REVISED CAPITAL INDUSTRIES PLANT 4
STAGE 1 FIELD IMPLEMENTATION WORK PLAN

West of 4th Group Site
Capital Industries, Inc.
5801 3rd Avenue South
Seattle, Washington

Submitted by:
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For:
West of 4th Avenue Group
Site Unit 2 Joint Deliverable
Capital Industries, Inc.
Blaser Die Casting Co.
Stericycle
Seattle, Washington

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
Cascade	Cascade Technical Services
CI	Capital Industries, Inc.
cis-1,2-DCE	cis-1,2-dichloroethene
COCs	constituents of concern
CVOCs	chlorinated volatile organic compounds
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
Farallon	Farallon Consulting, L.L.C.
HASP	Health and Safety Plan
Interim Action Work Plan	*Final Capital Industries Plant 4 Interim Action Work Plan, West of 4th Group Site, Capital Industries, Inc., 5815 4th Avenue South, Washington* dated December 21, 2017, prepared by Farallon Consulting, L.L.C.
ISCO	in-situ chemical oxidation
ITRC	Interstate Technology Regulatory Council
PCE	tetrachloroethene
PCULs	preliminary cleanup levels
PGG	Pacific Groundwater Group

QAPP	*Quality Assurance Project Plan, Appendix D of the Revised Capital Industries Plant 4 Stage 1 Field Implementation Work Plan, West of 4th Group Site, Capital Industries, Inc., 5801 3rd Avenue South, Seattle, Washington* dated May 10, 2018, prepared by Farallon Consulting, L.L.C.
RI	Remedial Investigation
ROI	radius of influence
SAP	*Sampling and Analysis Plan, Appendix C of the Revised Capital Industries Plant 4 Stage 1 Field Implementation Work Plan, West of 4th Group Site, Capital Industries, Inc., 5801 3rd Avenue South, Seattle, Washington* dated May 10, 2018, prepared by Farallon Consulting, L.L.C.
Site	the West of 4th Group Site consisting of Site Unit 1 and Site Unit 2
SU2	Site Unit 2
SU2 FS Report	*West of Fourth Site Unit 2 Feasibility Study, Seattle, Washington* dated August 11, 2016, prepared by the West of Fourth Group and Pacific Groundwater Group
TCE	trichloroethene
UIC	underground injection control
West of 4th Group	Art Brass Plating, Inc.; Blaser Die Casting Co.; Capital Industries, Inc.; and Burlington Environmental, LLC
Work Plan	*Revised Capital Industries Plant 4 Stage 1 Field Implementation Work Plan, Site Unit 2, Seattle, Washington* dated May 10, 2018, prepared by Farallon Consulting, L.L.C. (this document)

1.0 INTRODUCTION

Farallon Consulting, L.L.C. (Farallon) has prepared this Revised Capital Industries Plant 4 Stage 1 Field Implementation Work Plan (Work Plan) on behalf of Art Brass Plating, Inc.; Blaser Die Casting Co.; Capital Industries, Inc. (CI); and Burlington Environmental, LLC[1] (collectively referred to herein as the West of 4th Group), which are the potentially liable parties for the West of 4th Group Site (herein referred to as the Site), which consists of Site Unit 1 and Site Unit 2 (SU2), depicted on Figure 1. The Art Brass Plating, Inc. property is located at Site Unit 1. The CI and Blaser Die Casting Co. properties are located at SU2. The CI property comprises five buildings identified as Plants 1 through 5 (Figure 2). The Work Plan provides the technical approach to an interim action at CI Plant 4 that is being conducted on behalf of the West of 4th Group.

This Work Plan has been prepared in accordance with the requirements of Agreed Order No. DE 10402 entered into by the West of 4th Group and the Washington State Department of Ecology (Ecology) in April 2014; the First Amendment to Agreed Order No. DE 10402 dated November 20, 2017; and the Washington State Model Toxics Control Act Cleanup Regulation, as established in Chapter 173-340 of the Washington Administrative Code.

1.1 OBJECTIVES

The purpose of the Work Plan is to provide the details for implementation of the in-situ chemical oxidation (ISCO) interim action at CI Plant 4 (Figure 2), in SU2 as discussed in the *West of 4th Site Unit 2 Feasibility Study, Seattle, Washington* dated August 11, 2016, prepared by West of Fourth Group and Pacific Groundwater Group (PGG) (2016) (SU2 FS Report) and in the Final Capital Industries Plant 4 Interim Action Work Plan, West of 4th Group Site dated December 21, 2017 prepared by Farallon (2017b) (Interim Action Work Plan). The ISCO technology that will be used includes direct injection of potassium permanganate ($KMnO_4$) into the subsurface to treat shallow

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[1] Burlington Environmental, LLC, is a wholly owned subsidiary of PSC Environmental Services, LLC, which is a wholly owned subsidiary of Stericycle Environmental Solutions, Inc.

soil and groundwater. The interim action objectives are tied to the remedial action objectives for the Site, described in the SU2 FS Report, and include:

- Reducing concentrations of chlorinated volatile organic compounds (CVOCs) in soil beneath CI Plant 4 to concentrations less than the preliminary cleanup levels (PCULs) for the Site to reduce inhalation risks to acceptable levels (Table 1); and
- Reducing concentrations of CVOCs in shallow groundwater that allegedly originated from CI Plant 4 to concentrations less than the PCULs for the Site.

1.2 ORGANIZATION

This Work Plan summarizes pertinent background information and provides details for implementation of the ISCO interim action at SU2. This Work Plan is organized into the following sections:

- **Section 1, Introduction,** presents an overview of the Site, and the objectives and organization of the Work Plan.
- **Section 2, Background,** presents background information, including a summary of previous investigations conducted at CI Plant 4, and a description of the constituents of concern (COCs) that will be targeted during the interim action.
- **Section 3, Preliminary Cleanup Levels,** presents the revised PCULs for the Site.
- **Section 4, Conceptual Site Model,** presents a description of the Site features, geology, and hydrogeology; the nature and extent of contamination; and groundwater geochemistry.
- **Section 5, Interim Action,** presents a description of the interim action, including a discussion of the remedial technology, permitting, health and safety, spill prevention, utility clearance, baseline groundwater sampling, the interim action approach and design, Stage 1 injectability testing, and the process and performance monitoring programs.
- **Section 6, Interim Action Documentation,** presents a description of documents that will be generated during the interim action activities.

