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26 June 2023
File No. 134659-004

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

Attention: Jennifer Widlowski
Project Manager
Voluntary Remediation Program

Subject: Revised Final In-Situ Remedial Work Plan
SRP Crosscut Facility
1100 North Project Drive, Tempe, Arizona
ADEQ VRP Identification Number: 070280-00

Dear Ms. Widlowski:

Haley & Aldrich, Inc. (Haley & Aldrich), on behalf of Salt River Project (SRP), is pleased to submit this *Revised Final In-Situ Remedial Work Plan* (Final Work Plan) to the Arizona Department of Environmental Quality (ADEQ) for the Crosscut Facility located at 1100 North Project Drive in Tempe, Arizona (Site). As discussed in our 9 August 2022 meeting with SRP, Haley & Aldrich, and ADEQ, an in-situ remedial program will be performed to address the dissolved-phase tetrachloroethylene (PCE), trichloroethene (TCE), and associated daughter products, as well as low-level 1,4-dioxane concentrations, in groundwater within the former source area, in the vicinity of monitoring wells SVE-5 and XC-2R (Figures 1 through 3). This Final Work Plan has been updated to include the recommendations in the ADEQ Voluntary Remediation Program's (VRP) letter dated 27 January 2023 and an updated Community Involvement Section and inclusion of a Responsiveness Summary Section per VRP's email dated 13 June 2023.

Background

The Site history, geology, hydrogeology, previous investigations, source area, and remedial work are described in detail in the 12 June 2020 *Site Conceptual Model Technical Memorandum* (Tech Memo) prepared by Haley & Aldrich.

The SRP Crosscut Facility is located at 1100 North Project Drive in Tempe, Arizona (Figure 1). The SRP, known as the Salt River Valley Water Users' Association at the time, started construction of the Crosscut hydroelectric power plant in 1913, with electricity first produced at the end of 1914 using water from the Crosscut Canal. The generating facility has been operated by diesel and steam engines, constructed in 1938 and 1941, respectively. A broken transformer forced SRP to shut the plant down in 2013 and power generation has not resumed. The Crosscut Site historically and currently houses power construction and maintenance services and equipment as well as warehousing, salvage, an environmental laboratory, multiple field services groups, and vehicle maintenance.

Figure 2 shows relevant hydrologic features such as a series of interconnected ponds that receive water off the Crosscut Canal and flow through Papago Park and the Phoenix Zoo to the Crosscut Facility. Also shown are the Crosscut Canal, Grand Canal, various golf courses (potential groundwater recharge sources from irrigation), Tempe Town Lake, and the Salt River.

A wastewater sump was located adjacent to the Transformer Shop at the Power Construction and Maintenance (C & M) Building. Installed in 1972 during construction of the Power C & M Building, the dead-end sump was a 1,500-gallon, pre-cast concrete tank used to collect wash water from equipment steam cleaning activities.

In September 1989, SRP field construction crews were excavating a trench on the northwest side of the sump to install piping that would connect the sump to the facility wastewater system. During excavation, the crew observed oil-stained soil in the trench approximately 4 feet from the northwest side of the sump. Upon inspection, SRP determined that the soil contamination originated from a poorly-sealed joint where the upper concrete slab of the sump connected to the concrete manhole riser pipe.

As discussed in the Tech Memo, the sump was the source area for the chlorinated volatile organic compound (CVOC)-impacted soil and groundwater in the vicinity of the sump; the sump and surrounding soils were removed in 1990. The primary constituents of concern (COC) are:

- PCE, TCE, and its daughter products cis-1,2-dichloroethylene (DCE), trans-1,2-DCE, and vinyl chloride;
- 1,1,1-trichloroethane (1,1,1-TCA) and its daughter products 1,1-DCE, 1,1-dichloroethane (DCA), and 1,2-DCA; and
- To a lesser extent, 1,4-dioxane.

The depth to the water table is approximately 25 feet below ground surface (bgs).

Proposed Remedial Scope of Work

The purpose of the remedial scope of work is to present the components, method of implementation, monitoring and sampling protocols, and reporting requirements of the remedial program for groundwater at the Site. The remedial program will use in-situ chemical oxidation (ISCO) to introduce specific alkaline-activated sodium persulfate in two vertical treatment zones within the source area groundwater using bedrock injection wells. The program will include the following components.

