

**SECOND QUARTER 2017 PROGRESS REPORT / FIRST QUARTER 2018  
GROUNDWATER PERFORMANCE MONITORING REPORT**

**SITE: BP HARBOR ISLAND TERMINAL**

**CLEANUP SITE ID: 4426**

**1652 SW LANDER STREET**

**SEATTLE, WASHINGTON**

**CONSENT DECREE NO. 00-2-05714-8SEA**

**JULY 2018**

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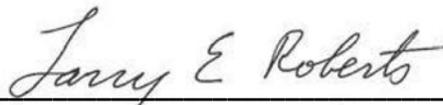
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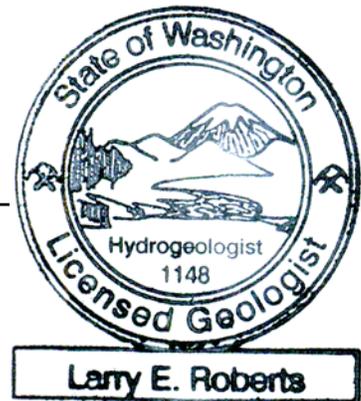
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## **1. INTRODUCTION**

TLP Management Services LLC is submitting this report prepared by TechSolve Environmental, Inc. (TechSolve) to summarize the First Quarter 2018 Groundwater Monitoring event and operation and maintenance of the waterfront remediation system through the second quarter (June) of 2018 for the BP Harbor Island Terminal Site. Groundwater monitoring and remediation system reporting periods are staggered due to the time required to receive and validate laboratory reports from groundwater monitoring events. The combination of these two summary reports was based upon the recommendation of the Washington State Department of Ecology (Ecology) project manager (Ecology, 2004a). This progress report satisfies reporting schedule submittal requirements pursuant to Ecology Consent Decree No. 00-2-05714-8SEA, entered into court March 24, 2000 (Ecology, 2000b).

## **2. REMEDIATION SYSTEM OPERATIONS**

Remediation systems were installed and completed at the Site in accordance with specifications outlined in the Engineering Design Report (EDR) (TechSolv and AG&M, 2000) and Cleanup Action Plan (CAP) (Ecology, 1999). Throughout 2018, a waterfront groundwater/Light Non-Aqueous Phase Liquid (LNAPL) remediation system operated to remove free-phase LNAPL and dissolved petroleum hydrocarbons from groundwater at Plant 1 (Figure 1).

### **2.1. WATERFRONT SYSTEM OPERATIONS**

Installation and startup of the final waterfront remediation system was completed in 2002 and operational testing was conducted through 2003. Standard operation began once testing showed the system operated as designed and in accordance with Consent Decree and EDR requirements. Reports were submitted to Ecology summarizing both construction and operation & maintenance (O&M) of the remediation system. The Construction Completion Report (CCR) (TechSolve, 2003b) summarized construction, installation, and startup testing of the final remediation system, and documented that systems met design criteria, attained desired capture, and hydraulic control along the waterfront. The Final O&M Manual (TechSolve, 2003c) contains procedures to operate and maintain systems, vendor-supplied manuals for components, and health and safety practices. Ecology stated that the CCR and O&M Manual complied with the requirements of the Consent Decree, the Groundwater Compliance Monitoring Program, and the Model Toxics Control Act (WAC 173-340-400) and, as such, were approved (Ecology, 2004b). The O&M Manual is updated as practices or procedures change, or as systems are altered.

O&M activities are conducted on systems weekly to ensure they operate as designed and in accordance with applicable permits. These activities include, but are not limited to:

- Weekly checks of groundwater recovery system pumping rates.
- Weekly inspections of system components and waste storage containers for integrity per the requirements of WAC 173-303-320.
- Monthly sampling of recovered groundwater influent and effluent streams to ensure compliance with King County Department of Natural Resources and Parks (KCDNR) Discharge Permit 7592-05 for discharge A43262.

- Monthly monitoring and calculation of system LNAPL recovery.
- Monthly sampling of system flow rates and hydrocarbon concentrations.

Additional maintenance activities are conducted as needed to maintain system operational integrity and to ensure discharges are within permitted ranges.

Operation of waterfront air sparging and SVE systems were discontinued in May 2008, as the bulk of available hydrocarbons had been recovered. System data collected during 5 years of operation prior to shutdown were presented in previous reports, and support system shutdown. These findings were presented to Ecology in a 5-year Review meeting, conducted October 8, 2008, and summarized in the 2008 Annual Site Report (TechSolve, 2009).

Combined LNAPL recovery (free-phase, residual, and dissolved) from final SVE and groundwater and LNAPL recovery systems is approximately 14,554 gallons (October 2002 to June 2018) (Table 1). Interim systems, operating from 1992 through 2002, recovered an additional 15,223 gallons of LNAPL, for a combined LNAPL recovery from interim and final remediation systems of 29,778 gallons. The majority of LNAPL recovered by interim remediation systems was free-phase LNAPL. The majority of LNAPL recovered by final remediation systems was from enhanced biodegradation, calculated from SVE vapor sampling for CO<sub>2</sub>. SVE system shutdown in 2008 was based, in part, on concentrations of CO<sub>2</sub> reaching atmospheric (background) levels.

Groundwater/LNAPL recovery system data in Table 1 show influent concentrations of dissolved benzene, diesel, and gasoline in recovered groundwater fluctuate slightly throughout the year but have decreased over time. Table 1 also shows that measurable volumes of free LNAPL have not been generated since 2008, which was the last time sufficient quantities of LNAPL were recovered to warrant off-site shipment. This data corresponds with the lack of free LNAPL observed in recovery wells utilized by the groundwater/LNAPL recovery system. Lack of free LNAPL in wells and limited free LNAPL recovery by the groundwater/LNAPL recovery system indicates that the recovery system has captured most available free LNAPL.

Effluent discharges from the groundwater/LNAPL recovery system to sanitary have been within KCDNR's permitted ranges (Table 1) in 2018 and system recovery rates have been effective in preventing sheens from occurring on the adjacent Duwamish Waterway. Average monthly effluent flow rates ranged from 1.74 to 1.10 gallons per minute (gpm) in 2018, below KCDNR's maximum permitted flow of 17.5 gpm, consistent with past rates.

Reductions in dissolved hydrocarbon concentrations through a diffused air stripper (DAS) (Table 1) show it effectively treats recovered groundwater and meets permit requirements. DAS Influent concentrations of dissolved hydrocarbons continue to be below permitted effluent discharge levels, indicating DAS operation is not necessary to achieve permit compliance. However, the DAS continues to operate, as influent concentrations of dissolved hydrocarbons vary over time and at times concentrations in individual recovery wells exceed permitted discharge levels.

