* Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition. Interstate Technology and Regulatory Cooperation Work Group, *In Situ* Chemical Oxidation Work Team. January.

TABLES

Table 1
Remediation Technology Screening Summary
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Technology	Retained?	Reason for Retention or Elimination
No Action	No	The vadose zone soil would not be remediated, resulting in potential risk to site occupants and the dilute groundwater plume could potentially propagate further downgradient. As a result, the ROs for the Site would not be met and the alternative is not retained.
Institutional Controls	No	Although institutional controls have been cost-effective means of managing impacts in place, and current vadose zone concentrations of VOCs do not appear to pose a continued source area release to groundwater, remaining vadose zone VOCs at the Former Maroney's facility could still pose potential vapor intrusion risks.
Groundwater Extraction & Treatment System (GETS)	Yes	Effectiveness for disperse dilute plume reduced but retained as effective for control of VOCs in groundwater and as potential wellhead treatment for contingency.
In Situ Chemical Oxidation (ISCO)	Yes	Cost prohibitive for overall plume due to relatively small radii of influence, low VOC concentrations, and size and depth of plume; retained for targeted treatment areas, including the VOCs source and areas immediately downgradient of the source, along the Grand Canal, using ozone sparge. Also includes the option of using a targeted liquid oxidant injection, such as hydrogen peroxide for the More Aggressive Remedy.
In Situ Chemical Reduction (ISCR)	No	Technically and economically infeasible due to thickness of impacted groundwater zone and the size and depth of the plume.

Table 1
Remediation Technology Screening Summary
32th Street and Indian School Road WQARF Site
Phoenix, Arizona

Enhanced Reductive Dechlorination (ERD)	Yes	Cost prohibitive for overall plume due to predominantly aerobic groundwater conditions, low VOC concentrations, and the size and depth of the plume; retained for potentially targeted treatment areas.
Air Sparging	No	Not likely to be cost-effective or improve treatment due to low groundwater concentrations immediately downgradient of the plume, the large extent of the dilute plume, and residual VOC mass in fine-grained intervals.
Monitored Natural Attenuation (MNA)	Yes	Retained remedial technology (primarily for abiotic processes).

Table 2
Remedy Evaluation
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Remedial Alternative	Vadose Zone / Groundwater	Will Alternative Meet Remedial Objectives?	Practicability			Protectiveness (Risk)	Costs	Benefits	Regulatory/Public Acceptance
			Feasibility	Short/Long Term Effectiveness	Reliability				
Reference Remedy	**Vadose Zone VOCs SVE System**	Yes, the continued SVE system will likely achieve residential SRLs and GPLs by increasing the duration of the source area treament, which will reduce VOC concentrations in the vadose zone and decrease risks to site occupants.	Very feasible, SVE infrastructure already constructed at the site. The remedy would only require a temporary SVE unit.	SVE is a known effective remedy for VOC contamination in the vadose zone; SVE has been successful in removing VOCs mass at the site. Effectiveness will be assessed as part of the system monitoring.	SVE is a known and reliable remediation technology.	The reference remedy is protective, as it removes VOCs from vadose zone and reduces possibility of residual VOCs acting as long-term source of vapor intrusion exposure pathways. The remedy is consistent with current and future land use.	There would be no capital costs for this remedy, and O&M costs would be similar to current SVE system operating costs.	The reference remedy would provide continued reduction of VOC concentrations and mass in the vadose zone, which would result in lower risk to site occupants.	Highly Likely
	ISCO Using Ozone, Semiannual MNA Monitoring Groundwater Well Network	Yes, the remedy will likely achieve AWQS by treating the source area, and cutting off the source area from the dilute plume, greatly decreasing natural attenuation time of PCE.	Ozone injection is an established groundwater remediation measure, successful VOC cleanup in groundwater is well documented. MNA is very feasible as groundwater monitoring is currently conducted at the site.	Ozone injection and MNA are known and effective remedies; Ozone will quickly reduce VOC concentrations, and ultimately reduce the number of years for monitoring; continued semiannual groundwater monitoring of existing monitoring well network will assess effectiveness.	Ozone injection and MNA are known and reliable remediation technology.	The reference remedy is protective, in that it will reduce VOC concentrations at the source and immediately downgradient, and it continues to monitor and evaluate Site contamination through the collection of data.	Although ozone injection would result in initially high capital costs associated with installation of injection wells, associated piping, and purchase of ozone generators, its effectiveness will result in a significant decrease in the number of years required for MNA; monitoring costs would be similar to current semiannual groundwater monitoring costs.	Ozone injection would result in achieving the groundwater RO within a relatively short period of time, and it would mitigate further dilution of VOC in groundwater, while the groundwater extraction system mitigates further downgradient PCE migration; MNA monitoring would provide data to evaluate VOC concentrations throughout the VOC plume and monitor for the potential need of implementing a contingecy to drinking water wells.	Likely
More Aggressive Remedy	**Vadose Zone VOCs SVE System**	Yes, the continued SVE system will likely achieve residential SRLs and GPLs by increasing the duration of the source area treament, which will reduce VOC concentrations in the vadose zone and decrease risks to site occupants.	Very feasible, SVE infrastructure already constructed at the site. The remedy would only require a temporary SVE unit and two additional SVE wells.	SVE is a known effective remedy for VOC contamination in the vadose zone; SVE has been successful in removing VOCs mass at the site. Effectiveness will be assessed as part of the system monitoring.	SVE is a known and reliable remediation technology.	This remedy is protective, as it removes VOCs from vadose zone and reduces possibility of residual VOCs acting as long-term source of vapor intrusion exposure pathways. The remedy is consistent with current and future land use.	Capital costs would include installation of additional SVE extraction wells, and upgrade in SVE capacity.	This remedy would provide continued reduction of VOC concentrations and mass in the vadose zone, which would result in lower risk to site occupants.	Highly Likely
	ISCO Using Ozone, Semiannual MNA Monitoring Groundwater Well Network	Yes, the remedy will likely achieve AWQS by treating the source area, and cutting off the source area from the dilute plume, greatly decreasing natural attenuation time of PCE.	Ozone injection is an established groundwater remediation measure, successful VOC cleanup in groundwater is well documented. MNA is very feasible as groundwater monitoring is currently conducted at the site.	Ozone injection and MNA are known and effective remedies; The simultaneous implementation of Stage 1 and 2 ozone sparge will reduce VOC concentrations more rapidly than the Reference Remedy, and ultimately reduce the number of years for monitoring; continued semiannual groundwater monitoring of existing monitoring well network will assess effectiveness.	Ozone injection and MNA are known and reliable remediation technology.	The More Aggressive Remedy is protective, in that it will simultaneously reduce VOC concentrations at the source and downgradient, and it continues to monitor and evaluate Site contamination through the collection of data.	This remedy would result in much higher upfront capital costs when compared to the Reference Remedy, due to the simultaneous implementation of Stages 1 an 2, Although ozone injection would result in initially high capital costs associated with installation of injection wells, associated piping, and purchase of ozone generators, its effectiveness will result in a significant decrease in the number of years required for MNA; monitoring costs would be similar to current semiannual groundwater monitoring costs.	Ozone injection would result in achieving the groundwater RO within a relatively short period of time, and it would mitigate further dilution of VOC in groundwater, while the groundwater extraction system mitigates further downgradient PCE migration; MNA monitoring would provide data to evaluate VOC concentrations throughout the VOC plume and monitor for the potential need of implementing a contingecy to drinking water wells.	Likely

