Work Plan for In Situ Chemical Oxidation Program

Former Bayliner Property
17825 59th Avenue NE
Arlington, Washington

Prepared for:

Brunswick Corporation
1 North Field Court
Lake Forest, IL 60045

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September 24, 2012

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1.0 Introduction

Stantec Consulting Services Inc. (Stantec) has prepared this workplan to treat shallow groundwater impacted with Tetrachloroethylene (PCE) beneath the former Bayliner Marine property located at 17825 59th Avenue NE, Arlington, Snohomish County, Washington (the "Site"). The remedial approach selected to treat impacted shallow groundwater is in-situ chemical oxidation (ISCO). This approach was included as one of the several potential alternatives for remedial options presented in the report prepared by Stantec titled 'Remedial Investigation and Feasibility Study' dated August 10, 2010 (RI/FS report). The RI/FS report was accepted and approved by Ecology in 2011.

This Work Plan is organized as follows:

- Section 2.0 describes the Site, background, including a description of past investigations and context for ISCO as a remedial approach;
- Section 3.0 describes the goal and approach of the ISCO approach;
- Section 4.0 describes the specific tasks and methods and procedures involved in the ISCO approach;
- Section 5.0 provides a discussion of health and safety issues relating to ISCO; and
- Section 6.0 presents a schedule for the ISCO approach.

2.0 Background

This section provides a brief review of the Site's background and an overview of current conditions. A complete and detailed description of the Site's background including details of all historical environmental investigations is provided in the August 2010 RI/FS report.

2.1 SITE DESCRIPTION AND BACKGROUND

The Site is a former Bayliner Marine industrial property and is 32.8 acres in size. The Site contains three office buildings and 13 industrial buildings constructed between 1969 and 1996. The Site also includes employee parking lots, boat storage areas, and three stormwater retention ponds. The Site operated as a fiberglass boat manufacturing facility from 1968 until operations ceased in December 2008. Prior to 1968, the Site consisted of undeveloped land.

Figure 1 in Appendix A shows the general Site location and Figure 2 provides a site plan with an overview of site features.

2.2 SITE CONDITIONS

Previous investigations have identified the presence of tetrachloroethene (PCE) in shallow groundwater at concentrations ranging from 5 to 59 micrograms per liter (µg/L). Several of the detected concentrations exceed the Method A Groundwater Cleanup Level (CUL) of 5 µg/L established under the Washington Model Toxics Control Act (MTCA).

The most recent groundwater monitoring event was completed in September 2011. Analytical results of this event and previous monitoring events are provided in Table 1 (attached). The September 2011 monitoring event indicated PCE concentrations in groundwater in the suspected source area ranging from 25 µg/L to 32 µg/L indicating contaminant concentrations in the vicinity of Building 11 are stable and trending lower. Down-gradient concentrations were generally below detections limits with the exception of one sample containing 2.4 µg/L. These results indicated contaminant concentrations downgradient of the suspected source area are also generally trending lower.

Figure 3 provides analytical results and Figure 2 provides the groundwater gradient and flow direction.

3.0 Approach to In Situ Chemical Oxidation Program

The goal of the in-situ chemical oxidation (ISCO) program is to reduce VOC concentrations to below MTCA Method A levels. The approach to the ISCO program is to target for treatment the former source area and plume core area containing the highest dissolved phase VOC. The source area is considered to be the former septic system leach field near the southeast corner of Building 11. Figure 2 shows the leach field location.

Results of a bench scale/pilot test indicated a natural oxidant demand (NOD) of between 12.5 grams per kilogram (g/kg) and 13.5 g/kg. Stantec also estimated that a sustainable injection rate of approximately 2.5 gallons per minute will generate an acceptable level of groundwater mounding. These results indicate acceptable soil conditions for injection of sodium permanganate ($NaMnO_4$) as a remedial solution.

The ISCO program includes oxidant injections at up to 12 locations as shown in Figure 4.

The treatment area includes oxidant injections in the following locations:

- Eight points in the suspected source area (the former septic leach field); and
- Four points on the downgradient side of Building 11.

Details of the tasks required to complete this scope of work are provided in the following section.

4.0 ISCO Program Tasks

The proposed ISCO program includes the following four major tasks: 1) preliminary planning and permitting; 2) oxidant injection; 3) performance monitoring; and 4) data evaluation and reporting. These tasks and the procedural details are described in the following sections.

4.1 PRELIMINARY PLANNING AND PERMITTING

This task includes preliminary planning, approvals and permitting activities including the following:

- Completing utility clearance work, including notifying Washington State One Call Utility Notification Service, to identify subsurface utilities located in the public rights-of-way. Working with Site representatives to identify locations of subsurface utilities and/or other obstructions and hazards in the work area, and conducting an on-site clearance of the work area with the assistance of a private utility locating contractor;
- Approval from the Washington State Department of Ecology (Ecology) for injecting chemicals into the subsurface is required. This work plan will be submitted to Ecology to secure approval;
- Registration of the planned injection points under Ecology's Underground Injection Control Program (UIC). UIC is part of the voluntary cleanup process. This registration is separate from Ecology's work plan approval;
- Ordering and securing the delivery and temporary storage location of $NaMnO_4$ solution at a the Site; and
- Coordinating access with tenants.

4.2 ISCO INJECTION

This section describes the methods and procedures for the ISCO injection using direct push technology as the delivery system.

4.2.1 Oxidant Solution and Dosing

RemOx® L ISCO reagent (RemOx®), a pre-mixed $NaMnO_4$ liquid solution, containing 40 percent $NaMnO_4$ by weight will be obtained from Carus Corporation. RemOx® is specifically manufactured for environmental applications such as remediation of groundwater and contains very low quantities of impurities relative to $NaMnO_4$ manufactured for industrial applications. A fact sheet describing RemOx® is provided in Appendix A.

The RemOx® solution will be delivered to the Site by truck in 260-gallon capacity high density polyethylene (HDPE) totes. The totes will be stored on-site in a location agreed to with the Site representative. Assuming injections in a total of 12 locations, a total of 3 totes or 780 gallons of RemOx® solution will be required to complete the injections.