- Focused ISCO application in the vicinity of source area groundwater monitoring wells SVE-5 and XC-2R (Figure 3);

- Sampling of select monitoring wells following completion of the ISCO application to monitor the effects on the PCE, TCE, daughter products, and 1,4-dioxine concentrations;
- Focused, enhanced in-situ bioremediation (EISB) application in the vicinity of monitoring wells SVE-5 and XC-2R, if needed based on the ISCO results;
- Identification of measurable remedy "factors of success";
- Reporting of the results; and,
- Estimated schedule.

ISCO Injection and Monitoring

The following presents a description of the proposed ISCO injection and post-ISCO monitoring and reporting activities, followed by EISB if necessary, based on the ISCO results. Alkaline-activated persulfate was selected as the ISCO amendment due to its soluble nature and its reactivity with the COCs, allowing it to quickly address dissolved-phase concentrations. EISB with sodium lactate and an anaerobic bioaugmentation culture was selected to follow ISCO, if needed, to create an environment conducive to monitored natural attenuation (MNA), creating a long-lasting reductive environment. Two vertical zones will be targeted: (1) 25 to 40 feet bgs (uppermost groundwater) and (2) 60 to 100 feet bgs.[1]

PHASED REMEDIATION APPROACH

A phased remedial approach is proposed with an initial ISCO program transitioning to EISB, if needed, following the exhaustion of the ISCO amendment. The remediation will target the elevated COC concentrations in the vicinity of monitoring wells XC-2R and SVE-5, as shown in Figure 3. Due to the low-level concentrations of 1,4-dioxane present in the treatment area, an ISCO approach followed by an EISB approach is proposed. While 1,4-dioxane does not biodegrade anaerobically, it is able to be oxidized via activated sodium persulfate. Therefore, while 1,4-dioxane is not the remediation driver, it was considered during the remedial design process.

As noted, the injection program will focus on two treatment zones in the vicinity of monitoring wells SVE-5 and XC-2R: (1) uppermost groundwater (25 to 40 feet bgs) and (2) groundwater present from approximately 60 to 100 feet bgs. Injection wells will be installed prior to remediation, and approximate locations are shown on Figure 3; the proposed locations may change based on Site conditions.

The injection wells shown on Figure 3 will be installed using air rotary methods as described below. At each injection location, the uppermost groundwater injection well will be completed to a depth of 40 feet bgs; the other injection well will be completed from 60 to 100 feet bgs. Each injection well will

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[1] The gap between the bottom of the upper (40 feet bgs) and top of the lower (60 feet bgs) vertical treatment zones was chosen to minimize the potential for short circuiting of ISCO during injection and prevent short circuiting of impacted uppermost groundwater within the paired injection wells over time. We assume that the ISCO injection in the upper injection well will likely travel some distance vertically to help cover this gap in vertical treatment zones.

be completed as an open hole with a steel surface casing grouted in place. The proposed injection well construction diagrams are provided in Figure 4.

A clean water injection test will be conducted prior to the ISCO injection event to determine the pressures, flow rates, and approximate time that will be required to emplace the remediation amendments into the subsurface.[2]

Well Drilling

Prior to field work, the following pre-mobilization activities will be completed:

- Review the Site-specific Health and Safety Plan to ensure the proposed work will be conducted accordingly;
- Conduct a Site visit to evaluate final access and other logistical issues, and identify and stake/mark-out the proposed drilling locations;
- Secure subcontractor agreements and schedules;
- Prepare and submit Arizona Department of Water Resources (ADWR) Notice of Intent permits and procure necessary signatures;
- Contact Arizona 811 to locate public utilities at least two full business days prior to drilling; and
- Provide appropriate advanced notice to the ADEQ.

The injection wells will be drilled and constructed by an ADWR-licensed drilling contractor with experience using the air rotary drilling method. For the uppermost groundwater injection well, a nominal 8-inch borehole will be drilled to 10 feet bgs (top of bedrock), and a nominal 5.5-inch, flush-threaded, steel surface casing will be installed and grouted with neat cement grout to surface. Once the grout is cured, a nominal 4.5-inch diameter borehole will be advanced to total depth of approximately 40 feet bgs. For the deeper injection well, the steel surface casing will be installed to 60 feet bgs, and a nominal 4.5-inch diameter borehole will be advanced to total depth of approximately 100 feet bgs. Drill cuttings will be collected and described by an experienced geologist during drilling. Other data to be collected include changes in penetration rates, water losses and/or additions, water production, and other events deemed pertinent to the characterization of the lithology and groundwater. The well construction diagrams are included as Figure 4.

ISCO EVENT

The ISCO injection event will include the mixing of the base, sodium hydroxide, and sodium persulfate as an up to 25 percent sodium persulfate solution with a 2 to 1 ratio of oxidant to base and its injection through the selected wells via minimal pressure. The injection will occur by using a single packer to isolate the vertical treatment zone in each of the wells and allow for the connection of injection hoses and pressure gauges to emplace the ISCO amendment.

