

**Draft Final Report
Remedial Investigation / Feasibility Study
Blaine Marina, Inc. Site
Blaine, Washington**

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Prepared for

**Port of Bellingham
Bellingham, Washington**

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LIST OF ABBREVIATIONS AND ACRONYMS

µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
µm	Micrometer
µg/m ³	Micrograms per Cubic Meter
Agreed Order	Agreed Order No. DE 9000
AN	Ammonium Nitrate
API	American Petroleum Institute
ARAR	Applicable or Relevant and Appropriate Requirement
ARI	Analytical Resources, Inc.
AS	Air Sparging
AST	Aboveground Storage Tank
B&R	Bouwer and Rice
BEHP	Bis(2-ethylhexyl)phthalate
BGS	Below Ground Surface
Blaine Marina	Blaine Marina Inc.
BMC	Blaine Municipal Code
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
C&J	Cooper and Jacob
CAP	Cleanup Action Plan
CFR	Code of Federal Regulations
cm	Centimeter
cm/sec	Centimeters per Second
COPC	Constituent of Potential Concern
CSL	Cleanup Screening Level
CSM	Conceptual Site Model
DCA	Disproportionate Cost Analysis
Development Plan	Port of Bellingham 2007 Blaine Wharf District Master Plan
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EDB	Ethylene Dibromide
EDC	1,2-Dichloroethane
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FS	Feasibility Study
ft	Feet
ft ²	Square Feet
ft ³	Cubic Feet
ft/yr	Feet per Year
gpm	Gallons per Minute
HIS	Indicator Hazardous Substances
LNAPL	Light Non-Aqueous Phase Liquid
MAP	Monoammonium Phosphate
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MLLW	Mean Lower Low Water
MNA	Monitored Natural Attenuation
MTBE	Methyl-Tert Butyl Ether
MTCA	Washington State Model Toxics Control Act

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCL	Preliminary Cleanup Level
PID	Photoionization Detector
Port	Port of Bellingham
PQL	Practical Quantitation Limit
RAO	Remedial Action Objective
RCW	Revised Code of Washington
RI	Remedial Investigation
Site	Blaine Marina Inc. Site
SL	Screening Level
SMS	Washington State Sediment Management Standards
SQS	Sediment Quality Standard
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TPH-D	Diesel-Range Total Petroleum Hydrocarbons
TPH-G	Gasoline-Range Total Petroleum Hydrocarbons
TPH-O	Oil-Range Total Petroleum Hydrocarbons
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WAC	Washington Administrative Code

1.0 INTRODUCTION

This document presents the results of the remedial investigation (RI) for the Blaine Marina Inc. Site (Site) in Blaine, Washington (Figure 1). The Site is owned by the Port of Bellingham (Port) and the Washington State Department of Natural Resources (DNR), and is a part of a larger area of land used to support the marine services that is being redeveloped by the Port (Figure 2). The RI activities described in this report were conducted in accordance with Agreed Order No. DE 9000 (Agreed Order) between the Washington State Department of Ecology (Ecology) and the Port (Ecology 2012), and in accordance with the approved RI Work Plan (Landau Associates 2012a).

As an owner of the Site, the Port has conducted a number of investigations to characterize soil, groundwater, soil vapor, marine sediment, and surface water conditions. These investigations have confirmed that contamination is present in Site media, which has been reported to Ecology as required under the Washington State Model Toxics Control Act [MTCA; Chapter 173-340 Washington Administrative Code (WAC)].

The Agreed Order included a requirement to conduct an interim action to repair an approximately 60-foot section of timber bulkhead that was progressively failing in an area on the east side of the former fuel office. The interim action was conducted to prevent the release of contaminated upland soil and groundwater to marine surface water and sediment in Blaine Harbor. The interim action is discussed further in the Interim Action Completion Report (Landau Associates 2013a), and summarized in Section 3.0 of this document. The RI portion of this report describes the environmental setting for the Site and identifies the nature and extent of contamination for affected media. Beginning in Section 11, a feasibility study (FS) will be prepared to develop and evaluate alternatives for cleaning up Site contamination, and select a preferred cleanup alternative based on the rationale outlined in Chapter 173-340 WAC.

1.1 SITE DESCRIPTION AND BACKGROUND

The Site, registered by Ecology as FSID 2888, is located in Blaine, Washington within Blaine Harbor. Blaine Harbor is at the north end of Drayton Harbor, in the northwest quarter of Section 1, Township 40 North, Range 1 West, Willamette Meridian. Blaine Marina Inc. (Blaine Marina) has leased approximately 39,000 square feet (ft²) of property at 214 Sigurdson Avenue from the Port since the 1950s. Blaine Marina operates a bulk fuel storage and transfer facility that has resulted in the release of petroleum hydrocarbons to soil and groundwater at the Site.

The Site, as described in Agreed Order DE 9000, is defined by the extent of contamination caused by the release of hazardous substances at the Site, and is not limited to lease area or property area

boundaries. The Site includes areas where hazardous substances have been deposited, stored, disposed of, placed, or otherwise have come to be located. The preliminary boundaries of the Site estimated before the RI are shown on Figure 2. With the exception of Figure 1, plan-view figures in this report are oriented to the northwest. Descriptions of direction in this report are in reference to *map north*, which is toward Marine Drive.

1.2 OBJECTIVES OF THE REMEDIAL INVESTIGATION

The objective of the RI is to characterize the nature and extent of contamination and to collect sufficient information regarding the Site to enable the development and evaluation of cleanup alternatives. This document presents the information collected and the evaluations conducted to achieve this purpose.

1.3 REPORT ORGANIZATION

This RI/FS report is organized as follows:

- Section 2.0 presents the project background, including a summary of Site history and a description of environmental investigations conducted prior to the signing of the Agreed Order.
- Section 3.0 describes the activities conducted by the Port as an interim action to repair a failing section of bulkhead, as required under the Agreed Order.
- Section 4.0 describes the investigations conducted by the Port to determine the nature and extent of contamination in soil, soil vapor, groundwater, surface water, and marine sediment, as required under the Agreed Order.
- Section 5.0 describes the environmental setting of the Site, including its physical features, geology, hydrogeology, natural resources, and land use.
- Section 6.0 develops Site screening levels for affected media.
- Section 7.0 describes the nature and extent of contamination.
- Section 8.0 discusses Site contaminant fate and transport, including contaminant sources and the fate and transport for identified exposure processes.
- Section 9.0 presents cleanup standards for the Site including establishing indicator hazardous substances, proposing cleanup levels, and discussing the conceptual Site model.
- Section 10.0 presents a brief summary of the RI conclusions.
- Section 11.0 presents the FS including a summary of remedial action objectives (RAOs) and potentially applicable laws, a screening summary of remedial technologies considered for Site cleanup, a description of evaluation criteria, and the evaluation of Site cleanup alternatives using a disproportionate cost analysis (DCA)
- Section 12.0 presents the FS summary and conclusions and a description of the preferred alternative.

2.0 PROJECT BACKGROUND

The Port entered into the Agreed Order with Ecology on May 25, 2012 to conduct an RI and FS for the Site. Prior to entering into the Agreed Order, the Port had conducted a number of environmental investigations. This section summarizes the Site history, environmental investigations, and independent actions conducted prior to the signing of the Agreed Order.

2.1 HISTORICAL SITE DEVELOPMENT AND OPERATIONS

The history of Site development and operations presented in this section is based on a review of existing environmental reports related to previous Site investigations and a review of historical aerial photographs taken between 1949 and 2011, which are provided in Appendix A.

Blaine Harbor was originally created in the late 1930s by dredging 2 acres of tideflats to create a small boat harbor. An access road was constructed and adjacent tidelands were filled to create uplands and provide shore support for the area. In the late 1940s, 4 additional acres were dredged, additional tidelands were filled, and a breakwater, bulkheads, floats, and ramps were constructed, as shown in the 1949 aerial photograph (Appendix A). The upland area created at the Site generally consists of dredge fill with timber bulkheads along the shoreline. In some areas, riprap was used instead of, or in conjunction with, the bulkheads to establish the shoreline. An additional 15-acre area of tideflats was dredged and an extension of the breakwater was completed in the mid-1950s (TEC 2001). The 1956 aerial photograph (Appendix A) shows the breakwater extending farther east and improvements to upland facilities including additional buildings and aboveground storage tanks (ASTs) to support the storage of fuel dispensed at the fuel dock.

The harbor and marina have been upgraded over the years to meet the demand for services. Despite the upgrades, most of the infrastructure supporting the harbor is from the original construction and the footprint of the upland industrial area has remained largely unchanged from that shown in the aerial photograph from 1949. In 2001, the Port completed an expansion project at Blaine Harbor that included enlarging the moorage basin and the addition of more than 300 slips. The 2010 aerial photograph of the Site (Appendix A) generally depicts the current layout of the Site and surrounding facilities.