- **Section 7, Schedule and Reporting,** summarizes the schedule for implementation of the interim action and associated reporting deliverables that will be submitted to Ecology.
- **Section 8, References,** lists the documents cited in this Work Plan.

2.0 BACKGROUND

This section presents background information, including a summary of previous investigations conducted at Plant 4, and a description of the COCs that will be targeted during the interim action.

2.1 PREVIOUS INVESTIGATIONS AT CI PLANT 4

Former operations at the CI property allegedly have resulted in releases of tetrachloroethene (PCE) and/or trichloroethene (TCE) to soil and groundwater. Details of historical CI operations and the results from prior environmental investigations, including a Remedial Investigation (RI) conducted by Farallon, are presented in the *Revised Draft Remedial Investigation Report, Capital Industries, Inc., 5801 3rd Avenue South, Seattle, Washington, Agreed Order No. DE 5348* dated October 2012, prepared by Farallon (2012). A hot solvent degreaser and associated former drum storage area historically were present in the south-central and west-central portions of CI Plant 4, respectively. The hot solvent degreaser was used in CI Plant 4 from approximately 1987 to 1992 and was removed in 1993.

During subsurface investigations conducted by Farallon (2012) at CI Plant 4 during the RI, neither TCE nor PCE was detected in soil samples collected from the boring/monitoring well locations at concentrations that accounted for the impacts to groundwater quality that occurred at and down-gradient of CI Plant 4. Concentrations of CVOCs detected in groundwater samples collected from the Water Table Interval (depths of from 0 to 20 feet below ground surface [bgs]) and/or the Shallow Interval (depths at and from 20 to 40 feet bgs) near the suspected source areas previously identified at the CI property suggest there may be areas where concentrations of CVOCs in soil are greater than those detected during the RI. Therefore, Ecology required that additional investigation be conducted at CI Plant 4.

Farallon (2016) conducted passive soil gas and bulk soil sampling at CI Plant 4 and in the South Fidalgo Street right-of-way to assess the lateral and vertical distribution of PCE and TCE in soil beneath CI Plant 4 to resolve data gaps associated with the RI for the CI property, described in the revised data gap memorandum for Site Unit 2 (Farallon 2015).

The soil gas survey results indicated that the highest concentrations of PCE in soil gas were present in an area extending from the east-central portion to the south-southwestern portion of CI Plant 4 (Figures 3A through 3C). The areas with the highest concentrations of TCE in soil gas correlated with the areas with the highest concentrations of PCE in soil gas. Elevated concentrations of TCE were detected also in the approximate location of the former drum storage area (Figure 3B).

The highest concentration of cis-1,2-dichloroethene (cis-1,2-DCE) in soil gas was detected at the east-central portion of CI Plant 4, and correlates with the locations of the highest concentrations of PCE and TCE (Figure 3C). The PCE, TCE, and cis-1,2-DCE data indicate potential releases at the former drum storage area at the west-central portion of CI Plant 4, at the former degreaser location at the south-central portion of the building, and at the east-central portion of the building. Soil sampling at these locations was conducted to supplement existing soil data from the RI and further evaluate the nature and extent of COCs in soil. Concentrations of PCE, TCE, and cis-1,2-DCE detected in soil gas at the east-central portion of CI Plant 4 could be the result of a release on the east-adjacent Pacific Food Systems property or encroachment of contamination from other areas beneath CI Plant 4. The specific source of CVOCs in soil gas on the Pacific Food Systems property is undetermined.

PCE was detected at concentrations exceeding the PCUL for air quality protection and/or the revised PCUL[2] for surface water quality protection in soil samples collected from borings P4-B6, P4-B7, P4-B8, and P4-B11 (Table 2; Figure 3A). The maximum PCE concentration detected was 0.64 milligram per kilogram at boring P4-B6, located in the southeastern portion of CI Plant 4, east of the former degreaser.

TCE was detected at concentrations exceeding the PCUL for air quality protection and/or the revised PCUL for surface water quality protection in soil samples collected from borings P4-B1, P4-B3 through P4-B9, and P4-B14 (Table 2; Figure 3B). The maximum TCE concentration

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[2] Certain PCULs were revised in January 2017 to accommodate U.S. Environmental Protection Agency (EPA) revisions to surface water quality criteria.

detected was 0.48 milligram per kilogram at boring P4-B7, located in the central portion of CI Plant 4.

Cis-1,2-DCE, trans-1,2-dichloroethene, and vinyl chloride were not detected at concentrations exceeding PCULs in the soil samples collected at and proximate to CI Plant 4 (Table 2; Figures 3A through 3C).

The soil analytical results indicate that the highest concentrations of CVOCs are present immediately beneath the CI Plant 4 building slab, and attenuate with depth. PCE and TCE were detected at low concentrations at CI Plant 4, which confirms that there was not a significant or extensive release of PCE or TCE at CI Plant 4. The groundwater data from the RI Report (Farallon 2012) and post-RI sampling also support the conclusions drawn from the soil data. The concentrations of COCs in the Water Table Interval are not indicative of a major release of PCE or TCE (Table 3; Figure 4). PCE or TCE was not detected in either the Shallow or Intermediate Groundwater Interval (depths greater than 40 feet bgs), indicating that the release(s) of PCE and TCE that did occur were of insufficient mass and/or volume to affect deeper groundwater.

Sufficient data were collected at CI Plant 4 to evaluate potential cleanup technologies for soil and groundwater, described in the SU2 FS Report. The potential active cleanup technologies evaluated and the media to be remediated were:

- ISCO (soil and groundwater);
- Soil excavation and off-Site disposal (soil);
- Soil vapor extraction/air sparging (soil and groundwater);
- Enhanced anaerobic biodegradation (groundwater); and
- In-situ chemical reduction (groundwater).

ISCO was the preferred cleanup technology for soil and groundwater due to its ability to be implemented with minimal interference with operations at CI Plant 4, and its ability to rapidly treat the low levels of CVOCs present in soil and groundwater (West of Fourth Group and PGG 2016).

2.2 CONSTITUENTS OF CONCERN FOR INTERIM ACTION

The COCs for soil are PCE and TCE. These COCs are a current and future risk to the soil-to-groundwater and soil-to-indoor-air pathways. The COCs for groundwater in the Water Table Interval are PCE and TCE. These COCs are a current and future risk to the groundwater-to-surface water and groundwater-to-indoor air pathways. PCE and TCE also have the potential to affect the Shallow Interval where anaerobic conditions exist and reductive dechlorination to vinyl chloride can occur. Oxidation of PCE and TCE in the Water Table Interval reduces the risk of vinyl chloride generation.