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[2] This will consist of using potable water to fill the injection well and measuring the time it takes for the water level to return to static conditions.

Using stoichiometric demand, an estimated porosity of 7 percent, and anticipated radius of influence of 25 feet, the following amounts are proposed to emplace in the subsurface:

Treatment Area	Concentration (µg/L)			Depth	Assumed ROI	Proposed Injection Volume
	PCE	TCE	cis-1,2-DCE			
SVE-5 (25 – 40 feet bgs)	16.2	167	1,290	25 to 40 feet	25 feet	3,000 gal
XC-2R (60 – 100 feet bgs)	13	116	301	60 to 100 feet	25 feet	7,500 gal

Notes:
Concentrations from the September 2022 monitoring event are used (see Figure 3).
µg/L = micrograms per liter
bgs = below ground surface
cis-1,2-DCE = cis-1,2-dichloroethene
gal = gallons PCE = tetrachloroethylene
ROI = radius of influence
TCE = trichloroethene

Following the ISCO application, approximately 50 gallons of potable water will be used to flush each well and allow for additional distribution of amendment into the formation.

EISB EVENT

If further enhancement is required, the EISB injection event will occur following the exhaustion of the ISCO amendment. The EISB event will include the dilution of an electron donor, such as sodium lactate, in water with an anaerobic bioaugmentation culture injected into the previously installed injection wells. A 5 to 10 percent sodium lactate solution would be injected in the subsurface with approximately 1 to 2 liters (L) of a bioaugmentation culture such as SDC-9 or KB-1. Like the ISCO event, the EISB injection will occur by using a single packer to isolate the vertical treatment zone in each of the injection wells and allow for the connection of injection hoses and pressure gauges to emplace the EISB amendment.

Using a target application rate of 5 grams fermentable electron donor per liter of groundwater, estimated porosity of 7 percent and anticipated radius of influence of 25 feet, the following amounts are proposed to emplace in the subsurface: 1,000 gallons of a 5 to 10 percent electron donor and bioaugmentation culture solution in the 25 to 40 feet treatment zone and 2,500 gallons in the 60 to 100 feet treatment zone.

Following the EISB application, approximately 25 to 50 gallons of potable water will be used to flush each of the wells and allow for additional distribution of amendment into the formation. The final amounts of amendment would be determined following the ISCO events.

POST-REMEDIATION MONITORING

The monitoring will be performed prior to and after the ISCO event to establish the baseline for comparison purposes and to evaluate the effect of the ISCO application on reducing the concentrations of PCE, TCE, associated daughter products, and 1,4-dioxane in nearby monitoring wells. The monitoring wells will be checked for ISCO amendment via field test kits or field parameters prior to sampling to determine if there is influence from the injection event. Quality control/quality assurance information is provided as an attachment to this Work Plan (Attachment A). Well construction details are provided in Table 1.

The ISCO monitoring will include groundwater monitoring in monitoring wells SVE-5, XC-2R, XC-9, XC-18, and XC-20 (see Figure 3) pre-injection (baseline) and at 3 months, 6 months, and 9 months following the application for:

- Volatile organic compounds (VOC);
- Sulfate;
- Total and dissolved iron;
- Dissolved gases included carbon dioxide, methane, ethene, and ethane;
- Chloride; and
- Sodium.

If EISB is conducted following the ISCO event, total organic carbon (TOC) and microbial testing as a baseline of natural attenuation parameters will be added to the analyses, and carbon dioxide will be removed.

The groundwater sampling and analysis will be conducted using the same protocols conducted during routine groundwater monitoring events. Depth to groundwater will be measured in the groundwater monitor wells using a calibrated and decontaminated electric water level sounder. Depth to groundwater will be measured from the top of the well casing (north side) to the nearest 0.01 feet. A HydraSleeve® no-purge sample device will be installed within the well screen at approximately the mid-point of the saturated screened interval. For each sampled monitoring well, a water quality data instrument (YSI 556 MPS or equivalent) will be used to measure the field water quality parameters: pH, temperature, dissolved oxygen, oxidation-reduction potential, and specific electrical conductance.