Business activity has historically been focused in the area along the western end of Blaine Harbor referred to herein as the Blaine Harbor Industrial Area, which comprises all of the upland area shown on Figure 2. A portion of the southwestern end of the harbor includes state-owned lands that are managed by the Port under a Port Management Agreement with DNR. The Inner Harbor Line shown on Figure 2 defines the boundary between property owned by the Port (east of the Inner Harbor Line), and property

that is owned by the State and managed by the Port under the agreement with DNR (west of the Inner Harbor Line).

2.1.1 BLAINE MARINA INC. HISTORICAL OPERATIONS

Blaine Marina is a family-owned retail business that sells furniture, appliances, and fuel products. The company has leased the property at 214 Sigurdson Avenue from the Port since the mid-1950s. The furniture and appliance retailing portion of the business is presumed not to have contributed to releases observed at the Site. Blaine Marina has continuously operated the tank farm at the Site to support the fuel retailing portion of its business from the mid-1950s to the present. This activity is suspected to have resulted in the contamination of soil and groundwater at the Site. The tank farm consists of three 8,500-gallon fuel ASTs that store diesel and gasoline to support Blaine Marina's onsite fueling facility.

A 4,000-gallon, horizontally oriented AST was formerly located at the tank farm; this AST stored home heating oil that was transferred to tanker trucks for offsite delivery. Because the horizontally oriented AST was supported above the ground surface leaks would have been noticed and likely remedied quickly. It is not considered a likely source of significant contamination at the Site. This horizontally oriented AST is no longer present at the Site, although it is not clear from the review of historical documents when it was removed from service.

Fuel from the three vertically oriented 8,500-gallon ASTs was historically transferred through steel pipes buried underground from the ASTs to the fuel dock. In recent years, the use of the steel pipes was discontinued and fuel is now transferred through flexible hose from the ASTs to the dock. Underneath Sigurdson Avenue, the flexible hose is run inside of the former steel pipe fuel pipelines.

The three 8,500-gallon vertically oriented steel tanks were installed in contact with the ground surface (or more accurately, slightly below ground surface) more than 55 years ago, in about 1956. Because the facility stores more than 1,320 gallons, it is subject to the federal requirements for a Spill Prevention Control and Countermeasures Plan (40 CFR Part 112). Tank and piping integrity testing are requirements under the applicable federal regulation and Chapter 173-180 WAC. On August 16, 2010, Ecology personnel visited the Site to evaluate compliance with these requirements and determined that Blaine Marina had not conducted annual inspections or tests of the pipelines that supplied fuel to the fuel dock. Ecology issued a Notice of Violation (Docket #8900) on December 1, 2011 (Ecology 2011) and Blaine Marina subsequently completed an inspection of the pipelines. Although the pipelines passed inspection, Blaine Marina replaced the remaining metallic pipes with non-metallic hose in December 2011 (Blaine Marina Inc. 2012). Blaine Marina reports that no fuel losses are apparent based on its records of fuel purchases and sales.

2.1.2 DOCUMENTED RELEASES OF CONTAMINATION

Two releases of petroleum hydrocarbons are reported to have occurred at the Site. There is some discrepancy in the reported release dates and volumes of the releases. The two releases described below were reported in a 2012 Environmental Data Resources Inc. report and a 1996 investigation report by RETEC.

1. A leaking pipe elbow was discovered and replaced in about 1986 according to Mike Dodd, of Blaine Marina. No record regarding the type of fuel released or the volume of fuel released was available for review (RETEC 1996a).
2. A spill of approximately 500 to 700 gallons of No. 2 diesel was reported to have occurred at the Site on May 2, 1990 due to a valve that connects two of the ASTs being accidentally left open during a fuel transfer. The spill was reportedly contained on site and cleaned up by a vactor truck (RETEC 1996a). According to the EDR report for the Site, an accidental release of 8,200 gallons of diesel occurred on May 4, 1990 due to an open valve (EDR 2011). The Blaine Fire Department's Incident report (No. 90-002875-000), dated May 3, indicates that approximately 500 gallons of fuel was recovered during the incident response effort on that day (Blaine Fire Department 1990). It is unclear from these reports whether one or more incidents occurred on May 2, 3, or (least likely) May 4. Also unclear is the actual volume released. For the purposes of this document, we assume these reports describe one release of contamination in early May 1990 of approximately 500 to 8,200 gallons of diesel fuel (although with a minor discrepancy regarding the release date).

2.2 CURRENT SITE FEATURES AND USES

Blaine Marina continues to operate at the Site selling furniture, appliances, and fuel products. The significant surface features are shown on Figure 2. The current surface features include a fueling dock and the floor of the former supporting office, the Blaine Marina retail building, smaller buildings that are used for storage, and the ASTs and equipment associated with the storage and dispensing of fuel products.

A secondary containment area with concrete walls to contain accidental spills was constructed in the immediate vicinity of the ASTs. The secondary containment area is large enough to hold approximately 25,000 gallons of fuel, although because it has a gravel unlined floor, it is unlikely to effectively contain a fuel spill. Additionally, the walls of the secondary containment area are constructed of cinder blocks and only some portions of the inner surfaces of the wall have been sealed. Although the secondary containment may prevent a catastrophic release near the ASTs from immediately flowing over the ground surface and into the surface waters of Blaine Harbor, it is likely that if spilled fuel were not immediately removed from the secondary containment area, it would seep through the walls and/or infiltrate into the subsurface.

It appears that stormwater runoff generated at the Site generally infiltrates in unpaved areas and may flow west into Blaine Harbor from adjacent paved surfaces. Except for the area in the immediate vicinity of the ASTs, the surface of the Site is covered by buildings or asphalt pavement. In the

immediate vicinity of the ASTs, both inside and outside the secondary containment area, the surface of the Site consists of soil and gravel. Stormwater collected on building rooftops is routed to the ground surface with gutters and downspouts. Downspouts on buildings in the vicinity of the ASTs generally discharge to soil and gravel surfaces just outside of the secondary containment area, where the collected stormwater runoff likely infiltrates. Stormwater that falls within the boundaries of the secondary containment area presumably infiltrates through the soil surface. Although onsite stormwater infiltration is typically a preferred method for stormwater management, stormwater should not infiltrate freely within a fuel-storage secondary containment area.

Four buildings are currently or were recently located at the Site, as shown on Figure 3:

1. The Blaine Marina Furniture and Appliance Retail building near the center of the Site covers approximately 5,400 ft² of area. The western half of the building is single-story, and the eastern half has two stories. Blaine Marina sells furniture and appliances on the ground level of the building with a public entrance on the south side of the building. This building is just south of the ASTs.
2. The former fuel office building was located on the west side of Sigurdson Avenue and occupied approximately 1,200 ft² on the dock adjacent to the fuel dock. The ground surface on the east side of the fuel office building (upland of the bulkhead) contained sinkholes and collapsed pavement that extended horizontally 3 to 4 feet (ft) behind (east of) the bulkhead due to a failing section of bulkhead underlying the eastern side of the building. Under the Agreed Order with Ecology, the Port implemented an interim action to repair the failing section of bulkhead, as described in more detail in Section 3.0. The building was deconstructed down to the floor to facilitate implementation of the interim action.
3. An approximately 1,000-ft² storage building is located just east of the ASTs and is used by Blaine Marina for storage.
4. An approximately 1,350-ft² storage building is located approximately 50 ft east of the ASTs (10 ft east of the smaller storage building) and is used by Blaine Marina for storage.

2.3 PRE-AGREED ORDER ENVIRONMENTAL ACTIVITIES

Several investigations were conducted at the Site before the Port entered into the Agreed Order with Ecology. Table 1 presents a chronology of investigative activities conducted at the Site. The following sections provide a summary of the investigations conducted prior to the signing of the Agreed Order. The analytical results of these investigations are provided in Tables 2, 3, and 4 and sample locations are shown on Figure 3. The logs of subsurface explorations are provided in Appendix B.

Analyses of samples collected during these previous investigations indicated the presence of diesel-range and gasoline-range total petroleum hydrocarbons (TPH-D and TPH-G) in soil and groundwater at concentrations that exceed the preliminary screening levels for the Site, which were developed in the RI Work Plan (Landau Associates 2012a).

2.3.1 SEACOR INVESTIGATION – 1990

In June 1990 (approximately 1 month after the reported release of 500 to 8,200 gallons of diesel; see Section 2.1.2), SEACOR advanced 12 hand-auger borings from the ground surface to various depths between 3.0 and 9.5 ft below ground surface (BGS; SEACOR 1990). The purpose of the investigation was to evaluate potential Site impacts from the release of petroleum hydrocarbons in May 1990. Soil samples were collected from the hand-auger borings and analyzed for total petroleum hydrocarbons (TPH). Sample locations are shown on Figure 3, and the results of the analyses are provided in Table 2. The results of this investigation were not consistently reported and sometimes not differentiated between the individual petroleum fractions (gasoline-, diesel-, or oil-range fractions; TPH-G, TPH-D, or TPH-O respectively). For hand-auger locations HA-1 to HA-6, the results are reported as TPH and not differentiated. Results for HA-7 and HA-8 are reported as TPH-G, HA-9 to HA-11 are reported as combined TPH-G and TPH-D, and HA-12 is reported as TPH-D. As indicated in Table 2, the concentration of TPH was above the screening level (SL) at 5 of the 12 sampling locations.

