RECORD OF DECISION AMENDMENT

PHOENIX-GOODYEAR AIRPORT: NORTH AREA SUPERFUND SITE

United States Environmental Protection Agency

Region 9

San Francisco, California

EPA ID: AZD980695902

September 2014

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I. SITE NAME AND LOCATION

Phoenix-Goodyear Airport North (PGA-North) Area Superfund Site
Goodyear, Maricopa County, Arizona
EPA ID. No. AZD980695902

II. STATEMENT OF BASIS AND PURPOSE

This decision document amends the U.S. Environmental Protection Agency's (EPA's) Record of Decision (1989 ROD) that was signed on September 26, 1989, for the Phoenix-Goodyear Airport (PGA) Superfund Site. The PGA site was listed on the National Priority List (NPL) in September 1983 with EPA ID. No. AZD980695902 (Federal Register, Volume 48, Number 175, Page 40671; September 8, 1983). This ROD Amendment provides for enhanced treatment at the PGA-North source area for trichloroethene (TCE) along with perchlorate, a PGA-North Site contaminant that was not addressed in the 1989 ROD. In addition to maintaining the existing pump-and-treat and soil vapor extraction (SVE) for groundwater and soil remediation, respectively, the selected remedy is a combination of in-situ remediation technologies consisting of chemical reduction using nano-scale zero-valent iron (nZVI) and zero-valent iron (ZVI), and anaerobic reductive dechlorination (ARD) using biostimulation and bioaugmentation, as well as an enhanced hydraulic barrier. This enhanced in-situ treatment will aggressively reduce the mass and concentration of the contaminants in the shallow groundwater (Subunit A) at the PGA-North source area, resulting in a reduced time frame to clean up the source area and limit contaminant contribution from the source area to the downgradient dissolved groundwater plumes (Subunits A & C).

A 1987 ROD was signed for the PGA Site that addresses the shallow portion of groundwater contamination at Township 1 North, Range 1 West, Section 16 of the Arizona Gila and Salt River Meridian with pump-and-treat in the PGA-South Area. In the 1989 ROD, EPA separated the Site into two distinctly different areas of contamination – PGA-North and PGA-South - and established a pump-and-treat remedy for groundwater contaminated with volatile organic compounds (VOCs) in the shallower and deeper portions of the PGA-North Area and in the deeper portions of the PGA-South Area, a remedy for chromium contamination in soil and groundwater in the PGA-South Area, and SVE for VOC contamination in the vadose zone of both areas.

This ROD Amendment amends the 1989 ROD remedy for the PGA-North Area in accordance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and

Reauthorization Act (SARA) and, the National Contingency Plan (NCP). The decisions set forth in this document are based on information contained in the Administrative Record for this Site.

The lead agency for the remedial efforts at this Site is EPA, and the support agency is the Arizona Department of Environmental Quality (ADEQ). The State of Arizona concurs with the remedy selected in this ROD Amendment.

III. ASSESSMENT OF SITE

The original remedial action for the Site included the pumping and treating of contaminated groundwater and soil vapor extraction (SVE) of the vadose zone in the Main Drywells Source Area (Source Area). This action has not yet fully contained the contamination plume or inhibited the migration of contaminated groundwater to other, less contaminated areas. In the Source Area, residual contamination mass has persisted in the shallow (Subunit A) groundwater which contributes to the downgradient groundwater plume. Contamination levels in groundwater remain consistently above cleanup standards for TCE and perchlorate.

The remedial actions selected in this ROD Amendment will address the residual contaminant mass and its contribution to downgradient contamination, and, as such, are necessary to protect human health from actual or threatened releases of hazardous substances in the environment.

IV. DESCRIPTION OF SELECTED REMEDY

This ROD Amendment modifies the previously selected groundwater remedy for the North Area Source Area at the PGA Superfund Site.

The main components of the original 1989 remedy, which applied to all areas of the Site and which will continue to operate, include:

- Groundwater pumping from extraction wells;
- Air stripping and granular activated carbon for treatment of contaminated groundwater;
- Beneficial use of treated groundwater through use of treated water in industrial operations, irrigation, or reinjection into the aquifer; and
- Groundwater monitoring.

The revised remedy (Alternative 4) enhances the original remedy in the PGA-North Area of the PGA Superfund Site with:

- Zero-valent iron (ZVI);

- Nano-scale ZVI (nZVI); Anaerobic reductive dechlorination (ARD) (with biostimulation and bioaugmentation); and
- Enhanced hydraulic barrier.

V. STATUTORY DETERMINATIONS

The revised remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The revised remedy satisfies the statutory preference for treatment as a principal element of the remedy as it uses nZVI, ZVI, and ARD, which will permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on the Site above levels that allow for unlimited use and unrestricted exposure, the statutory review cycle triggered by the original remedial action will continue to ensure that the remedy is protective of human health and the environment. The next Five-Year Review for the Site is required in 2015.

VI. ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Record of Decision Amendment:

- Chemicals of concern and their respective concentrations;
- Baseline risk represented by the chemicals of concern;
- Cleanup levels established for chemicals of concern and the basis for these levels;
- How source materials constituting principal threats are addressed; and
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD.

VII. AUTHORIZING SIGNATURE

Clancy Tenley, Assistant Director
Superfund Division
US EPA Region 9

9/30/14
Date

PART II: THE DECISION SUMMARY

This Decision Summary provides a description of the Phoenix-Goodyear Airport (PGA) Superfund Site, focusing on the North Area (PGA-North Area, also referred to herein as the Site), and the analyses that led to the amendment of the selected Site remedy. This Decision Summary includes background information about the Site, the nature and extent of contamination found at the Site, the assessment of human health and environmental risks posed by the contaminants at the Site, and the identification and evaluation of remedial action alternatives for the Site.

I. SITE NAME, LOCATION, AND DESCRIPTION

This Record of Decision (ROD) Amendment addresses the PGA-North Area, which is a portion of the PGA Superfund Site located in Goodyear, Maricopa County, Arizona. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) identification number is AZD980695902. The lead agency is the U. S. Environmental Protection Agency (EPA), and the support agency is the Arizona Department of Environmental Quality (ADEQ).

The PGA Superfund Site is located approximately 17 miles west of downtown Phoenix (**Figure 1**). EPA has divided the PGA Superfund Site into two distinct geographic areas: (1) PGA Superfund Site South Area, and (2) PGA Superfund Site North Area (**Figure 2**). The PGA-North Area includes the former Unidynamics-Phoenix, Incorporated (UPI) facility, which was located on approximately 58 acres. The physical boundaries of the former UPI facility are Van Buren Street to the north, Litchfield Road to the east, a vacant field to the south, and the abandoned Union Pacific Railroad right-of-way to the west. Contaminated groundwater (i.e., the groundwater plume) has extended more than two miles north of the former UPI facility. This ROD Amendment focuses on the PGA-North Main Drywells Source Area (Source Area). The Source Area is defined as the area south of Van Buren Street and north of the four main drywells that has shallow groundwater, also referred to herein as Subunit A groundwater, contaminated with a trichloroethene (TCE) concentration greater than 1,000 micrograms per liter (µg/L). The Site's perchlorate-contaminated groundwater above the cleanup level of 14 µg/L is found within this 1,000 µg/L TCE footprint.

More information on PGA-North Area contamination and cleanup activities can be obtained from the information repository located at the City of Goodyear Library, 14455 West Van Buren Street, Suite C-101, Goodyear, Arizona and the EPA Region 9 Records Center, located at 95 Hawthorne Street, San Francisco, California.

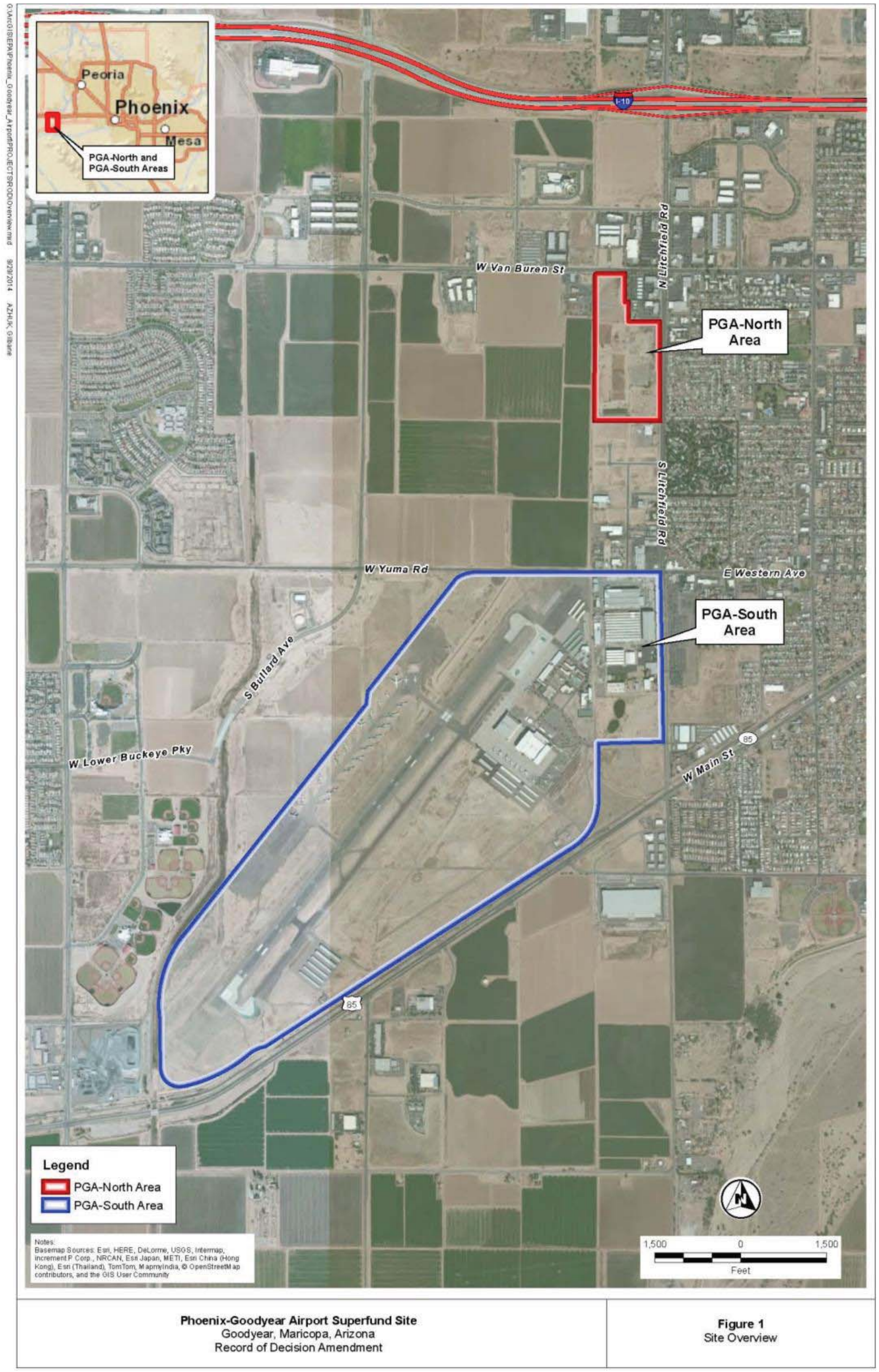

Figure 1: Map of Phoenix-Goodyear Airport Superfund Site North and South Areas

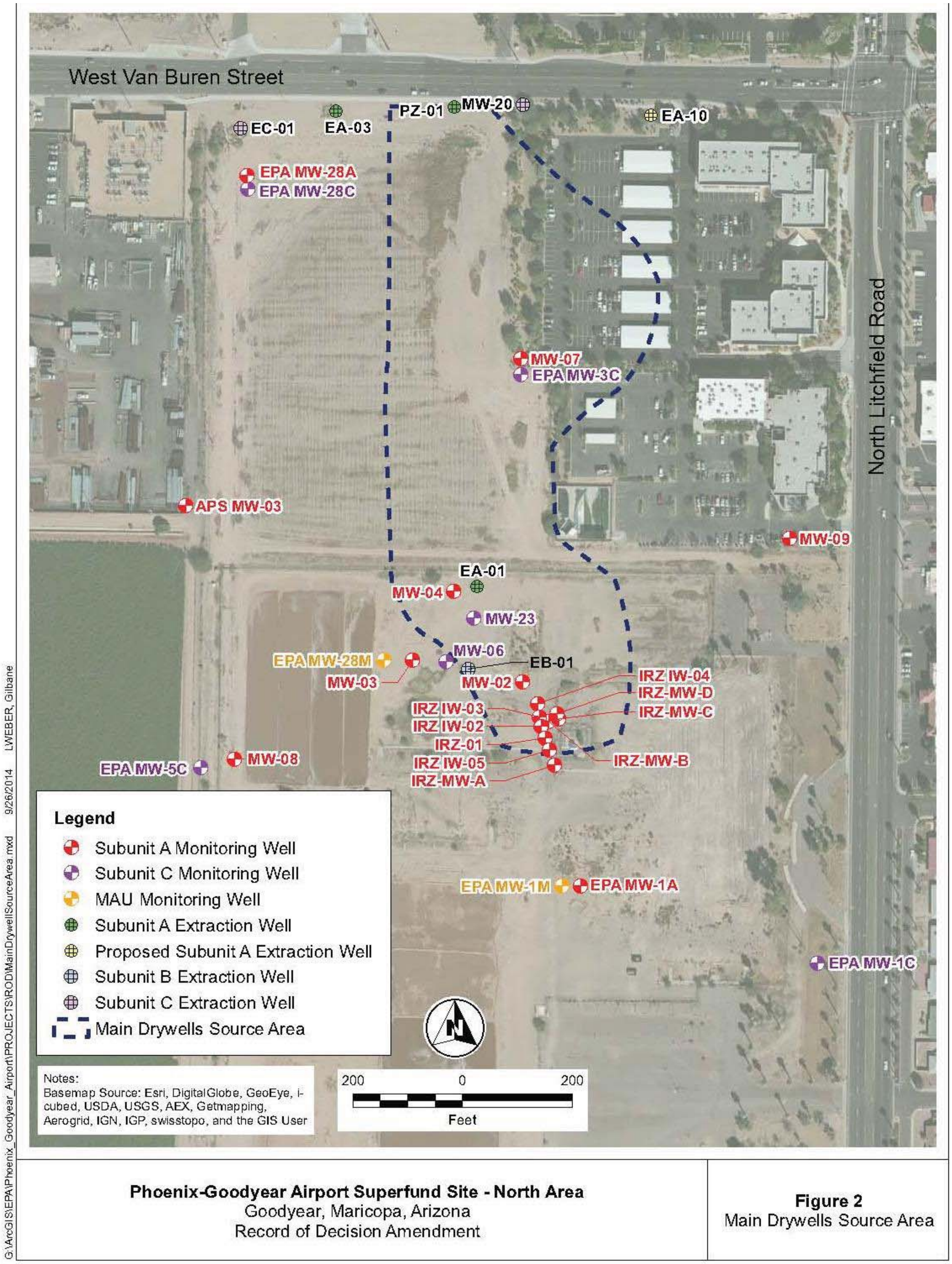

Figure 2: Map of PGA Superfund Site North Area: Source Area To be Treated

II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

A. Site History

The former UPI facility began operating in 1963 as Universal Match Corporation (UMC) as a research, design, development, testing, assembly, and manufacturing plant for ordnance components and related electromechanical devices. Operations at the facility involved the use of TCE, other VOCs (such as methyl ethyl ketone [MEK] and acetone), and perchlorate and included manufacturing rocket propellant, processing and blending powder, assembling ordnance, machining, testing explosives and ballistics, and related functions. Perchlorate is the primary chemical ingredient of solid rocket propellant. Both potassium perchlorate and ammonium perchlorate were associated with specific buildings and with wastes disposed of at the former UPI facility. Unidynamics-Phoenix, Inc. was incorporated as a subsidiary of UMC in 1970, and, in 1985, Crane Company (Crane Co.), merged with UMC and became the parent company of UPI, including ownership of the property. In April 1993, Crane Co. sold UPI (excluding buildings and land) to Pacific Scientific Energy Dynamics (Pacific Scientific). Pacific Scientific managed the business at this location for approximately 18 months before operations ceased in 1994. It is not known which buildings Pacific Scientific continued to use during its tenure. In October 1994, Pacific Scientific relocated its operations to Chandler, Arizona. Crane Co. demolished all Site buildings in 2009.

In 1981, the Arizona Department of Health Services (ADHS) discovered that groundwater at the PGA Site was contaminated with solvents and chromium. Additional sampling of wells in 1982 and 1983 found 18 wells contaminated with TCE. As a result, the EPA added the PGA Superfund Site to the National Priorities List (NPL) in September 1983 (at that time, the Site was called the Litchfield Airport Area Site). In 1984, EPA began a Remedial Investigation (RI) to characterize the nature and extent of contamination in soil and groundwater, and identify the potential source(s) that contributed to the contamination.

Historical data indicate activities at three primary facilities contributed to the groundwater contamination at the PGA Superfund Site:

- The former Goodyear Aerospace Corporation facility, currently owned by JRC Goodyear Corporation;
- The Litchfield Park Naval Facility, currently named the Phoenix-Goodyear Airport and owned by the City of Phoenix; and
- The former UPI facility, which was located on property currently owned by the Crane Co.

In 1984, UPI initiated a Phase I RI at the PGA-North Area. EPA took back the RI and completed the Phase II in 1988. The RI included the installation of 18 groundwater monitoring wells (MW-01 through MW-18). EPA completed a Feasibility Study (FS) in 1989.

In 1987, the EPA issued a ROD covering the shallower groundwater at the PGA-South Area (referred to as Section 16 in the 1987 ROD). In 1989, the EPA issued the 1989 Site ROD that established cleanup requirements for the groundwater remedy for the shallower and deeper portions of the PGA-North Area and in the deeper portions of the PGA-South Area. In 1990, the EPA issued an Amended Administrative Order for Remedial Design and Remedial Action to Crane Co. to implement the ROD groundwater and soil vapor remedies in the PGA-North Area. The initial groundwater remedial action has been operating since 1994; soil vapor extraction (SVE) also was initiated in 1994. Eight additional monitoring wells (MW-19 through MW-26) were installed between 1999 and 2000.