The appropriate mass of oxidant injected into the subsurface is dependent on the contaminant concentration and the NOD of soils within the treatment area. Stantec utilized an oxidant dosing calculation spreadsheet developed by CARUS® to estimate an appropriate oxidant mass and dilution factor. The dosing spreadsheet takes into account the estimated volume of area to be treated, average contaminant concentrations in groundwater, site-specific NOD, and the desired oxidant solution concentration. Based on these calculations, an estimated total of 8,923 pounds or approximately 780 gallons of RemOx® 40% solution is an appropriate mass for injection. Prior to injection, the RemOx® solution will be diluted with potable water to yield a solution containing approximately 5 percent $NaMnO_4$ by weight. A total volume of 688 gallons of 5 percent solution will be targeted for injection at each location. Actual volumes injected at each location may vary depending on the ability of the subsurface formation to accept the solution. The CARUS® dosing calculation spreadsheet is presented as Appendix B.

4.2.2 Oxidant Injection Procedures

As described in Section 3.0, oxidant injections will be completed using direct push technology.

Stantec field personnel will oversee chemical handling, injection rig operation, and Site cleanup. Stantec will retain Cascade Drilling Inc. (Cascade), to mix and inject the oxidant solution. Cascade owns and operates an injection rig equipped with specialized equipment designed for mixing and injecting permanganate solutions for remediation applications. Totes containing the RemOx® solution will be loaded onto the injection rig and transported to each injection location. Cascade will install 12 temporary wells in the locations shown on Figure 2. The bottom of the well screens will be set approximately 10 feet below the top of the groundwater level to a maximum depth of 22 feet and the screens will extend to approximately 5 feet above the top of the groundwater level. Note that the concrete at each well location will need to be cored prior to drilling. Concrete thickness is anticipated to be between 12 and 18 inches.

The injection rig will position itself near the temporary well head and connect a hose to transfer the oxidant solution from the injection rig into each wellhead. The RemOx® solution will be pumped directly from the tote into an on-board mixing hopper, where it will be mixed with potable water to achieve the desired concentration level and then injected directly into the well using a positive displacement pump.

A safety piping harness, hold downs, and plastic sheeting will be used to protect against injury from spills or spray, and gauges will be added at appropriate piping locations to monitor injection pressures. Oxidant injection rates for the individual well head are estimated to range from approximately 2 to 4 gallons per minute (gpm). During injection, wellhead pressures will be monitored and not exceed 50 pounds per square inch (psi) to protect the integrity of well screen and packing and prevent possible surface rupture.

Chemical handling and safety procedures will be in-place during oxidant mixing and injection (personal protective equipment or PPE, valve and operation instructions and sequence, worker and public buffer zones) to prevent over-pressurization, fitting and hose failures, spills, and to protect workers from potential exposures. Sodium meta-bisulfite will be on-hand in sufficient quantity to neutralize spills and protect pavement and equipment. Sufficient socks and absorbent pads will be available and placed around storm drains and near sensitive landscaping prior to movement or use of oxidant in injection areas.

At injection locations where nearby monitoring wells screened in the same flow zone are present, depth-to-water and color will be periodically checked during the injection process to assess the distance and direction of oxidant flow. Depth-to-water will be measured using an electronic water-level indicator. Color change will be assessed by lowering a clear bailer to the base of the screened interval, retrieving the bailer, and visually inspecting water color.

4.3 PERFORMANCE MONITORING

Baseline and post-treatment monitoring will be performed to evaluate the effectiveness of the ISCO injection. When collecting groundwater samples for chemical analysis, well purging and sampling will be conducted in accordance with the low-flow purging and sampling procedures previously used to conduct groundwater monitoring at the Site. Details of the performance monitoring program are provided below.

4.3.1 Baseline Monitoring

Baseline monitoring of all existing wells (MW-1 through MW-8) was completed in September 2011 to determine the baseline condition of groundwater quality prior to remedial action.

4.3.2 Post-Injection Monitoring

Following completion of ISCO injection, post-injection monitoring will be conducted for a period of 12 months. The objectives of the post-injection monitoring are: 1) to evaluate oxidant persistence and fate in the subsurface, 2) evaluate chemical concentration trends in groundwater at and downgradient from the treatment areas, 3) to assess the potential generation and fate of oxidant injection by-products.

The post-injection monitoring is intended to supplement data collected from periodic groundwater monitoring events. Quarterly groundwater monitoring was conducted in 2010 to establish a groundwater quality trend. Groundwater monitoring was conducted annually in 2011 and will be conducted quarterly following the injection event.

The $NaMnO_4$ solution that will be injected has a distinct purple color, which is easily identified when present in groundwater. Experience from other sites where ISCO has been performed has shown that when groundwater is visibly purple or pink in color from the presence of $NaMnO_4$, dissolved phase VOCs are not present. Accordingly, during post-injection monitoring,

wells exhibiting purple color will not be analyzed for VOCs until after the $NaMnO_4$ solution has dissipated and is no longer visibly present.

To meet the monitoring objectives, four post-injection monitoring events are planned. Monitoring will be conducted at 1-month, 3-months, 6-months, and 12-months following the injections. Details regarding each planned monitoring event are described below.

4.3.2.1 Monthly Monitoring Events

Monthly monitoring events will be conducted for the first three months following the ISCO event. During these monthly events, groundwater samples will be collected for visual color observation to assess oxidant distribution and persistence in MW-1, MW-2 and MW-8. These wells are chosen because of their proximity to the injection area. The other wells in the network are either up-gradient, cross gradient or too far down-gradient to be influenced by the injection event within three months and will therefore not be monitored.

In addition to the active presence of permanganate ion as indicated by color, the wells will also be monitored during each sampling event for the following field parameters:

- pH;
- ORP;
- Temperature;
- DO;
- Turbidity; and
- Conductivity.

These parameters will assist in determining the influence of the injection event on groundwater conditions.

4.3.2.2 Three Month Monitoring Event

During the three month event, groundwater samples from the full network of wells (MW-1 through MW-8) will be collected and submitted for VOC analysis (by EPA Method 8260B). Note that any wells exhibited purple color during this event will not be submitted for analysis due to the potential damage to laboratory testing equipment from the presence of $NaMnO_4$.

4.3.2.3 Six and 12 Month Monitoring Events

The six and 12 month monitoring events will be conducted in the same way as the three month monitoring event. It is anticipated that fewer wells will exhibit purple color as time elapses beyond the injection event.