2.3.2 RETEC INVESTIGATIONS – 1996

In 1996, RETEC conducted a compliance audit for the fuel tank farm at the Site, which was followed by a supplemental site investigation. This section describes investigations RETEC conducted at the Site and conclusions from its reports.

During the supplemental investigation, RETEC tested for the presence of light non-aqueous phase liquid (LNAPL) in groundwater monitoring wells at the Site. According to a letter report from RETEC to the Port dated April 2, 1996 (RETEC 1996a), three monitoring wells (MW-1 through MW-3) were installed at the Site prior to February 1996 near the ASTs (Figure 3). Initial gauging of apparent LNAPL thickness indicated 3.9 ft of LNAPL at MW-2 and 4.3 ft of LNAPL at MW-3. No LNAPL was reported present in MW-1. Apparent LNAPL thickness as gauged in a well is often 2 to 10 times greater than the thickness that is present outside of the well casing (Newell et al. 1995). On February 7, 1996, RETEC conducted recovery testing at MW-2 and MW-3 to evaluate the recoverability and actual thickness of the LNAPL. After pumping 6.5 quarts of LNAPL from MW-2 and 8.8 quarts of LNAPL from MW-3, RETEC gauged LNAPL thickness in the wells as it recovered over a period of 210 minutes. A LNAPL thickness of 3 inches at MW-2 and 7 inches at MW-3 was recorded after several minutes of recovery and reported as the actual LNAPL thickness. Although other methodologies to estimate actual LNAPL thickness might provide greater accuracy, the reported values appear reasonable based on the apparent LNAPL thickness within the well casing. Based on these estimates of actual product thickness, an estimated impacted area of 2,500 ft², and a typical value for soil porosity of 0.3, RETEC estimated in 1996 that approximately 1,400 to 3,300 gallons of pooled LNAPL was present in the Site subsurface.

RETEC submitted a sample of the LNAPL from monitoring well MW-2 to International Lubrication and Fuel Consultants to conduct a forensic analysis. The forensic analysis concluded that the sample contained primarily No. 2 diesel with 1 to 2 percent gasoline. The analysis concluded that the diesel was refined between the mid-1970s and the late 1980s and the gasoline was refined between 1978 and 1980. These results led to RETEC's conclusion that the source of subsurface TPH contamination at the Site was attributable to operations at the Site rather than off Site. Prior to this forensic work, there was speculation that contamination could have migrated on Site from the former Standard Oil property to the north, which is now an asphalt-paved parking lot. Standard Oil operated a bulk petroleum distribution center at that location from May 7, 1945 to October 31, 1974. Based on these dates of operation, the Standard Oil facility would not have handled fuel beyond the mid-1970s and, therefore, is not likely associated with the contamination observed at the Site, which was dated from between the mid-1970s to late 1980s. RETEC also advanced borings along the northern Site boundary between the Site and the former Standard Oil property, and one boring on the former Standard Oil property to evaluate the potential for contamination to have migrated on Site from that property. The sampling locations are shown on Figure 3 and the results are provided in Table 2. The results were interpreted to indicate that contamination did not migrate to the Site from the Standard Oil property. RETEC concluded that Blaine Marina Inc. was solely responsible for the observed petroleum contamination (RETEC 1996a).

In July 1996, RETEC conducted a soil and groundwater investigation at the Site to further assess the extent of contamination, the results of which are summarized in a letter report from RETEC to the Port dated August 28, 1996 (RETEC 1996b). During this investigation, soil and groundwater samples were collected from 13 direct-push borings (GP-1 through GP-13) advanced at the Site. The boring locations are shown on Figure 3. At each location, soil samples were collected near the water table (between approximately 8 and 10 ft BGS) and groundwater samples were collected with the well screen located between 8.5 and 10.5 ft BGS. Soil was evaluated for the presence of sheen and not submitted for laboratory analysis. Twelve of the 13 groundwater samples were analyzed for TPH-D, and the results are provided in Table 3. RETEC reported that the groundwater sample collected from boring GP-12 was estimated to be 90 percent free-phase hydrocarbons and was therefore not submitted to the laboratory for analytical testing. RETEC noted in the report that LNAPL was present in existing monitoring wells MW-2 and MW-3 and some LNAPL was present in groundwater samples collected from GP-6 and GP-10.

TPH-D was detected in groundwater samples at concentrations ranging from below the reporting limit (GP-5 and GP-7) to 251 milligrams per liter (mg/L; GP-10). Although TPH-D was not detected in GP-5 or GP-7, a light sheen was observed in GP-5, and a heavy sheen to a thin LNAPL layer was observed in GP-7. The inconsistency between the observed sheen and the lack of detected hydrocarbons in the groundwater samples collected from these locations could result from the samples being tested for

diesel, but not gasoline-range hydrocarbons, or that the groundwater sample may have been collected from below the top of the water table so the sheen was not contained in the sample. Based on the available data, RETEC concluded that the extent of impacted groundwater appeared to extend beyond the boundaries of its investigation to the southwest, northwest, and northeast.

RETEC conducted sheen tests on all 13 soil samples and noted the following:

- Droplets of LNAPL were observed in soil samples GP-4 and GP-10.
- A heavy sheen to a thin LNAPL layer was observed in soil samples GP-6, GP-7, GP-12, and GP-13.
- A light sheen was observed in samples GP-5, GP-8, GP-9, and GP-11.
- No sheen was observed in soil samples GP-1 and GP-2.
- Hydrocarbons observed in GP-4 and GP-10 had a light brown color, which differed from the clear hydrocarbons observed in other samples. RETEC speculated that there may have been two separate contaminants, or that the apparently different contaminants were from separate releases, with the older contaminant showing signs of weathering.

2.3.3 ACCORD ENVIRONMENTAL – 1997 TO 2011

Accord Environmental visited the Site, generally on a monthly basis, from February 1997 to at least February 2011. During the Site visits, a field representative used a bailer to remove the recoverable LNAPL from monitoring wells MW-1, MW-2, and MW-3. Based on a review of field notes by Accord Environmental (2011), approximately 350 to 400 gallons of LNAPL has been removed over the years from the wells. LNAPL removal decreased from an initial range of 3 to 5 gallons per month in the late 1990s to a range of 1 to 2 gallons per month in 2011. The notes indicate that LNAPL is not present in MW-1, and is generally present and recoverable at much greater volumes at MW-3 compared to MW-2.

2.3.4 LANDAU ASSOCIATES INVESTIGATION – 2001

Landau Associates conducted a sediment quality investigation in Blaine Harbor on behalf of the Port in 2001 (Landau Associates 2002). The purpose of the investigation was to evaluate compliance with the Washington State Sediment Management Standards (SMS) for surface sediments within Blaine Harbor that may have been affected by harbor activities. Surface sediment samples were collected from 16 locations within Blaine Harbor. Three of the 16 samples (BH-01, BH-09, BH-10; Figure 3) were collected from surface sediments [0 to 10 centimeters (cm)] that are near the Site, to the west and southwest.

The surface sediment sample collected from BH-01 was analyzed for SMS chemicals including metals, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organotins, and conventional parameters [total organic carbon (TOC),

total solids, total sulfides, ammonia, and grain size], and fecal coliform. The surface sediment sample collected from BH-09 was analyzed for SVOCs, PAHs, TOC, and total solids. The surface sediment sample collected from BH-10 was analyzed for organotins. Table 4 presents the sediment sample analytical results.

The analytical results indicated that the concentration of bis(2-ethylhexyl)phthalate (BEHP) [81.3 milligrams per kilogram, normalized based on organic carbon content (mg/kg OC)] at BH-01 was greater than the SMS sediment quality standard (SQS) of 47 mg/kg OC and the SMS cleanup screening level (CSL) of 78 mg/kg OC. Concentrations of other SMS chemicals at BH-01 were either less than the reporting limit or less than the current SQS and CSL standards. Additionally, concentrations of SMS chemicals sampled for at BH-09 (PAHs and SVOCs) and BH-10 (organotins) were either less than their reporting limit or less than the SQS and CSL standards for those chemicals. Because BEHP is not commonly associated with petroleum hydrocarbons, and BH-01 is located a distance from the shoreline closest to the Site, the presence of elevated BEHP at BH-01 does not appear to be associated with a Site release.

2.3.5 FARALLON INVESTIGATION – 2008

Farallon Consulting (Farallon) conducted subsurface investigations around the larger Blaine Harbor Industrial Area in January 2008 (Farallon Consulting 2008). For that investigation, 11 direct-push Geoprobe[®] borings (SIG-B1 through SIG-B11) were advanced around the Blaine Harbor Industrial Area to depths ranging between 12 and 16 ft BGS. Eight of the borings (SIG-B1 through SIG-B8) were near or on the Site (Figure 3), although most of these eight were not in the immediate vicinity of the ASTs, and only one appears to have been located hydraulically downgradient of the ASTs (SIG-B5, based on apparent groundwater flow to the southwest; see Section 5.3). Three of the 11 borings (SIG-B9 through SIG-B11) were advanced on the property to the west-northwest of the Site to further investigate the extent of hydraulic oil- and petroleum-contaminated soil associated with the former operations of T&M Protein and/or former underground storage tanks (USTs) previously removed from the Sea K Fish Co. property at 225 Sigurdson Avenue, and are not relevant to conditions at the Site.