In November 2000, EPA began to require that the analysis for perchlorate be incorporated into the groundwater monitoring program.

In August 2001, TCE and perchlorate contamination were discovered in several water supply wells located near the southern area of the PGA-North Area. Accordingly, EPA directed Crane Co. to conduct a Phase I groundwater investigation, including installation of monitoring well MW-27. The initial focus of the investigation was to evaluate the potential for contamination in the Upper Alluvial Unit (UAU), including the upper aquifer in this unit (Subunit A), to migrate via conduit wells into the deeper aquifers (Subunit C and the Middle Alluvial Unit [MAU]). In November 2001, as a result of increasing concentrations of TCE in Subunit C monitoring well MW-20, the scope of the Phase I investigation was expanded to encompass the entire PGA-North Source Area and to include perchlorate. Prior to 2001, impacts at the PGA-North Area generally were interpreted as being confined to within Subunit A, with underlying Subunit B acting as an aquitard.

In 2002, the scope of Phase I was further expanded to include investigation of the southeast, northeast, and north areas of the PGA-North Area. Specific activities included the installation of two sentinel monitoring wells (MW-28 and MW-29), aquifer testing, collection of hydrogeological data, identification of potential conduit wells, completion of an updated well inventory, and a series of aquifer tests on monitoring well MW-20.

In May of 2002, the EPA developed a Phase II Work Plan to further investigate the source and extent of impacts within Subunit C. EPA implemented the Phase II Work Plan from December 2002 through August 2003. This work included a transects-based investigation that characterized the spatial distribution of groundwater contamination within Subunit A, Subunit B, and Subunit C in 15 boreholes within the PGA-North Area. The investigation was focused on the extent of contamination in the Subunit C aquifer near West Van Buren Street, located north of the Source Area in the downgradient direction of groundwater flow. The goals of the investigation were (1) to identify the source of Subunit C contamination in the vicinity of monitoring well MW-20; (2) to determine the vertical and lateral extent of Subunit C contamination in the vicinity of MW-20 to develop plume definition; (3) to collect sufficient hydrogeological data to fill in data gaps needed for the development of the PGA-North Area groundwater model and to model Subunit C contamination fate and transport; and (4) to collect data to begin to characterize the vertical and lateral extent of dense non-aqueous phase liquid (DNAPL) in Subunit A at the Source Area and to monitor remedial effectiveness.

Phase II data indicate TCE is present throughout the vertical profile of Subunit A, B, and the upper portion of C near the northern boundary of the former UPI facility. Additionally, both TCE and perchlorate contamination was evident in Subunit B and in the lower portion of Subunit C, two intervals of the aquifer previously believed to be uncontaminated at the Source Area. The concentrations of TCE and perchlorate collected from Phase II boreholes were significantly higher than concentrations previously measured in PGA-North monitoring wells and extraction wells.

In order to address the perchlorate in groundwater, following extensive pilot testing, in October 2003, TCE-treated water began to be discharged to the City of Goodyear (COG) waste water treatment plant (WWTP) for perchlorate treatment. In April 2005, Crane Co. added to the Main Treatment System (MTS) perchlorate treatment using an ion exchange process. Injection of treated water resumed at the MTS well field in Subunit A. Because the Site remedy did not include perchlorate treatment, EPA issued an engineering evaluation and cost analysis (EE/CA) and a removal action memorandum in 2008 to require treatment of extracted Site groundwater for perchlorate contamination.

On April 26, 2006, EPA entered into a Consent Decree (2006 CD) with Crane Co. which included the requirement to complete the full characterization of the groundwater contamination, both horizontally and vertically, and established the subsequent need for additional remedial action. Pursuant to Task 2.0 of the Scope of Work of the CD, Crane Co. conducted the first three years of the groundwater investigation. This investigation has played an integral role in: (1) defining the contaminants of concern (COCs) in groundwater; (2) defining the vertical and lateral extent of impacts to groundwater in Subunit A, Subunit B, and Subunit C; (3) characterizing the aquifer properties of Subunit A, Subunit B, and Subunit C; (4) defining the hydraulic connections between Subunit A, Subunit B, and Subunit C; and (5) providing hydraulic parameters for the development and refinement of the numerical groundwater flow model. Groundwater investigation activities at the PGA-North Area are ongoing.

Detailed information regarding chemical use and waste handling at the former UPI facility can be found in the *Remedial Investigation/Feasibility Study, Phoenix-Goodyear Airport, Goodyear, Arizona,* published by EPA in June 1989 and in the *Revised Final Site Evaluation Report, Former Unidynamics/Phoenix Inc. Site, Phoenix-Goodyear North Superfund Site Goodyear, Arizona* by Arcadis, on behalf of Crane Co, in March 2007.

Crane Co. is currently conducting groundwater and soil vapor remediation activities at the PGA-North Area under the 2006 CD. The original 1994 groundwater pump-and-treat system (now called the MTS) has been expanded and several new groundwater pump-and-treat systems have been added in the following order:

In 1998, operation of the 33A groundwater pump-and-treat system was initiated to remediate and contain the Subunit A TCE plume in the northwest portion of the PGA-North Area. The 33A groundwater treatment system uses liquid-phase granular activated carbon (LGAC) technology to remove volatile organic compounds (VOCs). Treated groundwater from this system is discharged to the Roosevelt Irrigation District (RID) canal.

In 2002, monitoring well MW-20 was converted into an extraction well and groundwater from the well is conveyed to the MTS for treatment. The treated water is injected into Subunit A at the injection well field located south of the MTS.

In 2005, ion exchange treatment was added to the MTS for perchlorate treatment.

In 2006, the MTS was expanded to accept groundwater from the newly installed Subunit C extraction well EC-01.

In 2008, the EA-06 groundwater pump-and-treat system was initiated to remediate and contain the Subunit A TCE plume in the northeast portion of the PGA North Area. This system uses LGAC technology to remove VOCs.

In 2008, the EA-05 groundwater pump-and-treat system was initiated to remediate and contain the Subunit A TCE plume in the central portion of the PGA North Area. This system uses LGAC technology to remove VOCs. The treated groundwater is reinjected into Subunit A through injection well IA-10.

In 2009, monitoring well PZ-01 was converted to an extraction well, and groundwater from this well is conveyed to the MTS for treatment, with treated water reinjected into Subunit A at the injection well field located just south of the MTS.

In 2010, EA-07 was installed to enhance the hydraulic capture of contaminated Subunit A groundwater in the northeast portion of the PGA-North Area. Groundwater from EA-07 has been conveyed to the EA-06 compound for treatment, and a new pipeline was constructed to convey treated groundwater from both EA-06 and EA-07 for reinjection through injection wells IA-11 through IA-15 along Dysart Road (currently, only injection wells IA-11 through IA-13 are used).

In 2011, the EA-08 groundwater pump-and-treat system was initiated to remediate and contain the Subunit A TCE plume in the north-central portion of the PGA-North Area. This treatment system also uses LGAC technology. The treated groundwater is discharged to the RID canal.

In 2013, EA-09 was installed to enhance the groundwater remedy south of Interstate 10 (I-10). The groundwater extracted from this well is conveyed to the MTS for treatment and reinjection.

In November 2013, the *Source Area Remediation Focused Feasibility Study* (SARFFS) was finalized for PGA-North Area. The purpose of the SARFFS was to document the known nature and extent of the source area and to identify and evaluate potential remediation alternatives for that area. In addition to ongoing groundwater monitoring activities, the SARFFS investigation was an important source of information for establishing the need for enhancement to the source area remedy.

In 2014, pipelines were installed that convey treated groundwater from the EA-08 pump-and-treat system to an area beyond the extent of contaminated Subunit A groundwater in the northwest portion of the PGA-North Area for reinjection in wells IA-07 and IA-08. This reinjected groundwater provides a hydraulic barrier to help contain the portion of the Subunit A TCE plume in the vicinity of extraction wells 33A and EA-08.

The locations of the treatment facilities, extraction wells, injection wells, and the extent of TCE contaminated groundwater in Subunit A are shown on **Figure 3**.

The major Comprehensive Environmental Response Compensation and Liability Act (CERCLA) milestones for the PGA-North Area are summarized below in **Table 1**.

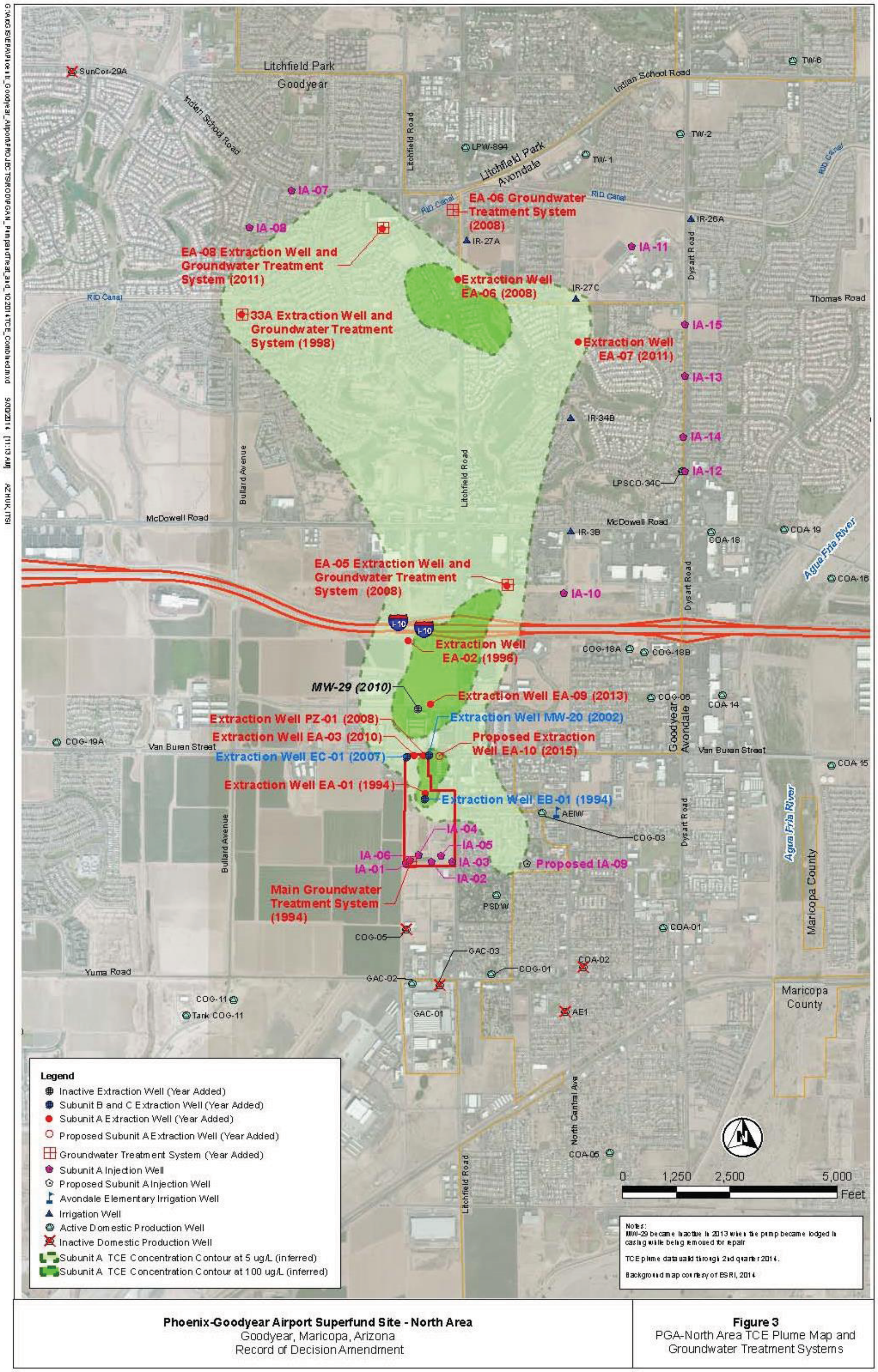

Figure 3: PGA-North Area TCE Plume Map and Groundwater Treatment Systems

TABLE 1: Summary of CERCLA Milestones for the PGA-North Area

Year	Document or Milestone Key Points
1983	EPA added the PGA Superfund Site (originally listed as the "Litchfield Airport Area Superfund Site") to the NPL.
1984	Phase I RIs began on the entire PGA Superfund Site.
1986	Phase II RIs on the PGA-North Area property.
1989	EPA published a RI/FS that identified two areas of noncontiguous contamination (PGA-North Area and PGA-South Area). Pump-and-treat technology was selected in the ROD as the remedial action for treatment of contaminated groundwater at the PGA Superfund Site to achieve TCE concentrations in groundwater of 5.0 µg/L or less site-wide. SVE was selected as the remedial action for treatment of VOC contamination in the vadose zone at the Site.
1991	EPA issued Explanation of Significant Differences (ESD) #1 to the 1989 ROD to revise the cleanup level for methyl ethyl ketone (MEK) in groundwater from 170 parts per billion (ppb) to 350 ppb; set a cleanup level for acetone in groundwater at 700 ppb; clarify the target area and criteria for establishing cleanup goals for soil at the PGA-North Area; and clarify the role of soil excavation as an option should the selected remedy be ineffective.
1993	EPA issued ESD #2 to (1) change the emission control technology for the SVE system from vapor-phase GAC to treatment by thermal oxidation with wet scrubbing; (2) change the designated end use for water treated by the Subunit C groundwater remedy from incorporation into the community potable water supply to reinjection back into the Subunit C section of the aquifer, with an option for municipal use after 1994; (3) suspend the remedial design and construction of the LGAC treatment requirement from the Subunit A groundwater remedy because ketones were no longer present in groundwater above remediation levels; (4) change the requirement for a centralized air stripping system for the Subunit B/C groundwater remedy to a decentralized system (e.g. two or more independent LGAC treatment systems); (5) change the designated end use for water treated by the Subunit B/C groundwater remedy from municipal use to reinjection back into the Subunit B/C section of the aquifer with an option to reconsider municipal use after 1994; (6) add the requirement that wellhead treatment be implemented at any private or municipal drinking water well in the vicinity of the PGA Superfund Site that has an occurrence of Site contaminants at levels in excess of the groundwater cleanup standards and such contamination is related to contamination in the Unidynamics or airport areas, such drinking water well(s) shall be treated as soon as possible by wellhead LGAC treatment or other similar technology as approved by EPA; and (7) establish four additional groundwater cleanup standards: benzene (5 ppb), ethylbenzene (700 ppb), 1,1,2,2-tetrachlorethane (0.18 ppb) and tetrachloroethene (PCE; 5 ppb).
1994	A Remedial Action groundwater pump-and-treat system was installed at PGA-North Area. An SVE system was installed at the PGA-North Area.
1998	Operation of 33A groundwater pump-and-treat system initiated.

TABLE 1: Summary of CERCLA Milestones for the PGA-North Area

Year	Document or Milestone Key Points
2002	EPA issued ESD #5, requiring the restart of the SVE system. Because there was no longer MEK or acetone in the influent, the air emissions control technology was changed to GAC from thermal oxidation with wet scrubbing, which had been required by ESD #2.
2006	The MTS expanded to accept Subunit C water from EC-01
2007	EA-06 groundwater pump-and-treat system installed.
2008	EPA issued the Removal Action Memorandum for Perchlorate; EA-05 groundwater pump-and-treat system and associate injection well IA-10 installed.
2009	PZ-01 monitoring well converted to extraction well with MTS accepting water for treatment.
2010	EA-07 extraction well installed.
2011	EA-08 extraction well installed.
2013	EPA approved the Source Area Focused Feasibility Study; EA-09 extraction well installed with MTS accepting water for treatment
2014	EPA issued the Proposed Plan for the enhanced Site cleanup. Injection wells IA-11 and IA-12 installed to reinject treated groundwater from EA-08 and 33A.

B. Enforcement Activities

In 1990, EPA issued to Crane Co. an Amended Unilateral Administrative Order (UAO) for Remedial Design and Remedial Action to implement the 1989 ROD groundwater and soil vapor remedies. In 2004, EPA issued a Second Amended UAO to Crane Co. to implement the SVE remedy as revised through ESD#2. On April 26, 2006, EPA entered into the 2006 CD with Crane Co. for the full investigation of Site VOC and perchlorate contamination and remedy implementation for the PGA North Area, as well as for EPA response and oversight costs. Crane Co. currently is conducting groundwater and soil vapor remediation activities at the PGA-North Area under the 2006 CD, and the remedial activities selected in this ROD Amendment will also be conducted under the 2006 CD.

III. COMMUNITY PARTICIPATION

EPA issued the Proposed Plan for the enhanced Site cleanup on January 21, 2014. A 30-day public comment period followed, ending on February 24, 2014. At a February 5, 2014, public meeting, EPA discussed and took public comment on the proposed addition of zero-valent iron (ZVI), nano-scale zero-valent iron (nZVI), and anaerobic reductive dechlorination (ARD) with an enhanced hydraulic barrier to treat elevated concentrations of TCE and perchlorate in ground water in the Source Area in addition to existing remedy.

An announcement of the Proposed Plan was printed in the *West Valley View* on February 4, 2014; a Spanish-language version was printed in the Prensa Hispana. More than 10,000 postcards announcing the availability of the Proposed Plan were mailed to the community and to interested parties of the PGA Superfund Site.

Copies of the SARFFS for the PGA-North Area, as well as the Proposed Plan, were made available at the City of Goodyear Public Library and at the EPA Region 9 Records Center, located at 95 Hawthorne Street in San Francisco, California. Electronic copies of the Proposed Plan and the SARFFS were posted on the EPA website for the PGA Superfund Site:

http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/vwsoalphabetic/Phoenix-Goodyear+Airport+Area.

