Prepared for:

Arizona Department of Environmental Quality
1110 West Washington Street
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REMEDIAL INVESTIGATION REPORT

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

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PHOENIX, ARIZONA

We certify that this document and attachments presented in this report are accurate and complete. This report was prepared by the staff of Geosyntec Consultants under our supervision to ensure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who are directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate and complete.

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EXECUTIVE SUMMARY

This report summarizes the findings of remedial investigation (RI) activities conducted by the Arizona Department of Environmental Quality (ADEQ) at the 32nd Street and Indian School Road Quality Water Assurance Revolving Fund (WQARF) site (herein referred to as the WQARF site or the site; **Figure 1**) of the East Central Phoenix (ECP) WQARF study area located in the City of Phoenix (COP), Arizona. The WQARF site is defined by the estimated tetrachloroethene (PCE) Arizona Aquifer Water Quality Standard (AWQS) concentration contour (the plume), which begins in the vicinity of the intersection of 32nd Street and Indian School Road and extends to the southwest. The plume is approximately bounded by East Indian School Road to the north, North 32nd Street to the east, East Harvard Street to the south, and North 16th Street to the west (**Figure 2**). The site has been assessed to a total depth of 250 feet (ft) below ground surface (bgs) in the northeast portion and 408 ft bgs towards the southwest extent. The Arizona Department of Water Resources (ADWR) defined three hydrogeologic units in the Basin and Range physiographic province fill. These include from the shallowest to deepest: the Upper Alluvial Unit (UAU), the Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU) (Corkhill *et al.*, 1993). The groundwater surface within the site lies within the UAU (Lluria, 2011).

Groundwater elevations in the UAU at the 32nd Street and Indian School Road site have been monitored since April 1992 (**Table 1; Appendix C**). Monitoring wells installed at the site are screened across both shallow (water table) and deeper intervals within the UAU. During the period of record for source area monitoring wells installed to investigate the site, groundwater elevations have generally declined with a more pronounced decline in the northeast the site near UMW-02. Depth to water at the site has ranged from approximately 35 ft below top of casing (btoc) in UMW-02 in 1997 to approximately 91 ft btoc in VCMW-24 in 2018. The direction of groundwater flow within the WQARF site is to the west-southwest at gradients ranging between approximately flat and 0.007 ft per foot. Historical groundwater elevations are shown in **Table 1** and discussed along with flow direction in **Section 2.6.1**.

The site has historically contained dry-cleaning and automobile service station facilities since the early 1960s. After several years of investigations, the source areas of the PCE were determined to be located at two dry-cleaning facilities. The facilities, the former Maroney's Cleaners & Laundry (Former Maroney's; **Figure 4)** and the former Viking

Cleaners (**Figure 5)**, historically operated near the intersection of 32^{nd} Street and Indian School Road.

The contaminants of concern at the site are PCE, trichloroethene (TCE), cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride. Other contaminants have also been historically detected in site media, including, but not limited to, petroleum hydrocarbon components (benzene, toluene, ethylene, and xylene).

Preliminary investigations (PIs) performed at the site began in 1984 with the sampling of soil at the Former Viking Cleaners and Former Unocal facilities, and the discovery of subsurface PCE and total petroleum hydrocarbon impacts. The site was placed on the WQARF Priority List in 1987. PIs were initiated at the Former Maroney's facility in 1989 with a soil vapor survey. The site was placed on the WQARF Registry List in May 2000.

RI activities were conducted from June 2007 through October 2018 and included: 1) installation of soil borings, soil vapor probes (SVPs), groundwater monitoring wells, soil vapor extraction (SVE), and air sparge wells; 2) monitoring of groundwater; 3) sampling of soil, soil vapor, indoor air, and groundwater; and 4) construction and operation of SVE systems at the Former Maroney's and Former Viking Cleaners facilities. In 2011, investigations in the area immediately downgradient of the former dry-cleaning facilities began.

Early response actions (ERAs) performed at the site began in 2003 with a soil, soil vapor, and groundwater investigation at the Former Viking Cleaners facility and subsequent installation of an air sparge (AS)/SVE system in 2004 to address chlorinated volatile organic compounds (CVOCs). AS was discontinued and the system was operated in SVE mode only, was expanded in 2006 and 2011, and was decommissioned and demobilized prior to installation of a new SVE system in June and July of 2014. This second SVE system was started in July 2014 and operated generally continuously, aside from shut down for maintenance in the third quarter of 2014, until June 2017. The SVE system was shut down for two separate soil vapor volatile organic compounds (VOC) rebound evaluations in 2017 and 2018. Localized residual impacts were observed where soil vapor concentrations were detected above site-specific risk-based cleanup goals for both events.

Two new SVE wells were installed after the rebound events to target the areas where the VOCs were detected above cleanup goals; SVE-09 was installed after the first event and SVE-10 was installed after the second event. An undocumented underground storage tank

(UST) was discovered during planned advancement of SVE-10 in September 2018; the UST was properly abandoned in-place in December 2018. The previously planned SVE-10 well was installed concurrently with UST abandonment. Brief continued operation of the SVE system and a subsequent rebound monitoring event was planned following UST abandonment and installation of SVE-10. SVE at the Former Viking Cleaners facility has broadly remediated subsurface impacts from CVOCs. Approximately 182 pounds of VOCs are estimated to have been cumulatively removed from the subsurface by the Former Viking Cleaners facility SVE systems.

The Former Maroney's facility SVE system was installed in 2011. The system appears to have mitigated soil vapor impacts from CVOCs to site-specific risk-based cleanup goals (the cleanup goals are the same as for the Former Viking Cleaner). Based on the SVE system performance and the rebound sampling, Geosyntec has recommended decommissioning and demobilization of the SVE system. Approximately 78 pounds of VOCs are estimated to have been removed from the subsurface by the SVE system between July 2016 and February 2018 for a final cumulative estimated mass removal of 115 pounds.

The Arizona Department of Health Services (ADHS) concluded in a December 2016 report that complete and potential exposure pathways from soil vapor/indoor air through vapor intrusion may be present as a result of people in ECP inhaling air that contains PCE and TCE. ADHS concluded there is no inherent public health concern from PCE; however, there is a potential public health concern from TCE. TCE in indoor air was concluded by ADHS to likely be from household sources and not due to vapor intrusion. The inhalation exposure route for indoor air presents a potentially complete exposure pathway; however, the risk is likely negligible (cancerous and long-term non-cancerous public health concerns are not expected) and is currently being mitigated. General population ingestion, inhalation, and dermal exposures to CVOCs in water could occur during activities such as showering, bathing, or washing. However, since the site is serviced by the public water supply, site groundwater is currently not used as a water supply. Potable use of groundwater is therefore not a complete pathway at the site.

Historical site characterization associated with the RI has demonstrated that the vadose zone was significantly impacted at the Former Maroney's and Former Viking Cleaners properties. Soil and soil vapor VOC impacts, primarily from PCE, have been observed from the shallow subsurface throughout the vadose zone to groundwater at both properties. The vadose zones of both properties are fully characterized for Site COCs and are discussed in **Section 8.1.** The vadose zone cleanup goals that were developed for both properties for the COCs were based on the Johnson and Ettinger (J&E) model (1991) for evaluating human health risk associated with vapor intrusion and United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) for commercial/industrial indoor air. The J&E model and the RSLs were used to develop sub slab soil vapor Health Protection Concentrations (HPCs). Standards were also developed to evaluate potential risk to underlying groundwater based on Arizona Groundwater Protection Levels (GPLs); however, the HPCs were typically an order of magnitude lower than the GPLs. Thus, the more conservative HPC values were selected for site-specific vadose zone cleanup goals.

The Former Maroney's and Former Viking Cleaners facilities appear to be the primary source of VOC impacts in the subsurface at the site. The groundwater CVOC impacts have attenuated within the site footprint areas over time. Groundwater impacted from ongoing vadose zone sources has advected hydraulically downgradient; however, concentration trends have been more recently observed to be either stable or declining, likely due to the vadose zone remediation that has been performed in source areas.

When examining the extent of PCE impacts two-dimensionally in plan view, as shown by the PCE Groundwater Isoconcentration Map (**Figure 13**), there appears to be an interaction (overlap) of the PCE plumes associated with this WQARF site and the PCE impacts to groundwater associated with the 24th Street and Grand WQARF site. The two plumes, however, are discrete, separate plumes traveling alongside each other and at different vertical elevations, with the plume associated with the 24th and Grand ECP WQARF site being shallower and located to the south. The independence of these plumes is shown in Geologic Cross Section B-B' (**Figure 16**) and in the three-dimensional EVS visualization of PCE impacts (**Figure 17**).

Petroleum hydrocarbon impacts that were identified during the completion of the ERA at the Site should be delineated back to their original source area. It should be noted that these impacts are not associated with the Former Viking and Former Maroney's dry-cleaning facilities.

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
1,2-DCA	1,2 dichloroethane
1,2-DCP	1,2-dichloropropane
A.A.C.	Arizona Administrative Code
A.R.S.	Arizona Revised Statutes
ACFM	actual cubic feet per minute
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
amsl	above mean sea level
APN	Assessor's Parcel Number
AS	air sparging
ASRAC	Arizona Superfund Response Action Contract
AST	aboveground storage tank
ASTM	American Society of Testing and Materials
AWQS	Aquifer Water Quality Standard
bgs	below ground surface
BTEX	benzene, toluene, ethene, and total xylenes
btoc	below top of casing
bwt	below the measured water table surface
caliche	heavily cemented sandy clay and clayey sand
CAP	Central Arizona Project
cfm	cubic feet per minute
cis-1,2-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
COP	City of Phoenix
CPT	cone penetrometer test
CVOC	chlorinated volatile organic compound
DNAPL	dense non-aqueous phase liquid
ECD	electron capture detector
ECP	East Central Phoenix
ERA	early response action
ESA	Environmental Site Assessment
EVS	Earth Volumetric Studio
FASA	Fairmount Avenue Study Area
Former Maroney's	Former Maroney's Cleaners & Laundry

Freon-12	dichlorodifluoromethane
FS	feasibility study
ft	feet
g/kg	grams per kilogram
GAC	granular activated carbon
GC	gas chromatography
GPC	groundwater protection concentration
GPL	Groundwater Protection Limit
gpm	gallons per minute
HBGL	Health-Based Guidance Level
HI	hazard index
HP	horsepower
HPC	Health Protective Concentration
HREC	historical recognized environmental condition
HVAC	heating, ventilating, and air conditioning
in Hg	inches of mercury
in WC	inches of water column
IPaC	Information, Planning and Conservation
J&E	Johnson & Ettinger
LAU	lower alluvial unit
lbs/day	pounds during any day
LUST	leaking underground storage tank
MAU	Middle Alluvial Unit
MEK	methyl ethyl ketone
mg/kg	milligrams per kilogram
MRL	minimal risk level
MTBE	methyl tert butyl ether
NOD	natural oxidant demand
NRCS	National Resources Conservation Service
NRSRL	Non-Residential Soil Remediation Level
O&M	operations and maintenance
PA	preliminary assessment
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PDB	passive diffusion bag
PI	preliminary investigation
PID	photoionization detector
PPA	Prospective Purchaser Agreement
ppbv	parts per billion by volume
ppmv	parts per million by volume
REC	recognized environmental condition

RES15	HPC residential risk at 15 ft bgs
RES5	HPC residential risk at 5 ft bgs
RI	remedial investigation
RL	reporting limit
ROI	radius of influence
ROs	remedial objectives
RSL	Regional Screening Level
RSRL	Residential Soil Remediation Level
scfm	standard cubic feet per minute
SECOR	SECOR International, Inc.
SRP	Salt River Project
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SVP	soil vapor probe
TCA	1,1,1-trichloroethane
TCE	trichloroethene
the Code	the 1980 Groundwater Management Code
the Former Unocal service station	Unocal Service Station #6453
the site/the WQARF site	32nd Street and Indian School Road
TMB	trimethylbenzene
TO-14A	USEPA Method TO-14A
TO-15 SIM	USEPA Method TO-15 Selective Ion Monitoring
TO-15	USEPA Method TO-15
TOC	total organic content
TPH	total petroleum hydrocarbons
trans-1,2-DCE	trans-1,2-dichloroethene
TSCA	Toxic Substances Control Act
TTHM	total trihalomethane
UAU	upper alluvial unit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Society
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound
WQARF	Water Quality Assurance Revolving Fund
WSRV	western portion of the Salt River Valley

1. INTRODUCTION

Geosyntec Consultants, Inc. (Geosyntec) has prepared this final *Remedial Investigation (RI) Report* for the East Central Phoenix (ECP) 32nd Street and Indian School Road Water Quality Assurance Revolving Fund (WQARF) site (herein referred to as the WQARF site or the site) located in Phoenix, Arizona (**Figure 1**). Geosyntec was contracted by Arizona Department of Environmental Quality (ADEQ) to prepare this report under an Arizona Superfund Response Action Contract (ASRAC).

A Salt River Project (SRP) water supply well is located near the intersection of 32nd Street and Indian School Road (SRP Well 17E-8N) (**Figure 2**). A detection of tetrachloroethene (PCE) in a sample from this supply well, recorded in the summer of 1983, initiated soil and groundwater investigations to locate a potential source. The vicinity surrounding the well was investigated to develop information on the presence of chlorinated solvent impacts in groundwater. According to a 1985 inspection by the Arizona Department of Health Services (ADHS), PCE impacts in SRP Well 17E-8N were suspected to have been caused by the surface disposal of PCE at the nearby Viking Cleaners facility (active at the time) as well as by a second unknown source (ADHS, 1985). This investigated area became part of the wider ECP Study Area. In 1987, the ECP Study Area was added to the WQARF Priority List.

Initial investigations focused on an automobile service station located near the well, and then were subsequently expanded to include investigations of a larger area surrounding the well inclusive of a former and current dry-cleaning facilities, a second service station, and a commercial retail and residential area along Fairmount Avenue to the south and west of the cleaners (**Figure 2**). Based on investigation results, two dry-cleaning establishments, the Former Viking Cleaners and Former Maroney's Cleaners & Laundry (Former Maroney's) facilities, and the Former Unocal service station are considered source areas for observed subsurface PCE impacts to the site.

The current boundary of the WQARF site is defined by the approximate limits of the PCE plume; it is approximately bounded by East Indian School Road to the north, North 32nd Street to the east, East Harvard Street to the south, and North 16th Street to the west. The PCE plume boundary depicted on the site Plan (**Figure 2**) represents ADEQ's interpretation of the data available at this time. The map is intended to provide the public with basic information as to the estimated extent of known PCE impacts to groundwater.

Two preliminary assessments (PAs) were prepared by Ecology and Environment, Inc. for the two former dry-cleaning establishments, Former Viking Cleaners and Former Maroney's facilities, in 1988 and 1989, respectively. Investigations and early response actions (ERAs), including the installation and operation of air sparging (AS) and soil vapor extraction (SVE) remediation systems, were performed at the site beginning in 1989. Full-scale SVE systems have been operated at both dry-cleaner facilities as ERAs, overlapping with the RI phase at the site.

The site was placed on the WQARF Registry List in May 2000, with an Eligibility and Evaluation Score of 29 out of 120. In June 2007, ADEQ sent out notices in accordance with Arizona Revised Statute (A.R.S.) §49-287.03 initiating the RI for the site. The most recent RI activity was a comprehensive site-wide groundwater sampling event in August 2018, and the most recent ERA activity was the attempted installation of a new SVE well in September 2018.

This report describes the results of RI activities conducted from June 2007 through October 2018. Historical information presented herein is a summary of investigations conducted by previous consultants and is summarized as necessary to meet the RI objectives described below.

1.1 Remedial Investigation Objectives

This RI report was prepared in accordance with A.R.S. §49-287.03 and Arizona Administrative Code (A.A.C.) R18-16-406(A). This RI summarizes field investigations in accordance with A.A.C. R18-16-406(C). Additionally, a site-specific risk evaluation to characterize the current risks to public health and the environment was conducted pursuant to A.A.C. R18-16-406(E).

1.2 Report Organization

This RI report summarizes the following information and data pertaining to the WQARF site:

- Physical setting of the site, including topography, climate, geology, and hydrogeologic setting;
- Site plans showing sampling locations;
- Analytical results for soil, soil vapor, indoor air, and groundwater samples, including comparisons to appropriate regulatory standards, criteria, and guidance;

- SVE system operations, monitoring, and maintenance;
- Groundwater flow direction, concentrations of groundwater contaminants of concern (COCs), and vertical profiling;
- An exposure route pathways model figure (depicted in **Figure 3** and discussed in **Section 6**);
- A discussion of the physical and analytical results;
- A land and water use study;
- Human health risk evaluations; and
- Gaps in data for the completion of the RI.

1.3 Site History

In 1997, ADEQ established the WQARF Registry, replacing the WQARF Priority List. In 1998, the ECP Study Area (of which this site was a part) was divided into six individual WQARF Registry sites:

- 24th Street and Grand Canal;
- 32nd Street and Indian School Road;
- 38th Street and Indian School Road;
- 40th Street and Osborn Road;
- 40th Street and Indian School Road; and
- 48th Street and Indian School Road.

The facilities investigated as potential source areas at 32nd and Indian School Road are located on three property parcels. The parcels have historically been occupied by dry-cleaning facilities and automobile service stations since the early 1960s, as described below. An *RI Final Letter Report* prepared by HydroGeoLogic, Inc. (2016) provides a more detailed description of operations, waste streams, releases, and regulatory actions for historical and current facilities located within the boundaries of the site. A copy is included as **Appendix A** for reference.

1.3.1 Former Maroney's Facility

The Former Maroney's facility (**Figure 4**), located at 3110/3188/3190/3192 East Indian School Road (Assessor's Parcel Number [APN] 163-01-020B, herein referred to as Parcel 020B), contains a former dry-cleaning and laundry facility that had been in operation from 1961 (Ecology and Environment, Inc., 1989) until September 2018, when it was sold. The suite is located within the Kachina Village Shopping Center property, which covers approximately 3.64 acres.

According to information provided to ADEQ by facility personnel during the 1988 PA, the dry-cleaning process involved mixing dry-cleaning solvents and detergent together in the dry-cleaning machine. Products reported to be used at the facility include PCE, Staticol, Picrin, and Pyratex. The spent solvents were reportedly stored in sealed containers, which were picked up by Safety-Kleen© once a month (estimated 55 gallons per month) (Ecology and Environment, Inc., 1989).

In 2015, a Phase I Environmental Site Assessment (ESA) was prepared by NV5 Environmental Services (NV5) of the Kachina Village Shopping Center; this assessment included Parcel 020B (NV5, 2015). At the time of the site reconnaissance on 20 July 2015, the Former Maroney's facility reportedly had a combined total of approximately 322 gallons of PCE inside three closed-system dry-cleaning machines. Based on NV5' review of hazardous waste files for the Former Maroney's facility, including annual summaries, annual fees, and waste manifests, it appeared that PCE hazardous waste was generated roughly every two months, with the quantity of waste ranging from 150 to 350 pounds. The waste was picked up, transported, and disposed of by Safety-Kleen©, an environmental subcontractor.

The facility operational history according to reviews by both NV5 and HydroGeoLogic, Inc. is as follows (NV5, 2015; HydroGeoLogic, Inc., 2016):

- Pride Laundry and Storage Co., Inc. – 1961 to 1962.
- Pride of Arizona – 1962.
- Flair Laundry-Cleaning & Storage, Inc. – 1962 to 1965.
- Maroney's Clean and Laundry / Maroney's Cleaners – 1964 to 2018.
- McKean's Laundry and Cleaning / Skaggs Drug Center/Liquors – 1968 to 1970.

1.3.2 Former Viking Cleaners Facility

The Former Viking Cleaners facility (**Figure 5**), located at 4027/4029 North 32nd Street (APN 127-34-135B, herein referred to as Parcel 135B), operated as a dry-cleaner and laundry from approximately 1966 until 2001 (the facility occupied the north portion of the building. In 2001, Viking Cleaners relocated their operations north to the property formerly occupied by Unocal Service Station #6453 (the Former Unocal service station) at 3201 East Indian School Road. Information on the products used at the Former Viking Cleaners facility was not available. The Former Viking Cleaners facility and the adjacent suite to the south (a former convenience store) are currently occupied by JC Printing. The facility operational history, according to HydroGeoLogic, Inc., is as follows:

- Viking Norge Village Dry Cleaning – 1966 to 1974.
- Former Viking Cleaners – 1973 or 1974 to 2001.
- Deluxe Leather Cleaners – 1975.
- Deluxe Leather Service – 1978 to 1982.
- Hollywood Autosport – 2002 to 2003.
- JC Printing – Present.

1.3.3 Former Unocal Service Station

The Former Unocal service station (**Figure 5**), located at 3201 East Indian School Road (APN 127-34-134B, herein referred to as Parcel 134B), operated at 3201 East Indian School Road from approximately 1960 to 1993; additionally, reportedly 18 different automobile service stations occupied this property beginning in 1960 (NV5, 2015). The underground storage tank (UST) system was removed in 1994 and the remaining site structures were demolished in 1995. In 1994, when PCE was detected in the soil beneath a removed waste oil UST and in used oil sludge from the UST interior, the property was sold to Viking Cleaners, LLC and redeveloped as the current Viking Cleaners. The facility operational history is as follows:

- Various automobile service stations, including Union Oil Company of California/ Unocal Service Station No. 6453 – approximately 1960 to 1993.
- [Current] Viking Cleaners – 1994 to Present.

The BTEX groundwater impacts from the Former Unocal service station commingled with the PCE impacts located near the Former Viking Cleaners site and extended from the Former Unocal service station southwest approximately 125 feet (ft); and in March 2008, ADEQ closed the Former Unocal service station LUST case based on declining BTEX concentrations (Stantec Consulting Services, Inc. [Stantec], 2012c). However, according to a 9 January 2018 Stantec notification letter to Viking Plaza LLC, Stantec contacted the property owner on behalf of Chevron Environmental Management Company to provide notification of proposed ADEQ-directed environmental field work on the parcel. Field work consisted of the installation and sampling of two groundwater monitoring wells and one soil boring. Further details were not provided in the document (Stantec, 2018). Work at this station is ongoing.

1.3.4 Fairmount Avenue Study Area

The Fairmont Avenue Study Area (FASA) is an area designated by ADEQ that is located southwest of and downgradient of the Former Maroney's and Former Viking Cleaners facilities (**Figure 6**). It is bounded to the north by Indian School Road, to the south by Clarendon Avenue, to the east by 32nd Street, and the west by N. 30th Street. The northern half of the FASA includes commercial and retail businesses, and the southern half includes residential condominiums and apartment complexes. During 2008 through 2013, ADEQ conducted a soil vapor investigation along 31st Street and Fairmont Avenue to help characterize COC impacts to the shallow subsurface soil. Results of investigations performed within the FASA are included herein as they pertain to the RI objectives.

1.3.5 Former Chevron Service Station #9-2599

A Former Chevron Service Station is located to the southeast of the Former Maroney's facility, near the intersection of 32nd Street and Indian School Road, at 3148 E Indian School Road in Phoenix (**Figure 4**). The APN is 163-01-020B. According to Stantec, as of February 2012, the property was occupied by a Chase Bank (Stantec, 2012a). According to a 2015 Phase I ESA, as of August 2015, the property continued to be occupied by Chase Bank (NV5, 2015). As part of the Phase I ESA, NV5 reviewed the LUST files for this facility. According to NV5' review, a total of four USTs were previously located at the Chevron facility. According to their review of ADEQ's records, there were three associated LUST cases, two of which were closed in 2002, and the other closed in 2006. NV5 considered this release to be a historical recognized environmental condition (HREC), since "the past release of petroleum products has been addressed to the satisfaction of the applicable regulatory authority and the LUST files were closed" (NV5, 2015).

1.3.6 Former Purcell Tire & Auto Service Facility

Goodyear and Purcell Tire Company, Inc. operated a tire and automobile service facility at the Kachina Village Shopping Center (**Figure 4**) at 3110 East Indian School Road, west of the Former Maroney's facility. This facility was included in the scope of the 2015 Phase I ESA by NV5. NV5 contracted Geo-Search to provide city directories on 15 July 2015 to identify past uses at this facility address. The directories were reviewed, if available, at approximately five-year intervals for the years spanning 1935 (or earliest developed use when applicable) through 2015 (not necessarily inclusive). The tenant history at this address according to the city directory review by year listed is as follows:

- Goodyear Tire Agency & Wholesaler/Western Stars Tire Sales – 1976, 1987, 1991.
- Goodyear Tire Agency & Wholesaler – 1981.
- Goodyear Tire/Purcell Western Stars – 1996, 2002.
- Purcell Tire & Rubber Co. – 2008.
- Purcell Tire & Auto Service – 2015 – unknown (currently closed and the building is vacant).

