SI AREA SUPPLEMENTAL GROUNDWATER REMEDIAL ACTION PLAN

TESORO ALASKA COMPANY, LLC

KENAI, ALASKA

August 30, 2022

Project No.: 39B-003-008

SUBMITTED BY: Trihydro Corporation

312 Tyee Street, Soldotna, AK 99669

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

Trihydro Corporation (Trihydro) is submitting this Supplemental Groundwater Remedial Action Plan (RAP) on behalf of Tesoro Alaska Company, LLC (Tesoro) at the Tesoro Kenai Refinery surface impoundment (SI) area in Kenai, Alaska (Figure 1). The RAP details the plan and schedule to install a permeable reactive barrier using activated carbon slurry within a localized portion of the SI area, downgradient of the current air sparge (AS) line. The RAP was developed in accordance with regulatory requirement 18 AAC 75.360 using guidance from Regenesis and historical site data.

The intent of installing the proposed carbon barrier downgradient of the AS line is to assess capture and migration mitigation of trichloroethylene (TCE), vinyl chloride (VC), and benzene contaminated groundwater in concert with a pilot shutdown of upgradient AS system.

1.1 BACKGROUND

The SI area (Figure 2) is located in the northeast corner of the Kenai Refinery where Tesoro constructed three unlined surface impoundments. The impoundments were used primarily to dispose oily waste generated at the refinery. Some drilling mud remnants mixed with crude oil were also placed in the surface impoundments. Tesoro discontinued using and closed the impoundments in 1980. Key constituents in SI area groundwater have historically included benzene and trichloroethene (TCE).

The post-closure corrective measures have included groundwater extraction for hydraulic control, air sparging for dissolved-phase plume treatment, and testing of in situ chemical oxidation for source mass removal. These measures have resulted in TCE and benzene groundwater plumes that have shrunk laterally over time, currently located across only portions of the former surface impoundments (Figure 3). The groundwater extraction system was shut down and decommissioned on July 1, 2009, leaving air sparging as the current remedial measure. A historical data review suggests reductive dechlorination may have been an important TCE attenuation mechanism in early stages of attenuation, but the process may have slowed or stopped because of decreased benzene concentrations. Groundwater samples collected during a focused monitoring event conducted in December 2015, showed TCE levels elevated above cleanup criteria within air sparge (AS) wells (temporarily shut down for sampling) and downgradient well SMW-31 (Figure 3). Sampling indicates the AS treatment system adequately treats dissolved phase benzene but shows a limited efficacy for treating residual low-concentration dissolved phase TCE at the site (Trihydro 2016).

To address TCE migration in the SI area, the Kenai Refinery Quarter 16-1 Monitoring Report, Appendix C (Trihydro 2016) proposed a general plan for remedy enhancement. The first phase included testing of the AS system to assess effectiveness of quicker on/off system pulsing to better volatilize TCE. The first phase was conducted from April 14 to July 28, 2016, and suggested a 3-minute pulse time was likely optimal, but post-test sampling results showed no improvement in TCE levels. The general plan for remedy enhancement stated if the first phase testing did not improve the remediation of TCE, Tesoro would then propose conducting a pilot test of enhanced reductive dechlorination.

ERD pilot testing was conducted within a localized portion of the SI area, downgradient of the current AS line. The proposed pilot test for ERD was conducted in October 2017 with injection of a carbon source (LactOil® bioremediation amendment) and a specialty bioaugmentation culture containing known reductive dechlorinators (Q17-4 Appendix F). Subsequent monitoring suggested the possibility of a slight increase in TCE biodegradation. However, methanogens were likely outcompeting the desired reductive dechlorinators for protons made available by fermentation of the carbon source. The consequence of the high methanogenic activity was incomplete dechlorination of TCE and its daughter products (cis-1,2-DCE and vinyl chloride). An interim pilot test monitoring report (Q18-3 Appendix B) recommended addition of a methanogen inhibitor and pH adjustment (increase) to make conditions more favorable for reductive dechlorination. These recommendations were not implemented due to COVID-19 site access restrictions during the planned implementation in the spring of 2020, and so potential effectiveness of further ERD coupled with methanogen inhibitor is not known. Rescheduling the methanogen inhibitor injection for spring of 2021 would have require reinjection of additional carbon source at the current stage of area groundwater chemistry and was therefore, not performed.

With suboptimal reductive dechlorination for the ERD pilot, a desktop evaluation of TCE and daughter product mass fluxes in the SI area was conducted in Q21-1 (Q21-1 Appendix B) to assess potential next steps. The evaluation inferred that much of the TCE + daughter products attenuation in the past may have been due to the presence of benzene, and possibly other hydrocarbons, in the TCE area to support reductive dechlorination. After the hydrocarbon mass flux had decreased, the attenuation of TCE + daughter products as groundwater flowed from the source area stalled. The subsequent ERD pilot test was able to provide modest decreases in TCE + daughter products downgradient of the source area, but overall, it was inferred that the primary attenuation mechanisms under current conditions are physical processes like dispersion. The desktop evaluation concluded with a suggestion that future remedial considerations incorporate either the calculated mass fluxes or field measurements with passive flux traps.

Field measurements of TCE + daughter products mass flux were conducted in September 2021 at SMW-24, SMW-I-1, SMW-31, and SMW-36. Results of the max flux evaluation are presented on Figure 4 and previously reported in

Q21-4 (Q21-4 Appendix D). Counter to expectation, the highest current mass fluxes were not measured at the two wells considered to be in the historical TCE source zone: SMW-34 and SMW-I-1. Instead, the highest mass flux was measured at SMW-31, at approximately 18.5 micromoles TCE per square meter per day (µmol m^{-2} day^{-1}) and cis-1,2-DCE at 13.0 µmol m^{-2} day^{-1}. This corresponds to a TCE + daughter products mass flux of approximately 31.5 µmol m^{-2} day^{-1}, which is more than twice that measured at other wells. These results suggest that the historical source zone is no longer contributing as much contaminant to the aquifer as SMW-31. Results indicate that, not only does TCE + daughter products mass flux continue, it actually is higher in the vicinity of the ERD pilot test than elsewhere. This condition has resulted in some mass flux being observed downgradient of the ERD pilot test.

1.2 HYDROGEOLOGIC CONDITIONS

Subsurface geology beneath the study area (Figure 5) is dominantly composed of fine to coarse grain sands, intermittently layered with medium-coarse grain gravels, with a thickness of approximately 50 to 60 feet. Based on borehole logs, the sand/gravels are underlain by a clay layer at a depth of approximately 60 to 70 feet below ground surface (bgs). Depth to groundwater within the SI area is approximately 45 to 60 ft bgs and groundwater elevation levels range from 75.0 to 88.75 feet above mean sea level (MSL). Groundwater flow direction trends to the south-southwest.

1.3 GROUNDWATER IMPACTS

Groundwater impacts are predominantly in the northern part of the site and occur primarily in the saturated fill. Figure 3 shows the approximate extent of benzene and TCE in groundwater and groundwater data from sampling conducted in Q22-2 and additional benzene and TCE groundwater concentrations in the SI for the past ten years are included as Table 1. Elevated benzene and TCE concentrations are associated with the waste materials historically deposed of in three unlined surface impoundments.

1.4 REMEDIAL OBJECTIVES AND SELECTED REMEDY

The objective of the planned remedy is to control migration of the TCE plume associated with the surface impoundments. Based on the remediation objective and implementability, the use of a liquid activated carbon is the preferred remedy option, given site conditions. With the mass flux data, the injection can be targeted to the optimal location (i.e., near SMW-31), and the dose can be designed. The approach would be expected to have the quickest effect on dissolved phase contaminant conditions and would have the smallest potential for generation of a mobile daughter product (e.g., vinyl chloride) plume. The use of a carbon barrier was selected based on (1) high likelihood of success, (2) the ability to perform a partial pilot shutdown of the SI air sparge system, and (3) the environmental and social benefit of installing the more green and sustainable remedy.

Due to low flux downgradient of SI-1 and ability of carbon to adsorb benzene as well as TCE, Tesoro recommends a pilot shut-down of air sparge wells SAS-01 to SAS-10 after injection, while impacts of the carbon injection are assessed. If groundwater concentrations of benzene are found above cleanup beyond the carbon injection site for two consecutive quarters, the pilot shut down would be reevaluated to determine if the air sparge wells would be restarted.

2.0 PLUMESTOP™ AND S-MICRO ZVI INJECTION

This section describes the construction, operation, and maintenance of the carbon slurry trap and treat barrier. The selected remedy is designed to treat benzene and TCE contaminated groundwater migrating downgradient of SI-1.

2.1 PRE-FIELD TASKS

Remedy selection evaluation was completed by Trihydro in conjunction with Regenesis and Tersus Environmental. Regenesis and Tersus provided guidance for the use of PlumeStop™ with S-Micro Zero Valent Iron (S-MZVI) and Tersus provided guidance NutriBind Powdered Activated Carbon with Zero Valent Iron respectively. Results of groundwater sampling and passive flux meters from wells within the injection area were used in conjunction with historical soil boring logs to evaluate each carbon injection option. As there is not a soil source within the injection area and an injection process consisting of lower injection pressures was desired PlumeStop™ with S-MZVI was selected for implementation. PlumeStop™ is utilized to remediate chlorinated solvent plumes and is also intended to address benzene migration in this area of the plume. S-MZVI was selected to aid in In Situ Chemical Reduction (ISCR) and is a special colloidal formulation which aids in ease of injection.

Regenesis worked in conjunction with Trihydro to develop an injection pilot study that would focus on injections within the areas of highest groundwater impacts and measured mass flux with additional less densely spaced injections on the edges of the TCE plume. Injections will be completed with two rows of injections with offset points on a six-foot spacing within the area of the highest groundwater impacts and measured mass flux and a single row of injections on an eight-foot spacing on the edges of the TCE plume. The injection area provides for treatment perpendicular to the groundwater flow across the TCE plume and has been optimized to focus on the areas of the plume with the highest TCE concentrations and mass flux. Figure 3 shows the injection area and extent of the TCE plume based on Q22-2 groundwater sampling data. Figure 5 shows a geological cross section of the SI area and SI injection area. Carbon loading calculations were completed based on soil and groundwater data. The calculations were completed based on an approximately 125-foot-long injection area perpendicular to TCE plume associated with SI-1. Carbon loading calculations are provided in Appendix A.

