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Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

Memorandum

To: Sunny Becker, Washington State Department of Ecology
Copies: Bob Code and Glen Dodge, Cascade Columbia
From: Tom Colligan, Floyd|Snider
Date: December 31, 2013
Project: Fox Ave-RA, Task 7
Re: **Biopolish Treatment Plan**

Full-scale electrical resistance heating (ERH) system operation (thermal), which consisted of power application to five treatment areas at the Fox Avenue Site (Site) in Seattle, Washington (Figure 1), commenced on January 8, 2013, and was completed by May 31, 2013. Per the requirements of the final Engineering Design Report (EDR) dated October 9, 2012, this Biopolish Treatment Plan is being submitted to the Washington State Department of Ecology (Ecology) to provide details of the planned post-thermal enhanced reductive dechlorination (ERD) remedial activities in the thermally treated areas at the Site. As discussed in the EDR, bacterial activity should be greatly accelerated if ERD is applied to the warm soil conditions after thermal treatment. The addition of substrate in these areas will lead to rapid declines in the residual concentrations of chlorinated compounds remaining after thermal treatment.

POST-THERMAL CONDITIONS

Soil Quality

Compliance soil samples were collected by Floyd|Snider in two stages, with the first stage occurring midway through the heating process in March 2013 and the second stage occurring in mid-May 2013 after 83 percent of the design energy for the ERH system was applied. During the 10 days of sampling, a total of 134 soil samples from 43 borings were analyzed. Results indicated that the average of the sums of trichloroethene (TCE) and tetrachloroethene (PCE) concentrations (PCE+TCE) in all of the treated areas of the Site had been reduced to much less than the soil remediation level of 10 parts per million (ppm) for average PCE+TCE concentration. Nearly all of the residual soil mass was found to occur in vadose zone soils in the Flammables Shed. These areas were further treated using soil vapor extraction as detailed in the monthly reports. Pre- and post-thermal soil concentrations of PCE+TCE are shown on Figure 2.

Groundwater Quality

On August 28, 2013, Floyd|Snider personnel collected 10 Geoprobe™ groundwater samples from seven locations throughout the thermal treatment areas to assess post-thermal groundwater conditions. On November 4 and 5, 2013, they collected an additional 20

Geoprobe™ groundwater samples from eight locations throughout the thermal treatment areas, one groundwater sample from an existing well (MW-14), and one sample from the 2nd Water Bearing Zone (WBZ) in the Loading Dock Area (Note: the 2nd WBZ in the Loading Dock Area was not subjected to thermal treatment but underwent ERD injections until the injection well in that area was abandoned before thermal operations began).

Samples were collected at depths ranging from 9 to 20 feet below ground surface (bgs) in the 1st WBZ and from depths ranging from 30 to 65 feet bgs in the 2nd WBZ. At some locations, multiple samples were collected at varying depths.

Groundwater samples were collected using temporary 4-foot-long stainless steel well screens inserted into the Geoprobe™ rods at specified depths. The samples were collected by means of a peristaltic pump and disposable polyethylene tubing. The filled sample vials were submitted to Fremont Analytical Laboratories for analysis by U.S. Environmental Protection Agency (USEPA) Method 8260. The results for all detected analytes from both groundwater sampling events are included in Table 1 along with the sample temperatures. The PCE and TCE concentrations, vinyl chloride (VC) and cis-1,2-dichloroethene (DCE) concentrations, and the summed concentrations of all chlorinated volatile organic compounds (CVOC) concentrations are shown on Figures 3 through 5, respectively.

The remediation level for total CVOCs at this Site is 250 micrograms per liter (µg/L), with the point of compliance being along Fox Avenue. Results indicate significant progress in terms of achieving the remediation level, especially for PCE and TCE for which concentrations in excess of the remediation level are now limited primarily to the Loading Dock Area (both 1st and 2nd WBZ) and one location in the Main Source Area (location GP-PT5, 2nd WBZ only). Pre- and post-thermal PCE+TCE concentrations in the Loading Dock Area and the Main Source Area are shown in the following table:

	Loading Dock, 1st WBZ	**Main Source Area, 1st WBZ**	**Main Source Area, 2nd WBZ**
Prethermal maximum PCE+TCE (µg/L)	7,500	64,500	45,000
Post-thermal Maximum PCE+TCE (µg/L)	1,005	416	8,312
Percent change	-87	-99.3	-81

For DCE and VC, the post-thermal groundwater samples also show large reductions in concentrations, except for samples collected in the 2nd WBZ in the Main Source Area near location PT-7, where the maximum combined concentrations were similar to those before thermal treatment began, as shown in the following table:

	Loading Dock, 1st WBZ	Main Source Area, 1st WBZ	Main Source Area, 2nd WBZ
Pre-thermal maximum DCE+VC (µg/L)	20,400	27,970	50,085
Post-thermal maximum DCE+VC (µg/L)	1,840	1,225	54,900
Percent change	-91	-96	+10

Based on current post-thermal groundwater conditions, both the 1st and 2nd WBZs in the Main Source Area and the Loading Dock Area require biopolish treatment to achieve the groundwater remediation level. Specific areas for treatment have been delineated for subsequent focused substrate injections, as discussed in the section "ERD Treatment Plan."

Groundwater Temperatures

Two temperature monitoring points (TMPs) and their thermocouples were left on-site by TRS Group (TRS) to monitor underground temperatures: B14 and E18. B14 is located in the West Rail Area and reaches a depth of 17 feet. E18 is located in the Flammables Shed and reaches a depth of 65 feet. Each of these TMPs allows monitoring of subsurface groundwater temperatures at different depth intervals. On December 31, 2013, temperatures measured in B14 ranged from 31 degrees Celsius (°C) at 2 feet to 65°C at 17 feet, and temperatures measured in E18 (in November 2013) were 66.1°C at 15 feet, 57°C at 35 feet, and 61°C at 55 feet. It is generally accepted that bacteria capable of dechlorination (*Dehalococcoides* spp.) cannot thrive at temperatures greater than 50°C. Cooling to that temperature threshold is expected to occur by early 2014 across most of the thermally treated areas, with the exception of the Loading Dock Area, where the temperature is already below that threshold.

POST-THERMAL BIOPOLISH TREATMENT AREAS

Contours that define the extent of groundwater contamination in excess of the remediation level for total CVOCs (250 µg/L) in the thermally treated areas of both the 1st and 2nd WBZ are shown on Figures 6 and 7. These areas will be targeted for biopolishing, except for the eastern portion of the Flammables Shed where DCE concentrations are marginally greater than the remediation level (locations PT-1 and PT-10). Treatment is not planned for these locations because they are well upgradient of Fox Avenue (the point of compliance), and the DCE concentrations at these locations are expected to gradually diminish with time.

POST-THERMAL BIOPOLISH TREATMENT PLAN

Loading Dock Area

Biopolishing has already been started in the Loading Dock Area. It began in late October 2013 when CALIBRE Systems, Inc. (CALIBRE) installed two new injection wells (CALIBRE 2013) to take advantage of the more rapid cooling that was found in this area. The two injection wells (R1-IW16 and R1-IW21) were installed at the upgradient edge of the loading dock plume. After

well development, food-grade waste sugars were injected into the thermally treated area, followed by bioaugmentation. Bioaugmentation was accomplished by the injection of a limited amount of Site groundwater from nearby well RI-IW-7. Prior bacterial census data for groundwater from this well indicated a strong population of dechlorinating bacteria. The introduction of these bacteria into the injection wells in the Loading Dock Area inoculated the thermally treated groundwater with the correct bacteria needed for dechlorination.