Maintenance and repair activities of remediation systems and wells are conducted to maintain integrity, effective operation, capture, and hydraulic control along the waterfront. Notable activities conducted in the second quarter of 2018 include:

- Piping and system inspections for corrosion and integrity to ensure system are operable.
- Relocate groundwater conveyance piping to facilitate completion of seawall replacement project.
- Repair of damaged monuments for Wells GM-16S and GM-17S by licensed drillers. Wells were damaged by seawall construction activities, detailed below.
- Piping and system back flushing and preventative maintenance to maintain conveyance piping and pumping wells.

Data show that the system continues to operate as designed and in accordance with permit requirements.

## **2.2. INLAND SYSTEM OPERATIONS**

An Inland SVE system operated from 2008 through 2014 to improve soil and groundwater conditions along the southern boundary of Plant 1. Past investigations and monitoring near the southern property boundary (Figure 1) showed petroleum hydrocarbons in soil and groundwater exceeded site cleanup levels with the bulk of hydrocarbons mainly at the vadose zone (unsaturated soils and capillary fringe).

SVE system designs, similar to the Waterfront SVE system, were approved by Ecology in 2007 (TechSolve, 2007 & Ecology, 2007). SVE components were installed and tested from October 2007 through August 2008. SVE air discharges were approved under Puget Sound Clean Air Agency (PSCAA) Notice of Construction (NoC) No. 9858.

Data from SVE startup in August 2008 through shutdown in December 2014 show the system captured approximately 7,940 pounds (1,291 gallons) of gasoline range hydrocarbons. Induced airflow that enhanced biodegradation of residual hydrocarbons is estimated to have reduced an additional 4,355 gallons of gasoline-range hydrocarbons, for a combined (biodegradation and vapor) recovery of gasoline-range hydrocarbons of 5,646 gallons (TechSolve, 2016).

The SVE system was shut down in December 2014 as data indicated the system no longer recovered measurable concentrations of petroleum hydrocarbons and induced airflow was no longer affecting biodegradation. By 2010, influent hydrocarbon concentrations recovered by the Inland SVE system were mainly below laboratory detection limits. By 2012 CO<sub>2</sub> levels had fallen to background levels (atmospheric), indicating biodegradation rates had decreased as the bulk of available hydrocarbons in this area had been reduced or captured. Additional information regarding shutdown of the Inland SVE system was provided in the 2015 Annual Site Report (TechSolve, 2016). In 2018, a plan (TechSolve, 2018) was submitted to and approved by Ecology (Ecology 2018) to decommission the mechanical and electrical components of the Inland SVE System that required ongoing maintenance. These components were subsequently decommissioned. The in-ground SVE piping and control manifold for this system remain onsite as a contingency in case operation of the system is warranted in the future.

Groundwater monitoring data collected along Plant 1's southern boundary, following Inland SVE startup in 2008, indicate the system has improved groundwater conditions at the southern property boundary, as discussed in the following section.

### **3. SUMMARY OF GROUNDWATER PERFORMANCE MONITORING PROGRAM**

The First Quarter 2018 Groundwater Monitoring Event was conducted in accordance with requirements of the Consent Decree, CAP, and Groundwater Compliance Monitoring and Contingency Program (TechSolve, 1999). The Groundwater Compliance Monitoring and Contingency Program describes the monitoring well network, sampling frequency, and analytes. Some revisions to the monitoring plan were included in the EDR, per Ecology's approval. Additional revisions have been made with Ecology's approval, as highlighted below. The current groundwater monitoring schedule is summarized in Table 2. Monitoring well locations are shown on Figure 2 for Plant 1 and Figure 3 for Plant 2.

Groundwater monitoring requirements at Plant 2 were revised in 2002, with concurrence from Ecology, to exclude sampling Wells MW-18-1, MW-18-2A, GM-21S, and GM-22S (Ecology, 2002). In 2004, remaining Plant 2 Wells GM-19S, GM-19D, MW-03R, and GM-22S were also excluded (Ecology, 2004b). However, Well GM-19S continues to be monitored for benzene and gasoline, as GM-19S has historically contained gasoline range hydrocarbons above cleanup levels, which previous investigations attributed to an unidentified off-site source (TechSolve, 2003a).

In 2005, four wells (MW-1-T9, MW-2-T9, MW-3-T9, and MW-4-T9) were installed along the southern property boundary of Plant 1 (Figure 2) to evaluate groundwater trends due to continuing cleanup level exceedances in Monitoring Well AR-03. These wells were monitored quarterly from December 2005 through March 2018, which aided in evaluating the effectiveness of the Inland SVE system in meeting cleanup objectives, as discussed in previous sections. In 2018, a monitoring revision plan (TechSolve, 2018a) was submitted to and approved by Ecology (Ecology 2018) to eliminate monitoring of Well MW-4-T9 and reduce the monitoring frequency in Wells AR-03, GM-15S, MW-1-T9, MW-2-T9, and MW-3-T9 from quarterly to semi-annual. Contingency actions were detailed in the plan to resume quarterly monitoring of Wells AR-03, GM-15S, MW-1-T9, MW-2-T9, and MW-3-T9 for specified periods if cleanup levels are exceeded in these wells.

Wells GM-16S and GM-17S are hydraulically upgradient from Plant 1. These wells were removed from most of the monitoring program with approval from Ecology in March 2000 (Ecology, 2000a) as sufficient upgradient data had been collected. Semiannual monitoring for hydrocarbons was voluntarily reinitiated in these wells in September 2007, as requested by Ecology, to monitor for potential petroleum hydrocarbons migration onto the property from upgradient, off-site sources.

Well GM-14S was historically used to monitor for sheens on groundwater, as discussed below. As sheens are no longer detected in GM-14S, quarterly groundwater monitoring for indicator hazardous substances (IHSs) was initiated in this well in 2007.

Revisions to the groundwater monitoring program were approved by Ecology in 2009 (Ecology, 2009), which reduced monitoring frequencies and required analyses. These revisions reduced the monitoring frequency from Wells GM-19S, 16S, and 17S from quarterly to semi-annual. The monitoring frequency from GM-19S was reduced based on consistent and stable benzene and gasoline monitoring results. The monitoring frequency from 16S, and 17S was reduced due to consistent monitoring data for total petroleum hydrocarbons (TPH) and benzene below cleanup levels. Additionally, the voluntary monitoring frequency of sampling for carcinogenic polynuclear aromatic hydrocarbons (cPAHs) was set to an annual basis in waterfront wells (AMW-01 through AMW-05) as extensive historical sampling does not indicate any significant detection trends.

Ecology agreed that analysis for cPAHs from these wells is voluntary until cleanup objectives are met (Ecology, 2003). Sampling for cPAHs was last conducted in the fourth quarter of 2017 (TechSolve, 2018a)

Wells monitored on a semi-annual basis are sampled in the first and third quarter, which typically correspond with seasonal groundwater highs and lows, respectively. Based upon these seasonal fluctuations in groundwater, Wells AR-03, GM-15S, GM-16S, GM-17S, GM-19S, MW-1-T9, MW-2-T9, and MW-3-T9 were sampled in the first quarter of 2018. These wells will next be sampled in the third quarter of 2018.