Table 2
Remedy Evaluation
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Remedial Alternative	Vadose Zone / Groundwater	Will Alternative Meet Remedial Objectives?	Practicability			Protectiveness (Risk)	Costs	Benefits	Regulatory/Public Acceptance
			Feasibility	Short/Long Term Effectiveness	Reliability				
Less Aggressive Remedy	**Vadose Zone VOCs Expanded SVE System**	Yes, MNA will likely achieve residential SRLs and GPLs and over time will reduce VOC concentrations in the vadose zone.	MNA monitoring is very feasible as monitoring is currently conducted at the site.	MNA is a known effective remedy for VOC contamination in the vadose zone; Effectiveness will be assessed as part of the system monitoring.	MNA is a known and reliable remediation technology.	The reference remedy is protective, as risk based calcuations indicate that no unacceptable risk is based on most recent data. The remedy is consistent with current and future land use.	Monitoring costs would be extended at least 30 years forward	The less aggressive remedy would provide continued reduction of VOC over time. non-r	Moderately Unlikely
	Source Area ISCO Using Ozone and Semiannual MNA Monitoring of Existing Groundwater Well Network	Yes, MNA will provide data for continued evaluation of the plume. However, this remedy may result in at least 30 years of MNA and implementation of contingencies for groundwater, if AWQS are not met.	MNA monitoring is very feasible as groundwater monitoring is currently conducted at the site. Untreated portions of the plume may result in expansion of the dilute plume beyond its current footprint. Additional monitoring wells may be required.	MNA is a known and effective remedy given the condition of the plume; semiannual monitoring will assess effectiveness.	MNA is a known and reliable remediation technology.	The less aggressive remedy is protective, in that it continues to monitor and evaluate Site contamination through the collection of data. However, it will not remediate groundwater. If SRP reactivates wells within or near the VOC plume, impacted water may be drawn into the wells, which would require implementation of the wellhead treatment contingencies.	MNA costs for this remedy would be similar to the current groundwater monitoring costs. Additional capital costs may be required if SRP reactivates production wells located within or near the VOC plume, resulting in the need for wellhead treatment, and potentially new monitoring wells if the plume expands.	MNA monitoring would provide data to evaluate VOC concentrations throughout the PCE plume and monitor for the potential need of implementing wellhead treatment as a contingency for either SRP wells.	Moderately Unlikely

Abbreviations:
MNA - Monitored Natural Attenuation
O&M - Operation and Maintenance
PCE = Tetrachloroethene
SRP - Salt River Project
SVE - Soil Vapor Extraction
VOC - Volatile Organic Compound

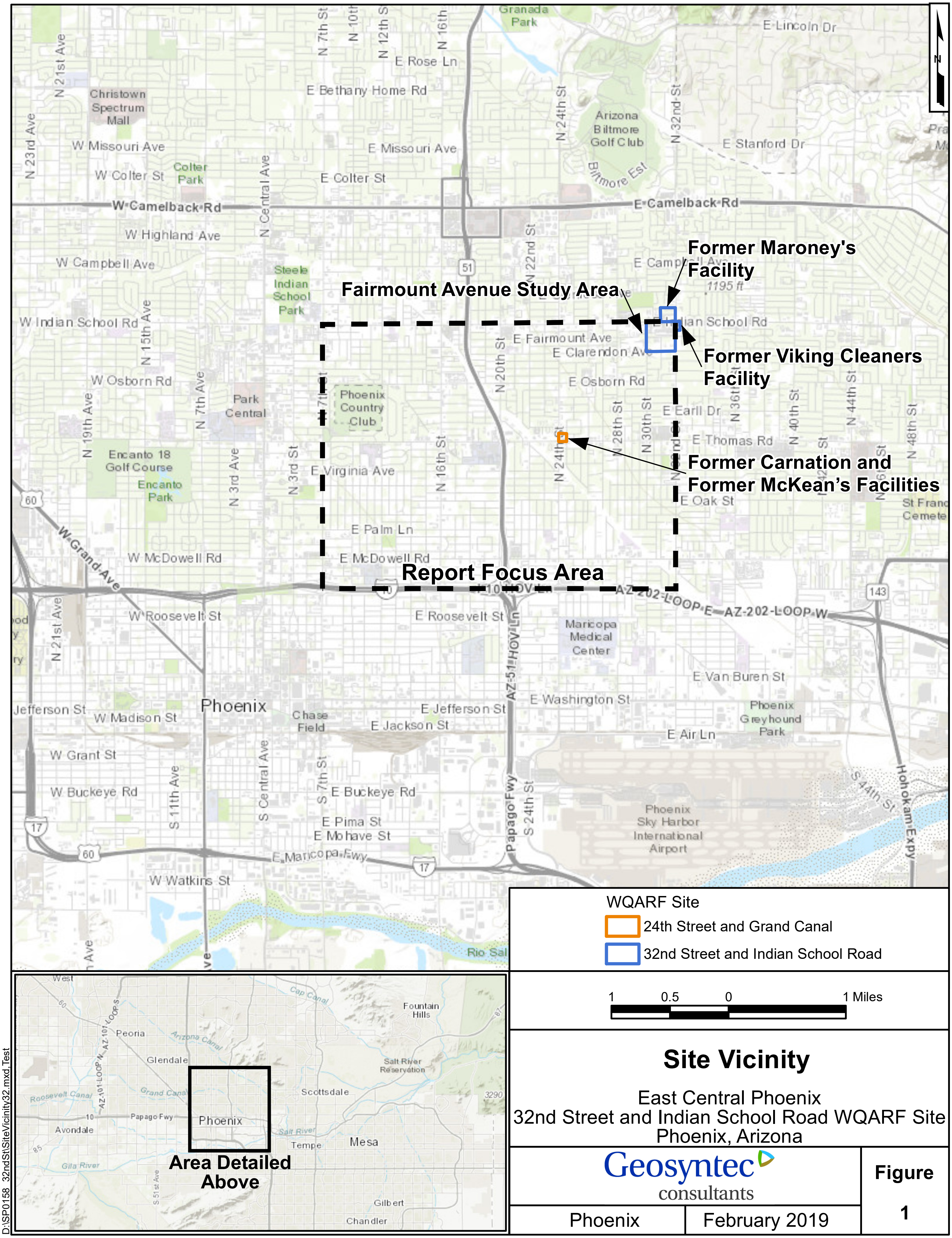
Table 3
Remedial Alternatives Cost Summary
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Remedial Alternative	Vadose Zone / Groundwater	Estimated Capital Costs	Estimated O&M Costs and Monitoring	Total Estimated Cost (Not Including Contingency)	Contingency	Total Remedy Estimated Cost Including Contingency		
						Total Cost	(-30%)	(+50%)
Reference Remedy	- SVE at Former Maroney's Facility; - Ozone Sparge, sequential: Step 1 FASA Injection; Step 2 Grand Canal Injection; - Semiannual Monitoring; - Installation of Performance Monitor Wells	$3,850,000	$975,000	**$4,825,000**	$4,816,000	**$9,641,000**	**6,749,000**	**14,500,000**
More Aggressive Remedy	- SVE at Former Maroney's Facility; - Ozone Sparge - simultaneous: Step 1 FASA Injection & Step 2 Grand Canal Injection; - Semiannual Monitoring; - Installation of Monitoring Wells	$3,864,000	$1,166,000	**$5,030,000**	$4,842,000	**$9,872,000**	**6,910,000**	**14,800,000**
Less Aggressive Remedy	- SVE at Former Maroney's Facility; - Semiannual MNA of Well Network; and - Installation of Monitoring Wells	$663,000	$1,941,000	**$2,604,000**	$3,600,000	**$6,143,000**	**4,300,000**	**9,215,000**