IV. SCOPE AND ROLE OF RESPONSE ACTION

The response action presented in this ROD Amendment is an enhancement to the Source Area portion of the remedy EPA selected in the 1989 ROD. EPA has determined that the existing remedy (pump-and-treat in combination with SVE) would not be fully effective in treating groundwater in the source areas in a reasonable time frame, due to the heterogeneous nature of the aquifer and residual high contaminant concentrations. Additionally, perchlorate-contaminated groundwater at this Site is being addressed only as it is extracted as a removal action, and thus a remedy is required to meet the Remedial Action Objective (RAO) of aquifer restoration. The goals of this action are to address the TCE and perchlorate contamination in the Subunit A groundwater; to minimize downgradient migration of contaminants in groundwater away from the Source Area by the means of permanent concentration reduction and mass removal through in-situ remediation technologies; and, ultimately, to shorten the duration of the overall remediation timeframe for the PGA-North Area. The selected remedy enhances the existing remedy with a combination of remediation technologies including in situ chemical reduction using nZVI, ZVI, and ARD (including biostimulation and bioaugmentation) to treat Subunit A groundwater contaminated with TCE and perchlorate.

V. SITE CHARACTERISTICS

A. Conceptual Site Model

A conceptual site model (CSM) for a Superfund Site identifies potential contaminant sources, the affected media, all release mechanisms, all routes of migration and potential receptors.

The environmental impacts associated with the PGA-North Area are the result of past disposal practices of waste materials by UPI into a series of dry wells located in the central portion of the former UPI facility (known as the Source Area). These drywells were approximately 13 feet deep and were installed exclusively within the vadose zone. When the drywells were in use, the waste materials disposed in them migrated downward, over time, through the vadose zone to the water table. Following migration through the vadose zone, the waste materials entered the groundwater and have since migrated horizontally and vertically into the local aquifer system through the processes of advection, dispersion, and diffusion. The potential exposure routes for contaminated groundwater are ingestion, dermal contact, and inhalation (due to volatilization when heated). Potential receptors are workers and residents who would come in contact with this groundwater. Currently the exposure pathways are incomplete because there are no supply wells in the contaminated groundwater plume.

While a number of hazardous materials and wastes were used and handled at the former UPI facility during historical operations, following completion of extensive soil and groundwater remedial investigations, it has been determined that the COCs are limited to TCE, a chlorinated volatile organic compound, and the inorganic compound perchlorate. Conditions at the PGA-North Area do not represent a potential for ecological risk.

B. Project Area Overview

Numerous investigations have been performed at the former UPI facility, including the Main Drywells Source Area Investigations (2006); Phase I Soil Gas Investigation (2011); and Phase I and Phase II Source Areas, Soils, and Facility Structures Investigations (2011). Results of these investigations did not identify any additional sources of groundwater contamination other than the Source Area. This has also been confirmed by the ongoing groundwater monitoring that shows that the greatest mass of TCE and perchlorate reside in Subunit A near and downgradient from the Source Area.

This ROD Amendment addresses enhancement of the current remedial action at the Source Area as shown on **Figure 3**. The Subunit A groundwater in the Source Area currently has the highest contaminant concentrations at the PGA-North Area (6,100 µg/L in MW-07 on site). Remedial actions implemented under this ROD Amendment will reduce the mass and concentrations of these COCs in groundwater at the Source Area thereby reducing impacts in the Source Area as well as downgradient areas.

C. Groundwater and Hydrogeology

Important characteristics of the regional hydrogeology, local hydrogeologic conditions, and groundwater movement are summarized in the following subsections.

(1) Regional Hydrogeology

The PGA-North Area lies within the Basin and Range physiographic providence, which consists of alluvial basins or plains separated by north- to northwest-trending mountain ranges. Specifically, the PGA-North Area is located within the West Salt River Valley (WSRV) sub-basin of the Salt River Valley (SRV), located in central Arizona. The regional geology of the WSRV consists of a deep alluvial basin bounded by bedrock mountain ranges consisting primarily of granitic, metamorphic, and volcanic rocks of Precambrian to Tertiary age. Mountain ranges surrounding the WSRV sub-basin include the Hieroglyphic Mountains, the

Phoenix Mountains, South Mountain, the Sierra Estrella Mountains, the Buckeye Hills, and the White Tank Mountains. These surrounding mountain ranges form nearly impermeable barriers to groundwater flow. The WSRV alluvial sub-basin consists of thick basin-fill deposits (alluvial fan, playa, and fluvial deposits) of unconsolidated to semi-consolidated clastic sediments of Late Tertiary to Quaternary age.

The alluvial deposits generally increase in thickness and grain size toward the central areas of the sub-basin. The basin-wide alluvial deposits have been subdivided into three hydrogeologic units, designated in descending order as: (1) the UAU, (2) the MAU, and (3) the Lower Alluvial Unit (LAU). The lithology of each alluvial unit is summarized below:

- UAU: Gravel, sand, and silt. Mostly unconsolidated with locally strong cementation near mountain fronts and major stream courses.
- MAU: Silt, siltstone, silty sand, and gravel. Mostly weakly consolidated, but moderately to well-cemented. Siltstone occurs locally; most commonly present in the center of the basin, and typically pinches out toward basin boundaries. The majority of drinking water supply wells draw from the MAU.
- LAU: Clays, silts, mudstone, evaporites, sandstone, gravel, conglomerate, and andesitic basalt. The lower and older part of this unit is moderately to well-cemented. The upper part of this unit is weakly to well-cemented and contains interbedded sand, gravel, and conglomerate.

The basin-fill deposits range in thickness from a couple of feet near the basin margins to over 10,000 feet in the central area of the sub-basin. The thickest basin-fill deposits in the WSRV occur near Luke Air Force Base, where the structure and lithology of basin-fill deposits have been influenced by a massive evaporite diapir referred to as the Luke Salt Body. The principal aquifers of the WSRV sub-basin are the alluvial units described above.

The UAU aquifer generally is hydraulically unconfined, while the MAU ranges from an unconfined to a semi-confined aquifer. The LAU aquifer ranges from semi-confined to confined conditions, but may be unconfined in areas where the MAU is not present. Natural recharge to the basin occurs as mountain-front recharge, along perennial and ephemeral streams, and as agricultural and urban irrigation.

(2) Local Geologic and Hydrogeologic Conditions

The local geologic and hydrogeologic conditions are described in the following subsections.

<u>Hydrostratigraphic Units</u>

In the vicinity of the PGA-North Area, the UAU is approximately 350 feet thick, and the local stratigraphic sequence includes three subunits that represent divisions of the UAU: Subunit A, Subunit B, and Subunit C. The depositional environments associated with each Subunit at the

PGA-North Area are suggested to be derived from a combination of regressive sequences of alluvial fan deposits (proximal facies, midfan facies, and distal facies) eroded from the White Tank Mountains and from ephemeral fluvial deposits associated with the ancestral Bullard Wash and Agua Fria River. Typically, the longitudinal axis of deposition of the alluvial fan deposits trends northwest to southeast.

Similarly, the longitudinal axis of deposition of the fluvial deposits associated with the ancestral Bullard Wash and Agua Fria River trends north to south and northeast to southwest, respectively.

The subunits of the UAU are described as follows:

- Subunit A generally is composed of interbedded sands, silty sands, and clayey sands that can locally contain sequences of gravel and cobbles. The predominance of sand and the presence of coarse-grained material suggest a medium- to high-energy depositional environment related to the braided stream deposits of the ancestral Agua Fria River and, to a limited extent, the ancestral braided drainage of Bullard Wash.

  Generally, these deposits are heterogeneous, anisotropic, and unconsolidated, although some cemented zones and well developed caliche have been identified locally in both the vadose and saturated zones. Subunit A typically extends from the ground surface to approximately 160–200 feet below ground surface (bgs) in the vicinity of the Site, and generally deepens to the north to depths of approximately 190–240 feet bgs. Approximately one-third to one-half of the lower portion of Subunit A is saturated and is considered an unconfined aquifer.
- Subunit B generally is composed of unconsolidated silt and clay deposits with interbedded lenses of fine to coarse sand. The ubiquitous nature of Subunit B and the predominance of fine-grained material suggest low-energy deposits representing the distal facies of an alluvial fan depositional environment. Subunit B generally has a variable thickness (20–70 feet thick near the Site), with depths extending from approximately 160 to 230 feet bgs, and is fully saturated. Based on data collected during drilling for remedial investigations and well installations, Subunit B is suggested to deepen and in places may not be laterally continuous due to washouts from braided stream deposits related to the ancestral Agua Fria River channel. The integrity of Subunit B varies at the Site. In some areas, Subunit B generally is considered to be an aquitard, while at other areas Subunit B allows leakage of contamination to Subunit C.
- Subunit C is composed of unconsolidated and interbedded mixtures of silty sands, clayey sands, and fine- to coarse-grained sands suggesting mid-fan facies of an alluvial fan sequence with braided channels interbedded with overbank deposits. On average, Subunit C is approximately 150 feet thick and extends from approximately 200 to 350 feet bgs in the vicinity of the PGA-North Area. Based on lithologic data collected from the drilling logs, Subunit C can be subdivided into an Upper Subunit C, Middle Subunit C, and Lower Subunit C based on a series of laterally continuous fine-grained sequences

that act as aquitards and occur at depths of approximately 270 and 310 feet bgs. Generally, the deposits of the Upper, Middle, and Lower Subunit C are similar, generally consisting of interbedded mixtures of fine to coarse sand, silty sands, and clayey sands, with occasional lenses of silt/clay. Few gravel-dominant deposits are found within Subunit C. Subunit C is fully saturated and is considered to be a leaky to confined aquifer.

(3) Groundwater Movement

Subunit A

Historically, the groundwater flow direction in Subunit A at the PGA-North Area was to the north-northwest, generally toward the Luke Sink pumping center and toward local irrigation and remediation extraction wells (i.e., the former Globe wells and extraction well 33A, respectively). Although a northern flow component still exists north of I-10 (toward extraction well 33A), between approximately 2001 and 2006, a northeasterly groundwater flow component had developed in this region causing a divergence of groundwater flow in the area. The northeastern flow component is most likely caused by the abandonment of the former Globe wells which were no longer needed for agricultural irrigation and increased groundwater pumping from City of Avondale and Litchfield Park Service Company (LPSCO) water supply wells.

In recent years, the operation of the extraction wells (EA-05, EA-06, and EA-07) and injection wells (IA-10 through IA-13) has created an effective hydraulic barrier west of Dysart Road between local water supply wells and the eastern/northeastern Subunit A TCE plume boundary, and has shifted the groundwater flow direction toward the west/northwest.

Recent groundwater monitoring data from the PGA-North Area indicate that the overall horizontal component of the hydraulic gradient in the Subunit A aquifer is variable. South of I-10, the flow direction is suggested to be uniform with variable gradients; and north of I-10, both the flow direction and hydraulic gradient appear to be variable. Generally, the hydraulic gradients for Subunit A groundwater in the area north of I-10 are smaller than in the area south of I-10. The groundwater hydraulic gradient ranges from 0.002 to 0.003 feet/foot in the area south of I-10, while it ranges from 0.0005 to 0.002 feet/foot north if I-10.

Aside from the spatial variability, the hydraulic gradients also change seasonally. This variability can likely be attributed to the remedial extraction and injection activities that are occurring north of I-10 and at the Site, as well as other regional and seasonal pumping influences from water supply wells that are screened within Subunit A.

Subunit B:

Only four monitoring wells at the PGA-North Area are screened in Subunit B, so it is not possible to determine a Subunit B groundwater flow direction and gradient. Additionally, since Subunit B generally is considered an aquitard, it is not considered a consistent zone of horizontal groundwater flow, and groundwater flow direction is downward since Subunit A has higher water levels than Subunit C.

Subunit C:

Overall, the groundwater flow direction in Subunit C in the PGA-North Area generally is north to northwest, with local variations in flow and hydraulic gradient. In the area south of I-10, the groundwater hydraulic gradient is relatively flat (from approximately 0.00004 feet/foot in Upper Subunit C to 0.002 feet/foot in Lower Subunit C). Water levels exhibit substantial fluctuation in Subunit C, making it difficult to identify a primary groundwater flow direction. Because of the minimal head differential within the individual sub-layers in Subunit C across the Site, the groundwater flow direction appears to change often in response to outside hydraulic influences, such as pumping of local water supply wells. These frequent directional changes, coupled with the small magnitude of the gradient, indicate that overall groundwater movement in Subunit C is slow. Groundwater flow directions vary in different portions of the area north of I-10. In the western portion, groundwater generally flows toward the northwest, whereas groundwater flows north to northeast in the central portion. In the eastern portion, groundwater flow direction varies from northwest to southeast, depending on the pumping status of extraction well IR-3B.

Vertical Groundwater Movement:

Vertically, groundwater generally flows from Subunit A to Subunit C through Subunit B. The changes in vertical hydraulic head over time are driven primarily by the seasonal fluctuations in water levels in Subunit C in response to the operation of nearby irrigation and water supply wells and, to a limited extent, by the operation of the groundwater extraction and injection remediation systems in Subunit A. The calculated differences in hydraulic head between the Subunit A and Subunit C monitoring well pairs show that the vertical gradient in hydraulic head appears to be greater in well pairs south of I-10. Additionally, the magnitude of the downward gradients generally decreases from south to north and near the remediation system extraction wells, and increases in the vicinity of the remediation system injection wells.

D. Location and Extent of Contamination

Various remedial investigations and actions have been performed since 1982 to establish the COCs for the Site. Contaminants identified in groundwater at the PGA-North Area currently are limited to VOCs and perchlorate. In accordance with the 1989 ROD, the following 20 compounds are listed as target COCs for the PGA-North Area: 1,1-dichloroethene (DCE), 1,1,2,2-tetrachloroethane, 1,2-dichloropropane, cis-1,2-DCE, trans-1,2-DCE, MEK, acetone, benzene, carbon tetrachloride, chloroform, ethylbenzene, methylene chloride, TCE, trichlorofluoromethane, toluene, m,p-xylenes, o-xylene, PCE, vinyl chloride, and perchlorate. Of the identified VOCs, only TCE is present in groundwater at concentrations above the maximum contaminant level (MCL; 5 µg/L for TCE).

The Site-specific perchlorate action level is the concentration in groundwater which, when exceeded, triggers the need for treatment to remove perchlorate. While EPA has not established an MCL for perchlorate, Arizona has adopted a Health-Based Guidance Level (HBGL) for perchlorate of 14 µg/L which has been adopted as the Site-specific action level for the PGA-North Area. The derivation of this level was described in detail in the May 22, 2008 Removal Action Memorandum, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona and summarized below.

Where MCLs are promulgated under the Safe Drinking Water Act, those standards generally are used as action levels for contaminants in groundwater. The MCLs protect the public from contaminants that might be found in drinking water, and the NCP defines MCLs as relevant and appropriate for groundwater that is a potential source of drinking water. Because perchlorate has no MCL, determination of a perchlorate action level for this Site is based on a risk analysis using "to be considered" (TBC) requirements found in federal or state guidance or other publications.

Two TBC values were taken into account in developing a Site-specific action level for perchlorate. In December 2008 EPA's Office of Water issued an Interim Drinking Water Health Advisory of 15 µg/L for perchlorate. The Interim Drinking Water Health Advisory level is based on the recommendations of the National Research Council (NRC) of the National Academies as reported in "Health Implications of Perchlorate Ingestion" (NRC, 2005). EPA's Interim Drinking Water Health Advisory for perchlorate considers pregnant women to be the most sensitive subpopulation and incorporates exposure from food. In January 2009, EPA's Office of Solid Waste and Emergency Response issued a memorandum that directs EPA Regions that where there are no applicable or relevant and appropriate (ARAR) requirements under state law, 15 µg/L (or 15 ppb) is recommended as the Preliminary Remediation Goal (PRG) for perchlorate for CERCLA site-specific cleanups where there is an actual or potential drinking water exposure pathway.

In this case, the State of Arizona has its HBGL for perchlorate of 14 µg/L. HBGLs are risk-based advisory levels developed by ADHS that represent a maximum concentration of a contaminant in drinking water that can be consumed without resulting in adverse health effects from long-term exposure. HBGLs are calculated by ADHS using a human health-based approach that is generally consistent with risk assessment methodologies recommended by EPA and the Agency for Toxic Substances and Disease Registry (ATSDR). The HBGL was also used as the perchlorate action level for the Apache Powder Superfund Site in Arizona.

To be protective at this Site and to remain consistent with other Arizona sites, EPA selected the ADHS perchlorate HBGL of 14 µg/L as the Site-specific action level.

The primary COCs and their cleanup levels are listed in **Table 2**.

TABLE 2: Cleanup Levels for the Primary COCs

Primary COCs	Cleanup Level
TCE	5 µg/L (MCL)
Perchlorate	14 µg/L (Arizona HBGL)

The distribution of TCE in Subunit A groundwater at PGA-North in February 2014 is shown on **Figure 3**. The Subunit A TCE plume extends from the Source Area to the southeast of the intersection of Indian School Road and Bullard Avenue, a total length of approximately 2.4 miles. At the widest transect, which is generally along Thomas Road, the Subunit A plume is approximately 1.5 miles wide, although it is much narrower in the area south of I-10, generally less than 0.5 mile. The Subunit A perchlorate plume is located in a small area at the Former UPI property, as defined by monitoring wells MW-3, MW-4, and MW-8 and extraction well EA-01.

The TCE plume in Subunit C is much smaller than the plume in Subunit A, and is limited to an area south of I-10 extending from monitoring well OW-C near the MTS injection well field to north of monitoring well EPA MW-47C. Perchlorate concentrations above the Site-specific action level are only found at one Subunit C monitoring well, EPA MW-3C.

There are only four monitoring wells for Subunit B, and contamination data are limited, which results in the lack of plume delineation. However, based on the depth-specific groundwater samples collected during the installation of the Subunit C monitoring wells, it appears that in most locations where TCE contamination is detected in Subunit C, Subunit B has TCE contamination above the MCL as well.