At the time of the site reconnaissance, NV5 observed five subgrade hydraulic lifts (Bays 1 through 5), one above-grade hydraulic lift (Bay 6), two 200-gallon aboveground storage tanks (ASTs) for antifreeze (one for new antifreeze, the other for used antifreeze), one 300-gallon AST for transmission fluid, one 700-gallon motor oil AST, and multiple containers, drums, and hazardous chemicals. Since NV5 observed minor amounts of staining on the concrete floor around the ASTs and hydraulic lift areas, they concluded that these features could have released chemicals into the environment and recorded this as a recognized environmental condition (REC) in the report. In August 2015, NV5 collected 10 wipe samples from the cylinders of the five hydraulic lifts and their associated reservoir plugs in the service bays. Bays 1 through 3 had one-cylinder hydraulic lifts, and Bays 4 and 5 had dual-cylinder hydraulic lifts. The 10 samples were submitted to an ADHS-certified laboratory for polychlorinated biphenyl (PCB) analysis per United States Environmental Protection Agency (USEPA) Method 8082. No PCBs were detected at or above laboratory reporting limits; thus, NV5 concluded "no further assessment regarding this REC is warranted at this time" (NV5, 2015).

NV5 reviewed records for this facility, including an April 1999 *UST Removal and LUST Site Assessment Report* prepared by Ryan-Murphy Inc. for the "Western States Tire and Auto Service" facility located at the same address. The report documented the excavation of one 500-gallon used oil UST located along the western wall of the facility. Since the original report was not available for review, the following is language from NV5' Phase I ESA regarding their review of the report:

> *"Based on the soil samples collected, the subsurface investigation indicated a minimal lateral and vertical extent of impact from the former used oil AST. Total petroleum hydrocarbons (TPH) were found in two of the shallow samples (10 feet or less) from the tank excavation area, however, TPH and [volatile organic compounds] were not detected above laboratory reporting limits in the other deeper samples. In addition, three offset borings were advanced near the UST excavation to further delineate any possible contamination. TPH and VOCs were not detected in soil samples collected in the soil borings. Groundwater was not encountered in the excavation or in the soil borings advanced near the UST excavation area. Ryan–Murphy concluded that the lateral extent of the contamination was limited to the UST excavation area, and the vertical extent was approximately 2 feet below the former UST cavity. Ryan-Murphy recommended that no further action was necessary at the tire facility."*

ADEQ closed the LUST file in 2000 and required no further action; thus, NV5 considered this release to be an HREC (NV5, 2015).

1.4 Contaminants of Concern

The following contaminants have been detected in samples collected from soil borings, soil vapor points (SVPs), SVE wells, and temporary and/or permanent groundwater monitoring wells installed to investigate and/or remediate the two dry-cleaner facilities and FASA.

Soil:

- PCE;
- Butyl benzyl phthalate;
- di-n-Butyl phthalate;
- di-n-Octyl phthalate;

- bis(2-Ethylhexyl) phthalate; and
- Metals (arsenic, barium, chromium, cobalt, copper, lead, mercury, nickel, selenium, vanadium, and zinc).

Soil Vapor:

- PCE;
- Trichloroethene (TCE);
- cis-1,2-Dichloroethene (cis-1,2-DCE);
- 1,2-Dichloroethane (1,2-DCA);
- 1,2,4-Trimethylbenzene (TMB) and 1,3,5-TMB;
- BTEX;
- 4-Ethyltoluene;
- Isopropylbenzene (cumene);
- Naphthalene;
- Cyclohexane and n-hexane;
- Methylene chloride;
- n-Heptane, n-nonane, and n-octane;
- Tetrahydrofuran;
- Chloroform, bromodichloromethane and dibromochloromethane;
- Tetrahydrofuran;
- Dichlorodifluoromethane (Freon 12); and
- Acetone.

Groundwater:

- PCE;
- TCE;
- cis-1,2-DCE;

- 1,2-DCA;
- 1,2-Dichloropropane (1,2-DCP) and propylene;
- Chloromethane;
- 1,2,4-TMB;
- TPH;
- BTEX;
- Methyl tertiary butyl ether (MTBE);
- 2-Butanone or methyl ethyl ketone (MEK);
- Diisopropyl ether;
- Isopropylbenzene (cumene) and n-propylbenzene;
- Acetone;
- Chlorobenzene; and
- Chloroform, chlorodibromomethane, dichlorobromomethane, total trihalomethanes (TTHM).

Based on the nature of the potential release from the two dry-cleaning establishments (Former Maroney's and Former Viking Cleaners facilities), the COCs at the site include the following based on their historical presence or based on their potential to be generated through biological transformations:

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

The detections of 1,2-DCA, 1,2-DCP, propylene (daughter product of 1,2-DCP), and chloromethane in groundwater were limited to single locations (three monitoring wells) and one-time sampling events in 2004, 2006, and 2007; since a locational pattern and concentration trend is lacking, and results were below respective Arizona Aquifer Water Quality Standards (AWQS), these are not considered site COCs.

The TPH, BTEX, cumene, naphthalene, cyclohexane, n-hexane, n-heptane, n-nonane, n-octane, n-propylbenzene, diisopropyl ether, 4-ethyltoluene, acetone, propylene, TMB, MEK, MTBE, and 1,2,4-TMB detections are likely associated with LUST releases from the Former Unocal and/or Former Chevron service stations and are not considered COCs. Although ADEQ began investigating benzene as a potential COC in 2011, it ceased to be within the scope of the site RI as of 2016 (HydroGeoLogic, Inc., 2016).

The trihalomethane detections (including chloroform, bromodichloromethane) and dibromomethane detections are likely associated with drinking water disinfection chemicals and not associated with source area facility operations; thus, are not considered site COCs.

The RI is focused on the distribution and fate and transport of the identified COCs; however, analytical results for additional contaminants analyzed are presented in the corresponding appendices (**Appendix H, Appendix I, and Appendix J**).

1.4.1 Chemical / Biological Transformation Processes

The chemical and biological transformation of the COCs is a relatively common occurrence. These transformation processes are discussed below.

Biological Transformation: The predominant degradation mechanism for natural attenuation of chlorinated ethenes is anaerobic reductive dechlorination, which involves the sequential replacement of chlorine atoms on the alkene molecule with hydrogen atoms. Under anaerobic conditions, PCE and TCE are dechlorinated through cis-1,2-DCE/trans-1,2-DCE and VC to ethene. Hydrogen typically produced during bacterial metabolism of simple organic carbon compounds such as alcohols (e.g., methanol) or organic acids (e.g., acetate), serves as the electron donor in the dechlorination reactions. Aerobic and anaerobic oxidation of lesser chlorinated ethenes (e.g., VC) can also occur. **Figure 7** shows the common biodegradation pathways for chlorinated ethenes.

Abiotic Transformation: Abiotic transformation of organic contaminants can occur naturally, without being mediated by microorganisms, and results in partial or complete contaminant degradation. Such processes include hydrolysis and, for select volatile organic compounds (VOCs), dehydrochlorination (elimination). Abiotic transformation is dependent on contaminant properties and groundwater geochemistry.

Abiotic transformation can also be facilitated by reactive minerals that are either present naturally (i.e., as part of the native geology/mineralogy) or produced/regenerated by biological processes (Brown *et al*., 2007; Parsons Infrastructure & Technology Group, Inc., 2008; Naval Facilities Engineering Command, 2014). Reactive minerals that promote abiotic transformation processes include iron sulfides (e.g., mackinawite, pyrite, greigite) and additional reduced iron minerals such as magnetite, green rust, and phyllosilicate clays (e.g., biotite and vermiculite). Abiotic transformation via reactive minerals has been documented for chlorinated solvents and is generally promoted in environments where both sulfate and iron are present under reducing conditions (Naval Facilities Engineering Command, 2014). Rates of abiotic transformation are typically much slower than for biodegradation.

Other Abiotic Mechanisms for Attenuation:

Sorption: Dissolved organic contaminants can sorb to aquifer materials (i.e., organic carbon, clay minerals). This process tends to reduce apparent contaminant transport velocity (i.e., retards transport relative to groundwater flow).

Dilution: Dilution is primarily the result of groundwater recharge (e.g., from precipitation), leading to reduced contaminant concentrations. This process is dependent on aquifer matrix properties, depth to groundwater, surface water interactions, and climate.

Dispersion: Dispersion is the result of fluid mixing due to groundwater movement and aquifer heterogeneities (causing tortious migration pathways), leading to longitudinal, transverse, and vertical spreading of groundwater impacts. This process, which reduces contaminant concentrations, is dependent on aquifer properties and scale of observation, but not contaminant properties.

Diffusion: Molecular diffusion results in the spreading and dilution of contaminants in groundwater. This process is dependent on COC properties and concentration gradients, as described by Fick's Laws. At most groundwater velocities, diffusion is less significant than dispersion.

Volatilization: Volatilization is the transfer of dissolved groundwater contaminants into the vapor phase (soil gas), resulting in lower contaminant concentrations in groundwater. This process is dependent on contaminant vapor pressure and Henry's Law constant.

These abiotic mechanisms are expected to reduce the concentrations of PCE and its daughter products as they migrate in groundwater downgradient of source area(s) through non-transformative processes.

2. PHYSICAL SETTING

The following subsections provide the physical setting of the WQARF site including topography, climate, and surface water.

2.1 Topography

Arizona is primarily divided into two main physiographic provinces: the Colorado Plateau and the Basin and Range (United States Geological Society [USGS], 1996). The site is situated within the Basin and Range physiographic province. The Basin and Range physiographic province consists of broad alluvial basins dissected by northwest-southeast trending block-faulted Precambrian through Tertiary igneous, sedimentary, and metamorphic highlands. These basins are filled with Holocene age alluvial sediments that are primarily derived from the weathering of these adjacent highlands, and consist primarily of fine-grained, well-sorted sediments, but also include coarse to gravelly channel, terrace, and alluvial fan deposits at depth (Rascona, 2005).

The site is located within the USGS Topo 7.5-Minute Phoenix map, which has a general topographic trend of decreasing elevations from the northeast to southwest. Monitoring well elevations in the central portion of the site range from 1,187 ft above mean sea level (amsl) in the northeast portion of the site (at monitoring wells MMW-04 and MMW-06) to 1,090 ft amsl in the southwest portion (at monitoring well VCMW-24; **Figure 2**).

2.2 Climate

The site is located within the semiarid climate of the northern Sonoran Desert. The region experiences hot summers and mild winters. Daytime high temperatures in July, typically the hottest month, are generally between 100 degrees Fahrenheit (°F) and 110°F, with overnight lows usually between 75°F and 85°F. January, usually the coolest month, typically experiences daytime highs between 60°F and 70°F and nighttime lows from 35°F to 45°F.

Annual precipitation is low, averaging from 7 to 8 inches for the greater Phoenix area. There are two distinct but erratic precipitation periods during the year: the monsoon season and the winter rains. The monsoon season occurs primarily in July and August, and in the winter months there are less intense but more widespread and longer-lasting rainfall events (Schmidli, 1996).

Prolonged droughts are common and shorter periods of drought even more so. Spring runoff from snow melt in the Salt, Gila, and Verde River watersheds provides most of the surface water stored by the reservoirs that serve portions of the metropolitan area's population. During years of winter drought, reduced surface water availability can result in elevated groundwater pumping (Schmidli, 1996).

2.3 Surface Water

The nearest man-made surface water body is the Arizona Canal, located approximately 1.75 miles to the northeast of the site; Grand Canal is located approximately 2 miles to the southwest. The closest natural surface water body to the is the Salt River, located approximately 5 miles south of the site.

Surface water usage associated with the Arizona Canal and Grand Canal is currently used for residential irrigation. The surface water source generally comes from the Salt River via the Arizona Canal, Grand Canal, associated laterals and various groundwater pumping wells.

2.4 Geology

2.4.1 Regional Geology

The site is located within the West Salt River Valley (WSRV) sub-basin, a broad, relatively level alluvial valley. The alluvium represents a combination of deposits from the surrounding mountains and fluvial deposits from the Salt River (HydroGeoChem, Inc., 2017).

2.4.2 Surficial Soil

Surficial soil in the area consists primarily of the Estrella loam and Gilman loam, with up to one percent slopes, according to H+A's review of 2017 data from the National Resources Conservation Service (NRCS) (United States Department of Agriculture [USDA], 2018). The Estrella loam is described as a loam to a depth of 24 inches, then a clay loam to a depth of 48 inches, underlain by gravelly clay loam to a depth of 60 inches. The Gilman loam is described as a loam to a depth of 37 inches where a very fine sandy loam is present to a depth of 64 inches.

2.4.3 Site Geology

Generally, the top 150 ft of subsurface is comprised of lenses of fine-grained and course-grained materials followed by primarily course-grained material. As described in the Arizona Department of Water Resources (ADWR) well registration records and boring log for SRP Well 17E-8N (ADWR 55-608431; **Figure 5**), when the well was drilled to a total depth of 250 ft below ground surface (bgs), sandy clay was encountered from 0 to 7 ft bgs, followed by caliche to 30 ft bgs, sandy clay and gravel to 125 ft bgs, cemented sand and gravel to 215 ft bgs, and bedrock to total depth. In the southwestern region of the site, the lithology has been investigated to a maximum depth of 408 ft bgs in monitoring well VCMW-24, and next maximum depth of 390 ft bgs at VCMW-29 (**Figure 2**). The lithology encountered in VCMW-24 was primarily sandy-silt and silty-sand with clay layers and gravel seams occurring at various depths. Caliche was observed at a depth of approximately 250 ft bgs in VCMW-24. The VCMW-24 boring log is included in **Appendix B**.

Soil physical parameters from site samples were evaluated under the direction of H+A in 2015. Five soil borings were drilled in areas surrounding the Former Viking Cleaner's facility (SS-01, SS-02, SS-03R, SS-04 and SS-05; **Figure 5**). Soil samples were collected from the borings at depths of approximately 5, 15, and 45 ft bgs. Samples were collected in Macro-Core® liners and transported to a geotechnical laboratory where they were analyzed for specific gravity by American Society of Testing and Materials (ASTM) D854 and percent organic matter content by ASTM D2974. The laboratory also calculated the dry density, porosity, and moisture content of the samples (H+A, 2015i). The results of the testing indicated site soils have an average specific gravity of 2.66, average percent of organic matter of 0.72%, average dry density of 92.4 pounds per cubic ft, average porosity of 0.44 and an average moisture content of 10.0%.

2.5 <u>Hydrogeologic Setting</u>

2.5.1 Regional Groundwater Conditions

The site lies within the WSRV Sub-basin of the Phoenix Active Management Area (AMA), which includes the communities of Phoenix, Buckeye, Surprise, Glendale, Peoria, Goodyear, Tolleson, and Avondale. The WSRV is one of seven sub-basins located in the Phoenix AMA. The AMA was established due to concerns of over-draft conditions, resulting in the passage of the 1980 Arizona Groundwater Management Act. Although conditions and circumstances vary across the Phoenix AMA, groundwater is generally pumped from the deeper portions of the Upper Alluvial Unit (UAU). Furthermore, groundwater conditions change and develop over time due to both natural and human-induced fluctuations in the amount of water being added or removed. Natural groundwater recharge occurs along stream channels and from mountain-front recharge. Groundwater also enters the sub-basin from the Lake Pleasant, northern Hassayampa, and East Salt River Valley sub-basins, and from the Maricopa-Stanfield Sub-basin in the Phoenix AMA. Agricultural irrigation water and effluent discharged from the COP 23rd and 91st Avenue wastewater treatment plants also contributes to recharging the aquifer (NV5, 2015).

2.5.2 Site Hydrostratigraphy

In 1993, ADWR released the results of its modeling study of the Salt River Valley (Corkhill *et al*., 1993). For modeling purposes, the ADWR defined three hydrogeologic units in the Basin fill by differences in grain size that occur throughout most of the Phoenix Basin and are generally correlative with the hydrostratigraphic units defined by the United States Bureau of Reclamation in 1976. These include from the shallowest to deepest: the UAU, the Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU).

2.5.2.1 Upper Alluvial Unit

The UAU consists of unconsolidated sands and gravels deposited by flowing drainages and is the most permeable unit. According to the ADWR, the UAU is typically 300 to 400 ft thick in the WSRV. Where thick saturated sections of the UAU are present, the groundwater production rates are the highest in the region.

2.5.2.2 Middle Alluvial Unit

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 LAU, coarser-grained sediments predominate near the Basin margins, where the MAU is indistinguishable from the overlying or underlying units.

2.5.2.3 Lower Alluvial Unit

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 Western Salt River Valley also contain some interbedded lava flows. The LAU overlies crystalline and volcanic bedrock (HydroGeoChem, Inc., 2017).

2.6 Site Hydrogeology

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; however, the UAU ranges in thickness from approximately 125 to more than 300 ft in the ECP WQARF sites region. The UAU within the ECP WQARF sites consists of predominantly fine-grained sands, silts and silt with sand, to sandy silts with trace amounts of gravel. The groundwater surface within the site lies within the UAU.

Groundwater elevations in the UAU have been monitored since December 1996 (**Table 1** and **Appendix C**). Monitoring wells installed at the site are screened across both shallow (water table) and deeper intervals within the UAU (**Table 2**). Water levels in co-located shallow and deeper screened monitoring wells are generally nearly identical.

During the period of record for source area monitoring wells in the Former Maroney's facility and Former Viking Cleaners facility, 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 in groundwater monitoring well VCMW-24.

Groundwater elevations at the site declined approximately 2 to 3 ft between 2013 and 2015. The decline may be due to the pumping operations of SRP well 17E-8N (**Figure 5**) and drought conditions.

Seasonal fluctuations in the groundwater elevation are commonly observed in the Phoenix AMA due to an increase in SRP (and COP) production well pumping rates typically occurring March through August. However, a review of the historical groundwater elevations (**Table 1**) does not suggest significant seasonal groundwater fluctuations within the boundary of the WQARF site (**Figure 2**).

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

2.7 Ecology

The site is located in an urban setting that provides low-quality habitat for native terrestrial or aquatic biota. Given the presence of roads and extensive man-made structures, it is likely that the natural vegetation, soils, and hydrology have been altered by filling, grading, and improvement activities in the past. There is a low potential for native terrestrial or aquatic biota to occur in the area. According to Google Maps, the closest large, natural open-space (Los Olivos Park) is located approximately 500 ft to the northwest of the site.

Based on information provided through the United States Fish and Wildlife Service (USFWS) online Information, Planning and Conservation (IPaC) System and by the Ecological Services Program, there are seven federally listed endangered species with the potential to occur on lands within Maricopa County, including: ocelot (*Leopardus* or *Felis pardalis*), Sonoran pronghorn (*Antilocapra americana sonoriensis*), California least tern (*Sterna antillarum browni*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax traillii extimus*), yellow-billed cuckoo (*Coccyzus americanus*), and Yuma clapper rail (*Rallus longirostris yumanensis*). Additionally, there are a six species of endangered fish and four species of flowering plants (USFWS, 2018). The site and immediate vicinity do not contain suitable habitat for these species.

3. PRELIMINARY ASSESSMENTS AND INVESTIGATIONS

This section presents a summary of PAs, Phase I ESAs, and preliminary investigations (PIs) performed at the 32nd Street and Indian School Road site prior to the commencement of ERA investigations and remediation activities. Analytical results from laboratory reports and electronic files (**Appendices G through J**) are included in **Tables 4 through 7**.

3.1 East Central Phoenix WQARF Site

The WQARF site has been the focus of environmental investigations since 1983, following the detection of VOCs in SRP production well 17E-8N (**Figure 5**). This well is located near the southeast corner of North 32nd Street and East Indian School Road, approximately 60 ft northeast of the Former Viking Cleaners facility (**Figure 5**). The reported concentrations of PCE in samples collected from well 17E-8N between 1983 and 1986 ranged from 6.75 micrograms per liter (µg/L) to 66.7 µg/L (ADHS, 1985; Ecology and Environment, Inc., 1988). Due to these PCE detections, several properties in the ECP region were investigated to locate potential sources for these VOC impacts to groundwater. The facilities listed below operated on-site and were investigated:

- Maroney's Cleaners & Laundry, Inc. / Former Chevron Service Station No. 9-2599 (Former Maroney's facility) (Parcel 020B).
- Former Viking Cleaners, Inc. / Viking Norge Village / Deluxe Leather Cleaners (Former Viking Cleaners facility) (Parcels 135B and 134B).
- Former Union Oil Company of California Service Station No. 6453 and prior service station occupants (Former Unocal service station) / Viking Cleaners (Former Viking Cleaners facility) (Parcel 134B).

The investigations are summarized below in chronological order. Historical analytical results are presented in **Tables 4** through **7**.

3.2 Former Maroney's Facility

This section summarizes assessments performed at the Former Maroney's facility and associated findings.

3.2.1 1989: Soil Vapor Survey

One soil vapor sample was collected in October 1989 from a borehole (Site-3; **Figure 4**) located on the north side of the Former Maroney's suite. The sample was collected from a depth of 18.5 ft bgs. The reported concentrations were greater than 15,000 micrograms per cubic meter (µg/m^3) of PCE, 80 µg/m^3 of TCE, and 60 µg/m^3 of 1,1,1-trichloroethane (TCA) (The Earth Technology Corporation, 1989).

3.2.2 2000-2007: Phase II Soil, Soil Vapor, and Groundwater Assessments

In June 2000, a limited Phase II ESA to was conducted to evaluate soil and groundwater in the vicinity of the Former Maroney's facility (Brown and Caldwell, 2000).

In June 2000, 10 SVP borings (SG-01 through SG-10) and groundwater monitoring wells (MMW-01 and MMW-02) were installed at the Former Maroney's facility (**Figure 4**). Probes were installed at 5 and 10 ft bgs in the 10 borings, and additional probes were installed at 15 ft bgs in SG-02 through SG-07. A total of 26 soil vapor samples were collected from these probes and analyzed for PCE, TCE, and TCA. The maximum reported PCE concentrations in soil vapor was 15,000,000 µg/m^3 in SG-05 (located near the sewer line in the alley just north of the Former Maroney's facility) at 15 ft bgs. The maximum reported TCE concentrations in soil vapor was 1,200,000 µg/m^3 in SG-06 at 5 ft bgs. These concentrations exceed the health-protective concentrations (HPCs), developed by ADEQ, for 5-foot samples. TCA was not detected in any of the soil gas probes. The wells were installed to depths of 60 ft bgs. The reported PCE concentrations in groundwater sampled by non-depth discrete methods were 8.2 µg/L in MMW-01 and 28 µg/L in MMW-02 The reported chloroform concentrations in groundwater were non-detect in MMW-01 and 3.4 µg/L in MMW-02 (H+A, 2002). TCE was not reported in samples from either well (Brown and Caldwell, 2000; H+A, 2002; NV5 , 2015).

Multiple groundwater monitoring and sampling events from 2002 to 2006 included these wells; details and results from these sampling events are included in the following sections.

3.3 <u>Former Viking Cleaners Facility</u>

This section summarizes assessments performed at the Former Viking Cleaners facility and associated findings.

3.3.1 1984: Soil Investigation

SRP received anonymous information about illegal solvent dumping, and on 25 July 1984, SRP collected two surface soil samples ("east sample" and "west sample") from a visually discolored area in the alley adjacent to the north of the Former Viking Cleaners facility. A sample location figure was not identified. The headspaces of the samples were analyzed for PCE, TCE, and TCA via chromatography. A chromatograph peak identified as PCE was reported in both samples; however, no other information is provided (H+A, 2002).

3.3.2 1989: Soil Vapor Survey

Two SVP borings (Site-1 and Site-6; **Figure 5**) were installed in the vicinity of the facility on 4 October 1989 and collected soil vapor samples from 17.5 ft bgs and 29.1 ft bgs in Site-1 and from 11.1 ft bgs in Site-6. The maximum reported concentrations were 25,000 $\mu g/m^3$ of PCE in Site-1 at 29.1 ft bgs, 2,200 $\mu g/m^3$ of TCE in Site-1 at 29.1 ft bgs, and 180 $\mu g/m^3$ of TCA in Site-1 at 17.5 ft bgs (The Earth Technology Corporation, 1989).

3.4 Former Unocal Service Station

The Former Unocal service station parcel is the location of the current active Viking Cleaners operations. The following is a summary of investigations that occurred on this parcel specifically in relation to historical service station operations.