Abbreviations:
WQARF = Water Quality Assurance Revolving Fund
O&M = operation and maintenance
% = percent
$ = United States dollars
GETS = Groundwater Extraction & Treatment System
VOCs = volatile organic compounds
SVE = soil vapor extraction
MNA = monitored natural attenuation

Notes:
Costs are rounded off to the nearest thousand
Costs are based on 2019 dollar values
Costs for O&M and contingencies include an assumed Net Present Value of 5%

FIGURES



Site Vicinity

East Central Phoenix
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Geosyntec consultants

Phoenix | February 2019

Figure 1

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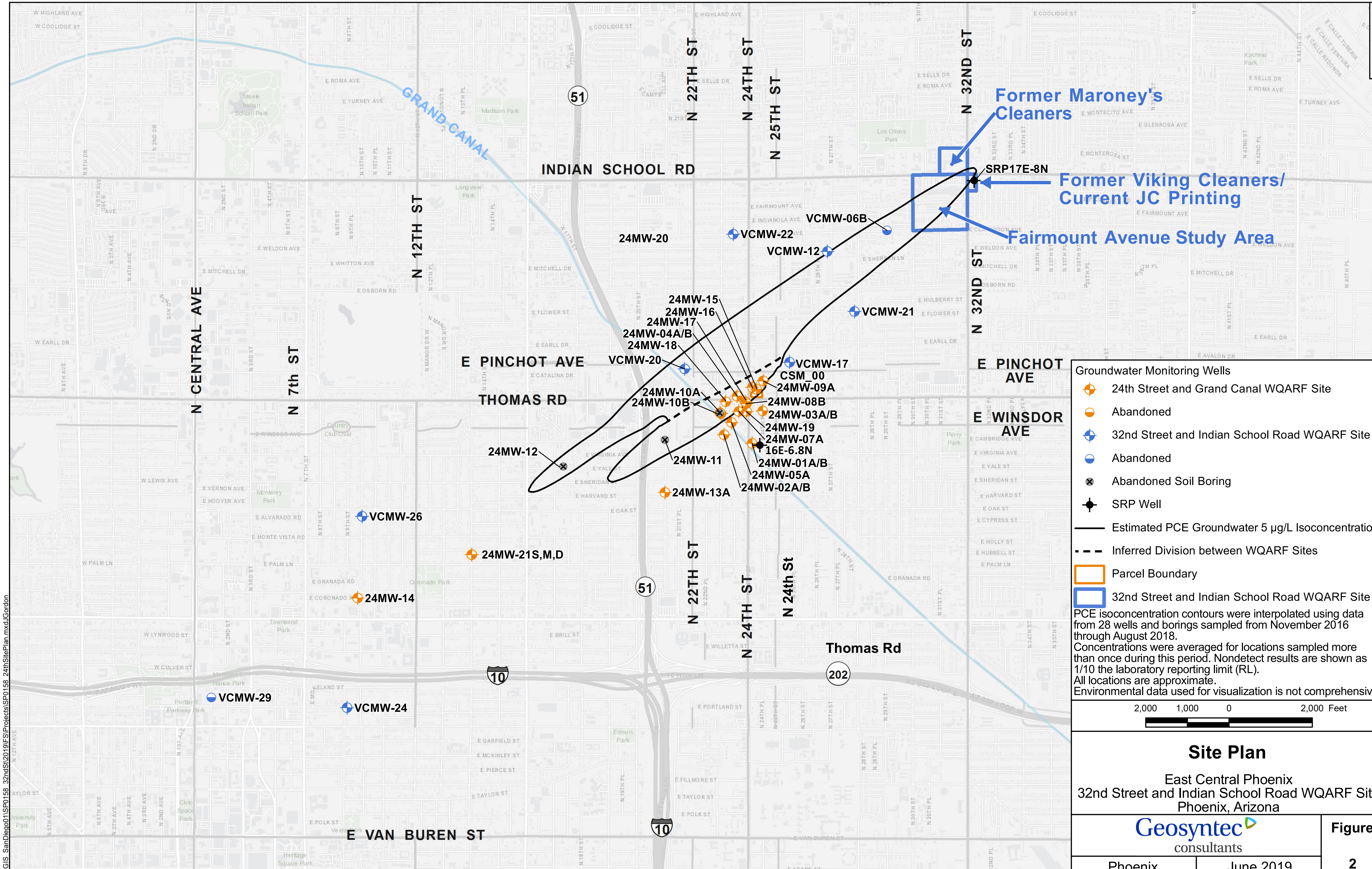
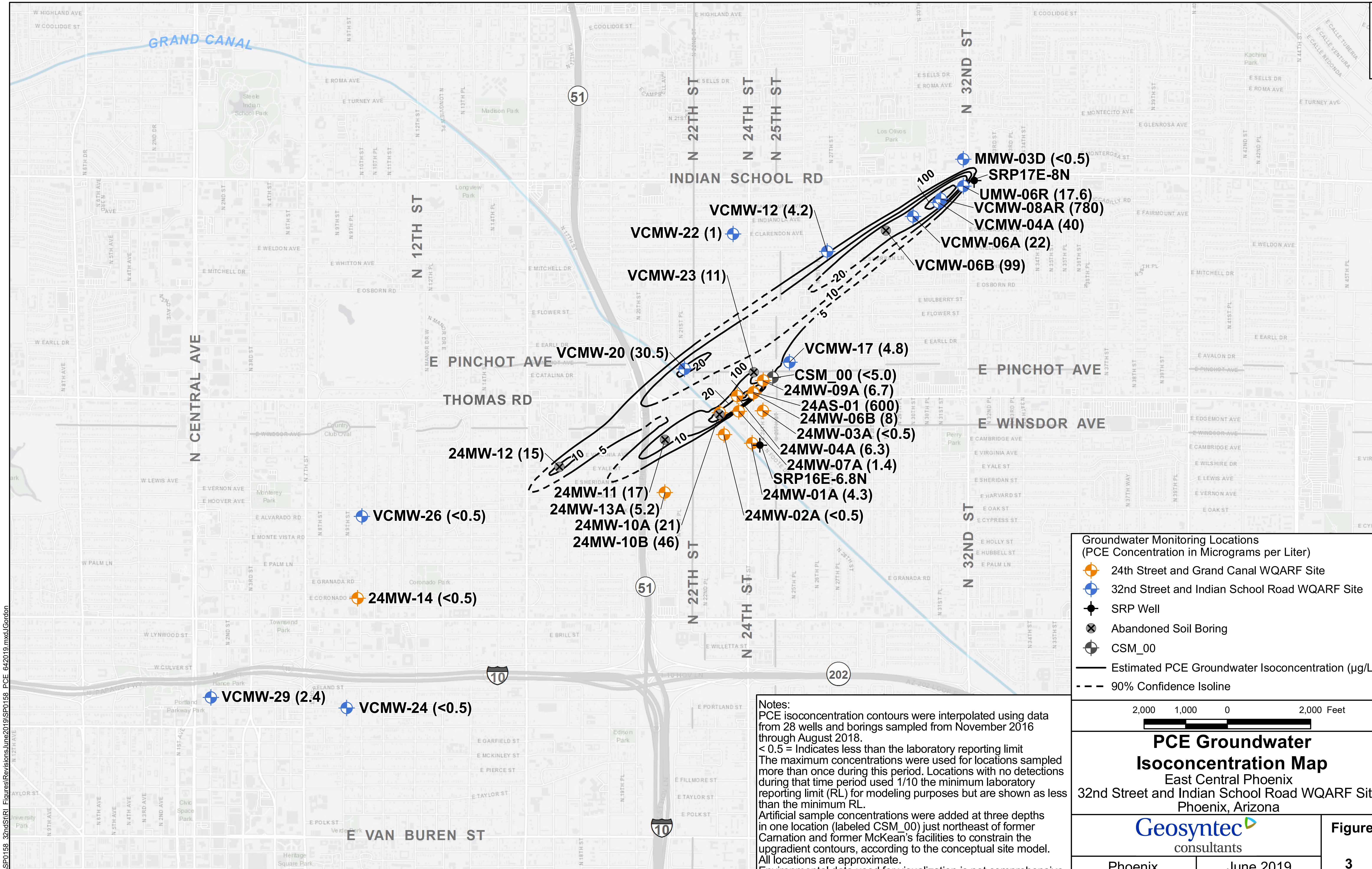