Changes to the post-injection monitoring plan as described above may be warranted as data is reviewed and evaluated. Bayliner will be notified and consulted on any proposed changes to the monitoring plan prior to implementation.

4.4 DATA EVALUATION AND REPORTING

Sampling and analysis results will be submitted to Bayliner in a memo report following the injection monitoring event and the first 3 months of monitoring. A detailed report describing the injection event and results of the baseline and all of the monitoring activities completed through the subsequent 12 months will be prepared and submitted to Bayliner following the final monitoring event. This report will include conclusions and recommendations.

5.0 Health and Safety

Activities described in this Work Plan will be performed in accordance with the site-specific Health and Safety Plan (HASP). The procedures described in the HASP will be implemented and enforced by a health and safety representative during site work. Compliance with the HASP will be required of all persons who enter the restricted areas for the project.

The HASP includes management practices and procedures that will be implemented during handling and use of $NaMnO_4$ that will reduce potential exposure and reactivity hazards associated with $NaMnO_4$. These practices include:

- Keeping $NaMnO_4$ containers sealed until immediately prior to use;
- Proper use of appropriate PPE, including respiratory protection, gloves, face and eye protection, and chemical resistant clothing;
- Frequently checking tightness of fittings on pressurized injection equipment and piping;
- Maintaining a current material safety data sheet (MSDS) with the product at all times;
- Require personnel responsible for transporting the $NaMnO_4$ to review the MSDS and become familiar with reactivity data;
- Transport the $NaMnO_4$ only in closed and sealed containers to prevent spillage; and
- Do not store or use $NaMnO_4$ near fuels or other incompatible substances.

Hazards associated with $NaMnO_4$ are primarily associated with the concentrated solution. The dilute solution to be injected is still a strong oxidizer, but does not exhibit many of the dangers associated with the more concentrated form. However, the same procedures and practices used to prevent exposure to or reaction of the concentrated form will be used during preparation and use of the dilute solution.

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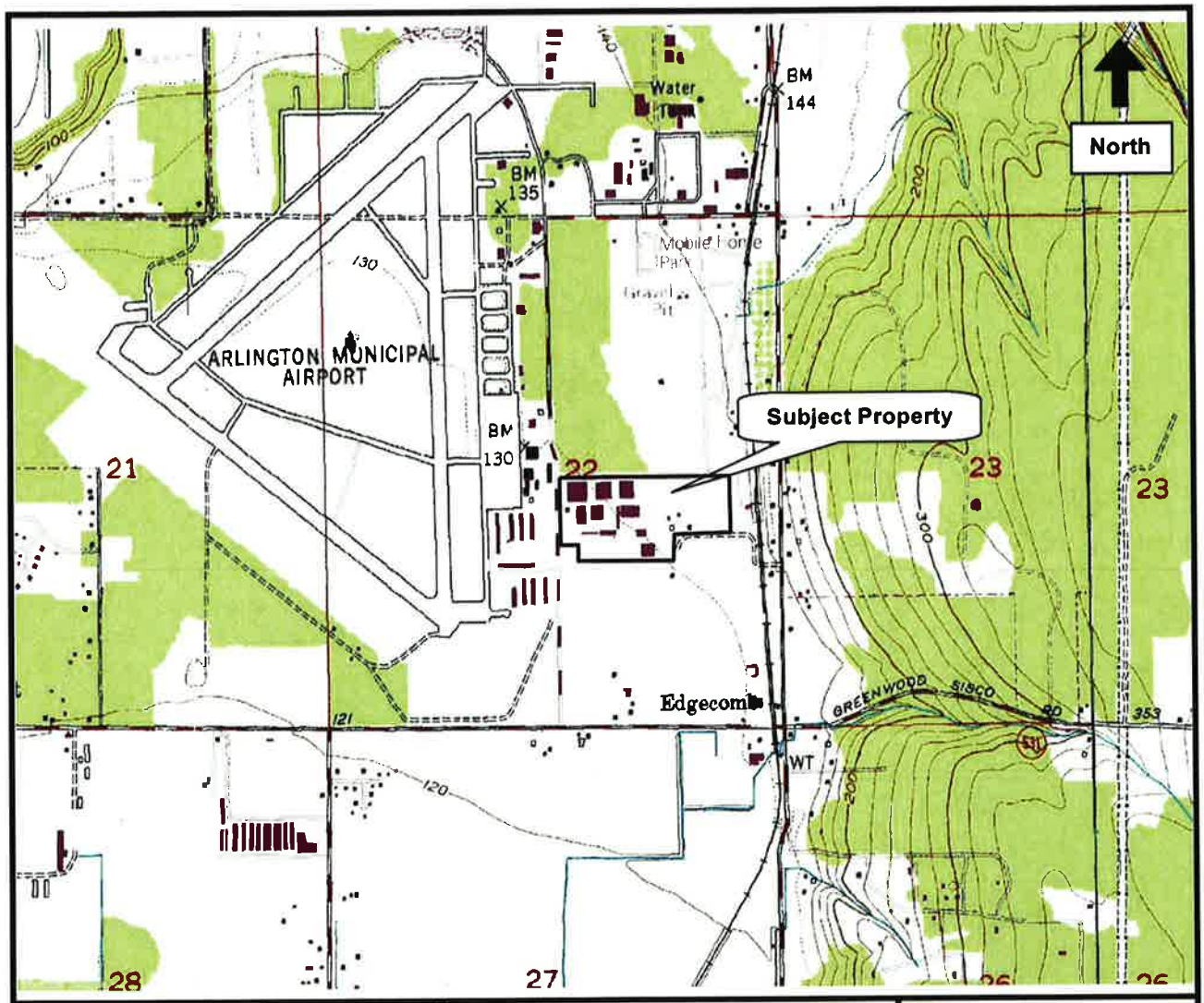
FIGURES