3.4.1 Pre-1994 to 1994: Soil and Sludge Investigation

In 1984, during excavation of a used oil UST, stained soil was observed, and there was visual evidence that the tank sides were leaking. The LUST case file number established with ADEQ was 876.01-876-06. Soil samples were collected at 10 ft bgs and 12 ft bgs and analyzed for TPH and VOCs. The sample from 12 ft bgs (Sample 9) contained PCE and TCA at concentrations of 13 milligrams per kilogram (mg/kg) and 0.72 mg/kg, respectively.

In 1989, during excavation of a steel waste oil UST, corrosion holes in the tank were observed. Impacted soils were excavated, and a confirmation soil sample was collected at the bottom of the excavation, approximately 8 ft bgs. The soil samples were analyzed for TPH, which was reported at 10 mg/kg.

3.4.2 1995: Phase I Preliminary Site Assessment and Phase II Soil Investigation

HLA conducted a Phase I preliminary site assessment of the service station property and prepared a 30 June 1995 report for the Former Unocal service station to document these activities (*Phase I Preliminary Site Assessment, Unocal Service Station No. 6453, 3201 East Indian School Road*, *Phoenix, Arizona*). HLA then conducted a second phase of soil investigations in March 1995 to vertically and horizontally delineate TPH impacts. One soil boring (SB-12) was drilled at the approximate center of the former tank and was sampled at 5-foot intervals between 11.5 ft and 26.5 ft bgs. Samples were analyzed for TPH and BTEX. The sample from 21.5 ft bgs (SB-12-21.5) was additionally analyzed for chlorinated VOCs (CVOCs); none were detected above laboratory reporting limits (RLs).

HLA prepared a 30 June 1995 report of these investigation activities for the Former Unocal service station (*Phase II Investigation, Interim Report, Unocal Service Station No. 6453, 3201 East Indian School Road, Phoenix, Arizona*). Further details of these Phase I and II assessments (including the boring log for SB-12) are unavailable since copies of these reports were not obtained from ADEQ records. However, according to the summaries of these documents prepared by H+A (2002) and SECOR (2007a), the surrounding borings were not drilled close enough to the potential source area to ascertain the potential extent of impacts.

3.4.3 1996-1998: Groundwater Investigation and Summary

The following groundwater wells installed to investigate the Former Unocal LUST case in the years indicated:

- 1996 – UMW-01 through UMW-04.
- 1997 – UMW-05.
- 1998 – UMW-06 through UMW-09.

The above wells were completed between 55 to 60 ft bgs (**Table 1**). Well UMW-05 was abandoned in 2016. Due to damage to the well, UMW-06 was replaced with a well advanced to 80 ft bgs, UMW-06R, in 2017 (H+A, 2017a). Currently, the majority of these wells are dry due to a declining water table in the area (**Appendix C**).

Basin & Range Hydrogeologists (B&R) summarized groundwater investigations conducted from 1996 to 1998 at the Former Unocal service station in a 16 June 1998 report for Tosco Marketing Company (*Site Characterization Report – Groundwater,* *Unocal No. 6453*). A copy of this report was not obtained from ADEQ records for review; however, according to H+A's summary of this document within its *Draft Data Needs Report* (2002), analyses of samples collected at upgradient and downgradient wells (UMW-01 and UMW-04; **Figure 5**) indicated a substantial increase of CVOC concentrations in the downgradient direction. Maximum detected PCE concentrations in groundwater samples were 150 μg/L in 1996 and 53 μg/L in 1998. TCE was detected in groundwater samples at a maximum concentration of 5.6 μg/L in 1996 and was not detected above the RL in 1998.

In 1998, a groundwater monitoring well (UMW-09, **Figure 5**) was installed in the alley north of the Former Viking Cleaners facility and south of the Former Unocal service station. This well was sampled once in January 1998 and once in April 1998. PCE was detected in both groundwater samples, with concentrations of 730 μg/L and 470 μg/L in January and April, respectively. Other VOCs were not detected. The investigation and results were summarized in a later report by H+A (2002).

PCE and TCE concentrations decreased over time, likely due to biodegradation associated with anaerobic conditions caused by the presence of hydrocarbons in soil and groundwater (H+A, 2002). Groundwater samples were collected and analyzed through 2006 as part of the WQARF groundwater monitoring program (SECOR, 2007b).

3.5 Fairmount Avenue Study Area

PA reports of this area were not obtained for review during preparation of this RI, since the FASA is not considered a source area for site COCs. An ERA conducted at the FASA to address downgradient impacts from the Former Viking Cleaners facility is discussed in **Section 5**.

4. REMEDIAL INVESTIGATION

In June 2007, based on groundwater monitoring results with reported PCE concentrations exceeding the AWQS, ADEQ sent out notices per A.R.S. Section 49-287.03 initiating the RI. The FASA (**Figure 6**) 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 (**Figures 4** and **5**). The FASA was investigated from 2008 through 2013 for potential impacts from the Former Viking Cleaners facility; a summary of findings is provided in this report. RI activities were conducted at the site from June 2007 through August 2018 and described herein.

4.1 Soil Investigations

From April 2011 to May 2012, approximately 26 soil borings were advanced (MSG-01 through MSG-10, VCMW-06, FMW-1 through FMW-4, and FSVE-01 through FSVE-11), approximately 30 SVPs were installed (VSG-01 through VSG-05, VSG-06 through VSG-11, VSG-15 through VSG-18, MSVE-01 through MSVE-05, MSG-11 through MSG-20), and two SVE wells were installed (SVE-06 and VSS-01) throughout the WQARF site. Soil samples were collected at various discrete depths from approximately 1 to 25 ft bgs and analyzed for VOCs. Reported PCE concentrations ranged from non-detect in several samples to 0.36 mg/kg in VSG-09 at 1 ft bgs in the eastern portion of the Former Viking Cleaners suite. TCE was not reported above the laboratory RL. Additionally, toluene was reported at a concentration of 0.07 mg/kg in MSG-10 at 5 ft bgs in the alley north of the Former Maroney's suite (Stantec, 2012c; Stantec, 2012d; Stantec, 2012e; Stantec, 2012j; Stantec, 2012k; Stantec, 2012l).

In February 2012, soil samples were collected from well VCMW-05A from 64 and 70 ft bgs. Soil treatability testing and microbial analyses (to evaluate microbial populations of de-chlorinating bacteria) were performed on both soil samples, which included testing for the following parameters: pH, alkalinity, percent moisture content, percent organic matter content, natural oxidant demand (NOD), soil reductive demand, arsenic, iron, and manganese. VOCs were not analyzed. Results were reported to ADEQ and may be incorporated into the future feasibility study (FS) report for the site (Stantec, 2012m). Results are as follows for the VCMW-06-64/VCMW-06-70 samples, respectively:

- Soil pH: 8.85 / 8.23;
- Soil alkalinity: 46.1 / 32.6 grams of calcium carbonate per kilogram of soil;

- Soil moisture: 19 / 7.4%;
- Soil organic matter: 1.7 / 0.7%;
- NOD: 7.7 / 3.7 grams per kilogram (g/kg);
- Soil reductive demand: 73 / 32 g/kg;
- *Dehalococcoides spp.*: 811 / <1,000 cells per gram;
- Arsenic by USEPA Method 6010B: 7.7 / 5.4 mg/kg;
- Iron by USEPA Method 6010B: 12,000 / 4,20 mg/kg; and
- Manganese by USEPA Method 6010B: 170 / 30 mg/kg.

In April 2015, five soil borings (SS-01 through SS-05) were advanced at the Former Viking Cleaners facility (**Figure 5**). A total of 15 soil samples were collected from approximately 5, 15, and 45 ft bgs and analyzed for physical parameters.

In May 2017, Geosyntec advanced angled boring MSVE-11 (**Figure 4**) to approximately 70 ft bgs beneath the Former Maroney's suite (Geosyntec, 2017b). Soil samples were collected at 10-foot intervals from 15 to 65 ft bgs and analyzed by USEPA Method 8260B. PCE was not detected above the laboratory RL in samples collected.

In September 2017, Geosyntec advanced vertical soil boring MSVE-12 (**Figure 4**) inside the Former Maroney's suite to approximately 12 ft bgs and collected soil samples at 3, 5, and 10 ft bgs (Geosyntec, 2017c). The samples were analyzed for VOCs by USEPA Method 8260B. PCE was detected above the laboratory RL in two samples: 77 mg/kg in the 3 ft bgs sample, exceeding the GPL and RSRL; and 0.16 mg/kg in the 5 ft bgs sample, below the GPL and RSRL.

4.2 Soil Vapor and Indoor Air Investigations

4.2.1 2008-2011: FASA Soil Vapor Investigations

From April 2008 to March 2011, passive soil vapor surveys were performed within the FASA. The passive soil vapor survey was a semi-quantitative evaluation, with results presented as mass uptake only (not concentrations). The highest PCE mass uptake was observed in samplers reportedly located in the FASA along East Fairmount Avenue between North 30th Street and North 31st Street, with a maximum concentration of 66,800 nanograms (Stantec, 2012b).

From April 2010 to May 2011, 33 triple-nested SVPs (at 5, 10, and 15 ft bgs) were installed (SG-01 through SG-33; **Figure 6**) in the FASA along East Fairmount Avenue between North 32nd Street and North 30th Street, along North 31st Street, and on the east side of the shopping center. The SVPs were sampled from April to June 2010 and in February 2011. The maximum reported PCE and TCE concentrations were 36,000 $\mu g/m^3$ at SG-13 and 240 $\mu g/m^3$ at SG-18, respectively; these SVP were located near the intersection of East Fairmount Avenue and North 31st Street. The SVPs were again sampled in January 2012. The maximum reported PCE and TCE concentrations were 22,000 $\mu g/m^3$ in SG-13 and 270 $\mu g/m^3$ in SG-18, respectively. The PCE concentrations exceeded the HPC for 5 and 15 ft bgs samples during both sampling events (ADEQ, 2018b; Stantec, 2011a; Stantec, 2012g).

4.2.2 2011: FASA Soil Vapor Pilot Testing

In January 2011, two SVE test borings were advance and completed as test wells (TW-1 and TW-2) to 31 and 51 ft bgs, respectively. Six triple-nested SVE observation borings were also advanced to 61 ft bgs that were converted to soil vapor wells (OBS-1 through OBS-6) screened from 10 to 20, 30 to 40, and 50 to 60 ft bgs. The soil vapor wells were installed within the FASA near the intersection of East Fairmount Avenue and North 31st Street (**Figure 6**)(Stantec, 2012b).

In February and December 2011, an SVE pilot test was conducted. TW-1, TW-2, and SVPs (OBS-1 through OBS-6, SG-10 through SG-15, and SG-17 through SG-20) in the vicinity of the test wells were sampled before, during, and after the test. The SVP and SVE system samples were analyzed for VOCs by USEPA Method 8260B. Initial PCE concentrations ranged from 1,100 $\mu g/m^3$ in SG-11 and SG-20 (both at 5 ft bgs) to 40,000 $\mu g/m^3$ in OBS-3 at 50-60 ft bgs. Results were below the HPCs for their respective 5 and 45 ft bgs depths. During and after the pilot test, the maximum concentrations of PCE in OBS-3 decreased to 9,200 $\mu g/m^3$ and 26,000 $\mu g/m^3$, respectively. Concentrations of PCE generally rebounded following pilot test completion. PCE concentrations rebounded following the pilot test but remained lower than original concentrations (Stantec, 2012a). The pilot test results indicate that SVE could be an effective treatment technology for the FASA.

4.2.3 2011: Former Maroney's Facility Soil Vapor Investigations

From February to May 2011, 10 triple-nested SVPs were installed at the former Maroney's facility (MSG-01 through MSG-10; **Figure 4**) and soil vapor samples were collected from groundwater monitoring well MMW-01 and dual-nested SVE/groundwater monitoring wells MMW-03S/D and MMW-04S/D at the Former Maroney's facility (**Figure 4**). Reported PCE and TCE concentrations in initial soil vapor samples ranged from non-detect for both analytes to 300,000 μg/m^3 of PCE and 3,800 μg/m^3 of TCE, both in MSG-09, at 5 ft bgs. Contaminants TCA and cis-1,2-DCE were also reported in the samples (Stantec, 2012c). The tracer leak detection vapor was reportedly detected in some of the samples (Stantec, 2012f), indicating dilution with ambient air likely occurred.

4.2.4 2011: Former Viking Facility Soil Vapor Investigations

In May 2011, triple-nested SVPs were installed (VSG-01 through VSG-05) with screen openings at 5, 10, and 15 ft bgs on the east side of the Former Viking Cleaners suite (**Figure 5**). Soil vapor samples were collected and analyzed for VOCs. Reported PCE concentrations ranged from 1,600 μg/m^3 in VSG-05 at 5 ft bgs to 350,000 μg/m^3 in VSG-02 at 5 ft bgs. PCE concentrations increased with depth in four out of the five SVPs. TCE was detected above the laboratory reporting limit only in samples collected from VSG-02, with reported concentrations ranging from 1,200 μg/m^3 to 2,400 μg/m^3, below the HPC for 5-foot samples (Stantec, 2012d; Stantec, 2012g).

4.2.5 2011: Former Maroney's Facility Soil Vapor Pilot Testing

From May to September 2011, an SVE pilot test was conducted at the Former Maroney's facility using test wells in locations where the highest PCE concentrations were previously reported, MMW-03S (screened 10 to 25 ft bgs) and MMW-03D (screened 30 to 80 ft bgs). Soil vapor samples had been collected in May 2011 (prior to the test) and were collected during and after the test from the soil vapor wells located closest to the extraction wells. Soil vapor samples were analyzed for VOCs by USEPA Method TO-15. Maximum reported PCE concentrations in soil vapor were 300,000 μg/m^3 in MSG-09 at 5 ft bgs at the start to 200,000,000 μg/m^3 in MSG-09 at 5 ft bgs at the end of the test, exceeding their 5-foot HPCs. Geosyntec's interpretation of the MSG-09 data is that the concentration units were incorrectly stated, as this result is three orders of magnitude greater than historical results from this SVP. Soil vapor results showed that PCE concentrations decreased in most SVPs. A rebound test was performed and PCE concentrations increased; however, overall results suggested that SVE could be an effective treatment technology for the Former Maroney's facility (Stantec, 2012h).

4.2.6 2011-2012: Former Viking Facility Soil Vapor Investigations

From 2011 to January 2012, multiple SVPs (VSG-15 through VSG-18 and others), approximately six sub-slab SVPs (VSG-06 through VSG-11), one SVE well (SVE-06), and one sub-slab vapor extraction well (VSS-01) were installed at the Former Viking Cleaners facility (**Figure 5**; Stantec, 2012e; Stantec, 2012i). The initial soil vapor samples collected from these SVPs had PCE concentrations ranging from non-detect to 350,000 $\mu g/m^3$ and TCE concentrations ranging from non-detect to 2,400 $\mu g/m^3$, exceeding the HPCs for 5 ft bgs samples for both analytes (Stantec, 2012g). Two SVE wells and another 10 SVPs were installed. Stantec conducted an SVE pilot test using test wells SVE-06 and VCMW-01, both screened from 35 to 60 ft bgs. Soil vapor samples were collected prior to, during, and after the SVE pilot test from the SVPs located closest to the extraction wells. Soil vapor samples were analyzed for VOCs. Before SVE commenced, reported PCE concentrations ranged from 77 $\mu g/m^3$ in V-SVE-01SR to 1,200,000 $\mu g/m^3$ in VSG-09. During SVE operations, reported PCE concentrations ranged from non-detect in VSG-05 to 230,000 $\mu g/m^3$ in VSG-02B. Immediately post-SVE operations, reported PCE concentrations ranged from 96 $\mu g/m^3$ in V-SVE-03S to 400,000 $\mu g/m^3$ in VSG-02A.

Some concentrations exceeded the depth-specific HPCs. Results demonstrated that PCE concentrations decreased in the majority of the SVPs. During a soil vapor rebound monitoring event, PCE concentrations increased; however, overall results suggested that SVE could be an effective treatment technology for the Former Viking Cleaners facility (Stantec, 2012g).

4.2.7 2012: Former Maroney's Facility SVE System Investigations

In January and February 2012, 10 triple-nested SVPs (MSG-11 through MSG-20) and five additional SVPs (MSVE-01 through MSVE-05) were installed at the Former Maroney's facility to monitor the SVE system. Borings MSG-11 through MSG-20 were advanced to approximately 15.5 ft bgs with probes at 5, 10, and 15 ft bgs. Borings MSVE-01 through MSVE-05 were advanced to approximately 50 ft bgs and screened from 10 to 50 ft bgs (Stantec, 2012l). Additionally, the SVE system piping was installed as discussed in **Section 5.1**.

4.2.8 2012: FASA Soil Vapor Investigations

From March to May 2012, boring SG-34 was advanced to 15.5 ft bgs and completed it as an SVP and 14 SVE wells were installed (FSVE-01 through FSVE-11, V-SVE-01SR, SVE-07, and SVE-08; **Figure 5**). SG-34 was located in the southwestern portion of the FASA along North 30th Street between East Fairmount Avenue and East Clarendon Avenue (**Figure 6**). Stantec sampled SG-01 through SG-34, as well as 45 temporary SVPs adjacent to the residential developments in the FASA (**Figure 6**). Maximum reported PCE concentrations were 27,000 $\mu g/m^3$ in SG-13 (similar to previous sampling events) and 99,000 $\mu g/m^3$ in SG-33, exceeding the depth-specific HPCs for 5- and 15-foot samples, respectively. Within the temporary SVPs, maximum reported PCE concentrations were detected near the intersection of East Fairmount Avenue and North 31st Street (SG-159) to North 30th Street between East Fairmount Avenue and East Clarendon Avenue (SG-133). TCE was not detected above the laboratory RL in the SVPs within the FASA (Stantec, 2012j; Stantec 2012k).

4.2.9 2012: Site-Wide Soil Vapor Investigations

In May and June 2012, 61 permanent nested SVPs were installed (SG-01 through SG-24, SG-26 through SG-34, MSG-01 through MSG-19, and VSG-15 through VSG-18) at multiple depths of 5, 10, and/or 15 ft bgs, and advanced 72 temporary SVPs (SG-100 through SG-161, SG-201 through SG-212, and SG-301 through SG-318) throughout the Former Viking Cleaners facility, Former Maroney's facility, and FASA (**Figures 4** through **6**). Soil vapor samples were collected and analyzed for PCE and TCE by USEPA Method TO-14, and approximately 10 percent of the samples were also analyzed for VOCs by USEPA Method 8260SV. A total of 331 samples were collected for the PCE and TCE TO-14 analysis and 37 samples were collected for the VOC 8260SV analysis. Site-wide results are discussed below:

- In the Former Viking Cleaners facility, soil vapor samples were collected from triple-nested monitoring wells and borings located at and in the alley north of the building. PCE was reported in 27 out of the 27 dedicated SVP samples and in 4 out of the 18 temporary SVP samples. Among the dedicated SVPs, the maximum detected PCE concentration was 4,400,000 $\mu g/m^3$ in VSG-02. TCE was detected above the laboratory reporting limit only in VSG-02 at 23,000 $\mu g/m^3$. Among the temporary SVPs, the maximum detected PCE concentration was 5,200 $\mu g/m^3$. TCE was not detected above the laboratory reporting limit.
- In the Former Maroney's facility, PCE was detected in 56 out of the 56 dedicated SVP samples and in 14 out of the 35 temporary SVP samples. Among the dedicated SVPs, the maximum reported PCE concentration was 510,000 $\mu g/m^3$ in MSG-09 (located adjacent to the pilot test previously conducted in well

MMW-03). TCE was reported in only one sample (MSG-04), at a concentration of 98 μg/m^3. Among the temporary SVPs, the maximum reported PCE concentration was 1,100 μg/m^3 in SG-313. TCE was not detected above the laboratory RL.

- In the FASA, PCE was detected in 78 out of the 107 SVPs samples and in 62 out of the 88 temporary soil vapor boring samples, with a maximum concentration of 4,100 μg/m^3. TCE was not detected above the laboratory RL (Stantec, 2012m).

Continued soil vapor monitoring through 2012 indicated that PCE impacts had not been fully delineated and that reported concentrations suggested a potential risk of vapor intrusion; this led to additional soil vapor sampling in 2013 (Hartman Environmental Geoscience [HEG], 2013), further discussed in **Section 4.2.13**.

4.2.10 2013: Former Viking Facility Soil Vapor Investigations

In 2013, two temporary SVPs were installed (VC-01 and VC-02) south of the Former Viking Cleaners facility (**Figure 5**). Detected PCE concentrations were 1,800 μg/m^3 and 85 μg/m^3, respectively, below the depth-specific HPC in both but exceeding the reported residential soil vapor screening level of 313 μg/m^3 and 70 μg/m^3, respectively, in VC-01. Results are provided in a 2014 report, *Soil Vapor Sampling and Indoor Air Assessment Summary Report* (HEG, 2014a).

4.2.11 2013: FASA Soil Vapor Investigations

In August 2013, 48 temporary SVPs were installed and sampled within the FASA at the northern and southern portions of Fairmount Villa Apartments, at the northern portion of the Lofts at Arcadia, within the western portion of Via Seville, and along East Clarendon Avenue east of North 28th Street. Results are provided in a Soil Gas Data Summary table (H+A, 2013d) and in a report (2014a), The maximum reported PCE concentrations were 3,500 μg/m^3 in FV-12, located near the Fairmount Villa Apartments, and 3,200 μg/m^3 in VS-31, located near Villa Seville at the intersection of North 28th Street and East Weldon Avenue. Both concentrations are below the HPC.

4.2.12 2013: Site-Wide Indoor Air Investigations

A request for access to sample was made to 290 residential locations located within and beyond the FASA (**Figure 6**) by door-to-door survey to evaluate the potential vapor intrusion pathway. Access was granted to 89 of the residences and the buildings were sampled in August 2013. It is assumed one sample was collected per residential structure (residence). Indoor air samples were collected from residences located at areas of soil vapor impacts; soil vapor samples were additionally collected from the vicinity of the Larry Kennedy School located at the intersection of East Osborn Road between North 27th and North 28th Street. Work was performed in accordance with a 28 August 2013 Work Plan (2013). According to a draft document from H+A, findings were reportedly summarized in a 2014 H+A summary document, *Soil Vapor Sampling and Indoor Air Assessment Summary Report*, that was not obtained from ADEQ for review.

The applicable USEPA Region 9 residential indoor air regional screening level (RSL) for PCE was 9.4 $\mu g/m^3$ (and for TCE, 2.1 $\mu g/m^3$) during the 2013 investigations. Instantaneous (grab) indoor air samples were collected in gas-tight, glass syringes. Samples were analyzed within 15 minutes, on-site by an ADHS-certified mobile laboratory, per USEPA Method TO-14A (TO-14A); gas chromatography (GC) was performed on the samples using an ultra-sensitive electron capture detector (ECD). At locations where exceedances of the residential indoor air RSL occurred, confirmation samples were collected in six-liter passivated canisters over an approximately 24-hour period (time-integrated canisters) and analyzed by an off-site ADHS-certified laboratory per USEPA Method TO-15 (TO-15). The following presents a summary of the investigation and findings:

- One residence was sampled in August 2013 near the Former Maroney's facility where an indoor air result for PCE of 85 $\mu g/m^3$ was reported. Since this house was actively being remodeled, H+A concluded it was likely that PCE vapors were emanating from construction materials observed in the house during sample collection.
- Three residences located east of the Former Viking Cleaners facility were sampled in August 2013 for indoor air. A sample from one residence had a PCE concentration of 24 $\mu g/m^3$, above its residential indoor air RSL. However, the reported value was deemed to be biased high by a factor of two based upon the comparison of the TO-14A data to the off-site TO-15 confirmation data. It was determined that, if PCE results were to exceed the residential indoor air RSL in the follow-up sampling event, multiple rooms in the residence would be sampled to determine whether a PCE source may be found inside the residence. The follow-up indoor air sampling is discussed in **Section 4.2.15**.