Site Plan

East Central Phoenix
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Figure 2



Notes:
PCE isoconcentration contours were interpolated using data from 28 wells and borings sampled from November 2016 through August 2018.
< 0.5 = Indicates less than the laboratory reporting limit
The maximum concentrations were used for locations sampled more than once during this period. Locations with no detections during that time period used 1/10 the minimum laboratory reporting limit (RL) for modeling purposes but are shown as less than the minimum RL.
Artificial sample concentrations were added at three depths in one location (labeled CSM_00) just northeast of former Carnation and former McKean's facilities to constrain the upgradient contours, according to the conceptual site model.
All locations are approximate.
Environmental data used for visualization is not comprehensive.

PCE Groundwater Isoconcentration Map
East Central Phoenix
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

Geosyntec consultants

Phoenix | June 2019

Figure 3

APPENDIX A

Detailed Cost Analysis

Table A-1
Estimated Costs for Reference Remedy
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

	Quantity	Unit	Unit Cost	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
Vadose Zone (VOCs) - Expansion of SVE System and Operation						
Estimated Vadose Zone Annual O&M Costs						
Routine Monitoring/Sampling/Reporting	1	LS	$30,000	$30,000	$21,000	$45,000
Repair and Maintenance	1	LS	$7,000	$7,000	$5,000	$11,000
Utilities (Electric)	12	MO	$200	$2,400	$2,000	$4,000
VGAC Changeout (assumes 1 changeout a year)	1	LS	$5,000	$5,000	$4,000	$8,000
Miscellaneous Field Supplies	1	LS	$6,000	$6,000	$5,000	$9,000
Project Management/Administration	15%	n/a	n/a	$8,000	$6,000	$12,000
Annual O&M Subtotal				**$61,000**	**$43,000**	**$92,000**
Estimated Vadose Zone Contingency Costs						
ERA Vadose Zone Contingencies:						
SVE Well Installation (1) and Associated Capital Improvements	1	LS	$15,000	$15,000	$11,000	$23,000
O&M Costs (6 months)	6	MO	$5,000	$30,000	$21,000	$45,000
Vadose Zone Contingency Costs Subtotal				**$60,000**	**$43,000**	**$91,000**
Total Estimated Vadose Zone O&M and Contingency Costs				**$121,000**	**$85,000**	**$182,000**
Groundwater (GW) - Source and Extended Area Ozone Sparge and MNA Monitoring of Existing Well Network						
STAGE 1 - Estimated Groundwater Capital Costs						
Ozone System Remedy Final Design						
Ozone System Remedy Final Design	1	LS	$100,000	$100,000	$70,000	$150,000
IW Installations						
Source area IWs at FASA Installation and Oversight	12	EA	$70,000	$840,000	$588,000	$1,260,000
Vertical Profile, Survey, Permitting, IDW Disposal	12	EA	$6,000	$72,000	$50,000	$108,000
Ozone Systems Installations						
Ozone Generator Purchase (Including Conex Box and Telemetry)	1	LS	$230,000	$230,000	$161,000	$345,000
Earthwork, Trenching and Pipe Installation (FASA)	1300	FT.	$150	$195,000	$137,000	$293,000
Asphalt Repair (FASA)	1300	FT.	$60	$78,000	$55,000	$117,000
Related Appurtenances, Equipment and Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
System Performance Monitor Well Installation						
Triple-Nested Monitor Well Installation and Oversight	5	LS	$100,000	$500,000	$350,000	$750,000
Vertical Profile, Survey, Permitting, Traffic Control, IDW Disposal, Tech Memo	1	LS	$30,000	$30,000	$21,000	$45,000
Project Management/Administration	15%	n/a	n/a	$312,000	$219,000	$468,000
Capital Costs Subtotal				**$2,387,000**	**$1,671,000**	**$3,581,000**
STAGE 1 - Estimated Ozone O&M and GW Monitoring Annual Costs						
Ozone System Annual O&M	1	YR	$50,000	$50,000	$35,000	$75,000
Semiannual GW Monitoring/Reporting	2	EA	$40,000	$80,000	$56,000	$120,000
Miscellaneous Sampling & Field Supplies	1	YR	$6,000	$6,000	$4,000	$9,000
Equipment Repairs (as needed)	1	YR	$10,000	$10,000	$7,000	$15,000
Project Management/Administration	15%	n/a	n/a	$22,000	$15,000	$33,000
Annual Costs for Ozone O&M Subtotal				**$50,000**	**$35,000**	**$75,000**
Annual Costs for GW Monitoring O&M Subtotal				**$118,000**	**$83,000**	**$177,000**
3-Year Costs Life Cycle (3-Yrs. Ozone O&M & Monitoring)				**$504,000**	**$830,000**	**$1,770,000**
Total GW Monitoring Costs for 6 Years (Net Present Value - Discounted 5%)				**$457,000**	**$641,000**	**$1,367,000**