Quadrangle Location Map

Job #: 190402126

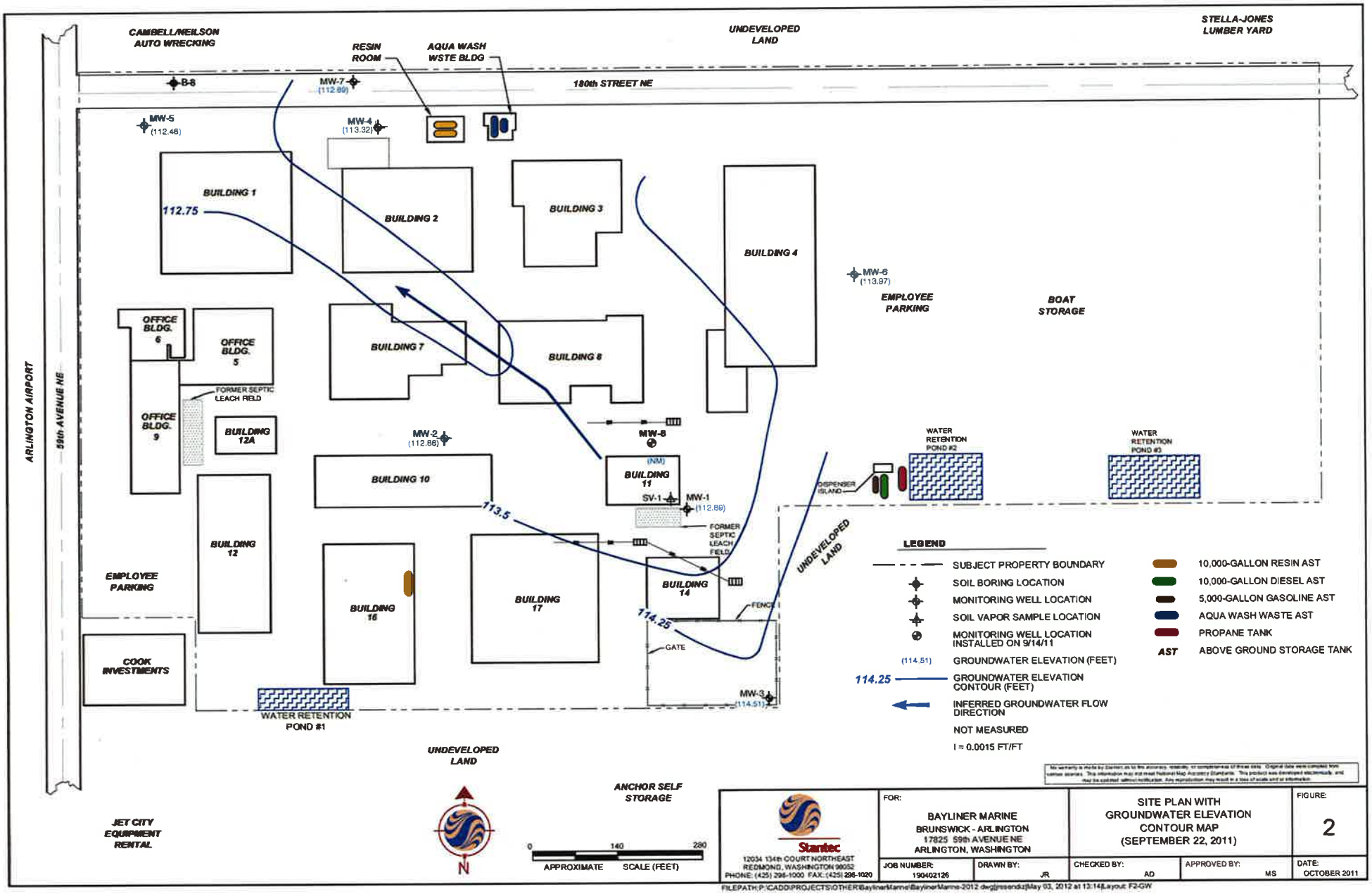
Site Location Map

Former Bayliner Property
17825 59th Avenue
Arlington, Washington

Stantec

9400 SW Barnes Rd.
Suite 100
Portland, Oregon
97225

DATE: 05/31/12	*Source: USGS Smokey Point, WA Quad 1981*	*Scale 1:25000*	*Figure: 1*
DWN: Alisa Howell	*APPR: Marc Sauze*		*Revision: 0*



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FOR:
BAYLINER MARINE
BRUNSWICK - ARLINGTON
17825 59th AVENUE NE
ARLINGTON, WASHINGTON

SITE PLAN WITH GROUNDWATER ELEVATION CONTOUR MAP (SEPTEMBER 22, 2011)

FIGURE: 2

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
190402126	JR	AD	MS	OCTOBER 2011