- An additional residence was sampled in October 2013 for indoor air with an (assumed six-liter passivated) canister. The PCE result was 2.3 $\mu g/m^3$, which is below its residential indoor air RSL.
- A total of 11 residences in the Fairmount Villa Apartments were sampled in August 2013. Time-integrated canister confirmation samples were collected in three of the residences and were analyzed by TO-15. None of the sample results exceeded the PCE residential indoor air RSL.
- Three residences in the Fairmount Gardens Condominiums were sampled for indoor air in August 2013. None of the sample results exceeded the PCE residential indoor air RSL.
- In August 2013, 25 residences in the Jamestown Condominium complex were sampled for indoor air. In 13 of the residences, indoor air sampling results for PCE exceeded the residential indoor air RSL ranging from 5.2 $\mu g/m^3$ to 830 $\mu g/m^3$. In October 2013, time-integrated canister confirmation samples were collected in 10 residences within the Jamestown Complex to verify the August results; five of these residences were the same ones sampled in August 2013. It is assumed HEG did not collect confirmation samples at all locations with residential indoor air RSL exceedances due to access restrictions. None of the October sample results exceeded the PCE residential indoor air RSL.
- Five residences in the Lofts at Arcadia complex were sampled for indoor air in August 2013. A time-integrated canister confirmation sample was collected from two residences where initial results exceeded the PCE residential indoor air RSL. Neither of the confirmation sample results exceeded the PCE residential indoor air RSL.
- Thirty-one residences in the Villa Seville complex were sampled for indoor air in August 2013. Two PCE residential indoor air RSL exceedances were reported in separate buildings, at 17 $\mu g/m^3$ and 29 $\mu g/m^3$. These values were deemed to be biased high by a factor of two. This was followed up by time-integrated (24-hour) canister confirmation samples were collected from three of the 31 residences, including one of the two with an exceedance. Two of the confirmation samples results were below the PCE residential indoor air RSL, and one exceeded, at 12 $\mu g/m^3$ PCE. It was decided that residences with PCE residential indoor air RSL exceedances would be re-tested in the winter of 2014. The follow-up indoor air sampling is discussed in **Section 4.2.15**.

- Six residences in the neighborhood south of the Villa Seville complex were sampled for indoor air in August 2013. Two residences had indoor air results for PCE that slightly exceeded its residential indoor air RSL, at 10 µg/m^3 and 13 µg/m^3. Time-integrated canister confirmation samples were collected in both residences. Neither of the sample results exceeded the PCE residential indoor air RSL.
- H+A and/or HEG (unconfirmed) conducted soil vapor sampling in the vicinity of the Larry Kennedy School in October 2013. A total of 16 temporary SVPs were installed and sampled. The maximum reported PCE concentration was 830 µg/m^3 in LKS-09.

In summary, of the 91 total residences sampled in August 2013, 19 locations had reported indoor air PCE concentrations from TO-14 analysis above the applicable residential indoor air RSL. Thirteen of these locations were in the Jamestown Condominium complex southwest of the Former Viking Cleaners facility (HEG, 2014a). It is Geosyntec's opinion that follow-up indoor air investigations would be required to confirm whether the exceedances originated from indoor air sources rather than vapor intrusion (**Section 4.2.14**).

4.2.13 2013: Soil Vapor Investigations

Soil vapor samples were collected in October 2013 at the Former Viking Cleaners facility, which at that time was occupied by an active printing facility, JC Printing. Reported PCE concentrations ranged from 2,400 µg/m^3 at VSG-17C to 23,000,000 µg/m^3 at VSG-02B (HEG, 2014b). The October 2013 and subsequent indoor air investigations conducted at JC Printing are further described in **Section 4.2.15** below.

4.2.14 2014: Site-Wide Indoor Air Investigations

According to H+A's draft RI report for the site, some information and results of the follow-up winter (February) 2014 residential indoor air investigation were provided to ADEQ in a 2014 HEG report, *Work Plan for Indoor Air Assessment to Evaluate the Vapor Intrusion Pathway at the JC Printing Facility (Former Viking Cleaners)*, and the full results were later summarized in a 2014 H+A report, *Summary of Notification of Residential Indoor Air Results - Winter 2013/2014 Sampling Event*. Copies of these two reports were not obtained from ADEQ file reviews and communication with H+A; however, methods and results provided in a HEG work plan for the activities (HEG, 2014a) and an ADHS report that included an evaluation of the results (ADHS, 2016) are summarized herein. Confirmation samples were collected at an additional nine locations and were analyzed for VOCs by TO-14; results are summarized below.

- At four locations where PCE initially exceeded its residential indoor air RSL, confirmation sampling was conducted, and results were below the PCE residential indoor air RSL. Two locations (32-F-327 and 32-M-002) reported PCE concentrations of 13 $\mu g/m^3$ and 15 $\mu g/m^3$, respectively, above the residential indoor air RSL of 9.4 $\mu g/m^3$.
- Six soil vapor samples were collected from beneath the JC Printing building in February 2014 following SVE system operations; reported PCE concentrations ranged from 1,200 $\mu g/m^3$ to 3,600 $\mu g/m^3$, indicating that the SVE system notably decreased PCE concentrations HEG recommended conducting additional investigations inside the facility to determine the relationship between indoor air PCE concentrations and the subsurface PCE plume (HEG, 2014b).
- Reportedly, four indoor air sampling locations had TCE concentrations that exceeded the TCE residential indoor air RSL of 2.1 $\mu g/m^3$ (ADHS, 2016).

4.2.15 2013-2016: JC Printing Indoor Air Investigations

In October 2013, indoor air samples were collected from 20 different locations inside the JC Printing building. Fifteen samples were collected within the production area and five samples were collected within the office area. Indoor air PCE results ranged from 25 to 89 $\mu g/m^3$, averaging 61 $\mu g/m^3$. Some of the values exceeded the PCE non-residential indoor air RSL of 47 $\mu g/m^3$. The maximum PCE concentrations were detected inside and adjacent to the bathroom in the production area. Results were reported by HEG to ADEQ and later summarized by H+A (2015h).

For seasonal comparison, an additional indoor air sampling assessment was performed in February 2014. This additional event included the collection of six samples within the building. PCE concentrations ranged from 1,200 to 3,600 $\mu g/m^3$, averaging approximately 2,700 $\mu g/m^3$. Based on these results, HEG recommended additional investigation occur to determine the relationship, if any, between the indoor air PCE detections and the soil vapor plume at the Former Viking Cleaners facility (H+A, 2015h).

In June 2014 and February 2015, an indoor air quality assessment was performed at the facility to evaluate the potential for vapor intrusion and to compare indoor air conditions during the summer and winter (heating) seasons. In June 2014, a product inventory was performed. An inspection was also performed of the heating, ventilation, and air conditioning (HVAC) system and exhaust. Five continuous indoor air monitors (P1 through P5) were placed at various locations; two were placed in external locations (near HVAC intake and soil excavation work) and three were placed in production areas. The continuous monitors and system consisted of a GC with an ECD, a stream selection valve, a sample injection valve with one cubic centimeter sample loop, and a computerized data acquisition system. The analysis time per sample was approximately six minutes, which resulted in each location being sampled approximately every 30 minutes. A total of 606 analyses by TO-14A were performed at each of the five locations. Additional details of the system were provided by HEG to ADEQ in a work plan (HEG, 2014b). Confirmation grab samples were collected in passivated 400-milliliter canisters at selected times during the monitoring program to confirm results and submitted to an ADHS-certified laboratory for analysis by USEPA Method TO-15 Selective Ion Monitoring (TO-15 SIM) (H+A, 2015h).

For the June 2014 event, reported PCE concentrations in indoor air ranged from 1 $\mu g/m^3$ in P5 to 849 $\mu g/m^3$ in P1. This result exceeded the PCE industrial indoor air Regional Screening Level applicable at the time of 47 $\mu g/m^3$ (H+A, 2015h). Confirmation canister results from an indoor location near the 700 $\mu g/m^3$ were analyzed by TO-15 and ranged from 180 $\mu g/m^3$ to 280 $\mu g/m^3$; these results exceeded the applicable PCE industrial indoor air RSL. TCE concentrations were not reported (H+A, 2015h).

The same methodology as above was repeated in February 2015. The analysis time during this event was approximately eight minutes, which resulted in each location being sampled approximately every 40 minutes. A total of approximately 530 analyses were performed at each of the five sampling locations over the 15-day period. Reported PCE concentrations in indoor air ranged from 0.6 $\mu g/m^3$ in P5 to 57.3 $\mu g/m^3$ in P4. This result exceeded the PCE industrial indoor air RSL applicable at the time of 47 $\mu g/m^3$ (H+A, 2015h). PCE concentrations were generally below the industrial indoor air RSL of 47 $\mu g/m^3$, and below levels reported during the June 2014 event for the same production area locations. Confirmation canister results from two indoor sampling locations near production equipment (P4 and P5) showed PCE was not detected above the laboratory reporting limit. TCE concentrations were not reported (H+A, 2015h).

H+A concluded that the decrease in PCE concentrations from June 2014 to February 2015 was likely due to SVE system operations, since the system was commissioned after the June 2014 event. H+A also concluded that the observed decrease in PCE concentrations could have also been due to the varying operation of the HVAC system during cooler months (diurnal variation). According to H+A, since measured PCE concentrations overall during the February 2015 event were below the industrial indoor air RSL, the February 2015 event data did not indicate a threat to human health from PCE. H+A recommended that indoor air be sampled again during the summer of 2015 when presumably the HVAC would be operating under similar conditions (H+A, 2015h).

Instead of conducting follow-up sampling in the summer of 2015, H+A performed another air quality assessment in the fall of 2015. The goal was to evaluate whether the operation of the HVAC system and restricting ambient air flow through the facility contributed to the elevated PCE concentrations measured during the June 2014 event. The September-October 2015 event was specifically conducted during warm temperatures when the HVAC system was in operation (as prior, during the June 2014 event). Work was completed in accordance with a work plan prepared by HEG dated 28 May 2014 (H+A, 2015k).

In September and October 2015, continuous air monitors were placed at five internal and external facility locations (P1 through P5) for 14 days. The same methodology as above for the February 2015 event was repeated, except TO-15 (not SIM) was utilized for confirmation analyses. The analysis time per sample was approximately six minutes, which resulted in each location being sampled approximately every 45 minutes. Over 400 analyses were performed at each of the five sampling locations. PCE concentrations in the office area (P2) generally ranged from 2 to 10 $\mu g/m^3$ (below the PCE industrial indoor air RSL), with occasional short-term detections above 10 $\mu g/m^3$ (approximately three percent of the time). PCE concentrations in the two production area locations (locations P3 and P4) generally ranged from 5 $\mu g/m^3$ to 10 $\mu g/m^3$, with occasional short-term detections above 10 $\mu g/m^3$ (approximately five percent of the time); four of the 800 measurements exceeded the PCE industrial indoor air RSL. Confirmation canister results from the ‘North production area’ and the ‘office area’ were 52 and 5.4 $\mu g/m^3$ for PCE, respectively; the production area sample result exceeded the applicable PCE industrial indoor air RSL (H+A, 2015j).

H+A noted these concentrations were consistent with the February 2015 results for the same locations; also, the diurnal variation previously recorded in June 2014 occurred at a much lower magnitude. H+A concluded that indoor air PCE concentrations did not show a dependence on, or correlation with, either facility operations or HVAC system operations and ‘patterns and values’ were consistent on days the facility was open and closed for business. H+A also concluded that decreased PCE concentrations could be attributed to SVE system operations, indoor PCE impacts did not present a risk to the health of industrial workers, and impacts would remain acceptable if the SVE system continued to operate (H+A, 2015j).

At the request of ADEQ, ADHS reviewed the laboratory results from the September – October 2015 event that occurred at the facility and summarized its findings in a 2016 Health Consultation report (ADHS, 2016). The ADHS' findings are summarized in **Section 6.5.2**.

4.2.16 2014: Former Maroney's Facility – Soil Vapor Rebound Testing

In 2014, soil vapor rebound testing was conducted at the Former Maroney's facility. Samples were analyzed for VOCs by TO-15. PCE was reported at a maximum concentration of 4,200 $\mu g/m^3$, below the HPC for 5-foot samples. In general, PCE concentrations were an order of magnitude lower than concentrations collected in June 2013. Compounds 2-butanone, acetone, and tetrahydrofuran were also reported in soil vapor samples. Results are provided in a 2014 H+A report, *Quarterly Remediation Status Report No. 4, Second Quarter 2014* (H+A, 2014c).

4.2.17 2015: Site-Wide Soil Vapor Investigation

From September to November 2015, a site-wide (Former Maroney's, Former Viking Cleaners, and the FASA) soil vapor sampling event was performed. Soil vapor samples were collected from depths between 5 and 50 ft bgs and analyzed for VOCs by TO-15. Reported PCE concentrations ranged from non-detect in several samples to 190,000 $\mu g/m^3$ in MSG-09B and MSG-11A. Reported TCE concentrations ranged from non-detect in the majority of samples to 180 $\mu g/m^3$ in VSS-01 (H+A, 2015l).

Additionally, analytical results from the Former Viking Cleaners facility showed reported BTEX compounds at maximum concentrations of 13,000 $\mu g/m^3$, 110,000 $\mu g/m^3$, 28,000 $\mu g/m^3$, and 480 $\mu g/m^3$, respectively. The BTEX impacts are suspected to be associated with the Former Unocal service station located north of the Former Viking Cleaners facility.

Soil vapor PCE concentrations at the Former Maroney's facility exceeded the HPC at four locations at the 5-foot bgs depth interval, and at 18 locations at the 10 and 15-foot bgs depth intervals. TCE concentrations exceeded the HPC at one location at the 5-foot bgs depth interval.

4.3 Groundwater Investigations

Between April 2008 and October 2011, groundwater sampling was performed at the Former Maroney's facility, Former Viking Cleaners facility, and the FASA. During this time, several new groundwater monitoring wells were installed. Well locations are indicated in **Figures 4 through 6**. Details and results are provided in a 2012 Stantec report, *Groundwater Monitoring Report – April 2008 to October 2011* (Stantec, 2012i). During this period, the reported PCE concentrations ranged from 1.6 µg/L in the SRP well to 2,700 µg/L in VCMW-04A, exceeding the AWQS of 5 µg/L. TCE concentrations were not reported.

In May and June 2008, boring VCMW-04 was advanced west of the Former Viking Cleaners facility building, within the FASA near 31st Street and Fairmount Avenue. The boring was completed as a dual-nested groundwater monitoring well, screened from 40 to 80 ft bgs (VCMW-04A) and from 90 to 115 ft bgs (VCMW-04B).

Initial groundwater samples were collected from multiple groundwater monitoring wells, and reported PCE concentrations ranged from 32 µg/L to 2,400 µg/L, exceeding the AWQS. TCE concentrations were not reported. Results are provided in a 2012 Stantec report (2012i).

In January 2011, groundwater grab samples were collected from the bottom of borings OBS-1 through OBS-6 (at 61 ft bgs) during drilling via a Hydropunch™-type sampler. The borings are located at the corner of 31st Street and Fairmount Avenue (**Figure 6**), and the samples were collected to provide qualitative groundwater VOC concentration data in the study area around VCMW-04. Reported PCE concentrations in the groundwater samples ranged from 1.13 µg/L in OBS-6 to 1,860 µg/L in OBS-3, exceeding the AWQS. Reported TCE concentrations for the observation wells ranged from non-detect in OBS-2, OBS-5, and OBS-6 to 3.47 µg/L in OBS-4, below the AWQS of 5 µg/L (Stantec, 2012a).

In May 2011, groundwater monitoring well VCMW-05A was installed in the parking lot adjacent to Food City/Arcadia Fiesta in the northeastern area of the FASA (**Figure 6**). Boring VCMW-05 was advanced to 82 ft bgs and completed as a groundwater monitoring well screened from 45 to 80 ft bgs (Stantec, 2011b; Stantec, 2012b). The Stantec report does not describe groundwater sampling from this well, however, a data table provided by H+A shows that the initial PCE concentration was 1,100 µg/L (**Table 6**).

Historical groundwater flow was to the west-southwest at a gradient of approximately 0.009 ft per horizontal foot, consistent with historical measurements. Depth-to-water measurements from nested well pair VCMW-04A/VCMW-04B at the Former Viking Cleaners facility (**Figure 5**) indicated that groundwater displayed an apparent downward gradient of approximately 0.0009 ft per vertical foot. Water level measurements from nested well pair MMW-06-124/MMW-06-160 at the Former Maroney's facility (**Figure 4**) indicated that groundwater displayed an apparent upward gradient of approximately 0.001 ft per vertical foot (Stantec, 2012f).

From February to April 2012, groundwater monitoring was conducted. Reported PCE concentrations ranged from 1.3 µg/L to 890 µg/L at unreported locations. Reported TCE concentrations ranged from 6.0 to 6.8 µg/L, exceeding the AWQS in VCMW-04A (**Table 6; Figure 6**). Details and results are provided in a 2012 Stantec report, *Groundwater Monitoring Report – April 2012* (2012l).

From February to May 2012, one groundwater monitoring well (VCMW-06), four groundwater injection wells (FIN-1 through FIN-4), and four groundwater treatment monitoring wells (FMW-1 through FMW-4) were installed (**Figures 5** and **6**). A groundwater sample was collected using a Hydropunch™-type sampler from VCMW-06; initial reported PCE concentrations ranged from 140 µg/L to 196 µg/L, increasing with depth. Following well development, PCE and TCE were reported at concentrations of 100 µg/L and 2.8 µg/L in VCMW-06, respectively, exceeding the AWQS for PCE (Stantec, 2012k).

In April 2012, cone penetrometer testing (CPT) borings were advanced and grab groundwater samples were collected. CPT borings were advanced at the following locations:

- Former Maroney's facility (MCPT-1 through MCPT-9);
- Former Viking Cleaners facility (VCPT-1 through VCPT-5); and
- FASA (FCPT-1 through FCPT-4).

Grab groundwater samples via Hydropunch® were collected and analyzed for VOCs by USEPA Method 8260B. Reported PCE concentrations ranged from 0.660 µg/L in FHP-1 at 97 ft bgs to 1,940 µg/L in FHP-9 at 68 ft bgs. Reported TCE ranged from non-detect in most samples to 8.82 µg/L in FHP-11 at 58 ft bgs. Other analytes (including chloroform, 1,2-DCA, cis-1,2-DCE, MTBE) were also reported (Stantec, 2012p).

From October 2013 to May 2015, a site-wide groundwater monitoring was performed for analysis of VOCs. During these sampling events, reported PCE concentrations ranged from non-detect in several samples to 830 µg/L in VCMW-08A, exceeding the AWQS.

Reported TCE concentrations ranged from non-detect in most samples to 14 µg/L in VCMW-01, exceeding the AWQS (H+A, 2015g). Except for four wells (MMW-06-124, MMW-06-160, VCMW-03, and VCMW-04B), wells installed prior to 2015 to investigate the site were shallow (60-80 ft bgs). Therefore, the depth of PCE contamination further down the plume had not been defined. The Food City/Arcadia Fiesta property in the FASA, which already contained six wells (SG-33, VCMW-05A, UMW-05, UMW-06, UMW-07, and UMW-08) (**Figure 6**), was chosen to attempt to determine the depth of impacts. In February 2015, monitoring wells VCMW-05B, VCMW-07A, VCMW-07B, and VCMW-08A were installed on this property. Reported PCE concentrations ranged from non-detect in several samples to 2,100 µg/L, exceeding the AWQS, at 61 ft bgs in VCMW-08A. TCE was reported only in VCMW-08A at 61 ft bgs at a concentration of 3.2 µg/L, below the AWQS(H+A, 2015g).

Between 2015 and 2018, the triad approach of systematic project planning, dynamic work strategies, and real-time measurement technologies (i.e., vertical aquifer profiling) were employed to aid in defining the lateral and vertical extent of the PCE plume. Wells were only installed when conditions met the pre-selected objectives. Nineteen groundwater boreholes were drilled (**Figure 2**). Drilling was performed using rotosonic drilling techniques with groundwater samples collected from within the borehole using a drive ahead Hydropunch™-type sampler beginning at the water table (approximately 65 to 70 ft bgs) and approximately every 20 ft until the total borehole depth was reached. Groundwater samples were collected from discrete intervals, using low-flow methods, and submitted to a local laboratory for PCE analysis. Groundwater results were used to determine the need for additional sampling or well installation. This information is taken from the following documents, which were not obtained from ADEQ for review: 1) *2013 Work Plan to Conduct Groundwater Characterization* (H+A, 2013a); 2) *2013 Work Plan to Conduct Soil Vapor Sampling* (H+A, 2013b); 3) *2013 Work Plan to Drill and Construct Additional Monitor Wells Within Four Potential Source Areas of the ECP WQARF Site* (H+A, 2013j); 4) *2013 Quality Assurance Project Plan, Revision 1.1* (H+A, 2013k); and 5) *2015 Quality Assurance Project Plan Revision 1.2* (H+A, 2015j).

In October 2015, a site-wide groundwater sampling event was conducted at 23 monitoring wells. Samples were analyzed for VOCs. Reported PCE concentrations ranged from non-detect in several samples to 1,100 µg/L in VCMW-08A, exceeding the AWQS. Reported TCE concentrations ranged from non-detect in several samples to 6.2 µg/L in VCMW-04A, exceeding the AWQS (H+A, 2015l).

In December 2015, boring VCMW-12 was advanced to 215 ft bgs in the northeastern portion of the FASA (**Figure 8**). During drilling, grab groundwater samples were collected using a Hydropunch™-type sampler at 70, 110, 132, 150, 172, 193, and 210 ft bgs and analyzed for VOCs. PCE was not detected above the laboratory RL near the top of the water column and was reported at a maximum concentration of 10 µg/L at 132 ft bgs, exceeding the AWQS. TCE was not detected above the laboratory RL in any of the samples. The boring was converted to a groundwater monitoring well screened from 169.9 to 209.6 ft bgs (H+A, 2016b).

From March to June 2016, the following wells were discovered to be either damaged or covered by asphalt in the Food City/Arcadia Fiesta parking lot in the FASA (likely due to redevelopment): SG-33, UMW-05 through UMW-08, VCMW-05A, VCMW-05B, VCMW-07A, VCMW-07B, and VCMW-08A.

In May and June 2016, borings VCMW-16 and VCMW-15 were advanced as step-out locations near VCMW-12. During drilling, discrete grab groundwater samples were collected at discrete depths using low-flow methods beginning at the water table (approximately 65 to 70 ft bgs). Reported PCE concentrations ranged from 0.49 µg/L at 165 ft bgs in VCMW-15 to 16.7 µg/L at 185 ft bgs in VCMW-15, exceeding the AWQS. TCE concentrations were not reported (H+A, 2016d).

In August 2016, a site-wide groundwater sampling event was performed. Reported PCE concentrations ranged from 1.2 µg/L in VCMW-03 to 270 µg/L in VCMW-04A, exceeding the AWQS. Reported TCE concentrations ranged from 1.7 µg/L in VCMW-06A to 3.5 µg/L in VCMW-04A, below the AWQS (H+A, 2016e).

From October 2016 to February 2017, borings VCMW-03B (location unknown), VCMW-06B, VCMW-22, VCMW-20, VCMW-23, VCMW-08AR, and UMW-06 were advanced (**Figures 8 and 13)**. During drilling, grab groundwater samples were collected by the same methodology as the May 2016 event. Reported PCE concentrations ranged from non-detect in several samples to 560 µg/L in VCMW-08AR, exceeding the AWQS. Reported TCE concentrations ranged from non-detect in several samples to 7.2 µg/L at 250 ft bgs in VCMW-20, exceeding the AWQS. MTBE and toluene were also reported in VCMW-08AR (H+A, 2017a).

In February 2017, borehole 24MW-12 was advanced to delineate the southern extent of groundwater impacts. Groundwater was sampled using Hydropunch^{TM} methodology at 98, 125, 145, 165, 185, 205, 225, 245, 265, 285, 305, 325, 345 ft bgs,respectively. This boring was abandoned and not completed as a groundwater monitoring well. PCE concentrations identified ranged from non-detect to a maximum concentration of 15 µg/L at a depth of approximately 225 ft bgs. No samples contained PCE at levels exceeding AWQS below 265 ft bgs.

In May 2018, groundwater monitoring well 24MW-14 was advanced to a depth of 380 ft bgs and completed with a screen interval from 260 to 320 ft bgs. Groundwater was sampled water using Hydropunch TM methodology at 104, 125, 145, 165, 185, 205, 225, 245, 265, 285, 305, 325, 345 and 365 ft bgs respectively. No COCs were identified at concentrations exceeding AWQS. 24MW-14 effectively delineated the downgradient extent of groundwater impacts. In May 2017, Geosyntec collected a groundwater sample from dual-purpose SVE well and groundwater monitoring well MSVE-11 (**Figure 4**) and analyzed the sample for VOCs by USEPA Method 8260B. VOCs were not detected above their laboratory RLs (Geosyntec, 2017b). A dual-nested SVE well (MSVE-11A/B) was constructed within the boring (**Section 5.1.3**).

From June 2017 to May 2018, borings VCMW-29, VCMW-24, and VCMW-26 were advanced (**Figure 2**). Reported PCE concentrations ranged from non-detect in several samples to 2.89 µg/L at 127 ft bgs, below the AWQS, in VCMW-24. TCE was not detected above the laboratory RL in the samples. The borings were converted to groundwater monitoring wells. VCMW-24 and VCMW-29 were screened from 311 to 371 ft bgs and VCMW-26 was screened from 299 to 349 ft bgs (H+A, 2017b; H+A, 2018b).