STAGE 2 - Estimated Groundwater Capital Costs						
Ozone System Remedy Final Design						
Ozone System Remedy Final Design	1	LS	$100,000	$100,000	$70,000	$150,000
IW Installations						
Grand Canal IWs Installation and Oversight	11	EA	$70,000	$770,000	$539,000	$1,155,000
Vertical Profile, Survey, Permitting, IDW Disposal	11	EA	$6,000	$66,000	$46,000	$99,000
Ozone Systems Installations						
Ozone Generator Purchase (Including Conex Box and Telemetry)	1	LS	$230,000	$230,000	$161,000	$345,000
Earthwork, Trenching and Pipe Installation (Grand Canal Property)	1400	FT.	$50	$70,000	$49,000	$105,000
Asphalt Repair (QT Property Repairs)	100	FT.	$60	$6,000	$4,000	$9,000
Related Appurtenances, Equipment and Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
Project Management/Administration	15%	n/a	n/a	$191,000	$134,000	$287,000
Capital Costs Subtotal				**$1,463,000**	**$1,024,000**	**$2,195,000**
STAGE 2 - Estimated Ozone O&M and GW Monitoring Annual Costs						
Ozone System Annual O&M	1	YR	$50,000	$50,000	$35,000	$75,000
Semiannual GW Monitoring/Reporting	2	EA	$40,000	$80,000	$56,000	$120,000
Miscellaneous Sampling & Field Supplies	1	YR	$6,000	$6,000	$4,000	$9,000
Equipment Repairs (as needed)	1	YR	$10,000	$10,000	$7,000	$15,000
Project Management/Administration	15%	n/a	n/a	$22,000	$15,000	$33,000
Annual Costs for Ozone O&M Subtotal				**$50,000**	**$35,000**	**$75,000**
Annual Costs for GW Monitoring O&M Subtotal				**$118,000**	**$83,000**	**$177,000**
3-Year Costs Life Cycle (3-Yrs. Ozone O&M& GW Monitoring)				**$504,000**	**$830,000**	**$1,770,000**
Total GW Monitoring Costs for 3 Years (Net Present Value - Discounted 5%)				**$457,000**	**$641,000**	**$1,367,000**
Reference Remedy Capital, Monitoring, and O&M Costs				**$4,825,000**	**$3,378,000**	**$7,238,000**

Table A-1
Estimated Costs for Reference Remedy
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

	Quantity	Unit	Unit Cost	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
Estimated GW Contingency Costs						
Hydrogen Peroxide Injection at FASA	1	LS	$140,000	$140,000	$98,000	$210,000
Ozone System O&M and GW Monitoring for 1 Additional Year	1	LS	$118,000	$118,000	$83,000	$177,000
Additional Downgradient ISCO						
Ozone System Remedy Design	1	EA	$50,000	$50,000	$35,000	$75,000
ISCO IWs Installation (Between FASA and Grand Canal)	10	EA	$50,000	$500,000	$350,000	$750,000
IDW Disposal	10	EA	$6,000	$60,000	$42,000	$90,000
Earthwork, Trenching and Pipe Installation	800	FT	$150	$120,000	$84,000	$180,000
Asphalt Repair	800	FT	$60	$48,000	$34,000	$72,000
Equipment/Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
One-time ISCO Injection and Oversight	2	LS	$100,000	$200,000	$140,000	$300,000
Ozone Sparge IWs Near SRP Well 17E-8N (Installation and Oversight)	2	EA	$50,000	$100,000	$70,000	$150,000
Earthwork, Trenching and Pipe Installation	100	FT	$150	$15,000	$11,000	$23,000
Asphalt Repair	100	FT	$50	$5,000	$4,000	$8,000
Equipment/Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
Use of FASA Area Ozone Generator and O&M for 1 Year	2	LS	$40,000	$80,000	$56,000	$120,000
Vertical Profile, Survey, Permitting, IDW Disposal	2	EA	$6,000	$12,000	$8,000	$18,000
Project Management/Administration	15%	n/a	n/a	$37,000	$26,000	$56,000
Wellhead Treatment						
Engineering Design/Procurement Services	15%	n/a	$228,000	$228,000	$160,000	$342,000
Treatment Compound (Foundation, Fencing, Mechanical, Instrumentation and Controls, Site Improvements, etc.)	1	LS	$500,000	$500,000	$350,000	$750,000
Estimated 2,000 gpm Treatment System (Two LGAC Vessels [including offload/installation[, Bag Filtration System, Interconnecting Piping)	1	LS	$985,000	$985,000	$690,000	$1,478,000
Conveyance Piping Modifications	1	LS	$30,000	$30,000	$21,000	$45,000
System Commissioning and Startup	1	LS	$35,000	$35,000	$25,000	$53,000
Construction Services (System Installation, Oversight, etc.)	15%	n/a	n/a	$233,000	$163,000	$350,000
O&M costs (assuming 20 Years Net Present Value - Discounted 5%)	1	LS	$1,200,000	$1,200,000	$840,000	$1,800,000
GW Contingency Costs Subtotal				**$4,756,000**	**$3,329,000**	**$7,134,000**
Total Reference Remedy Costs (Including Contingencies)				**$9,641,000**	**$6,749,000**	**$14,500,000**