Therefore, no additional wells are necessary for the thermally treated portion of the plume in the 1st WBZ in the Loading Dock Area. However, the deeper plume in the 2nd WBZ was not thermally treated and needs additional treatment by ERD. There are currently no injection wells in the 2nd WBZ in that area. Three additional injection wells will be installed, as shown on Figure 8. These wells will be installed in the warehouse, slightly upgradient of the loading dock plume to ensure that the full extent of the 2nd WBZ plume is treated. Biopolishing will involve the regular addition of soluble sugar substrate in accordance with the Fox Avenue ERD Interim Action Work Plan (FloydSnider and CALIBRE 2008).

Main Source Area

Given the relatively higher residual concentrations of CVOCs in the Main Source Area, the approach for biopolishing will involve the injection of a suitable electron donor (carbohydrate substrate) such as emulsified vegetable oil (EVO) or waste sugars in a series new injection wells aligned in three rows transverse to the axis of the plume. These new wells will form three "biobarriers," as shown on Figure 8. If EVO is used, it will provide a much longer acting substrate that will lessen the need for more frequent injections as compared to soluble sugar substrates. However, the cost for EVO is significant higher compared to that of waste sugars. A combination of EVO and soluble sugars may also be used, with EVO injected into areas of higher CVOC concentrations and soluble sugars injected into areas in which the concentrations are marginally above the remediation level. The selected substrate will be injected in 14 new injection wells constructed of 2-inch-diameter polyvinyl chloride (PVC). The wells will be spaced approximate 30 feet apart, based upon a presumed radius of influence of 15 feet for the sandy aquifer conditions at the Site. Each injection well will target either the 1st or 2nd WBZ or both. Wells in the 2nd WBZ will be screened to treat the most contaminated zone that is generally between 40 and 65 feet bgs. In locations requiring treatment in both the 1st and 2nd WBZ, two wells will be constructed in the same injection well borehole, under an approved well variance from Ecology.

EVO or waste sugars need to be diluted prior to injection to allow for greater downgradient transport in the aquifer. Dilution will be accomplished by using aquifer water until the substrate is between 5 and 10 percent strength. Nutrients or other amendments or buffers may be added as necessary to promote growth and control pH. The aquifer will also be bioaugmented with cultured bacteria (KB-1 or equivalent) to replace the bacteria killed by the thermal heating as quickly as possible. Prior to injection, Underground Injection Control permits/registration will be obtained from Ecology.

ENHANCED REDUCTIVE DECHLORINATION TREATMENT PLAN

Downgradient Plume and Northwest Corner

The last ERD injection event occurred in 2013 and included the injection of soluble sugar in wells in the Northwest (NW) Corner, along Fox Avenue, within the property boundary of Seattle Boiler Works, and in Myrtle Street. It is likely that only one more event is necessary in mid-2014. Given that the source of the plume has been significantly reduced in mass, permanent reductions in contaminant concentrations to less than the remediation level are expected in some areas. It is, therefore, possible that only limited areas of the Downgradient Plume and the NW Corner will need additional substrate. A groundwater sampling event of all monitoring wells in the Downgradient Plume and NW Corner will occur in March 2014. Data from this event will be used to identify areas needing additional ERD injections in 2014. These injections will consist of soluble sugars, consistent with those that have been performed since 2009.

Seep Area

Currently, contaminant concentrations in three of the four seeps are in compliance with the final cleanup levels. Resampling of the seeps is proposed in early April 2014 to evaluate whether contaminant concentrations in all of the seeps have achieved the cleanup levels. If not, installation of additional injection wells upgradient of the seeps will be considered, and a plan for seep treatment will be proposed to Ecology at that time.

MONITORING

Two new monitoring wells will be installed on the west side of Fox Avenue directly downgradient of the loading dock plume to measure compliance and performance (Figure 8). One well will monitor the 1st WBZ and the other will monitor the 2nd WBZ, similar to the existing well pairs along Fox Avenue. To measure performance of ERD in the Main Source Area, a total of three new well pairs will be installed at the locations shown on Figure 8. Each well pair will monitor both the 1st and 2nd WBZ. Baseline samples will be collected prior to injections, as well as quarterly to semi-annually during the first year after the injections, to monitor performance. Samples will be analyzed for the same suite of analytes as those previously reported to Ecology (e.g., VOCs, total organic carbon, ethene, ethane, methane, etc).

REPORTING

The activities described in this plan will be reported to Ecology in a comprehensive report summarizing all ERD activities conducted in 2014. This report will be prepared in the 1st quarter of 2015. Recommendations will be made for continued ERD activities as necessary.

REFERENCES

CALIBRE Systems, Inc. (CALIBRE). 2013. *Technical Memorandum ERD Expansion within the Loading Dock of the Fox Avenue Site*. 9 October.

FloydSnider and CALIBRE Systems, Inc. (CALIBRE). 2008. *Fox Avenue Site Interim Action Enhanced Reductive Dechlorination for Groundwater Work Plan*. Prepared for Fox Avenue Building LLC. 5 September.

ATTACHMENTS

Table 1	August 2013 Geoprobe™ Groundwater Results
Figure 1	Site Location
Figure 2	Comparison of Pre- and Post-thermal PCE+TCE Concentrations in Soil
Figure 3	Post-thermal PCE and TCE Concentrations in Groundwater
Figure 4	Post-thermal cis-Dichloroethene and Vinyl Chloride Concentrations in Groundwater
Figure 5	Post-Thermal Total CVOC Concentrations in Groundwater
Figure 6	Comparison of Post-thermal PCE and TCE and CVOC Concentrations in Groundwater in 1st Water Bearing Zone
Figure 7	Comparison of Post-thermal PCE and TCE and CVOC Concentrations in Groundwater in 2nd Water Bearing Zone
Figure 8	Post-thermal Biopolish Areas