3.0 PRELIMINARY CLEANUP LEVELS

The PCULs for the Site are based on potential exposure pathways, and were defined in the Technical Memorandum regarding Revised Preliminary Cleanup Standards, W4 Joint Deliverable, Seattle, Washington dated September 12, 2014, from Farallon (2014) to Mr. Ed Jones of Ecology. The PCULs were updated on January 17, 2017 to reflect updates to human health criteria in the Clean Water Act promulgated by EPA on November 15, 2016.

The current PCULs for the Site are summarized in Table 1 of this Work Plan.

4.0 CONCEPTUAL SITE MODEL

This section presents a summary of the conceptual site model elements pertinent to the ISCO injection work described herein.

4.1 GEOLOGY

Soil conditions at CI Plant 4 consisted of approximately 1 foot of silty sand underlain by silt with sand to depths ranging from approximately 6 to 7.5 feet bgs, underlain by fine sand with trace silt to the maximum depth explored of 18 feet bgs. Groundwater generally was encountered at a depth of 8 to 9 feet bgs. The silty sand layer near the ground surface pinches out in the South Fidalgo Street right-of-way.

4.2 HYDROGEOLOGY

The hydrogeologic units at the Site are:

- The Water Table Interval, extending to a depth of up to 20 feet bgs.
- The Shallow Interval, ranging in depth from 20 to 40 feet bgs.
- The Intermediate Interval, which includes groundwater monitored at the Site at depths below 40 feet bgs.

Groundwater in these three hydrogeologic units flows to the west and southwest toward the Duwamish River, with little seasonal fluctuation. A downward vertical gradient is present between the Water Table and Shallow Intervals. The vertical gradients between the Shallow and Intermediate Intervals fluctuate between upward and downward in monitoring well clusters east of East Marginal Way. The vertical gradient between the Shallow and Intermediate Intervals in monitoring well clusters west of East Marginal Way, proximate to the Duwamish River, generally is upward.

Tidal studies were documented in RI reports prepared for Art Brass Plating, Inc. (Aspect Consulting 2012) and CI (Farallon 2012). Water levels in the western portions of the Site are tidally influenced by Puget Sound. This tidal influence is demonstrated in localized, transient flow reversals similar to those observed at other sites near the Duwamish River. Tidal flow reversals diminish to 0.5 foot or less, 800 feet east-northeast of the Duwamish River.

4.3 NATURE AND EXTENT OF CONTAMINATION

The following sections present the nature and extent of contamination observed in soil gas, soil, and groundwater.

4.3.1 Soil Gas

The highest concentrations of PCE and TCE in soil gas were detected in an area extending from the east-central to the south-southwestern portions of CI Plant 4 (Figures 3A through 3C). The highest concentration of cis-1,2-DCE in soil gas was detected in the east-central portion of CI Plant 4, and correlates with the locations of the highest concentrations of PCE and TCE (Figure 3C).

4.3.2 Soil

The highest concentrations of PCE and TCE in the borings advanced at and proximate to CI Plant 4 were detected at a depth of approximately 1 foot bgs. Additional soil samples with concentrations of PCE and TCE exceeding PCULs were collected in silty material at borings P4-B1, P4-B4 through P4-B8, and P4-B14, located primarily at the southeastern portion of CI Plant 4 and the northern right-of-way of South Fidalgo Street. The vertical extent of soil contamination exceeding PCULs appears to be less than 10 feet bgs (Figures 3A through 3C).

4.3.3 Groundwater

PCE and TCE in the Water Table Interval allegedly originated from a former degreaser that was present on the south-central portion of CI Plant 4. CVOCs in groundwater in the Water Table, Shallow, and Intermediate Intervals, including PCE, TCE, and vinyl chloride, migrate to the southwest in SU2, toward Slip 2 at the Lower Duwamish Waterway (Aspect Consulting 2014). The portion of the interim action that addresses groundwater will be focused on the Water Table Interval. The interim action will not extend into the Shallow Interval, because the up-gradient plume from other sources will re-contaminate the remediated groundwater, and reductive dechlorination is occurring in the Shallow and Intermediate Intervals at a rate that will achieve the PCULs in a reasonable restoration time frame.

4.4 GROUNDWATER GEOCHEMISTRY

The groundwater at the Site generally is anaerobic and conducive to reductive dechlorination of CVOCs via microbial biodegradation. However, the Water Table Interval overall is the least reducing of the groundwater intervals, bordering on aerobic to anoxic conditions, whereas reducing conditions increase with depth (Farallon 2017a). Table 4 presents the geochemical data for monitoring wells MW-6 and MW-7, which are in the interim action area and will be monitored for changes in geochemistry resulting from ISCO injections.

5.0 INTERIM ACTION

This section presents a description of the interim action, including a discussion of the remedial technology, permitting, health and safety, spill prevention, utility clearance, baseline groundwater monitoring, interim action approach and design, Stage 1 injectability testing, and process and performance monitoring.

5.1 REMEDIAL TECHNOLOGY

Permanganate is a non-specific oxidizer of contaminants, meaning it will oxidize COC and natural organic materials in the soil. It can be used over a wide range of pH values and does not require a catalyst. Permanganate is a stable oxidant and can persist in the subsurface for months, allowing for more contaminant contact and the potential for reducing rebound. As permanganate oxidizes organic materials, including COCs, manganese oxide forms as a dark brown to black precipitate. Prior to oxidation, permanganate has a purple color.