Abbreviations:

WQARF = Water Quality Assurance Revolving Fund
% = percent
ERA - early response action
GW - groundwater
IDW - Investigation Derived-Wastes
IW - injection well
LF = linear feet
LGAC = liquid phase granular activated carbon
LS = lump sum
MNA = monitored natural attenuation
MO - month
O&M = operations and maintenance
PLC = programmable logic controller
VGAC = vapor phase granular activated carbon
VOCs = volatile organic compounds

Notes:

1. Total costs are rounded up to the nearest thousand dollars ($1000).
2. Pricing is subject to commodity pricing increases. Contingencies for possible price escalation due to steel or other tariffs is not included.
3. No estimated costs have been included for taxes or other fees relative to the project.
4. Net Present Value - The labor, materials or equipment value in the present of a sum of money, in contrast to a future value when it has been invested at compound interest (assumed at 5%).

Wellhead Treatment Assumptions:

1. Wellhead treatment system installation would be adjacent to SRP Well 14.0E-9.6N within available existing property with adequate footprint.
2. Estimated costs do not include land acquisition and/or access agreements.
3. Estimated costs do not include permitting.
4. LGAC system includes two, 20,000-pound lead/lag systems in parallel for maximum flowrate of up to 2,200 gallons per minute.
5. Treated water recipient will accept a system flowrate of 2,200 gpm.
6. The existing production well pump will have enough capacity to overcome hydraulic head of wellhead treatment system.
7. No production well pump, booster pumps, effluent discharge pumps, or inclusion of equalization tanks will be required for wellhead treatment.
8. Treated water discharge will be tied in to the existing production well conveyance pipeline.
9. Treatment system concrete slab will be 1-foot thick on grade with secondary containment curbing.
10. Treatment system metal mesh fencing will be 8-feet in height.
11. Treatment system would have at minimum a gravel pathway to the treatment compound from the nearest paved roadway.
12. Installation of a new electrical service/transformer will not be required.
13. Instrumentation and controls will be connected to existing PLC.
14. No modifications will be needed for existing wellhead instrumentation and controls.
15. O&M costs assume monthly bag filter changeouts, quarterly sampling, and bi-annual carbon vessel changeouts for a total of 80,000 pounds of LGAC per year.
16. O&M costs exclude utility costs.

Table A-2
Estimated Costs for More Aggressive Alternative Remedy
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

	Quantity	Unit	Unit Cost	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
Vadose Zone (VOCs) - Expansion of SVE System and Operation						
Estimated Capital Costs						
Installation of two SVE Well and Mobile SVE unit	1	LS	$20,000	$20,000	$14,000	$30,000
Capital Costs Subtotal				**$20,000**	**$14,000**	**$30,000**
Estimated Vadose Zone Annual O&M Costs						
Routine Monitoring/Sampling/Reporting	1	LS	$30,000	$30,000	$21,000	$45,000
Repair and Maintenance	1	LS	$7,000	$7,000	$5,000	$11,000
Utilities (Electric)	6	MO	$200	$1,200	$1,000	$2,000
VGAC Changeout (assumes 1 changeout a year)	1	LS	$5,000	$5,000	$4,000	$8,000
Miscellaneous Field Supplies	1	LS	$6,000	$6,000	$5,000	$9,000
Project Management/Administration	15%	n/a	n/a	$8,000	$6,000	$12,000
Annual O&M Subtotal				**$60,000**	**$42,000**	**$90,000**
Total O&M Costs for 3 Years (Net Present Value - Discounted 5%)				**$163,000**	**$114,000**	**$245,000**
Estimated Vadose Zone Contingency Costs						
ERA Vadose Zone Contingencies:						
SVE Well Installation (1) and Associated Capital Improvements	1	LS	$15,000	$15,000	$11,000	$23,000
O&M Costs (6 months)	6	MO	$5,000	$30,000	$21,000	$45,000
Vadose Zone Contingency Costs Subtotal				**$60,000**	**$43,000**	**$91,000**
Total Estimated Vadose Zone Capital, O&M and Contingency Costs				**$243,000**	**$170,000**	**$365,000**
Groundwater (GW) - Source and Extended Area Ozone Sparge and MNA Monitoring of Existing Well Network						
STAGE 1 - Estimated Groundwater Capital Costs						
Ozone System Remedy Final Design						
Ozone System Remedy Final Design	1	LS	$100,000	$100,000	$70,000	$150,000
IW Installations						
Source area IWs at FASA Installation and Oversight	12	EA	$70,000	$840,000	$588,000	$1,260,000
Vertical Profile, Survey, Permitting, IDW Disposal	12	EA	$6,000	$72,000	$50,000	$108,000
Ozone Systems Installations						
Ozone Generator Purchase (Including Conex Box and Telemetry)	1	LS	$230,000	$230,000	$161,000	$345,000
Earthwork, Trenching and Pipe Installation (FASA)	1300	FT.	$150	$195,000	$137,000	$293,000
Asphalt Repair (FASA)	1300	FT.	$60	$78,000	$55,000	$117,000
Related Appurtenances, Equipment and Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
Monitoring Well Installation						
Triple-Nested Monitoring Well Installation and Oversight	5	LS	$100,000	$500,000	$350,000	$750,000
Vertical Profile, Survey, Permitting, Traffic Control, IDW Disposal, Tech Memo	1	LS	$25,000	$25,000	$18,000	$38,000
Project Management/Administration	15%	n/a	n/a	$311,000	$218,000	$467,000
Capital Costs Subtotal				**$2,381,000**	**$1,667,000**	**$3,572,000**
STAGE 2 - Estimated Groundwater Capital Costs						
Ozone System Remedy Final Design						
Ozone System Remedy Final Design	1	LS	$100,000	$100,000	$70,000	$150,000
IW Installations						
Grand Canal IWs Installation and Oversight	11	EA	$70,000	$770,000	$539,000	$1,155,000
Vertical Profile, Survey, Permitting, IDW Disposal	11	EA	$6,000	$66,000	$46,000	$99,000
Ozone Systems Installations						
Ozone Generator Purchase (Including Conex Box and Telemetry)	1	LS	$230,000	$230,000	$161,000	$345,000
Earthwork, Trenching and Pipe Installation (Grand Canal Property)	1400	FT.	$50	$70,000	$49,000	$105,000
Asphalt Repair (QT Property Repairs)	100	FT.	$60	$6,000	$4,000	$9,000
Related Appurtenances, Equipment and Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
Project Management/Administration	15%	n/a	n/a	$191,000	$134,000	$287,000
Capital Costs Subtotal				**$1,463,000**	**$1,024,000**	**$2,195,000**
STAGE 1 and 2 - Estimated Ozone O&M and GW Monitoring Annual Costs						
Ozone System Annual O&M	1	YR	$100,000	$100,000	$70,000	$150,000
Semiannual GW Monitoring/Reporting	2	EA	$40,000	$80,000	$56,000	$120,000
Miscellaneous Sampling & Field Supplies	1	YR	$12,000	$12,000	$8,000	$18,000
Equipment Repairs (as needed)	1	YR	$20,000	$20,000	$14,000	$30,000
Project Management/Administration	15%	n/a	n/a	$32,000	$22,000	$48,000
Annual Costs for Ozone O&M Subtotal				**$100,000**	**$70,000**	**$150,000**
Annual Costs for GW Monitoring O&M Subtotal				**$144,000**	**$101,000**	**$216,000**
6-Year Costs Life Cycle (3-Yrs. Ozone O&M + 6 GW Monitoring)				**$1,164,000**	**$1,010,000**	**$2,160,000**
Total GW Monitoring Costs for 6 Years (Net Present Value - Discounted 5%)				**$1,003,000**	**$780,000**	**$1,668,000**
Reference Remedy Capital, Monitoring, and O&M Costs				**$5,030,000**	**$3,521,000**	**$7,545,000**