The First Quarter 2018 Groundwater Monitoring event was conducted March 20<sup>th</sup> and 21<sup>th</sup>, 2018. Overall, the first quarter 2018 groundwater elevations (Table 3) were slightly lower than the elevations measured in the fourth quarter of 2017, but were higher than elevations measured in the second and third quarters of 2017. These data indicate that the seasonal groundwater high occurred in late 2017 to early 2018. This groundwater elevation trend corresponds with historic trends, which show groundwater elevations rise to seasonal highs in the winter and spring and fall to seasonal lows in the summer and fall.

First Quarter 2018 Groundwater Monitoring Event samples were submitted to Test America Laboratories of Tacoma, Washington for laboratory analysis of IHSs identified in the CAP. The IHSs include TPH as gasoline (TPH-G), TPH as diesel (TPH-D), TPH as oil (TPH-O), and benzene.

Petroleum hydrocarbon monitoring results for the First Quarter 2018 Groundwater Monitoring Event are included in Table 4 and Figures 2 and 3. There were no detections of IHSs (benzene, TPH-G, TPH-D, or TPH-O) above cleanup levels from any of the samples analyzed in the first quarter of 2018. Data were within historical ranges and consistent with historical trends. Data trend evaluations will be presented in the next Annual Site Report, in accordance with Consent Decree requirements.

Three wells (GM-11S, GM-12S, and GM-13S) are examined monthly for the presence of free LNAPL and sheens. Laboratory analysis for IHSs will not be conducted on groundwater from these Wells until they are removed from the monthly LNAPL gauging program, as required by the Groundwater Compliance Monitoring and Contingency Program. Historically, gauging for free LNAPL was conducted at five wells; however, gauging of Wells GM-14S and MW-03R has been discontinued with concurrence from Ecology. LNAPL monitoring of Well MW-03R at Plant 2 was discontinued in 2004 (Ecology, 2004b), as Plant 2 monitoring has been mostly discontinued as discussed above. Monthly monitoring for LNAPL in Monitoring Well GM-14S at Plant 1 was discontinued in 2004, with concurrence from Ecology (Ecology, 2004c), and converted to a monitoring well in 2007, as it has been free of LNAPL since 1999.

No sheens were detected in Well GM-12S in 2018. A slight sheen was detected in well GM-11S in April, May, and June of 2018. A slight sheen was also detected in GM-13S in January and May 2018. The results of LNAPL monitoring for 2018 are within historic ranges and consistent with past trends. LNAPL and sheen monitoring results are presented in Table 5.

#### **4. SUMMARY OF DATA VALIDATION**

Laboratory analytical results were reported with associated laboratory quality assurance/quality control data (QA/QC). Analytical reports were reviewed and data were validated. During this quarter, limited data were qualified with a J qualifier (the associated value is approximate). A summary of the data qualified during validation, qualifiers assigned, and reasons for data qualification are provided in Table 6. All laboratory reports are retained at the TechSolve office.

#### **5. ADDITIONAL ACTIVITIES**

From July 2017 through May 2018, BP constructed a new seawall waterward of the preexisting timber bulkhead that separated the Duwamish West Waterway from Plant 1. The project is intended to provide long-term seismic protection of the Site.

Ecology was consulted prior to initiating the project regarding seawall design, construction activities, and potential impacts to ongoing remedial actions. These consultations resulted in the development of the Water Quality Monitoring Plan (WQMP) (ERM West and TechSolve, 2017), which was implemented to track the performance of best management practices and compliance with the Consent Decree during seawall construction. Monitoring conducted in accordance with the WQMP included both surface water and groundwater monitoring. Surface water monitoring included ongoing monitoring for sheen, LNAPL, and turbidity whenever work was occurring on or over-water. Groundwater monitoring conducted as part of the project included visual monitoring for sheen and LNAPL at various stages, as well as baseline and post-construction monitoring events for concentrations of IHSs and other analytes. Monitoring results from the implementation of the WQMP have been included in a post construction WQMP summary report that will be submitted to Ecology within the next month. No exceedances of water quality standards defined in the WQMP occurred throughout the project.

Additional evaluations of the seawall's impact on site hydrology will occur upon completion of the seawall installation.

#### **6. SUMMARY**

This progress report and groundwater monitoring report summarizes operation of remediation systems through the second quarter of 2018 (June 2018) and the First Quarter 2018 Groundwater Monitoring Event. In accordance with the Consent Decree, the Third Quarter 2018 Progress Report / Second Quarter 2018 Groundwater Monitoring Report will be the next quarterly progress report submitted to Ecology. This report will be submitted to Ecology by October 15, 2018. More detailed information than is provided in the quarterly reports, such as this report, is provided in the Annual Site Report, which is submitted yearly to Ecology by April 15.