2.2 PLUMESTOP™ AND S-MZVI INJECTION PROCEDURE

The injection of PlumeStop™ and S-MZVI is proposed along an approximately 120 foot long transect of the TCE plume. Injections will be completed utilizing two offset rows of injection points within the portion of the TCE plume with the highest TCE concentrations and mass flux, with a single row of injection points on the outer areas of the TCE plume with lower TCE concentrations and mass flux. Injections will be completed at up to 24 locations

utilizing a bottom-up injection approach with 3-foot injection probes from approximately 50 to 75 ft bgs depending on the location, resulting in an estimated 7 injection intervals based on an average vertical injection interval of 3 ft. Injections will be completed by utilizing a Geoprobe drill rig with 1.5-inch injection tooling and specialized injection tips to inject across a three-foot interval at one time. The PlumeStop™ and S-MZVI material will be mixed in a poly tote with water sourced from the Refinery water system. The material will be continuously mixed to keep in solution. A diaphragm pump or similar will be used to complete the injections. Injection pressures at the tip are expected to be in the range of 10 pounds per square inch (psi) allowing for a radius of influence of approximately 3-4 feet. Injections will be completed at a flow rate of approximately 3-6 gallons per minute at each point with multiple injection points being completed at once to increase the total flow rate of the injections. Pressures and flow rates will be monitored and controlled via a manifold system.

The injection process will be monitored using flow meters and pressure gauges at the manifold system as well as utilizing up to two temporary 1-inch monitoring wells that will be decommissioned following injections and existing wells SMW-21A and SMW-35. These wells will be used to collect groundwater samples and monitor the PlumeStop™ and S-MZVI distribution.

The approximate total quantities anticipated to be used are included in the Regenesis design and summarized below:

- 23,600 gallons injected (approximately 875 to 1,625 gallons per point [35 to 65 gallons per foot] dependent upon location)
  - 21,819 gallons mixing water
  - 1,332 gallons of plume stop (12,000 pounds)
  - 397 gallons of S-MZVI (6,000 pounds)

The mechanisms which the PlumeStop™ and S-MZVI will control the dissolved phase TCE and benzene are a trap and treat process consisting of: a) trapping of the dissolved phase TCE and benzene within the activated carbon; b) direct chemical reaction and by c) stimulating anaerobic biological degradation by creating a reducing environment favorable for reductive dechlorination. Additional information on the PlumeStop™ and S-MZVI product is included in Appendix A.

2.3 OPERATION AND MAINTENANCE

The operation of this carbon barrier is minimal. To maintain efficiency, PlumeStop™ and S-MZVI may need to be injected in the future as needed. These injections can be completed using a direct push Geoprobe drill rig. Therefore, as the system is monitored a better understanding of the need for additional injections will be obtained.

2.4 REMEDIATION EFFECTIVENESS MONITORING

Quarterly groundwater sampling events will be utilized to monitor benzene, toluene, ethylbenzene, xylenes (BTEX), VC, TCE, and specific PlumeStop analysis in selected wells to evaluate remedy effectiveness. Groundwater monitoring activities and wells selected for sampling will continue to be identified in the quarterly monitoring reports and will be evaluated to optimize the groundwater sampling program. If necessary, additional monitoring wells may be proposed. To monitor the effectiveness, monitoring wells SMW-09, SMW-29, and SMW-36, will serve as the key downgradient locations. Monitoring wells SMW-35 and SMW-21A will serve as a key location within the injection areas, with SMW-31 as a key location immediately downgradient of the injection area. It is anticipated that results of the remedy implementation will take one to two field seasons to observe TCE and benzene reductions at SMW-36 based on groundwater flow velocity in the area. Monitoring wells SMW-09, SMW-29, SMW-31, and SMW-35 are currently sampled during spring and fall quarters, with SMW-36 sampled quarterly. These key monitoring wells will be sampled quarterly following the carbon injection and sampling is summarized in Table 2. After two field seasons of sampling has been completed the carbon barrier monitoring will be reevaluated and likely reduced to sampling outline in the Region 10 Environmental Protection Agency (EPA) Post-Closure Permit No. AKD 04867 9682 (Permit).

2.5 SUBCONTRACTORS

A drilling company will complete direct push injection services. Regenesis staff will be onsite to assist with and ensure proper injection of the product for approximately the first half of the injections. Trihydro will be onsite throughout the process to oversee all field activities.

2.6 WASTE MANAGEMENT

Waste soil and water generation is not anticipated during the installation of this carbon barrier. Installation will be completed using direct push injection. If soil or wastewater is generated during the injection process it will be containerized in 55-gallon drums and stored on-site for disposal, managed by Tesoro. Additional waste such as PPE, carbon bags, etc. will be disposed of as municipal waste.

2.7 UTILITY LOCATES AND PRECLEARING

Prior to completion of drilling activities 28 locations will be precleared via submitting an 811-utility notification as well as a Refinery excavation permit. Each location will be pre-cleared using soft digging to between five and eight feet.

3.0 DATA EVALUATION, REPORTING, AND SCHEDULE

3.1 DATA EVALUATION

Prior to collecting data, the sampling methods will be presented in the quarterly monitoring reports. Sample results will be compared to cleanup levels. Data validation in accordance with ADEC guidance will be completed on data collected to support decision making.

3.2 COMMUNICATION AND REPORTING

Carbon barrier assessment monitoring and maintenance will be reported in the quarterly monitoring reports.

3.3 SCHEDULE

The proposed schedule for 2022 remediation installation activities is:

- September 1 – Order PlumeStop™ and S-MZVI product
- September 23 – Materials arrive at Refinery
- September 6 through September 19 – Conduct pre- field tasks including utility locates, preclearing, and staging
- September 26 – Project Kick-off meeting, safety meeting, and startup of injection
- September 26 through October 10 – Complete Injections
- Quarter 4 – Conduct quarterly groundwater sampling

4.0 REFERENCES

Trihydro. 2016. Quarterly Progress Report No. 16-1, Appendix C. Kenai, Alaska, submitted to Tesoro Alaska Company. February 29.

Trihydro. 2017. Quarterly Progress Report No. 17-4, Appendix F. Kenai, Alaska, submitted to Tesoro Alaska Company. November 30.

Trihydro. 2018. Quarterly Progress Report No. 18-3, Appendix B. Kenai, Alaska, submitted to Tesoro Alaska Company. August 31.

Trihydro. 2021. Quarterly Progress Report No. 21-1, Appendix B. Kenai, Alaska, submitted to Tesoro Alaska Company. February 26.

Trihydro. 2021. Quarterly Progress Report No. 21-4, Appendix D. Kenai, Alaska, submitted to Tesoro Alaska Company. November 30.

TABLES

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
IWS-6	09/12/17	2.38	16.4	3.32	ND(1)	0.4
	12/13/17	1.76	7.11	--	--	ND(0.15)
	03/07/18	2.24	9.66	5.43	ND(1)	ND(0.15)
	06/12/18	2.42	9.95	4.04	ND(1)	ND(0.15)
	09/26/18	1.49	17.6	3.56	ND(1)	0.28
	12/05/18	1.4	13.6	3.27	ND(1)	ND(0.15)
	03/13/19	1.51	21	4.34	ND(1)	0.25
	06/25/19	1.24	17.7	3.85	ND(1)	ND(0.15)
	08/14/19	1.34	14.7	4.15	ND(1)	ND(0.15)
	11/12/19	1.62	13.4	3.09	ND(1)	ND(0.15)
	02/11/20	1.91	15.4	3.49	ND(1)	ND(0.15)
	06/02/20	1.28	15.2	2.77	ND(1)	0.188
	08/03/20	0.716	9.27	1.81	ND(1)	ND(0.15)
	11/11/20	0.685	16.8	2.35	ND(1)	ND(0.15)
	03/02/21	2.58	19.6	--	--	ND(0.15)
	08/25/21	1.37	12.7	--	--	--
	03/29/22	ND(0.4)	15.4	--	--	--
SMW-05	03/05/12	ND(1)	ND(1)	--	--	--
	09/10/12	ND(1)	ND(1)	--	--	--
	04/04/13	ND(1)	ND(1)	--	--	--
	09/10/13	ND(1)	ND(1)	--	--	--
	03/12/14	4.7	ND(1)	--	--	--
	06/18/14	4	ND(1)	--	--	--
	09/17/14	4.099999999999999	ND(1)	--	--	--
	12/08/14	4.299999999999999	1.6	--	--	--
	03/04/15	3	1.1	--	--	--
	06/08/15	1.7	ND(1)	--	--	--
	09/09/15	ND(1)	ND(1)	--	--	--
	12/02/15	ND(1)	ND(1)	--	--	--
	02/18/16	0.66	ND(1)	--	--	--
	09/01/16	0.69	ND(1)	ND(1)	--	ND(1)
	02/24/17	0.45	ND(1)	--	--	--
	09/11/17	ND(0.4)	ND(1)	--	--	ND(0.15)
	03/06/18	ND(0.4)	ND(1)	--	--	--
	10/02/18	ND(0.4)	ND(1)	--	--	--
	03/12/19	ND(0.4)	ND(1)	--	--	--
	08/13/19	ND(0.4)	ND(1)	--	--	--

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-05	02/13/20	ND(0.4)	ND(1)	--	--	--
	08/03/20	0.451	ND(1)	--	--	--
	03/01/21	ND(0.4)	ND(1)	--	--	--
	08/25/21	ND(0.4)	ND(1)	--	--	--
	03/28/22	ND(0.4)	ND(1)	--	--	--
SMW-06	03/05/12	ND(1)	ND(1)	--	--	--
	06/26/12	ND(1)	ND(1)	--	--	--
	09/10/12	ND(1)	1.2	--	--	--
	12/03/12	ND(1)	ND(1)	--	--	--
	04/04/13	ND(1)	1.3	--	--	--
	09/10/13	ND(1)	1	--	--	--
	11/14/13	ND(1)	1.1	--	--	--
	03/12/14	ND(1)	1	--	--	--
	02/23/17	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	12/13/17	ND(0.4)	ND(1)	--	--	ND(0.15)
	03/13/18	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	06/12/18	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	09/26/18	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	12/04/18	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	03/20/19	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	06/25/19	ND(0.4)	1.03	ND(1)	ND(1)	ND(0.15)
	08/14/19	ND(0.4)	1.61	ND(1)	ND(1)	ND(0.15)
	11/13/19	ND(0.4)	1.44	ND(1)	ND(1)	ND(0.15)
	02/11/20	ND(0.4)	1.48	ND(1)	ND(1)	ND(0.15)
	06/01/20	ND(0.4)	1.49	ND(1)	ND(1)	ND(0.15)
	08/03/20	ND(0.4)	1.33	ND(1)	ND(1)	ND(0.15)
	11/10/20	ND(0.4)	2.11	ND(1)	ND(1)	ND(0.15)
	03/01/21	ND(0.4)	1.6	--	--	ND(0.15)
	08/26/21	ND(0.4)	--	--	--	--
SMW-09	04/09/12	ND(1)	ND(1)	--	--	ND(1)
	09/10/12	ND(1)	ND(1)	--	--	--
	12/03/12	ND(1)	ND(1)	--	--	--
	04/03/13	ND(1)	ND(1)	--	--	ND(1)
	03/13/14	ND(1)	ND(1)	--	--	ND(1)
	06/19/14	ND(1)	ND(1)	--	--	--
	09/17/14	ND(1)	ND(1)	--	--	--
	12/09/14	ND(1)	1.1	--	--	--