Sodium permanganate and $KMnO_4$ were evaluated as possible chemical oxidants for the interim action. $KMnO_4$ is appropriate for this interim action due to the low concentrations of COCs present beneath CI Plant 4, and its ease of use (i.e., it ships to the Site as a solid, is not as highly reactive as sodium permanganate, and is not as hazardous for workers to handle in the field) (The Interstate Technology & Regulatory Council [ITRC] 2005). The oxidation of CVOCs by $KMnO_4$ is described by the following reactions:

PCE

$$3C_2Cl_4 + 4KMnO_4 + 4H_2O \rightarrow 6CO_2 + 4MnO_2(s) + 4K^+ + 12Cl^- + 8H^+$$

Where:

C_2Cl_4 = PCE

H_2O = water

CO_2 = carbon dioxide

$MnO_2(s)$ = manganese dioxide as a solid

K^+ = potassium ion

Cl^- = chlorine ion

H^+ = hydrogen ion

TCE

$C_2HCl_3 + 2KMnO_4 \rightarrow 2MnO_2 + 3Cl^- + H^+ + 2CO_2(g) + 2K^+$

Where:

C_2HCl_3 = TCE

MnO_2 = manganese dioxide

Cl^- = chlorine ion

H^+ = hydrogen ion

$CO_2(g)$ = carbon dioxide as a gas

K^+ = potassium ion

cis-1,2-DCE

$3C_2H_2Cl_2 + 8KMnO_4 + 2H^+ \rightarrow 6CO_2 + 8MnO_2(s) + 8K^+ + 6Cl^- + 4H_2O$

Where:

$C_2H_2Cl_2$ = cis-1,2-DCE

H^+ = hydrogen ion

CO_2 = carbon dioxide

$MnO_2(s)$ = manganese dioxide as a solid

K^+ = potassium ion

Cl^- = chlorine ion

H_2O = water

<u>Vinyl chloride</u>

$3C_2H_3Cl + 10KMnO_4 \rightarrow 6CO_2 + 10MnO_2(s) + 10K^+ + 3Cl^- + 7OH^- + H_2O$

Where:

C_2H_3Cl = vinyl chloride

CO_2 = carbon dioxide

$MnO_2(s)$ = manganese dioxide as a solid

K^+ = potassium ion

Cl^- = chlorine ion

OH^- = hydroxide ion

H_2O = water

In general, CVOCs with higher chlorine substitution consume less oxidant (per the stoichiometric requirement) and produce fewer manganese dioxide solids. Four moles of permanganate are needed to mineralize 3 moles of PCE producing 4 moles of manganese dioxide solids, compared to 10 moles of permanganate needed to mineralize 3 moles of vinyl chloride producing 10 moles of manganese dioxide solids. These equations represent the minimum amount of $KMnO_4$ necessary to oxidize the CVOCs.

Distribution of $KMnO_4$ will be implemented through direct-push ISCO injection points to force the oxidant into the formation. The approach and design of the oxidant delivery are presented in Section 5.7, Interim Action Approach and Design; injection monitoring is presented in Section 5.9, Process and Performance Monitoring. Preliminary steps, including permitting, health and safety, spill prevention planning, utility clearance, and baseline groundwater sampling, are discussed in the following sections.

5.2 PERMITTING

Ecology requires an Underground Injection Control (UIC) permit prior to injection of any material into groundwater. Farallon will secure the UIC permit for the ISCO injection. Ecology issued a State Environmental Policy Act threshold determination of non-significance for the interim action in 2017.

5.3 HEALTH AND SAFETY

A Health and Safety Plan (HASP) is required for all field activities (Section 810 of Chapter 173-340 of the Washington Administrative Code). Farallon and all subcontractors will be required to provide HASPs for their own employees that are appropriate to their role in the interim action and in accordance with the laws under which their work is regulated. Farallon's HASP will comply with the requirements of the Occupational Safety and Health Act of 1970 and the Washington Industrial Safety and Health Act (Chapter 49.17 of the Revised Code of Washington). Handling, storage, and incompatibility associated with $KMnO_4$ are discussed in the safety data sheet and fact sheet provided by Carus Corporation, the supplier of the $KMnO_4$, which is provided as Attachment 10 of the draft project-specific HASP prepared by Farallon (Appendix A of this Work Plan). Ecology approval of the HASP is not required.

Farallon and subcontractor personnel will be required to have 40-Hour Hazardous Waste Operations and Emergency Response training as hazardous waste operators in accordance with Part 1910.120 of Title 29 of the Code of Federal Regulations.

Skin and eye contact with oxidizing chemicals should be avoided, and special care should be taken to avoid breathing the chemicals in the form of dust or mist. Accordingly, proper personal protective equipment should be employed per the safety data sheet, and workers should handle the chemicals in a manner that minimizes creation of dust or mist. Proper respiratory, eye, face, and skin protection always should be worn during work involving exposure to these chemicals.

Prior to each injection, a safety meeting will be held to discuss specific concerns for each ISCO injection point. The depth interval, desired flow rate, and desired injection pressure will be discussed. The location of spill kits necessary to neutralize, contain, and recover $KMnO_4$ that could surface will be discussed. The location of underground utilities and other underground structures near the injection point will be identified, clearly marked, and discussed.

Workers at CI and at east-adjacent Pacific Foods Services will be notified of the work, and asked to notify the Farallon Project Manager and/or Site Health and Safety Officer if they observe anything unusual that may be connected with the interim action.

5.4 SPILL PREVENTION

The injection equipment and tote used for mixing the 3 percent $KMnO_4$ solution being injected will be placed within secondary containment compatible with the $KMnO_4$ solution, and capable of holding 100 percent of the volume of the tote. A spill kit with items capable of neutralizing, containing, and absorbing a potential spill will be present when the 3 percent $KMnO_4$ solution is being mixed, and when it is being injected into the subsurface. Photographs of the injection equipment and spill kits provided by Cascade Technical Services (Cascade), the equipment owner and designer, are provided in Appendix B.

Sudden changes in injection rates and pressure usually are the first signs of oxidant surfacing during pressurized ISCO injection. If surfacing occurs, injection will be stopped immediately. The spill kit will be mobilized to contain and neutralize the spill. If necessary, a large amount of water may be used to dilute the $KMnO_4$ to safe levels. The liquid will be recovered, containerized, and disposed of in accordance with applicable federal, state, and local laws. A Site meeting will be held with Cascade to discuss the surfacing occurrence, and what actions can be taken to prevent recurrence. The injection point and surfacing location will be sealed with bentonite before moving to a new injection point. Injection pressures, flow rates, volumes, and/or location may be adjusted to prevent future surfacing.

5.5 UTILITY CLEARANCE

Public and private utility locating services will be contracted to clear the ISCO injection and performance boring locations prior to drilling activities. New information pertaining to subsurface utility locations not documented during prior investigation work will be mapped for future reference. Utility locations will be evaluated at CI Plant 4 and the east-adjacent Pacific Food Systems property prior to implementation of the interim action to assess the potential for surfacing and/or dispersion of the oxidant via utility corridors. As-built details will be obtained from CI and Pacific Food Services to assess utility construction materials to evaluate potential susceptibility to damage from $KMnO_4$. According to information provided by Carus Corporation, the 3 percent $KMnO_4$ solution is compatible with construction materials for subsurface utilities such as metal and plastic piping and conduit. Natural rubber is the only material that could be damaged through injection of $KMnO_4$. Drilling locations may be modified during field activities as necessary based on access considerations and the locations of utilities and other features.