Fox Avenue Site

Biopolish Treatment Plan

Table

Table 1
August 2013 Geoprobe™ Groundwater Results

Location		GP-PT1	GP-PT2	GP-PT3	GP-PT4	GP-PT5	GP-PT6		GP-PT7			GP-PT8	
Sample ID[1]		GP-PT1(9-13)	GP-PT2(9-13)	GP-PT3(9-13)	GP-PT4(10-14)	GP-PT5(50-54)	GP-PT6(11-15)	GP-PT6(41-45)	GP-PT7(11-15)	GP-PT7(51-55)	GP-PT7(61-65)	GP-PT8 (9-13)	GP-PT8 (50-54)
Sample Date		8/28/2013	8/28/2013	8/28/2013	8/28/2013	8/28/2013	8/28/2013	8/28/2013	8/28/2013	8/28/2013	8/28/2013	11/4/2013	11/4/2013
Sample Temperature[2]		57.7°C	62.2°C	61.1°C	44.4°C	40°C	62.2°C	53.3°C	66.7°C	48.9°C	41.1°C	37.7°C	34.7°C
Analyte	**Units**												
Chlorinated Volatile Organic Compounds													
1,1-Dichloroethane	µg/L	1 U	1 U	1 U	4.93	1 U	1 U	1 U	1 U	2.76	35.9	1 U	1 U
1,1-Dichloroethene	µg/L	1 U	1 U	1 U	16.1	23.2	6.6	4.79	1 U	8.34	105	3.03	1 U
1,2-Dichlorobenzene	µg/L	1 U	1.95	3.4	2.44	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	µg/L	1 U	1 U	1 U	1.35	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	µg/L	1 U	1 U	1.23	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	µg/L	1 U	1 U	1 U	1.53	1 U	1 U	1 U	1 U	2.81	1 U	1 U	1 U
Chloromethane	µg/L	1 U	1 U	3.69	1 U	1 U	1.13	1 U	1 U	1 U	1 U	1.07	1 U
Methylene chloride	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	5.96	1 U
cis-1,2-Dichloroethene	µg/L	323	1,150	557	1,780	3,480	904	1,720	530	1,810	20,900	555	23.3
Tetrachloroethene	µg/L	24.8	29.6	19.8	126	193	53	1 U	7.45	1.46	1 U	5.96	1 U
trans-1,2-Dichloroethene	µg/L	2.39	7.63	4	101	131	5.06	57.2	2.53	48.3	462	11.3	` U
Trichloroethene	µg/L	36.4	26.9	17.1	558	8120	343	8.44	21.4	1.96	2.08	70.5	1 U
Vinyl chloride	µg/L	5.32	75.5	46.4	69	35.8	13.3	384	11.1	2,880	34,000	20.6	94.6
Total CVOCs[3]	µg/L	392	1,290	653	2,660	12,000	1,330	2,170	572	4,760	55,500	667	118
Other Volatile Organic Compounds													
Benzene	µg/L	14.7	4.02	6.93	11.9	1 U	3.61	2.24	2.62	3.44	8.61	6.97	3.68
Ethylbenzene	µg/L	1 U	9.8	11.5	1.03	1.45	1.66	1.88	1.92	44.7	11.8	2.52	1 U
Toluene	µg/L	15.6	21.9	24.2	7.86	9.73	9.01	6.68	5.54	42	261	27.5	1.3
Xylene (meta & para)	µg/L	2.37	6.92	8.95	6.94	2.12	2.26	1.26	1.59	7.98	6.89	3.88	1 U
Xylene (ortho)	µg/L	1 U	2.75	3.59	1 U	1 U	1 U	1 U	1 U	1.34	5.3	2.17	1 U
1,2,4-Trimethylbenzene	µg/L	1.16	2.41	2.14	4.6	3.74	1.25	1 U	1 U	3.45	1 U	1.5	1 U
1,3,5-Trimethylbenzene	µg/L	1 U	1 U	1 U	1.92	1.76	1 U	1 U	1 U	1 U	1 U	1 U	1 U
iso-Propylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1.14	1 U	1 U	1 U
n-Propylbenzene	µg/L	1 U	1 U	1 U	1 U	1.01	1 U	1 U	1 U	1.1	1 U	1 U	1 U
2-Hexanone	µg/L	7.9	4.94	1 U	1 U	1 U	4.61	1 U	4.03	1 U	1 U	8.69	1 U
Acetone	µg/L	2,020	2,090	896	5 U	5 U	1,990	85.5	588	5 U	5 U	1,710	5 U
Cymene	µg/L	1.17	1 U	1.41	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Naphthalene	µg/L	4.78	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methyl iso butyl ketone	µg/L	58.6	47.6	22.4	5 U	5 U	15.9	5 U	13.7	5 U	5 U	16.1	10.6
Methyl ethyl ketone	µg/L	520	435	240	1 U	100	368	1 U	55.5	1 U	1 U	373	1 U

Notes:

1 Sample collection depth (below ground surface) is noted in parentheses in the sample ID.

2 Temperature was measured ex-situ with a digital thermometer prior to sample collection.

3 Total CVOC value is the sum of detected values only and rounded to three significant figures.

Abbreviations:

CVOC Chlorinated volatile organic compound

°C Degrees Celsius

µg/L Micrograms per liter

Qualifier:

U Undetected at the specified concentration

Table 1
August 2013 Geoprobe™ Groundwater Results

Location		GP-PT9			GP-PT10			GP-PT11	GP-PT12		GP-PT13		
Sample ID[1]		GP-PT9 (11-15)	GP-PT9 (30-34)	GP-PT9 (61-65)	GP-PT10 (11-15)	GP-PT10 (30-34)	GP-PT10 (61-65)	GP-PT11 (50-54)	GP-PT12 (16-20)	GP-PT12 (50-54)	GP-PT13 (11-15)	GP-PT13 (30-34)	GP-PT13 (61-65)
Sample Date		11/4/2013	11/4/2013	11/4/2013	11/4/2013	11/4/2013	11/4/2013	11/4/2013	11/4/2013	11/4/2013	11/5/2013	11/5/2013	11/5/2013
Sample Temperature[2]		35.1°C	34.7°C	34.7°C	47.4°C	45.2°C	37.3°C	31.1°C	45°C	32.9°C	41.9°C	39.5°C	39.4°C
Analyte	**Units**												
Chlorinated Volatile Organic Compounds													
1,1-Dichloroethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	µg/L	1.79	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	µg/L	1 U	1 U	1 U	1.47	1 U	1 U	1 U	1 U	1 U	1.71	1 U	1 U
Chloromethane	µg/L	2.34	1 U	1 U	1.38	1 U	1 U	1 U	1 U	1 U	1.34	1 U	1 U
Methylene chloride	µg/L	1 U	1 U	1.21	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,2-Dichloroethene	µg/L	217	6.12	1 U	332	17.9	1 U	83.7	281	1.28	194	187	1 U
Tetrachloroethene	µg/L	1 U	1 U	1.21	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,2-Dichloroethene	µg/L	3.59	1 U	1 U	9.95	1.46	1 U	1 U	2.33	1 U	5.31	1.81	1 U
Trichloroethene	µg/L	6.85	1 U	1 U	5.78	1 U	1 U	1.82	1 U	1 U	7.16	1.8	1 U
Vinyl chloride	µg/L	5.18	0.58	0.2 U	6.15	3.01	0.2 U	0.2 U	3.96	1.12	2.73	4.62	0.2 U
Total CVOCs[3]	µg/L	237	6.7	1.21	357	22.4	1 U	85.5	287	2.4	212	195	1 U
Other Volatile Organic Compounds													
Benzene	µg/L	6.11	1 U	2.21	11.6	1 U	2.9	3.06	4.13	1 U	4.19	4.65	1 U
Ethylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.6	1 U	1 U	1 U	1 U
Toluene	µg/L	10.9	1 U	1 U	4.01	1 U	1 U	1 U	3.79	1 U	4.39	4.46	1 U
Xylene (meta & para)	µg/L	1.46	1 U	1 U	1.62	1 U	1 U	1 U	2.1	1 U	1.28	1 U	1 U
Xylene (ortho)	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	2.77	1 U	1 U	1 U	1 U	1 U
1,3,5-Trimethylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	2.42	1 U	1 U	1 U	1 U	1 U
iso-Propylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
n-Propylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1.23	1 U	1 U	1 U	1 U	1 U
2-Hexanone	µg/L	1 U	1 U	1 U	2.21	1 U	1 U	1 U	2.67	1 U	10.7	1.01	1 U
Acetone	µg/L	7.34	5 U	5 U	1,490	5 U	15.7	5 U	455	5 U	2,660	10.2	5 U
Cymene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Naphthalene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methyl iso butyl ketone	µg/L	5 U	5 U	5 U	20.6	5 U	5 U	5 U	5 U	5 U	17.8	5 U	5 U
Methyl ethyl ketone	µg/L	1 U	1 U	1 U	276	1 U	1 U	1 U	85.6	1 U	625	10.5	1.32

Notes:

1 Sample collection depth (below ground surface) is noted in parentheses in the sample ID.

2 Temperature was measured ex-situ with a digital thermometer prior to sample collection.

3 Total CVOC value is the sum of detected values only and rounded to three significant figures.

Abbreviations:

CVOC Chlorinated volatile organic compound

°C Degrees Celsius

µg/L Micrograms per liter

Qualifier:

U Undetected at the specified concentration

Table 1
August 2013 Geoprobe™ Groundwater Results

Location		GP-PT14			GP-PT15		GP-PT16	MW-14
Sample ID[1]		GP-PT14 (11-15)	GP-PT14 (30-34)	GP-PT14 (61-65)	GP-PT15 (11-15)	GP-PT15 (50-54)	GP-PT16 (50-54)	MW-14-110513
Sample Date		11/5/2013	11/5/2013	11/5/2013	11/5/2013	11/5/2013	11/5/2013	11/5/2013
Sample Temperature[2]		48°C	43.3°C	40.1°C	44.7°C	36°C	24.2°C	38.4°C
Analyte	**Units**							
Chlorinated Volatile Organic Compounds								
1,1-Dichloroethane	µg/L	1 U	1 U	1.61	1 U	1 U	1 U	1 U
1,1-Dichloroethene	µg/L	1 U	1 U	19.6	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	µg/L	1.6	1 U	1 U	2.51	1 U	1 U	1 U
1,2-Dichloroethane	µg/L	1 U	1 U	1 U	1 U	1 U	1.54	1 U
1,2-Dichloropropane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	2.24
1,4-Dichlorobenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene chloride	µg/L	1	1 U	1 U	1 U	1 U	1,000	1 U
cis-1,2-Dichloroethene	µg/L	128	79	9,080	132	4.05	7.14	48.6
Tetrachloroethene	µg/L	1	1 U	1 U	1 U	1 U	1,000	1 U
trans-1,2-Dichloroethene	µg/L	20	3.23	207	6.5	1 U	1 U	1 U
Trichloroethene	µg/L	57.1	2.13	4.35	26	1 U	4.62	1 U
Vinyl chloride	µg/L	1.82	25.2	1,050	1.9	1.69	0.2 U	235
Total CVOCs[3]	µg/L	210	109	10,400	169	5.74	1,010	287
Other Volatile Organic Compounds								
Benzene	µg/L	3.09	1 U	5.42	2.15	1 U	1 U	41.2
Ethylbenzene	µg/L	4.04	1 U	21	1.96	1 U	1 U	5.7
Toluene	µg/L	9.32	1.19	11.9	5.22	1 U	1 U	11.2
Xylene (meta & para)	µg/L	4.46	1 U	15.4	1.92	1 U	1 U	3.14
Xylene (ortho)	µg/L	1.62	1 U	4.88	1 U	1 U	1 U	1.11
1,2,4-Trimethylbenzene	µg/L	1.43	1 U	4.51	1 U	1 U	1 U	1.03
1,3,5-Trimethylbenzene	µg/L	1 U	1 U	1.44	1 U	1 U	1 U	1 U
iso-Propylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
n-Propylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Hexanone	µg/L	8.89	1 U	1.5	5.79	1 U	1 U	1.53
Acetone	µg/L	5,370	9.07	209	2,430	5.37	164	5 U
Cymene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Naphthalene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methyl iso butyl ketone	µg/L	44.6	5 U	5 U	27	5 U	5 U	7.64
Methyl ethyl ketone	µg/L	817	4.69	388	441	1.18	292	4.16

Notes:

1 Sample collection depth (below ground surface) is noted in parentheses in the sample ID.

2 Temperature was measured ex-situ with a digital thermometer prior to sample collection.

3 Total CVOC value is the sum of detected values only and rounded to three significant figures.

Abbreviations:

CVOC Chlorinated volatile organic compound

°C Degrees Celsius

µg/L Micrograms per liter

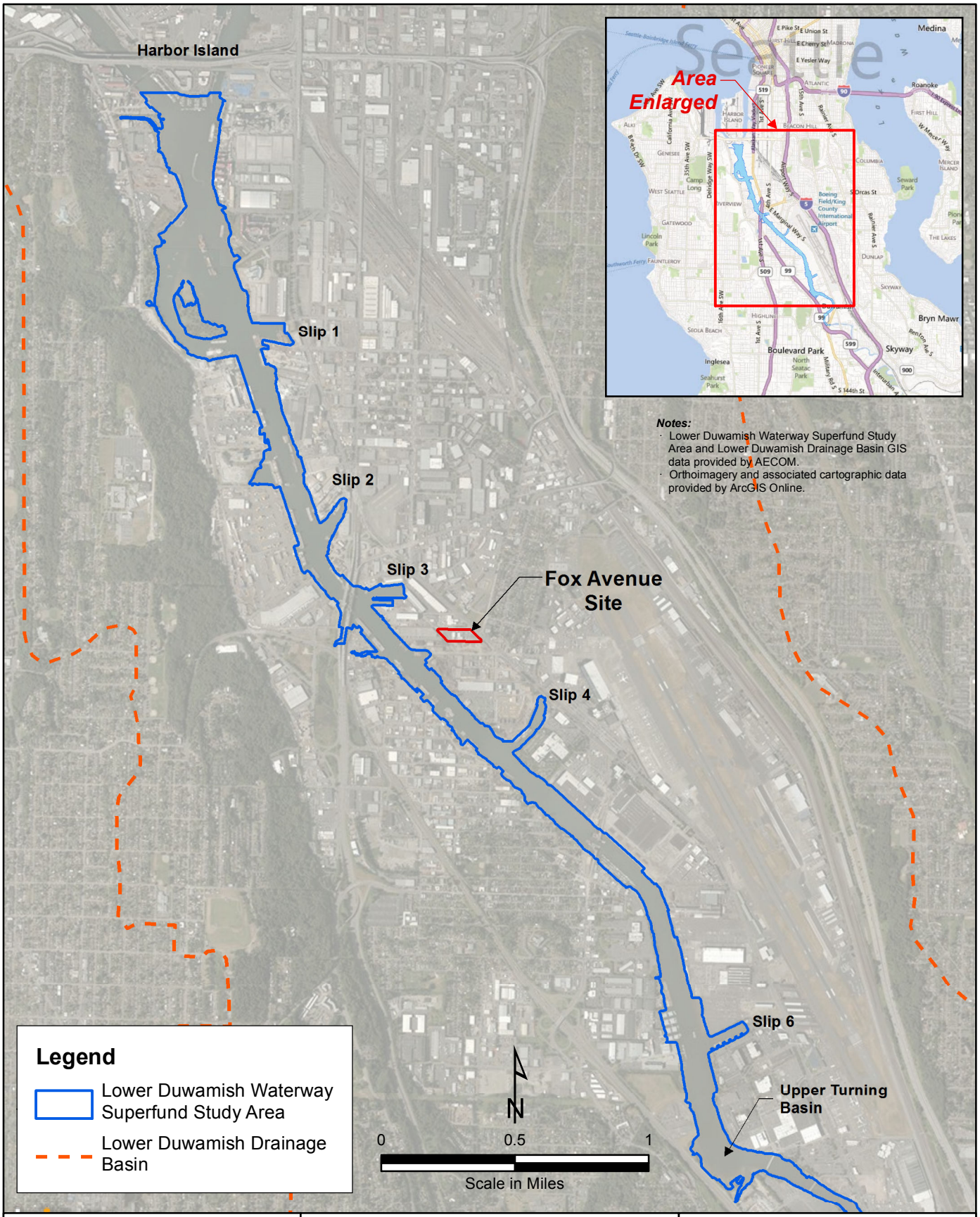
Qualifier:

U Undetected at the specified concentration

Fox Avenue Site

Biopolish Treatment Plan

Figures



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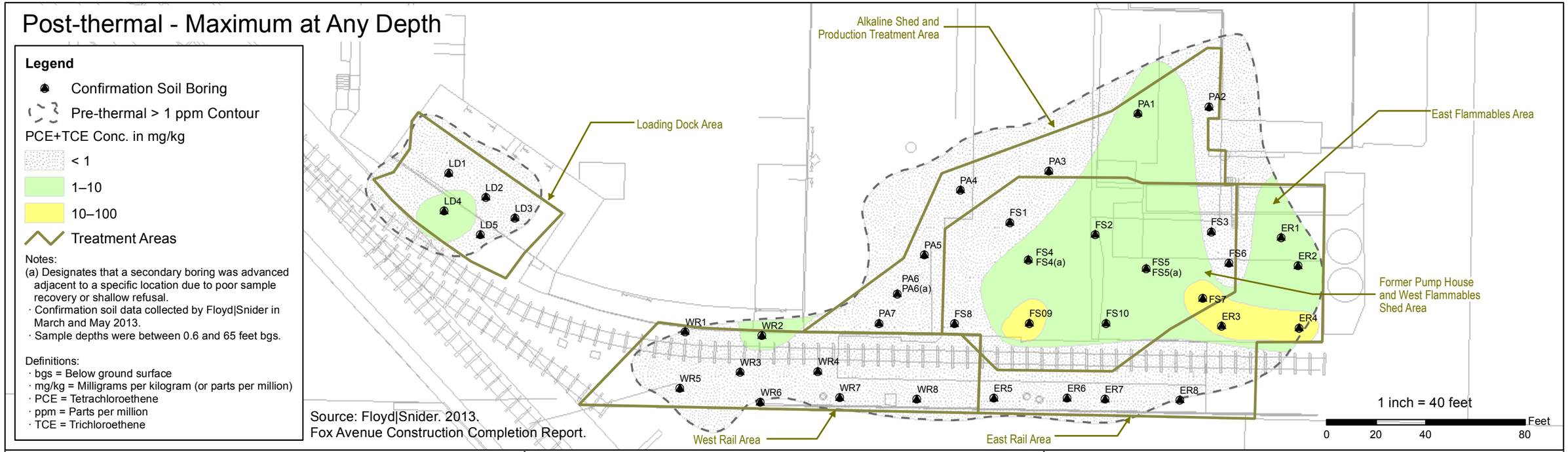
Biopolish Treatment Plan
Fox Avenue Site
Seattle, Washington

Figure 1
Site Location

Path: I:\GIS\Projects\FOXAVE-RA\MXD\Biopolish Treatment Plan\Figure 1 (Site Location).mxd 12/27/2013

Pre-thermal - Maximum at Any Depth

Post-thermal - Maximum at Any Depth



Source: Floyd|Snider. 2013.
Fox Avenue Construction Completion Report.

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Biopolish Treatment Plan
Fox Avenue Site
Seattle, Washington

Figure 2
Comparison of Pre- and Post-thermal PCE+TCE Concentrations in Soil

I:\GIS\Projects\FOXAVE-RA\MXD\Biopolish Treatment Plan\Figure 2 (Comparison of Pre- and Post-thermal PCE+TCE Concentrations in Soil).mxd 12/27/2013

GP-PT14			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0	µg/L	11-15
TCE	57.1	µg/L	
PCE	1.0 U	µg/L	30-34
TCE	2.13	µg/L	
PCE	1.0 U	µg/L	61-65
TCE	4.35	µg/L	

GP-PT12			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	16-20
TCE	1.0 U	µg/L	
PCE	1.0 U	µg/L	50-54
TCE	1.0 U	µg/L	

GP-PT5			
Analyte	Result	Units	Depth (ft) bgs
PCE	193	µg/L	50-54
TCE	8,120	µg/L	

GP-PT11			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	50-54
TCE	1.82	µg/L	

GP-PT15			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	11-15
TCE	26	µg/L	
PCE	1.0 U	µg/L	50-54
TCE	1.0 U	µg/L	

GP-PT10			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	11-15
TCE	5.78	µg/L	
PCE	1.0 U	µg/L	30-34
TCE	1.0 U	µg/L	
PCE	1.0 U	µg/L	61-65
TCE	1.0 U	µg/L	

MW-14			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	55-60
TCE	1.0 U	µg/L	

GP-PT16			
Analyte	Result	Units	Depth (ft) bgs
PCE	1,000	µg/L	50-54
TCE	4.62	µg/L	

GP-PT6			
Analyte	Result	Units	Depth (ft) bgs
PCE	53.0	µg/L	11-15
TCE	343	µg/L	
PCE	1.0 U	µg/L	41-45
TCE	8.44	µg/L	

GP-PT4			
Analyte	Result	Units	Depth (ft) bgs
PCE	126	µg/L	10-14
TCE	558	µg/L	

GP-PT7			
Analyte	Result	Units	Depth (ft) bgs
PCE	7.45	µg/L	11-15
TCE	21.4	µg/L	
PCE	1.46	µg/L	51-55
TCE	1.96	µg/L	
PCE	1.0 U	µg/L	61-65
TCE	2.08	µg/L	

GP-PT13			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	11-15
TCE	7.16	µg/L	
PCE	1.0 U	µg/L	30-34
TCE	1.80	µg/L	
PCE	1.0 U	µg/L	61-65
TCE	1.0 U	µg/L	

GP-PT9			
Analyte	Result	Units	Depth (ft) bgs
PCE	1.0 U	µg/L	11-15
TCE	6.85	µg/L	
PCE	1.0 U	µg/L	30-34
TCE	1.0 U	µg/L	
PCE	1.21	µg/L	61-65
TCE	1.0 U	µg/L	

GP-PT2			
Analyte	Result	Units	Depth (ft) bgs
PCE	29.6	µg/L	9-13
TCE	26.9	µg/L	

GP-PT3			
Analyte	Result	Units	Depth (ft) bgs
PCE	19.8	µg/L	9-13
TCE	17.1	µg/L	

GP-PT1			
Analyte	Result	Units	Depth (ft) bgs
PCE	24.8	µg/L	9-13
TCE	36.4	µg/L	

GP-PT8			
Analyte	Result	Units	Depth (ft) bgs
PCE	5.96	µg/L	9-13
TCE	70.5	µg/L	
PCE	1.0 U	µg/L	50-54
TCE	1.0 U	µg/L	

Loading Dock Area

Alkaline Shed

Production Area

Flammables Shed

Legend

- Geoprobe Groundwater Sample
- Monitoring Well
- Thermally Treated Areas

Notes:
- GP-PT1 through GP-PT7 were collected by Floyd|Snider in August 2013.
- GP-PT8 through GP-PT16 were collected by Floyd|Snider in November 2013.
- U The analyte was not detected greater than or equal to the concentration reported.

Definitions:
bgs = Below ground surface
µg/L = Micrograms per liter
PCE = Tetrachloroethene
TCE = Trichloroethene

N

0 15 30 60 Feet

1 inch = 30 feet

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Biopolish Treatment Plan
Fox Avenue Site
Seattle, Washington

Figure 3
Post-thermal PCE and TCE Concentrations in Groundwater

I:\GIS\Projects\FOXAVE-RA\MXD\Biopolish Treatment Plan\Figure 3 (Post Thermal PCE and TCE Concentrations in GW).mxd

GP-PT14			
Analyte	Result	Units	Depth (ft) bgs
DCE	128	µg/L	11-15
VC	1.82	µg/L	
DCE	79	µg/L	30-34
VC	25.2	µg/L	
DCE	9,080	µg/L	61-65
VC	1,050	µg/L	

GP-PT12			
Analyte	Result	Units	Depth (ft) bgs
DCE	281	µg/L	16-20
VC	3.96	µg/L	
DCE	1.28	µg/L	50-54
VC	1.12	µg/L	

GP-PT5			
Analyte	Result	Units	Depth (ft) bgs
DCE	3,480	µg/L	50-54
VC	35.8	µg/L	

GP-PT11			
Analyte	Result	Units	Depth (ft) bgs
DCE	83.7	µg/L	50-54
VC	0.2 U	µg/L	

GP-PT15			
Analyte	Result	Units	Depth (ft) bgs
DCE	132	µg/L	11-15
VC	1.9	µg/L	
DCE	4.05	µg/L	50-54
VC	1.69	µg/L	

MW-14			
Analyte	Result	Units	Depth (ft) bgs
DCE	48.6	µg/L	55-60
VC	235	µg/L	

GP-PT10			
Analyte	Result	Units	Depth (ft) bgs
DCE	332	µg/L	11-15
VC	6.15	µg/L	
DCE	17.9	µg/L	30-34
VC	3.01	µg/L	
DCE	1.0 U	µg/L	61-65
VC	0.2 U	µg/L	

GP-PT16			
Analyte	Result	Units	Depth (ft) bgs
DCE	7.14	µg/L	50-54
VC	0.2	µg/L	

GP-PT6			
Analyte	Result	Units	Depth (ft) bgs
DCE	904	µg/L	11-15
VC	13.3	µg/L	
DCE	1,720	µg/L	41-45
VC	384	µg/L	