In June 2017, a groundwater monitoring event was performed using passive diffusion bags (PDBs) to collect depth-specific samples from VCMW-20, VCMW-22, UMR-06R, and VCMW-08AR (**Figures 5** and **6**). Reported PCE concentrations ranged from non-detect in VCMW-22 to 780 µg/L in VCMW-08AR, exceeding the AWQS. Reported TCE concentrations ranged from 1.4 µg/L in VCMW-20 to 2 µg/L in VCMW-08AR, below the AWQS (H+A, 2017c).

In August 2018, Geosyntec conducted groundwater sampling at 22 wells within the boundaries of the WQARF site and the 24th and Grand Canal WQARF site: 24AS-01, 24MW-01, 24MW-02, 24MW-03, 24MW-04, 24MW-06, 24MW-07, 24MW-09, 24MW-10, 24MW-13, 24MW-14, MMW-03, UMW-06, VCMW-04A, VCMW-06, VCMW-08, VCMW-12, VCMW-17, VCMW-20, VCMW-22, VCMW-24, and VCMW-26. Reported PCE concentrations ranged from non-detect in several samples to 600 µg/L in 24AS-01, exceeding the AWQS. Reported TCE concentrations ranged from non-detect in several samples to 1.1 µg/L in both VCMW-06 and VCMW-26, below the AWQS. Several other VOC analytes were also reported in the samples: acetone, chloroform, 2-butanone, and toluene.

Geosyntec used Hydrasleeves™ to collect samples from three of the wells (24AS-01, 24MW-14, and VCMW-04A). The samples were collected from the following depths:

- 24AS-01, screened from 68 to 118 ft below top of casing (btoc), was sampled at 106 ft btoc.
- 24MW-14, unconfirmed screen interval, was sampled at 245 ft btoc.
- VCMW-04A, screened from 40 to 80 ft btoc, was sampled at 72 ft btoc.

Other VOCs, discussed in **Section 1.4**, were also reported in groundwater samples throughout the site during the various groundwater monitoring events. These detections are not believed to be associated with the Former Maroney's and Former Viking Cleaners sources, as discussed in **Section 1.4**.

Geosyntec created hydrographs and VOC concentration versus time plots using available groundwater data from March 1998 to August 2018 (**Appendices C** and **D**, respectively). The wells were grouped regionally to best present the data, and the groupings are as follows:

- North of PCE plume (M-series wells): MMW-01, MMW-02, MMW-03D, MMW-04D, MMW-05, MMW-06-124, and MMW-06-160.
- Northeast of PCE plume (VC-series wells): VCAS-01, VCAS-02, VCAS-03, VCMW-01, VCMW-02, VCMW-03, VCMW-05A, VCMW-05B, UMW-07, and UMW-08.
- Near Former Viking Cleaners facility (VC-series wells): VCMW-04A, VCMW-04B, VCMW-06A, VCMW-07A, VCMW-07B, and VCMW-08AR.

5. EARLY RESPONSE ACTIONS

The objective of the ERA investigations was to evaluate whether the source(s) of VOC impacts should be addressed due to their potential to impact human health and/or the environment. Initial investigations conducted in 2006 at the Former Maroney's facility and in 2003 at the Former Viking Cleaners facility led to the installation and operation of remediation systems at these locations to address the observed VOC impacts to soil, soil vapor, and groundwater. The following is a summary of the ERA investigations and the remedial technologies implemented up until June 2007, when ADEQ sent out notices per A.R.S. Section 49-287.03 initiating the RI for the site. RI activities are discussed in **Section 4**.

An ERA was also conducted within the FASA that consisted of SVE pilot testing activities. Although this work was conducted in 2011 after the RI phase of site work, it is discussed in this section since the FASA was not the subject of the RI.

ERAs have been implemented at the both the Former Maroney's and Former Viking Cleaners facilities. The ERA implemented for both sites was SVE. This section presents a summary of the infrastructure, commissioning, operation and maintenance (O&M), shutdown and rebound evaluations, and forthcoming decommissioning of the SVE systems, by facility. Soil, soil vapor, and groundwater investigation results, when obtained concurrently with SVE system activities at both facilities, were previously discussed in **Section 4**.

5.1 Former Maroney's Facility (Parcel 020B)

5.1.1 ERA Investigation

Following the detection of PCE in groundwater monitoring wells MMW-01 and MMW-02 in 2000 (described in **Section 3.2.2**), an ERA investigation was initiated. The results of the ERA investigation were reported to ADEQ in the *Work Plan for RI*, dated 27 April 2007 (SECOR, 2007b). The following is a summary of field activities and results.

5.1.1.1 2006: ERA Soil Sampling, Groundwater Monitoring Well Installation, and Soil Vapor Sampling

From 9 through 17 January 2006, three borings were advanced to investigate soil, soil vapor, and groundwater near the Former Maroney's facility as part of an ERA to assess the extent of groundwater impacts. The borings were advanced to 80 ft bgs. Nested SVE/groundwater wells were constructed at two locations (MMW-03S/D and MMW-04S/D). The shallow 'S' sections of the two wells were screened from 10 to 25 ft bgs; the deeper 'D' sections of the two wells were screened from 30 to 80 ft bgs. A groundwater monitoring well was constructed at the third location, screened from 30 to 80 ft bgs MMW-05). Soil boring and well completion logs are included in **Appendix B**. Well construction details are provided in **Table 2** and well locations are shown in **Figure 4**.

Soil samples were collected from MMW-03S/D at 3 and 15 ft bgs, from MMW-04S/D at 5 and 50 ft bgs, and from MMW-05S/D at 40 and 50 ft bgs. Samples were analyzed for PCE by USEPA Method 8260B. PCE was not detected above the laboratory RL in the samples.

Soil vapor samples were collected from MMW-03S/D through MMW-05S/D at multiple depths (5, 15, 25, 40, and 50 ft bgs), as well as from 10 ft bgs from MMW-04S. Select soil vapor samples were analyzed for PCE by either USEPA Method 8021B or TO-15. Reported PCE concentrations in soil vapor ranged from non-detect in MMW-04D (at 40 ft bgs) and in MMW-05S/D (at samples collected 5 to 50 ft bgs), to 468,000 µg/m^3 in MMW-03S at 5 ft bgs.

Grab groundwater samples were collected from the borings using a sampler. Reported PCE concentrations ranged from non-detect in a few samples to 100 µg/L in MMW-04D at 56 ft bgs (SECOR, 2006b), exceeding the AWQS.

5.1.1.2 2006: ERA Groundwater Sampling

"Shallow" and "deep" groundwater samples were collected on 16 March, 25 and 26 October, and 13 December 2006 using depth discrete samplers. MMW-03D samples were collected from approximately 26 ft below the measured water table surface (bwt) and 27 ft bwt, MMW-04S samples were collected from 2 and 3 ft bwt; MMW-04D samples were collected from 24 ft bwt, and MMW-05 samples were collected from 2 and 23 ft bwt.

Reported PCE concentrations in groundwater ranged from non-detect in MMW-05 at 23 ft bwt to 100 µg/L in MMW-05 at 2 ft bwt. Results for PCE exceeded the AWQS of 5 µg/L. Reported TCE concentrations in groundwater ranged from non-detect in various depths in MMW-03, MMW-04, and MMW-05, to 1.3 µg/L in MMW-03 at 27 ft bwt. TCE results did not exceed the AWQS (SECOR, 2007b).

5.1.1.3 2006: ERA Groundwater Sampling

In May 2007, MMW-06-124 and MMW-06-160 were installed as a nested pair at 124 and 160 ft bgs, respectively, located south of the Maroney's Cleaners facility. The wells were installed to measure vertical hydraulic gradients and to estimate the vertical thickness of PCE impacts. Initial groundwater samples collected from the wells had shallow and deep PCE results that were below the AWQS. Results are provided in a 2012 Stantec report, *Groundwater Monitoring Report – April 2012* (Stantec, 2012l).

5.1.2 Purpose of ERA

The 2007 Work Plan information submitted to ADEQ indicated that PCE was present in soil vapor and groundwater near the site. Maximum PCE concentrations of 468,000 $\mu g/m^3$ at 5 ft bgs in soil vapor at SG-5 (**Figure 4**) and 92 µg/L in groundwater (MMW-04) were observed. TCE was also reported in groundwater near the site at a maximum concentration of 1.3 µg/L at 27 ft bwt (SECOR, 2007b).

5.1.3 Overview of Subsurface Conditions

Boring logs indicate that the lithology underlying the site generally ranges from sandy silt to sand with gravel. Geosyntec assumed responsibility for this SVE system in July 2016 and immediately performed a remediation optimization review. Geosyntec concluded from its review that these zones may have significant disparity in pneumatic permeabilities, which may lead to potential short circuiting of extraction flow rates from the zones with higher permeabilities, whereas the less permeable zones receive much less flow and pore volume exchanges (Geosyntec, 2016a).

Based on the results of a September 2015 soil vapor monitoring event, VOC impacts appeared to be primarily highest in shallow soil and attenuate with depth. Nested probes in the soil vapor monitoring network are generally screened at 5, 10, and 15 ft bgs. Minimal interval-specific soil vapor data were available for depth intervals deeper than 15 ft bgs.

The depth to groundwater at the site generally ranges from approximately 55 to 65 ft bgs based on data collected in October 2015. VOCs, primarily PCE, have been detected in groundwater downgradient of the site. In general, historical soil vapor sampling data indicate that PCE is the primary COC within the vadose zone, and impacts were generally concentrated beneath the northern portion of the Former Maroney's facility building. This observation was based on monitoring data from the SVE wells and SVP network, which was entirely outside of the Former Maroney's facility building prior to 2017.

Radius of influence (ROI) data collected during a 2012 SVE pilot test indicated that the subsurface is moderately to highly permeable and amenable for SVE, with ROIs ranging from 77 to 126 ft. The ROI increased with depth during the pilot test, indicating that the subsurface lithology may become increasingly permeable at deeper intervals. While this quality is favorable for SVE remediation, it may have allowed most of the VOC mass that was released to pass rapidly through the vadose zone and into underlying groundwater. Additionally, while the ROI evaluation indicated that the subsurface lithology is generally favorable for SVE remediation, H+A concluded that subsurface heterogeneities were lessening the effectiveness of SVE remediation, and vapor flow was preferentially targeting coarser intervals, leaving residual VOC mass in fine-grained intervals (H+A, 2014a). H+A further concluded such scenarios can create significant challenges for SVE remediation, leading to potentially long remediation timeframes.

As part of the optimization evaluation, Geosyntec concluded that a primary challenge for the system was that the remediation and monitoring infrastructure did not include extraction wells or SVPs within the footprint of the dry-cleaner suite, the northeastern corner of which was suspected to be the primary residual source area. Geosyntec installed extraction and monitoring features in this area in 2017. After installing these features and performing subsequent extraction and rebound monitoring, the residual source area appears to have been adequately addressed, as discussed in the following sections.

5.1.4 Extraction and Treatment System Summary

The SVE system installed in 2011 primarily consisted of a 40 horsepower (HP), positive displacement extraction blower capable of flow rates up to 1,000 actual cubic feet per minute (ACFM) and a system vacuum of up to 6 inches of mercury (in Hg). Extracted soil vapor was routed through three 1,450-pound capacity vapor-phase granular activated carbon (GAC) vessels configured in series.

The original SVPs and SVE wells were constructed in a linear manner around the eastern perimeter of the plaza, of which the Former Maroney's facility occupied the eastern-most suite (**Figure 10**). The original SVE network of five wells was connected to a trunk line that fed into the extraction and treatment system compound located on the western edge of the site. SVE pilot testing was conducted with two SVE wells and several SVPs. The extraction well and vapor monitoring network was subsequently expanded and currently consists of 14 SVE wells and 23 SVPs.

The majority of the SVE wells in the network are located immediately north of the Former Maroney's building. Five SVE wells, MSVE-01 through MSVE-05, were initially constructed for the SVE system; these wells are screened from 10 to 50 ft bgs. Well screens of this length are not uncommon, but longer well screens such as these increase the probability that flow short-circuiting may occur when the well screen is located across even a small lithologic zone of high permeability relative to the rest of the well screen. MSVE-06 through MSVE-10 were subsequently constructed with shorter well screens (7 to 17 ft bgs) to focus on the shallow VOC impacts observed during soil vapor monitoring (**Figure 10**). SVPs are located collinearly along the trunk line in fairly evenly-spaced intervals (**Figure 10**). The SVPs are generally triple-nested, screened at 5, 10, and 15 ft bgs.

5.1.5 ERA Implementation

In June 2011, a four-day SVE pilot test was conducted at the Former Maroney's facility to evaluate the efficacy of SVE for vadose zone remediation. Extraction was performed within two SVE wells, MMW-03A and MMW-03B. Vacuum ROI from the extraction was estimated to range from 65 to 135 ft, based on evaluating data from MMW-03A and MMW-03B. Although PCE soil vapor concentrations were observed to have significantly decreased during the pilot test, detected concentrations partially rebounded within two months following the pilot test, and rebounded to levels similar or exceeding pre-test concentrations during a monitoring event performed one year later (H+A, 2014a).

In June 2013, the SVE system was commissioned. Operation of the system was considered an 'interim' remedial action (H+A, 2014a).

In October 2013, ROI and step testing evaluations of the system were performed. Vacuum ROI from the highest vacuum step extraction was estimated to range from 50 to over 100 ft, with the exception of MSVE-03, which showed almost no ROI (H+A, 2014a).

In November 2013, the system at the Former Maroney's facility was shut down due to low VOC yield (approximately 0.038 pounds per day at the time of shutdown). H+A concluded that a heterogeneous lithology was the primary cause of low VOC yield, particularly a relatively coarse shallow vadose zone, which was likely allowing significant breakthrough of ambient air into the SVE wells (H+A, 2014a). According to Geosyntec's calculations, approximately 26 pounds of VOCs are estimated to have been removed from the subsurface during the five-month operational period.

In December 2014, five new SVE wells were installed (MSVE-06 through MSVE-10), screened from approximately 7 to 17 ft bgs, on the northeast end of the Former Maroney's facility behind the building (**Figure 4**). These wells were added to the extraction network to enhance remediation in the shallow vadose zone along the northeast perimeter of the Former Viking Cleaners building. Details were presented in a 2014 H+A document, *Work Plan: SVE Wellfield Expansion* (H+A, 2014f).

In January 2015, the system at the Former Maroney's building was restarted based on elevated VOC soil vapor rebound results. The system was shut down again in May 2015 due to low VOC yield (approximately 0.068 pounds per day at the time of shutdown). According to Geosyntec's calculations, approximately 11 pounds of VOCs are estimated to have been removed from the subsurface during the four-month operational period, for a cumulative estimated mass removal of 37 pounds.

In October 2015 and January 2016, rebound testing was conducted at the Former Viking Cleaners facility by evaluating soil vapor total VOC concentrations in the field with a PID. Significant VOC rebound was observed at MSVE-08 through MSVE-10, MMW-03S, and MSG-09A/B/C through MSG-11A/B/C. This information is provided in a 2016 H+A document, *Semi-Annual Remediation Status Report, No. 5, July through December 2015* (H+A, 2016a).

In July 2016, Geosyntec assumed responsibility for the SVE system and performed a soil vapor rebound monitoring event. The system was restarted, and vapor samples were collected from SVE wells MSVE-01 through MSVE-10. Following an extended shutdown period, the maximum reported PCE concentration was 160,000 $\mu g/m^3$ in MSVE-10. The results demonstrated a significant VOC rebound in soil vapor since the system was previously shut down. Geosyntec recommended additional SVE remediation by restarting and operating the SVE system (Geosyntec, 2016b).

In October 2016, Geosyntec performed an SVE evaluation for potential alternatives for optimization of operations and a data gap analysis (Geosyntec, 2016b). Geosyntec concluded that SVE wells were needed directly in the suspected source area within the building footprint in the northeast corner of the suite. Soil vapor characterization within the building footprint was also identified as a data gap at the time.

In May 2017, Geosyntec advanced an angled boring (MSVE-11) below the northeastern corner of the Former Maroney's facility building to approximately 70 ft bgs. The boring was advanced to groundwater and a grab groundwater sample was collected; PCE was not detected above the laboratory RL in the sample. Soil vapor samples from MSVE-11 were collected at 10-foot intervals during advancement of the boring from 15 to 55 ft bgs using SimulProbe™ sampling technology. Samples were analyzed for VOCs by USEPA Method TO-15. PCE was reported at concentrations ranging from 95 $\mu g/m^3$ at 55 ft bgs to 220 $\mu g/m^3$ at 15 ft bgs, below the respective 15- and 45-foot HPCs. Concentrations were observed to attenuate with depth, demonstrating that residual VOCs were primarily in the shallow subsurface in the northeastern corner of the Former Maroney's suite (Geosyntec, 2017b).

The boring was converted to a dual-nested SVE well screened from 21.5 to 36.5 ft and from 48 to 73 ft bgs. After installation of the well, the SVE system was operated for approximately one month, with a shutdown performed on 28 June 2017 corresponding with the end of the ADEQ fiscal year. SVE extraction was focused primarily from the medium-depth casing in this well after installation. No significant VOCs were observed in the mid-to-deep vadose zone upon commissioning this dual-nested well (Geosyntec, 2017b).

In September 2017, Geosyntec installed SVE well MSVE-12 and 3 SVPs, MSG-21 through MSG-23 (**Figure 4**) inside the Former Maroney's facility building to directly address suspected VOC concentrations in the residual source area. The SVP screen openings were screened at 5 ft bgs and the SVE well was screened from 3 to 10 ft bgs (Geosyntec, 2017c). The SVE well was advanced to approximately 12 ft bgs and the probes were each installed at approximately 5 ft bgs. PID readings were collected at 3, 5, and 10 ft bgs during drilling; VOCs were not detected. On 13 September 2017, the SVPs were sampled. PCE was reported in soil vapor samples ranging from 12,800 $\mu g/m^3$ to 46,100 $\mu g/m^3$, exceeding the 5-foot bgs HPC. Geosyntec recommended that the SVE system be restarted and extractions be focused from the new SVE well, MSVE-12 (Geosyntec, 2017c).

On 28 November 2017, the SVE system at the Former Maroney's facility was restarted after approximately five months of downtime. SVE extraction was focused primarily on MSVE-12 after installation to directly address VOCs in the suspected residual source area beneath the building (Geosyntec, 2018a).

On 19 February 2018, the SVE system was shut down for a rebound evaluation. 'Shutdown' soil vapor samples were collected from a subset of SVPs in the vicinity of the dry-cleaner suite at the time of shutdown and 'rebound' samples were collected from SVPs and SVE wells from 5 to 80 ft bgs 38 days later on 29 March 2018. Reported PCE concentrations ranged from 30 $\mu g/m^3$ in MSG-10 at 5 ft bgs (in February) to 2,270 $\mu g/m^3$ in MSG-23 at 5 ft bgs (in March); reported TCE concentrations ranged from non-detect in several samples to 59 $\mu g/m^3$ in MSG-08 at 10 ft bgs (in March). Detected PCE and TCE concentrations were observed to rebound generally less than one order of magnitude. The rebound concentrations were also one to three orders of magnitude below their respective depth-specific HPCs (11,000 $\mu g/m^3$ for PCE and 540 $\mu g/m^3$ for TCE). As such, Geosyntec concluded that the SVE system had effectively mitigated the soil vapor impacts and that ADEQ should consider decommissioning the system (Geosyntec, 2018a).

Approximately 78 pounds of VOCs are estimated to have been removed from the subsurface by the SVE system between July 2016 and February 2018 for a final cumulative estimated mass removal of 115 pounds.

5.2 Former Viking Cleaners Facility (Parcel 134B)

5.2.1 ERA Investigation

SECOR prepared and submitted a work plan to ADEQ to conduct vadose zone and groundwater assessment activities on 6 February 2003 at the Former Viking Cleaners facility, 4029 N. 32nd Street on Parcel 134B. A copy of this work plan was not obtained from ADEQ records for review. The subject site did not include the Former Unocal service station on Parcel 135B. An ERA investigation was conducted in March 2003 and an indoor air investigation was conducted in April 2003. Investigation methodology and results were reported to ADEQ in May 2003 (SECOR, 2003a). A written rationale for conducting an ERA as defined by A.A.C. R18-16-405(A) was included in this report. A summary is provided below.

5.2.1.1 2003: Soil, Soil Vapor, and Groundwater Investigation

In March 2003, four soil borings were advanced (SB-1 through SB-4; exact locations unknown) to 49-50 ft bgs and collected soil and soil vapor at 5- or 10-foot intervals. Two borings were installed inside and two were installed outside of the Former Viking Cleaners building, as shown in Figure 5 of the ERA investigation report (SECOR, 2003a).

Soil and soil vapor samples were collected at 5-foot vertical intervals beginning at approximately 5 ft bgs in borings SB-1 and SB-2. Borings SB-3 and SB-4 were sampled at 5 to 10-foot intervals beginning at 5 ft bgs. The borings were drilled to intercept groundwater, at which point a Hydropunch™-type sampler was utilized to extract a grab groundwater sample.

Soil vapor samples were analyzed at a mobile on-site laboratory for nine VOCs: PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-dichloroethene and BTEX compounds. Groundwater samples were analyzed for the full suite of VOCs by USEPA Method 8260B at an off-site laboratory. Physical parameters were additionally analyzed from two SB-3 samples, a representative silty sand (typically 0 to 30 ft bgs) and sandy silt (typically 30 to 45 ft bgs). These parameters included total organic content (TOC), wet and dry density, water-filled and total porosity, and moisture content.

PCE was reported in each soil and soil vapor sample. Concentrations in soil samples ranged from 0.15 mg/kg in SB-4 at 40 ft bgs to 6,600 mg/kg in SB-1 at 15 ft bgs, exceeding the minimum PCE Arizona GPL of 1.3 mg/kg, the Non-Residential Soil Remediation Level (NRSRL) of 13 mg/kg, and the USEPA PCE RSRL of 0.51 mg/kg. Reported PCE concentrations in soil vapor samples exceeded 1,200,000 μg/m^3. Concentrations of PCE in groundwater samples ranged from 7,500 μg/L in SB-4 to 200,000 μg/L in SB-1, exceeding the AWQS of 5 μg/L. No other VOCs were detected above the laboratory reporting limits in soil, soil vapor, or groundwater (SECOR, 2003a).

5.2.1.2 2003: Indoor Air Investigation

Due to these cleanup criterion exceedances and at the request of ADEQ, SECOR prepared an indoor air sampling work plan to evaluate the potential presence of VOCs within the Former Viking Cleaners building (SECOR, 2003a). It was submitted on 9 April 2003 to ADEQ and field work was conducted 12 and 13 April 2003. Four 6-liter Summa™-type canisters equipped with 24-hour automatic flow controllers were placed on the ground floor inside the facility and the adjacent convenience mart (Figure 3 of SECOR, 2003a). Samples were analyzed for VOCs by USEPA Method TO-15 at on off-site laboratory. Results indicate 11 VOCs were detected above RLs. The reported PCE concentrations in indoor air ranged from 108.53 μg/m^3 from a sample collected in the back of the convenience store to 1,288.88 μg/m^3 from a sample collected near soil boring SB-1. Results were reported to ADEQ in a report by SECOR (2003a). ADHS evaluated these results and provided ADEQ with a health consultation. ADHS advised there was no unacceptable risks to workers inside the building under current exposure scenarios (SECOR, 2003a).

A water sample was collected from a flush-mounted valve box located in the northern end of the building and analyzed at an off-site laboratory by USEPA Method 8260B. The sample was collected given the possibility expressed by SECOR that the box may have provided valve access to subgrade pumping that supplied water or steam to laundering equipment when the dry-cleaner facility was operated. The results of the water sample analysis indicate that three VOCs were detected above laboratory RLs, as follows: 39 µg/L of PCE, 1,000 µg/L of 4-isopropyltoluene, and 12,000 µg/L of acetone.

5.2.1.3 2003: Soil Boring Adjacent to UMW-09

In June 2003, SECOR attempted to advance a soil boring (VB1) to an approximate depth of 120 ft bgs and install a new nested groundwater monitoring well at a location approximately 6 ft west of UMW-09. However, drillers encountered a layer of silt at approximately 60 to 70 ft bgs that was considered a substantial aquitard at that time, and in consultation with ADEQ, the boring was backfilled with bentonite chips and a 20-foot cement grout plug to surface grade (SECOR, 2003b).