The targeted treatment zone in the Source Area is approximately 250 feet wide and 700 feet long. In the Source Area, the highest historical TCE concentration was reported at monitoring well MW-02 in August 1986, at a concentration of 350,000 µg/L. TCE concentrations have declined greatly since the 1980s. The current (March 2014) maximum TCE concentration in the Source Area was reported in monitoring well MW-07, at a concentration of 3,070 µg/L (down from a concentration of 6,200 µg/L in August 2013).

The highest historical perchlorate concentration in the Source Area was reported in monitoring well MW-07 in February 2010, at a concentration of 94 µg/L, although perchlorate was detected in a Simulprobe groundwater sample at a concentration of 200 µg/L at one soil boring location immediately downgradient from the four main dry wells. The current maximum perchlorate concentration in the Source Area was reported at monitoring well MW-4 in February 2014, at a concentration of 72 µg/L.

E. Risk Assessment

In 2012, Crane Co. completed the *Final Source Areas, Soil, and Facility Structures Baseline Human Health Risk Assessment* (2012 HHRA), and in 2013, Crane Co. completed the *Final*

Source Areas, Soil, and Facility Structures Screening Level Ecological Risk Assessment (2013 Ecological Risk Assessment). Part II, Section VII, provides additional detail regarding these two risk assessments.

VI. CURRENT AND FUTURE SITE AND RESOURCE USE

A. Current Land Use

Land use in the area surrounding the PGA-North Area Source Area is varied. Agricultural land is found to the west, vacant land zoned industrial lies to the south, residential and commercial properties lie to the east, and commercial properties are located to the north on West Van Buren Street.

B. Accommodation of Future Use at the Source Area Portion of the PGA-North Area

Land uses at the Source Area portion of the PGA-North Area are not expected to change in the foreseeable future. Crane Co. indicates that it intends to keep the former UPI property vacant while the soil and groundwater remedies are in operation.

C. Anticipated Future Groundwater Use

Under Arizona Revised Statutes Title 49, all groundwater resources in the state are protected for drinking water use. The 1989 ROD anticipated that the groundwater treated at the PGA-North Area would be mainly used for reinjection, with some portions for other beneficial reuse. For the past several years, treated groundwater has been used for irrigation at the on-site re-vegetation plots for site beautification and dust control; for irrigation use for golf courses and a community park north of I-10; for circulation in a school heating ventilation and air conditioning system; and for downstream agricultural irrigation via discharge to the RID Canal. Future treated groundwater use is expected remain similar to current uses.

VII. SUMMARY OF SITE RISKS

The summary of Site risks for soil and groundwater is based on the Baseline Human Health Risk Assessment (BHHRA) for the PGA Superfund Site presented in the 1989 ROD, the 2012 HHRA, and the 2013 Ecological Risk Assessment.

A. Human Health Risks

The BHHRA in the 1989 ROD evaluated risks associated with soil, groundwater, and soil gas exposures to residential and/or industrial receptors under potential current/future land use conditions to chemicals from sources at the Site, the former UPI facility. The BHHRA used validated data from the RI/FS and the focused RI to evaluate health risks from potential exposure to contaminants in groundwater and soil gas.

In general, baseline risk assessments provide an evaluation of the potential threat to human health and the environment in the absence of any remedial action. The baseline risk assessment included in the 1989 ROD for the PGA-North Area identified and assessed three potential human exposure pathways to the PGA-North Area groundwater. These exposure pathways are:

- Ingestion by private residents who use private wells for potable water supply;
- Inhalation of volatiles stripped from drinking water during in-home uses such as bathing and cooking; and
- Dermal contact with contaminated groundwater from residents' private wells.

Because the property is vacant and there are no domestic wells in the Source Area, none of the above-listed pathways are of concern. The only residential or commercial activity in this area is the Goodyear Financial Center, where a portion of the plume is located beneath a paved parking lot. Thus for the Source Area, these exposure pathways remain incomplete. The subsurface to indoor air exposure pathway was also considered for the Source Area. Indoor air sampling was conducted in overlying buildings, and no significant risk was identified. These findings were presented in the September 2005 Air Sampling Report (Arcadis 2005).

A Site HHRA was completed in November 2012. In the final step of the risk assessment process, a risk characterization was completed. In this step, the results of the exposure and toxicity assessments are integrated into quantitative or qualitative estimates of potential health risks. In general, the conclusions associated with the 2012 HHRA were consistent with the finding of the BHHRA from the 1989 ROD and the 2005 indoor sampling results.

- Source Area groundwater is being actively remediated and the baseline evaluation of this hypothetical worst-case exposure scenario suggests that on-site groundwater is not currently suitable for use as tap water because TCE and perchlorate concentrations exceed the cleanup levels identified in **Table 2**.
- Predicted exposures to volatile chemicals in indoor air of future buildings, using data collected from 2005 to 2011, are within or below the acceptable risk range and below the acceptable hazard index for future indoor commercial/industrial workers. This indicates that the SVE system has been successful at reducing potential health risks (predicted risk and hazard indexes) in the Source Area.
- Predicted exposure to soil is within the CERCLA risk management range ($1x10^{-4}$ to $1x10^{-6}$) for potential trespassers, future construction workers, and future outdoor commercial/industrial workers.

B. Ecological Risk

Historical soil and soil vapor data from the PGA-North Area were screened during the 2013 Ecological Risk Assessment to identify contaminants of potential ecological concern (COPECs) requiring evaluation of potential ecological risk. Of the 21 VOCs detected in soil vapor samples from 10 feet below ground surface (bgs), all were less than their corresponding ecological screening values and were eliminated from further consideration in the Screening Level Ecological Risk Assessment (SLERA). Of the original 63 analytes detected in the ecologically accessible soil (0 to 6 feet bgs), 11 were identified as COPECs and were carried forward through the SLERA process. These included six metals (boron, manganese, mercury, selenium, silver, and vanadium), four organochlorinated insecticides (4,4'-DDE, 4,4'-DDT, Dieldrin, and toxaphene), and perchlorate.

The potential for ecological risk from exposure to these COPECs was estimated for plants, soil invertebrates, and avian and mammalian receptors representing herbivorous, insectivorous, and carnivorous diets. The potential for risk was estimated using the Hazard Quotient (HQ) approach. An initial risk evaluation was conducted using maximum concentrations of chemicals in soil. Based on that initial evaluation, silver and toxaphene were estimated to have HQs less than 1 for all receptors and were not considered further in the refined assessment.

Overall, the estimated HQs for this Site are low. An analysis of uncertainties found that the estimations of exposure and potential toxicity used in calculating the HQs are based on conservative assumptions of exposure concentration, bioavailability, bioaccumulation, and toxicological threshold. The resulting HQs are likely to overestimate the potential for risk to ecological populations of the Site. Based on this evaluation, it can be concluded that the conditions at the PGA-North Area do not represent a potential for ecological risk.

VIII. REMEDIAL ACTION OBJECTIVES

RAOs are site-specific goals for remedial activities to protect human health and the environment. These goals are used in measuring the effectiveness of remedial actions in achieving cleanup. The RAOs established for groundwater and soil in the 1989 ROD for PGA-North Area are:

- Restoration of Subunits A and C of the aquifer by reduction of groundwater contamination equal to or less than Applicable or Relevant and Appropriate Requirements (ARARs).
- Reduction of soil contamination in the Source Area where soil gas samples show VOCs greater than 1 μg/L, an area which may be expanded or reduced to include removal of 99 percent of the contamination.
- For soils, prevent migration of TCE into Subunit A groundwater and preserve uses of Subunit C groundwater.
- For groundwater, preserve the current use of Subunit C groundwater and protect future uses.

This ROD Amendment establishes additional remediation goals to improve and accelerate cleanup of the TCE and perchlorate contamination in the Source Area in order to reach the PGA-

North Area RAOs established in the 1989 ROD. The additional RAOs under this ROD Amendment are:

- Achieve permanent contaminant mass reduction of at least 80 percent for TCE and perchlorate in Subunit A groundwater within the Source Area.
- Achieve permanent TCE and perchlorate concentration reduction of at least 80 percent for Subunit A groundwater within the Source Area.

These additional RAOs were selected to achieve sufficient contaminant mass and concentration reduction to prevent continued contaminant mass discharge from the Source Area to the downgradient groundwater plumes. Achieving these mass and concentration reductions should enable achievement of the remedial goals from the 1989 ROD in a reasonable time frame.

These additional RAOs are being applied to Subunit A groundwater within the Source Area which is where most of the remaining contaminant mass is located. Reduction of contaminant mass and concentrations in Subunit A groundwater at the Source Area will have a long-term effect on cleanup of the downgradient Subunit A and C plumes. Limiting the Source Area remediation to Subunit A groundwater will protect the integrity of Subunit B, which importantly provides a low-permeability barrier to limit vertical movement of Site contaminants.

Multiple lines of evidence will be used to evaluate the performance of the cleanup in the Source Area with respect to the additional RAOs of this ROD Amendment. The current contaminant removal rates from extraction wells EA-03 and PZ-01 (see **Figure 3**) will be used as a baseline to evaluate the performance of the cleanup in the Source Area. Contaminant concentration and mass data will be collected before the Source Area cleanup begins, and these data will be compared to the changes in contaminant levels after cleanup to evaluate performance. The performance of the cleanup in the Source Area will take into account a time lag between cleanup at the Source Area and the change in contaminant concentrations in Subunit A groundwater along West Van Buren Street due to the distance between the Source Area and West Van Buren Street. Given this time lag, performance monitoring will be conducted after each phase of cleanup. During the design of the Source Area cleanup, multiple strategies to evaluate cleanup effectiveness will be selected to monitor the progress of the reduction of COC mass/concentrations in Subunit A groundwater at the Source Area. These strategies will include, but are not limited to, monitoring points downgradient from the treatment area (in the direction of groundwater flow), pumping tests, quantification of key performance parameters for the selected remedy, and groundwater flow and modeling simulation to evaluate mass/concentration/mass flux changes. In addition, confirmation borings will be drilled at select locations within the treatment zone, with soil and groundwater samples collected at each boring to evaluate the effectiveness of the cleanup.

IX. DESCRIPTION OF ALTERNATIVES

Below is the description of the remediation alternatives which were evaluated in the SARFFS using CERCLA's nine criteria.

A. ALTERNATIVE 1 – No Action

EPA is required to consider a "no action" alternative as a baseline for comparison to the other remedial alternatives. As there is already a groundwater remedy at PGA-North Area, the "no action" alternative here assumed that the existing remedy will remain in place but that no additional remedial efforts would be employed to reduce contaminant mass and speed up the cleanup of the Source Area. The existing remedy consists of SVE in the vadose zone of the Source Area together with the pumping of contaminated groundwater from subunits A, B, and C, treatment of the extracted groundwater, and reuse and/or reinjection of the treated groundwater. The existing groundwater pump-and-treat system includes a hydraulic barrier which protects the public supply wells in the vicinity of PGA-North Area by preventing the spread of contamination. The "no action" alternative is used as a baseline that allows for a comparison with the expedited cleanup of the Source Area by the other alternatives.

B. ALTERNATIVE 2 – In-Well Air Stripping (IWAS) + Hydraulic Barrier

This alternative combines the following remedial technologies:

- IWAS to treat Source Area TCE impacts in Subunit A groundwater.
- A hydraulic barrier along West Van Buren Street to contain the Subunit A groundwater contamination.

The current groundwater remedy of SVE in the Source Area together with pump-and-treat for groundwater remediation throughout the Site would remain in place. The hydraulic barrier would consist of the existing Subunit A extraction wells (EA-03 and PZ-01) with groundwater treatment at the MTS. Additionally, the hydraulic barrier would be enhanced with the installation of proposed new extraction well EA-10 (to be located near EA-04). This hydraulic barrier would achieve hydraulic capture of contamination in Subunit A groundwater at West Van Buren Street. The effectiveness of the Subunit A extraction well network would be assessed, and modified, if necessary, for hydraulic control and capture of the subunit A plume along West Van Buren Street. Treatment and/or operational modifications would also be completed at the MTS, if necessary, to maintain the treatment of extracted groundwater and the suitability of the treated groundwater for reinjection and reuse.

IWAS combines modified in-situ air stripping/air sparging with SVE within the water column of each IWAS well. Reduction of contaminant mass and concentrations is achieved using a network of IWAS wells with capture zones that engulf the defined treatment zone. Each IWAS well is constructed with two well screens that are separated by at least 20 feet. Groundwater extracted from the bottom screen is pumped to the top of the well and released to free-fall down the well casing. This process aerates the downward-flowing water, thereby enhancing the removal of TCE. The SVE system connected to the top of the well casing would capture the TCE vapors for treatment. A treatability study and/or pilot test would be completed, as necessary, to define the specific design and operational parameters for implementing the IWAS technology.

C. ALTERNATIVE 3 – Anaerobic Reductive Dechlorination (ARD) + Hydraulic Barrier

This alternative combines the following remedial technologies:

- In situ treatment by ARD to bioremediate TCE and perchlorate contamination in Subunit A groundwater at the Source Area.
- A hydraulic barrier along West Van Buren Street to contain the Subunit A groundwater contamination. This hydraulic barrier will be as described for Alternative 2.

The current groundwater remedy of SVE in the Source Area together with pump-and-treat for groundwater remediation throughout the Site would remain in place. The hydraulic barrier would consist of the existing Subunit A extraction wells (EA-03 and PZ-01) with groundwater treatment at the MTS. Additionally, the hydraulic barrier would be enhanced with the installation of proposed new extraction well EA-10 (to be located near EA-04). This enhanced hydraulic barrier would achieve hydraulic capture of contamination in Subunit A groundwater at West Van Buren Street. The effectiveness of the Subunit A extraction well network would be assessed, and modified, if necessary, for hydraulic control and capture of the subunit A plume along West Van Buren Street. Treatment and/or operational modifications would also be completed at the MTS, if necessary, to maintain the treatment of extracted groundwater and the suitability of the treated groundwater for reinjection and reuse.

In situ treatment by ARD would involve the reduction of TCE and perchlorate to non-toxic end-products (ethene, ethane, chloride, and carbon dioxide for TCE and chloride for perchlorate). Appropriate injection techniques would be used to distribute the necessary chemicals and/or microorganisms throughout the in situ target treatment zone. A monitoring program would assess the effectiveness and extent of the ARD zone, and determine if additional injections and/or injection modifications are necessary to sustain the in situ ARD activity. A treatability study and/or pilot test would be completed, as necessary, to define the specific design and operational parameters for implementing the ARD technology.

D. ALTERNATIVE 4 – Zero-Valent Iron (ZVI) + Nano-scale Zero Valent Iron (nZVI) + ARD + Hydraulic Barrier

This alternative combines the following remedial technologies:

- In situ treatment by nZVI, ZVI, and ARD to degrade TCE and perchlorate contamination in Subunit A groundwater at the Source Area.
- A hydraulic barrier along West Van Buren Street to contain the Subunit A groundwater contamination. This hydraulic barrier will be as described for Alternative 2.

The current groundwater remedy of SVE in the Source Area together with pump-and-treat for groundwater remediation throughout the Site would remain in place. The hydraulic barrier would consist of the existing Subunit A extraction wells (EA-03 and PZ-01) with groundwater treatment at the MTS. Additionally, the hydraulic barrier would be enhanced with the installation of proposed new extraction well EA-10 (to be located near EA-04). This enhanced hydraulic barrier would achieve hydraulic capture of contamination in Subunit A groundwater at West Van Buren Street. The effectiveness of the Subunit A extraction well network would be assessed, and modified, if necessary, for hydraulic control and capture of the subunit A plume along West Van Buren Street. Treatment and/or operational modifications would also be completed at the MTS, if necessary, to maintain the treatment of extracted groundwater and the suitability of the treated groundwater for reinjection and reuse.

For this alternative, nZVI and ZVI would enhance the abiotic reductive dechlorination of TCE and perchlorate, with ARD providing biotic reductive dechlorination of these COCs as described for Alternative 3. Like ARD, reductive dechlorination by nZVI and ZVI results in the formation of non-toxic end products. This alternative combines the injection of nZVI, ZVI, and bioamendments to stimulate reducing conditions and remove contaminants in the Subunit A groundwater at the Source Area.

Appropriate injection techniques such as jet-assisted injection would be used to distribute the nZVI, ZVI, and bioamendments (chemicals and microorganisms for ARD) so that these additives come in contact with the contaminants throughout the in situ treatment zone. While nZVI will effectively remove TCE and perchlorate over a short period of time, ZVI and ARD will stimulate reducing conditions and COC removal from Subunit A groundwater in the Source Area over a longer time frame. Injection dosages of nZVI, ZVI, and bioamendments will be based on stoichiometric demand, treatability studies, and/or pilot tests. This alternative includes a monitoring program to assess the effectiveness and extent of the in situ treatment zone and to determine if additional injections and/or injection modifications are necessary to sustain the in situ nZVI, ZVI, and/or ARD activity and achieve the RAOs. A treatability study and/or pilot test will be completed, as necessary, to define the specific design and operational parameters for implementing this alternative.

E. ALTERNATIVE 5 – ZVI + ARD + Hydraulic Barrier

This alternative combines the following remedial technologies:

- In situ treatment by ZVI and ARD to degrade TCE and perchlorate contamination in Subunit A groundwater at the Source Area.
- A hydraulic barrier along West Van Buren Street to contain the Subunit A groundwater contamination. This hydraulic barrier will be as described for Alternative 2.

The current groundwater remedy of SVE in the Source Area together with pump-and-treat for groundwater remediation throughout the Site would remain in place. The hydraulic barrier would consist of the existing Subunit A extraction wells (EA-03 and PZ-01) with groundwater treatment at the MTS. Additionally, the hydraulic barrier will be enhanced with the installation of proposed new extraction well EA-10 (to be located near EA-04). This enhanced hydraulic barrier would achieve hydraulic capture of contamination in Subunit A groundwater at West Van Buren Street. The effectiveness of the Subunit A extraction well network would be assessed, and modified, if necessary, for hydraulic control and capture of the subunit A plume along West Van Buren Street. Treatment and/or operational modifications would also be completed at the MTS, if necessary, to maintain the treatment of extracted groundwater and the suitability of the treated groundwater for reinjection and reuse.