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## **TABLES**

**Table 1. Waterfront Groundwater System Petroleum Hydrocarbon Recovery Rates**  
**Site: BP Harbor Island Terminal**

**GROUNDWATER SYSTEM EFFICIENCIES**

SAMPLE DATE	UNITS	Influent Benzene	Effluent Benzene	% Reduction	Influent Diesel	Effluent Diesel	% Reduction	Influent Ethylbenzene	Effluent Ethylbenzene	% Reduction	Influent Gasoline	Effluent Gasoline	% Reduction	Influent Oil	Effluent Oil	% Reduction	Influent Toluene	Effluent Toluene	% Reduction	Influent Xylenes	Effluent Xylenes	% Reduction
2002 Averages	µg/L	225.3	14.3	91%	7,315	7,020	4%	55.2	6.2	75%	1,770	336	82%	831	804	5%	17.0	2.5	88%	88.8	9.9	87%
2003 Averages	µg/L	137.7	19.5	76%	4,945	4,648	-1%	44.5	12.9	69%	1,854	678	62%	760	763	0%	42.7	5.4	61%	154.1	50.3	68%
2004 Averages	µg/L	93.5	3.2	82%	10,285	9,342	-6%	76.8	4.7	79%	4,383	840	59%	762	1,026	-8%	116.6	5.2	82%	356.6	23.0	75%
2005 Averages	µg/L	76.7	14.5	84%	4,162	5,987	-9%	170.8	45.4	81%	10,090	3,229	70%	864	750	15%	566.9	121.0	84%	1,327.7	367.9	78%
2006 Averages	µg/L	38.9	1.2	89%	11,263	2,174	42%	42.1	0.9	90%	4,944	202	94%	665	666	0%	55.6	0.8	77%	485.1	5.2	96%
2007 Averages	µg/L	8.8	1.5	60%	1,223	906	18%	6.6	0.8	56%	407	115	63%	598	598	0%	1.0	0.5	21%	19.8	1.9	50%
2008 Averages	µg/L	10.0	1.1	70%	540	468	6%	5.5	0.7	39%	279	76	61%	505	504	0%	0.7	0.5	40%	10.6	1.6	65%
2009 Averages	µg/L	5.2	1.0	48%	369	561	8%	4.1	1.6	31%	407	182	46%	497	489	2%	0.8	0.7	44%	15.2	7.4	33%
2010 Averages	µg/L	3.9	0.7	76%		2,193	NA	6.8	1.7	78%	915	336	65%		410	NA	0.9	0.9	NA	26.3	6.7	69%
2011 Averages	µg/L	3.2	0.5	80%		1,714	NA	2.4	1.0	53%	439	89	69%		492	NA	1.0	1.0	NA	7.1	3.0	29%
2012 Averages	µg/L	3.6	1.3	48%		2,787	NA	1.9	1.2	37%	362	144	61%		636	NA	1.0	1.0	NA	5.7	3.4	48%
2013 Averages	µg/L	1.0	0.5	45%		1,333	NA	1.1	0.5	49%	356	124	57%		433	NA	0.5	0.5	NA	2.4	1.0	78%
2014 Averages	µg/L	1.7	0.3	61%		1,699	NA	0.6	0.3	46%	539	122	79%		236	NA	0.5	0.3	NA	1.5	0.5	61%
2015 Averages	µg/L	2.3	0.4	66%		5,175	NA	1.6	0.4	60%	1,146	406	64%		396	NA	0.5	0.4	NA	2.8	0.5	74%
2016 Averages	µg/L	2.2	0.6	76%		2,292	NA	2.3	0.5	81%	1,282	582	50%		246	NA	0.4	0.4	NA	2.9	1.0	62%
2017 Averages	µg/L	1.9	0.4	74%		4,325	NA	1.0	0.4	63%	1,421	641	56%		349	NA	0.5	0.4	NA	1.0	0.7	55%
1/17/2018	µg/L	3	0.20	93%		4,200	NA	0.68	0.20	71%	1,400	390	72%		320	NA	0.20	0.20	NA	0.66	0.50	24%
2/14/2018	µg/L	1.9	0.20	89%		1,100	NA	0.20	0.20	NA	310	51	84%		260	NA	0.20	0.20	NA	0.50	0.50	NA
3/14/2018	µg/L	0.29	0.20	31%		820	NA	0.20	0.20	NA	830	130	84%		260	NA	0.20	0.20	NA	0.50	0.50	NA
4/18/2018	µg/L	3.0	3.0	NA		1,100	NA	3.0	3.0	NA	250	110	56%		370	NA	2.0	2.0	NA	3.0	3.0	NA
5/16/2018	µg/L	0.2	0.2	NA		760	NA	0.34	0.20	41%	210	68	68%		360	NA	0.20	0.20	NA	3.0	0.50	83%
6/13/2018	µg/L	0.20	0.20	NA		1,200	NA	0.20	0.20	NA	330	200	39%		380	NA	0.20	0.20	NA	0.77	0.50	35%
SURFACE WATER CLEANUP LEVELS		71 µg/L			10,000 µg/L			NA			1,000 µg/L			10,000 µg/L			NA			NA		
KCDNR DISCHARGE LIMITS			70 µg/L			100,000 µg/L			1,700 µg/L			NA			100,000 µg/L			1,400 µg/L			NA	
2017 Averages:		1.4 µg/L	.67 µg/L	71%	NA	1,530 µg/L	NA	.77 µg/L	.67 µg/L	56%	555 µg/L	158 µg/L	67%	NA	325 µg/L	NA	.5 µg/L	.5 µg/L	NA	1.4 µg/L	.92 µg/L	48%

**METRO DISCHARGE DATA**

Observation Date	Days Operational since last monitoring reading	Average flow (GPM)	Total Flow Between Observation dates (gallons)	Pounds of Benzene Removed	Pounds of Gasoline Removed	Pounds of Diesel Removed	Pounds of Oil Removed	Pounds of Toluene Removed	Pounds of Ethylbenzene Removed	Pounds of Xylenes Recovered	Total Gallons Gas, Diesel, and Oil
2002 Totals and Averages	65	4.18	322,785	0.62	4.99	19.42	2.30	0.05	0.13	0.22	3.90
2003 Totals and Averages	361	8.03	4,114,867	4.43	62.20	169.14	26.05	1.18	1.47	5.05	37.76
2004 Totals and Averages	338	9.58	4,570,461	3.54	175.70	419.25	28.95	5.35	3.16	14.66	92.43
2005 Totals and Averages	359	11.17	5,827,144	3.43	447.43	155.78	41.55	25.29	7.69	59.98	100.52
2006 Totals and Averages	365	6.40	3,220,733	0.80	192.72	663.65	19.09	2.85	1.89	20.04	128.92
2007 Totals and Averages	360	3.17	1,599,607	0.15	9.08	18.30	8.40	0.02	0.11	0.48	5.20
2008 Totals and Averages	363	3.19	1,645,810	0.14	3.95	7.21	6.95	0.01	0.08	0.15	2.59
2009 Totals and Averages	369	2.98	1,569,390	0.07	5.75	7.81	6.40	0.01	0.06	0.22	2.89
2010 Totals and Averages	372	2.17	1,185,127	0.04	8.62	18.84	4.26	0.01	0.05	0.19	4.66
2011 Totals and Averages	356	1.90	949,880	0.03	5.13	17.55	3.54	0.01	0.03	0.13	3.81
2012 Totals and Averages	371	1.89	948,600	0.03	3.97	25.92	3.47	0.01	0.02	0.04	4.81
2013 Totals and Averages	365	1.33	700,450	0.01	2.26	8.80	3.43	0.00	0.01	0.02	2.08
2014 Totals and Averages	332	1.62	761,480	0.01	3.43	10.95	1.55	0.00	0.00	0.01	2.33
2015 Totals and Averages	358	1.71	874,680	0.02	6.56	36.53	2.92	0.00	0.01	0.02	6.68
2016 Totals and Averages	370	1.90	999,770	0.02	13.12	20.02	1.94	0.00	0.03	0.03	5.26
2017 Totals and Averages	363	1.65	866,030	0.01	11.96	33.39	2.62	0.00	0.01	0.01	7.52
January-18	35	1.53	77,220	0.0018	1.92	6.03	0.3422	0.0002	0.0007	0.0006	1.67
February-18	28	1.74	70,090	0.0014	0.50	1.55	0.17	0.0001	0.0003	0.0003	0.33
March-18	28	1.14	45,940	0.0004	0.22	0.37	0.10	0.0001	0.0001	0.0002	0.10
April-18	35	1.04	52,530	0.0007	0.24	0.42	0.14	0.0005	0.0007	0.0008	0.12
May-18	28	1.19	48,160	0.0006	0.09	0.37	0.15	0.0004	0.0007	0.0012	0.09
June-18	28	1.10	44,520	0.0001	0.10	0.36	0.14	0.0001	0.0001	0.0007	0.09
2018 Totals and Averages	182	1.29	338,460	0.005	3.07	9.11	1.03	0.001	0.002	0.004	2.38
<b>TOTALS:</b>			<b>30,495,274 gal</b>	<b>13.35</b>	<b>959.9</b>	<b>1641.7</b>	<b>164.5</b>	<b>34.80</b>	<b>14.75</b>	<b>101.25</b>	
<b>Maximum permitted GPM:</b>		<b>17.5</b>	<b>Gallons Gas, Diesel, &amp; Oil Recovered:</b>		<b>156.1</b>	<b>235.2</b>	<b>21.6</b>	<b>TOTAL GALLONS RECOVERED:</b>			<b>413.72</b>