5.6 BASELINE GROUNDWATER SAMPLING

Prior to initiation of ISCO injection, five semi-permanent 1-inch-diameter observation wells with pre-pack screens (monitoring wells OBW-1 through OBW-5) will be installed in CI Plant 4 using direct-push drilling methods (Figure 5). Baseline groundwater samples will be collected from Water Table Interval monitoring wells MW-6 and MW-7 and the five newly installed monitoring wells. The groundwater sampling will be conducted in general accordance with the standard procedures cited in the Technical Memorandum regarding FINAL West of 4th Groundwater Monitoring Program Plan, 2017 through Draft Cleanup Action Plan, W4 Joint Deliverable, Agreed Order No. DE 10402 dated March 21, 2017, from Ms. Janet Knox of PGG (2017) to Mr. Ed Jones of Ecology, and the attached Sampling And Analysis Plan (SAP) (Appendix C). Quality assurance and quality control will be managed in accordance with the Quality Assurance Project Plan (QAPP) (Appendix D).

The groundwater samples will be submitted to a Washington-accredited laboratory for analysis for:

- CVOCs by EPA Method 8260D. Initial concentrations will be compared to post-injection concentrations as a measure of the effectiveness of the ISCO treatment.
- Dissolved arsenic and total and dissolved chromium, manganese, cadmium, and lead by EPA Method 200.8; total and dissolved iron by EPA Method 6010D; and total and dissolved mercury by EPA Methods 7470A/245.1. ISCO can change the oxidation state of some metals or release metals through oxidation reactions, resulting in mobilization of metals. Baseline measurements of metals at select wells will be used to evaluate whether

mobilization of metals is occurring, and whether mobilization is limited to the treatment zone. Mobilization of metals typically is limited to the zone of oxidation.

- Hexavalent chromium by Standard Method SM3500-CR B. Hexavalent chromium is a potential by-product of oxidation of existing trivalent chromium and is mobile and toxic. Although there is no risk of Site groundwater being used as a potable water source, hexavalent chromium should be monitored to confirm that if formed, it returns to the stable trivalent state outside the treatment zone is necessary. Hexavalent chromium will only be analyzed in the groundwater sample collected from monitoring well MW-7, which is down-gradient of the ISCO treatment zone.
- Total dissolved solids by Standard Method SM2540C. Monitoring will provide data on the effects of ISCO on major cations and the solids that may be generated by ISCO reactions. The baseline condition of groundwater will be compared to conditions observed during subsequent performance monitoring events to evaluate potential oxidant demand, and for generation of solid by-products that may reduce permeability of the soil matrix.

Additional field and geochemical parameters that will be directly measured using field instrumentation during sample collection include turbidity, temperature, pH, dissolved oxygen, oxidation-reduction potential, and specific conductance. These parameters will be compared to future performance monitoring data to evaluate the effects of ISCO and the potential radius of influence (ROI).

5.7 INTERIM ACTION APPROACH AND DESIGN

The interim action involves a two-stage approach to oxidant delivery, and was designed based on guidance provided by ITRC (2005). Stage 1 involves injectability testing into five separate locations in CI Plant 4. Stage 2 involves full-scale implementation of ISCO based on the results from the injectability testing conducted during Stage 1. This Work Plan focuses on implementation of the Stage 1 injections.

The scope of work for implementation of the Stage 2 injections will be documented in a draft Stage 2 Field Implementation Work Plan that will be prepared after the Stage 1 injections have been completed and the process and performance monitoring data have been evaluated.

5.8 STAGE 1: INJECTABILITY TESTING

Injectability testing is performed to evaluate the data necessary for implementation of a full-scale design. Stage 1 will be conducted to evaluate injection rates, injection pressures, injection volumes, ROI, injection well/point spacing, and oxidant concentrations. Subsurface environments rarely are homogeneous and isotropic, which the injection design must take into account. Injectability testing is performed to understand the variation in ROI and subsurface permeability to enable effective distribution of the oxidant throughout the subsurface. Stage 1 will include the following ISCO injection points, shown on Figure 5:

- ISCO injection points B3, C5, D4, and F5 in the silt with sand layer in the vadose zone from approximately 1 to 8 feet bgs; and
- ISCO injection point E5 from 1 foot bgs in the vadose zone to 20 feet bgs in the Water Table Interval.

These depth intervals were selected to allow evaluation of injection pressure, flow rate, and volume in areas where COC concentrations exceed PCULs in different soil types and/or in the Water Table Interval. These depth intervals also will allow evaluation of ROI in different soil types and under different pressures. The locations were selected because they will not interfere with one another, but will be useful in evaluating potential modifications to the ISCO approach for Stage 2. High-pressure injection points D4 and C5 were chosen because they are a safe distance from subsurface utilities.

Low-pressure injections into two different depth intervals at pressures of 5 pounds per square inch or less will be conducted at injection points B3, E5, and F5 (Figure 5) to evaluate their delivery parameters and ROI. High-pressure injections at pressure ranges of 50 to 100 pounds per square inch will be conducted at injection points D4 and C5 to evaluate delivery parameters and ROI at two depth intervals. Injection points D4 and C5 were specifically chosen in areas away from subsurface utilities to minimize the risk of the oxidant surfacing at higher injection pressures. Concrete packers will be placed around the injection rods to prevent surfacing of the oxidant from the injection borehole. A process flow diagram for the ISCO injections provided by Cascade is included as Appendix E.

Representatives of CI, Farallon, Cascade, and Ecology will hold a meeting at CI Plant 4 on the first day of injection to ensure that all parties are aware of the activities that are planned for the Stage 1 injections, and that questions regarding these activities can be discussed and answered. The three low-pressure injections will be conducted first, followed by the high-pressure injections into injection points D4 and C5. This will allow Farallon and Cascade to assess whether there will be any potential safety issues prior to injecting into injection point C5, proximate to the Pacific Food Systems North Building on the east-adjacent property (Figure 5). The subslab vapor monitoring points used to monitoring the negative-pressure field applied beneath the building slab that were installed as part of the subslab depressurization system for the Pacific Foods Systems North Building will be monitored for pressure changes prior to and throughout the injection process at injection point C-5. The pressure changes before, during, and after the injection process will be evaluated for safety purposes and for the potential influence of the high-pressure injection process at this adjacent property.