GP-PT4			
Analyte	Result	Units	Depth (ft) bgs
DCE	1,780	µg/L	10-14
VC	69	µg/L	

GP-PT7			
Analyte	Result	Units	Depth (ft) bgs
DCE	530	µg/L	11-15
VC	11.1	µg/L	
DCE	1,810	µg/L	51-55
VC	2,880	µg/L	
DCE	20,900	µg/L	61-65
VC	34,000	µg/L	

GP-PT13			
Analyte	Result	Units	Depth (ft) bgs
DCE	194	µg/L	11-15
VC	2.73	µg/L	
DCE	187	µg/L	30-34
VC	4.62	µg/L	
DCE	1.0 U	µg/L	61-65
VC	0.2 U	µg/L	

GP-PT9			
Analyte	Result	Units	Depth (ft) bgs
DCE	217	µg/L	11-15
VC	5.18	µg/L	
DCE	6.12	µg/L	30-34
VC	0.58	µg/L	
DCE	1.0 U	µg/L	61-65
VC	0.2	µg/L	

GP-PT2			
Analyte	Result	Units	Depth (ft) bgs
DCE	1,150	µg/L	9-13
VC	75.5	µg/L	

GP-PT3			
Analyte	Result	Units	Depth (ft) bgs
DCE	557	µg/L	9-13
VC	46.4	µg/L	

GP-PT1			
Analyte	Result	Units	Depth (ft) bgs
DCE	323	µg/L	9-13
VC	5.32	µg/L	

GP-PT8			
Analyte	Result	Units	Depth (ft) bgs
DCE	555	µg/L	9-13
VC	20.6	µg/L	
DCE	23.3	µg/L	50-54
VC	94.6	µg/L	

Loading Dock Area

Alkaline Shed

Production Area

Flammables Shed

Legend

- Geoprobe Groundwater Sample
- Monitoring Well
- Thermally Treated Areas

Notes:
- GP-PT1 through GP-PT7 were collected by Floyd|Snider in August 2013.
- GP-PT8 through GP-PT16 were collected by Floyd|Snider in November 2013.
- U The analyte was not detected greater than or equal to the concentration reported.

Definitions:
bgs = Below ground surface
DCE = cis-1,2-Dichloroethene
µg/L = Micrograms per liter
VC = Vinyl chloride

N

0 15 30 60 Feet

1 inch = 30 feet

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Biopolish Treatment Plan
Fox Avenue Site
Seattle, Washington

Figure 4
Post-thermal cis-Dichloroethene and Vinyl Chloride Concentrations in Groundwater

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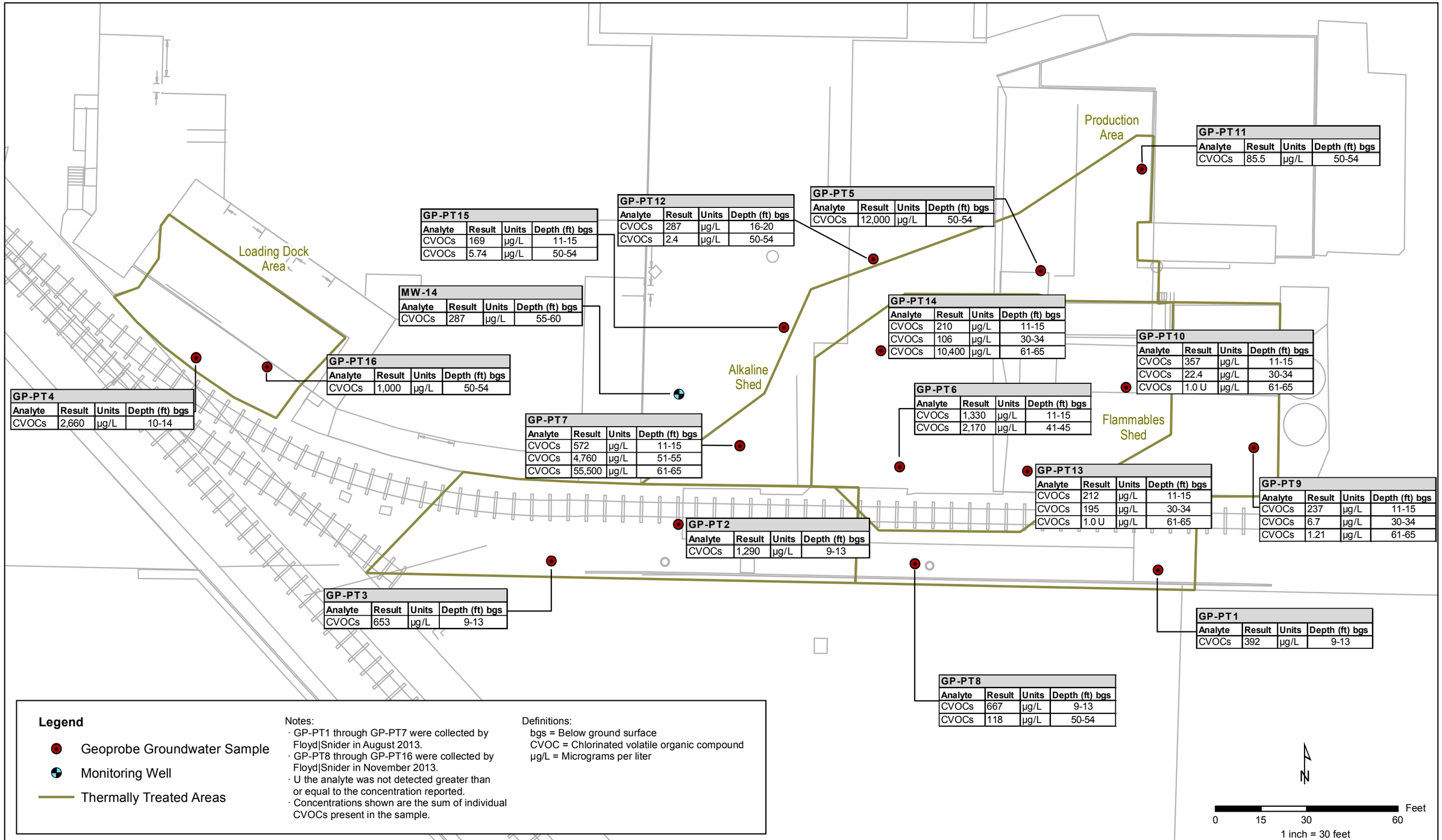

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Figure 5
Post-thermal CVOC Concentrations in Groundwater

I:\GIS\Projects\FOXAVE-RA\MXD\Biopolish Treatment Plan\Figure 5 (Post Thermal Total cVOC Concentrations in GW).mxd