Injection techniques will be used to distribute the ZVI and bioamendments (chemicals and microorganisms for ARD) throughout the in situ treatment zone to enhance contact of ZVI and the ARD microorganisms with the COCs. Injection dosages of ZVI and bioamendments would be based on stoichiometric demand, treatability studies, and/or pilot tests. A monitoring program, similar to that for Alternative 4, would assess the effectiveness and extent of the in-situ treatment zone, and determine if additional injections and/or injection modifications are necessary to sustain the in situ ZVI and/or ARD activity and achieve contaminant removal to meet the RAOs. A treatability study and/or pilot test would be completed, as necessary, to define the specific design and operational parameters for implementing this alternative.

F. ALTERNATIVE 6 – In situ Chemical Oxidation (ISCO) + Hydraulic Barrier

This alternative combines the following remedial technologies:

- In situ treatment by ISCO to degrade TCE contamination in Subunit A groundwater at the Source Area.
- A hydraulic barrier along West Van Buren Street to contain the Subunit A groundwater contamination. This hydraulic barrier will be as described for Alternative 2.

The current groundwater remedy of SVE in the Source Area together with pump-and-treat for groundwater remediation throughout the Site would remain in place. The hydraulic barrier would consist of the existing Subunit A extraction wells (EA-03 and PZ-01) with groundwater treatment at the MTS. Additionally, the hydraulic barrier would be enhanced with the installation of proposed new extraction well EA-10 (near EA-04). This enhanced hydraulic barrier would achieve hydraulic capture of contamination in Subunit A groundwater at West Van Buren Street. The effectiveness of the Subunit A extraction well network would be assessed, and modified, if necessary, for hydraulic control and capture of the subunit A plume along West Van Buren Street. Treatment and/or operational modifications would also be completed at the MTS, if necessary, to maintain the treatment of extracted groundwater and the suitability of the treated groundwater for reinjection and reuse.

For ISCO, an appropriate oxidant (such as potassium permanganate) is added to the in situ treatment zone to enable a chemical reaction that destroys TCE and produces non-toxic end-products. Appropriate injection techniques would be used to distribute the necessary oxidant chemical and achieve a sufficient oxidant dosage throughout the in situ treatment zone. A monitoring program would assess the effectiveness and extent of the ISCO zone, and determine if additional injections and/or injection modifications are necessary to sustain the ISCO activity. A treatability study and/or pilot test would be completed, as necessary, to define the specific design and operational parameters for implementing the ISCO technology.

G. ALTERNATIVE 7 – Electrical Resistive Heating (ERH) / Steam + Hydraulic Barrier

This alternative combines the following remedial technologies:

- In situ treatment thermal treatment using ERH and/or steam to volatilize VOCs such as TCE. Resulting vapors would be captured by SVE and treated at an aboveground facility.
- A hydraulic barrier along West Van Buren Street to contain the Subunit A groundwater contamination. This hydraulic barrier will be as described for Alternative 2.

The current groundwater remedy of SVE in the Source Area together with pump-and-treat for groundwater remediation throughout the Site would remain in place. The hydraulic barrier would consist of the existing Subunit A extraction wells (EA-03 and PZ-01) with groundwater treatment at the MTS. Additionally, the hydraulic barrier will be enhanced with the installation of proposed new extraction well EA-10 (to be located near EA-04). This enhanced hydraulic barrier would achieve hydraulic capture of contamination in Subunit A groundwater at West Van Buren Street. The effectiveness of the Subunit A extraction well network would be assessed, and modified, if necessary, for hydraulic control and capture of the subunit A plume along West Van Buren Street. Treatment and/or operational modifications would also be completed at the MTS, if necessary, to maintain the treatment of extracted groundwater and the suitability of the treated groundwater for reinjection and reuse.

Due to extremely high energy demands and cost, only a portion of the Source Area would be treated with this alternative. ERH and/or steam injection would address the portion of the Source

Area with the highest TCE concentrations in Subunit A groundwater. Vertical electrodes and/or steam injection wells arranged in a suitable grid pattern would be used to heat the subsurface and volatilize TCE. Vapors that form as the subsurface is heated would be recovered by SVE and treated at an aboveground treatment facility. During the installation of the thermal treatment system, any wells or subsurface features of incompatible materials (polyvinyl chloride piping, etc.) would be abandoned or removed.

X. COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents the comparative analysis of the alternatives with respect to EPA's nine evaluation criteria listed in 40 Code of Federal Regulations (CFR) § 300.430 which formed the basis for selection of Alternative 4. The first two criteria, overall protection of human health and the environment and compliance with federal and state ARARs, are threshold criteria. The next five criteria are balancing criteria and include long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The final two criteria – state acceptance and community acceptance – are modifying criteria.

A. Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment, and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls. Due to the remedial focus of this ROD Amendment, protection of human health and the environment pertains to an alternative's ability to be additionally protective with respect to exposure to contaminated Subunit A groundwater in the Source Area.

Alternative 1 (No Further Action) would not change the current conditions in the Source Area, nor would this alternative provide additional protection of human health or the environment beyond the existing remedy (groundwater pump-and-treat with SVE and removal for extracted perchlorate contamination). This alternative would continue the current remedy and take no additional action toward a Source Area remedy and would not address the perchlorate in situ. Achievement of the original PGA-North Area RAOs would take decades. Similarly, relying on the current groundwater pump-and-treat system only, which is included under this "no action" alternative, would also take decades to satisfy the RAOs for this ROD Amendment. Currently, contamination at the PGA-North Area does not have direct pathways that impact human health. The elevated concentrations of TCE and other COCs present in groundwater at the Source Area would not be addressed beyond the current groundwater remedy. Consequently, the "no further action" alternative would not provide additional reduction in potential health risks, potential environmental impacts, or the time frame to achieve clean-up of contamination.

Alternative 2 (IWAS + Hydraulic Barrier) is expected to be protective of human health for TCE exposure, but would not enhance perchlorate removal beyond what is achieved by the current groundwater remedy.

Alternative 3 (ARD + Hydraulic Barrier) would be protective of human health and the environment. This alternative would treat TCE and perchlorate contamination in the Source Area. Implementation of this remedial alternative would not contribute to the development of exposure pathways discussed in the baseline risk assessment (Part II, Section 7). ARD could result in a temporary increase in vinyl chloride concentrations if the reductive chlorination process is not complete, and vinyl chloride, if formed, may in turn volatilize into the vadose zone. However, ARD is not likely to cause persistent elevated vinyl chloride concentrations if bioaugmentation is successful. Under reducing conditions, arsenic could be mobilized, and hydrogen sulfide and methane might be released as dissolved gases due to biological activity. Anaerobic water created by Alternative 3 could be persistent in the Source Area, but might mix with aerobic groundwater as the groundwater migrates downgradient of the in situ treatment zone. The hydraulic barrier would capture any anaerobic water, and treatment processes at the MTS would need to handle the changes in water quality resulting from this alternative appropriately.

Alternatives 4 (nZVI/ZVI/ARD + Hydraulic Barrier) and 5 (ZVI/ARD + Hydraulic Barrier) would be protective of human health and the environment since nZVI and ZVI injections, in conjunction with enhancing ARD, would result in the reduction of COC mass and concentrations in the Source Area. These alternatives would be effective in treating TCE and perchlorate. In situ treatment by ARD, and to a lesser extent chemical reduction by nZVI and/or ZVI, can result in a temporary increase in vinyl chloride concentrations if the reductive dechlorination process is not complete. If formed, vinyl chloride may volatilize into the vadose zone and be captured by the SVE system. However, these alternatives would not be likely to cause persistent elevated vinyl chloride concentrations because vinyl chloride formation from chemical reduction is minor and appropriate, and successful bioaugmentation for ARD minimizes vinyl chloride persistence. Under reducing conditions, arsenic could be mobilized, and hydrogen sulfide and methane may be released as dissolved gases due to biological activity. Anaerobic water created by Alternatives 4 or 5 could be persistent in the Source Area, but might mix with aerobic as the groundwater migrates downgradient of the treatment area. The hydraulic barrier would capture any anaerobic ground water, and treatment processes at the MTS will need to appropriately handle the changes in water quality resulting from these alternatives.

Alternative 6 (ISCO/Hydraulic Barrier) would be moderately protective of human health and the environment; however, the oxidant (notably if permanganate is used) could be persistent in the Subunit A groundwater. Permanganate would be effective in treating TCE, but not perchlorate. In addition, if permanganate-impacted water reached the hydraulic barrier and was recirculated in the aboveground water treatment processes at MTS, there would be a low-level health risk to treatment system workers. Finally, the application of an oxidizing technology may result in the conversion of trivalent chromium to hexavalent chromium, which is more mobile and exhibits a higher toxicity. Uranium and selenium also may be mobilized under oxidative conditions.

Alternative 7 (ERH/Steam) would be moderately protective of human health and the environment. TCE mass would be reduced and treated ex situ by the MTS, providing resource protection, but this alternative would not be effective in treating perchlorate. Health and safety plans and process controls implemented during treatment would provide protective measures for environmental workers.

B. Compliance with ARARs

Section 121(d) of CERCLA requires that remedial actions at Superfund sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations, which are collectively referred to as ARARs. ARARs for all of the alternatives were identified in the SARFFS; those for the selected remedy are listed in **Table 3**.

All alternatives have the potential to meet and comply with the ARARs for TCE and perchlorate. However, Alternatives, 1, 2, 6, and 7 would take a longer time frame to meet ARARs due to the lack of active in-situ perchlorate treatment.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
Chemical-Specific				
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)[1]	40 Code of Federal Regulations (CFR) Part 141	The National Primary Drinking Water Regulations provide a list of MCLs established by the SDWA.	Applicable	Trichloroethylene (TCE) in groundwater will be compared to the Federal MCL of 5 micrograms per liter (µg/L). No MCL has been established for perchlorate.
Arizona Department of Health Services (ADHS) Perchlorate Health-Based Guidance Level (HBGLs)	ADHS, 2000	HBGLs are risk-based levels developed by ADHS to represent concentrations of contaminants in drinking water that are protective of public health during long-term exposure. The ADHS process for determining HBGLs accounts for exposure to children.	To Be Considered (TBC)	Arizona's HBGL for perchlorate of 14 parts per billion (ppb) is to be considered in setting the risk-based cleanup level for perchlorate. See reference below.
Water Quality Criteria (WQC)[1]	Clean Water Act (CWA) 304	WQC are developed under the CWA and are based on the latest scientific knowledge about the effects of pollutants on aquatic life and human health. WQC is used by Arizona to protect the uses of their waters based on designated use.	TBC	Groundwater below the Main Dry Wells Source Area (MDWSA) has been designated as a drinking water source, therefore WQC should be considered in implementation of the remedy.
Regional Screening Levels (RSLs)	U.S. Environmental Protection Agency (USEPA) Region 9	The USEPA Region 9 has developed RSLs for soil, ambient air, and tap water. These screening levels are chemical specific concentrations for individual contaminants that may warrant further investigation or site cleanup.	TBC	There is the potential for discovery of COC mass in vadose zone soil during implementation of the MDWSA groundwater remedy, therefore RSLs may be used to determine additional need for site investigation or cleanup.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
State of Arizona[1]	Arizona Administrative Code (A.A.C.) § R18-7-202	The State of Arizona has established Soil Remediation Levels (SRLs) to apply to persons legally required to conduct soil remediation under the following programs: • The Aquifer Protection Permit (APP) Program • The Hazardous Waste Management Program • The Solid Waste Management Program • The Special Waste Management Program • The Underground Storage Tank Program • The Water Quality Assurance Revolving Fund • Any other program under Arizona Revised Statutes (A.R.S.) Title 49 that regulates soil remediation.	Relevant and Appropriate	Non-residential SRLs are those found in A.A.C. R18-7, Appendix A. They will only apply if TCE is found in soil during subsurface investigation activities associated with implementation of the chosen remediation alternative. The SRL for TCE is 65 milligrams per kilogram (mg/kg).
Location-Specific				
Resource Conservation and Recovery Act (RCRA) Solid Waste Disposal General Provisions	42 USC § 6901 et seq. A.R.S. § 49-921 et seq. 40 CFR § 141.5b	Design, construction, operation, and maintenance requirements for new facilities and expansion of old facilities to prevent damage due to earthquakes or washout of any hazardous waste by a 100-year flood.	Relevant and Appropriate	Provides requirements for the design of treatment facilities that may be constructed or modified as a result of the implementation of a MDWSA groundwater remedy.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
Aquifer Water Quality Standards (AWQS)	A.R.S. § 49-223	Recharged or reinjected groundwater must meet Arizona AWQS. A discharge shall not cause a pollutant to be present in an aquifer classified as protected for drinking water in a concentration which endangers human health, or if it could impair existing or reasonably foreseeable uses of water in an aquifer.	Applicable	Subunit A groundwater does not currently meet AWQS standards and is not considered potable regardless of the presence of site COCs; however, it is still classified as a potential source of drinking water.
Aquifer Identification, Classification and Reclassification	A.R.S. § 49-224	Aquifers in the State identified and defined under this statute, and other aquifers subsequently discovered, identified, and defined, shall be classified for drinking water protected use.	Applicable	Subunit A groundwater does not currently meet AWQS standards and is not considered potable regardless of the presence of site COCs; however, it is still classified as a potential source of drinking water.
Arizona Historic Preservation and Archaeological Discovery	A.R.S. §§ 41-841-847, 865	This Arizona state law and guidelines require that if archaeological artifacts are found during excavation, construction or other activities, the activity must temporarily stop to allow for investigation and preservation of artifacts.	Applicable	The probability of this occurring is very low, as this property has been developed and operated on an industrial basis since 1963.
National Historic Preservation Act (NHPA)	16 U.S.C. 470	Requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	Applicable	The probability of this occurring is very low, as this property has been developed and operated on an industrial basis since 1963.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
Minimum Design Criteria	A.A.C. §§R18-5-501 and 502	Requirements for new treatment units including appropriate siting	Applicable	Applies to the design of new treatment units, if necessary for implementation of the MDWSA groundwater remedy.
Action-Specific				
Arizona Groundwater Management Act	A.R.S. § 45-454.01, §§ 45-594, 595, 596, 600 and 605	Statute exempts new well construction and withdrawal, treatment, and reinjection of groundwater into the aquifer that occur as a part of, and on the site of, a remedial action undertaken pursuant to CERCLA from needing to obtain Arizona Department of Water Resources (ADWR) approval to extract groundwater except that a well that is exempt is subject to §§45-594, 595, 596, 600 and 605 but authorization to drill is not needed before drilling.	Relevant and Appropriate	By its own terms, this statute does not apply to CERCLA remedial actions; however the substantive requirements of these well construction and operation regulations apply for wells installed during implementation of the MDWSA groundwater remedy.
Arizona Remedial Action Criteria; rules	A.R.S. § 49-282.06(A)(2)	To the extent practicable, remedial actions shall provide for the control, management, or cleanup of the hazardous substances in order to allow the maximum beneficial use of the waters of the state.	Relevant and Appropriate	
Hazardous Waste Determination	40 CFR § 262.11 and A.A.C. § R18-8-262	Establishes procedures to determine if wastes are hazardous wastes. Generators of waste from construction and operation of remedial actions are required to	Applicable	Both solid and liquid wastes will be generated during drilling activities during implementation of the remedy.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
		follow procedures to determine if wastes are hazardous wastes.		
Safe Drinking Water Act	42 USC § 300f et seq. 40 CFR § 144.12 through § 144.16	Regulates the reinjection of groundwater through establishment of criteria and standards for the Underground Injection Control Program. These criteria include current and future use, yield and water quality characteristics and are applicable for determining exempt aquifers. Sets forth design construction, operation, and maintenance requirements for injection wells.	Relevant and Appropriate	During remedy implementation, where treated water is reinjected into the aquifer, these regulations apply to design, construction, operation, and maintenance of Class V injection wells. While a UIC permit would not be required, the substantive portion of these regulations may be relevant and appropriate.
Well Permitting, Construction and Drilling Standards	A.R.S. § 45-591 through § 45-604; A.A.C. § R12-15-801,822	State statutes and rules specify requirements for the permitting, drilling, construction, and abandonment of wells, including monitoring, supply and injection wells.	Relevant and Appropriate	Applies to monitoring wells and groundwater withdrawal wells. The substantive portions of these requirements are relevant and appropriate for drilling and abandoning wells.
Protection of the Environment, Solid Wastes	40 CFR Part 261 A.A.C. § R18-8-261	Establishes procedures and numeric limits for identification and management of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes.	Relevant and Appropriate	These requirements are relevant and appropriate to management of waste materials generated as a result of construction and operation of the response action.
Hazardous Waste Regulations Accumulation	40 CFR § 262.34	Regulate temporary accumulation of hazardous waste on site. Specifies procedures for accumulation of	Relevant and Appropriate	The substantive requirement of this section is relevant and appropriate to management of