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-09	03/05/15	ND(1)	ND(1)	--	--	ND(1)
	09/09/15	1.3	1.2	--	--	--
	12/03/15	ND(1)	ND(1)	ND(1)	--	ND(1)
	02/19/16	0.78	1.12	--	--	ND(1)
	06/06/16	0.89	1.1	--	--	ND(1)
	09/01/16	0.83	1.38	1.98	--	ND(1)
	12/01/16	0.59 J+	ND(1)	1.37	--	ND(1)
	02/23/17	0.54	ND(1)	1.62	ND(1)	1.02
	02/23/17	0.54	ND(1)	--	--	ND(0.15)
	06/12/17	ND(0.4)	ND(1)	--	--	0.65
	09/11/17	ND(0.4)	ND(1)	--	--	ND(0.15)
	12/12/17	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	03/07/18	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	06/06/18	0.4	ND(1)	ND(1)	ND(1)	0.35
	09/11/18	0.4	ND(1)	ND(1)	ND(1)	0.32
	12/04/18	ND(0.4)	ND(1)	ND(1)	ND(1)	ND(0.15)
	03/20/19	ND(0.4)	ND(1)	ND(1)	ND(1)	0.26
	06/24/19	0.519	ND(1)	ND(1)	ND(1)	0.389
	08/15/19	0.93	ND(1)	1.13	ND(1)	0.86
	11/13/19	0.856	ND(1)	ND(1)	ND(1)	1.17
	02/11/20	0.517	ND(1)	1.06	ND(1)	0.768
	06/01/20	0.859	ND(1)	2.03	ND(1)	2.16
	08/03/20	0.821	ND(1)	1.92	ND(1)	2.12
	11/10/20	0.948	ND(1)	3.03	ND(1)	2.37
	03/01/21	0.74	ND(1)	--	--	1.65
	08/26/21	0.554	ND(1)	--	--	1.08
	06/21/22	0.538	ND(1)	--	--	0.508
SMW-21A	03/15/12	ND(1)	ND(1)	--	--	ND(1)
	09/10/12	ND(1)	ND(1)	--	--	--
	12/03/12	ND(1)	ND(1)	--	--	--
	03/21/13	ND(1)	ND(1)	--	--	ND(1)
	09/10/13	ND(1)	ND(1)	--	--	--
	03/12/14	ND(1)	ND(1)	--	--	ND(1)
	09/17/14	ND(1)	ND(1)	--	--	--
	03/05/15	ND(1)	ND(1)	--	--	ND(1)
	09/09/15	ND(1)	ND(1)	--	--	--
	02/18/16	ND(0.4)	1.31	--	--	ND(1)

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-21A	09/01/16	ND(0.4)	2.5	ND(1)	--	ND(1)
	02/23/17	ND(0.4)	1.34	ND(1)	ND(1)	ND(0.15)
	02/23/17	ND(0.4)	1.26	--	--	ND(0.15)
	12/12/17	ND(0.4)	2.12	ND(1)	ND(1)	ND(0.15)
	03/07/18	ND(0.4)	2.15	ND(1)	ND(1)	ND(0.15)
	06/06/18	ND(0.4)	1.92	ND(1)	ND(1)	ND(0.15)
	09/11/18	ND(0.4)	2.89	1.53	ND(1)	ND(0.15)
	12/04/18	ND(0.4)	3.81	1.5	ND(1)	ND(0.15)
	03/12/19	ND(0.4)	3.17	1.42	ND(1)	ND(0.15)
	06/24/19	ND(0.4)	2.38	ND(1)	ND(1)	ND(0.15)
	08/15/19	ND(0.4)	2.25	ND(1)	ND(1)	ND(0.15)
	11/13/19	ND(0.4)	3.25	1.48	ND(1)	ND(0.15)
	02/11/20	ND(0.4)	3.58	2.41	ND(1)	0.717
	06/01/20	ND(0.4)	2.04	ND(1)	ND(1)	ND(0.15)
	08/03/20	ND(0.4)	2.08	1.08	ND(1)	ND(0.15)
	11/10/20	ND(0.4)	1.62	ND(1)	ND(1)	ND(0.15)
	03/03/21	ND(0.4)	4.78	--	--	ND(0.15)
	08/25/21	ND(0.4)	4.6	--	--	ND(0.15)
	03/28/22	0.482	5.4	--	--	1.44
SMW-29	06/26/12	ND(1)	ND(1)	--	--	--
	09/10/12	ND(1)	1.3	--	--	--
	11/30/12	ND(1)	1	--	--	--
	04/03/13	ND(1)	1.2	--	--	--
	06/25/13	ND(1)	1.1	--	--	--
	09/10/13	ND(1)	1.3	--	--	--
	11/14/13	ND(1)	1.2	--	--	--
	03/13/14	ND(1)	1.2	--	--	--
	06/19/14	ND(1)	1.3	--	--	--
	12/09/14	1.1	1.5	--	--	--
	03/04/15	1.1	1.1	--	--	--
	12/03/15	1.2	1.2	--	--	--
	02/19/16	1.21	1.45	--	--	--
	02/23/17	0.896	1.58	ND(1)	ND(1)	ND(0.15)
	02/23/17	0.87	1.54	--	--	--
	12/12/17	0.84	1.37	ND(1)	ND(1)	ND(0.15)
	03/07/18	1	1.59	ND(1)	ND(1)	ND(0.15)
	06/06/18	0.99	2.07	ND(1)	ND(1)	ND(0.15)

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-29	09/11/18	0.88	1.9	ND(1)	ND(1)	0.17
	12/04/18	1.03	2.11	1.04	ND(1)	ND(0.15)
	03/12/19	0.878	ND(1)	ND(1)	ND(1)	0.164
	06/24/19	0.85	2.6	1.01	ND(1)	ND(0.15)
	08/14/19	0.99	2.79	1.14	ND(1)	ND(0.15)
	11/13/19	0.856	2.84	1	ND(1)	ND(0.15)
	02/12/20	0.937	3.66	1.31	ND(1)	ND(0.15)
	06/01/20	0.868	2.99	1.14	ND(1)	0.169
	08/04/20	0.596	4.04	1.19	ND(1)	ND(0.15)
	11/10/20	0.823	2.52	1.1	ND(1)	ND(0.15)
	03/01/21	0.9	2.41	--	--	ND(0.15)
	08/25/21	0.77	2.23	--	--	ND(0.15)
	03/29/22	0.801	2.01	--	--	0.205
SMW-31	03/05/12	2.6	6.4	--	--	--
	06/26/12	2.1	6.9	--	--	--
	09/10/12	2.299999999999999	9	--	--	--
	12/03/12	1.1	11	--	--	--
	04/04/13	1.5	18	--	--	--
	06/25/13	1.6	19	--	--	--
	09/09/13	1.6	21	--	--	--
	11/14/13	1.2	20	--	--	--
	03/13/14	ND(1)	14	--	--	--
	03/13/14	ND(1)	16	--	--	--
	06/19/14	ND(1)	14	--	--	--
	09/17/14	1.2	17	--	--	--
	12/08/14	1.8	36	--	--	--
	03/04/15	1.6	32	--	--	--
	06/08/15	1.4	36	--	--	--
	09/09/15	1.9	28	--	--	--
	12/03/15	2	26	3.8	--	ND(1)
	02/18/16	1.65	32.1	--	--	--
	06/06/16	1.43	39.1	--	--	ND(1)
	09/01/16	2.31	36.8	5.37	--	ND(1)
	12/01/16	1.84 J+	28.3	4.27	--	ND(1)
	02/23/17	2.04	28.5	4.9	ND(1)	0.371
	02/23/17	2.12	28.6	--	--	--
	06/12/17	2.28	24.4	--	--	0.73

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-31	09/11/17	2.66	16.2	--	--	2.26
	12/13/17	3.58	19.1	--	--	ND(0.15)
	03/07/18	3.34	21.8	7.13	ND(1)	1.01
	06/06/18	3.59	23.6	7.98	ND(1)	0.98
	09/11/18	3.56	19.8	8.4	ND(1)	1.76
	12/05/18	3.68	18.3	8.43	ND(1)	2.11
	03/13/19	3.63	18.5	9.16	ND(1)	1.84
	06/24/19	3.52	26.3	12.8	ND(1)	0.736
	08/14/19	3.15	31.6	12.7	ND(1)	ND(0.15)
	11/12/19	3.26	27.5	11.1	ND(1)	0.671
	02/12/20	3.47	31.5	13.4	ND(1)	0.661
	06/01/20	2.94	39.2	12.1	ND(1)	0.755
	08/04/20	2.87	45.2	13.1	ND(1)	0.341
	11/11/20	2.7	44	12.8	ND(1)	0.509
	03/03/21	3.73	36.1	--	--	ND(0.15)
	08/26/21	3.22	27.7	--	--	--
	03/29/22	3.83	17.1	--	--	--
SMW-32	03/06/12	9	ND(1)	--	--	--
	03/06/12	9.699999999999999	ND(1)	--	--	--
	06/26/12	16	ND(1)	--	--	--
	09/10/12	ND(1)	ND(1)	--	--	--
	12/06/12	28	ND(1)	--	--	--
	04/04/13	85	ND(2)	--	--	--
	04/04/13	78	ND(1)	--	--	--
	06/24/13	110	ND(2)	--	--	--
	09/09/13	12	ND(1)	--	--	--
	11/14/13	3.399999999999999	ND(1)	--	--	--
	03/12/14	16	ND(1)	--	--	--
	06/18/14	3	ND(1)	--	--	--
	09/17/14	5.599999999999999	ND(1)	--	--	--
	12/08/14	ND(1)	ND(1)	--	--	--
	03/04/15	ND(1)	ND(1)	--	--	--
	06/08/15	18	ND(1)	--	--	--
	07/27/15	15 J-	--	--	--	--
	09/09/15	ND(1)	ND(1)	--	--	--
	12/02/15	ND(1)	ND(1)	--	--	--
	02/18/16	1.03	ND(1)	--	--	--