PCE and TCE in 1st Water Bearing Zone

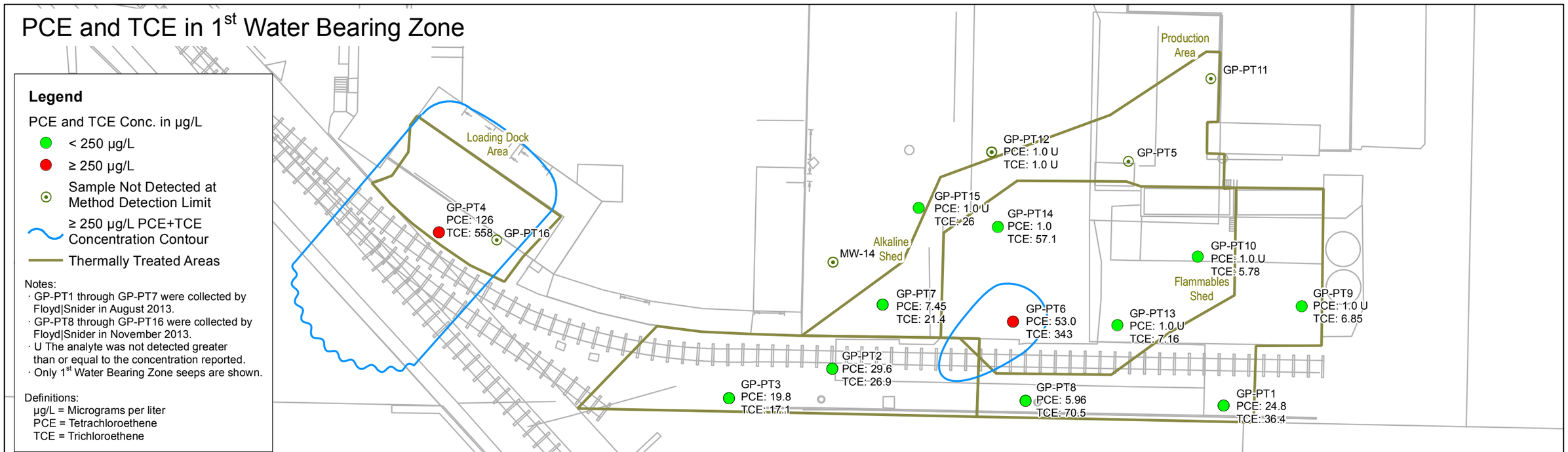
Legend

PCE and TCE Conc. in µg/L

- < 250 µg/L
- ≥ 250 µg/L
- Sample Not Detected at Method Detection Limit
- ≥ 250 µg/L PCE+TCE Concentration Contour
- Thermally Treated Areas

Notes:
- GP-PT1 through GP-PT7 were collected by Floyd|Snider in August 2013.
- GP-PT8 through GP-PT16 were collected by Floyd|Snider in November 2013.
- U The analyte was not detected greater than or equal to the concentration reported.
- Only 1st Water Bearing Zone seeps are shown.

Definitions:
µg/L = Micrograms per liter
PCE = Tetrachloroethene
TCE = Trichloroethene



CVOCs in 1st Water Bearing Zone

Legend

CVOC Conc. in µg/L

- < 250 µg/L
- ≥ 250 µg/L
- Sample Not Detected at Method Detection Limit
- ≥ 250 µg/L Total CVOC Concentration Contour
- Thermally Treated Areas

Notes:
- GP-PT1 through GP-PT7 were collected by Floyd|Snider in August 2013.
- GP-PT8 through GP-PT16 were collected by Floyd|Snider in November 2013.
- Only 1st Water Bearing Zone seeps are shown.

Definitions:
CVOC = Chlorinated volatile organic compound
µg/L = Micrograms per liter

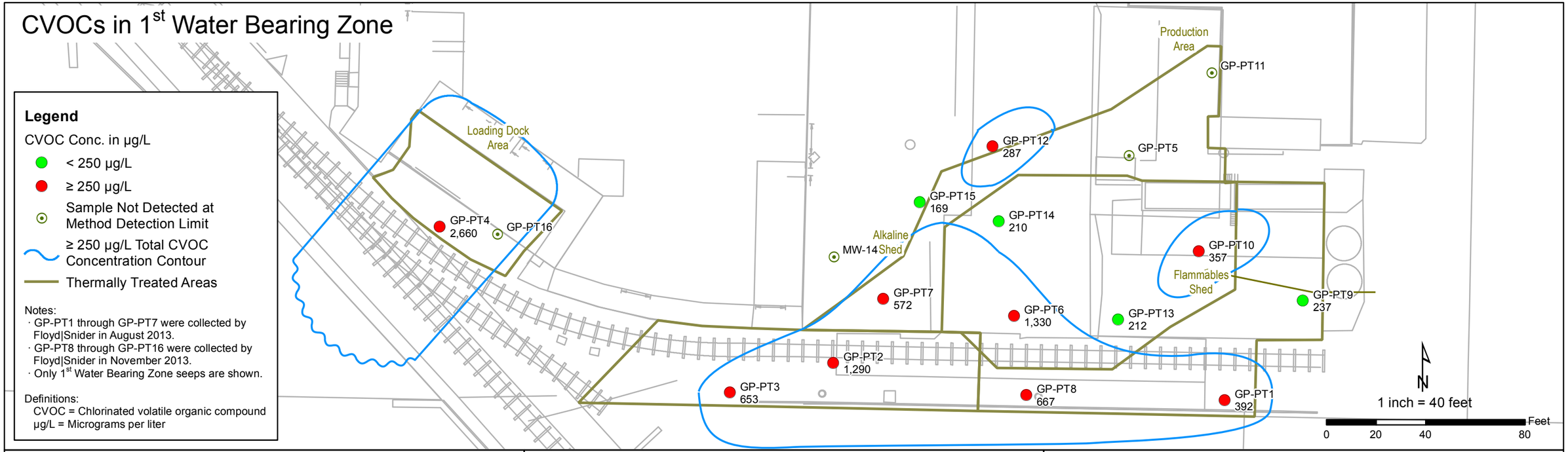


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Figure 6
Comparison of Post-thermal PCE and TCE and CVOC Concentrations in Groundwater in 1st Water Bearing Zone

I:\GIS\Projects\FOXAVE-RA\MXD\Biopolish Treatment Plan\Figure 6 (Post Thermal Concentrations in GW 1st WBZ).mxd 12/31/2013

PCE and TCE in 2nd Water Bearing Zone

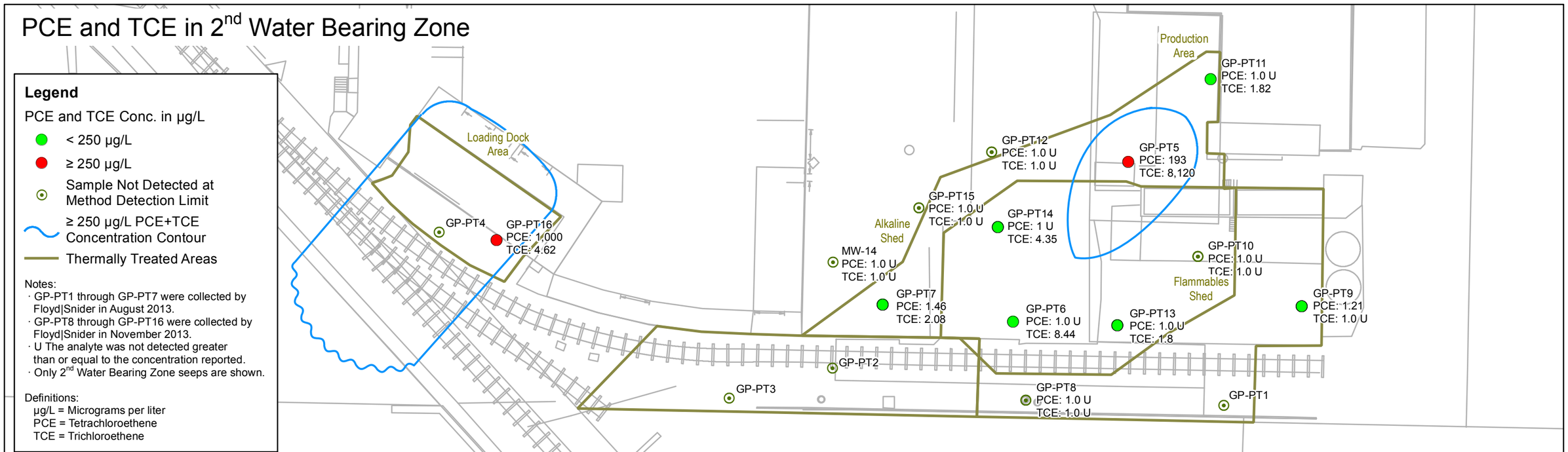
Legend

PCE and TCE Conc. in µg/L

- < 250 µg/L
- ≥ 250 µg/L
- Sample Not Detected at Method Detection Limit
- ≥ 250 µg/L PCE+TCE Concentration Contour
- Thermally Treated Areas

Notes:
- GP-PT1 through GP-PT7 were collected by Floyd|Snider in August 2013.
- GP-PT8 through GP-PT16 were collected by Floyd|Snider in November 2013.
- U The analyte was not detected greater than or equal to the concentration reported.
- Only 2nd Water Bearing Zone seeps are shown.