Table A-2
Estimated Costs for More Aggressive Alternative Remedy
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

	Quantity	Unit	Unit Cost	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
Estimated GW Contingency Costs						
Hydrogen Peroxide Injection at FASA	1	LS	$140,000	$140,000	$98,000	$210,000
Ozone System O&M and GW Monitoring for 1 Additional Year	1	LS	$144,000	$144,000	$101,000	$216,000
Additional Downgradient ISCO						
Ozone System Remedy Design	1	EA	$50,000	$50,000	$35,000	$75,000
ISCO IWs Installation (Between FASA and Grand Canal)	10	EA	$50,000	$500,000	$350,000	$750,000
IDW Disposal	10	EA	$6,000	$60,000	$42,000	$90,000
Earthwork, Trenching and Pipe Installation	800	FT	$150	$120,000	$84,000	$180,000
Asphalt Repair	800	FT	$60	$48,000	$34,000	$72,000
Equipment/Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
One-time ISCO Injection and Oversight	2	LS	$100,000	$200,000	$140,000	$300,000
Ozone Sparge IWs Near SRP Well 17E-8N (Installation and Oversight)	2	EA	$50,000	$100,000	$70,000	$150,000
Earthwork, Trenching and Pipe Installation	100	FT	$150	$15,000	$11,000	$23,000
Asphalt Repair	100	FT	$50	$5,000	$4,000	$8,000
Equipment/Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
Use of FASA Area Ozone Generator and O&M for 1 Year	2	LS	$40,000	$80,000	$56,000	$120,000
Vertical Profile, Survey, Permitting, IDW Disposal	2	EA	$6,000	$12,000	$8,000	$18,000
Project Management/Administration	15%	n/a	n/a	$37,000	$26,000	$56,000
Wellhead Treatment						
Engineering Design/Procurement Services	15%	n/a	$228,000	$228,000	$160,000	$342,000
Treatment Compound (Foundation, Fencing, Mechanical, Instrumentation and Controls, Site Improvements, etc.)	1	LS	$500,000	$500,000	$350,000	$750,000
Estimated 2,000 gpm Treatment System (Two LGAC Vessels [including offload/installation[, Bag Filtration System, Interconnecting Piping)	1	LS	$985,000	$985,000	$690,000	$1,478,000
Conveyance Piping Modifications	1	LS	$30,000	$30,000	$21,000	$45,000
System Commissioning and Startup	1	LS	$35,000	$35,000	$25,000	$53,000
Construction Services (System Installation, Oversight, etc.)	15%	n/a	n/a	$233,000	$163,000	$350,000
O&M costs (assuming 20 Years Net Present Value - Discounted 5%)	1	LS	$1,200,000	$1,200,000	$840,000	$1,800,000
GW Contingency Costs Subtotal				**$4,782,000**	**$3,347,000**	**$7,173,000**
Total Reference Remedy Costs (Including Contingencies)				**$9,872,000**	**$6,910,000**	**$14,800,000**

Abbreviations:

WQARF = Water Quality Assurance Revolving Fund
% = percent
ERA - early response action
GW - groundwater
IDW - Investigation Derived-Wastes
IW - injection well
LF = linear feet
LGAC = liquid phase granular activated carbon
LS = lump sum
MNA = monitored natural attenuation
MO - month
O&M = operations and maintenance
PLC = programmable logic controller
VGAC = vapor phase granular activated carbon
VOCs = volatile organic compounds

Notes:

1. Total costs are rounded up to the nearest thousand dollars ($1000).
2. Pricing is subject to commodity pricing increases. Contingencies for possible price escalation due to steel or other tariffs is not included.
3. No estimated costs have been included for taxes or other fees relative to the project.
4. Net Present Value **-** The labor, materials or equipment value in the present of a sum of money, in contrast to a future value when it has been invested at compound interest (assumed at 5%).

Wellhead Treatment Assumptions:

1. Wellhead treatment system installation would be adjacent to SRP Well 14.0E-9.6N within available existing property with adequate footprint.
2. Estimated costs do not include land acquisition and/or access agreements.
3. Estimated costs do not include permitting.
4. LGAC system includes two, 20,000-pound lead/lag systems in parallel for maximum flowrate of up to 2,200 gallons per minute.
5. Treated water recipient will accept a system flowrate of 2,200 gpm.
6. The existing production well pump will have enough capacity to overcome hydraulic head of wellhead treatment system.
7. No production well pump, booster pumps, effluent discharge pumps, or inclusion of equalization tanks will be required for wellhead treatment.
8. Treated water discharge will be tied in to the existing production well conveyance pipeline.
9. Treatment system concrete slab will be 1-foot thick on grade with secondary containment curbing.
10. Treatment system metal mesh fencing will be 8-feet in height.
11. Treatment system would have at minimum a gravel pathway to the treatment compound from the nearest paved roadway.
12. Installation of a new electrical service/transformer will not be required.
13. Instrumentation and controls will be connected to existing PLC.
14. No modifications will be needed for existing wellhead instrumentation and controls.
15. O&M costs assume monthly bag filter changeouts, quarterly sampling, and bi-annual carbon vessel changeouts for a total of 80,000 pounds of LGAC per year.
16. O&M costs exclude utility costs.