Observation Date	Monthly LNAPL Recovery (gal)	
February-03	19.6	
April-03	6.9	
May-03	2.5	
July-03	2	
December-03	20	
January-04	25	
June-04	35	
August-04	50	
September-04	8	
November-04	10	
December-04	3.5	
January-05	0	
February-05	35	
July-05	110	
February-06	5	
March-06	2	
December-06	30	
March-08	30	
<b>Total Gallons LNAPL Recovered</b>		<b>395</b>

<b>TOTAL PETROLEUM RECOVERY</b>	
Total lbs Dissolved Gas, Diesel, and Oil Recovered in Groundwater (2002-Present)	2,766 lbs
<b>Total Gallons Dissolved Gas, Diesel, and Oil Recovered in Groundwater (2002-Present)*</b>	<b>414 gal</b>
<b>Total Gallons LNAPL Recovered by Final Recovery System (2002-Present)</b>	<b>395 gal</b>
<b>Total Gallons LNAPL Recovered by Interim Recovery System (1992-2002)</b>	<b>9,312 gal</b>
<b>Total Gallons of TPH Vapor Recovered by Final SVE System (2003-2008)**</b>	<b>2,334 gal</b>
<b>Total Gallons of TPH Vapor Recovered by Interim SVE System (1996-2002)**</b>	<b>1,248 gal</b>
<b>Total Gallons TPH Recovered from Final SVE System due to Biodegradation (2003-2008)***</b>	<b>11,411 gal</b>
<b>Total Gallons TPH Recovered from Interim SVE System due to Biodegradation (1996-2002)***</b>	<b>4,664 gal</b>
<b>Total Gallons Recovered by Final Recovery Systems (2002-Present)</b>	<b>14,554 gal</b>
<b>Total Gallons Recovered by Interim Recovery Systems (1992-2002)</b>	<b>15,223 gal</b>
<b>Total Gallons of Petroleum Removed (1992-Present)</b>	<b>29,778 gal</b>

**Notes:**

LNAPL Recovery is recorded periodically when sufficient product has been accumulated to be transported off-site for disposal.  
 Influent diesel and oil samples are no longer analyzed, as influent and effluent samples are collected before and after, respectively, a diffused air stripper, which is not intended or effective at removing diesel or oil.  
 Effluent sample data are representative of the outflow water to King County Metro sanitary sewer.  
 The average µg/L of the preceding month and the month of reference are used to calculate pounds of compound removed.  
 If the influent concentrations are below the laboratories method detection limit, the percent reduction is calculated using the method detection limit. The actual percent reduction is ≥ the reported value.

\* Calculation of lbs of Recovered Product

To convert µg/L to lbs/gallon - (µg/L)x(3.785/gal)=ug/gal, (ug/gal)x(µg/(2.2046x10-9lbs))=lbs/gal

lbs/gal of chemical constituent x total gallons recovered =lbs of chemical recovered

Density of Gasoline utilized for conversions from pounds to gallons is 6.15 lbs/gal

Density of Diesel utilized for conversions from pounds to gallons 6.98 lbs/gal

Density of Oil utilized for conversions from pounds to gallons 7.63 lbs/gal

Benzene, toluene, ethylbenzene, and xylenes volumes are not included in the Total Gallons calculations, as they are assumed to be included in TPH as gasoline.

\*\* / \*\*\* SVE Recovery Calculations for TPH and Biodegradation, which are maintained in separate tables.

C = Average Influent TPH concentration (ppmv)

Q = Influent Flow Rate (SCFM)

Mc = Molecular wt. of Carbon Dioxide = 44

Mg = Molecular wt. of Gasoline = 87

Density of Gasoline for conversions is 6.15 lbs/gal

\*\* TPH recovered by SVE system was calculated in lbs/hr = C x Q x Mg x 1.583 x 10<sup>-7</sup>

1.583 x 10<sup>-7</sup> is a constant and is derived as follows:

10<sup>-6</sup> ppmv x 60min/1hr x 1 lb Mole/379 cu.ft.

SVE TPH recovery calculations are based on TPH concentrations in the SVE stream, SVE hrs of operation, and SVE measured flow rates.

**Definitions:**

- gal - gallons
- GPM - Gallons per minute
- NA - Not available
- LNAPL - Light non-aqueous phase liquid (oil)
- SVE - Soil vapor extraction
- TPH - Total petroleum hydrocarbons
- µg/L - micrograms per liter

Table 2. Groundwater Performance Monitoring Schedule  
 Site: BP Harbor Island Terminal

Analyses Conducted by Quarter				
Well	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
<b>Plant 1</b>				
MW-1-T9	Benzene, TPH-G, TPH-D, TPH-O	(1)	Benzene, TPH-G, TPH-D, TPH-O	(1)
MW-2-T9	Benzene, TPH-G, TPH-D, TPH-O	(1)	Benzene, TPH-G, TPH-D, TPH-O	(1)
MW-3-T9	Benzene, TPH-G, TPH-D, TPH-O	(1)	Benzene, TPH-G, TPH-D, TPH-O	(1)
GM-14S	Benzene, TPH-G, TPH-D, TPH-O			
GM-15S	Benzene, TPH-G, TPH-D, TPH-O	(1)	Benzene, TPH-G, TPH-D, TPH-O	(1)
GM-16S	Benzene, TPH-G, TPH-D, TPH-O		Benzene, TPH-G, TPH-D, TPH-O	
GM-17S	Benzene, TPH-G, TPH-D, TPH-O		Benzene, TPH-G, TPH-D, TPH-O	
<b>GM-24S</b>	Benzene, TPH-G, TPH-D, TPH-O			
AR-03	Benzene, TPH-G, TPH-D, TPH-O	(1)	Benzene, TPH-G, TPH-D, TPH-O	(1)
<b>AMW-01</b>	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O, cPAHs
AMW-02	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O, cPAHs
AMW-03	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O, cPAHs
AMW-04	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O, cPAHs
AMW-05	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O	Benzene, TPH-G, TPH-D, TPH-O, cPAHs
<b>Plant 2</b>				
GM-19S	Benzene, TPH-G		Benzene, TPH-G	

Notes: Field Duplicate and QA/QC samples collected from wells highlighted in bold.  
 TPH-G - Gasoline Range organics utilizing NWTPH-Gx method  
 TPH-D - Diesel Range Organics utilizing NWTPH-Dx  
 TPH-O - Extended Range Organics (Motor Oil) utilizing NWTPH-Dx  
 Benzene is analyzed for utilizing EPA 8021 or 8260B.  
 cPAHs - Carcinogenic Polycyclic Aromatic Hydrocarbons utilizing EPA 8270SIM  
 Field Parameters (pH, Temperature, Conductivity, Turbidity, Water Level, & Product Level) are recorded from all wells sampled  
 (1) - If a groundwater cleanup level exceedance occurs in first or third quarter in any of these highlighted wells, all (1) wells will be sampled the following quarter. Wells exceeding cleanup levels will continue quarterly monitoring until four consecutive quarters below cleanup level are achieved.