Definitions:
µg/L = Micrograms per liter
PCE = Tetrachloroethene
TCE = Trichloroethene



CVOCs in 2nd Water Bearing Zone

Legend

CVOC Conc. in µg/L

- < 250 µg/L
- ≥ 250 µg/L
- Sample Not Detected at Method Detection Limit
- ≥ 250 µg/L Total CVOC Concentration Contour
- Thermally Treated Areas

Notes:
- GP-PT1 through GP-PT7 were collected by Floyd|Snider in August 2013.
- GP-PT8 through GP-PT16 were collected by Floyd|Snider in November 2013.
- Only 2nd Water Bearing Zone seeps are shown.

Definitions:
CVOC = Chlorinated volatile organic compound
µg/L = Micrograms per liter

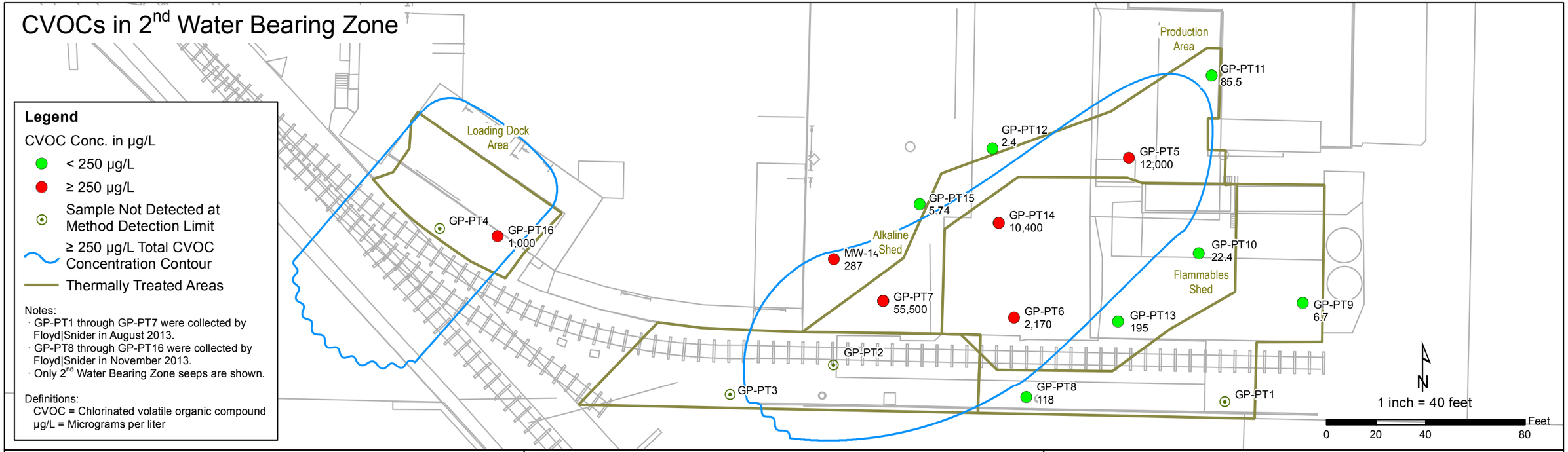


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Figure 7
Comparison of Post-thermal PCE and TCE and CVOC Concentrations in Groundwater in 2nd Water Bearing Zone

I:\GIS\Projects\FOXAVE-RA\MXD\Biopolish Treatment Plan\Figure 7 (Post Thermal Concentrations in GW 2nd WBZ).mxd 12/31/2013

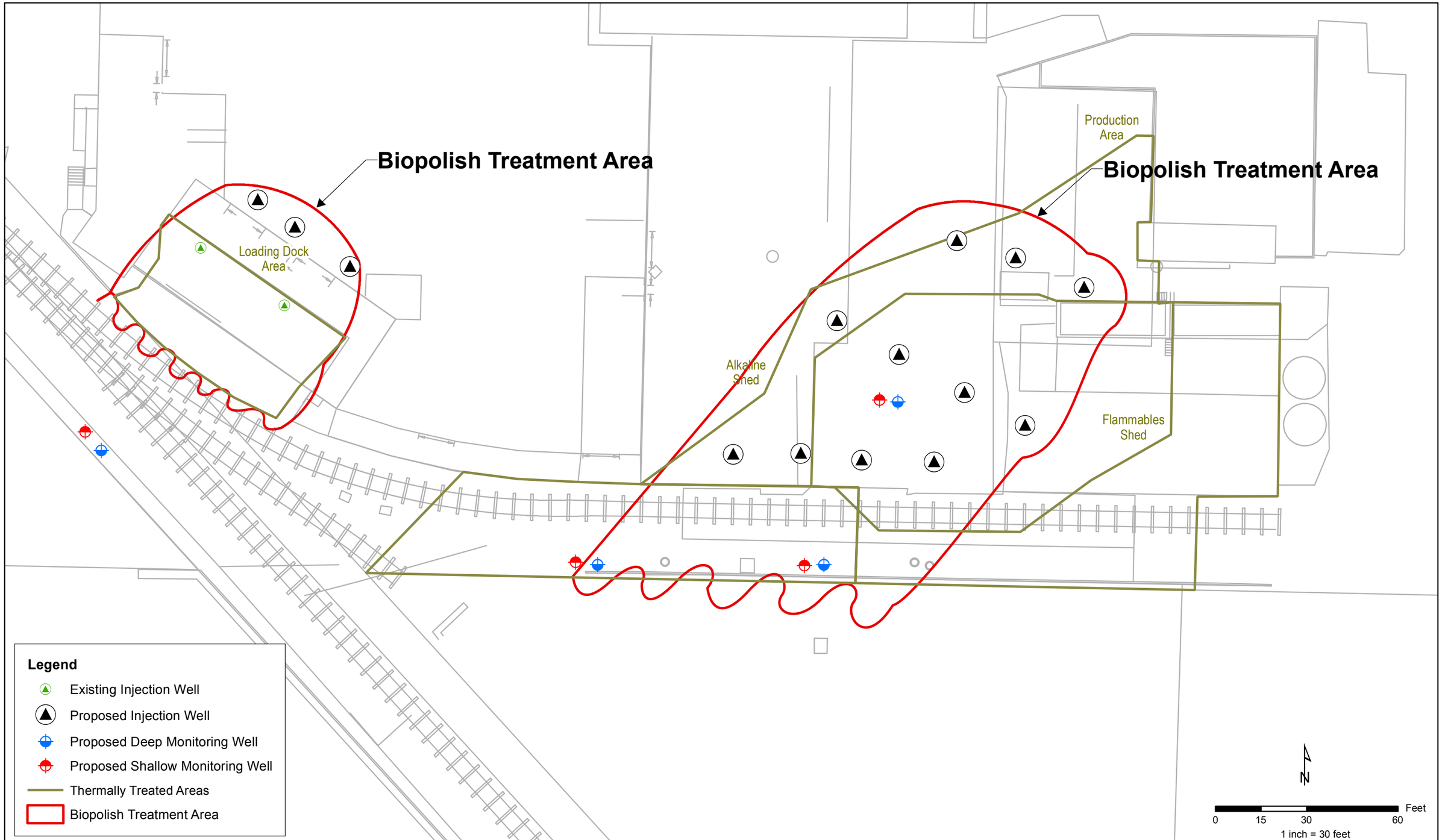

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Figure 8
Post-thermal Biopolish Areas

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