Soil samples were collected and screened continuously during advancement of the borings. Based on photoionization detector (PID) readings, selected soil samples (one from each boring) were sent to the laboratory and analyzed for TPH-D, TPH-O, TPH-G, and benzene, toluene, ethylbenzene, and xylenes (BTEX). TPH-D was detected in SIG-B2 (3,300 mg/kg) at a concentration greater than the screening level (2,000 mg/kg). The analytical results are provided in Table 2.

3.0 INTERIM ACTION – BULKHEAD REPAIR

This section summarizes the marine sediment interim action conducted at the Site in 2012 to fulfill one of the Agreed Order requirements. The purpose of the interim action was to repair approximately 60 linear feet of existing timber bulkhead at the Site that was progressively failing. This section of bulkhead is located along the western side of Sigurdson Avenue, and consisted of timber piling and timber lagging, with riprap placed along the toe of the structure. Most of the bulkhead in this area, including the piling and lagging, was damaged. It had shifted and bowed, and the top of the bulkhead was rotated outward toward the water.

Repairing this section of bulkhead was deemed critical to preventing the release of contaminated upland soil and groundwater to marine surface water and sediment in Blaine Harbor. The interim action included implementing a permanent repair to the bulkhead in the location indicated on Figure 2 as “Sheetpile Wall.” The repair will ultimately be integrated with broader bulkhead repair and replacement, which will occur during redevelopment of the Blaine Harbor Industrial Area.

Several alternatives for addressing the failing bulkhead were presented in the Interim Action Plan (Landau Associates 2012b). The selection of the preferred alternative was reviewed and approved by Ecology and the interim action was implemented between August 20, 2012 and October 16, 2012 without any significant deviations from the Interim Action Plan. This section presents a summary of the interim action including the basis for implementation.

3.1 BASIS FOR INTERIM ACTION

MTCA distinguishes an interim action from a cleanup action in that an interim action only partially addresses the cleanup of a Site and achieves one of the following purposes [WAC 173-340-430(1)]:

- Is technically necessary to reduce the threat to human health and the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance [WAC 173-340-430(1)(a)].
- Corrects a problem that may become substantially worse or cost substantially more to address if the remedial action is delayed [WAC 173-340-430(1)(b)].
- Is needed to complete a site hazard assessment, remedial investigation/feasibility study, or design a cleanup action [WAC 173-340-430(1)(c)].

An interim action must also meet one of the following general requirements [WAC 173-340-430(2)]:

- Achieve cleanup standards for a portion of the Site
- Provide a partial cleanup (clean up hazardous substances from all or part of the Site, but not achieve cleanup standards)

- Provide a partial cleanup and not achieve cleanup standards, but provide information on how to achieve cleanup standards.

The interim action was deemed necessary to effectively contain the contamination and allow proper implementation of the complete RI/FS process. The Port presented the proposed action to Ecology, which determined that the action would meet the requirements of MTCA described above by reducing the threat to human health and the environment through eliminating or substantially reducing one or more pathways for exposure to a hazardous substance, as well as correcting a problem that may become substantially worse if remedial action is delayed. The interim action provided a partial cleanup by containing contaminated soil that might otherwise have been released to marine surface water and sediment.

3.1.1 EVALUATION OF INTERIM ACTION ALTERNATIVES

The following three interim action alternatives were evaluated as potential options for repairing the failing timber bulkhead (Reid Middleton 2011):

- Alternative 1: Sheetpile Bulkhead
- Alternative 2: Concrete Block Wall and Sheetpile Bulkhead
- Alternative 3: Riprap Slope and Sheetpile Bulkhead.

For each of the alternatives, it was assumed that the fuel office building would be deconstructed to the floor level by the tenant to relieve vertical and lateral loads on the existing bulkhead

In accordance with MTCA [WAC 173-340-430(7)(b)(ii)], the alternatives were evaluated based on the following:

- Permanence and effectiveness of the remedy
- Potential environmental impacts during implementation
- Potential impacts to long-term Site use
- Potential to preclude future remedial action
- Cost.

Based on an evaluation of the three alternatives according to the criteria listed above, Alternative 1 was selected as the preferred alternative for the interim action.

3.1.2 INTERIM ACTION IMPLEMENTATION

The interim action was implemented at the Site from August 20 to October 16, 2012. The action included the installation of interlocking steel sheet piles, which is a standard construction technique for marine bulkheads. The sheetpile bulkhead was installed about 2 to 3 ft behind (east of) the existing

timber bulkhead. Because soil at the Site is generally soft and loose, a vibratory hammer was used to drive the sheet piles into the subsurface.

The sheet piles were driven into the soil after excavating a shallow key trench along the alignment of the wall. The key trench extended only 1 to 2 ft BGS and, as such, did not encounter any TPH-impacted soil. After the sheet piles were driven into the key trench, the tops of the sheet piles were cut off and a concrete sheetpile cap was poured. The sheetpile cap was completed at the existing ground surface and the surrounding area was paved with asphalt to create a smooth surface for vehicle traffic.

4.0 REMEDIAL INVESTIGATION FIELD ACTIVITIES

This section describes activities conducted during the RI. RI field methods are described in the RI Work Plan, which included a Sampling and Analysis Plan for both the upland and marine sediment investigations. Descriptions of all relevant Site characterization activities are presented in this section by medium of concern (i.e., soil, soil vapor, groundwater, marine sediment, and surface water) to provide the reader a comprehensive understanding of the scope of the RI activities. The results of the RI are discussed in Section 7.0. The development of SLs used for evaluating Site data is discussed in Section 6.0.

4.1 UPLAND SOIL INVESTIGATION

The upland soil investigation included a general characterization of soil lithology, field screening for contamination and LNAPL, and collection of soil and soil vapor samples for laboratory analysis. The investigation included geotechnical borings advanced by hollow-stem auger, upland investigation borings advanced with a direct-push drilling rig, and supplemental soil data collected during the installation of groundwater monitoring wells by hollow-stem auger. The upland soil investigation is detailed in the following sections. Exploration logs, including the results of field-screening observations, are provided in Appendix B.

4.1.1 GEOTECHNICAL INVESTIGATION

Landau Associates completed a geotechnical investigation along the failing Blaine Marina Inc. fuel pier bulkhead in January 2012 as part of the interim action described in Section 3.0. A truck-mounted, hollow-stem auger drill rig was used to advance three borings (B-1-12, B-2-12, and B-3-12) on Sigurdson Avenue along the length of the damaged bulkhead (Figure 4). One boring was advanced to a depth of approximately 16 ft BGS (B-3-12), one boring (B-1-12) was advanced to a depth of approximately 21 ft BGS, and one boring (B-2-12) was advanced to a depth of 47 ft BGS.

Although conducted for geotechnical purposes, environmental samples were collected when odor, sheen, and high PID readings indicated the potential presence of TPH contamination. Soil boring samples were submitted to Analytical Resources, Inc. (ARI), in Tukwila, Washington for analysis of TPH-G by Method NWTPH-Gx, TPH-D and TPH-O by Method NWTPH-Dx, and BTEX by U.S. Environmental Protection Agency (EPA) Method 8260C.

4.1.2 DIRECT-PUSH SOIL INVESTIGATION

The primary phase of the upland soil investigation was conducted in October 2012. Twenty-two (22) direct-push soil borings were advanced at the Site to delineate the lateral and vertical extent of soil contamination. Each soil boring was completed from the ground surface to at least 3 ft below the groundwater table. Some borings were extended deeper to characterize geologic conditions or delineate the vertical extent of contamination. Groundwater levels observed at the time of drilling ranged from 6 to 7 ft BGS near the bulkhead and 8 to 11 ft BGS for borings further inland. As a result, most borings were advanced to approximately 15 ft BGS.

Soil at each boring was field-screened for the presence of TPH by observing for stains, sheen, or odor. The soil was also screened by PID for volatile organic compounds (VOCs) that are often associated with gasoline- and diesel-range petroleum hydrocarbon contamination. Because LNAPL has been observed at the Site, the soil was visually observed for the presence of sheen or LNAPL. When visual observation for LNAPL or sheen was unclear, field personnel used hydrophobic dye to assist in the evaluation. Soil samples were collected from each of the borings and submitted for laboratory analysis for Site constituents of potential concern (COPCs). The 22 soil borings were advanced with a truck-mounted Geoprobe direct-push rig in locations that were selected to identify the lateral extent of Site soil contamination, as shown on Figure 4. Based on previous investigations, contamination may have been released at or near the ground surface near the location of the ASTs or ancillary equipment, then subsequently migrated vertically down to the groundwater and then laterally along the water table surface. As a result, it was anticipated prior to the investigation that at many soil boring locations, the soil near the surface would be unaffected while a discrete vertical interval of soil near the groundwater table would be contaminated. For this reason, when field screening indicated contaminated soil was encountered in a boring, soil samples were collected for analysis from: 1) above the zone of contamination in apparently “clean” soil; 2) within the zone of the most apparently affected soil; and 3) below the zone of contamination in apparently “clean” soil.