Table 3. Groundwater Performance Monitoring Groundwater Elevations  
 First Quarter 2018  
 Site: BP Harbor Island Terminal

Well	Date	TOC Elevation (ft msl)	Depth to Water (ft below TOC)	Groundwater Elevation (ft msl)
<b>Plant 1</b>				
GM-14S	3/21/2018	8.57	4.05	4.52
GM-15S	3/20/2018	8.92	4.99	3.93
GM-16S	3/21/2018	8.53	4.53	4.00
GM-17S	3/21/2018	9.19	4.30	4.89
GM-24S	3/21/2018	4.69	3.12	1.57
AR-03	3/21/2018	9.35	5.65	3.70
AMW-01	3/20/2018	8.88	10.09	-1.21
AMW-02	3/20/2018	12.14	12.82	-0.68
AMW-03	3/20/2018	12.07	12.73	-0.66
AMW-04	3/20/2018	8.00	4.60	3.40
AMW-05	3/20/2018	8.14	3.45	4.69
MW-1-T9	3/21/2018	9.07	5.47	3.60
MW-2-T9	3/21/2018	9.23	5.23	4.00
MW-3-T9	3/21/2018	8.73	4.82	3.91
<b>Plant 2</b>				
GM-19S	3/21/2018	7.68	3.02	4.66

ft Feet

msl Mean sea level

NA Not available. Well elevations have not been surveyed.

NM Not measured. Well was not gauged or sampled due to inaccessibility caused by the Island redevelopment activities.

TOC Top of casing

Elevations measurements are calculated using NGVD29 Datum.

Table 4. Summary of Analytical Results for Groundwater - TPH-G, TPH-D, TPH-O, and Benzene  
 First Quarter 2018  
 Site: BP Harbor Island Terminal

Well	Date	TPH-G WTPH-G (µg/L)	TPH-D WTPH-DX (µg/L)	TPH-O WTPH-DX (µg/L)	Benzene (µg/L)
<b>Plant 1</b>					
GM-14S	3/21/2018	870 J	590	ND	ND
GM-15S	3/20/2018	ND	ND	ND	ND
GM-16S	3/21/2018	160	350	ND	ND
GM-17S	3/21/2018	56	ND	ND	ND
GM-24S	3/21/2018	790	370	ND	ND
AR-03	3/21/2018	66	ND	ND	ND
AMW-01	3/20/2018	240	ND	ND	ND
AMW-02	3/20/2018	53	ND	ND	2.3
AMW-03	3/20/2018	ND	ND	ND	ND
AMW-04	3/20/2018	74 J	ND	ND	ND
AMW-05	3/20/2018	ND	ND	ND	ND
MW-1-T9	3/21/2018	200	ND	ND	ND
MW-2-T9	3/21/2018	490	ND	ND	ND
MW-3-T9	3/21/2018	750	ND	ND	1.90
<b>Plant 2</b>					
GM-19S	3/21/2018	140	NR	NR	ND
Cleanup Level		1,000	10,000	10,000	71
Method Reporting Limit		50	250	750	0.5

Note: Values in **bold** exceed the cleanup level.  
 µg/L Micrograms per liter.  
 ND Constituent not detected above reporting limit.  
 NR Not required. Well was not tested for these analyses, as per Ecology approval.  
 redevelopment activities.  
 TPH Total petroleum hydrocarbons.  
 TPH-D Total petroleum hydrocarbons as diesel.  
 TPH-G Total petroleum hydrocarbons as gasoline.  
 TPH-O Total petroleum hydrocarbons as oil.  
 WTPH-DX Washington State Method for Analysis of Diesel in Soil and Water - Extended.  
 WTPH-G Washington State Method for Analysis of Gasoline in Soil and Water.  
 J Estimated value.  
 UJ Not detected at an estimated value.  
 R Rejected value.

Table 5. Summary of Free Product Measurement Results for Groundwater  
 2018 Monitoring Data  
 Site: BP Harbor Island Terminal

Well	Date	Free Product (feet)
<b>Plant 1</b>		
GM-11S	1/17/2018	None
GM-11S	2/14/2018	None
GM-11S	3/14/2018	None
GM-11S	4/18/2018	<b>Sheen</b>
GM-11S	5/16/2018	<b>Sheen</b>
GM-11S	6/13/2018	<b>Sheen</b>
GM-12S	1/17/2018	None
GM-12S	2/14/2018	None
GM-12S	3/14/2018	None
GM-12S	4/18/2018	None
GM-12S	5/16/2018	None
GM-12S	6/13/2018	None
GM-13S	1/17/2018	<b>Sheen</b>
GM-13S	2/14/2018	None
GM-13S	3/14/2018	None
GM-13S	4/18/2018	None
GM-13S	5/16/2018	<b>Sheen</b>
GM-13S	6/13/2018	None
Cleanup Level		No Sheen

Notes: Values in **bold** exceed the cleanup level.

Table 6. Summary of Data Validation Results  
 Groundwater Performance Monitoring  
 First Quarter 2018  
 Site: BP Harbor Island Terminal

Sample ID	Constituent	Qualifier	Reason
P1-GWAMW-04-118 & P1-GWAMW-204-118	Gasoline	J	Relative percent difference (RPD) for this field duplicate pair exceeded the control limit of 20%. These results are, therefore, qualified as estimated values (J).
P1-GWGM-14S-118	Gasoline	J	The recovery of one surrogate in this sample exceeded the control limit. This result is, therefore, qualified as an estimated value.