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-32	06/06/16	29.6	ND(1)	--	--	ND(1)
	09/01/16	ND(0.4)	ND(1)	ND(1)	--	ND(1)
	12/01/16	1.51 J+	ND(1)	ND(1)	--	ND(1)
	02/24/17	24.4	ND(1)	--	--	ND(0.15)
	06/12/17	17.7	ND(1)	--	--	ND(0.15)
	09/11/17	16.7	ND(1)	--	--	ND(0.15)
	03/06/18	10	ND(1)	--	--	--
	09/26/18	5.76	ND(1)	--	--	--
	03/20/19	ND(0.4)	ND(1)	--	--	--
	09/30/19	2.16	ND(1)	--	--	--
	02/10/20	1.15	ND(1)	--	--	--
	08/04/20	28.1	ND(1)	--	--	--
	03/03/21	9.91	ND(1)	--	--	--
	08/27/21	10.3	ND(1)	--	--	--
	03/29/22	22	ND(1)	--	--	--
SMW-35	09/12/17	0.75	22.5	4.36	ND(1)	0.23
	12/13/17	2.91	21.4	--	--	ND(0.15)
	03/07/18	3.61	30.4	8.06	ND(1)	ND(0.15)
	06/06/18	3.95	34.2	8.43	ND(1)	ND(0.15)
	09/11/18	3.69	30.6	9.14	ND(1)	1.52
	12/05/18	3.7	25.7	10.9	ND(1)	3.52
	03/13/19	3.71	18.2	14.5	ND(1)	5.14
	06/25/19	3.77	32.6	14.8	ND(1)	2.68
	08/13/19	3.61	40.5	14.1	ND(1)	ND(0.15)
	11/13/19	1.68	19.7	7.4	ND(1)	1.49
	02/12/20	3.99	37.7	15	ND(1)	3.46
	06/02/20	2.77	39	9.12	ND(1)	3.42
	08/04/20	3.67	35.2	9.53	ND(1)	4.38
	11/11/20	2.13	32.4	7.26	ND(1)	1.79
	03/02/21	3.21	28.5	--	--	1.38
	08/26/21	2.66	31.3	--	--	--
	03/29/22	1.36	17	--	--	--
	06/21/22	3.34	20.4	--	--	--
SMW-36	09/30/19	1.6	ND(1)	--	--	--
	11/12/19	1.26	1.02	--	--	--
	02/10/20	1.63	1.05	--	--	--
	06/01/20	1.09	1.3	--	--	4.76

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-36	08/04/20	0.912	1.29	--	--	3.11
	11/10/20	0.845	2.04	--	--	1.1
	03/02/21	1.69	3.7	--	--	3.59
	06/22/21	1.49	5.22	--	--	--
	08/25/21	1.68	7.61	--	--	--
	11/15/21	1.77	9.78	--	--	--
	03/29/22	1.94	12.1	--	--	--
SMW-I-1	03/06/12	4.299999999999999	46	--	--	ND(1)
	06/26/12	ND(1)	44	--	--	--
	09/10/12	1.2	61	--	--	--
	12/06/12	3.5	35	--	--	--
	04/04/13	4	38	--	--	ND(1)
	06/25/13	3.799999999999999	36	--	--	--
	09/09/13	3.399999999999999	35	--	--	--
	11/14/13	2.799999999999999	32	--	--	--
	03/13/14	3.799999999999999	35	--	--	ND(1)
	06/19/14	3.2	35	--	--	--
	09/17/14	4.4	39	--	--	--
	12/09/14	5.099999999999999	55	--	--	--
	03/05/15	7.3	110	--	--	ND(2)
	06/08/15	1.5	12	--	--	--
	09/09/15	ND(1)	10	--	--	--
	12/02/15	1.2	11	1.6	--	ND(1)
	02/19/16	4.65	65.5	--	--	ND(1)
	09/01/16	ND(0.4)	9.96	1.32	--	ND(1)
	02/23/17	5.22	13.8	2.53	ND(1)	0.394
	02/24/17	4.78	13.1	--	--	ND(0.15)
	09/11/17	3.03	73.2	--	--	ND(0.15)
	12/12/17	3.94	69.8	17.8	ND(1)	ND(0.15)
	03/12/18	3.68	45.3	11	ND(1)	0.16
	06/06/18	3.42	83.6	19.5	ND(1)	ND(0.15)
	09/26/18	2.86	53.1	13.9	ND(1)	0.16
	12/04/18	2.53	54.3	13.5	ND(1)	ND(0.15)
	03/13/19	3.07	25.6	6.56	ND(1)	ND(0.15)
	06/25/19	4.01	34.1	7.79	ND(1)	ND(0.15)
	08/13/19	4.22	40.9	9.59	ND(1)	ND(0.15)
	11/13/19	2.99	51.3	11.9	ND(1)	ND(0.15)

Notes:

TABLE 1. 2012-2022 SI MONITORING WELL ANALYTICAL DATA

Location ID	Date Sampled	Benzene (ug/L)	Trichloro- ethene (ug/L)	cis-1,2- Dichloro- ethene (ug/L)	1,1-Dichloro- ethene (ug/L)	Vinyl Chloride (ug/L)
SMW-I-1	02/12/20	4.77	16.9	4.71	ND(1)	ND(0.15)
	06/02/20	3.95	44.4	10.2	ND(1)	0.171
	08/04/20	4.73	26.8	6.5	ND(1)	0.158
	11/11/20	4.74	32.9	6.98	ND(1)	ND(0.15)
	03/03/21	4.12	62	--	--	ND(0.15)
	08/26/21	3.62	53.1	--	--	ND(0.15)
	03/29/22	3.56	41.6	--	--	ND(0.15)

Notes:

TABLE 2. GROUNDWATER EFFECTIVENESS MONITORING PLAN

Monitoring Well	Location	Field Parameters	EPA 8260	EPA 6000 Series	EPA 6000 Series	EPA 9056	EPA 9060	EPA 310.2	EPA 130.1
		pH, DO, ORP, Conductivity, temperature	BTEX, TCE, VC	Total Ca, Fe, Mg, Mn	Dissolved Ca, Fe, Mg, Mn	Sulfate & Nitrate	Total Organic Carbon	Alkalinity	Hardness Total as CaCO3
SMW-09	Downgradient sample locations	Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
SMW-29		Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
SMW-36		Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
SMW-31	Injection area/near injection area sample locations	Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
SMW-35		Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
SMW-21A		Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
IWS-6	Upgradient sample locations	Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
SMW-06		Quarterly[1]	Quarterly[1]	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly

Notes:

Quarterly[1] - Increase to quarterly sampling for two field seasons.

PlumeStop sampling includes: SMW-06, -09,-21A, -29, -31, -35, -36, and IWS-6.

FIGURES

SITE LOCATION

ALASKA

QUADRANGLE LOCATION

N

0 2,000'

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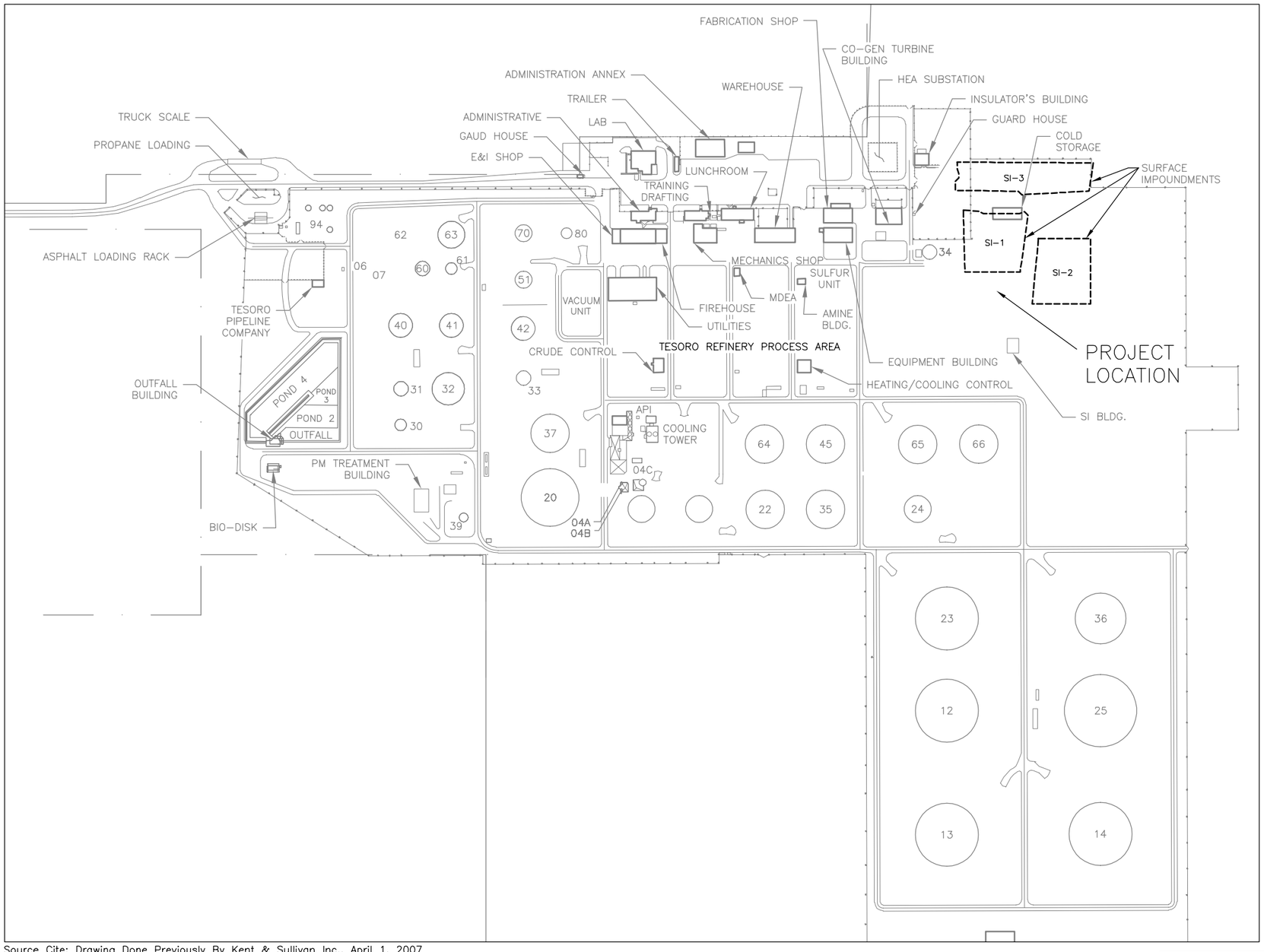
FIGURE 1