Injections will be conducted using a “top down” approach, during which the injection tooling will be advanced to the first treatment interval, and the desired volume of the 3 percent $KMnO_4$ solution will be injected into the formation at the predetermined flow rate and pressure. Upon completion of the injection at that interval, the injection tooling will be advanced to the next interval, and the process will be repeated until the selected injection point has been completed. Injection rates and total flow will be measured using digital turbine flow meters. Various pressure gauges are used by Cascade to monitor injection point pressures.

Although it is possible to evaluate the hydraulic behavior of unconsolidated materials by injecting clean water with direct-push tools, Stage 1 will use a 3 percent $KMnO_4$ solution. According to ITRC (2005), a solution of up to 4 percent concentration is typical for $KMnO_4$ ISCO injection projects. A 3 percent $KMnO_4$ solution will be used for Stage 1 based on the low concentrations of COCs in soil and in groundwater in Water Table Interval groundwater. Oxidation of COCs with $KMnO_4$ requires direct electron transfer, and therefore requires contact between the oxidant and the COC. A 3 percent $KMnO_4$ solution is expected to allow sufficient longevity of the $KMnO_4$ for contact to be made between the oxidant and COCs in soil and in groundwater in the Water Table Interval.

The following equations were used to calculate the effective pore volume and the amount of $KMnO_4$ needed to treat each grid square depicted on Figure 5 (assuming a 14-foot ROI). The calculations below will be adjusted for Stage 2 following evaluation of the Stage 1 results.

Effective Pore Volume Calculation

$$\text{ROI (area in square feet)} \cdot \text{depth interval (feet)} \cdot \text{soil porosity (unitless)} = \text{Volume (feet}^3\text{)}$$

Unit Conversion for Effective Pore Volume Calculation

$$\text{Volume (feet}^3\text{)} \cdot \frac{7.48 \text{ gallons}}{\text{foot}^3} = \text{Volume (gallons)}$$

Total Design Mass of Permanganate per Injection Point

$$\text{MnO}_4 \text{ Demand from COCs (pounds)} + (\text{Effective PNOD [pounds]} \cdot \text{Safety Factor[unitless]}) = \text{Design Mass of KMnO}_4 \text{ (pounds)}$$

The permanganate demand from COCs was estimated using equations based on the soil bulk density, the effective pore volume, the stoichiometric requirement of the COCs, and COC concentrations in soil and groundwater beneath CI Plant 4. The effective permanganate natural oxidant demand is an estimate because there are no Site-specific data. The safety factor is an estimate that takes into consideration contaminant mass estimates and the contact and residence time of the $KMnO_4$ based on seepage velocity derived during the RI. A safety factor of 2 was used in the vadose zone and of 1 in the Water Table Interval.

According to Carus Corporation, 0.25 pound of $KMnO_4$ per 1 gallon of water is needed to generate a 3 percent $KMnO_4$ solution. The following equation was used to calculate the volume of water needed to dilute the total design mass of permanganate per injection point:

Water Volume for 3 Percent Solution

$$\text{Mass of KMnO}_4 \text{ (pounds)} \cdot \frac{1 \text{ gallon}}{0.25 \text{ pounds}} = \text{Water Volume for Solution (gallons)}$$

The following values were used in injection design calculations. Site-specific values from the feasibility study prepared by the West of Fourth Group and PGG (2016) were used whenever possible.

- Effective porosity = 25 percent
- Hydraulic gradient = 0.0012 foot per foot
- Soil bulk density = 1.51 kilogram per liter
- Fraction of organic carbon = 0.2 percent

Using the equations above, the following $KMnO_4$ mass and water volumes were calculated for each injection point.

Injection point	Depth Interval (feet bgs)	Mass of Potassium Permanganate (pounds)	Volume of Water (gallons)
B3	1 to 8	948	3,792
D4	1 to 8	948	3,792
C5	1 to 8	948	3,792
F5	1 to 8	948	3,792
E5	1 to 20	1,761	7,044

Vadose zone injections will be conducted using a 2-foot screen; injections into the Water Table Interval will be conducted using a 5-foot screen. Concrete packers will be placed around the tooling above and below the screen to minimize the possibility of surfacing from the borehole. Flow rates are expected to range from approximately 1 gallon per minute for low-pressure injection points B3, E5, and F5, to 20 gallons per minute for high-pressure injection points D4 and C5, based on other injection projects conducted by Cascade in the general vicinity of the Site. The minimum pressure typically is applied to achieve flow of the injected solution into the formation. Pressure is gradually increased, and the resulting increase in the flow rate is observed to determine the optimum injection pressure and flow rate to maximize distribution of the $KMnO_4$ solution. Injection pressures must be balanced to avoid over-pressurizing the formation, which can lead to surfacing. Each temporary injection point is equipped with a pressure gauge and relief valve, and is controlled by an injection manifold equipped with a pressure regulator and a system pressure-relief valve. Each individual injection line has a pressure gauge and flow meter. As pressure is applied to each injection point, the pressure at the injection boring and manifold is observed, to monitor the permeability of the formation, and to ensure there is no pressure buildup where more pressure than the formation can accommodate is being applied. If the pressure at the injection boring exceeds the pressure at the injection manifold, the pressure at the injection boring will be decreased to allow the formation to equilibrate to prevent surfacing.

When injection has been completed, each injection boring will be backfilled with bentonite grout to approximately 1 foot from the ground surface to mitigate settling, and patched with concrete or asphalt at the ground surface to match the surface material and existing grade. The bentonite grout will mitigate the potential for preferential pathways and surfacing in future ISCO injections.

The Stage 1 ISCO injections will be monitored and evaluated in accordance with the process and performance monitoring program described below.

5.9 PROCESS AND PERFORMANCE MONITORING

Process and performance monitoring is conducted frequently during the most-active phase of remediation to evaluate the distribution of the oxidant, and to monitor migration of solubilized metals, and destruction versus migration of COCs. Process monitoring is conducted as a quality control measure before, during, and immediately after the injection operation. Objectives of process monitoring for the Stage 1 injections include confirmation of oxidant injection concentrations, volumes, flow rates, and pressures; and of the ROI of the injection. Performance monitoring includes establishing baseline conditions (see Section 5.6, Baseline Groundwater Sampling) at a site prior to remediation, and measuring the contaminant reduction, by-products of the ISCO reaction, and changes in groundwater geochemistry. The following sections describe the monitoring for Stage 1.