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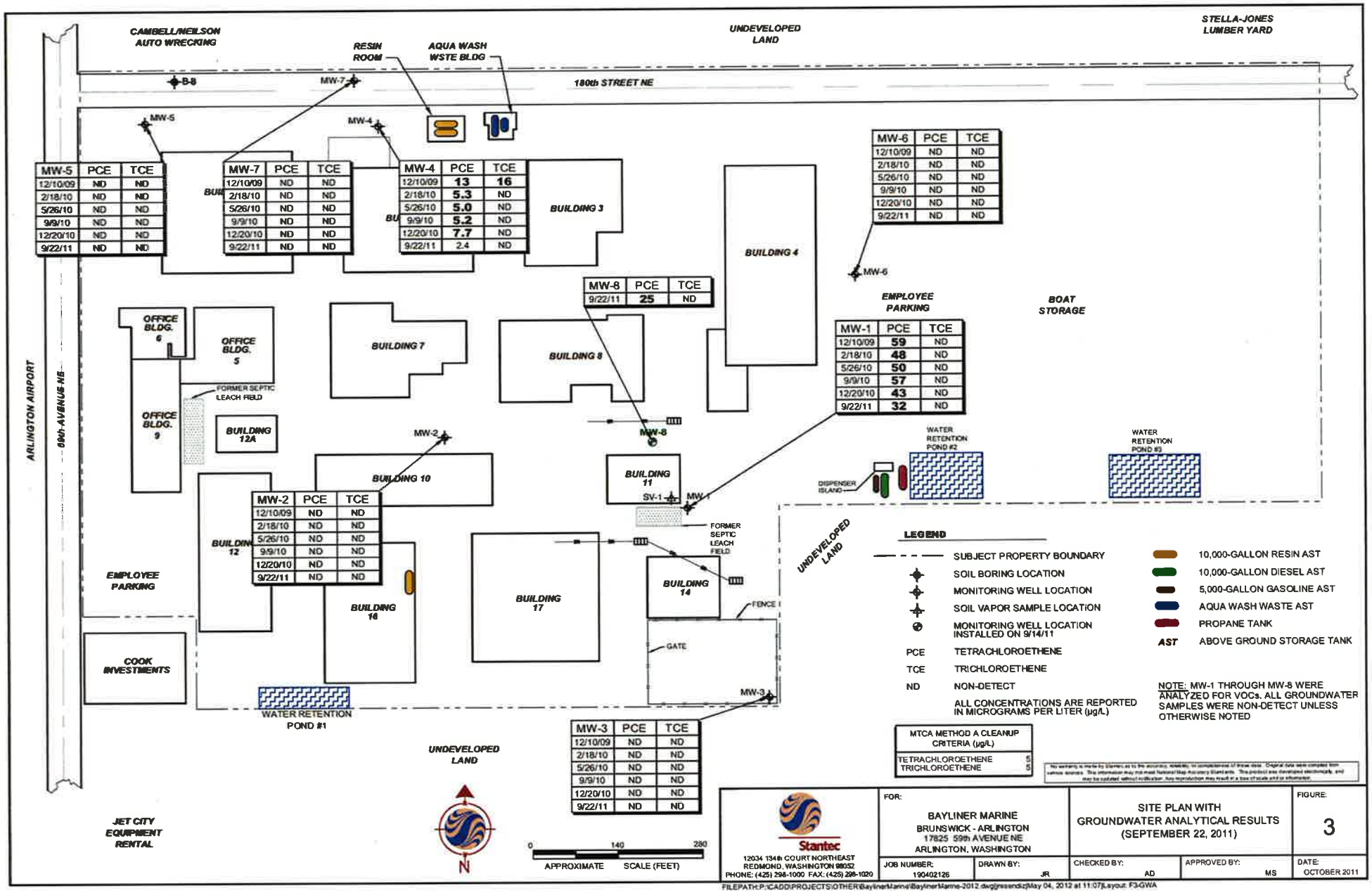

MW-5	PCE	TCE
12/10/09	ND	ND
2/18/10	ND	ND
5/26/10	ND	ND
9/9/10	ND	ND
12/20/10	ND	ND
9/22/11	ND	ND

MW-7	PCE	TCE
12/10/09	ND	ND
2/18/10	ND	ND
5/26/10	ND	ND
9/9/10	ND	ND
12/20/10	ND	ND
9/22/11	ND	ND

MW-4	PCE	TCE
12/10/09	13	16
2/18/10	5.3	ND
5/26/10	5.0	ND
9/9/10	5.2	ND
12/20/10	7.7	ND
9/22/11	2.4	ND

MW-6	PCE	TCE
12/10/09	ND	ND
2/18/10	ND	ND
5/26/10	ND	ND
9/9/10	ND	ND
12/20/10	ND	ND
9/22/11	ND	ND

MW-8	PCE	TCE
9/22/11	25	ND

MW-1	PCE	TCE
12/10/09	59	ND
2/18/10	48	ND
5/26/10	50	ND
9/9/10	57	ND
12/20/10	43	ND
9/22/11	32	ND

MW-2	PCE	TCE
12/10/09	ND	ND
2/18/10	ND	ND
5/26/10	ND	ND
9/9/10	ND	ND
12/20/10	ND	ND
9/22/11	ND	ND

MW-3	PCE	TCE
12/10/09	ND	ND
2/18/10	ND	ND
5/26/10	ND	ND
9/9/10	ND	ND
12/20/10	ND	ND
9/22/11	ND	ND

LEGEND

- SUBJECT PROPERTY BOUNDARY
- SOIL BORING LOCATION
- MONITORING WELL LOCATION
- SOIL VAPOR SAMPLE LOCATION
- MONITORING WELL LOCATION INSTALLED ON 9/14/11
- PCE TETRACHLOROETHENE
- TCE TRICHLOROETHENE
- ND NON-DETECT
- ALL CONCENTRATIONS ARE REPORTED IN MICROGRAMS PER LITER (µg/L)
- 10,000-GALLON RESIN AST
- 10,000-GALLON DIESEL AST
- 5,000-GALLON GASOLINE AST
- AQUA WASH WASTE AST
- PROPANE TANK
- AST ABOVE GROUND STORAGE TANK

NOTE: MW-1 THROUGH MW-8 WERE ANALYZED FOR VOCs. ALL GROUNDWATER SAMPLES WERE NON-DETECT UNLESS OTHERWISE NOTED

MTCA METHOD A CLEANUP CRITERIA (µg/L)	
TETRACHLOROETHENE	5
TRICHLOROETHENE	5

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FOR: BAYLINER MARINE
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SITE PLAN WITH GROUNDWATER ANALYTICAL RESULTS (SEPTEMBER 22, 2011)

FIGURE: 3

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190402126	JR	AD	MS	OCTOBER 2011