In addition to submitting the three soil samples for immediate laboratory analyses from each boring as described above, at least one sample was collected from above and below these intervals for archiving at the laboratory for potential follow-up analyses. At locations where contamination was not indicated by field observations, one sample was collected for laboratory analysis at the groundwater table and samples collected from above and below this location were archived for potential follow-up analyses. Soil samples were submitted to ARI in Tukwila, Washington for analysis for TPH-G by Method NWTPH-Gx, TPH-D and TPH-O by Method NWTPH-Dx, lead by EPA Method 6020, naphthalenes (which consists of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene) by EPA Method 8270D, and VOCs related to TPH contamination including BTEX, and fuel additives 1,2-dichloroethane (EDC),

ethylene dibromide (EDB), and methyl-tert butyl ether (MTBE) by EPA Method 8260C. Follow-up analyses were conducted for specific contaminants based on detections or exceedances of SLs in adjacent soil samples.

The investigation was extended laterally by advancing borings progressively farther from the apparent source area until field screening for petroleum hydrocarbons indicated the borings were outside the extent of significant petroleum hydrocarbon impacts. Two additional borings beyond those identified on the RI Work Plan were added based on field-screening results, BMI-GP-21 and BMI-GP-22. The data from the additional borings provide a boundary for the extent of contamination observed in BMI-GP-5 and BMI-GP-9, respectively.

Additional soil quality data were collected at the Site during the installation of groundwater monitoring wells in April 2013. The additional data provided further delineation of the extent of contamination along the east and southwest boundaries of the Site. Six soil samples were collected during the installation of monitoring wells MW-6, MW-7, MW-9, and MW-10. All soil samples from monitoring wells were submitted to ARI for laboratory analysis for COPCs that were present at concentrations greater than SLs in neighboring RI soil borings. Soil samples were analyzed for TPH-G by Method NWTPH-Gx, TPH-D and TPH-O by Method NWTPH-Dx, naphthalenes by EPA Method 8270D, and VOCs by EPA Method 8260C.

4.2 GROUNDWATER INVESTIGATION

The groundwater investigation was implemented in two phases to evaluate the nature and extent of groundwater contamination, and to evaluate Site hydrogeology. The scope of the groundwater investigation is discussed below, separated into two phases:

- **Phase 1:** Twelve (12) groundwater grab samples were collected from direct-push borings during the initial uplands soil investigation and were analyzed for the list of COPCs below.
- **Phase 2:** Nine (9) groundwater monitoring wells were installed at the Site in locations that were selected based on analytical results from Phase 1 of the groundwater investigation. Groundwater samples were collected from the monitoring wells and analyzed for the list of COPCs below.

The groundwater grab samples collected during Phase 1 are useful for screening purposes to determine whether a hazardous substance is present, but may not accurately reflect the concentration of detected hazardous substances in groundwater because of the potential for particulates (turbidity) to be entrained in the sample as compared to samples collected from a properly designed and constructed groundwater monitoring well. As a result, the analytical results from samples collected from direct-push borings are potentially biased high for analytes that tend to partition to soil, such as metals and diesel- and oil-range petroleum hydrocarbons. The potential for biased-high analytical results makes collecting

groundwater grab samples with from direct-push borings a conservative groundwater screening approach, but the results may not be sufficiently accurate for evaluating the nature and extent of contamination. As a result, the groundwater quality results from the Phase 1 direct-push borings are primarily for screening purposes and for locating the Phase 2 monitoring wells, and the groundwater samples collected from the Phase 2 monitoring wells will be used for evaluating the nature and extent of groundwater contamination.

Groundwater COPCs identified for the Site RI were evaluated using the following test methods:

- TPH-G by Method NWTPH-Gx
- TPH-D by Method NWTPH-Dx
- Total and dissolved lead by EPA Method 6020
- VOCs by EPA Method 8260C
 - BTEX, EDB, EDC, MTBE
- Naphthalenes by EPA Method 8270D.

4.2.1 PHASE 1 GROUNDWATER CHARACTERIZATION

Groundwater grab samples were collected from 12 Geoprobe direct-push locations in October and November 2012 to characterize groundwater quality. The results of the Phase 1 groundwater investigation were used to identify monitoring well installation locations.

Groundwater grab samples were collected from the nine locations specified in the Work Plan (BMI-GP-4, BMI-GP-5, BMI-GP-8, BMI-GP-9, BMI-GP-11, BMI-BP-12, BMI-GP-16, BMI-GP-18, and BMI-GP-19) and from three additional locations (BMI-GP-10, BMI-GP-21, and BMI-GP-22). These additional locations were sampled for groundwater based on observation of petroleum sheen (BMI-GP-10), and to provide additional delineation of the northern extent of the plume based on field observations (BMI-GP-21 and BMI-GP-22).

Groundwater grab samples were collected from direct-push borings in accordance with the approved RI Work Plan. The samples were collected from a temporary well consisting of a 4-ft-long, wire-wrapped, stainless steel screen (0.010-inch slot size) with a retractable protective steel sheath. The temporary well was advanced to the sample depth (4 ft below the groundwater table). The depth to groundwater at the time of drilling the direct-push borings was estimated based on the observations of saturated soil. The analytical results for the groundwater grab samples are discussed in Section 7.3.

Saturated conditions observed in the direct-push borings generally ranged from 8.0 to 8.5 ft BGS. Saturated conditions were observed at BMI-GP-13 through BMI-GP-15 at shallower depths due to the presence of a clay layer in this area. At locations BMI-GP-14 and BMI-GP-15, the soil was saturated almost to the ground surface and a clay layer was encountered at approximately 1.5 ft BGS. At

BMI-GP-13, saturated conditions were observed at approximately 5 ft BGS, just above the clay layer at this location.

4.2.2 PHASE 2 GROUNDWATER INVESTIGATION

The Phase 2 groundwater investigation consisted of the installation, development, and monitoring of Site groundwater monitoring wells. The field activities associated with the Phase 2 investigation are described in the following sections.

4.2.2.1 Monitoring Well Installation and Development Procedures

Based on the results of the first phase of the RI, seven groundwater monitoring wells (MW-4 through MW-10) were installed to evaluate groundwater quality at the apparent limits of petroleum hydrocarbon contamination. An eighth monitoring well (MW-11) was installed following the first groundwater sampling event to assess how far contaminated groundwater had advanced in a southern direction along the sheetpile wall, based on TPH-G, VOC, and naphthalene detections at concentrations exceeding the Site SLs at monitoring well MW-7. Additionally, one LNAPL pilot recovery well (RW-1) was installed near the ASTs and where other monitoring wells indicated the presence of LNAPL. This pilot recovery well was installed to evaluate whether sufficient free-phase LNAPL is present at the Site to warrant consideration of LNAPL recovery during development of the remedial alternatives that will be evaluated in the FS. The monitoring wells and LNAPL recovery well were constructed in accordance with Washington State Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC) and the RI Work Plan. Monitoring wells were drilled using conventional hollow-stem auger techniques with 4.25-inch inside diameter augers. Well installation was overseen by Landau Associates field personnel familiar with environmental sampling and construction of resource protection wells. A detailed record of the well construction and observed soil lithology is provided in the boring and well construction logs (Appendix B).

The groundwater monitoring wells were constructed with 2-inch-diameter, flush-threaded, Schedule 40 PVC pipe, 10-ft screens with 0.010-inch machine-slotted perforations, and a filter pack consisting of pre-washed number 20/40 silica sand. The pilot LNAPL recovery well was drilled using a 6-inch-diameter hollow-stem auger and constructed with a 4-inch-diameter Schedule 40 PVC pipe, a 10-ft screen with 0.040-inch machine-slotted perforations, and a filter pack consisting of pre-washed number 8/12 silica sand. The pilot recovery well was designed to allow LNAPL (which can be more viscous than water) to flow as freely as possible into the well, rather than to minimize sample turbidity.

The well screens were generally placed from 5 to 15 ft BGS to intersect the water table and the filter packs were placed from the bottom of the well to approximately 1 ft above the top of the screen. A

bentonite seal was placed above the filter pack material to within about 3 ft of the ground surface. Grout was used to backfill the boring to the subgrade for placement of the protective cover and a flush-mounted monument was cemented in place for each monitoring well. Well construction details are provided in Appendix B.

The newly installed wells were not developed until at least 24 hours following installation. Development was accomplished by repeatedly surging the well with a surge block and purging water from the well until the water was relatively clear. During development, the purged groundwater was monitored for the following field parameters:

- pH
- Conductivity
- Temperature
- Turbidity
- Oxidation reduction potential (ORP)
- Dissolved oxygen.