Stage 1 will be conducted to evaluate injection rates, pressures, and volumes; ROI; injection spacing; and oxidant longevity and concentration. Process monitoring will include documenting injection rates, pressures, and volumes during each of the five Stage 1 injections. Sudden changes in injection rates and pressure usually are the first signs of surfacing during pressurized ISCO injection. If oxidant surfaces, injection will be stopped immediately. The injection contractor will immediately contain and neutralize oxidant that surfaces.

Subslab pressure at the Pacific Food Systems North Building will be monitored during high-pressure ISCO injection at injection point C5 using the subslab monitoring ports that were installed as part of the subslab depressurization system at the Pacific Food Systems North Building. Prior to injection at ISCO injection point C5, the subslab depressurization system will be turned off, and the subsurface will be allowed to equilibrate for at least 30 minutes before baseline subslab pressure measurements are obtained at subslab monitoring ports SSMP-1 and SSMP-3 (Figure 5). Subslab pressure will be monitored every 30 to 60 minutes, depending on back pressure observations at the injection point. High back pressures will require more-frequent monitoring, and will be assessed in the field based on process monitoring at the injection point. Subslab pressures will be monitored using a low-range Dwyer magnehelic gauge with a range of 0 to 2 inches of water. The pressure data and other process-monitoring data will be used to evaluate the injection radius of influence, and potential safety concerns associated with higher-pressure injection work.

Evaluation of the ROI, oxidant longevity, and oxidant concentration will be conducted as follows. Three continuous cored performance borings will be drilled around each Stage 1 ISCO injection point (a total of 15 performance borings) at various distances and directions from the injection point to evaluate the distribution of $KMnO_4$. Performance borings will be advanced the same day or the day following the Stage 1 ISCO injections. These performance borings will be advanced at distances of 5 feet north, 10 feet southeast, and 15 feet southwest of each Stage 1 ISCO injection point to a total depth a maximum of 2 feet deeper than the ISCO injection point to assess the actual injection radius of each pilot test injection point and the distribution of the $KMnO_4$ in the soil matrix. Each of the borings will be inspected for color. $KMnO_4$ will cause the soil to exhibit a purple to pink hue based on distribution and concentration, which becomes black as the soil is exposed to air. The color distribution and detailed lithology of each boring will be logged by a Farallon Field Geologist on a boring log, with depth noted, and photographed to document the distribution and to estimate the concentration of KMnO4 based on visual observations. A minimum of one soil sample per 5-foot depth interval exhibiting a pink or purple hue will be collected and submitted for analysis for $KMnO_4$ by Standard Method SM4500 to determine the concentration of $KMnO_4$ in the soil. Additional soil samples may be analyzed based on observations of soil conditions at the time of drilling. Conditions that may warrant analysis of additional samples may include extreme differences in coloration within a sampling interval that would suggest the potential for a less-uniform oxidant demand or a distribution pattern related to the soil matrix composition. The data will be used collectively to evaluate oxidant demand and distribution potential beneath CI Plant 4, to allow for a more-effective Stage 2 injection program regarding dosing and distributing the oxidant. If $KMnO_4$ is not observed in a Stage 1 performance boring, one soil sample will be collected from each soil type and analyzed for $KMnO_4$ natural oxidant demand analysis by ASTM International Method D7262-10, Test Method A (Appendix F). These data will be used to evaluate competing oxidant demands from natural materials in the soil. Each boring will be sealed with bentonite to within 1 foot of the ground surface, and capped with concrete or asphalt to match the existing surface.

Groundwater will be visually inspected for color at observation wells OBW-3 and OBW-5 and monitoring wells MW-6 and MW-7 during and immediately following injection. The color will be compared to the color chart correlating color with $KMnO_4$ concentration in the RemOx Desk Reference provided in Appendix G. Standard spectrophotometric methods using the Hach DR 890 will be used to measure $KMnO_4$ concentrations (Appendix H). The concentration and color will be logged to document the distribution and concentration of $KMnO_4$ injected into the formation. If evidence of $KMnO_4$ is identified following injection, the wells will be monitored daily for 1 week following the injection period to evaluate the rate at which the oxidant is expended. If $KMnO_4$ persists after the first week of monitoring, the frequency of monitoring will become weekly for up to 4 weeks, and the rate of degradation will continue to be evaluated. If $KMnO_4$ persists without significant reduction, the performance monitoring borings described below will be completed to evaluate soil conditions. If $KMnO_4$ is expended, groundwater samples will be collected from observation wells OBW-3 and OBW-5 and monitoring well MW-6. The sampling and analysis will be conducted as described in Section 5.6, Baseline Groundwater Sampling. If there is no evidence of permanganate in groundwater at monitoring well MW-7, a groundwater sample will be collected for analysis for hexavalent chromium to assess the potential formation and mobilization of this oxidation by-product. If groundwater samples are collected and analyzed for CVOCs and/or metals, the samples will be “quenched” through application of ascorbic acid. The “quenching” process neutralizes residual oxidant present in the sample so reactions do not continue between the time of sample collection and analysis by the laboratory.

Four weeks following advancement of the first series of performance borings described above, a second series of performance monitoring borings will be advanced proximate to the initial set of borings to evaluate changes in parameters collected and noted above. This schedule may be accelerated if $KMnO_4$ is observed in the observation wells cited above, and the monitoring conducted indicates that $KMnO_4$ is expended prior to 4 weeks.

Each of the second series of performance monitoring borings will be inspected for color. The color distribution and detailed lithology of each boring will be recorded by a Farallon Field Geologist on a boring log, with depth noted, and photographed to document the distribution and to estimate the changes in the concentrations of $KMnO_4$ based on visual observations. A minimum of one soil sample per 5-foot depth interval exhibiting a pink or purple hue will be collected and submitted for analysis for $KMnO_4$ by Standard Method SM4500. The results will be compared to the initial performance sampling results. When field observations indicate that the oxidant has been expended, performance soil samples will be collected at depths where previous sampling indicated COCs were detected. The samples will be submitted to the analytical laboratory for analysis for CVOCs by EPA Method 8260C to assess the reduction in COC concentrations as a result of chemical oxidation.