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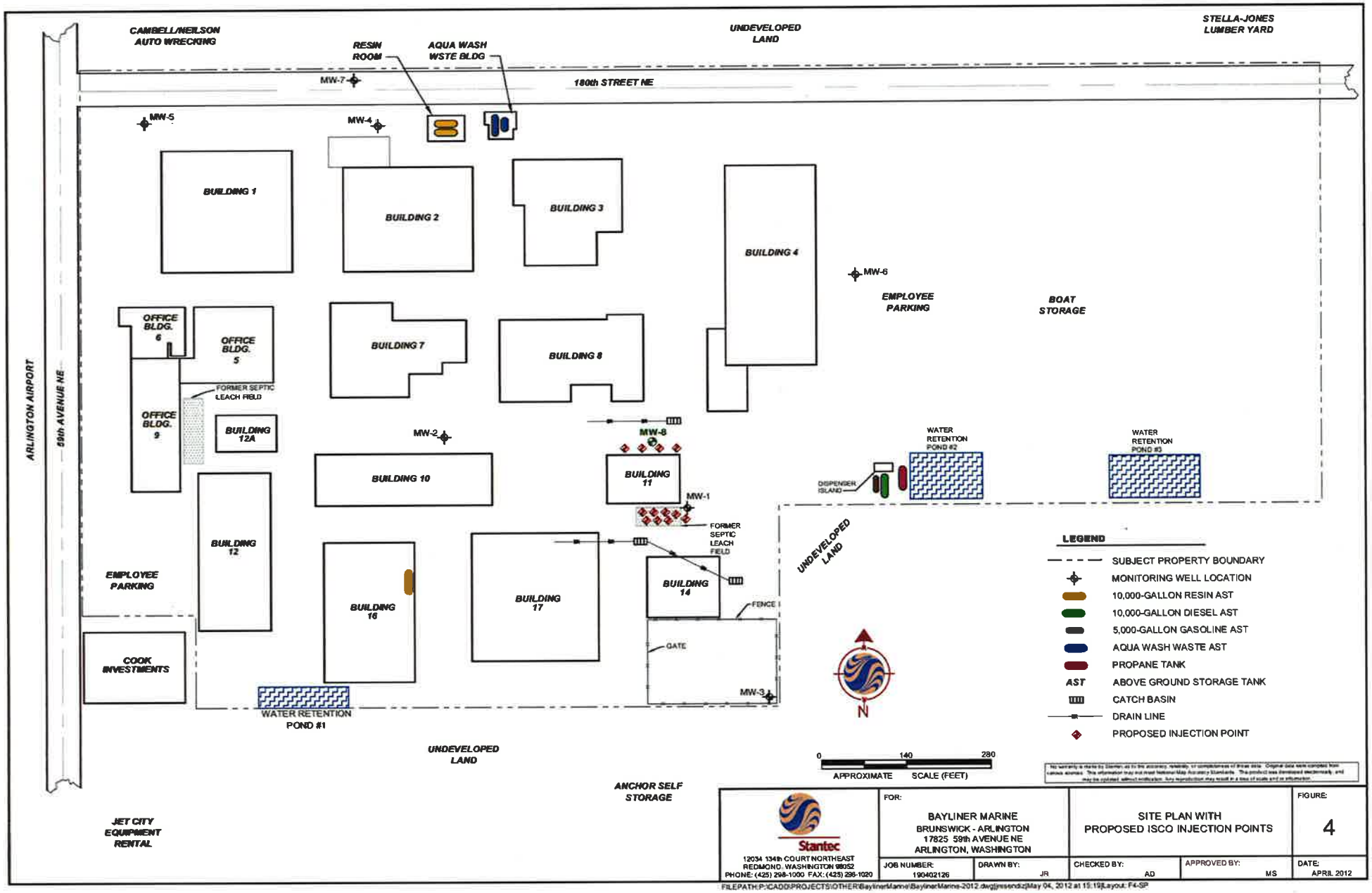

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ARLINGTON, WASHINGTON

SITE PLAN WITH PROPOSED ISCO INJECTION POINTS

FIGURE: 4

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
190402126	JR	AD	MS	APRIL 2012

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TABLE

Table 1
Groundwater Monitoring and Analytical Results
Brunswick - Arlington, Washington

Well No.	Measurement Date	Total Depth of Well (feet)	Top of Casing Elevation (ft. MSL)	Screened Interval (ft. bgs) Top	Screened Interval (ft. bgs) Bottom	Screened Interval (ft. MSL) Top	Screened Interval (ft. MSL) Bottom	Depth to Groundwater (feet)	Groundwater Elevation (ft. MSL)	Volatile Organic Compounds (VOCs) (µg/L) Tetrachloroethene (PCE)	Trichloroethene (TCE)	All Remaining VOCs
B-1	5/20/2009	NM	NM	NM	NM	NM	NM	NM	NM	ND	ND	ND
B-2	5/21/2009	NM	NM	NM	NM	NM	NM	NM	NM	1.5	ND	ND
B-3	5/21/2009	NM	NM	NM	NM	NM	NM	NM	NM	3.3	ND	ND
B-4	5/21/2009	NM	NM	NM	NM	NM	NM	NM	NM	42	ND	ND
B-5	5/21/2009	NM	NM	NM	NM	NM	NM	NM	NM	31	ND	ND
B-6	5/21/2009	NM	NM	NM	NM	NM	NM	NM	NM	18	ND	ND
B-7	5/21/2009	NM	NM	NM	NM	NM	NM	NM	NM	ND	ND	ND
MW-1	12/10/2009	29.95	129.42	15	30	114.42	99.42	18.89	110.53	59	ND	ND
	2/18/2010	29.95	129.42	15	30	114.42	99.42	16.71	112.71	48	ND	ND
	5/26/2010	29.95	129.42	15	30	114.42	99.42	16.51	112.91	50	ND	ND
	9/9/2010	29.95	129.42	15	30	114.42	99.42	19.22	110.2	57	ND	ND
	12/20/2010	29.95	129.42	15	30	114.42	99.42	17.28	112.14	43	ND	ND
	9/22/2011	30.10	129.42	15	30	114.42	99.42	16.53	112.89	32	ND	ND
MW-2	12/10/2009	27.25	129.68	15	30	114.68	99.68	20.02	109.66	ND	ND	ND
	2/18/2010	27.25	129.68	15	30	114.68	99.68	17.64	112.04	ND	ND	ND
	5/26/2010	27.25	129.68	15	30	114.68	99.68	17.41	112.27	ND	ND	ND
	9/9/2010	27.25	129.68	15	30	114.68	99.68	18.48	111.2	ND	ND	ND
	12/20/2010	27.25	129.68	15	30	114.68	99.68	18.49	111.19	ND	ND	ND
	9/22/2011	29.30	129.68	15	30	114.68	99.68	16.80	112.88	ND	ND	ND
MW-3	12/10/2009	24.30	129.90	10	25	119.90	104.90	16.89	113.01	ND	ND	ND
	2/18/2010	24.30	129.90	10	25	119.90	104.90	15.02	114.88	ND	ND	ND
	5/26/2010	24.30	129.90	10	25	119.90	104.90	14.85	115.05	ND	ND	ND
	9/9/2010	24.30	129.90	10	25	119.90	104.90	19.20	110.7	ND	ND	ND
	12/20/2010	24.30	129.90	10	25	119.90	104.90	15.28	114.62	ND	ND	ND
	9/22/2011	24.00	129.90	10	25	119.90	104.90	15.39	114.51	ND	ND	ND
MW-4	12/10/2009	28.40	130.42	15	30	115.42	100.42	21.20	109.22	13	16	ND
	2/18/2010	28.40	130.42	15	30	115.42	100.42	18.55	111.87	5.3	ND	ND
	5/26/2010	28.40	130.42	15	30	115.42	100.42	18.24	112.18	5	ND	ND
	9/9/2010	28.40	130.42	15	30	115.42	100.42	19.79	110.63	5.2	ND	ND
	12/20/2010	28.40	130.42	15	30	115.42	100.42	19.62	110.8	7.7	ND	ND
	9/22/2011	28.60	130.42	15	30	115.42	100.42	17.10	113.32	2.4	ND	ND
MW-5	12/10/2009	33.95	130.39	20	35	110.39	95.39	21.96	108.43	ND	ND	ND
	2/18/2010	33.95	130.39	20	35	110.39	95.39	19.45	110.94	ND	ND	ND
	5/26/2010	33.95	130.39	20	35	110.39	95.39	19.17	111.22	ND	ND	ND
	9/9/2010	33.95	130.39	20	35	110.39	95.39	20.50	109.89	ND	ND	ND
	12/20/2010	33.95	130.39	20	35	110.39	95.39	20.38	110.01	ND	ND	ND
	9/22/2011	33.80	130.39	20	35	110.39	95.39	17.91	112.48	ND	ND	ND
MW-6	2/19/2010	25.00	130.39	15	25	114.59	104.59	16.68	113.71	ND	ND	ND
	5/26/2010	25.00	130.39	15	25	114.59	104.59	16.51	113.88	ND	ND	ND
	9/9/2010	25.00	130.39	15	25	114.59	104.59	19.21	111.18	ND	ND	ND
	12/20/2010	25.00	130.39	15	25	114.59	104.59	16.40	113.99	ND	ND	ND
	9/22/2011	25.20	130.39	15	25	114.59	104.59	16.42	113.97	ND	ND	ND
MW-7	2/19/2010	30.00	131.27	15	30	116.27	101.27	19.90	111.37	ND	ND	ND
	5/26/2010	30.00	131.27	15	30	116.27	101.27	19.61	111.66	ND	ND	ND
	9/9/2010	30.00	131.27	15	30	116.27	101.27	21.13	110.14	ND	ND	ND
	12/20/2010	30.00	131.27	15	30	116.27	101.27	20.89	110.38	ND	ND	ND
	9/22/2011	30.20	131.27	15	30	116.27	101.27	18.38	112.89	ND	ND	ND
MW-8	9/22/2011	26.70	NM	12	27	NM	NM	16.76	NM	25	ND	ND
MTCA Method A Cleanup Level										5	5	--