The wells were developed until the stabilization criteria presented in the RI Work Plan were met. Based on the visibly clear water quality and low turbidity values recorded during subsequent groundwater sampling efforts, the well installation and development activities were effective.

4.2.2.2 Hydrogeologic Characterization

Hydrogeologic data were collected during the RI to evaluate groundwater flow direction, saturated interval thickness, and tidal influence as detailed in Section 5.3. The groundwater elevation at each monitoring well was determined by subtracting the measured length from the top of the monitoring well casing to the top of groundwater from the surveyed elevation at the top of the casing. Measurements and surveying data recorded to the nearest 0.01 ft. Groundwater elevations were measured at high and low tides during wet (April 2013) and dry (August 2013) seasons to evaluate tidal influence and seasonal variations in groundwater elevations and flow direction at the Site.

Four soil samples were collected from the saturated zone at the time of drilling—one from MW-8 and RW-1, and two from MW-9—and submitted to the laboratory for grain size analyses to support the estimation of the hydraulic conductivity for the uppermost hydrostratigraphic unit (Section 5.3.2). The hydraulic conductivity data, in conjunction with the average hydraulic gradient determined from monitoring well gauging, were used to estimate Site groundwater horizontal velocities (Sections 5.3.2 and 5.3.3).

4.2.2.3 Groundwater Monitoring

During the Phase 2 groundwater investigation, groundwater samples were collected from the monitoring wells during both the wet and dry season (two monitoring events) and analyzed for the COPCs identified in Section 4.2. After the first monitoring event (wet season, April 2013), monitoring well MW-11 was installed in the southwestern portion of the Site uplands, near the bulkhead, because TPH-G, VOCs, and naphthalene were detected at concentrations greater than the SLs in groundwater collected from monitoring well MW-7.

During each Phase 2 groundwater monitoring event, samples were collected from monitoring wells in accordance with procedures detailed in the RI Work Plan and analyzed for the COPCs listed in Section 4.2. Additional sampling of selected groundwater monitoring wells was conducted to assess whether natural attenuation of petroleum hydrocarbon compounds is occurring along the upland perimeter of the Site boundary, where concentrations of COPCs are expected to be low enough that natural attenuation may be potentially observable by evaluating typical monitored natural attenuation (MNA) parameters such as dissolved oxygen, nitrate, dissolved manganese, dissolved iron, or sulfate. The analytical data for the Phase 2 investigation are discussed in Section 7.0.

4.3 SOIL VAPOR INVESTIGATION

Four soil vapor samples were collected to assess the presence of vapor-phased COPCs in the Site subsurface, and to evaluate the potential human health risk associated with intrusion of soil vapor into indoor ambient air. The sampling locations were selected to evaluate soil vapor quality near the ASTs, where soil vapor has the highest potential to have elevated concentrations of VOCs, and would have the greatest impact on indoor air quality if vapor intrusion is occurring (BMI-GP-6, BMI-GP-13, and BMI-SVSS-1), and to evaluate the potential for offsite migration of affected soil vapor (BMI-GP-9).

Soil vapor samples were collected in accordance with the procedures presented in the RI Work Plan (Landau Associates 2012a) from three direct-push soil boring locations (BMI-GP-9, BM-GP-13, and BMI-GP-6, and one location from beneath the floor slab in the Blaine Marina Inc. furniture and appliance retail building through a temporary Vapor Pin™ installed in the floor slab (BMI-SVSS-1), at the locations shown on Figure 4. A soil vapor sample was collected from BMI-GP-6 instead of BMI-GP-14 as originally identified in the Work Plan because saturated conditions were encountered at 0.5 ft BGS at BMI-GP-14, which precluded collecting a soil vapor sample at that location. Soil vapor samples from direct-push boring locations were collected using a temporary 6-inch stainless steel screen exposed from 4.5 to 5 ft BGS. The sub-slab vapor sample was collected from approximately 4 to 6 inches below the 8-inch-thick concrete building floor slab.

Soil vapor samples were collected in 6-liter Summa canisters and submitted to Columbia Analytical Services laboratory in Simi Valley, California for VOC analysis by EPA Method TO-15. In accordance with the RI Work Plan, one blind field duplicate sample was collected at sample location BMI-SVSS-1. The results of the soil vapor investigation are discussed in Section 7.0.

4.4 LIGHT NON-AQUEOUS PHASE LIQUID TRANSMISSIVITY EVALUATION

An LNAPL baildown test was conducted to estimate LNAPL transmissivity. LNAPL transmissivity is a site-specific parameter that provides a measure of LNAPL mobility and potential recoverability. MTCA requires the recovery of LNAPL free product at the groundwater interface using “normally accepted engineering practices” [WAC 173-340-360(2)(c)(ii)(A)], and in the context of underground storage tanks (USTs), “to the maximum extent practicable” [WAC 173-340-450(4)(a)].

The baildown tests were conducted according to the RI Work Plan Addendum (Landau Associates 2013b), which was developed based on the American Petroleum Institute (API) protocol (API 2012). In addition to providing technical guidance on conducting the baildown test, the API document provides a spreadsheet tool used to analyze the resulting data.

The baildown test was intended to be conducted at the pilot LNAPL recovery well, RW-1. However, this well did not meet the performance criterion of accumulating greater than 6 inches of apparent LNAPL thickness required to conduct the baildown test. As a result, the test was conducted on existing monitoring well MW-3, which had an apparent LNAPL accumulation of more than 2 ft. Two baildown tests were conducted at well MW-3 to evaluate the reproducibility of the baildown test results. The first test was completed on April 23, 2013 and the second on August 20, 2013. The depth to groundwater was measured at MW-3 prior to the first baildown test at low tide and 5 hours later [8.40 and 8.43 ft mean lower low water (MLLW)], which indicated that groundwater elevation changes in the vicinity of MW-3 are minor during tide exchanges. This observation was substantiated by similarly small changes in groundwater elevations at nearby wells MW-1, MW-2, and RW-1.

Both baildown tests were initiated within 1 hour of low tide. First, LNAPL was rapidly removed from the well using a peristaltic pump, with approximately 0.8 and 1.2 gallons of LNAPL recovered during the first and second events, respectively. The test involves measuring and recording depth to groundwater and depth to LNAPL as the well recovers to its static condition. These measurements of depth to groundwater and LNAPL began immediately. Twenty (20) measurements were recorded over a period of 12 hours during the first baildown test. Because it was determined during this test that most recovery occurred in the first few hours, a modification to the timing of measurements was made for the second baildown test. During the second baildown test, 34 measurements were recorded over a period of

only 4 hours. The increased number of measurements for the second test permitted the identification of data outliers caused by soil stratigraphic differences and recharge from the sandpack. The results of the transmissivity evaluation are discussed in Section 7.3.4, and additional supporting data are provided in Appendix B.

4.5 SEDIMENT QUALITY INVESTIGATION

Based on the close proximity of soil and groundwater contamination in the uplands to the bulkhead—which was failing prior to the Port conducting the interim action—there is a potential for contaminants to migrate from the uplands portion of the Site to marine sediment via groundwater. Additionally, upland soil may have directly migrated to marine sediment in the vicinity of the section of bulkhead repaired during the interim action. Based on these considerations, a limited sediment quality investigation was conducted that focused on shallow sediment near the shoreline.

No dredging for either harbor maintenance or redevelopment of the uplands is anticipated in this area. As a result, the assumed point of compliance for marine sediment is the upper 10 cm of the current sediment surface. The marine sediment investigation consisted of collecting three surface sediment samples at the locations shown on Figure 4. The locations from where the surface sediment samples were collected were shifted slightly from that presented in the RI Work Plan based on the presence of riprap, which is located along much of this shoreline. Field personnel conducted a reconnaissance of the sediment sampling area near the former fuel office building and determined that sufficient sediment accumulation had occurred in the interstices of the riprap underlying the former fuel office building to allow for surface sediment sampling closer to the shoreline than originally anticipated. As a result, a surface sediment sample was collected from BMI-SS-2 by hand during low tide as close to the bulkhead as possible.

The surface sediment samples were analyzed by ARI for selected COPCs, including lead, TPH, and PAHs (naphthalenes), as well as grain size and total organic carbon (TOC). The petroleum hydrocarbon testing included analysis of petroleum hydrocarbon fractions using volatile petroleum hydrocarbon (NWVPH), extractable petroleum hydrocarbon (NWEPH), NWTPH-Dx, and NWTPH-Gx methodologies. A bioassay test was planned to be conducted using the sediment sample with the highest concentrations of these constituents if TPH constituents were detected in sediment at concentrations that indicated a release from the Site may have occurred. As discussed in Section 7.4, the Port reviewed the sediment data and, in consultation with Ecology, determined that bioassay testing was not required. Results of the sediment investigation are discussed in Section 7.4.