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
Time		hazardous wastes on site for limited quantities of hazardous waste and for limited time periods under generator status.		waste materials generated as a result of remedy implementation.
Standards Applicable to Generators of Hazardous Waste	40 CFR § 262.11	Requires waste generators to determine whether wastes are hazardous wastes, and establishes procedures for such determinations. Requirement for management of waste material generated as a result of construction of the selected action or operation of any groundwater treatment units.	Relevant and Appropriate	The substantive requirement of this section is relevant and appropriate to management of waste materials generated as a result of remedy implementation.
RCRA Hazardous Waste and Arizona Hazardous Waste Management Requirements	40 CFR § 264.18(a) and (b) A.A.C. § R18-8-264 A.R.S. § 49-901 - § 49-973	Both the USEPA and the State have comprehensive rules for the management of hazardous wastes. These requirements include container storage, secondary containment, and leak detection. Off-site disposal of hazardous waste must also meet the requirements in these sections, including those for notification, disposal methods, and transport. Keeping an operating record as described in 40 CFR § 264.73 is required for hazardous waste facilities where the waste is stored and or treated in the same place as it is generated. This substantive requirement is likely	Relevant and Appropriate	These requirements could be relevant and appropriate to any impacted soil excavated or groundwater withdrawn during remedy implementation that contains a hazardous waste or exhibits a hazardous waste characteristic. Historically, drilling waste has been characterized as non-hazardous and has been manifested and disposed of as such; however, the possibility exists that drilling in the MDWSA could yield soil that exceeds SRLs, and in that case, these regulations would apply to the characterization, handling, and

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
		applicable to the MDWSA groundwater remedy.		disposal of that soil.
RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	40 CFR § 264.1(j)(2-6, 10-12) A.A.C. § R18-8-264(j) (2-6, 10-12) A.R.S. § 49-921 et seq.	Requirements for waste management sites, specifically waste analysis, inspection requirements, personnel training requirements, and contingency and emergency plans.	Relevant and Appropriate	These requirements could be relevant and appropriate to any impacted soil excavated or groundwater withdrawn during remedy implementation that contains a hazardous waste or exhibits a hazardous waste characteristic.
RCRA Hazardous Waste Management	40 CFR § 264.600 - 603	Requirement for operation of treatment, storage, and disposal facilities. Miscellaneous treatment units must satisfy environmental performance standards by protection of groundwater, surface water, and air quality, and by limiting surface and subsurface migration.	Relevant and Appropriate	The substantive requirements in 40 CFR § 264 and A.A.C. § R18-8-264 may be relevant and appropriate to storage and disposal of hazardous wastes generated on site.
RCRA Hazardous Waste Management	40 CFR § 264.73 A.R.S. § 49-921 et seq.	Requires keeping an operating record as described in 40 CFR § 264.73 for hazardous waste facilities where the waste is stored and or treated in the same place as it is generated.	Relevant and Appropriate	The substantive requirements in 40 CFR § 264 and A.A.C. § R18-8-264 may be relevant and appropriate to the MDWSA groundwater remedy where there is storage and disposal of hazardous wastes generated on site.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
RCRA Tank Systems	40 CFR Subpart J, except § 264.192(a) A.A.C. § R18-8-264.190 et seq, except §§ R18-264.192(a) A.R.S. § 49-921 et seq.	Requirements for tank systems used to store or treat hazardous waste, including design and installation, containment and detection of releases, operating requirements, inspections, responses to leaks or spills, and closure and post-closure. Substantive provisions apply.	Relevant and Appropriate	The substantive requirements in 40 CFR § 264 and A.A.C. § R18-8-264 may be relevant and appropriate to storage and disposal of hazardous wastes generated on site.
Hazardous Waste Transportation	49 CFR Subchapter C; 10 CFR § 71; 10 CFR § 20.2006	Transportation of contaminated media constituting a hazardous waste to an off-site treatment or disposal facility is subject to federal and state hazardous materials transportation requirements.	Applicable	These rules could apply to any impacted soil excavated or groundwater withdrawn during remedy implementation that contains a hazardous waste or exhibits a hazardous waste characteristic.
Well Location	A.A.C. § R12-15-818	Prohibits new well construction, except for monitor wells and piezometer wells, within 100 feet of any septic tank system, sewage disposal area, landfill, hazardous waste facility, storage area of hazardous material or petroleum storage areas and tanks, unless authorized in writing by the Director.	Relevant and Appropriate	The location of potential new wells, other than monitor wells and piezometer wells, relative to potential hazardous waste facilities will be considered during implementation of the chosen groundwater remedy. The substantive portions of this regulation may be relevant and appropriate.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
AWQS Reinjection Standards	A.R.S. § 49-223	Recharged or reinjected groundwater must meet AWQS.	Applicable	Subunit A groundwater in the Site are is classified as a potential source of drinking water.
Aquifer Water Quality Standards	A.A.C. § R18-11-405(a) and (c)	Narrative AWQS requiring that 1) a discharge not cause a pollutant to be present in an aquifer classified for a protected drinking water used in a concentration which endangers human health; and 2) a discharge not cause a pollutant to be present in an aquifer which impairs existing or reasonably foreseeable uses of water in an aquifer.	Applicable	Requires that the use of amendments as part of the remedy not negatively impact current or future use of the water.
Aquifer Protection Permit	A.R.S. § 49-241 et. seq.	The APP program requires that, unless exempted under A.R.S. §49-250, any facility that discharges a pollutant either directly to an aquifer or to the land surface above the vadose zone in such a manner that the pollutant has a reasonable probability to reach the aquifer must obtain an APP from the Arizona Department of Environmental Quality (ADEQ) in accordance with A.A.C. R18-9-101. Individual permit requirements include use of best available control technology and showing that the discharge would not cause AWQS to be violated at a	Relevant and Appropriate	Facilities used in response or remedial actions undertaken pursuant to CERCLA are exempt from obtaining an APP by A.R.S. §49-250(18)(b). Remedial actions performed on-site also are exempt from obtaining State permits by CERCLA §121(e). However the substantive portions of these regulations may be relevant and appropriate.

TABLE 3: Applicable Or Relevant And Appropriate Requirements Evaluation

Requirement	Citation	Description	Preliminary Determination	Comments
		point of compliance.		
Anti-degradation	A.R.S. § 49-243	Prohibits discharges that cause or contribute to a violation of AWQS. In aquifers where standards have been exceeded, no further degradation is permitted.	Applicable	Subunit A groundwater in the Site area is classified as a potential source of drinking water.
(1) = USEPA, 1989. Record of Decision: Phoenix-Goodyear Airport Area, Arizona. AZ980695902, OU 01. September 26.				

C. Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risks and the ability of an alternative's remedy to maintain reliable protection of human health and the environment over time once RAOs have been achieved.

Alternative 1 (No Further Action) is not effective at achieving all of the RAOs within a reasonable time frame for groundwater remediation. The No Action alternative does not meet the mass and concentration reduction RAO within the Source Area.

Alternative 2 (IWAS) relies on flushing a portion of the aquifer within the influence of the IWAS well field to strip TCE from groundwater. Effectiveness of this technology's treatment approach is dependent on the radius of influence, hydraulic properties of the aquifer, and the treatment zone dimensions. This technology relies on the heterogeneity of the aquifer for horizontal migration of recirculated groundwater. However, the presence of contiguous low-permeability layers in Subunit A may impact the effectiveness of this alternative since the IWAS technology assumes that approximately 45 percent of the captured water is recirculated. Water that is returned to the aquifer may not be recaptured by the lower extraction component of the IWAS well system. Due to the subsurface heterogeneity in Subunit A, this alternative is expected to be low to moderately effective at achieving the RAOs in the long term. This alternative would be effective for TCE removal, but would not provide remediation of perchlorate contamination in the Subunit A groundwater.

Alternatives 3 (ARD), 4 (nZVI/ZVI/ARD), 5 (ZVI/ARD), 6 (ISCO), and 7 (ERH/Steam) would likely be moderately to highly effective at permanently reducing source area COC concentrations in the long term; however, each alternative has issues relative to reliably protecting human health that would need to be addressed. The alternatives that create reducing conditions are also effective in treating perchlorate in groundwater. While effective for TCE removal, Alternative 6 (ISCO) and Alternative 7 (ERH/Steam) will not provide remediation of perchlorate contamination in the Subunit A groundwater because the perchlorate molecule is highly oxidized and/or is resistant to thermal destruction. However, for the removal of TCE alone, Alternative 7 has the highest likelihood of success in the area treated.

Any alternative that involves injection of amendments–such as Alternatives 3 (ARD), 4 (nZVI/ZVI/ARD), 5 (ZVI/ARD), and 6 (ISCO)–may result in initial mass reductions followed by localized and/or temporary rebounding of COC concentrations. The hydraulic barrier combined with repeated amendment injections would be included in the design of these alternatives to address this possibility.

Alternative 3 (ARD/Hydraulic Barrier) would require a longer time period in order to establish a high population of active, COC-degrading bacteria, since the current native soil has a very low organic content and microbial count. For Alternative 7 (ERH/Steam) initial mass removal would occur over an estimated half-year time frame. Although rebound is less likely for Alternative 7 than for ARD or ISCO, the possibility of rebound after thermal treatment is an unknown that could necessitate additional remedial efforts.

Alternatives 4 (nZVI/ZVI/ARD) and 5 (ZVI/ARD) would provide the most effective and permanent long-term mass and concentration reduction. The Source Area remediation RAOs will be met in a short time frame, since TCE will be destroyed through contact with nZVI and/or ZVI as well as by ARD, and the nZVI injections also will provide a reducing environment in the Source Area that will bolster the effectiveness of ARD in the long term. These alternatives also have been found to reduce perchlorate concentrations.

The effectiveness of Alternatives 3 (ARD/Hydraulic Barrier), 4 (nZVI/ZVI/ARD), and 5 (ZVI/ARD), which depend on COC reduction by chemical and/or biological processes, and Alternative 6 (ISCO), are all dependent on distribution of amendments (chemicals and/or microorganisms) and on achieving contact between the injected amendments and the target COCs. The achievement of complete and uniform distribution of amendments across the in situ treatment zone is unlikely given the geologic heterogeneity and injection techniques. All of these alternatives would result in changes to the oxidation-reduction potential state of the Subunit A groundwater in the Source Area, and would produce temporary changes in secondary water quality parameters. Reduced groundwater produced through application of nZVI, ZVI, and/or ARD eventually would be diluted with aerobic groundwater some distance downgradient of the in situ treatment area. Oxidized groundwater from Alternative 6 also would be subject to eventual dilution; however, a change in the oxidation-reduction potential state is less likely because Subunit A already has an oxidizing oxidation-reduction potential. While some pilot testing has been performed, none of these remediation alternatives has been sufficiently pilot-tested under site-specific conditions to confirm that the assumed injection approaches would create a comprehensive and complete in situ treatment zone in the Source Area. Therefore, modifications based on field data from the remedial design may be necessary to implement these alternatives.

Permanganate, the assumed Alternative 6 (ISCO) amendment, has been known to persist in local groundwater due to the naturally low concentrations of organic carbon and high dosing concentrations used for ISCO. Permanganate, when dosed in sufficient quantity, may diffuse into fine-grained and no-flow zones, thereby reducing the potential for back-diffusion of TCE over time. This persistence would allow permanganate to diffuse into lower-permeability zones within the aquifer; however, if permanganate-laden groundwater were to reach the extraction wells within the Source Area and/or at the hydraulic barrier, the aboveground treatment process might be affected negatively. This is also true for groundwater that has been affected by anaerobic and reducing conditions due to the potential presence of metals, sulfide, and methane which affect the aesthetic qualities of the water. Injections in phases are anticipated for all of the alternatives requiring amendment injection into the Subunit A groundwater at the Source Area (Alternatives 3, 4, 5, and 6).

Modifications to the MTS (design and/or operation) may be necessary to prevent negative impacts from secondary water quality effects associated with extracted groundwater following the implementation of any enhanced remedy. The potential for fouling in the extraction and injection wells could add additional costs as a result of well rehabilitation and/or replacement over the long term. The likelihood of fouling (biological or chemical) is higher for those alternatives including ARD due to the potential presence of organic carbon and soluble iron in the extracted groundwater.

The effectiveness of any of these alternatives would need to be evaluated as the remedy is applied and as part of the regular Site Five-Year Reviews, as long as groundwater contaminants remain on the Site at concentrations above cleanup levels established in the original ROD.

D. Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment

For this criterion, the evaluation was based on the proven ability of the remedial technologies associated with an alternative to reduce toxicity, mobility, or volume through treatment of the COCs associated with Subunit A groundwater at the Source Area.

Alternative 1 (No Further Action) does not include treatment beyond the existing groundwater remedy, and would not expedite the reduction of toxicity, mobility, or volume of contaminants at the Source Area and the other impacted groundwater at the PGA-North Area.

Alternative 2 (IWAS) would result in low to moderate reduction in toxicity, mobility, or contaminant volume. IWAS may not address high TCE concentrations in deeper Subunit A groundwater. If the recirculation path is not complete, inadequately-treated groundwater may be recirculated to the upper aquifer zone. Plume migration from the Source Area would continue to be mitigated by the existing hydraulic barrier, however. COC reduction for this alternative occurs by treatment, likely using vapor-phase GAC, of the captured vapors from the IWAS wells. The spent vapor-phase GAC requires off-site transportation and regeneration for destruction of the VOC contaminants. Treatment of perchlorate would not occur by this alternative.

Alternatives 3 (ARD), 4 (nZVI/ZVI/ARD), 5 (ZVI/ARD), and 6 (ISCO) would likely result in moderate to high reductions in toxicity, mobility, or contaminant volume through treatment for TCE. Use of jet-assisted injection for delivery of amendments in Alternatives 3, 4, 5, and 6 may establish new flow paths that could mobilize sorbed-phase mass and expand the size of the plume. In each case, the hydraulic barrier would control plume migration from the Source Area adequately. Implementation of ARD may result in the temporary production of vinyl chloride and mobilization of arsenic. Alternatives 3 (ARD), 4 (nZVI/ZVI/ARD), and 5 (ZVI/ARD) also have the potential to treat perchlorate.

Alternative 6 (ISCO) may locally and temporarily mobilize chromium, uranium, and selenium. Persistence of permanganate would be dependent on dosage, reaction with naturally-occurring and anthropogenic organic carbon and minerals, and mixing with untreated groundwater and dispersion as groundwater travels downgradient. This alternative would not treat perchlorate.

Alternative 7 (ERH/Steam) would provide the highest reduction in toxicity and contaminant mass, which could reach 90 percent to 99 percent reduction in mass at the area treated. There exists a slight possibility that the higher temperature resulting from in-situ thermal treatment could mobilize TCE in both the gaseous and dissolved phases; however, this alternative would be implemented in concert with SVE and hydraulic control systems. This alternative would not treat perchlorate.

E. Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the alternative and any adverse impacts that may affect workers, the community, or the environment during the construction and operation of the alternative until cleanup levels are achieved.

Alternative 1 (No Action) would not require any new construction or operations, as the existing groundwater remedy is installed and operational. This alternative would take a long time (decades) to achieve the Source Area RAOs.

Alternatives 2 (IWAS), 3 (ARD), 4 (nZVI/ZVI/ARD), 5 (ZVI/ARD), 6 (ISCO), and 7 (ERH/Steam) can be implemented in a way that protects the community, workers, and the environment. Alternatives 4, 5, and 6 are anticipated to require use of jet-assisted injection methods, which represents a minor risk to overlying land use and a slight risk to workers due to the high pressures used during the injection process. Alternative 6 (ISCO) also may pose potential risk to workers due to handling of the chemical oxidants used for ISCO. The potential presence of permanganate in extracted groundwater represents an interference with the ion exchange resin currently used treating for perchlorate. The construction time for Alternatives 2 and 7 would be less than one year, although the operational time for each alternative (i.e., achievement of the RAOs) would be different. Alternatives 3, 4, 5, and 6 would require an estimated one to three years for complete installation, as the injections would likely be performed in phases and the need for reinjections is assumed.

The timeframe to achieve the RAOs of this ROD Amendment (Part II, Section VIII) varies for Alternatives 2 through 7. The following evaluation of the alternatives with respect to short-term effectiveness pertains to the time to achieve the RAOs, with low meaning a longer time frame while high is associated with the shortest time frame.

Alternative 2 (IWAS) would be low with respect to short-term effectiveness in achieving the RAOs for TCE only. The IWAS system would be effective at removing dissolved VOCs in groundwater within the influence of each IWAS well; however, the degree to which stripping occurred would depend on the recirculation ratio achieved. Alternative 2 would not meet the RAOs for perchlorate removal.

For Alternative 3 (ARD), the short-term effectiveness in achieving the RAOs for VOCs and perchlorate would be low to moderate. Current groundwater chemistry and microbial populations are not conducive to ARD. An acclimation period of at least six months to a year would be required to reach anaerobic and reducing conditions, and grow microbial COC-degrading populations sufficient to observe significant degradation rates. This technology is likely to be effective with enhancing the degradation of perchlorate at similar rates to TCE. Additionally, ARD could result in a temporary increase in vinyl chloride concentrations if the reductive chlorination process is not complete, and vinyl chloride from ARD may in turn volatilize into the vadose zone. However, ARD is not likely to cause persistent elevated vinyl chloride concentrations if bioaugmentation is successful. The existing SVE system will continue to be operated and monitored during the implementation of ARD. The SVE influent gas monitoring will enable detection of any vinyl chloride that may be formed and volatize from groundwater into the vadose zone. As previously stated, arsenic mobilization could possibly occur under the reducing conditions associated with ARD, and hydrogen sulfide and methane may be released as dissolved gases due to biological activity. Operational modifications might be necessary at MTS to treat the anaerobic water created by Alternative 3 and maintain the reinjection of treated water.

Alternative 4 (nZVI/ZVI/ARD) would be moderate to high with respect to short-term effectiveness in achieving the RAOs for VOCs and perchlorate. Alternative 5 (ZVI/ARD) would be moderate with respect to short-term effectiveness in achieving the RAOs for VOCs and perchlorate. The use of nZVI would result in Alternative 4 achieving RAOs in a shorter time frame than Alternative 5. By using nZVI and/or ZVI, Alternatives 4 and 5 are less likely to have a temporary increase in vinyl chloride concentrations than Alternative 3. Similar to Alternative 3, hydrogen sulfide and methane formation, along with possible MTS operational modifications, are short-term effectiveness considerations for Alternatives 4 and 5.

Alternative 6 (ISCO) would be moderate with respect to short-term effectiveness in achieving the RAOs for VOCs only. This alternative would not be effective in reducing perchlorate contaminant mass.