5.2.1.4 2003: Purpose of ERA

The May 2003 report conclusions presented by SECOR and submitted to ADEQ were as follows (SECOR, 2003a):

- PCE was present in soil at the site; a maximum concentration of 6,600 mg/kg of PCE was observed at 15 ft bgs;
- The likely source of PCE soil impacts was the PCE drum storage area formerly located along the eastern side of the facility (on Parcel 135B);
- PCE was present in site groundwater above the AWQS of 5 µg/L, since grab groundwater results ranged from 7,500 µg/L to 200,000 µg/L of PCE in samples collected in 2003. Also, historical concentrations of PCE in groundwater from monitoring well UMW-9 (located approximately 10 ft north of the facility) had ranged from 190 µg/L to 2,300 µg/L of PCE; and
- Prior investigations indicated groundwater has been impacted to a depth of at least 12 ft below the static water table.

Based on SECOR's assessment, the likely source of PCE impacts to groundwater were impacted soils at the static water table (in the capillary fringe) and impacted soils above the static water table (in the vadose zone). SECOR stated the purpose of an ERA would be to remove VOCs from the vadose zone and capillary fringe horizon. The remedial technology proposed was a combined AS/SVE system (SECOR, 2003a).

5.2.1.5 2004: ERA Well Installations and Sampling

In January and February 2004, three dual-nested SVE wells were installed (V-SVE-01S/D through V-SVE-03S/D), three air sparge wells (VCAS-01 through VCAS-03), and two groundwater monitoring wells (VCMW-01 and VCMW-02) at the Former Viking Cleaners facility (SECOR, 2004a and SECOR, 2007b). Locations of the SVE wells are shown in **Figures 5** and **11**.

VCMW-01 and VCMW-02, screened from 35 to 60 ft bgs, were installed to assess shallow VOC impacts to groundwater. In February 2004, reported PCE concentrations of initial samples from VCMW-01 and VCMW-02 were 26 µg/L and 230 µg/L, respectively, and reported TCE concentrations were non-detect and 52 µg/L, respectively (**Table 6;** SECOR, 2004a). These wells were sampled from February 2004 through October 2008.

5.2.1.6 2004: Fluid Level Monitoring and Sampling Activities

In March and April 2004, the following groundwater monitoring wells at the Former Maroney's and Former Viking Cleaners facilities were gauged and sampled: MMW-01, MMW-02, UMW-02 through UMW-09, and the SRP Well 17E-8N (**Figure 5)** at one or two depths with PDBs. Well UMW-01 (location unknown) was not sampled due to being dry. Samples were analyzed for VOCs by USEPA Method 8260B. Reported PCE concentrations ranged from non-detect in UMW-08 and SRP Well 17E-8N to 8,600 µg/L in UMW-09 (SECOR, 2004b).

5.2.1.7 2005: Fluid Level Monitoring and Sampling Activities

In October 2005, the following groundwater monitoring wells at the Former Maroney's and Former Viking Cleaners facilities were gauged and sampled: MMW-01, MMW-02, UMW-06, UMW-07, UMW-08, and UMW-09 at one or two depths with PDBs. Wells UMW-01, UMW-02, UMW-03, UMW-04, and UMW-05 were not sampled due to being dry. Samples were analyzed for VOCs by USEPA Method 8260B. Reported PCE concentrations ranged from non-detect in UMW-07 to 13 µg/L in MMW-02 (SECOR, 2006a).

5.2.1.8 2006: Groundwater Monitoring Well Installation

In February 2006, groundwater monitoring well VCMW-03 was installed near the Former Viking Cleaners facility to further assess the vertical extent of VOCs in the impacted groundwater. The well was installed to a total depth of 163 ft bgs to assess deeper VOC impacts to groundwater and was screened from 100 to 160 ft bgs. During drilling, groundwater samples were collected from 60, 80, 100, and 120 ft bgs using a SimulProbe™-type sampler. Additionally, PDBs were placed at 55, 107, and 158 ft bgs after well construction. Groundwater samples were analyzed for VOCs by USEPA Method 8260B. Reported PCE concentrations ranged from 2.6 µg/L at 100 ft bgs to 3,100 µg/L at 60 ft bgs using the SimulProbe™-type sampler, and from 2.7 µg/L at 158 ft bgs to 2.9 µg/L at 107 ft bgs using the PDBs. TCE was reported in the SimulProbe™ groundwater sample from 80 ft bgs at a concentration of 5 µg/L (SECOR, 2006c).

5.2.2 AS/SVE System and Groundwater Investigation (2004-2008)

5.2.2.1 2004: Groundwater Monitoring Well, AS Points, and SVE Well Installations

In January 2004, three AS points (VCAS-01 through VCAS-03) and three nested SVE wells (V-SVE-01S/D through V-SVE-03S/D) were installed, as described previously. The nested SVE wells were constructed such that vapor extraction could occur from two different 15-foot zones per well, between 10 and 25 ft bgs, and between 30 and 45 ft bgs. The SVE wells are thus named V-SVE-01S/D, V-SVE-02S/D, and V-SVE-03S/D to describe the extraction zone (S for shallow or D for deep). Well V-SVE-01S/D was later replaced by SVE-01SR in March 2012. The well specifications are summarized in **Table 2** and the locations are indicated in **Figures 5 and 11**. The AS wells were screened from 55 to 60 ft bgs. Locations of the AS wells are shown in Figure 1 of an ERA well installation report submitted to ADEQ in February 2004 (SECOR, 2004a). It is unknown whether these three AS wells and three SVE wells were abandoned.

5.2.2.2 System Specifications and Operation

In June 2004, an AS/SVE system was constructed that consisted of a compressor, an extraction blower, and two vessels of GAC (Stantec, 2012a). Initially the system was connected to the three AS wells and three SVE wells. Two SVE wells (SVE-04 and SVE-05) were added later as described in **Section 5**.

The current SVE system consists of a 30 HP positive displacement blower, capable of flow rates up to 550 ACFM and a system vacuum of up to 8 in Hg. Extracted soil vapor is routed through three 1,050-pound vapor-phase GAC vessels configured in series and manufactured to withstand a maximum pressure of one pound per square inch. The GAC vessels are located on the downstream (pressure) side of the extraction blower. A heat exchanger is located between the blower and the GAC to reduce the temperature of the vapor stream prior to passing through the GAC. After GAC treatment, the treated soil vapors are vented through effluent piping (i.e., the stack) (Geosyntec, 2016a). Additional details of SVE operations are provided in **Section 5**.

5.2.2.3 2006: SVE and Vapor Mitigation Well Installations, System Operations, and Soil Investigation

In March and April 2006, four additional SVE wells (SVE-04, SVE-05, VMW-1 and VMW-2A) were installed to meet the requirements of the ADEQ-approved Prospective Purchaser Agreement (PPA) (Tierra Dynamic Company [TDC], 2006b). SVE-04 and SVE-05 were screened from 35 to 60 ft bgs. Two SVE wells designed to provide potential vapor intrusion mitigation (VMW-1 and VMW-2A) were also installed, screened from 10 to 25 ft bgs. The well specifications are summarized in **Table 2** and the locations are indicated in **Figure 5** (TDC, 2006).

During the SVE well installations, an additional soil boring (VCMW-02) was advanced to 39 ft bgs at a location beneath the Former Viking Cleaners suite. Soil samples were generally collected at 5-foot intervals during the advancement of borings for SVE-04, SVE-05, and VCMW-02 (**Figure 5**). Samples were analyzed by USEPA Method 8260B to evaluate the possible presence of PCE and TCE in soil beneath the building. PCE and TCE were not detected above laboratory RLs in the soil samples collected, except for one sample from SVE-05 at 59.5 ft bgs. The reported PCE concentration in this sample was 0.83 mg/kg, below both the GPL and RSRL for PCE (TDC, 2006b).

According to an O&M summary report for November 2006 (SECOR, 2007a), by this time the remedial system consisted of three nested SVE wells, four additional SVE wells, three AS wells, a 225 cubic feet per minute (cfm) blower exhausting through two 1,000-pound vapor-phase GAC vessels connected in series and a 31-cfm rotary-screw AS compressor. Underground vapor conveyance lines were connected to the wells and then plumbed to the existing on-site SVE system pipeline manifold. During November 2006, the AS system was not operational during this period due to the lowered groundwater table (SECOR, 2007a).

During AS/SVE system operations at the Former Viking Cleaners from June 2004 through November 2006, approximately 3,000 pounds of PCE were estimated to have been removed from the subsurface (SECOR, 2007a). The AS/SVE system remained operational through June 2007. The system's operation and optimization during the RI period are discussed further in **Section 5.2.5.**

5.2.3 Overview of Subsurface Conditions

Boring logs indicate that the lithology underlying this facility generally ranges from clayey silt to gravel with sand and silt. Geosyntec assumed responsibility for this SVE system in July 2016 and immediately performed a remediation optimization review. Geosyntec concluded from its review that these zones may have significant disparity in pneumatic permeabilities, which may lead to potential short circuiting of extraction flow rates from the zones with higher permeabilities, whereas the less permeable zones receive much less flow and pore volume exchanges (Geosyntec, 2016a). The disparity of flow rates can be addressed with shorter SVE wells with screens that target specific lithological zones.

Based on a soil vapor monitoring event performed during a March 2016, there did not appear to be a clear trend in regard to the vertical distribution of soil vapor VOC impacts within the upper 15 ft of the vadose zone, based on variable VOC concentrations detected at 5, 10, and 15 ft bgs within nested SVPs at the site. Minimal interval-specific soil vapor data were available below 15 ft bgs, though in some cases, samples collected from the deeper SVE wells contained higher VOC concentrations than their shallower counterparts (e.g., V-SVE-2D compared to V-SVE-2S). This might have been due to the off-gassing of VOCs from impacted groundwater accumulating in deeper intervals within the vadose zone or may indicate that residual impacts may be present in fine-grained soil lenses at varying depth intervals.

ROI data collected during a 2012 SVE pilot test indicated that the subsurface is moderately to highly permeable, with ROIs ranging from 36 to 127 ft (Stantec, 2012i). Higher ROIs generally corresponded with deeper intervals, indicating that the subsurface lithology may become increasingly permeable with depth.

As part of the optimization evaluation in 2016, Geosyntec concluded that only minor residual soil vapor VOC impacts appeared to remain. Flow balancing was recommended to address the locations with the highest detected concentrations of VOCs. Subsequently, flow balancing was performed resulting in favorable mass removal rates and reduced soil vapor concentrations. Based on low VOC mass yield, two shutdown and soil vapor rebound evaluations were performed to assess progress towards achieving cleanup goals (discussed in **Section 5.2.5** below). Minor localized areas were observed to rebound above the depth-specific HPCs following both events. The site appears to be in the final stages of the vadose zone ERA.

5.2.4 Extraction and Treatment System Summary

The Former Viking Cleaners SVE system installed in 2011 primarily consists of a 30-HP positive displacement blower, capable of flow rates up to 550 ACFM and a system vacuum of up to 8 in Hg. Extracted soil vapor is routed through three 1,050-pound vapor-phase GAC vessels configured in series. A heat exchanger is located between the blower and the GAC to reduce the temperature of the vapor stream prior to passing through the GAC. After GAC treatment, the treated soil vapors are vented through effluent piping (i.e., the stack).

The original extraction well and vapor monitoring network for pilot testing consisted of two SVE wells and 10 SVPs. The extraction well and vapor monitoring network was later expanded and currently includes 15 SVE wells and 15 SVPs. SVE well screen intervals are variable. Some SVE wells are double-nested (V-SVE-1 through V-SVE-3), offering separate shallow and deep screen intervals. SVPs include sub-slab probes and triple-nested probes with screens at 5, 10, and 15 ft bgs. The SVE wells and SVPs are mostly located within and along the perimeter of the suite formerly occupied by the Former Viking Cleaners suite (**Figure 11**). Extracted soil vapor is conveyed within individual conveyance pipes to a large manifold near the SVE compound located along the eastern exterior of the suite.

5.2.5 ERA Implementation

In June 2011, two extraction wells and 10 SVPs were installed to perform an SVE pilot test. Based on the pilot test results, Stantec concluded that SVE could be an effective treatment technology for this area.

By the summer of 2014, construction of the full-scale SVE system near the Former Viking Cleaners facility was completed. The system was commissioned by H+A in July 2014 (H+A, 2015d), but was non-operational from October to December 2014 during expansion of the SVE wellfield (H+A, 2015a).

In June 2016, the system was shut down pending transition of O&M responsibility from H+A to Geosyntec. In July 2016, Geosyntec assumed responsibility for O&M of the SVE system. The system was operated generally continuously from July 2016 through June 2017, with brief shutdown periods for GAC changeouts and system maintenance. Approximately 72 pounds of VOCs were estimated to have been removed from July 2014 through June 2016, for an estimated cumulative mass removal of 109 pounds.

On 20 June 2017, the system was shut down for a rebound evaluation due to low VOC yield and observation of soil vapor monitoring results below the depth-specific HPCs. At the time of shutdown and after approximately five weeks of downtime, soil vapor samples were collected in a subset of 15 discrete SVP intervals, at 5 and 15 ft bgs. PCE was reported at concentrations of 16,700 μg/m3 at 5 ft bgs and 87,500 $\mu g/m^3$ at 15 ft bgs in VSG-02, exceeding their respective depth-specific HPCs. Additionally, PCE was detected at 21,800 $\mu g/m^3$ in sub-slab probe VSG-09. Although an HPC was not calculated for a sub-slab depth, this concentration exceeds the HPC for the 5-foot bgs depth interval. As such, additional remediation was warranted in the vicinity of these two SVPs. Geosyntec recommended a new SVE well be constructed outside the building in proximity to VSG-02 and VSG-09 (Geosyntec, 2018b).

On 20 November 2017, Geosyntec advanced a boring to approximately 13 ft bgs and constructed SVE well SVE-09 outside the building in the vicinity of VSG-02 to address residual VOCs in this area following the rebound results (Geosyntec, 2017d). Soil samples from 5, 10, and 13 ft bgs were screened in the field with a PID; VOCs were not detected. The SVE well was screened from 3 to 13 ft bgs (Geosyntec, 2018b). The conveyance for connecting the new SVE well to the manifold was constructed on 30 November 2017. The well was connected to the SVE system and the system was restarted immediately thereafter. The system operated generally continuously, and extraction was primarily focused from the new SVE well until shutdown to allow for a subsequent soil vapor rebound evaluation in early 2018, as discussed below.

On 19 February 2018, the system was shut down to initiate a second soil vapor rebound evaluation. Shutdown soil vapor samples were collected immediately after the system was shut down, and rebound samples were collected from SVPs and SVE wells from 5 to 60 ft bgs after four days and again after a rebound period of 37 days in a subset of site SVPs. Reported PCE concentrations ranged from non-detect in SVE-04 and VMW-1 (in February) to 20,800 $\mu g/m^3$ in VSG-09 at 5 ft bgs (in March); TCE was not detected above the laboratory RL. Geosyntec recommended continued operations and monitoring of the

SVE system, and that a new shallow SVE well be installed near VSG-09 and connected to the SVE system (Geosyntec, 2018b).

In September 2018, Geosyntec attempted to construct the new SVE well (proposed SVE-10) to address the residual soil vapor VOCs in this area; however, a UST was encountered during advancement of the 12-inch-diameter boring through the concrete floor slab (**Figures 5** and **11**). The tank was encountered approximately 1.5 to 2.0 ft bgs during drilling and appeared to be approximately 3 ft deep by 5 ft long. The top of the tank was observed to be rusted and brittle; however, the bottom was in competent condition and contained dry residual material 'cemented' along the tank sides and bottom. Residue samples were collected from the interior of the tank in duplicate, and the drill bit was advanced through the tank bottom to collect soil samples. Samples were collected at approximately 5 ft bgs (one foot below the tank bottom) and 8 ft bgs. Samples were analyzed by USEPA Methods 8260B, 8270C, and 6010C to assist with identifying potential tank contents. The maximum reported PCE concentration from the tank residue sample was 2.5 mg/kg, and PCE was not detected above the laboratory RL in soils collected below the tank. Four semi-volatile organic compounds (SVOCs) were detected in the tank residue and in lesser concentrations in the soil samples, but at levels below their respective GPLs. Further, the SVOC detected concentrations attenuated with depth to trace levels in the 8-foot bgs sample. The laboratory analytical report is included in **Appendix H**. The UST will be properly abandoned and the SVE-10 installation in the same location will be completed in the future; a memorandum of activities will be provided to ADEQ as requested.

Approximately 73 pounds of VOCs are estimated to have been removed from the subsurface by the SVE system between July 2016 and February 2018 for a cumulative estimated mass removal of 182 pounds.

5.3 ERA Investigation (Unocal)

As part of the historical review of the Former Viking Cleaners facility conducted by SECOR, LUST files for the Former Unocal service station were reviewed, since it is located adjacent to the Former Viking Cleaners facility to the north (**Figure 5**). According to SECOR's review, the owner was planning to operate an AS/SVE system to remediate soil and groundwater impacted with gasoline range hydrocarbons. As reported by H+A in a 2002 report, a corrective action plan including an AS/SVE system for the Former Unocal service station was approved by ADEQ; however, as of 2002, remedial activities had not yet begun (H+A, 2002).

5.4 Fairmount Avenue Study Area: 2011 SVE Pilot Test

On behalf of ADEQ under ASRAC EV09-0100, Stantec conducted SVE pilot testing activities at the FASA in February and December of 2011. The primary objectives of the tests were to evaluate the effectiveness of SVE at reducing PCE concentrations in soil vapor and to estimate the maximum ROI for vapor extraction (Stantec, 2012a).

Two SVE test wells (TW-1 and TW-2), 33 triple-nested SVPs (SVMWs; SG-01 through SG-33), and six triple-nested observation wells (OBS-1 through OBS-6) were installed within the FASA. TW-1 was screened from 15 to 30 ft bgs and TW-2 was screened from 40 to 50 ft bgs. The observation wells contained an “A” casing screened from 10 to 20 ft bgs, a “B” casing screened from 30 to 40 ft bgs, and a “C” casing screened from 50 to 60 ft bgs. The SVMW SVPs contained an “A” screen at 5 ft bgs, a “B” screen at 10 ft bgs, and a “C” screen at 15 ft bgs (Stantec, 2012a).

Pilot testing operations consisted of extracting soil vapors from test wells TW-1 and TW-2 using a trailer-mounted extraction blower while monitoring induced vacuum in observation wells and SVMWs. The SVE test was performed using a trailer-mounted, 25 HP, positive-displacement extraction blower and a 50-gallon air/water separator for condensate collection. Extracted vapor was treated by two 1,000-pound GAC vessels prior to discharge to the atmosphere (Stantec, 2012a).

According to Stantec, at the time of the SVE system’s emissions permitting the Maricopa County Air Quality Department required an air permit for total uncontrolled PCE emissions exceeding 5.5 pounds during any day (lbs/day). Stantec estimated the potential maximum PCE emissions would be 0.88 lbs/day, based on the maximum observed total PCE concentration in soil vapors at the FASA and the anticipated flow rate; therefore, Stantec did not obtain an air permit (Stantec, 2012a).

The SVE pilot test included a February test that ran for 37.5 consecutive hours and a December test ran 20.4 consecutive hours using a different extraction blower type. Soil vapor samples were collected prior to, during, and after testing from selected SVMW and observation wells to evaluate the effect of SVE on PCE soil vapor concentrations in the vadose zone. Soil vapor samples were collected using batch-certified Summa™-type canisters and transferred to an ADHS-licensed laboratory under chain-of-custody protocol for analysis of VOCs using USEPA Method TO-15. The following table summarizes the maximum flow rates for the extraction wells using different extraction blower capacities, and the results of soil vapor testing (Stantec, 2012a):

Date (Extraction Blower Type)	Flow Rates for Extraction Well TW-1	Flow Rates for Extraction Well TW-2	PCE Concentration Range (ppmv)
February 2011 (extraction blower rated for 500 ACFM at 177 in WC)	92.6 scfm at 130 in WC	42.6 scfm at 114 in WC	5.62 – 1.60
December 2011 (extraction blower rated for 300 ACFM at 354 in WC)	144 scfm at 204 in WC	57 scfm at 299 in WC	0.89 – 0.30

scfm – standard cubic ft per minute
ppmv – parts per million by volume
in WC – inches of water column

The Stantec report includes these results and conclusions (Stantec, 2012a):

- An estimated 0.40 pounds of PCE was removed from the vadose zone during the 35.7 hours of testing in February 2011. Estimated mass removal rates ranged from approximately 0.13 to 0.88 lbs/day.
- An estimated 0.02 lbs of PCE was removed from the vadose zone during the 20.4 hours of testing in December 2011. Estimated mass removal rates in December 2011 ranged from approximately 0.01 to 0.08 lbs/day.
- The estimated ROI ranged from 72 to 98 ft from observation well depth intervals of 10 to 20 ft bgs and 50 to 60 ft bgs, respectively.
- After pilot testing, concentrations of PCE rebounded (increased from concentrations reported during testing) as expected. However, concentrations remained lower than the original PCE concentrations in 57 percent of the soil vapor and observation wells (24 of 42 depth-specific samples).
- Based on detected PCE concentrations in extracted soil vapors, the ROI observed during pilot testing, and a decrease of PCE concentrations in vapor samples collected from soil vapor wells at least 150 ft from the extraction wells, pilot test results suggest that SVE could be an effective treatment technology to reduce the concentrations of PCE in soil vapor in the vadose zone within the FASA.

The groundwater monitoring wells within the FASA (UMW-05 through UMW-08, VCMW-04A/B, VCMW-05A, and VCMW-05B; **Figure 6**) were not monitored or sampled as part of the pilot test activities.

5.5 SRP Well Routine Groundwater Monitoring

SRP owns groundwater supply well SRP Well 17E-8N (**Figure 5**), located at the intersection of 32nd Street and Indian School Road (near the Former Viking Cleaners facility). SRP conducts routine groundwater sampling from its wells and submits water quality records to the ADEQ groundwater database. The following provides a summary of PCE and TCE analytical results from well sampling events, based on the chronology on ADEQ's website (ADEQ, 2018b).

2003: During a routine groundwater monitoring event, PCE was detected in the SRP well at a concentration of 8.1 µg/L, marginally above the AWQS of 5.0 µg/L. The maximum PCE concentration observed in a groundwater monitoring well (UMW-09) west of the SRP well was 3,600 µg/L.

2004: During a routine groundwater monitoring event, PCE was detected in the SRP well at a concentration of 4.6 µg/L. The maximum PCE concentration observed in a groundwater monitoring well (VCMW-02) southwest of the SRP well was 12,900 µg/L.

In response to an inquiry from H+A during preparation of the site *Land and Water Use Report* (H+A, 2018a), SRP provided the following water quality data for SRP Well 17E-8N in its 3 October 2017 completed questionnaire: PCE concentrations as high as 46 µg/L (1991); TCE concentrations as high as 1.5 µg/L (1996); PCE and TCE concentrations were 0.6 µg/L and below laboratory detection levels, respectively (2017); and well status was active.

6. RISK EVALUATION

An objective of the WQARF program is to evaluate potential public and environmental health concerns or risks associated with the site to support remedial action decision-making. The following tasks were performed as part of this evaluation:

- Characterize environmental and health hazards associated with exposure to site COCs;
- Describe the applicable regulatory criteria for site media impacted with site COCs;
- Identify potential receptors within the vicinity of the site;
- Identify the potential migration/exposure pathways to potential receptors, and the potential completion of such pathways; and
- Evaluate the potential risk to receptors based on the concentrations of site COCs in site media.

6.1 Environmental and Human Health Hazards

The predominant site COCs from source operations are PCE and TCE; thus, this section focuses on these two VOCs. PCE is a clear, colorless, nonflammable solvent that readily evaporates at room temperature. PCE is widely used for dry-cleaning of fabrics and degreasing/drying of metals. TCE is a nonflammable, colorless solvent that readily evaporates at room temperature. TCE is used mainly for degreasing/drying of metals and spot-cleaning of fabrics.

When present in groundwater or soil vapor, PCE and TCE can emit vapor and move through void spaces in the soil into buildings, potentially through cracks in the building foundation or slab. The vapors may accumulate in homes and other occupied buildings to levels that may pose health risks. This movement of VOCs from the subsurface into buildings is called vapor intrusion (ADHS, 2016). Due to the nature and location of the release in relation to commercial/industrial and residential areas, potential health hazards from the vapor intrusion pathway were evaluated and are discussed further below.

PCE and TCE are both included on a list of 10 chemical substances that are the subject of USEPA's initial chemical risk evaluations, currently being performed as required by USEPA under the Toxic Substances Control Act (TSCA), as amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act. USEPA recently published two comprehensive risk assessment documents for these compounds: one describing the scope of the risk evaluation and one stating the problem formulation. The content of these documents was reviewed to provide the summary information below, which represents USEPA's latest understanding of environmental and health hazards from exposure to these VOCs.