SITE LOCATION MAP

TESORO KENAI REFINERY
KENAI, ALASKA

Drawn By: RJ	Checked By: SP	Scale: 1" = 2,000'	Date: 3/12/2019	File: 36C-KENAI-SITELOCATIONMAP

\\TRIHYDRO.COM\CLIENTS\STOV\TESORO\CADD\KENAIREFINERY_COREFILES_BASEMAPS\36C-KENAI-SITELOCATIONMAP



Source Cite: Drawing Done Previously By Kent & Sullivan Inc., April 1, 2007

0 400'
APPROXIMATE

N

EXPLANATION

API	AMERICAN PETROLEUM INSTITUTE
BLDG.	BUILDING
E&I	ELECTRICAL AND INSTRUMENTATION
HEA	HOMER ELECTRIC ASSOCIATION
MDEA	METHYL DIETHANOLAMINE
PM	PHILLIPS MARATHON
SI	SURFACE IMPOUNDMENT

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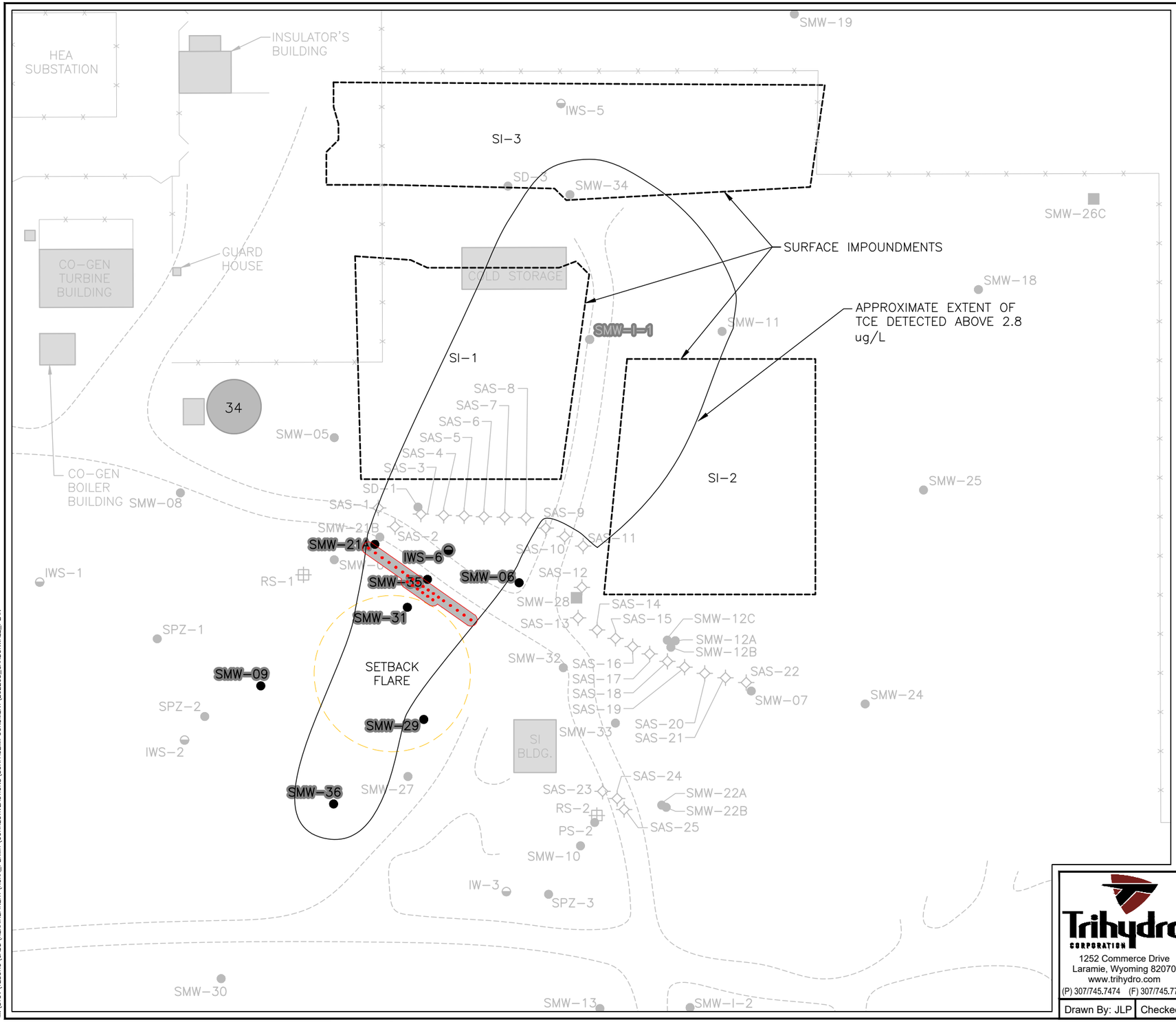
FIGURE 2

FACILITY LAYOUT

TESORO KENAI REFINERY
KENAI, ALASKA

Drawn By: RJ	Checked By: BF	Scale: 1" = ~400'	Date: 8/15/2022	File: 202208_CARBONWALL_FACILITY_LAY

M:\STOV\TESORO\CADD\KENAIREFINERY\RCRA_PERMIT\CORRECTIVEACTIONS\SURFACEIMPOUNDMENT\202208_CARBONWALL_FACILITY_LAYOUT



EXPLANATION

SMW-35	PILOT STUDY MONITORING WELL LOCATION AND DESIGNATION
●	PLANNED CARBON INJECTION POINT
SMW-19	MONITORING WELL AND DESIGNATION
RS-1	RECOVERY WELL AND DESIGNATION
SAS-22	AIR SPARGE WELL AND DESIGNATION
SMW-26C	DEEP MONITORING WELL AND DESIGNATION
IWS-5	INJECTION WELL AND DESIGNATION
- - - - -	FLARE RADIUS: 75 FEET
- - - - -	ROAD (APPROXIMATE)
x x	FENCE
	BUILDING, TANK, OR OTHER STRUCTURE
BLDG.	BUILDING
HEA	HOMER ELECTRIC ASSOCIATION
SI	SURFACE IMPOUNDMENT

N

0 100'

APPROXIMATE

M:_STOV_TESORO_CADD_KENAIREFINERY_RCRA_PERMIT_CORRECTIVEACTIONS_SURFACEIMPOUNDMENT_202208_CARBONWALL_PLAN

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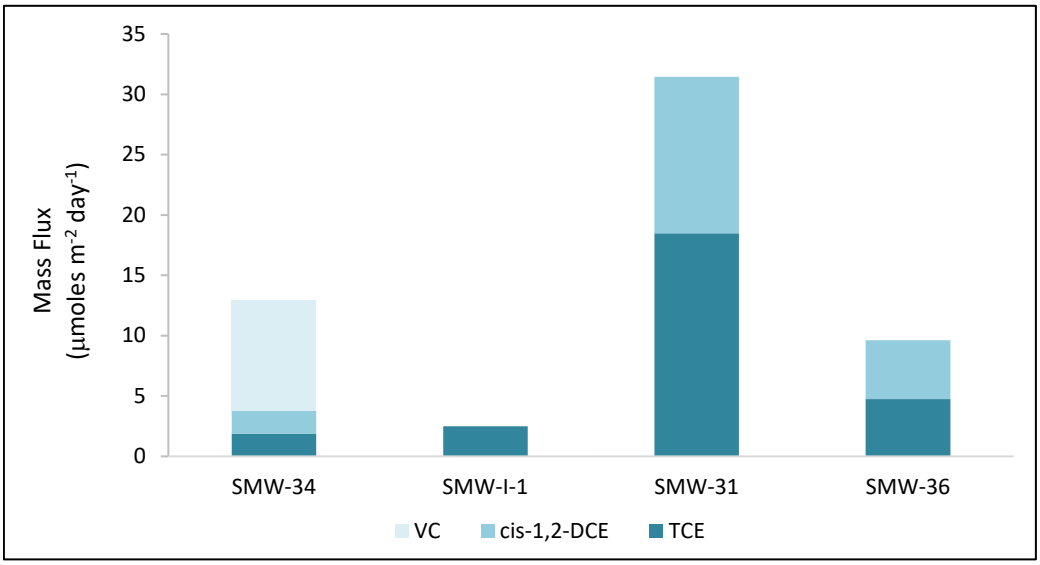
FIGURE 3