The short-term effectiveness of Alternatives 3, 4, 5, and 6 with respect to achieving RAOs would depend on the injection effectiveness, i.e., achieving the desired pattern of amendment distribution and concentration. The need for reinjection would depend upon this effectiveness of laterally and vertical amendment distribution from the initial injections. Additionally, alternatives that use in situ injection would likely be implemented in phases, which might extend the time frame to achieve the RAOs.

Alternative 7 (ERH/Steam) would be the highest with respect to short-term effectiveness in achieving the RAOs for VOCs only. Alternative 7 would not be effective in reducing perchlorate contaminant mass.

F. Implementability

Implementability addresses the technical and administrative feasibility of an alternative, from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other government entities also are considered.

Because Alternative 1 (No Further Action) only requires continued operation of the existing groundwater pump-and-treat system, this alternative could be implemented readily. Technical and administrative feasibility are satisfied as the existing pump-and-treat system has been constructed, operated, monitored, and found to be reliable.

Alternative 2 (IWAS) would involve installation of a network of IWAS wells for adequate coverage of the contaminated Subunit A groundwater at the Source Area. Installation, operation, and monitoring of the IWAS equipment are feasible from both a technical and administrative perspective. Construction of the IWAS well network would involve moderate disruption at the Site. IWAS has the potential for scale formation in the well. This technology has been used for unconfined groundwater remediation, such as the Subunit A groundwater, so vendors and equipment are available. The overall implementability rating for Alternative 2 is moderate to high.

Overall, the implementability of Alternative 3 is rated as moderate. Alternative 3 (ARD) may require a treatability study and/or pilot program to evaluate the injection requirements, as injection performed is a key factor in the technical feasibility of this alternative as a standalone remedial alternative for the Source Area. With regard to technical feasibility, bioamendments can be injected using direct-push methods, which are relatively rapid and straightforward to implement. However, hydraulic fracturing may be required to enhance amendment distribution, and the presence of gravel and cobbles in Subunit A likely would impede direct-push methods. Bioaugmentation, injection of a liquid containing a commercial culture of COC-degrader microorganisms, should occur during a separate event, after the biostimulation injection has created the geochemical conditions necessary for the in situ survival and growth of these microorganisms. The bioaugmentation culture only needs to be injected once, as the microbes will multiply as long as in situ conditions are favorable (i.e., available organics, nutrients, and reducing conditions). Sustaining suitable conditions for ARD would require extensive monitoring, and reinjections may be necessary. Extensive evaluation of early performance-monitoring data will need to be applied as lessons learned to subsequent phases of the injection program. While both technically and administratively feasible, the injection program would result in low to moderate disruption at the Site. Since the injection programs will be phased over an anticipated three to five-year period, the injection program would be optimized, as necessary, during each phase of the injections. Bioamendment and injection service providers for ARD are commercially available.

The implementability of Alternative 4 (nZVI/ZVI/ARD) is rated as moderate to high. While the technical and administrative feasibility issues are similar to Alternative 3, the use of nZVI and ZVI in conjunction with ARD would create more consistent conditions in the in situ treatment zone. Monitoring would be performed to evaluate the distribution of amendments, with the findings used to optimize the injection program. Since the injection programs would be phased over an anticipated three to five-year period, the injection program would be optimized, as necessary, during each phase of the injections. Suppliers of amendments, as well as injection service providers, for nZVI, ZVI, and ARD are commercially available.

The rating for implementability of Alternative 5 (ZVI/ARD), including the basis and associated issues, is similar to Alternative 4, moderate to high.

The overall rating for implementability of Alternative 6 (ISCO) is moderate to high. The technical and administrative feasibility issues for this alterative are associated primarily with injection of the oxidant, similar to those discussed for Alternatives 3, 4, and 5. A difference pertaining to injection for Alternative 6 is that only a chemical oxidant solution will be injected. The heterogeneity in Subunit A could result in preferential pathways that would hinder uniform distribution of the oxidant solution. Like Alternatives 3, 4, and 5, the Alternative 6 injection program would result in low to moderate disruption at the Site (i.e., nearby residents, businesses, tenants). A phased injection program is anticipated, enabling lessons learned and field monitoring to optimize the injections that would occur over a multi-year time frame.

The implementability of Alternative 7 (ERH/Steam) has an overall rating of low to moderate, since this technology is generally applied at shallow depths over a smaller footprint. Thermal treatment capacity may be reduced because of the power requirements for in situ thermal treatment relative to local availability. This technology requires a significant amount of cabling, piping, and installation of controls and checkpoints. In addition, existing incompatible subsurface features such as wells would need to be abandoned, removed, or replaced during construction. Monitoring wells would need to be installed after application of this remedy in order to monitor for residual COC concentrations in groundwater. Any residual VOC contamination would be characterized and addressed depending on the extent and magnitude of the remaining mass.

G. Cost

For the cost criterion, EPA compares alternatives based on the present-worth cost, which is a measure of the total project cost over the timeframe required to achieve the RAOs. The estimated present-worth costs for each alternative are listed in **Table 4**.

TABLE 4: Summary of Present Worth Costs[4] – Source Area Groundwater Remediation

Alternative	Duration[1] (years)	Capital Cost ($)	Annual Costs ($)	Closure Costs ($)	Total ($)
1 – No Action	Decades	0	0	0	0
2 – IWAS + Hydraulic Barrier	20[2]	5,160,000	1,540,00	676,000	7,376,000
3 – ARD + Hydraulic Barrier	8	7,470,000	820,000	521,000	8,811,000
4 – nZVI, ZVI, ARD + Hydraulic Barrier	8	10,320,000	820,000	455,000	11,595,000
5 – ZVI + Hydraulic Barrier	11	11,290,000	1,360,000	627,000	13,277,000
6 – ISCO + Hydraulic Barrier	8[3]	6,210,000	820,000	458,000	7,488,000
7 – ERH/Steam + Hydraulic Barrier	1[3]	10,470,000	15,620,000	4,529,000	30,619,000

Notes:

1 Estimated time frame to achieve RAOs.

2 Current treatment likely will achieve perchlorate cleanup for groundwater in the Source Area within the same time frame.

3 RAOs for TCE only; perchlorate treatment through the existing pump-and-treat system will likely take longer to achieve RAOs.

4 Costs were estimated by EPA to perform the comparative analysis of the seven remedial alternatives. Actual costs are expected to vary considerably as field work progresses – based on the Triad approach – and actual field conditions are assessed to accomplish the remedy enhancement.

(1) Capital Costs

- Alternatives 2 (IWAS), 3 (ARD), and 6 (ISCO) have the lowest capital costs.
- Alternatives 4 (nZVI/ZVI/ARD), 5 (ZVI/ARD), and 7 (ERH/Steam) have moderate capital costs.

(2) Operational and Maintenance (O&M) Costs

- Alternatives 3 (ARD), 4 (nZVI/ZVI/ARD), 5 (ZVI/ARD), and 6 (ISCO) are primarily injection programs with lower O&M costs.
- Alternative 2 (IWAS) has moderate O&M costs mainly associated with analytical testing, reporting, and maintaining and replacing equipment over an estimated 20-year system operational life span.
- Alternative 7 (ERH/Steam) has high O&M costs, primarily driven by electrical usage.

(3) Total Present Worth

- Alternatives 2 (IWAS), 3 (ARD), and 6 (ISCO) have the lowest total present worth costs.
- Alternatives 4 (nZVI/ZVI/ARD) and 5 (ZVI/ARD) have moderate total present worth costs because of the combined injection programs of bioamendments and a variant of ZVI.

- Alternative 7 (ERH/Steam) has the highest total present worth cost mainly due to capital (e.g., number of electrodes and depths required to heat), O&M costs for in-situ thermal treatment of the Source Area, and much higher closure costs.

H. State Acceptance

In a letter dated July 31, 2014 from ADEQ's Federal Projects Unit to EPA, ADEQ provides its support for the proposed Source Area remedy of in-situ treatment with ZVI, nZVI, ARD, and enhanced groundwater monitoring. A copy of this letter is included to this ROD Amendment as **Attachment 1**.

I. COMMUNITY ACCEPTANCE

During the public comment period, EPA received a number of comments from the community, most of which were supportive of EPA's preferred Alternative (Alternative #4). EPA received oral comments from members of the public who attended the February 5, 2014, public meeting, and the entire transcript of the public comments is included in the Administrative Record file for this ROD Amendment. EPA also received written comments from the community, including residents, property owners, and the Responsible Party. All of the comments, along with EPA's responses to them, are presented in Part III, Responsiveness Summary, of this ROD Amendment.

XI. PRINCIPAL THREAT WASTE

The NCP establishes an expectation that the EPA will use treatment to address the principal threats posed by a site wherever possible (NCP §300.430(a)(1)(iii)(A)). Highly toxic or highly mobile source materials that would present a significant risk to human health are generally classified as "principal threat wastes." Principal threat waste at the Site was addressed in the 1989 ROD. Although NAPL was likely present at the Site in the past based on the nature of the release and groundwater TCE concentrations well over 100,000 µg/L), there is no indication of remaining NAPL or mobile NAPL. There was no indication of NAPL in soil when drilling was conducted as part of the MDWSA Investigation, and current groundwater concentrations are not indicative of NAPL. The primary contamination at the Site is now in the dissolved phase contamination and is coming from the relatively slow release of dissolved TCE from less permeable geologic lenses and strata. Because EPA Region 9 found that no principal threat waste remains at the Site, principal threat waste was not given additional consideration in this ROD Amendment.

XII. SELECTED REMEDY

EPA, in conjunction with ADEQ, selects Alternative 4 (ZVI, nZVI, ARD, plus Hydraulic Barrier) to supplement the current Site remedy. Alternative 4 meets the threshold criteria and addresses the balancing and modifying criteria adequately. As discussed further in Part II, Section XIII, EPA expects the selected remedy to satisfy the following statutory requirements of

CERCLA §121(b): (1) be protective of human health and the environment; (2) comply with ARARs; (3) be cost-effective; (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (5) satisfy the preference for treatment as a principal element.

A. Summary of the Rationale for the Selected Remedy

EPA's selected remedy is Alternative 4: ZVI, nZVI, ARD, plus Hydraulic Barrier.

The selected remedy continues the use of the original remedy (groundwater extraction, treatment, and reinjection or reuse) with additional remediation of the Subunit A groundwater at the Source Area. Alternative 4 was selected because this alternative would protect human health and the environment and meet ARARs by relying on achieving suitable conditions within the in-situ treatment zone to degrade abiotically (nZVI and ZVI) and biologically (ARD) the COCs, notably TCE and perchlorate, in the Subunit A groundwater sufficiently to achieve the mass and concentration reduction RAOs of this ROD Amendment within a reasonable time frame. The RAOs and selected remedy focus on Subunit A groundwater in the Source Area, as described in Section VIII Remedial Action Objectives. In addition, the in-situ treatment to be used for the selected remedy will result in a large mass of highly reduced Subunit A groundwater suitable for the complete anaerobic reduction of TCE and perchlorate to innocuous end products. The downward hydraulic gradient that exists between Subunits A and B groundwater would likely promote downward groundwater migration, resulting in appropriate conditions to support biodegradation of TCE and perchlorate into the portions of Subunit B that may be vertical pathways for contaminated groundwater migration at the Source Area. Implementation of this remedy can be achieved with minimal Site disruption at the Source Area. In addition, the selected remedy, as described in **Table 5**:

- Achieves the RAOs in a reasonable time frame (approximately 8 years) and at a reasonable cost relative to the other alternatives;
- Minimizes the potential formation of undesirable degradation products, notably vinyl chloride;
- Applies a combination of proven in situ remediation technologies; and
- Has minimal impact on the operation and performance of the existing remedy.

B. Description of the Selected Remedy

The remedy will be designed with a phased injection program over a multi-year timeframe in order to allow for adaptation of the injections protocol based on prior injections. The initial phase would apply the in-situ treatment followed by an extensive evaluation of performance data that would provide findings and recommendations for development of later phases of in-situ treatment. This approach would be repeated for subsequent phases to enhance the performance of the in-situ treatment and achievement of the RAOs.

Presented in **Table 5** are descriptions of the components of the selected remedy.

TABLE 5: EPA's Selected Remedy for Subunit A Groundwater Remediation in the Source Area – ZVI, nZVI, ARD, plus Hydraulic Barrier

Remedy Description
Injection of ZVI, nZVI, and bioamendments to treat COC contamination in the Subunit A groundwater at the Source Area. Besides degrading the primary COCs (TCE and perchlorate), the resulting reducing conditions resulting from these injections will sustain contaminant degradation over time.
Two existing extraction wells (EA-03 and PZ-01; **Figure 3**) will provide a hydraulic barrier along West Van Buren Street. The effectiveness of this hydraulic barrier will be evaluated, and additional extraction and/or injection wells will be added as needed to establish hydraulic capture of Subunit A groundwater at West Van Buren Street.
The dose of nZVI will be based on the stoichiometric hydrogen demand of major electron acceptors, including target VOCs, sulfate, nitrate, and oxygen within a 35-foot radius of each injection point. The nZVI will be formulated with additives to enhance transport.
ZVI injections will occur between the area of highest COC concentrations and the hydraulic barrier. ZVI particles will increase the longevity of the chemical degradation process in the Source Area.
ARD enhancement will include injections for biostimulation (emulsified oil and necessary nutrients) and bioaugmentation (commercial microbial cultures) to establish conditions that degrade TCE and perchlorate to non-toxic end products.
Jet-assisted injection techniques will be used to deliver nZVI, ZVI, and bioamendments. The injection locations will be placed in a configuration that covers a majority of the Source Area with the number of lifts determined by the extent of impacted groundwater.
A treatability study and/or pilot testing may be performed as part of the remedial system design to evaluate and select the actual bioamendments, injection scheme, and other remedial design details. A Triad approach[1] will be used to determine the actual vertical placement of the injection lifts, details of the nZVI, ZVI, and bioamendments injections, and other aspects of the remedy design, implementation, and optimization.
Source Area Characteristics
• COCs are TCE and perchlorate. The treatment area is defined by TCE concentrations greater than 1,000 µg/L • Source Area treatment is focused on the saturated portion of the Subunit A aquifer. • The Source Area is approximately 250 feet wide and 700 feet long. • Depth to groundwater is 90 feet below ground surface (bgs). • The targeted vertical treatment interval is 60 feet thick (from 90 to 150 feet bgs).

1 The Triad approach uses (1) systematic project planning, (2) dynamic work strategies, and (3) real-time measurement technologies to make project decisions regarding contaminant presence, fate, and risk reduction, thereby reducing decision uncertainty and increase project efficiency (EPA, 2010. *Best Management Practices: Use of Systematic Project Planning Under a Triad Approach for Site Assessment and Cleanup*. EPA 542-F-10-010. September.

Actual implementation of the remedy will include a long-term monitoring program that will continue until the RAOs have been achieved. The current monitoring program for the groundwater remedy will be enhanced to verify the performance of the remedy, which will encompass in situ treatment by ZVI, nZVI, and ARD, as well as Subunit A groundwater capture by the hydraulic barrier and subsequent treatment at MTS and reinjection/reuse of the treated water. The enhanced monitoring program will include establishing multiple lines of evidence to verify the remedy performance, with the lines of evidence including, but not limited to, geochemical analyses, microbial analyses (including verification of an active and growing population of contaminant-degrading microorganisms and the ability of these organisms to produce enzymes necessary for the degradation pathways to ensure complete degradation of TCE to non-toxic end-products), and other parameters to be identified in an updated Sampling and Analysis Plan approved by EPA for the selected remedy. Groundwater modeling also will be used to assess both the effectiveness of the hydraulic barrier and the transport impact of injections on the COCs.

The current land use will not be affected by the selected remedy for the area associated with the remedy's implementation.

C. Summary of Estimated Remedy Costs

Table C-1 from the SARFFS Screening Results Summary compared the engineering cost estimates for all alternatives. From that estimate, the -30% to +50% Contingency Total Cost for Alternative 4 was estimated to be $8,490,000 to $18,200,00. While this represents a wide range in estimated costs, the actual costs are expected to vary considerably as field work, based on the Triad approach, progresses and actual field conditions have to be assessed to accomplish construction of the remedy enhancement.

D. Expected Outcomes of Selected Remedy

The expected outcome of the selected remedy is the acceleration of the Source Area remediation to achieve the maximum reduction of COC mass/mass flux and concentrations in a relatively short time frame. By achieving reductions of 80 percent or more in COC mass and concentration, the Subunit A groundwater plume should stabilize and start to shrink. The COC mass and concentration reductions at the Source Area will contribute to reaching the cleanup goals established in the original ROD in a reasonable time frame.

XIII. STATUTORY DETERMINATIONS

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that achieve adequate protection of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that, during the implementation and upon completion of, the selected remedial action must comply with applicable or relevant and appropriate environmental standards established under federal and State environmental laws unless a waiver is justified.

The selected remedy must also be cost-effective and utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following section discusses how the selected remedy addresses these statutory requirements and preferences.

A. Protection of Human Health and the Environment

The baseline risk assessment included in the 1989 ROD for the PGA-North Area identified and assessed three potential human exposure pathways to the PGA-North Area groundwater through ingestion, inhalation, and dermal contact. Relative to remediation of source area groundwater, completion of these exposure pathways is not possible because the Source Area is wholly located on the Site, in Subunit A to the south of Van Buren Street. In addition, a subsurface-to-indoor-air exposure pathway was considered for the Site. However, indoor air sampling has been conducted, and no significant risk was identified. In general, the conclusions associated with the 2012 HHRA were consistent with the finding of the BHHRA from the ROD and the indoor sampling results.

- Source Area groundwater is being actively remediated and the baseline evaluation of this hypothetical worst-case exposure scenario suggests that on-site groundwater is not currently suitable for use as tap water.
- Predicted exposures to volatile chemicals in indoor air of future buildings, using data collected from 2007 to 2011, are within or below the acceptable risk range and below the acceptable hazard index for future indoor commercial/industrial workers. This indicates that the SVE system has been successful at reducing potential health risks (predicted risk and hazard indexes) in source areas.