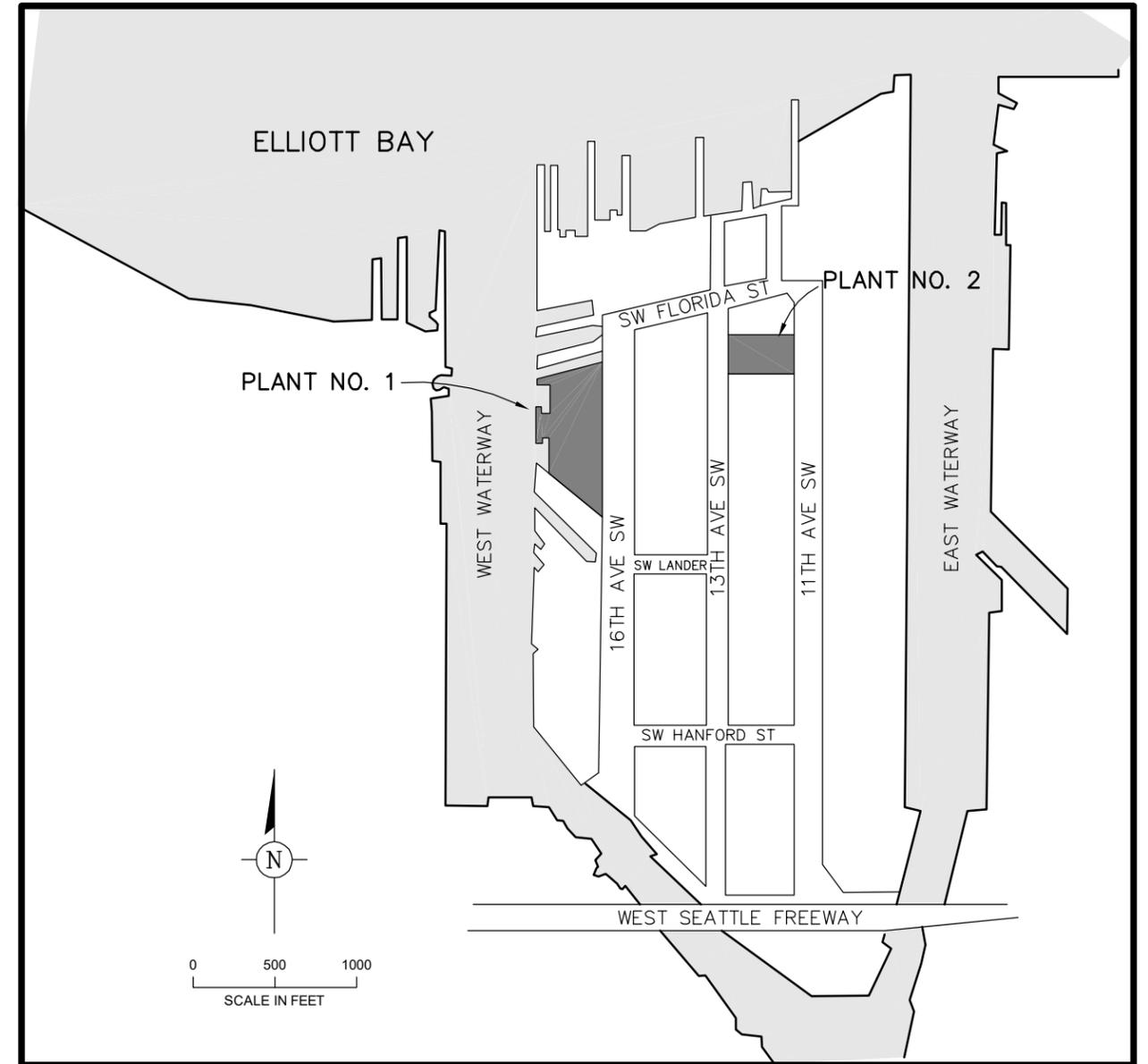
Definitions:

J The associated value is approximate.  
 RPD Relative Percent Difference

## FIGURES

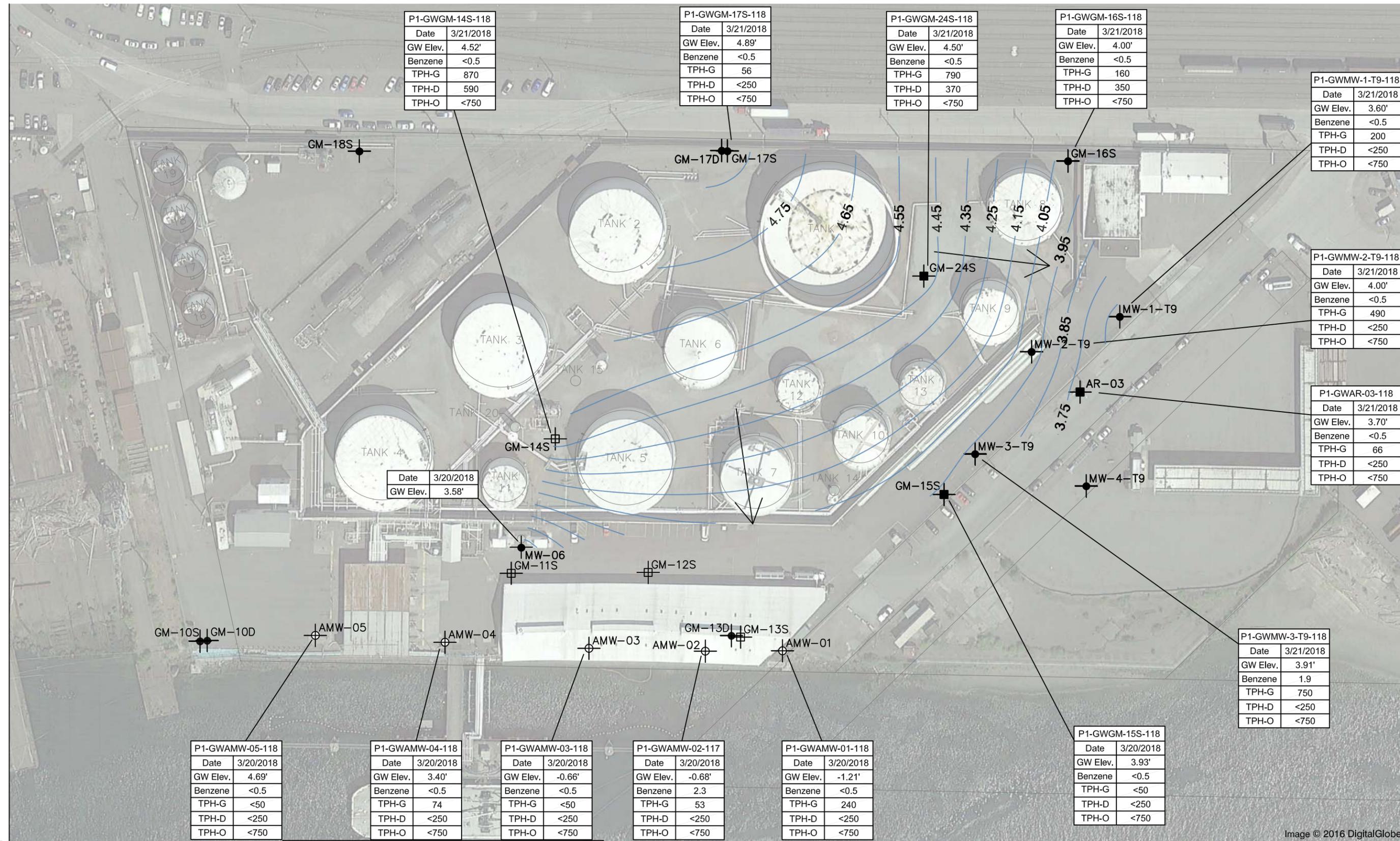


AREA PLAN



SITE PLAN

\\server\ServerData\data\Project\ARCD 21\Drawings and CAD files\Autocad files: Plant 1 GWM Flgs. dwg June 28, 2017