SITE PLAN AND INJECTION LAYOUT

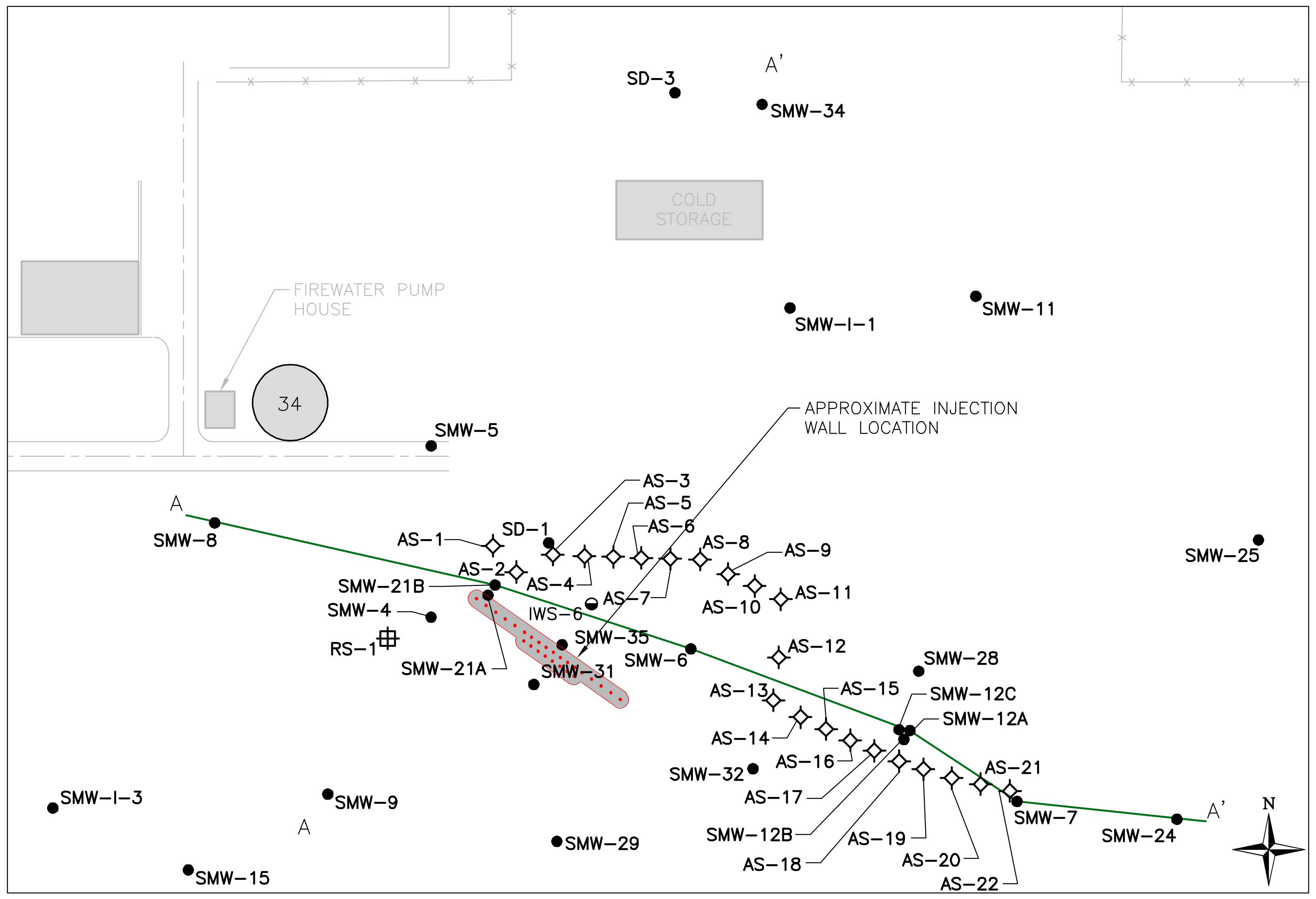
KENAI MARATHON REFINERY
KENAI, ALASKA

Drawn By: JLP	Checked By: BM	Scale: 1" = ~100'	Date: 8/30/2022	File: 202208_CARBONWALL_PLAN

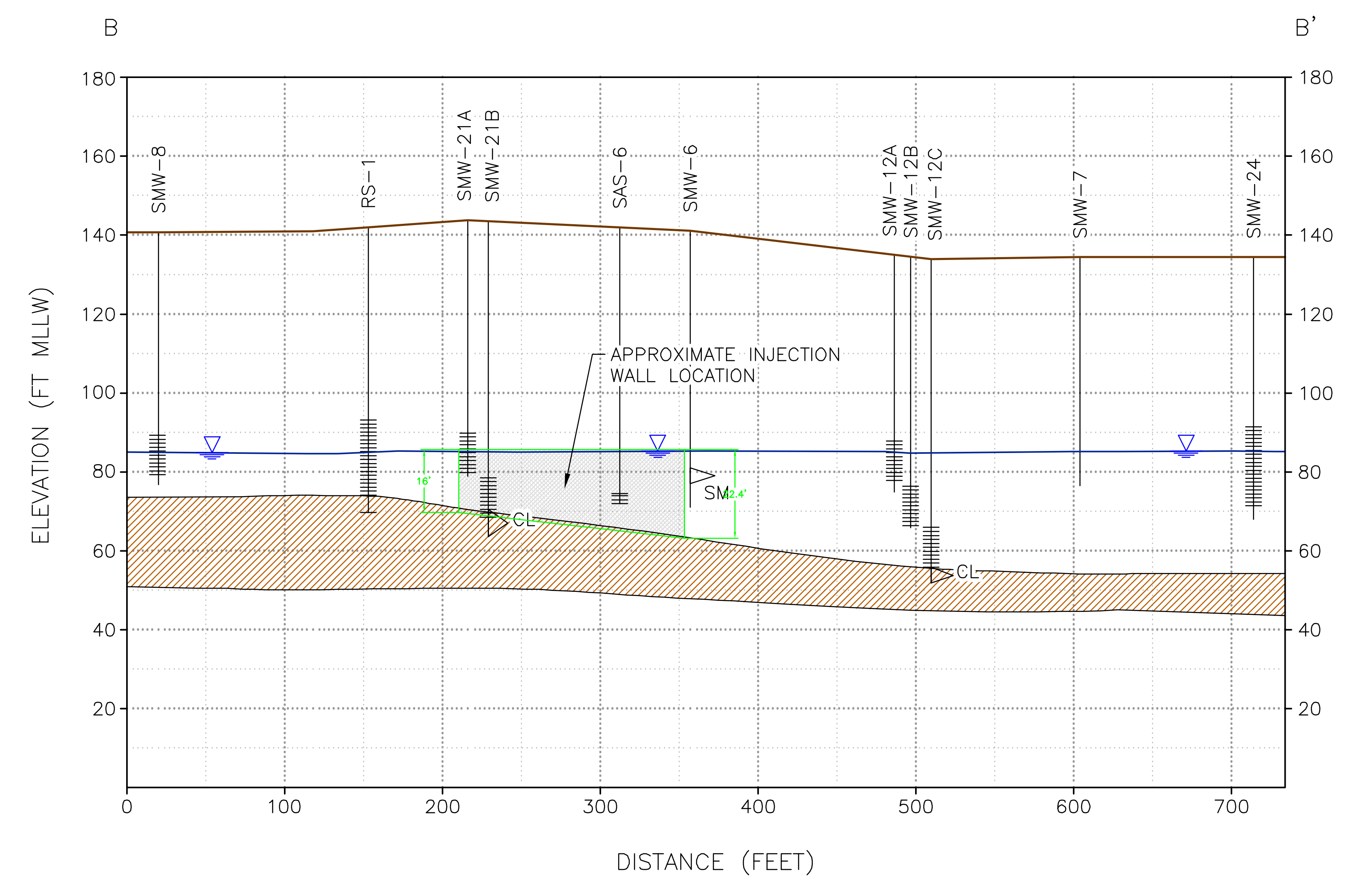
FIGURE 4. MEASURED MASS FLUXES FOR TCE AND DAUGHTER PRODUCTS
KENAI MARATHON REFINERY, KENAI, ALASKA



Notes:
µmol m^{-2} day^{-1}: micromoles per square meter per day cis-1,2-DCE: cis-1,2-dichloroethene
TCE: trichloroethene
VC: vinyl chloride



1 **GEOLOGIC CROSS SECTION LOCATION MAP**
SCALE: 1" = 100'
0 100'



A **CROSS SECTION (A-A')**
SCALE: H: 1" = 100' V: 1" = 40'
0 100' HORIZONTAL
0 40' VERTICAL
VERTICAL EXAGGERATION = 2.5X

EXPLANATION

- SMW-24 — WELL DESIGNATION
- MONITORING WELL OR BORING
- MONITORING WELL SCREENED INTERVAL
- STATIC WATER LEVEL (FT MLLW)
- GROUND SURFACE
- UNCONFINED AQUIFER WATER TABLE (APRIL 1998)
- UPPER CONFINED AQUIFER POTENTIOMETRIC SURFACE (APRIL 1998)
- MAIN AQUITARD (MASSIVE AND VARVED CLAY AND UNDIFFERENTIATED SEQUENCES)
- MAIN AQUITARD (INTERBEDDED CLAY, SILT, SILTY SAND, AND SAND)
- CL — CLAY (LOW PLASTICITY)
- FT MLLW — FEET MEAN LOWER LOW WATER
- SM — SILTY SAND
- SMW-35 — PROPOSED MONITORING WELL AND DESIGNATION
- IWS-6 — PROPOSED INJECTION WELL AND DESIGNATION
- SMW-24 — MONITORING WELL AND DESIGNATION
- RS-1 — RECOVERY WELL AND DESIGNATION
- AS-22 — AIR SPARGE WELL AND DESIGNATION
- A — A' — CROSS SECTION (A-A')
- B — B' — CROSS SECTION (B-B')
- FENCE
- ROAD (CENTERLINE)
- 34 — BUILDING, TANK, OR OTHER STRUCTURE
- SI — SURFACE IMPOUNDMENT

NOTES:

1. BASE MAP AND DATA SOURCE; KENT & SULLIVAN, INC., JULY 10, 1998.
2. GROUNDWATER ELEVATION BASED ON DECEMBER 2015 GAUGING.

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FIGURE 5

SI CROSS SECTION AND INJECTION AREA

KENAI MARATHON REFINERY
KENAI, ALASKA

Drawn By: RJ	Checked By: BF	Scale: AS SHOWN	Date: 8/14/2022	File: 202208_CARBONWALL_SECTION

APPENDIX A

REGENESIS DESIGN AND MATERIALS FACT SHEETS

REGENESIS®

To: Chris Schultz (Trihydro)

From: Andrew Punsoni (Pacific Northwest District Technical Manager)
APunsoni@regenesis.com; 503-504-1399

Ryan Hardenburger (Design Specialist)
RyanH@regenesis.com; 949-342-4982

Date: August 19, 2022

Subject: **Revised Design and Cost Estimate for the Marathon Refinery in Kenai, AK**

Chris,

We appreciate the opportunity to evaluate this project and provide this revised remedial design for the Marathon Refinery in Kenai, AK. We have provided a cost estimate for a single 125-ft permeable reactive barrier (PRB) with 1 to 2 rows of direct push injection points to install the remediation materials cross-gradient to the direction of groundwater flow. Our understanding of your treatment goal for this application is to treat low-level TCE, 12DCE, and VC concentrations in groundwater within the barrier reactive zone and prevent the plume from spreading past the barrier line.

Revisions 8/19/2022: Decreased vertical interval thickness to 20 feet. This reduced the total injection volume from 29,500 gallons to 23,600 gallons. Product quantities decreased as well.