MTCA - Model Toxics Control Act
NM = Not Measured
ND = Non Detect at the laboratory's Reported Detection Limit; all reporting limits are below MTCA Method A Cleanup Level
-- = MTCA Method A Cleanup Level is Based on the Parameter Tested
ft. bgs = feet below ground surface
ft. MSL = feet above mean sea level
(µg/L) = micrograms per liter

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APPENDIX A

RemOx® Fact Sheet

RemOx® UP ISCO Reagent

CAS Registry No. 7722-64-7
EINECS No. 231-760-3

Fact Sheet

RemOx® UP ISCO Reagent has been specifically manufactured for environmental applications such as remediation of soils and associated groundwater. This product goes through additional purification steps to remove trace metals and has significantly lower trace metal content than RemOx® S ISCO Reagent. RemOx® UP ISCO Reagent is shipped with a Certificate of Analysis (COA) to document product specifications and trace metal content. This product can be used to degrade a variety of contaminants such as chlorinated solvents, polyaromatic hydrocarbons, phenolics, organo-pesticides and substituted aromatics.

Product Specifications

Assay, %	≥ 99 as $KMnO_4$
Insolubles, %	≤ 0.2
Weight Loss (18 hrs. over silica gel), %	≤ 0.5
Trace Metals	See Table 1

Chemical/Physical Data

Formula	$KMnO_4$
Formula Weight	158.0 g/mol
Form	Granular Crystalline
Specific Gravity	
Solid	2.703 g/cm³
3% Solution	1.020 g/mL by weight, 20°C / 4°F
Bulk Density	Approximately 100 lb/ft³

Decomposition may start at 150°C.

Applications

RemOx® UP ISCO Reagent is used for soil and groundwater remediation by in-situ or ex-situ chemical oxidation and as an active agent in subsurface reactive barriers for treatment of:

- Chlorinated Ethenes-PCE, TCE, Vinyl Chloride, etc.
- Phenolics-PCP, Phenol, Cresol, etc.
- Polyaromatic Hydrocarbons-Naphthalene, Phenanthrene, Benzo(a) Pyrene, etc.
- TNT, RDX, HMX, etc.
- Various Pesticides

Solubility in Distilled Water

Temperature °C	Temperature °F	Solubility g/L	Solubility oz/gal
0	32	27.8	3.7
20	68	65.0	8.6
40	104	125.2	16.7
60	140	230.0	30.7
70	158	286.4	38.3
75	167	323.5	43.2

Shipping Containers

150 kg drum (330.75 lb) net, made of 22-gauge steel, weighs 22.4 lbs. It stands approximately 29½ inches high and is approximately 19¾ inches in diameter.

Special Packages will be considered on request.

Packaging meets UN performance oriented packaging requirements.

Description

Crystals or granules are dark purple with a metallic sheen, sometimes with a dark, bronze-like appearance. RemOx® UP ISCO Reagent has a sweetish, astringent taste and is odorless.

Handling and Storage

Protect containers against physical damage. When handling RemOx® UP ISCO Reagent, respirators should be worn to avoid irritation of, or damage to, mucous membranes. Eye protection should also be worn when handling RemOx® UP ISCO Reagent as a solid or in solution.

RemOx® UP ISCO Reagent is stable and will keep indefinitely if stored in a cool, dry area in closed containers. Concrete floors are preferred to wooden decks. To clean up spills and leaks, follow the steps recommended in the MSDS. Be sure to use goggles, rubber gloves, and respirator when cleaning up a spill or leak.