Groundwater samples will be collected into the following laboratory-certified sample containers and analyzed for the following analytes using the designated testing methods (a summary of analytical methods, sample volumes and containers, holding times, and preservation is provided in Table 2):

Post-ISCO Groundwater Sampling Analyses

- VOCs using U.S. Environmental Protection Agency (USEPA) Test Method 8260B. Three 40-milliliter (mL) vials preserved with hydrochloric acid.
- 1,4-Dioxane using USEPA Test Method 8260B SIM. Three 40-mL vials preserved with hydrochloric acid.
- Sulfate using USEPA Test Method 9038. One 250-mL plastic bottle, no preservative.
- Total iron using test method SW 846 6020. One 250-mL plastic bottle preserved with nitric acid.
- Dissolved iron using test method SM3500 Fe-B. One 250-mL glass bottle, no preservative.
- Methane, ethene, and ethane using test method Modified RSK 175. Three clear 40-mL vials preserved with hydrochloric acid.
- TOC using SW846 Test Method 9060. Two amber 40-mL bottles bottle preserved with sulfuric acid *(following EISB).*
- Carbon dioxide using test method SM 4500. One 150-mL plastic bottle, no preservative *(only after ISCO).*
- Chloride using USEPA Test Method 9251. One 250-mL plastic vial, no preservative.
- Sodium using USEPA Test Method 200.7. One 250-mL plastic vial preserved with nitric acid.
- Shotgun Metagenomics. Two 1-liter amber glass bottle, no preservative *(prior to EISB/MNA, and following EISB).*

FACTORS OF SUCCESS – METRICS AND MILESTONES

The ISCO remedial event will be considered successful if downward trends of targeted compounds (PCE, TCE, and 1,4-dioxane) are observed for at least two quarters following the remedial event within the vicinity of monitoring wells SVE-5 and XC-2R. As noted, if necessary, based on the ISCO results, an additional event to emplace EISB reagents will be conducted following the ISCO amendment exhaustion. Initially following the remedial event, localized increases in VOC concentrations can occur from the desorption of VOCs from aquifer material and from the homogenization/mixing of the subsurface due to the injection process. However, it is anticipated that the concentrations will normalize with time following the ISCO allocation when equilibrium is reached in the subsurface, allowing for trend analysis.

The presence of ISCO amendment will be monitored via field test kits and following the exhaustion of the persulfate, an EISB event will be conducted if required. If concentrations decrease significantly in monitoring wells SVE-5 and XC-2R, however, EISB may not be conducted until concentrations warrant additional remediation. Metrics indicating that EISB is warranted include increasing VOC trends and/or geochemical conditions that are not supportive of natural attenuation. These conditions include strongly oxidizing and aerobic conditions in the subsurface, lack of daughter and/or end-product formation, and lack of microbial species capable of either reductive dechlorination or co-metabolic degradation of the contaminants of concern.

In addition to concentration decreases of PCE and TCE, influence of the ISCO application will be observed via the destruction of byproducts of the remedial event, and by "tracer" cations that are present in the ISCO amendments. The ISCO amendment includes the cation sodium; therefore, the concentration of sodium will be monitored within the injection treatment area as well as in the downgradient wells. The monitoring of sodium will provide an indication of the radius of influence of the ISCO application in groundwater.

Concentrations of PCE, TCE, and the intermediate/daughter products, and 1,4-dioxane will be monitored following the ISCO application as discussed above at 3, 6, and 9 months and compared to pre-remediation concentrations. In addition to PCE and TCE, the byproducts of the ISCO application will also be monitored via chloride concentrations, carbon dioxide concentrations, and dissolved gases (methane, ethene, and ethane). The increase in chloride, carbon dioxide, and dissolved gases will be evaluated regarding the efficacy of the ISCO application.

If EISB is conducted or a MNA approach following the ISCO application is chosen, in addition to CVOCs, the byproducts of the remedy will also be monitored via chloride concentrations, TOC, and dissolved gases (methane, ethene, and ethane). The increase in chloride, TOC, and dissolved gases will be evaluated regarding the efficacy of the EISB application or to evaluate the applicability of MNA.

Contingency plans for the initial ISCO event include a clean water test prior to injection, different implementation techniques (if there are issues with injection), and for MNA, the implementation of EISB activities. The clean water test allows for the evaluation of injection pressures and flow rates needed prior to amendment delivery so that additional injection techniques can be evaluated. If there are concerns with pressures or flow rates needed to inject, e.g., pressures too high or flow rates too low, different injection processes will be evaluated. These include but are not limited to, use of straddle packers to target fractures, use of low-flow, low-volume injection techniques, or increasing of sodium persulfate solution concentration to decrease volumes required.