The results will be used to evaluate whether the initial 3 percent concentration of $KMnO_4$ is sufficient to overcome the natural oxidant demand of the soil matrix and reduce COC concentrations to less than PCULs. These data will be used to adjust the spacing between injection points and the vertical injection volume for subsequent injection points, and possibly the method of ISCO delivery, to maximize distribution in the soil matrix.

The analytical results for the soil and groundwater samples will be compared to historical analytical results for co-located soil and groundwater samples to evaluate rebounding. Any necessary adjustments in design spacing and the number of Stage 2 injection points will be documented in a Stage 2 Field Implementation Work Plan, and submitted to Ecology for approval prior to implementation of Stage 2 injections.

6.0 INTERIM ACTION DOCUMENTATION

This section summarizes the interim action documents that will be prepared during the interim action activities.

6.1 PROJECT DOCUMENTS AND REPORTING

6.1.1 Revised Stage 1 Field Implementation Work Plan

This Work Plan provides details regarding implementation of Stage 1 of the interim action, including the initial ISCO injection points, initial ISCO injection design criteria, performance monitoring details, criteria for evaluating the effectiveness of Stage 1 of the interim action, and reporting requirements based on comments from Ecology regarding the Interim Action Work Plan. This Work Plan also includes the following supporting documents.

6.1.1.1 Health and Safety Plan

A draft HASP (Appendix A) for the field activities was prepared in accordance with Section 810 of Chapter 173-340 of the Washington Administrative Code. The HASP complies with the requirements of the Occupational Safety and Health Act of 1970 and the Washington Industrial Safety and Health Act (Chapter 49.17 of the Revised Code of Washington).

6.1.1.2 Sampling and Analysis Plan

A SAP (Appendix C) was prepared to guide the sampling efforts associated with Stage 1 of the interim action. The SAP includes a discussion of sampling locations, frequency, and analytical parameters. The SAP contains standard operating procedures related to the specific field tasks that will be performed during the interim action. These standard operating procedures include field sampling and documentation, soil sampling, groundwater sampling, and waste management.

6.1.1.3 Quality Assurance Project Plan

A QAPP (Appendix D) was prepared to assess the quality and reproducibility of analytical data generated in association with Stage 1 of the interim action. The QAPP discusses quality assurance/quality control samples that will be collected to support the interim action.

6.1.2 Quarterly Status Reports

Quarterly status reports will be submitted to Ecology in the standard Quarterly Progress Reports prepared by CI. The Quarterly Progress Reports will include a summary of the interim action activities conducted. If necessary, more-frequent progress reporting will occur via email messages and/or meetings with Ecology to refine the scope of work based on performance monitoring data for the interim action.

6.1.3 Stage 2 Field Implementation Work Plan

When the Stage 1 injections and the evaluation of associated process and performance monitoring data have been completed, a Stage 2 Field Implementation Work Plan will be prepared. The Stage 2 Field Implementation Work Plan will include a summary and evaluation of the Stage 1 injections, and will incorporate lessons learned into the design and implementation details for the full Stage 2 implementation of ISCO at CI Plant 4.

7.0 SCHEDULE AND REPORTING

This section summarizes the schedule for implementation of Stage 1 of the interim action and associated reporting deliverables that will be prepared. The anticipated interim action schedule is presented as a timeline in Appendix I. The milestones associated with implementation of Stage 1 of the interim action and the potential schedule to achieve those milestones are provided below.

Submittal of Deliverable	**Completed or Anticipated Schedule**
Draft Interim Action Work Plan	Completed Week of July 24, 2017
Final Interim Action Work Plan	Completed December 22, 2017
Draft Field Implementation Work Plan	Completed March 8, 2018
Revised Capital Industries Plant 4 Stage 1 Field Implementation Work Plan	Within 30 days of receipt of Ecology’s comments regarding Draft Field Implementation Work Plan
Stage 2 Capital Industries Plant 4 Field Implementation Work Plan Addendum	Within 45 days of evaluation of Stage 1 injection data
Quarterly Progress Reports	Each quarter during and following implementation of the interim action

Field Work	**Anticipated Schedule**
Obtain UIC Permit	Upon Ecology approval of Final Interim Action Work Plan
Installation and development of five semi-permanent 1-inch-diameter monitoring wells	Approximately 2 weeks prior to baseline groundwater monitoring event
Baseline groundwater monitoring event	Within 2 weeks prior to Stage 1 ISCO injections

Stage 1 ISCO injections	To be scheduled upon Ecology approval of Revised Capital Industries Plant 4 Stage 1 Field Implementation Work Plan, receipt of UIC permit, and review of data from baseline groundwater monitoring event
Stage 1 performance monitoring	First-round Stage 1 performance borings to be advanced immediately following Stage 1 ISCO injections for visual observation of ISCO injection radius. Performance groundwater monitoring to be conducted 2 weeks after Stage 1 injection to observe distribution of $KMnO_4$, and collect groundwater samples if oxidant has been expended. Second-round performance borings to be advanced 4 weeks after Stage 1 injection for visual observation of persistence of $KMnO_4$, and assessment of CVOC concentrations in soil proximate to Stage 1 injection points if $KMnO_4$ has been expended. This schedule will be modified accordingly if evidence of $KMnO_4$ persists.

8.0 REFERENCES

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FIGURES

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN

West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

TABLES

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX A
HEALTH AND SAFETY PLAN

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX B
CASCADE TECHNICAL SERVICES
INJECTION EQUIPMENT PHOTOGRAPHS

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX C
SAMPLING AND ANALYSIS PLAN

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX D
QUALITY ASSURANCE PROJECT PLAN

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX E
CASCADE TECHNICAL SERVICES PROCESS FLOW DIAGRAM

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX F
CARUS REMEDIATION PERMANGANATE NATURAL OXIDANT DEMAND PROCEDURE BRIEF

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX G
CARUS REMEDIATION REMOX DESK REFERENCE

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX H
CARUS REMEDIATION REMOX ISCO REAGENT RESIDUAL DETERMINATION BRIEF

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008

APPENDIX I
ANTICIPATED INTERIM ACTION SCHEDULE

REVISED CAPITAL INDUSTRIES PLANT 4 STAGE 1 FIELD
IMPLEMENTATION WORK PLAN
West of 4th Group Site
5801 3rd Avenue South
Seattle, Washington

Farallon PN: 457-008