4.6 SURFACE WATER INVESTIGATION

To evaluate surface water quality in Blaine Harbor for potential impacts from the TPH release in the Site uplands, a surface water sample was collected during the ebbing tide, within 2 hours of low tide, at the location shown on Figure 4 (BMI-SW1). Because the Site is located within an active harbor with recreational and commercial vessels, it was understood prior to sampling that there could be many potential sources of petroleum hydrocarbons in surface water unrelated to Site releases. As a result, personnel observed for petroleum sheen on the water prior to sample collection. If a petroleum sheen was observed on the water surface that did not appear to be emanating from the Site uplands, either sampling would not be conducted at that time or the sampling location would be moved to avoid collecting a surface water sample that may be affected by non-Site releases. There was no sheen observed at the time of sampling, so the surface water sample was collected and submitted to ARI for analysis of TPH-G using Method NWTPH-Gx; TPH-D and TPH-O by Method NWTPH-Dx (with acid/silica gel cleanup procedures); VOCs (including BTEX, EDB, EDC, and MTBE) by EPA Method 8260C, PAHs (naphthalenes) by EPA Method 8270D, and lead by EPA Method 6020. The analytical results are discussed in Section 7.5.

5.0 ENVIRONMENTAL SETTING

This section describes the Site environmental setting to provide the reader a comprehensive understanding of physical conditions, geology, hydrogeology, natural resources, and land and navigational uses at the Site. The Site is located in an upland area that was created by placing fill, primarily dredge spoils, over former tideflats in the northeastern portion of Drayton Harbor. Dredging of these former tideflats created Blaine Harbor, and provided fill for creating the uplands. The dredged area now provides boat access to the uplands portion of the Site, which supports the local marine commercial industry and private boaters. Boat fueling, fish processing, and net storage are the primary marine commercial industries supported at the Site and in the immediate vicinity.

5.1 PHYSICAL CONDITIONS

Site physical conditions are relevant because they have the potential to affect the fate and transport of contaminants. Physical conditions discussed below include Site shoreline features, topography, bathymetry, surface cover, and stormwater management.

5.1.1 SHORELINE FEATURES

Shoreline features have not changed significantly since the late 1940s or early 1950s. As discussed in Section 2.1, the uplands were created by placing locally sourced dredge fill over the former tideflats. The shoreline was created by constructing a timber bulkhead armored with riprap around the perimeter of the upland fill area. The most significant recent change to this configuration that is relevant to the RI was the repair of the bulkhead completed as part of the interim action, discussed in Section 3.0. Although this repair did not change the location of the shoreline, the installation of the sheetpile wall appears to have changed the way groundwater discharges to Blaine Harbor, as discussed in Section 5.3. Current shoreline features, including the location of the sheetpile wall installed to repair the failing section of bulkhead, are shown on Figure 4. The section of shoreline just north of the recently repaired section consists mainly of a riprap slope, which does not appear to be failing. The original shoreline in this section may have consisted solely of the timber bulkhead, and the riprap visible along the shoreline now may have been placed sometime in the 1950s to stabilize a section of timber bulkhead.

5.1.2 TOPOGRAPHY AND BATHYMETRY

The upland portion of the Site is relatively flat with a surface elevation ranging between 14 ft and 15 ft MLLW. Because of the limited topographic relief, a Site topographic map was not prepared for this report. The bathymetry contours in Blaine Harbor near the Site are shown on Figures 3 and 4.

5.1.3 TIDES, FLOODING, STORM SURGE, TSUNAMIS, AND CLIMATE CHANGE

The tides for 2013 in Drayton Harbor (which Blaine Harbor resides within) ranged from a minimum of -3.1 ft to a maximum of 10.8 ft MLLW, according to the National Oceanic and Atmospheric Administration website (NOAA website 2013). Flooding, storm surge, and tsunamis (in decreasing order of probability of occurrence) may increase the water levels in Blaine Harbor on rare occasions. Additionally, the Port is planning for a potential 2.4-ft rise in sea level in response to the changing climate over the next 100 years. This estimate is based on a variety of projections made by the University of Washington Climate Impacts Group (UWCIG and Ecology 2008) and the Intergovernmental Panel on Climate Change (IPCC 2007). To provide greater shoreline protection, it is anticipated that the Port will improve the bulkhead around the entire perimeter of the Blaine Harbor industrial area during the area redevelopment. The design for redevelopment is in preliminary planning phases and does not yet include details regarding shoreline improvements.

5.1.4 SURFACE COVER

The Site upland is almost entirely covered by impermeable surfaces consisting of either asphalt pavement or buildings. The only unpaved areas of the Site are around and within the secondary containment system associated with the ASTs, as shown on Figure 2.

5.1.5 STORMWATER MANAGEMENT

There are currently no catch basins or other engineered stormwater management systems at the Site. Stormwater at the Site generally flows over paved surfaces toward Blaine Harbor, except where stormwater may infiltrate in unpaved surfaces near the ASTs.

5.2 GEOLOGY

General geologic information for the Site was obtained from the *Geologic Map of the Bellingham 1:100,000 Quadrangle, Washington* (Lapen 2000), published by the Washington State Department of Natural Resources. According to Lapen, fill is present at the Site and overlies glaciomarine drift. Glaciomarine drift can have various distributions of gravel, sand, silt, and clay, although finer sediments (silt and clay with fine sand) are most typical, with coarse sand and gravel occurring as “dropstones.” Glaciomarine drift in the area is typically soft or loose, although where exposed to drying or other consolidation after deposition, it can form a hardened crust several feet thick.

Much of the Site is covered with asphalt pavement or buildings, which is underlain by 0.5 to 2 ft of granular fill trafficking layer (sand and gravel), though in some locations, such as along the bulkhead in the western portion of the Site, the maximum thickness of the trafficking layer was observed to be 4 ft.

Beneath the trafficking layer, up to 15 ft of dredge fill was encountered, which consists of two general geologic units. One unit consists of a sandy to silty clay unit that is generally present in large lenses, including a massive deposit underlying the fuel storage area. The second fill unit consists primarily of interbedded fine sand, slightly silty to silty fine sand, and sandy silt.

Below the interpreted limits of the dredge fill, fine sand to silty fine sand was encountered, which appear to be native marine deposits. Because the dredge fill was sourced from areas adjacent to the Site, the composition of the dredge fill and underlying marine deposits are similar so the contact between these two units was not always readily apparent. As a result, this contact was inferred based on changes in the abundance of shells, observations of sulfur-like odors, or a darkening from light to dark gray color. Lithologic changes typically observed at the fill/native interface included the reduced presence of clay deposits, reduced silt content, and an increase in poorly graded, fine sand. Observed soil conditions beneath the fill/native soil contact were generally more consistent in soil type and structure than observed in the overlying fill, and significant clay deposits were not encountered.

Only one boring (B-2-12) was advanced to a sufficient depth to encounter the underlying glaciomarine drift. The glaciomarine drift was encountered at approximately 25 ft BGS and consisted of very soft to medium stiff, silty clay and pockets of sandy clay to the maximum depth of the exploration (46.5 ft BGS). It is likely that the clay deposits encountered in the dredge fill originated from dredging of glaciomarine drift.

Geologic cross sections through the Site are presented on Figures 5 and 6. The alignments of the geologic cross sections are shown on Figure 4. The locations of the cross-section alignments were selected to show subsurface geology near the bulkhead (Section A-A') and from the bulkhead area in the western portion of the Site through the AST source area (Section B-B'). As illustrated on Figure 6, the upper 15 ft of soil in the AST source area is predominantly clay. However, clay deposits are much less prevalent in the vicinity of the shoreline, as shown on Figure 5.

5.3 HYDROGEOLOGY

Groundwater flow at the Site appears to be heavily influenced by recharge in the unpaved, gravelly area near the ASTs because the remainder of the Site and adjacent areas are covered by buildings or asphalt pavement. Groundwater flows outward from the vicinity of the ASTs toward marine surface water in Blaine Harbor, and possibly north toward Semiahmoo Bay. However, flow appears to be primarily to the west or southwest, which is the closest point of discharge for Site groundwater to surface water.

Groundwater flow through the Site is primarily through the sand and silty sand deposits in the dredge fill and the upper portions of the underlying native deposits. The glaciomarine drift unit is

assumed to form the uppermost aquitard throughout the Site, although groundwater flow is likely limited to the upper 5 to 10 ft of saturated soil due to the close proximity of the surface water discharge and the limited elevation difference between the maximum groundwater elevation (approximately 7.7 ft MLLW) and mean sea level (5.8 ft MLLW). The hydrogeologic properties of the uppermost hydrogeologic unit consisting of fill materials and the underlying native marine deposits are discussed in the following sections.

5.3.1 SATURATED THICKNESS, GROUNDWATER FLOW DIRECTION, AND TIDAL INFLUENCE

Groundwater elevation data collected from monitoring wells during the RI are presented in Table 5. The depth to groundwater ranged from approximately 7 to 10 ft BGS based on these data, and is shallower during the wet season than the dry season. The saturated thickness of the fill unit and underlying native marine deposits located above the glaciomarine drift unit is approximately 17 ft, although groundwater flow is likely limited to the upper 5 to 10 ft of saturated soil, as discussed in the previous section. The saturated thickness of the uppermost hydrostratigraphic unit is greatest in the vicinity of the AST containment area and decreases radially outward, although groundwater flow appears to be predominantly to the west and the east.