This design was modeled for at least a 7-year lifespan for both PlumeStop and S-MZVI (reduced from 10-year lifespan to match project budget). Because only a single PFM sample was collected within the proposed barrier location, we recommend installing a Passive Flux Meter across the saturated screen interval in well SMW-35 to collect additional mass flux data with samples collected every 1-2 feet. This will provide greater resolution on the contaminant mass distribution across the target treatment zone. We have found that contaminant mass is typically unevenly distributed across a vertical cross-section of a plume and we design to prioritize high mass flux zones that could be present by targeting them with increased volumes of PlumeStop and S-MZVI. These discrete high mass flux zones can be missed when looking at the bulk average of mass flux across a large screen interval.

Other design verification elements that should be considered before proceeding to a full-scale level are continuous core samples across the 125-ft barrier length to characterize the soils (for example, identifying top of clay layer at the bottom of the target treatment zone). A clear water injection test (1,500-2,500 gallons of water injected into the target treatment zone) may be valuable as well to assess the aquifer's volumetric acceptance rates.

Revised Design

"Barrier Centerline" is intended to be injected upgradient of your performance monitoring well (~10-15 ft). This design uses two rows of injection points on 6.0-ft spacing within rows and 6.0-ft spacing between rows.

Project Info

Marathon Kenai Refinery
Kenai, AK
Revised Design - Barrier Centerline
Prepared For:
Chris Schultz (Trihydro)

Target Treatment Zone (TTZ) Details	Unit	Value
Barrier Length	ft	50
Top of Application Depth	ft bgs	55.0
Bottom of Application Depth	ft bgs	75.0
Vertical Treatment Interval	ft	20.0
Treatment Zone Volume	ft^3	10,000
Treatment Zone Volume	cy	370
Soil Type	---	sand
Porosity	cm^3/cm^3	0.33
Effective Porosity	cm^3/cm^3	0.25
Treatment Zone Pore Volume	gal	24,686
Treatment Zone Effective Pore Volume	gal	18,701
Treatment Zone Pore Volume	liters	93,445
Treatment Zone Effective Pore Volume	liters	70,792
Fraction Organic Carbon (foc)	g/g	0.001
Soil Density	g/cm^3	1.7
Soil Density	lb/ft^3	103
Soil Weight	lb	1.0E+06
Darcy Speed	ft/yr	50
Seepage Velocity	ft/yr	200

PlumeStop® and S-MZVI® Application Design Summary

Revised Design - Barrier Centerline

Design Details		Technical Notes
Treatment Type	**Barrier**	Estimated Product Radius-of-Influence from Injection Point (feet)
Barrier Width Perpendicular to Flow (ft)	50.0	**3.4**
Spacing Within Rows (ft)	6.0	
Number of Rows	2	
DPT Injection Points	**17**	PlumeStop Injection Concentration (mg/L)
Top of Application Depth (ft bgs)	55.0	**12,324**
Bottom of Application Depth (ft bgs)	75.0	
PlumeStop to be Applied (lb)	**6,000**	Injection Point Spacing Between Rows (ft)
PlumeStop to be Applied (gal)	666	**6.0**
In Situ Chemical Reduction - S-MZVI		
S-MZVI to be added to PlumeStop (lb)	**3,100**	
S-MZVI to be added to PlumeStop (gal)	205	
PlumeStop + S-MZVI Volume Totals		
Mixing Water (gal)	11,002	
Total Application Volume (gal)	**11,900**	***The proposed injection volumes shown in this table may change based upon product distribution observations made while injecting.***
Injection Volume per Point (gal)	700	
Injection Volume per Point per Foot (gal/ft)	35	

"Barrier Margins" is intended to be injected on the edges of the "Barrier Centerline" area. This design uses a single row of injection points on 8.0-ft spacing. Note: we don't recommend injecting PlumeStop at > 8.0 ft spacing.

Project Info

Marathon Kenai Refinery
Kenai, AK
Revised Design - Barrier Margins
Prepared For:
Chris Schultz (Trihydro)

Target Treatment Zone (TTZ) Details	Unit	Value
Barrier Length	ft	75
Top of Application Depth	ft bgs	55.0
Bottom of Application Depth	ft bgs	75.0
Vertical Treatment Interval	ft	20.0
Treatment Zone Volume	ft^3	10,500
Treatment Zone Volume	cy	389
Soil Type	---	sand
Porosity	cm^3/cm^3	0.33
Effective Porosity	cm^3/cm^3	0.25
Treatment Zone Pore Volume	gal	25,920
Treatment Zone Effective Pore Volume	gal	19,636
Treatment Zone Pore Volume	liters	98,118
Treatment Zone Effective Pore Volume	liters	74,331
Fraction Organic Carbon (foc)	g/g	0.001
Soil Density	g/cm^3	1.7
Soil Density	lb/ft^3	103
Soil Weight	lb	1.1E+06
Darcy Speed	ft/yr	38
Seepage Velocity	ft/yr	150

PlumeStop® and S-MZVI® Application Design Summary

Revised Design - Barrier Margins

Design Details		Technical Notes
Treatment Type	**Barrier**	Estimated Product Radius-of-Influence from Injection Point (feet)
Barrier Width Perpendicular to Flow (ft)	75.0	**4.6**
Spacing Within Rows (ft)	8.0	
Number of Rows	1	
DPT Injection Points	**9**	PlumeStop Injection Concentration (mg/L)
Top of Application Depth (ft bgs)	55.0	**12,523**
Bottom of Application Depth (ft bgs)	75.0	
PlumeStop to be Applied (lb)	**6,000**	~~Injection Point Spacing Between Rows (ft)~~
PlumeStop to be Applied (gal)	666	**~~0.0~~**
In Situ Chemical Reduction - S-MZVI		
S-MZVI to be added to PlumeStop (lb)	**2,900**	
S-MZVI to be added to PlumeStop (gal)	192	
PlumeStop + S-MZVI Volume Totals		
Mixing Water (gal)	10,817	
Total Application Volume (gal)	**11,700**	***The proposed injection volumes shown in this table may change based upon product distribution observations made while injecting.***
Injection Volume per Point (gal)	1,300	
Injection Volume per Point per Foot (gal/ft)	65	

PlumeStop

PlumeStop is composed of micron-scale colloidal activated carbon that has been milled to 1 to 3 µm per particle and mixed with a proprietary biodegradable polymer to prevent particle agglomeration. This formulation allows the colloidal activated carbon to be injected under low pressure to provide uniform and controlled distribution within the conductive zones of the aquifer. The result is a permeable reactive zone that allows groundwater to flow through the activated carbon without affecting the hydraulic conductivity of the aquifer and sorb the dissolved phase mass from the groundwater.

S-MZVI

Zero valent iron (ZVI) technology rapidly destroys chlorinated volatile organics by a direct chemical reaction and by stimulating anaerobic biological degradation by creating a reducing environment favorable for reductive dechlorination. In 2019, Regenesis began production of S-MZVI, which is composed of micron-scale iron particles (1 to 4 µm per particle – approximately the size of a red blood cell) that are sulfidated to provide multi-year reactivity with chlorinated hydrocarbons and which increases its stability by minimizing undesirable side reactions. Unlike commodity ZVI, S-MZVI simply requires dilution with water to apply and does not require thickeners or hydraulic fracturing equipment to apply. Due to its micron-scale particle size, S-MZVI is also applied under low pressure and can be mixed with PlumeStop into a single injectate. The co-application of PlumeStop and S-MZVI provides powerful and long-lasting contaminant destruction.

Please feel free to contact us if you need additional information or have any questions regarding our evaluation and/or this correspondence (contact information listed above).

Thank you for considering Regenesis as part of your remedial solution for this project.

Sincerely,

Andrew Punsoni
Pacific Northwest District Technical Manager
REGENESIS

Ryan Hardenburger
Design Specialist
REGENESIS

APPENDICES

(1) REGENESIS PRODUCT(S) SPECIFICATION SHEET(S)

(2) REGENESIS TERMS AND CONDITIONS

(3) REGENESIS REMEDIAL DESIGN ASSUMPTIONS AND QUALIFICATIONS

PlumeStop® Liquid Activated Carbon™ Technical Description

PlumeStop Liquid Activated Carbon is an innovative groundwater remediation technology designed to rapidly remove and permanently degrade groundwater contaminants. PlumeStop is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, binding to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

This unique remediation technology accomplishes treatment with the use of highly dispersible, fast-acting, sorption-based technology, capturing and concentrating dissolved-phase contaminants within its matrix-like structure. Once contaminants are sorbed onto the regenerative matrix, biodegradation processes achieve complete remediation at an accelerated rate.

Distribution of PlumeStop in water

To see a list of treatable contaminants with the use of PlumeStop, view the Range of Treatable Contaminants Guide.

Chemical Composition

- Water - CAS# 7732-18-5
- Colloidal Activated Carbon ≤2.5 - CAS# µm 7440-44-0
- Proprietary Additives

Properties

- Physical state: Liquid
- Form: Aqueous suspension
- Color: Black
- Odor: Odorless
- pH: 8 - 10

Storage and Handling Guidelines

Storage
Store in original tightly closed container
Store away from incompatible materials
Protect from freezing

Handling
Avoid contact with skin and eyes
Avoid prolonged exposure
Observe good industrial hygiene practices
Wash thoroughly after handling
Wear appropriate personal protective equipment

PlumeStop® Liquid Activated Carbon™ Technical Description

Applications

PlumeStop is easily applied into the subsurface through gravity-feed or low-pressure injection.

Health and Safety

Wash hands after handling. Dispose of waste and residues in accordance with local authority requirements. Please review the Material Safety Data Sheet for additional storage, usage, and handling requirements here: PlumeStop SDS.

REGENESIS

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S-MicroZVI Specification Sheet

S-MicroZVI Technical Description

S-MicroZVI™ is an *In Situ* Chemical Reduction (ISCR) reagent that promotes the destruction of many organic pollutants and is most commonly used with chlorinated hydrocarbons. It is engineered to provide an optimal source of micro-scale zero valent iron (ZVI) that is both easy to use and delivers enhanced reactivity with the target contaminants via multiple pathways. S-MicroZVI can destroy many chlorinated contaminants through a direct chemical reaction (**see Figure 1**). S-MicroZVI will also stimulate anaerobic biological degradation by rapidly creating a reducing environment that is favorable for reductive dechlorination.