6.1.1 PCE Hazards

6.1.1.1 Human Health

According to the *Problem Formulation of the Risk Evaluation for Perchloroethylene (Ethene, 1,1,2,2-Tetrachloro), CASRN: 127-18-4* (USEPA, 2018a), and based on reasonably available information to USEPA, these are the potential human health hazards associated with PCE exposure:

- Non-cancer hazards: the central nervous system (neurotoxicity), kidney toxicity, liver toxicity, reproductive/developmental toxicity, and irritation.
- Genotoxicity and cancer hazards: likely to be carcinogenic in humans by all routes of exposure. Associated with several cancer types, including non-Hodgkin's lymphoma, multiple myeloma and bladder cancer, with more limited evidence for esophageal, kidney, lung, cervical and breast cancer.

6.1.1.2 Ecological Health

USEPA calculated acute and chronic toxicity PCE concentrations to aquatic and terrestrial species from a review of existing literature. According to the "Ecological Hazard Characterization of PCE" (Table 2-9, USEPA, 2018a), which presents a summary of USEPA's calculations, PCE can impact some species' mortality, growth, biomass/abundance, and reproduction.

6.1.2 TCE Hazards

6.1.2.1 Human Health

According to the *Problem Formulation of the Risk Evaluation for Trichloroethylene, CASRN: 79-01-6* (USEPA, 2018b), and based on reasonably available information to USEPA, these are the potential human hazards associated with TCE exposure:

- Non-cancer hazards: acute toxicity, liver toxicity, kidney toxicity, reproductive/developmental toxicity, neurotoxicity, immunotoxicity, and sensitization.
- Genotoxicity and cancer hazards: carcinogenic to humans by all routes of exposure and calculated quantitative estimates of risk from oral and inhalation exposures. Studies in humans have shown convincing evidence of a causal association between TCE exposure in humans and kidney cancer as well as human evidence of TCE carcinogenicity in the liver and lymphoid tissues. TCE is considered to have genotoxic carcinogenic, non-genotoxic carcinogenic, and teratogenic mechanisms.

6.1.2.2 Ecological Health

USEPA calculated acute and chronic toxicity TCE concentrations of concern to aquatic species, terrestrial species, and microorganisms from a review of existing literature. According to the "Ecological Hazard Characterization of TCE" (Table 2-8, USEPA, 2018b), which presents a summary of USEPA's calculations, TCE can impact some species' mortality, growth, deformities, abundance and reproduction. In microorganisms, TCE can impact respiration and growth.

6.2 Applicable Regulatory Standards and Screening Criteria

The following section describes the applicable regulatory standards for site COCs in soil, indoor air, and groundwater, both historically and present-day. ADEQ has not established state-wide soil vapor screening criteria but decided to establish site-specific criteria to guide its decision-making regarding continued operation of site SVE systems; thus, site-specific health- and groundwater-protective soil vapor concentrations are also discussed below.

6.2.1 Soil Remediation Standards

A discussion of soil remediation levels is presented herein to explain historical investigation results in relation to applicable criteria. The soil remediation standards conservatively selected by ADEQ for the site are based on the potential for future residential use, meaning those uses of remediated property where persons are reasonably expected to be in frequent, repeated contact with soil under a residential exposure scenario (A.R.S. §49-15l). In addition, ADEQ has selected a cumulative excess lifetime cancer risk of 1 x 10^{-6} (10^{-6} risk) level for site soil remediation standards, which are defined as concentrations of site COCs remaining in the soil after remediation, that would result in a 10^{-6} ("one in a million") risk and a hazard index (HI) no greater than 1.0, based on residential exposure assumptions. Although the Former Maroney's and Former Viking Cleaners facilities are zoned commercial/industrial, the FASA contains residential parcels and properties within the WQARF site estimated PCE plume boundary (**Figures 2** and **9**). Remediation to a 10^{-6} risk level was selected to allow for unrestricted future redevelopment and provide the most conservative protection to potential future occupants of the site.

6.2.1.1 Soil Remediation Levels

6.2.1.1.1 Current

The pre-determined RSRLs for carcinogenic compounds with a 10^{-6} risk level are listed in Appendix A of A.A.C., Title 18, and were adopted as permanently effective on 4 December 1997, and amended by final rulemaking on 5 May 2007. For site COCs, they are as follows:

- PCE RSRL = 0.51 mg/kg.
- TCE RSRL = 3.0 mg/kg (ADEQ, 2009).

PCE was detected in soil above its RSRL in samples collected from the Former Viking Cleaners facility in 2003 and 2006, and from the Former Maroney's facility in 2017 (**Table 4**). Other VOCs including TCE were not detected in soil above laboratory RLs nor above applicable ADEQ criteria.

The sample collected at 3 ft bgs (MSVE-12-03) in 2017 (Geosyntec, 2017c) with an exceedance of the PCE RSRL was delineated as a shallow impact, since results for deeper samples collected at the same location (5 ft bgs and 10 ft bgs) were below the RSRL and non-detect, respectively. Soil results in the context of the site RI are further described in **Section 8.1**.

6.2.1.1.2 Historical

Historically, soil results were sometimes compared to the 10^{-5} ("ten in a million") risk level for PCE of 5.1 mg/kg. During the site's investigative history prior to December 1997, the applicable soil criteria for PCE was the Human Health-Based Guidance Level (HBGL) of 27 mg/kg. The HBGL for TCE was 120 mg/kg. One soil sample from the Former Unocal service station collected in 1994 (Sample 9) contained PCE at 13 mg/kg, which was below the applicable criteria at the time. The depth of this sample was not reported and a figure depicting the sample location is not available. Tabulated historical soil results for PCE are included in **Table 4**.

6.2.1.2 Groundwater Protection Levels

The minimum GPLs (soil cleanup levels protective of groundwater quality) were used to evaluate groundwater data collected from the site. The minimum GPL for PCE is 1.3 mg/kg. The minimum GPL for TCE is 0.61 mg/kg.

Prior consultants in consultation with ADEQ opted to use the default minimum GPL of 1.3 mg/kg for PCE when evaluating soil data for the site. The PCE GPL was exceeded at three soil boring locations at the site: Sample 9 at the Former Unocal service station in 1994, and SB-1 and SB-2 at the Former Viking Cleaners facility in 2003 (**Table 4**). Soil results in the context of the site RI are further described in **Section 4.1**.

6.2.2 Soil Vapor: Health- and Groundwater-Protective Concentrations

In 2015, The Fehling Group, LLC (TFG) was subcontracted by H+A as a contractor to ADEQ to develop HPCs and groundwater-protective soil vapor concentrations (GPCs) for the Former Maroney's and Former Viking Cleaners facilities. TFG summarized their evaluation in two reports (one per facility) submitted to ADEQ: *Health and Groundwater Protective Site-Specific Vapor Intrusion and Groundwater Risk Screening Evaluations* (TFG, 2015d and 2015e). Geosyntec provided evaluation comments to ADEQ for both reports in a letter dated 5 January 2017 (Geosyntec, 2017a).

Work was performed in accordance with TFG's revised Work Plan dated 11 March 2015 (TFG, 2015b) and approved by ADEQ. Drilling and soil sampling were performed north of the Former Maroney's facility to collect soil physical parameters for input into the

USEPA Johnson & Ettinger (J&E) model (Johnson and Ettinger, 1991). Sampling and results are described in **Section 2.4.3**. Site- and compound-specific parameters were input into the J&E model to perform the evaluation. Soil properties used for strata A and B in the model were based on assuming engineered fill would be applied to the site prior to constructing a future building.

HPCs are soil vapor concentration ‘criteria’ that can be derived for compounds with a known carcinogenic and/or non-cancer health endpoint, correlated to a potential human receptor. HPCs are also developed for specific soil vapor sample depths. In general, a measured soil vapor concentration for a compound that is below its corresponding HPC could be considered protective of the potential receptor’s health. For both facilities, HPCs were developed for two categories of potential receptors, commercial/industrial workers and potential future residents.

GPCs are soil vapor concentration criteria applicable to the site. A measured soil vapor concentration for a compound that is below its corresponding GPC could be considered protective of groundwater. ADEQ’s minimum GPLs established in September 1996 were used as the GPCs for the VOCs evaluated; they were converted to soil vapor equivalent concentrations to perform the evaluation.

6.2.2.1 Former Maroney’s Facility

Concentrations of PCE and 13 other VOCs that were detected in the influent SVE soil vapor stream at least once during four monthly system sampling events were evaluated. The sampling events occurred January through April 2015. The VOC list included:

- PCE, TCE, and cis-1,2-DCE;
- Benzene;
- Toluene;
- Ethylbenzene;
- Cumene;
- Naphthalene;
- Chloroform;
- Bromodichloromethane and dibromochloromethane;
- Tetrahydrofuran;

- Freon 12; and
- Acetone.

HPCs were calculated per compound for the three sample depths (5, 15, and 45 ft bgs) and for both receptor categories. Of the multiple HPC values calculated, ADEQ selected the most conservative human health risk values for the site as the remedial benchmarks, the "$HPC_{RES\text{-}risk,SG}$" at 5 and 15 ft bgs sample depths (HPC-RES5 and RES15). This is a chemical-specific, soil vapor-based value in units of µg/m^3 that represents a cancer endpoint for the residential exposure scenario. For PCE, the HPC-RES5 is 11,000 µg/m^3 and HPC-RES15 is 20,000 µg/m^3.

The GPCs are expressed as soil concentrations (equal to GPLs from ADEQ, 1996) and as soil vapor concentrations using compound-specific conversion factors. For PCE, the GPC is 1,460,000 µg/m^3. The GPCs are found to be substantially higher than the HPCs. The influent concentrations to the SVE treatment system are found to be well below the GPCs. As such, TFG recommended that HPC-based risk values should be the remedial benchmarks; and HPC-based risk values should be calculated based on soil vapor concentrations measured in the existing network of SVPs. Soil vapor results for samples from SVPs installed at 5 or 15 ft bgs are compared to these values to assess whether continued operation of the SVE system is warranted.

6.2.2.2 Former Viking Cleaners Facility

Concentrations of PCE and 17 other VOCs that were detected in the influent SVE soil vapor stream at least once during four monthly system sampling events were evaluated. The sampling events occurred January through April 2015. The VOC list included:

- PCE;
- 1,2-DCA;
- 1,2,4-TMB and 1,3,5-TMB;
- BTEX (m/p-xylenes and o-xylenes were evaluated distinctively);
- 4-Ethyltoluene;
- Cumene;
- Cyclohexane and n-hexane;
- Methylene chloride;

- n-Heptane;
- n-Nonane;
- n-Octane; and
- Tetrahydrofuran.

Following the same methodology as described above, the GPC, HPC-RES5, and HPC-RES15 values were calculated for PCE and TCE. For PCE: the HPC-RES5 is 11,000 $\mu g/m^3$; the HPC-RES15 is 20,000 $\mu g/m^3$; and, the GPC is 1,460,000 $\mu g/m^3$, which are the same values calculated for the Former Viking Cleaners facility. For TCE: the HPC-RES5 is 54,000 $\mu g/m^3$; the HPC-RES15 is 96,000 $\mu g/m^3$; and, the GPC is 570,000 $\mu g/m^3$.

6.2.3 Indoor Air Screening Levels

Indoor air investigations were conducted at select buildings within the WQARF site to evaluate the quality of indoor air and to determine the level of VOC exposure to residents and commercial/industrial workers. A discussion of historical and current indoor air screening levels is presented herein to compare investigation results to applicable criteria.

6.2.3.1 Current

The USEPA Region 9 Indoor Air RSLs were used as the applicable indoor air screening values. The following indoor air RSLs are currently applicable for PCE and TCE, for residential indoor air RSL and industrial indoor air RSL scenarios:

- PCE residential indoor air RSL = 11 $\mu g/m^3$;
- PCE industrial indoor air RSL = 47 $\mu g/m^3$;
- TCE residential indoor air RSL = 0.48 $\mu g/m^3$; and
- TCE industrial indoor air RSL = 3.0 $\mu g/m^3$.

These values have been applicable since May 2014. The indoor air investigations conducted at the time these standards were applicable include the following (described in further detail in the referenced report sections):

- June 2014, and February, September, and October 2015: JC Printing - commercial (**Section 4.2.18**).

6.2.3.2 Historical

The following indoor air RSLs were applicable for PCE and TCE from May 2013 through April 2014:

- PCE residential indoor air RSL = 9.4 µg/m^3;
- PCE industrial indoor air RSL = 47 µg/m^3;
- TCE residential indoor air RSL = 0.43 µg/m^3; and
- TCE industrial indoor air RSL = 3.0 µg/m^3.

The change in residential indoor air RSL values for PCE and TCE in May 2014 was likely due to an adjustment in the assumed exposure duration for residents (from 30 years to 26 years). The indoor air investigations conducted at the time these screening levels were applicable include the following (described in further detail in the referenced report sections):

- August and October 2013: FASA – residential (**Section 4.2.17**); and
- October 2013 and February 2014: JC Printing – commercial (**Section 4.2.18**).

The earliest indoor air investigation conducted at the site was in April 2003 at the Former Viking Cleaners facility (**Section 5.2.1.2**); at that time, the following screening levels were applicable (from the October 2002 RSL tables):

- PCE residential indoor air RSL = 0.67 µg/m^3;
- PCE industrial indoor air RSL = 1.4 µg/m^3;
- TCE residential indoor air RSL = 0.017 µg/m^3; and
- TCE industrial indoor air RSL = 0.036 µg/m^3.

6.2.4 Groundwater Standards

AWQS are State of Arizona maximum levels for contaminants, which apply to groundwater in aquifers designated for drinking water use. The applicable AWQS were adopted effective 24 April 1996 and most recently amended by final rulemaking effective 2 August 2016 (A.A.C., Title 18, Ch. 11). The following AWQS are applicable:

- PCE = 5 µg/L;

- TCE = 5 µg/L; and
- cis-1,2-DCE = 70 µg/L.

Site COCs detected in groundwater above these levels include: PCE, TCE, and cis-1,2-DCE. However, cis-1,2-DCE was only detected once above its AWQS, at a concentration of 98 µg/L in one sample from UMW-01 collected on 20 December 1996.

6.3 Potential Receptors

Prior to performing the exposure pathway evaluation, potential receptors to site COCs are identified. The WQARF site (**Figure 1**) includes an area encompassing residential and commercial/industrial settings. Potential receptors are identified as current and future residential individuals, commercial/industrial workers, and construction workers occupying areas within the WQARF site. The following descriptions are presented as defined in ADEQ's *Site Investigation Guidance Manual* (ADEQ, 2014).

Residential individuals include children and adults occupying residential locations within the WQARF site. A residential location is typically one where someone is present for an average of more than eight hours a day. It includes, but is not limited to: schools, dwellings, residences, correctional facilities, any other human activity areas of repeated, frequent use and/or chronic duration and locations that typically sensitive populations such as grade schools, hospitals, child care centers, and nursing homes. Several apartment complexes are located within the site and PCE plume boundary, including, but not limited to, Jamestown Condominiums, Fairmount Villa Apartments, Fairmount Garden Condominiums, and Lofts at Arcadia (Figure 1C of H+A, 2013h). Individual residential properties are also located within the WQARF site.

Commercial/industrial workers include adults working at the commercial/industrial businesses within the WQARF site, which include but are not limited to service stations, dry-cleaners, a printing facility, and retail shopping areas.

Construction workers include adults who are performing construction work for a substantial period (e.g., months to years), resulting in sub-chronic exposures for on-site construction workers for only that period equal to the duration of the project.

Two categories of sensitive receptors, schools and medical centers, are located within a half-mile radius of the estimated PCE plume boundary. A list of these schools and medical centers was prepared from reviewing Google Earth and Google Map data (accessed online in October 2018) and is presented in **Table 8**.

6.4 Ecological Risk Evaluation

As defined in A.A.C., an ecological receptor is "a specific ecological community, population, or individual organism, protected by federal or state laws and regulations, or a local population that provides an important natural or economic resource, function, and value" (A.A.C., Title 18, Ch. 7, 201). Wildlife or vegetation that is present in the study area is likely non-native to the area, is habituated to human presence, or has been maintained in a horticultural setting. Areas and land use within the WQARF site (**Figure 2**) do not contain suitable habitat for the five federally listed species. Due to the presence of COCs at depth, urban character of the site, and lack of ecological receptors within the WQARF site, an evaluation of ecological receptors is not warranted.

6.5 Exposure Pathways and Potential Risk

An exposure or migration pathway is the route by which the potential hazard (identified COCs) migrates from the source (soil vapor, soil, surface water, or groundwater) to a potential receptor. Pathways can include:

- Inhalation of impacted vapors;
- Dermal contact with impacted soil, groundwater, or surface water; or
- Ingestion of impacted soil, groundwater, or surface water.

An exposure pathway is complete when all four of these components are present: 1) a source and mechanism of chemical release; 2) a retention or transport medium (pathway); 3) an exposure point (i.e., a setting where potential human contact with the chemical-affected medium or media occurs); and 4) a route of exposure at the exposure point (e.g., ingestion, dermal, inhalation).

The land use at the site is currently commercial/industrial, residential, and public open space. This exposure pathway evaluation, therefore, assesses potential pathways by which long-term commercial workers, short-term construction workers, visitors to the site, and residents may be exposed to the predominant site COCs, PCE and TCE. This section evaluates whether the pathways are currently complete, and if so, assesses the potential risk to receptors based on the concentrations of site COCs.

6.5.1 Conceptual Site Model

The impacts present at the 32nd Street and Indian School Road WQARF site are thought to be the direct result of releases of dry-cleaning solvents, primarily PCE at the Former Viking and Former Maroney's facilities. **Figure 12** depicts conceptual site model for 32nd Street and Indian School Road WQARF site. This figure is intended to convey how the impacts originated beneath the Former Viking and Former Maroney's facilities, traveled through the vadose zone the geology and ultimately how the resultant groundwater plume has migrated to its current observed extent.

Figure 12 also indicates vadose zone impacts beneath the source of the COC releases. These are currently depicted in the conceptual site model; however, it is believed that these impacts have been successfully remediated by SVE implementation as an ERA. The ERA activities are detailed in **Section 5** of this report.

Based on the assessment work completed, it is apparent that the COCs from the Former Viking and Former Maroney's facilities travelled vertically until they encountered groundwater at a depth of approximately 60 ft bgs. Once in contact with groundwater, the COCs, primarily PCE, dissolved into the groundwater and migrated in a southwesterly direction for approximately 15,000 ft, at which point the COCs on the leading edge of the plume were below their applicable AWQS. Along the flow path, the COCs descend with the midpoint of plume stabilizing at a depth of approximately 240 ft bgs.

Also relevant to the conceptual site model is the presence of the Grand Canal and SRP wells 16E-6.8N and 17E-8N shown in **Figures 5** and **12**. Although the figure appears to indicate SRP wells directly adjacent to the groundwater plumes, they are located approximately 1,000 ft and 100 ft respectively to the south of the current plume extents. As such, there is currently an incomplete groundwater pathway from 32nd Street and Indian School Road WQARF site to the Grand Canal, as COC impacts in the vicinity of SRP wells do not exceed the drinking water AWQS. However, if pumping of SRP wells was to increase in the future, the potential exists for COCs to be drawn toward the wells, which could result in groundwater with COC concentrations above the applicable AWQS being pumped water into Grand Canal.

Similarly, COP well COP-626528 is currently located approximately 3,500 feet southwest of the extent of COC impacts to groundwater and is currently not in use and does not exceed the AWQS. However, if pumping of COP-626528 was to resume and pump on a regular basis, the potential exists for COCs to be drawn toward the well, which could result in groundwater with COC concentrations above the applicable AWQS being pumped. As such, this is another incomplete groundwater pathway from 32nd Street and Indian School Road WQARF site to the COP water utility.

6.5.2 Vapor Pathway

Transport of vapor-phase COCs present in soil vapor to indoor air could result in exposure to human health risk via inhalation.

ADHS evaluated 2003 indoor air evaluation results from the Former Viking Cleaners facility (**Section 5.2.1.2**) and provided ADEQ with a health consultation. ADHS advised there was no unacceptable risks to workers inside the building under current exposure scenarios (SECOR, 2003a).

In April 2016, ADHS published a draft health consultation report to evaluate health concerns associated with potential vapor intrusion of PCE and TCE to residential and commercial buildings located at the site. In December 2016, ADHS published its final report, *Health Consultation – Vapor Intrusion of PCE and TCE in Residential and Commercial Buildings* (ADHS, 2016).

The following is a summary of the ADHS' findings and conclusions (ADHS, 2016):

- ADHS concluded that complete and potential exposure pathways may be present as a result of people in ECP inhaling air that contains levels of PCE and TCE, as an effect of vapor intrusion.
- Based on the PCE data, ADHS concluded the estimated cancer risk did not exceed the USEPA target risk range of 10^{-6} to 10^{-4}.
- Based on the TCE data, ADHS believes there is a potential public health concern from TCE because, at three residences, its reported indoor air concentrations were highly variable, and the averaged concentrations were above the health guideline (chronic MRL). ADHS also concluded the elevated TCE concentrations in indoor air at these locations were not likely due to vapor intrusion, but instead were likely due to common household sources of TCE. ADHS pledged to make available health education materials to the residents of these three buildings regarding ways to reduce TCE exposure from common household sources; however, no literature was found in file reviews confirming whether this occurred.
- Since vapor intrusion of impacted site soil vapor into buildings is not the cause of the potential public health concern from TCE, and cancerous and long-term non-

cancerous public health concerns are not expected from vapor intrusion of PCE-impacted soil vapor into site buildings per ADHS' assessment, site soil vapor impacts do not pose unacceptable risk to public health by this exposure pathway.

Indoor air concentrations of PCE in the JC Printing facility from 2013 to 2016 exceeded the industrial indoor air RSL in the production area. H+A concluded that exposure to PCE impacts did not present an unacceptable risk to the health of commercial/industrial workers, and impacts would remain acceptable if the SVE system continued to operate (H+A, 2015j). This conclusion would suggest that the indoor air sampling occurred while the SVE system was temporarily shut down and that operation of the system would mitigate vapor intrusion; however, it is unclear whether this was the sampling approach, as the SVE system operational status was not discussed in the report. An indoor air evaluation may need to be performed at the conclusion of ERA implementation if site-specific soil vapor cleanup criteria are not met. SVE has been effective at reducing soil vapor concentrations to below the HPCs since the time the indoor sampling was performed, with only one SVP location remaining to pass VOC rebound testing (VSG-9).

The transport mechanism for a soil vapor pathway is volatilization and the secondary impacted media are indoor and outdoor air, as indicated on the attached exposure route pathways figure (**Figure 12**). Geosyntec's assessment is that the inhalation exposure route that could affect certain exposed receptors presents a potentially complete exposure pathway; however, the risk is less than the target risk for cancer or the target hazard index, and either has been or is currently being mitigated.

6.5.3 Soil Pathway

Limited soil sampling activities were conducted during initial site investigations at the Former Unocal service station, Former Viking Cleaners facility, and Former Maroney's facility. Reported PCE concentrations above the RSRL occurred at depth below barriers (i.e., concrete slabs, paved or asphalted surfaces) where they are inaccessible to direct contact by humans unless there is an excavation beneath the barrier. The land use for these properties is currently industrial/commercial. For a continued future commercial/industrial scenario, the soil direct contact pathway would remain incomplete. If these properties are redeveloped for residential purposes, this exposure pathway would require re-evaluation.

The transport mechanisms for a soil pathway include excavation and fugitive dust (**Figure 12**). For excavation, the secondary impacted media is trench spoils. Geosyntec's assessment is that the dermal and incidental ingestion exposure route (to affect construction workers in contact with trench spoils) presents a potential exposure pathway. Limited soil sampling has been conducted on the property, and there are not recent results. However, soil vapor data collected during the final rebound event (discussed in **Sections 5.1.5 and 5.2.5**) was used to estimate soil concentrations.

- At the Former Maroney's facility, the maximum reported concentrations of PCE and TCE in soil vapor following the final rebound test were 2,270 $\mu g/m^3$ and 59 $\mu g/m^3$, respectively. Using the ADEQ Soil Vapor Sampling Guide (ADEQ, 2011) to relate these soil vapor concentrations to soil concentrations, Geosyntec calculated a soil PCE concentration of approximately 0.0032 mg/kg, well below the PCE RSRL of 0.51 mg/kg, and a soil TCE concentration of approximately 0.00015 mg/kg, well below the TCE RSRL of 3.0 mg/kg.
- At the Former Viking Cleaners facility, the maximum reported concentration of PCE in soil vapor following the final rebound test was 20,800 $\mu g/m^3$. TCE in soil vapor was not reported above the laboratory reporting limit. Using the ADEQ Soil Vapor Sampling Guide (ADEQ, 2011) to relate this soil vapor concentration to a soil concentration, Geosyntec calculated a soil PCE concentration of approximately 0.03 mg/kg, well below the PCE RSRL of 0.51 mg/kg.