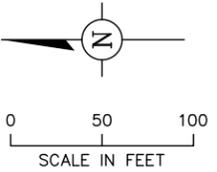


**LEGEND**

- GM-16S Monitoring Well
- ⊕ AMW-01 Performance/Confirmation Well
- GM-13D Performance Well
- GM-13S Product Performance Well
- 3.1 Groundwater Contour (Feet MSL)

Sample ID	
Date	Date Sample Collected
GW Elev.	Groundwater Elevation in Feet Mean Sea Level (MSL)
Benzene	Benzene (EPA 8260) in µg/L
TPH-G	Total Petroleum Hydrocarbons as Gasoline (NWTPH-GX) in µg/L
TPH-D	Total Petroleum Hydrocarbons as Diesel (NWTPH-DX) in µg/L
TPH-O	Total Petroleum Hydrocarbons as Oil (NWTPH-DX) in µg/L

Notes: **Bold** - Detected concentration exceeds site specific cleanup level  
 < = Not detected at listed laboratory reporting limit



**TECHSOLVE**  
 ENVIRONMENTAL

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 Kenmore, WA 98028  
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**Plant 1 First Quarter 2018**  
**Groundwater Monitoring Analytical Results**

BP Harbor Island Terminal  
 1652 Southwest Lander Street  
 Seattle, WA 98134

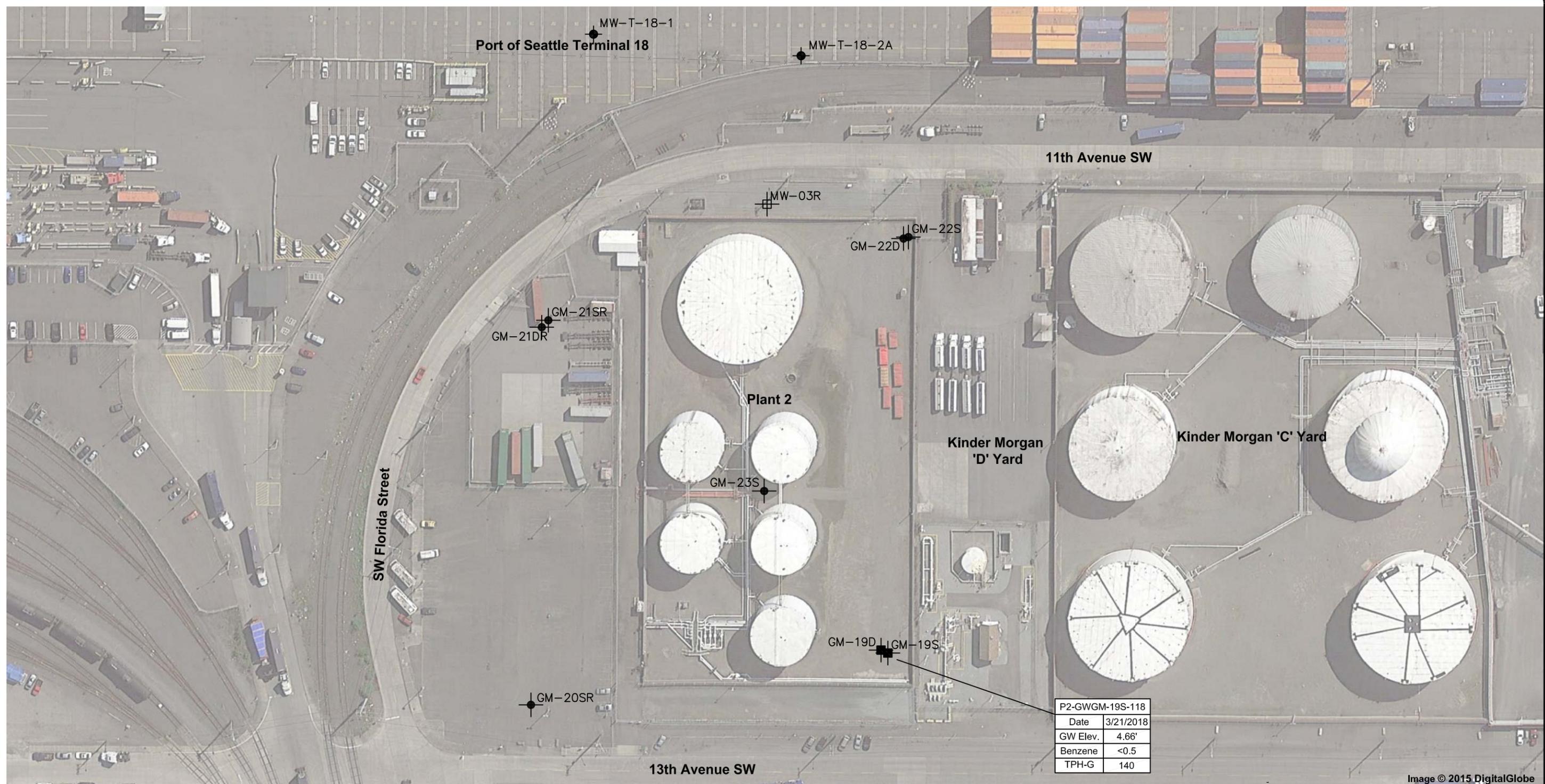


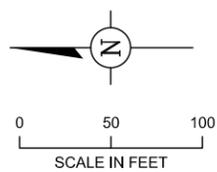
Image © 2015 DigitalGlobe

LEGEND

-  GROUNDWATER MONITORING WELL
-  PRODUCT PERFORMANCE WELL
-  PERFORMANCE WELL

Sample ID	
Date	Date Sample Collected
GW Elev.	Groundwater Elevation in Feet Mean Sea Level (MSL)
Benzene	Benzene (EPA 8260)
TPH-G	Total Petroleum Hydrocarbons as Gasoline (NWTPH-GX)

Notes: **Bold** - Detected concentration exceeds site specific cleanup level  
 < = Not detected at listed laboratory detection limit  
 All listed concentrations are reported in µg/L



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**Plant 2 First Quarter 2018**  
**Groundwater Monitoring Analytical Results**

Site: BP Harbor Island Terminal  
 2406 13th Avenue SW  
 Seattle, WA 98134