Predicted exposure to soil is below the de minimis risk level or within the acceptable risk range for potential trespassers, future construction workers, and future outdoor commercial/industrial workers.

Conditions at the PGA-North Area do not represent a potential for ecological risk.

The enhanced source area remedy will expedite the source area remediation and shorten the overall cleanup time for the Site thereby decreasing the potential for risks to human health and the environment.

B. Compliance with ARARs

Remedial actions selected under CERCLA must comply with all ARARs under federal environmental laws or, where more stringent than the federal requirements, State environmental or facility siting laws. Where a State has delegated authority to enforce a federal statute, such as RCRA, the delegated portions of the statute are considered to be a Federal ARAR unless the State law is broader or more stringent that the federal law. ARARs are identified on a site-specific basis from information about site-specific chemicals, specific actions that are being considered, and specific features of the site location. There are three categories of ARARs: (1) chemical-specific requirements; (2) action-specific requirements; and (3) location-specific requirements.

Chemical-specific ARARs are promulgated standards or risk-based cleanup standards or methodologies which, when applied to site-specific conditions, provide the basis for cleanup standards for COCs.

Location-specific ARARs are restrictions placed on the conduct of activities due to the location of the actions, which may have important geographical, biological, or cultural features or requirements. Examples of special locations include wetlands, flood plains, sensitive ecosystems, seismic areas, and runways.

Action-specific ARARs are technology-based or activity-based requirements or limitations on remedial activities. They are triggered by the particular remedial activities selected to accomplish a remedy.

The selected remedy will comply with all ARARs.

C. Cost Effectiveness

In making this determination, EPA used the following definition: “A remedy shall be cost-effective if its costs are proportional to its overall effectiveness.” (NCP Section 300.430(f)(1)(ii)(D)). EPA evaluated the “overall effectiveness” of those alternatives that satisfied the threshold criteria (i.e., the alternatives are both protective of human health and the environment and are ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination, and then overall effectiveness was compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of remedial Alternative 4 was determined to be proportional to its costs and hence this alternative was determined to be cost-effective.

D. Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at PGA-North Area. Of those alternatives that are protective of human health and the environment and comply with ARARs, the EPA has determined that Alternative 4 provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and considering state and community acceptance.

E. Preference for Treatment as a Principal Element

The selected remedy includes active treatment as a principal element. The additional expense of actively treating the Source Area groundwater by continuing the use of the original remedy (groundwater extraction, treatment, and reinjection or reuse) with additional remediation of the Subunit A groundwater at the Source Area will provide protection of human health and the environment and will remediate Site contaminants in a shorter timeframe.

F. Five-Year Review Requirements

The next review will be conducted in 2015, five years after the completion of the second Five-Year Review Report.

XIV. DOCUMENTATION OF SIGNIFICANT CHANGES

EPA has not made any changes to the amended remedy as a result of comments received during the comment period. The Responsiveness Summary includes a summary of comments received and EPA's response to these comments.

PART III: RESPONSIVENESS SUMMARY

This Responsiveness Summary provides EPA's response to written and oral comments received from the public and governmental agencies on EPA's February 2014 Proposed Plan for the Phoenix-Goodyear Airport Superfund Site ROD Amendment.

On January 21, 2014 an announcement was mailed to over 10,000 residents of the cities of Goodyear, Avondale and Litchfield Park, Arizona which explained the posting of the Proposed Plan on EPA's website, stated the url where the document could be found and gave the date, time and location for EPA's public meeting to present the Proposed Plan. That same day, the Proposed Plan was also distributed to EPA's Record Center and to the Goodyear Library (Van Buren Ave branch). On February 5, 2014, EPA held a public meeting at Estrella Mountain Community College in Avondale, AZ to present the proposed remedy amendment and to record verbal comments. At the meeting, there were three commenters. In addition to the public meeting, there was a 30-day comment period from January 23 to February 24, 2014. During the public comment period EPA received comments from 13 different commenters, including the Cities of Goodyear, Avondale and Litchfield Park as well as the Western Avenue Water Quality Assurance Revolving Fund (WQARF) Site Community advisory Group (CAG). A transcript of the public meeting and copies of the written comments are included in the Administrative Record for this ROD Amendment and is available at the repositories for the Site.

In general, the comments received during the public comment period show that the public supports EPA's efforts to clean up ground water contamination in the Main Drywells Source Area at PGA North. At the same time, there is concern that the enhanced remedy be safe and effective and that EPA remains vigilant in monitoring the existing remedy to ensure containment. The comments can be separated into two categories: comments about the preferred alternative and comments requesting other technical information.

COMMENTS ON EPA'S PREFERRED ALTERNATIVE

1) **Comment:** Several commenters expressed concern about possible mobilization of secondary contaminants and therefore recommended that the hydraulic barrier along Van Buren should be maintained and enhanced.

EPA Response: Due to the risk that the enhanced remedy may mobilize secondary contaminants, EPA has included the enhancement of the hydraulic barrier along Van Buren Avenue north of the Main Drywells Source Area as part of taking this action. Additionally, the current treatment system does not treat arsenic - one element which could be mobilized by treatment. Downgradient monitoring will include sampling for all elements which could be mobilized by the treatment.

2) **Comment**: Several commenters expressed concern that EPA continue operating an adequate monitoring network downgradient of the enhanced treatment.

EPA Response: EPA agrees on the importance of monitoring as this treatment is implemented and will require a sufficient number of monitoring wells as part of the Remedial Design/Remedial Action (RD/RA) Work Plan.

3) **Comment:** One commenter suggested monitoring mass flux to assess whether the enhanced treatment meets EPA's objectives.

EPA Response: In selecting the enhanced remedy, EPA included additional RAOs to specifically address mass reduction in the Source Area. Downgradient monitoring will include high resolution groundwater monitoring, integral pumping tests and groundwater flow and transport model simulations to evaluate mass flux as treatment proceeds.

4) Comment: Several commenters expressed concern that EPA verify the effectiveness of injection, including that EPA ensure injected treatment materials reach the highest mass zones.

EPA Response: Drilling logs for numerous recent monitoring wells have given us a better understanding of where in the subsurface Source Area contamination exists. Additional soil borings in the Source Area are being drilled now to add to our understanding and will help us determine where to inject treatment materials to maximize contact with the contamination. The drilling logs generated when the treatment monitoring and injection wells are drilled will also add to our understanding of where the contamination exists. Geophysical technologies such as electrical resistivity imaging and magnetic susceptibility, and confirmation soil boring after injection will provide critical information for the actual treatment substrate distribution in the field.

5) Comment: One commenter inquired as to how EPA would adjust the plan if the enhanced treatment does not perform as expected.

EPA Response: In order to accomplish the remedy enhancement, EPA will require an RD/RA Work Plan which will clearly state how the action will be accomplished. The work plan will include performance measures to assess whether the treatment results are operating as expected and are meeting RAOs. The triad approach will be adopted in the implementation of the RD/RA Work Plan, so that based on the field conditions encountered and monitoring results, the plan can be adjusted accordingly. In addition, the RD/RA will be implemented in a phased approach, with remediation performance evaluations to be conducted in each phase.

6) Comment: One commenter asked how EPA plans to communicate various stages of the Source Area treatment to the public.

EPA Response: EPA will continue to make Site-related documents available on our website, at the local repository, and at our Records Center. In addition, EPA will issue periodic Fact Sheets to describe work progress. The first of the Fact Sheets will include a timeline based on the RD/RA Work Plan. EPA will also continue to hold an annual Open House to communicate work accomplishments. In addition, EPA will continue to seek opportunities to meet with residents to provide progress reports as the enhanced treatment proceeds.

7) Comment: One commenter expressed concern about the continuing safety of existing potable wells.

EPA Response: The extraction and treatment remedy for groundwater at PGA North and South, including the injection of treated water into the subsurface, has the effect of preventing the movement of the contamination plume toward production wells in the vicinity. In addition, EPA requires the sampling of production wells to ensure that contamination from the Site does not reach production wells. Sampling of the existing monitoring well network will also ensure that the plume is contained and contamination does not reach production wells.

8) **Comment:** One commenter inquired about PGA South Area and why it is not included in this ROD Amendment.

EPA Response: This ROD Amendment applies to PGA Superfund Site North Area only because it is the PGA-North Source Area where the high TCE contamination remains and there is perchlorate contamination that is not being addressed in situ. At PGA South, the pump-and-treat and SVE remedies have greatly reduced the concentrations of contaminants such that there is no high-concentration source area remaining at the PGA-South Area.

COMMENTS REQUESTING OTHER TECHNICAL INFORMATION

9) **Comment:** Several commenters requested more technical information about the technologies that will be employed with the selected treatment alternative.

EPA Response: The technical references cited in both the Focused Feasibility Study and the Proposed Plan are included in the Administrative Record for this ROD Amendment. All Site-related documents are available at the City of Goodyear Public Library and at the EPA Region 9 Records Center, located at 95 Hawthorne Street, San Francisco, California.

ATTACHMENT 1

PGAN – ADEQ LETTER OF SUPPORT FOR THE DRAFT RECORD OF DECISION (ROD) AMENDMENT – NORTH SUPERFUND SITE LOCATED IN GOODYEAR, ARIZONA

Janice K. Brewer
Governor

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

1110 West Washington Street • Phoenix, Arizona 85007
(602) 771-2300 • www.azdeq.gov

Henry R. Darwin
Director

VIA EMAIL

July 31, 2014
FPU 15-013

Catherine Brown
Superfund Remedial Project Manager
US Environmental Protection Agency
75 Hawthorne Street (SFD-6-2)
San Francisco, CA 94105

RE: PGAN –ADEQ Letter of Support for the Draft Record of Decision (ROD) Amendment– North Superfund Site located in Goodyear, Arizona

Dear Ms. Brown:

The Arizona Department of Environmental Quality's Federal Projects Unit has reviewed the Draft ROD Amendment - North Superfund Site. The ROD amendment will modify the current groundwater remedy to include in-situ injection with zero-valent iron (ZVI), nano-scale (nZVI), anaerobic reductive dechlorination (ARD) (with biostimulation and bioaugmentation), and enhanced groundwater monitoring. This amendment is designed to address the persisting source area contamination in subunit A. ADEQ supports the proposed draft amendment for PGAN.

If you have any questions regarding this correspondence, please contact me at (602) 771-6801.

Sincerely,

Patrick Shinabery
Federal Project Unit
Remedial Projects Section
Waste Programs Division

cc:
Michael Long, Hargis (electronic)
Lawrence Phillips, ITSI Gilbane (electronic)

ATTACHMENT 2

PGAN – LIST OF ACRONYMS AND ABBREVIATIONS

List of Acronyms and Abbreviations

µg/L	Micrograms per Liter
AAC	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
APP	Aquifer Protection Permit
ARD	Anaerobic Reductive Dechlorination
ARARs	Applicable and Relevant and Appropriate Requirements
ARS	Arizona Revised Statutes
ATSDR	Agency for Toxic Substances and Disease Registry
AWQS	Aquifer Water Quality Standards
BHHRA	Baseline Human Health Risk Assessment
CAG	Community Advisory Group
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COG	City of Goodyear
COPEC	Contaminant of Potential ecological Concern

Crane Co.	Crane Company
CSM	Conceptual Site Model
CWA	Clean Water Act
DCE	1,1-Dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquid
EE/CA	Engineering Evaluation and Cost Analysis
EPA	US Environmental Protection Agency
ERH	Electrical-Resistive Heating
ESD	Explanation of Significant Difference
FS	Feasibility Study
HBGL	Health-Based Guidance Level
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
I-10	Interstate 10
ID	Identification
ISCO	In-Situ Chemical Oxidation
IWAS	In-Well Air Stripping
LAU	Lower Alluvial Unit
LGAC	Liquid-Phase Granulated Activated Carbon
LPSCO	Litchfield Park Service Company
MAU	Middle Alluvial Unit
MCL	Maximum Contaminant Level
MDWSA	Main Drywell Source Area

MEK	Methyl Ethyl Ketone
MTS	Main Treatment System
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHPA	National Historic Preservation Act
No.	Number
NPL	National Priorities List
NRC	National Research Council
nZVI	Nano-Scale Zero-Valent Iron
Pacific Scientific	Pacific Scientific Energy Dynamics
PCE	Tetrachloroethene
PGA	Phoenix-Goodyear Airport
PPB	Parts Per Billion
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
RID	Roosevelt Irrigation District
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SARFFS	Source Area Remediation Focused Feasibility Study
SDWA	Safe Drinking Water Act

SLERA	Screening Level Ecological Risk Assessment
Source Area	Main Drywells Source Area
SRL	Soil Remediation Level
SRV	Salt River Valley
SVE	Soil Vapor Extraction
TBC	To Be Considered
TCE	Trichloroethylene
UAO	Unilateral Administrative Order
UAU	Upper Alluvial Unit
UMC	Universal Match Corporation
UPI	Unidynamics-Phoenix, Incorporated
USC	United States Congress
VOC	Volatile Organic Compound
WQARF	Water Quality Assurance Revolving Fund
WQC	Water Quality Criteria
WSRV	West Salt River Valley
WWTP	Waste Water Treatment Plant
ZVI	Zero-Valent Iron

ATTACHMENT 3

PGAN – GLOSSARY

Glossary

Aquifer: An underground layer of soil, sand or gravel that can store and supply groundwater for wells and springs.

Aquitard: A barrier to the flow of groundwater in an aquifer.

Autotrophic: Organisms that derive carbon for the manufacture of cell mass from inorganic carbon (carbon dioxide).

Bioaugmentation: Addition of microbes to a given native population to increase their numbers as their potential to change contaminants into harmless gases like carbon dioxide and ethene to augment a remediation.

Bioremediation: The use of microbes to clean up contaminated soil and groundwater to eat and digest contaminants, usually changing them into small amounts of water and harmless gases like carbon dioxide and ethene.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as Superfund). This law, enacted by Congress on December 11, 1980, created the Superfund program which (1) established prohibitions and requirements concerning closed and abandoned hazardous waste sites, (2) provided for liability of persons responsible for releases of hazardous waste at these sites, and (3) established a trust fund to provide for cleanup when no responsible party could be identified.

Cleanup: The term used for actions taken to deal with a release or threat of release of a hazardous substance that could affect human health and/or the environment. The term is sometimes used interchangeably with the terms remedial action, removal action, response action, or corrective action.

Contaminant of concern (COC): Chemicals that exceed regulatory limits which have been linked to previous activities at the Site and may pose a significant risk to human health and the environment.

Feasibility Study: A study that evaluates options to clean up environmental contamination at a Superfund site.

Groundwater: The supply of fresh water found below the ground surface, usually in an aquifer.

Hydraulic barrier: A general term referring to modifications of a groundwater flow system to restrict or impede movement of contaminants.

Information repository: A location accessible to community members (such as a local library) that houses documents, reports and other Site-related information

National Priorities List (NPL): EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under the Superfund program. The NPL, which EPA is required to update at least once a year, is based primarily on the score a site receives from EPA's Hazard Ranking System.

Oxidation: When a compound loses electrons in a chemical reaction, it is said that oxidation has occurred. See also redox.

Oxidizing agent: The chemical, compound, or ion in a chemical equation which causes another secondary chemical, compound, or ion in the same equation to lose electrons and become more negatively charged than at the start of the reaction. See also redox.

Perchlorate (ClO4): Perchlorate is both a naturally occurring and man-made chemical that is used to produce rocket fuel, fireworks, flares and explosives. Perchlorate can also be present in bleach and in some fertilizers. Perchlorates have been found in at least 49 of the 1,581 current or former NPL sites.

Plume: A defined area of contamination in groundwater, soil or the air; often used to describe the dispersion of contamination in soil and/or groundwater.

Record of Decision (ROD): The primary legal document at a site, which sets forth EPA's selected remedy as well as the factors that led to its selection.

Redox: Since reduction and oxidation happen in the same reaction, this is known as a redox reaction. An example of a redox reaction is shown below:

The reducing agent (elemental magnesium or Mg) reduces the copper (II) ions (Cu2+) by giving the Cu2+ two negatively charged particles called electrons to create elemental copper or Cu. At the same time, the copper (II) ion (Cu2+) acts as the oxidizing agent when it oxidizes or removes electrons from the magnesium (Mg), a neutral element, to create magnesium ions (Mg2+), positively charged ions. Thus, the Cu2+ removed electrons from Mg to create Mg2+, and Mg gave electrons to Cu2+ to create Cu.

Reducing agent: The chemical, compound, or ion in a chemical equation which causes another secondary chemical, compound, or ion in the same equation to gain electrons and become more positively charged than at the start of the reaction. See also redox.

Reduction: When a compound undergoes the gain of electrons in a chemical reaction, it is said that reduction has occurred. See also redox.

Reductive dechlorination: Degradation of chlorinated organic compounds (including TCE) by chemical reduction (See reduction) with release of inorganic chloride ions which are less toxic as ions than as part of a chlorinated compound.

Remedial Action Objectives: Cleanup objectives that specify the level of cleanup, area of cleanup (area of attainment), and time required to achieve cleanup (restoration time frame).

Remedial Investigation: An in-depth study to determine the nature and extent of contamination at a Superfund site.

Remediation: Cleanup or other methods used to remove or contain a toxic spill or hazardous materials.

Remedy: A long-term action that stops or substantially reduces a release or threat of a release of hazardous substances.

Superfund: The common name for the EPA program established by CERCLA to investigate and clean up abandoned or uncontrolled hazardous waste sites [see "Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)" above]

Trichloroethene (trichloroethylene): A colorless liquid which is used as a solvent for cleaning metal parts.

Volatile Organic Compounds (VOCs): A large group of carbon-containing compounds that are easily dissolved into water, soil, or the atmosphere and evaporate readily at room temperature. These contaminants typically are generated from metal degreasing, printed circuit board cleaning, gasoline, and wood preserving processes. Examples of VOCs include tetrachloroethene and trichloroethene.