Avoid contact with acids, peroxides, and all combustible organic or readily oxidizable materials including inorganic oxidizable materials and metal powders. With hydrochloric acid, chlorine gas is liberated. RemOx® UP ISCO Reagent is not combustible, but will support combustion. It may decompose if exposed to intense heat. Fires may be controlled and extinguished by using large quantities of water. Refer to the *MSDS* for more information.

Shipping

RemOx® UP ISCO Reagent is classified by the Hazardous Materials Transportation Board (HMTB) as an oxidizer. It is shipped under Interstate Commerce Commission's (ICC) Tariff 19.

Harmonized Code for Export:	2841.61.0000
Proper Shipping Name:	Potassium Permanganate
Hazard Class:	Oxidizer
Identification Number:	UN 1490
Packaging Requirements:	49 CFR Parts 100 to 199 Sections: 173.152, 173.153, 173.194
Label Requirements:	Oxidizer, 5.1

Shipping Limitations:

Minimum quantities

Rail car: Rail car: See Tariff for destination

Truck: No minimum

Postal regulations

Information applicable to packaging of oxidizers for shipment by the U.S. Postal service to domestic and foreign destinations is readily available from the local postmaster.

United Parcel Service accepts 25 lbs as largest unit quantity properly packaged; consult United Parcel Service.

Regulations concerning shipping and packing should be consulted regularly due to frequent changes.

Corrosive Properties

RemOx® UP ISCO Reagent is compatible with many metals and synthetic materials. Natural rubbers and fibers are often incompatible. Solution pH and temperature are also important factors. The material must be compatible with either the acid or alkali also being used.

In neutral and alkaline solutions, RemOx® UP ISCO Reagent is not corrosive to iron, mild steel, or stainless steel. However, chloride corrosion of metals may be accelerated when an oxidant such as RemOx™ UP ISCO Reagent is present in solution. Plastics such as polypropylene, polyvinyl chloride Type I (PVC I), epoxy resins, fiberglass reinforced plastic (FRP) and TFE, and Tefzel ETFE are best. *Refer to Material Compatibility Chart*.

Aluminum, zinc, copper, lead, and alloys containing these metals may be slightly affected by RemOx® UP ISCO Reagent solutions. Actual studies should be made under the conditions in which RemOx® UP ISCO Reagent will be used.

Table 1: Trace Metal Specification

Element	Specification (mg/kg)	DL* (mg/kg)	Element	Specification (mg/kg)	DL* (mg/kg)
Ag	0.2	0.048	Hg	0.05	0.004
Al	20	0.28	Na	100	NA
As	0.5	0.006	Ni	0.1	0.048
Ba	15	0.016	Pb	0.7	0.2
Be	0.10	0.01	Sb	1.0	0.2
Cd	0.1	0.02	Se	1.0	0.002
Cr	2.0	0.028	Tl	5.0	1.0
Cu	2	0.034	Zn	3.0	0.016
Fe	15	0.066			

Carus Chemical Company

During its 90-year history, Carus' ongoing emphasis on research and development, technical support, and customer service has enabled the company to become the world leader in permanganate, manganese, oxidation, and base-metal catalyst technologies.

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APPENDIX B

Oxidant Dosing Calculation

Version 3.0 0104

Parameters	Units	Estimates	
*** Site Description ***			
Length	Ft.	60	
Width	Ft.	60	
Area	Sq. Ft.	3600	
Thickness	Ft.	10	
Total Volume	Cu. Yd.	1333	
Porosity	%	20	
Plume Total Pore Volume	Gal.	53867	
Avg. Contaminant Conc.	ppm	0.25	
Mass of Contaminant	lb.	0.112384451	
PSOD	g/kg	13.5	
Effective PSOD %	2.5	0.3375	
PSOD	2.5	1.002375	
PSOD Oxidant Demand	lb	1336.50	
Avg. Stoichiometric Demand	lb/lb	2.4	
Contaminant Oxidant Demand	lb.	0.269722682	
Theoritical Oxidant Demand	lb.	1336.77	
Confidence Factor	???	3	
Calculated Oxidant Demand		4010.31	
*** Injection Design ***		KMnO4	NaMnO4
Radius of Influence	Ft.	10.00	10
Number of Injection Points		11.46	11.46
Injection Concentration	% wt/wt	2.50%	5.00%
Flow Rate - Per Injection Point	GPM	-	0
Number of Wells per Phase		-	0
Total Injection Flow Rate	GPM	-	0
Estimated Injection Pressure	PSIG	-	0
Injection Volume/Hole	Gal	1,636.53	721.87
*** Injection Schedule ***			
Hours per Day	Hrs		0
Days Per Week	Days		0
Number of Inj. Days	Days	#DIV/0!	#DIV/0!
Number of Inj. Weeks	Weeks	#DIV/0!	#DIV/0!

40% NaMnO4 Injection Options

Pounds of 40% NaMnO4 Solution	Gallons of 40% Solution	Number of Pails	Number of Drums	Number of Totes	Price per Lb of Solution	Total Cost of Chemical
8,923	782.71	156.54	16.31	3.56		$ -

Total Gallons of Dillution Water Required	Dillution Water Flow Rate - GPM	NaMnO4 40% Solution Flow Rate - GPM	OR	Dillution Water Gals per Pail	Dillution Water Gals per Drum	Dillution Water Gals per Tote
7,489.28	0.00	0.00		47.84	459.28	2,105.04

Dry KMnO4 Injection Options

Pounds of KMnO4 (Dry Crystals)	Number of Pails	Number of Drums	Number of Totes	Price per Lb (Dry)	Total Cost of Chemical
4,010	72.91	12.15	1.22		$0.00

Total Gallons of Dillution Water Required	Dillution Water Flow Rate - GPM	OR	Dillution Water Gals per Pail	Dillution Water Gals per Drum	Dillution Water Gals per Tote
18,753.24	0.00		257.19	1,543.17	15,431.65

Instructions: Fill in all white colored blanks. Leave all shaded cells - these calculate themselves.
Please call Carus at 800/435-6856 for current chemical pricing.

				assumed density		Result
g KMnO4 ~~kg soil~~	lb KMnO4 ~~454 g KMnO4~~	~~kg soil~~ ~~1000 g soil~~	454 g soil ~~lb soil~~	110 lb soil ~~ft^3~~	27 ~~ft^3 soil~~ yd^3 soil	2.97

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