Table A-3
Estimated Costs for Less Aggressive Alternative Remedy
32nd Street and Indian School Road WQARF Site
Phoenix, Arizona

	Quantity	Units	Cost Per Unit	Total Cost	Total Cost (-30%)	Total Cost (+50%)
Vadose Zone (VOCs) - Expansion of SVE System and Operation						
Estimated Vadose Zone Annual O&M Costs						
Routine Monitoring/Sampling/Reporting	1	LS	$30,000	$30,000	$21,000	$45,000
Annual O&M Subtotal				**$61,000**	**$43,000**	**$92,000**
Estimated Vadose Zone Contingency Costs						
ERA Vadose Zone Contingencies:						
SVE Well Installation (1) and Associated Capital Improvements	1	LS	$65,000	$65,000	$46,000	$98,000
O&M Costs (6 months)	6	MO	$5,000	$30,000	$21,000	$45,000
Vadose Zone Contingency Costs Subtotal				**$110,000**	**$78,000**	**$166,000**
Total Estimated Vadose Zone Capital, O&M and Contingency Costs				**$171,000**	**$120,000**	**$257,000**
Groundwater - MNA Monitoring Limited Well Network Annually						
Estimated Capital Costs						
Monitoring Well Installation						
Triple-Nested Monitoring Well Installation and Oversight	5	LS	$100,000	$500,000	$350,000	$750,000
Vertical Profile, Survey, Permitting, Traffic Control, IDW Disposal, Tech Memo	1	LS	$25,000	$25,000	$18,000	$38,000
Project Management/Administration	15%	n/a	n/a	$138,000	$97,000	$207,000
Capital Costs Subtotal				**$663,000**	**$464,000**	**$995,000**
Estimated Monitoring Costs						
Semiannual Groundwater Monitoring/Reporting	2	LS	$50,000	$100,000	$70,000	$150,000
Miscellaneous Sampling & Field Supplies	1	LS	$6,000	$6,000	$4,000	$9,000
Project Management/Administration	15%	n/a	n/a	$16,000	$11,000	$24,000
Annual Groundwater Monitoring Subtotal				**$122,000**	**$85,000**	**$183,000**
30-Year Life Cycle				**$3,660,000**	**$2,562,000**	**$5,490,000**
Total Groundwater Monitoring Costs for 30 Years (Net Present Value - Discounted 5%)				**$1,880,000**	**$1,316,000**	**$2,820,000**
Groundwater Monitoring Capitol and O&M Costs				**$2,543,000**	**$1,780,000**	**$3,815,000**
Reference Remedy Capital, Monitoring, and O&M Costs				**$2,604,000**	**$1,823,000**	**$3,906,000**
Estimated Groundwater Contingency Costs						
Ozone Sparge IWs Near SRP Well 17E-8N (Installation and Oversight)	2	EA	$50,000	$100,000	$70,000	$150,000
Earthwork, Trenching and Pipe Installation	100	FT	$150	$15,000	$11,000	$23,000
Asphalt Repair	100	FT	$50	$5,000	$4,000	$8,000
Equipment/Repairs	1	LS	$30,000	$30,000	$21,000	$45,000
Use of FASA Area Ozone Generator and O&M for 1 Year	2	LS	$40,000	$80,000	$56,000	$120,000
Vertical Profile, Survey, Permitting, IDW Disposal	2	EA	$6,000	$12,000	$8,000	$18,000
Project Management/Administration	15%	n/a	n/a	$37,000	$26,000	$56,000
Wellhead Treatment						
Engineering Design/Procurement Services	15%	n/a	$228,000	$228,000	$160,000	$342,000
Treatment Compound (Foundation, Fencing, Mechanical, Instrumentation and Controls, Site Improvements, etc.)	1	LS	$500,000	$500,000	$350,000	$750,000
Estimated 2,000 gpm Treatment System (Two LGAC Vessels [including offload/installation[, Bag Filtration System, Interconnecting Piping)	1	LS	$985,000	$985,000	$690,000	$1,478,000
Conveyance Piping Modifications	1	LS	$30,000	$30,000	$21,000	$45,000
System Commissioning and Startup	1	LS	$35,000	$35,000	$25,000	$53,000
Construction Services (System Installation, Oversight, etc.)	15%	n/a	n/a	$233,000	$163,000	$350,000
O&M costs (assuming 20 Years Net Present Value - Discounted 5%)	1	LS	$1,200,000	$1,200,000	$840,000	$1,800,000
GW Contingency Costs Subtotal				**$3,490,000**	**$2,443,000**	**$5,235,000**
LESS AGGRESSIVE REMEDY COSTS (INCLUDING CONTINGENCY)				**$6,143,000**	**$4,300,000**	**$9,215,000**

Abbreviations:

WQARF = Water Quality Assurance Revolving Fund
% = percent
LS = lump sum
LF = linear feet
VOCs = volatile organic compounds
PLC = programmable logic controller
O&M = operations and maintenance
Qtrly = quarterly
MNA = monitored natural attenuation
LGAC = liquid phase granular activated carbon

Notes:

Net Present Value - The value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest (Assumed 5%)
Costs rounded off to nearest thousand

Wellhead Treatment Assumptions

1. Wellhead treatment system installation would be adjacent to SRP Well 14.0E-9.6N within available existing property with adequate footprint.
2. Estimated costs do not include land acquisition and/or access agreements.
3. Estimated costs do not include permitting.
4. LGAC system includes two, 20,000-pound lead/lag systems in parallel for maximum flowrate of up to 2,200 gallons per minute.
5. Treated water recipient will accept a system flowrate of 2,200 gpm.
6. The existing production well pump will have enough capacity to overcome hydraulic head of wellhead treatment system.
7. No production well pump, booster pumps, effluent discharge pumps, or inclusion of equalization tanks will be required for wellhead treatment.
8. Treated water discharge will be tied in to the existing production well conveyance pipeline.
9. Treatment system concrete slab will be 1-foot thick on grade with secondary containment curbing.
10. Treatment system metal mesh fencing will be 8-feet in height.
11. Treatment system would have at minimum a gravel pathway to the treatment compound from the nearest paved roadway.
12. Installation of a new electrical service/transformer will not be required.
13. Instrumentation and controls will be connected to existing PLC.
14. No modifications will be needed for existing wellhead instrumentation and controls.
15. O&M costs assume monthly bag filter changeouts, quarterly sampling, and bi-annual carbon vessel changeouts for a total of 80,000 pounds of LGAC per year.
16. O&M costs exclude utility costs.