For EISB, if concentrations increase prior to the exhaustion of the sodium persulfate in the monitoring wells, EISB will not be conducted until the active persulfate is depleted. This may take up to 6 months to occur and will be monitored via persulfate test kits. Approximately 9 to12 months following the ISCO, EISB would be conducted. The final design of the EISB will rely on a "baseline" monitoring event that will evaluate the microbial populations present in the subsurface, as well as MNA parameters that provide information on the geochemical conditions. The microbial populations will also allow for the evaluation of bioaugmentation to determine if it is necessary for the final remedy. Final EISB amendment amounts and concentration will be provided to VRP prior to implementing the remedy and will contain the amendments and their associated safety data sheets.

PERMITTING

No explicit permitting is required for the injection of the ISCO amendments at the Site due to the exception for permit requirements detailed in Title 49-290 – Exemption from Permit Requirements:
A. Notwithstanding any other statute, a person who performs a remedial action or a portion of a remedial action that has been approved by the department if that action or portion is conducted in

compliance with this article is not subject to any requirement to obtain any permit or approval that may otherwise be required by the department. Potable water will be obtained from the Site and will not require a permit.

COMMUNITY INVOLVEMENT

A Notice to the Public announcing the availability of the Remedial Action Plan (RAP) on ADEQ's website at www.azdeq.gov was issued for a 30-day public comment period on 12 May 2023. A copy of the notice was mailed to the stakeholders for the Site and any other interested parties. ADEQ accepted written comments on the RAP that were postmarked within the comment period and submitted to:

Arizona Department of Environmental Quality
Attention: Jennifer Widlowski
1110 Washington Street
Phoenix, Arizona 85007
Email: widlowski.jennifer@azdeq.gov

RESPONSIVENESS SUMMARY

The RAP was released for public comment during a 30-day comment period that ran from 12 May 2023 through 12 June 2023. ADEQ received one written comment from the City of Tempe. The comment and ADEQ's response are included in the Responsiveness Summary that is included as Attachment B. SRP has agreed to provide copies of future site characterization, monitoring, and/or closure reports to the City of Tempe.

REPORTING

Haley & Aldrich will report the results of the ISCO application and monitoring activities via summary emails following each sampling event, and in an annual comprehensive report. The emails will include tabulated data on the volume of sodium persulfate delivered to each well, as well as the field and laboratory concentrations of monitored analytes. The annual comprehensive report will include tabulated data on the volume of sodium persulfate delivered to each well, as well as the field and laboratory concentrations of monitored analytes, tables, figures, and charts, and appended laboratory reports. The annual comprehensive report may be combined with the annual groundwater monitoring report. The annual report will include an evaluation of the ISCO application, potential EISB application, and provide recommendation(s) on additional remedial action(s), if necessary.

SCHEDULE

Following VRP approval of this Final Work Plan, Haley & Aldrich and SRP will move forward with the well installation and ISCO application. A tentative schedule is provided below.

Task	Anticipated Start *	Anticipated Duration
VRP Work Plan Approval	April 2023	-
Public Comment	June 2023	30 days
VRP Final Work Plan Approval	July 2023	
Injection Well Installation	September 2023	15 days
ISCO Injection	October 2023	15 days
Post-ISCO Monitoring	January 2024 April 2024 July 2024 (potential baseline for EISB)	-
Annual Reporting	Q1 2024, Q1 2025	-
EISB Design/Finalization, if necessary	July 2024	60 days
EISB, if necessary	August-September 2024	10 days
Post-EISB/MNA Monitoring	December 2024 March 2025 June 2025	-

Notes:
**Start date is tentative and subject to change.*
EISB = enhanced in-situ bioremediation
ISCO = in-situ chemical oxidation
MNA = monitored natural attenuation
VRP = Voluntary Remediation Program

Closing

Thank you in advance for your review of this Final Work Plan. If you have any questions or need additional information, please do not hesitate to contact us.

Sincerely yours,
HALEY & ALDRICH, INC.

Elizabeth Bishop
Senior Technical Specialist

Eric Pigati, R.G.
Senior Hydrogeologist

Bruce Travers, R.G.
Senior Hydrogeologist

Enclosures:

- Table 1 – Well Construction Details
- Table 2 – Analytical Parameters, Methods, Volume, Container, Preservation, and Hold Time
- Figure 1 – Project Locus
- Figure 2 – Regional Site Features
- Figure 3 – Proposed Injection Well Locations
- Figure 4 – Proposed Injection Well Diagrams
- Attachment A – Quality Control/Quality Assurance Information
- Attachment B – Responsiveness Summary Information

TABLES

FIGURES

ATTACHMENT A
Quality Control/Quality Assurance

ATTACHMENT B
Responsiveness Summary Information