The results indicate that there is no unacceptable risk associated with residual CVOC soil impacts.

6.5.4 Groundwater Pathway

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, since the site is serviced by sewers and the public water supply, 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, as further discussed in **Section 7.4**. If these supply wells are utilized in the future for water supply, as discussed in **Section 7.5**, 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 (**Figure 12**). Geosyntec's assessment is that 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.

6.5.5 Surface Water Pathway

There are no points of natural discharge of groundwater to surface water within 1 mile of the site. The nearest surface water conveyance is the SRP Arizona Canal. Therefore, surface water is not a complete pathway at the site.

7. CURRENT AND FUTURE LAND AND WATER USE

Pursuant to A.A.C. R18-16-406 (A)(3) and (D), the scope of this RI includes the collection of information regarding current and reasonably foreseeable uses of land and/or waters of the state that have been or could be impacted by the release of site COCs, and projected time-frames for future changes in those uses. Reasonably foreseeable future land uses are those that are likely to occur at the site. Reasonably foreseeable future water uses are those that are likely to occur within 100 years unless a longer period is shown to be reasonable based on site-specific circumstances.

ADEQ prepared a standardized questionnaire requesting specific information regarding property, on-site wells, water use, and waste streams and mailed it to municipalities and utilities in the site area. Responses were received from COP and SRP. Additional information was obtained by H+A from publicly available COP, SRP, and ADWR databases and/or documents. A *Land and Water Use Report* (H+A, 2018a) for the site was prepared by H+A and submitted to ADEQ on 2 February 2018, a copy of which is included in **Appendix E**.

Evaluation of land and water uses took place as part of the draft RI Report public comment period; comments received are reflected in the Final Remedial Objectives (ROs) Report (**Appendix K**). The 30-day public comment period associated with the draft Proposed RO Report occurred subsequent to the Draft RI public comment period. The land and water use findings that are relevant to the ROs are summarized below.

7.1 Current Land Use

The site is located within the COP in Maricopa County. There are three villages impacted by the PCE plume: Camelback East Village, Encanto Village, and Central City Village. The primary land uses within the site are single family residential (38%), parks/open space (26%), multiple family residential (12%), commercial/industrial (12%), public/transportation (8%), and vacant (4%) (H+A, 2018a).

The Former Viking Cleaners and Former Maroney's facilities are designated as C-2, Commercial–Intermediate Commercial.

7.2 Future Land Use

Requests for zoning changes must go through a public hearing and be approved by the City Council prior to finalization. According to the response received from COP, there are no current foreseeable plans to alter current zoning districts in the site vicinity. According to the questionnaire response from the COP, future zoning plans or area plans within the WQARF site include:

- Encanto Village Core;
- Downtown – MAG Designated Major Employment Center;
- Infill Development District;
- Good Samaritan Area Redevelopment Plan;
- Downtown Code;
- Coronado Neighborhood SPD;
- Squaw Peak Parkway Specific Plan;
- TOD-District Midtown;
- TOD-1 (Interim Transit Overlay District-1); and
- Central Avenue Development Standards.

Grand Canalscape is a special project by the COP being developed partly within the WQARF site. The Grand Canalscape project aims to create a nearly 12-mile continuous trail system along the Grand Canal from 1-17 to the Phoenix/Tempe border. Phase II, Segment Two of the project encompasses the Grand Canal section from 16th Street to 36th Street, which crosses the WQARF site. Phase II project improvements will include a hard surface trail along the north bank of the Grand Canal; it is planned for construction completion by spring of 2019 (http://www.grandcanalscape.com/).

7.3 Potential Sensitive Receptors

There are seven public school districts and 31 private schools located in these villages. The school districts include: Phoenix Union High School District, Creighton School District, Isaac School District #5, Madison School District, Osborn School District No. 8, Phoenix Elementary School District #1, and Wilson Elementary School District #7 (H+A, 2016a). The schools that are located within 0.5 mile of the estimated plume boundary are listed in **Table 8**. Hospitals and medical facilities located within 0.5 mile of the estimated plume boundary are also listed in **Table 8**. Sensitive receptors located in areas within the 5 µg/L PCE groundwater isoconcentration plume (shown in **Figure 2**) are as follows:

- Maggie’s Place (medical/community center);
- Creighton School District Compass Center (school);
- Larry C. Kennedy Elementary (school);
- William T. Machan Elementary School (school); and
- Create Academy (school).

7.4 Current Water Use

The site lies within the Phoenix AMA, one of the four original AMAs established by the 1980 Groundwater Management Code (the Code). The AMA is depicted in Figure F-5 in **Appendix E**. The Code set up a comprehensive management framework and established the ADWR to administer the Code's provisions. In accordance with the Code’s provisions, a person must have a groundwater right or permit to pump groundwater legally, unless the person is withdrawing groundwater from an "exempt" well. A well is considered "exempt" if it has a maximum pump capacity of 35 gallons per minute (gpm) and “non-exempt” if its capacity exceeds 35 gpm. Within an AMA, water can be withdrawn from “non-exempt” wells under grandfathered rights, service area rights or withdrawal permits (ADWR, 2008). According to information supplied in the Land and Water Use Report (**Appendix H**), there are no grandfathered rights to groundwater at the site (H+A, 2018a).

7.4.1 Non-Exempt Wells

A review of ADWR’s registered withdrawal well records indicates that there are 28 “non-exempt” withdrawal wells located within 1 mile of the estimated PCE plume boundary. Of these wells, 10 are owned by SRP, one is owned by COP, and the remainder are owned by private entities, aside from one well with ownership not reported. Well construction, ownership, and pump capacities are included in Table F-3 of the attached *Land and Water Use Report*, locations are depicted in Figure F-6, and ADWR well records are included in Attachment B (**Appendix E**). The wells and usage are discussed by ownership below.

7.4.1.1 SRP

SRP provides surface water via deliveries from the Arizona Canal and Grand Canal through several lateral canals in the AMA. The site area receives water from SRP Lateral 6.1, which in turn receives water from the Arizona Canal, SRP Well 17.9E-7.5N, and SRP Well 17E-8N (**Figure 5**). Water from SRP Lateral 6.1 is used for residential irrigation and discharges to the Grand Canal (Figure F-10 of **Appendix E**). The Arizona Canal, located approximately 1.75 miles to the northeast of the site, is the nearest surface water body. Groundwater typically comprises approximately 15 percent of the total water supplied by SRP to municipal treatment plants. The groundwater contribution varies seasonally with the highest contribution occurring March through August.

According to SRP's 3 October 2017 questionnaire response to H+A, within the estimated PCE plume boundary, SRP owns and operates water production and conveyance structures including the Grand Canal, piped laterals, and groundwater supply wells 16E-6.8N (**Figure 2**) and 16E-7.5N for its shareholders. In addition to SRP Wells 16E-6.8N and 16E-7.5N, SRP has multiple other groundwater supply wells, power transmission and distribution lines, and telecom assets in or directly adjacent to the site. A total of 10 groundwater supply wells are located within 1.25 miles of the estimated PCE plume boundary, as depicted in Figure F-6 of the *Land and Water Use Report* (**Appendix E**). Of these wells, SRP provided the following status information and water quality data for wells that have shown elevated PCE or TCE levels since 1990:

- SRP Well 16E-7.5N (ADWR 55-617715) is inactive and located within the estimated plume. Water quality data is not available for this well;
- SRP Well 16E-8.0N (ADWR 55-607715) is active and located at the corner of 24th Street and Indian School Road. It has a historical maximum PCE detection of 2.0 μg/L (1993), historical maximum TCE detection of 0.6 μg/L (1999), and in 2017, PCE and TCE were 0.4 μg/L and not detected above the laboratory RL, respectively;
- SRP Well 16.9E-6N (ADWR 55-608380) is active and located at the corner of 32nd Street and East McDowell Road, south of the plume. It has a historical maximum PCE detection of 2.7 μg/L (2014), historical maximum TCE detection of 10 μg/L (2014), and in 2017, PCE and TCE were 1.2 μg/L and 6.2 μg/L, respectively;
- SRP Well 17E-8N (ADWR 55-608431) is active. It is located along 32nd Street and Indian School Road and has a historical maximum PCE detection of 46 μg/L (1991), historical maximum TCE detection of 1.5 μg/L (1996), and in 2017, PCE and TCE were 0.6 μg/L and not detected above the laboratory RL, respectively;
- SRP Well 17.1E-7.4N (ADWR 55-607731) is active. It is located south of the Former Viking Cleaners along 32nd Street and has a historical maximum PCE detection of 5.8 μg/L (1998), TCE concentrations below laboratory RLs since

1990, and in 2017, PCE and TCE were 1.1 µg/L and not detected above the laboratory RL, respectively; and

- SRP Well 17.9E-7.5N (ADWR 55-617857) is active. It is located southeast of the Former Viking Cleaners along 40th Street and has a historical maximum PCE detection of 210 µg/L (1998), historical maximum TCE detection of 9.9 µg/L (1996), and in 2017, PCE and TCE were 1.6 µg/L and not detected above the laboratory RL, respectively.

As noted previously in this report, the reported concentrations of PCE in samples collected from SRP Well 17E-8N between 1983 and 1986 ranged from 6.75 µg/L to 66.7 µg/L (ADHS, 1985; Ecology and Environment, Inc., 1988). It is possible SRP did not report this value as a historical maximum since they provided data from 1990 to 2017.

7.4.1.2 City of Phoenix

The COP relies on four primary water supply sources: SRP, Central Arizona Project (CAP), groundwater pumped from COP wells, and reclaimed water. The non-exempt supply well owned by the COP (Coronado Park Well 55-626528) and located adjacent to the southwestern portion of the estimated PCE plume is not currently operating. It was installed for the adjacent Coronado Park at 12th Street and Coronado Street. As indicated in the COP questionnaire response, no active groundwater pumping by the COP occurs in or near the site.

COP has indicated that recharge and recovery locations in the 2011 Water Resource Plan (WRP) are no longer accurate and that, as of the time of preparing this report, COP is in the process of revising the 2011 WRP. COP will provide ADEQ with a copy of the revised WRP as soon as it is published.

7.4.2 Exempt Wells

According to H+A's review of ADWR's registered withdrawal well records, there are 14 "exempt" withdrawal wells located within 1 mile of the estimated PCE plume boundary. Water withdrawal from these wells are intended either for domestic irrigation or non-contact cooling water purposes. There is no documented private drinking use of groundwater within the site (Table F-3, Figure F-6, and Attachment B in **Appendix E**).

7.5 Future Water Use

7.5.1 City of Phoenix

According to the *Land and Water Use Report*, several factors may impact the available COP water supply:

- Cyclical drought;
- Increasing demands in the Upper Colorado River Basin States (Utah, Colorado, Wyoming, and New Mexico) affecting Arizona's supply of Colorado River water;
- The availability of water supplies from the Arizona Water Banking Authority to the CAP to offset shortages;
- Climate variability impacts on long-term flows, reservoir storage, and deliveries by SRP and CAP;
- The probability of low reservoir conditions occurring in both watersheds simultaneously;
- State legal, institutional, or policy changes impacting surface water availability;
- The availability and volume of groundwater supplies without aquifer replenishment; and
- Impacts of increased groundwater pumping in the SRP watershed on river flow and reservoir storage.

As a buffer to potential surface water supply reductions, the COP has been recharging to underground storage or banking unused CAP allotments for future use. These recharge and recovery locations are depicted in Figure F-8 in **Appendix E**, adapted from the COP's 2002 General Plan, Water Resources Element. According to 10- and 20-year cyclical deficit scenarios adapted from the COP's 2011 W*ater Resources Plan*, depicted in Figure F-9 in **Appendix E**, high demand coupled with severe SRP and CAP shortages could deplete these reserves by 2020 (H+A, 2018a).

Since local groundwater is an alternate water source for COP, planning is ongoing for the expansion of well capacity within the service area via well rehabilitation or the development of new service area wells (Attachment A in **Appendix E**).

As indicated in COP's questionnaire response, due to possible shortages of surface water supplies (CAP-Colorado River and SRP-Salt and Verde Rivers), the COP maintains an inventory of its active and inactive municipal water supply wells. When SRP and/or CAP water supplies are reduced, the COP supplements water supplies with groundwater pumped from COP wells. Inactive water supply wells such as the Coronado Park Well 55-626528 or new production wells in the COP service area could be used in the future to augment supplies during a severe drought (Attachment A in **Appendix E**).

7.5.2 Salt River Project

According to SRP's 3 October 2017 questionnaire response (Attachment A in **Appendix E**), SRP anticipates its supply wells in the vicinity of the site will remain in use over the next 100 years. The SRP also responded with the following statement:

> *"Though SRP has no current plans to develop additional groundwater supplies within the ECP WQARF site, it is very likely they will be added in the future... To meet its water delivery needs SRP may elect to increase its groundwater use in close proximity to the WQARF site... SRP may do this by constructing additional groundwater supply wells or by connecting its existing water supply wells to direct municipal delivery to provide greater flexibility in its delivery operations."*

With respect to SRP Well 16E-8.0N, SRP responded that it is currently negotiating for the purchase of a replacement well site that is located less than 0.25 mile southeast of the original well site. In accordance with ADWR requirements, SRP must drill this replacement well within 660 ft of the original site to maintain the associated water right. The replacement well would be situated north and cross-gradient of the estimated plume boundary and would be closely adjacent to the WQARF site. SRP responded that it would like to be informed of any potential pumping restrictions and the "respective well depths that should be considered to support WQARF efforts. SRP is looking to resolve these concerns prior to purchasing the new well site location."

In addition, SRP responded that it has recently signed a contract to supply water to the City of Goodyear via the Grand Canal to a designated drinking water treatment facility. Once this agreement goes into effect, the 10 SRP supply wells located within 1.25 miles of the estimated PCE plume boundary (Figure F-6 in **Appendix E**) will be located upstream of the water to be supplied to the drinking water plant. SRP responded that it will have to "strategically select wells to supply water to the drinking water plant to avoid potential contamination from the site." In addition to contracting with the City of Goodyear, SRP responded that it has been transitioning certain groundwater supply wells from irrigation to municipal service (potable supply); thus, "it may become necessary to construct additional groundwater supply wells near the WQARF site in the future."

8. CONCLUSIONS

This section presents a summary of the interpretation of the findings of the RI activities and associated conclusions. Conclusions are provided separately for the vadose zone and groundwater. The effectiveness of ERAs implemented to-date are also discussed.

8.1 Vadose Zone

Historical site characterization associated with the RI, as well as PIs, PAs, and ESAs, 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 throughout the vadose zone to groundwater at both properties. However, the vadose zones of both properties are considered to be fully characterized. Historical investigations and numerous sampling events using temporary borings and a network of dedicated SVPs and extraction wells have provided requisite delineation of the VOC vadose zone impacts. The investigations have defined both the lateral and vertical extent of the COC impacts.

Several years of SVE remediation have been implemented at both properties for effective vadose zone cleanup. Periodic system upgrades have been performed for optimization of VOC mass removal, including constructing new SVE wells with shorter screens targeting specific vertical and horizontal locations, and frequent flow balancing to focus extraction primarily on the SVE wells with the highest VOC concentrations. ERA implementation has reduced soil vapor concentrations to below the site-specific HPCs at both properties, with VOC rebound evaluations pending.

Soil vapor concentrations have been evaluated relative to the site-specific soil vapor HPCs that have developed for the facilities. Residential HPCs are used as the metric for the site based on ADEQ's preference of performing remediation to this more conservative cleanup standard, as opposed to non-residential (commercial/industrial) standards. Facility-specific evaluations are presented in the following subsections.

8.1.1 Former Maroney's Facility

Several soil vapor rebound monitoring events have been performed for the Former Maroney's facility. Historically, VOC concentrations in soil vapor have fully rebounded after long periods of system shutdown. Typically, these events were followed with optimization efforts to enhance mass removal rates (e.g., installation of new SVE wells with focused screen intervals). The potentially most effective optimization action was the construction of an SVE well (MSVE-11) directly in the suspected source area within the building footprint in 2017. Prior to installing this well, no wells were located within the building footprint. After installation, extraction was focused primarily from this well (from November 2017 to February 2018).

The SVE system was shut down in February 2018 for rebound evaluation. Samples collected approximately five weeks later did not contain concentrations above the HPCs. A subsequent soil vapor rebound evaluation was performed in October 2018 with samples collected from the three SVPs located within the dry-cleaner suite (MSG-21 through MSG-23, approximately eight months after system shutdown). The results of the rebound evaluation will be discussed in future site reporting.

8.1.2 Former Viking Cleaners Facility

The vadose zone of the Former Viking Cleaners facility has been impacted by both CVOCs and hydrocarbons. The hydrocarbons are assumed to be related to the LUST site adjoining to the north and not the former dry-cleaning operation. Thus, they have not been the focus of site cleanup operations and their detection and impacts are incidental to the remediation of PCE and degradation byproducts associated with the dry-cleaning operations.

Several soil vapor rebound monitoring events have been performed for the Former Viking Cleaners facility. Historically, VOCs have only partially rebounded after periods of shutdown, with only one or a few SVPs exhibiting a detected concentration above depth-specific HPCs. Typically, these events were followed with optimization efforts to enhance mass removal rates, which were generally effective at enhancing mass removal rates. Currently only one SVP, VSG-09, has yet to pass rebound evaluation.

During indoor air monitoring performed at the site in 2014 and 2015, VOC concentrations were detected that did not exceed USEPA non-residential RSLs, indicating that VOC vapor intrusion was not occurring at levels that would result in unacceptable human health risk based on a commercial/industrial exposure scenario. The favorable indoor air monitoring results could have been used as a basis to discontinue the SVE ERA; however, ADEQ conservatively has continued to operate the SVE system with the objective of achieving the residential HPC soil vapor cleanup levels. Once soil vapor concentrations pass rebound evaluations (remain lower than the HPCs following an adequate shutdown period), system decommissioning and demobilization will be warranted.

8.2 Groundwater

8.2.1 Source Areas / Distribution Trends

The Former Viking Cleaners and Former Maroney's facilities appear to be the source of most VOC impacts at the site. This determination is based on review of the numerous investigative studies completed at the site, combined with review of the data using Earth Volumetric Studio (EVS) software (C Tech, 2018). EVS modeling was conducted to improve the understanding of both the lithology and the distribution of PCE in groundwater at the site.

The lithology model output, consisting of static cross-section images (**Figures 14** through **16**) and a three-dimensional visualization image (**Figure 17**) was partly created from lithologic information provided in boring logs from 158 total borings advanced on-site by various consultants. United Soil Classification System soil classifications are grouped into five main lithologic types for the purposes of interpolation. The indicator Krig algorithm computes the most likely lithology for each model cell. A horizontal-to-vertical ratio (anisotropy) of 150 was used for the interpolation, dipping at 0.5 degrees to the southwest (225-degree bearing). These two values (anisotropy and direction) were determined experimentally by running various iterations and examining the connectivity of the units. Due to the sparseness of the boring log dataset, in some site areas the lithologies in the model were interpolated using data mainly from one or two borings. **Figures 15** and **16** show the cross-sections through the lithologic model, and **Figure 14** shows the lines of section (in plan view).

The chemical impact volumetric model for PCE was interpolated in EVS using the Krig algorithm and concentrations from 28 groundwater monitoring wells sampled from November 2016 through August 2018. Concentrations were averaged for locations sampled more than once during this period. Non-detect results were replaced with a value one-tenth of the RL. A horizontal-to-vertical ratio (anisotropy) of 52 was used with a directional anisotropy of 6 in the southwest direction (233-degree bearing) at a dip angle of 1.25 degrees to account for the groundwater gradient. These values were derived using experience from similar sites and professional judgement. The PCE impact volumetric models, coupled with the lithology model, were used to improve the understanding of subsurface conditions and the conceptual site model.

8.2.2 General Distribution Trend

Based on data collected in 2017 and 2018, 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, 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 vertically 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 long and relatively narrow plume bounded by the 5 µg/L PCE isoconcentration contour.

When examining the extent of PCE impacts two-dimensionally in plan view, as shown by the PCE Groundwater Isoconcentration Map (**Figure 13**), there appears to be an interaction (overlap) of the PCE plumes associated with WQARF site and the PCE impacts to groundwater associated with the 24^{th} Street and Grand WQARF site. The two plumes, however, are discrete, separate plumes traveling alongside each other and at different vertical elevations, with the plume associated with the 24^{th} and Grand ECP WQARF site being shallower and located to the south. The independence of these plumes is shown in Geologic Cross Section B-B' (**Figure 16**) and in the three-dimensional EVS visualization of PCE impacts (**Figure 17**).

Groundwater COC impacts, exclusively PCE, at concentrations above 5 µg/L are limited to a plume originating at the Former Viking Cleaners and Former Maroney's facilities, extending downgradient approximately 15,000 ft in a southwesterly direction.

Groundwater COC impacts, exclusively PCE, at concentrations above 10 µg/L are limited to a plume originating at the Former Viking Cleaners and Former Maroney's facilities, extending downgradient approximately 12,000 ft in a southwesterly direction.

Groundwater COC impacts, primarily PCE, at concentrations above 20 µg/L are limited to a plume originating at the Former Viking Cleaners and Former Maroney's facilities, extending downgradient approximately 8,000 ft in a southwesterly direction.

Groundwater COC impacts, PCE, at concentrations above 100 µg/L are limited to a plume originating at the Former Viking Cleaners and Former Maroney's facilities, extending downgradient approximately 1,000 ft in a southwesterly direction.

Since 2016, TCE concentrations in groundwater above 5 µg/L (maximum concentration of 7.6 µg/L at a depth of 240 ft bgs) were limited to data collected by the Hydropunch™ method during the drilling of one location (VCMW-20) in December of 2016. This would suggest that TCE impacts associated with the Former Viking Cleaners and Former Maroney's facilities have been naturally attenuating over time.

In 2002, cis-1,2-DCE was detected at concentrations above the AWQS in monitoring well UMW-01. In 2006, cis-1,2-DCE was detected at concentrations above the AWQS in monitoring well UMW-09. Since 2006, no groundwater samples have been collected that have shown exceedances of cis-1,2-DCE above the AWQS. This suggests that cis-1,2-DCE impacts to groundwater associated with the Former Viking Cleaners and Former Maroney's facilities have been naturally attenuating over time.

No other COCs have been detected in groundwater above AWQS.

The groundwater CVOC impacts have attenuated within the Former Maroney's and Former Viking Cleaners footprint areas over time. The highest CVOC concentrations during recent monitoring have been located immediately downgradient from these areas along the southern sections of the FASA (it should be noted that no COC source area(s) were identified on the FASA). These results demonstrate that implementation of SVE beneath the former dry-cleaner facilities has effectively remediated vadose zone impacts in these areas; groundwater impacted from ongoing vadose zone sources has advected hydraulically downgradient, and groundwater less impacted by CVOCs is 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.

However, a review of historical and recent groundwater monitoring data suggests that the remaining PCE impacts within the saturated zone, although diminished from prior, remain above the AWQS. These remaining impacts are primarily contained within the saturated geology and therefore are not expected to be treatable using SVE. 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 COP further develop their groundwater extraction well network and pumping capacities in the region.

Review of the historical groundwater data and the EVS PCE visualization model do not appear to suggest additional, unidentified sources of PCE downgradient of the 32nd Street site primary suspected source areas.

8.3 Final RI Document

This Final RI Report includes two documents that were related to the public comment period for the draft version of the report. The Final Remedial Objectives (RO) Report is presented in Appendix K. The Responsiveness Summary Report that discusses the public comments received is included in Appendix L.

9. DATA GAPS

Petroleum hydrocarbon impacts that were identified during the completion of the ERA at the Site should be delineated back to their original source area. It should be noted that these impacts are not associated with the Former Viking and Former Maroney's dry-cleaning facilities.

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11. LIMITATIONS

This remedial investigation was performed according to an agreed upon scope of work and does not represent an exhaustive investigation of all potential environmental impacts at the site. The findings of this report, to the best of our knowledge, are valid as of the date the work was performed. However, changes in the conditions of a site can occur with the passage of time, whether due to natural processes or the works of man on this site or adjacent properties. In addition, changes in applicable or appropriate regulations and standards may occur, whether they result from legislation, from the broadening of knowledge, or from other reasons. The work was performed using the degree of care and skill ordinarily exercised under similar circumstances by environmental consultants practicing in this or similar localities. No other warranty or guarantee, expressed or implied, is made as to the findings, opinions, conclusions, and recommendations included in this report.