S-MicroZVI is Best in Class For

- ☑ Longevity
- ☑ Kinetics
- ☑ Transport

Sulfidated ZVI

S-MicroZVI is composed of colloidal, sulfidated zero-valent iron particles suspended in glycerol using proprietary environmentally acceptable dispersants. The passivation technique of sulfidation, completed using proprietary processing methods, provides unparalleled reactivity with chlorinated hydrocarbons like PCE and TCE and increases its stability and longevity by minimizing undesirable side reactions. In addition to superior reactivity, S-MicroZVI is designed for easy handling that is unmatched by any ZVI product on the market. Shipped as a liquid suspension, S-MicroZVI requires no powder feeders, no thickening with guar, and pneumatic or hydraulic fracturing is not mandatory. When diluted with water prior to application, the resulting suspension is easy to inject using either direct push or permanent injection wells.

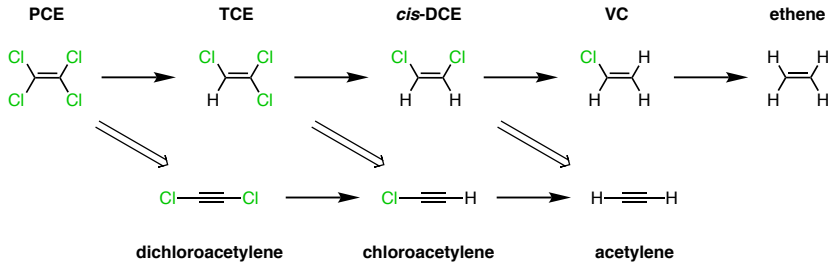

Figure 1: *Chlorinated ethene degradation pathways and products. The top pathway with single line arrows represent the reductive dechlorination (hydrogenolysis) pathway. The lower pathway with downward facing double line arrows represent the beta-elimination pathway.*

To see a list of treatable contaminants, view the S-MicroZVI treatable contaminants guide.

S-MicroZVI
Sulfidated Zero-Valent Iron

S-MicroZVI Specification Sheet

Chemical Composition

Iron, powders CAS 7439-89-6
Iron (II) sulfide CAS 1317-37-9
Glycerol CAS 56-81-8

Properties

Physical State: Liquid
Form: Viscous metallic suspension
Color: Dark gray
Odor: Slight
pH: Typically 7-9 as applied
Density: 15 lb/gal

Storage and Handling Guidelines

Storage:

- Use within four weeks of delivery
- Store in original containers
- Store at temperatures below 95F°
- Store away from incompatible materials

Handling:

- Never mix with oxidants or acids
- Wear appropriate personal protective equipment
- Do not taste or swallow
- Observe good industrial hygiene practices

Applications

S-MicroZVI is diluted with water on site and easily applied into the subsurface through low-pressure injections. S-MicroZVI can also be mixed with products like 3-D Microemulsion® or PlumeStop® prior to injection.

Health and Safety

The material is relatively safe to handle; however, avoid contact with eyes, skin and clothing. OSHA Level D personal protection equipment including: vinyl or rubber gloves and eye protection are recommended when handling this product. Please review the Safety Data Sheet for additional storage, and handling requirements here: S-MicroZVI SDS.

REGENESIS®

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Terms and Conditions
Products and Services

1. PAYMENT TERMS. Net 30 Days. Accounts outstanding after 30 days will be assessed 1.5% monthly interest. Volume discount pricing will be rescinded on all accounts outstanding over 90 days. An early payment discount of 1.5% Net 10 is available for cash or check payments only. We accept Master Card, Visa and American Express.

2. **RETURN POLICY.** A 15% re-stocking fee will be charged for all returned goods. All requests to return product must be pre-approved by seller. Returned product must be in original condition and no product will be accepted for return after a period of 90 days.

3 FORCE MAJEURE. Seller shall not be liable for delays in delivery or services or failure to manufacture or deliver due to causes beyond its reasonable control, including but not limited to acts of God, acts of buyer, acts of military or civil authorities, fires, strikes, flood, epidemic, war, riot, delays in transportation or car shortages, or inability to obtain necessary labor, materials, components or services through seller's usual and regular sources at usual and regular prices. In any such event Seller may, without notice to buyer, at any time and from time to time, postpone the delivery or service dates under this contract or make partial delivery or performance or cancel all or any portion of this and any other contract with buyer without further liability to buyer. Cancellation of any part of this order shall not affect Seller's right to payment for any product delivered or service performed hereunder.

4. LIMITED WARRANTY. Seller warrants the product(s) sold and services provided as specified on face of invoice, solely to buyer. Seller makes no other warranty of any kind respecting the product and services, and expressly DISCLAIMS ALL OTHER WARRANTIES OF WHATEVER KIND RESPECTING THE PRODUCT AND SERVICES, INCLUDING ALL WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE AND NON-INFRINGEMENT.

5. DISCLAIMER. Where warranties to a person other than buyer may not be disclaimed under law, seller extends to such a person the same warranty seller makes to buyer as set forth herein, subject to all disclaimers, exclusions and limitations of warranties, all limitations of liability and all other provisions set forth in the Terms and Conditions herein. Buyer agrees to transmit a copy of the Terms and Conditions set forth herein to any and all persons to whom buyer sells, or otherwise furnishes the products and/or services provided buyer by seller and buyer agrees to indemnify seller for any liability, loss, costs and attorneys' fees which seller may incur by reason, in whole or in part, of failure by buyer to transmit the Terms and Conditions as provided herein.

6. LIMITATION OF SELLER'S LIABILITY AND LIMITATION OF BUYER'S REMEDY. Seller's liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from the manufacture, sale, delivery, resale, repair or use of any goods or performance of any services covered by or furnished hereunder, shall in no case exceed the lesser of (1) the cost of repairing or replacing goods and repeating the services failing to conform to the forgoing warranty or the price of the goods and/or services or part thereof which gives rise to the claim. IN NO EVENT SHALL SELLER BE LIABLE FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING LOST PROFITS, OR FOR DAMAGES IN THE NATURE OF PENALTIES.

7. INDEMNIFICATION. Buyer agrees to defend and indemnify seller of and from any and all claims or liabilities asserted against seller in connection with the manufacture, sale, delivery, resale or repair or use of any goods, and performance of any services, covered by or furnished hereunder arising in whole or in part out of or by reason of the failure of buyer, its agents, servants, employees or customers to follow instructions, warnings or recommendations furnished by seller in connection with such goods and services, by reason of the failure of buyer, its agents, servants, employees or customers to comply with all federal, state and local laws applicable to such goods and services, or the use thereof, including the Occupational Safety and Health Act of 1970, or by reason of the negligence or misconduct of buyer, its agents, servants, employees or customers.

8. EXPENSES OF ENFORCEMENT. In the event seller undertakes any action to collect amounts due from buyer, or otherwise enforce its rights hereunder, Buyer agrees to pay and reimburse Seller for all such expenses, including, without limitation, all attorneys and collection fees.

9. TAXES. Liability for all taxes and import or export duties, imposed by any city, state, federal or other governmental authority, shall be assumed and paid by buyer. Buyer further agrees to defend and indemnify seller against any and all liabilities for such taxes or duties and legal fees or costs incurred by seller in connection therewith.

10. ASSISTANCE AND ADVICE. Upon request, seller in its discretion will furnish as an accommodation to buyer such technical advice or assistance as is available in reference to the goods and services. Seller assumes no obligation or liability for the advice or assistance given or results obtained, all such advice or assistance being given and accepted at buyer's risk.

11. SITE SAFETY. Buyer shall provide a safe working environment at the site of services and shall comply with all applicable provisions of federal, state, provincial and municipal safety laws, building codes, and safety regulations to prevent accidents or injuries to persons on, about or adjacent to the site.

12. INDEPENDENT CONTRACTOR. Seller and Buyer are independent contractors and nothing shall be construed to place them in the relationship of partners, principal and agent, employer/employee or joint ventures. Neither party will have the power or right to bind or obligate the other party except as may be expressly agreed and delegated by other party, nor will it hold itself out as having such authority.

13. REIMBURSEMENT. Seller shall provide the products and services in reliance upon the data and professional judgments provided by or on behalf of buyer. The fees and charges associated with the products and services thus may not conform to billing guidelines, constraints or other limits on fees. Seller does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where seller may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by seller, it is the sole responsibility of the buyer or other entity seeking reimbursement to ensure the products and services and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, seller does not knowingly present or cause to be presented any claim for payment to the Government.

14. APPLICABLE LAW/JURISDICTION AND VENUE. The rights and duties of the parties shall be governed by, construed, and enforced in accordance with the laws of the State of California (excluding its conflict of laws rules which would refer to and apply the substantive laws of another jurisdiction). Any suit or proceeding hereunder shall be brought exclusively in state or federal courts located in Orange County, California. Each party consents to the personal jurisdiction of said state and federal courts and waives any objection that such courts are an inconvenient forum.

15. ENTIRE AGREEMENT. This agreement constitutes the entire contract between buyer and seller relating to the goods or services identified herein. No modifications hereof shall be binding upon the seller unless in writing and signed by seller's duly authorized representative, and no modification shall be effected by seller's acknowledgment or acceptance of buyer's purchase order forms containing different provisions. Trade usage shall neither be applicable nor relevant to this agreement, nor be used in any manner whatsoever to explain, qualify or supplement any of the provisions hereof. No waiver by either party of default shall be deemed a waiver of any subsequent default.

Remedial Design Assumptions and Qualifications

Cost Estimate Disclaimer: The cost listed assumes conditions set forth within the proposed scope of work and assumptions and qualifications. Changes to either could impact the final cost of the project. This may include final shipping arrangements, sales tax or application related tasks such as product storage and handling, access to water, etc. If items listed need to be modified, please contact Regenesis for further evaluation.

Shipping Estimates: Shipping estimates are valid for 30 days. All shipping charges are estimates and actual freight charges are calculated at the time of invoice. Additional freight charges may be assessed for any accessorial requested at the time of delivery. The estimate included within assumes standard shipping.

Standard delivery is between 8am -5pm Monday –Friday. *accessorial – can include, but not limited to lift gate and pallet jack at delivery, inside delivery, time definite deliveries, and delivery appointments.

Please communicate any requirements for delivery with the customer service department at the time the order is placed.

Return Policy: To initiate a return please contact your local sales manager for an RMA. A 15% re-stocking fee will be charged for all returned goods. Return freight must be prepaid. All requests to return product must be in original condition and no product will be accepted for return after 90 days from date of delivery.

Professional Judgement: In generating this estimate, REGENESIS relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s), and in reliance upon REGENESIS' prior experience on similar project sites. The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, *it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission*. When serving as a supplier or subcontractor to an entity which seeks reimbursement from Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the government.