The observed “mounding” of the groundwater table near the AST containment area is consistent with groundwater recharge occurring primarily in the unpaved gravel area within and surrounding the AST containment area. The mounding is likely also caused by the presence of the large clay lens underlying this area in close proximity to the surface.

The direction of groundwater flow and the horizontal hydraulic gradient were estimated based on water levels measured during the RI and converted to elevations. Groundwater levels measured at both low and high tides in April and August 2013 were contoured to show groundwater flow direction and gradient during wet (April) and dry (August) season conditions. These contours are shown on Figures 7 through 10 with groundwater flow direction assumed to be perpendicular to water level contour lines. As shown on these figures, groundwater at the Site emanates outward from the center of the Site in most directions including the west-southwest, east, and to a lesser degree to the south.

As is most evident in the dry season (Figures 9 and 10), the recently installed sheetpile bulkhead on the west side of the Site appears to provide a partial barrier to groundwater flow. Water level contour lines flatten near the bulkhead and groundwater appears to flow around the ends, which is particularly evident at the south end, between monitoring wells MW-7 and MW-11. This effect likely also occurs during the wet season, though it is not evident on Figures 7 and 8 because the installation of monitoring well MW-11 occurred after wet season data were collected.

Tidal influence on groundwater at the Site was evaluated by comparing water level data in all monitoring wells at low and high tides during both the dry and wet seasons. Groundwater levels at low tide were subtracted from those at high tide to determine the change (delta) due to tidal influence. Monitoring wells on the west side of the Site closest to marine water experienced changes in groundwater levels of between 0.19 ft (wet season minimum delta) and 1.89 ft (dry season maximum delta) between low and high tide. Monitoring wells in the center of the Site near the AST containment area experienced deltas between 0.09 ft and 0.69 ft. Because there is generally some degree of time lag between tidal maxima or minima and groundwater maxima or minima measured in tidal-influenced aquifers, it is possible that actual tidal effects are slightly greater than measured during the RI.

Saturated conditions were observed at much shallower depths during drilling at BMI-GP-13 through BMI-GP-15 than other explorations. This is attributable to the thick clay lens present in this area, shown on Figure 7, which locally controls stormwater infiltration and shallow groundwater migration in the AST source area. Because this clay unit was not consistently present in other borings, it does not appear to be contiguous or play a prominent role in groundwater flow conditions outside of this localized area.

5.3.2 HYDRAULIC CONDUCTIVITY, GROUNDWATER FLOW AND WATER BALANCE

Hydraulic conductivity of the uppermost hydrostratigraphic unit was estimated using the Hazen method (Fetter 2000) and verified with a water balance approach. In the Hazen method, hydraulic conductivity is estimated based on grain size from subsurface soil samples:

$$K = C (d_{10})^2$$

K: hydraulic conductivity [centimeters per second (cm/sec)]

d_{10} : effective grain size (10% finer) (cm)

C: correction coefficient based on soil type (40 – 80 for very fine sand, poorly sorted).

The correction coefficient was selected as 50 due to the predominance of fine-grained material at the Site. Grain size distribution was analyzed for soil samples collected from pilot recovery well RW-1 (8 to 8.5 ft BGS) and monitoring well MW-9 (10 to 11.5 ft and 13.5 to 15 ft BGS). It was determined that soil from RW-1 (gravel and coarse sand) is likely not representative of the soil conditions of the Site at large; thus, RW-1 grain size data were not used further in estimates of hydraulic conductivity. The effective grain size of soil from MW-9 at depths between 10 and 11.5 ft BGS is 15 micrometers (μm ; 1.5×10^{-3} cm), which leads to an estimate of $K = 1.1 \times 10^{-4}$ cm/s (0.32 ft/day), which is likely close to a lower limit of hydraulic conductivity for soil units at the Site through which groundwater is migrating. The effective grain size of soil from MW-9 at depths between 13.5 and 15 ft is 66 μm (6.6×10^{-3} cm),

which leads to an estimate of $K = 2.2 \times 10^{-3}$ cm/s (6.2 ft/day), which is likely close to an upper limit of hydraulic conductivity for soil units at the Site through which groundwater is migrating. Based on these results, the likely range of hydraulic conductivity for soil units at the Site through which groundwater is migrating is between approximately 1×10^{-4} cm/s (0.3 ft/day) and 2×10^{-3} cm/s (6 ft/day), although less permeable soils (silts and clays) are also present within the uppermost hydrostratigraphic unit. These values are within expected literature ranges for similar slightly silty to silty fine sand (Freeze and Cherry 1979).

To confirm that this range represents reasonable values at the Site, a qualitative water balance analysis was conducted. For this evaluation, we rely on several important assumptions, listed below:

- The groundwater system beneath the Site is at a relatively steady state during any given month (that is, flow into the Site is equivalent to flow leaving the Site, and the amount of groundwater storage/mounding does not significantly change).
- All recharge to the groundwater system occurs via the gravel area at the center of the Site directly from precipitation falling onto the gravel area directly or on the surrounding buildings (then into the gravel area via downspouts). Based on downspouts located adjacent to the gravel area, half the roof area for the two adjacent buildings is assumed to contribute to recharge at the center of the Site.
- Seventy (70) percent of precipitation infiltrates in the gravel area, with the remainder lost to evapotranspiration.
- Precipitation falling on the paved areas outside of the gravel area sheet-flow off Site toward marine waters and do not recharge groundwater.
- There is no regional groundwater flow pattern affecting the flow immediately beneath the Site from the outside.
- The Site boundary conditions and stratigraphy limit groundwater flow to the upper 10 ft of saturated thickness.
- Groundwater flow is primarily to the west-southwest although mounding at the Site results in some flow radiating outward including toward the east.

With these assumptions, water enters the system via the gravel area and flows outward to the west-southwest and east through the upper hydrostratigraphic dredge fill unit (assumed to be approximately 10 ft thick). The total area of direct groundwater recharge is calculated to be 7,100 ft² (approximately 3,600 ft² of gravel area and approximately 3,500 ft² of roof area for adjacent buildings that appear to contribute to recharge). Using an average precipitation in Blaine, Washington for the month of April of 2.83 inches (U.S. Climate Data website 2013) and a precipitation infiltration of 70 percent, total recharge into the groundwater system was estimated to be 55 cubic feet per day [ft³/day; 0.29 gallons per minute (gpm)] during the wet season. Using an average precipitation in Blaine, Washington for the month of August of 1.5 inches (U.S. Climate Data website 2013), total recharge into the groundwater system was calculated to be 29 ft³/day (0.15 gpm) during the dry season.

Under steady-state conditions, flow out of the system is governed by Darcy's Law:

$$Q_{\text{out}} = KiA \text{ (ft}^3\text{/day)}$$

- Q_{out} : Total volumetric flow rate emanating outward through upper hydrostratigraphic unit (ft³/day)
- K : Hydraulic conductivity (ft/day)
- i : Average hydraulic head gradient [feet per foot (ft/ft)]
- A : Cross-sectional surface area through which groundwater flows (ft²), where
 A = Cross sectional area of discharge
 $\pi = 3.14$
- r : Radial distance away from center of groundwater mound
- b : Thickness of upper stratigraphic unit.

A rough estimate of average horizontal hydraulic gradient (measured from water level contour plots) was approximately 0.01 ft/ft about 50 ft away from the center of the groundwater mound for both dry and wet seasons, based on low tide water levels. Assuming an average upper unit saturated thickness of 10 ft, and that the groundwater discharges radially from the gravel area, which is approximately a 60 ft square, the cross-sectional area of flow is 2,400 ft². Using the lower limit of estimated hydraulic conductivity (0.3 ft/day), total outflow through the groundwater system was estimated to be approximately 7 ft³/d. Using the upper limit of estimated hydraulic conductivity (6 ft/day), total outflow through the groundwater system was calculated to be approximately 140 ft³/day. These estimated outflows limit the estimated range of recharge calculated above to 29 to 55 ft³/day, indicating that the range of estimated hydraulic conductivity (0.3 ft/day to 6 ft/day) appears to be reasonable.

5.3.3 GROUNDWATER VELOCITY

Groundwater average linear velocity (v) was estimated from the equation:

$$v = Ki/n$$

where:

- K = Hydraulic conductivity (length/unit time)
- i = Hydraulic gradient (dimensionless)
- n = Effective porosity (dimensionless).

The hydraulic gradient for the Site was estimated to be approximately 0.01 based on the groundwater elevation data from several monitoring wells shown on Figures 7 through 10. Based on the range of estimated hydraulic conductivity of 0.3 ft/day to 6 ft/day and an assumed effective porosity of 0.30, the average linear velocity was estimated to be between 0.01 ft/day [4 feet per year (ft/yr)] and 0.2 ft/day (70 ft/yr).

5.4 NATURAL RESOURCES

This section summarizes information on natural resources at and near the Site. Included is a discussion of the types and functions of habitats, and plants and animal species. Because it has been used for commercial and industrial purposes since its creation, there is limited natural resource value and function to Site uplands. Because it has been determined through the RI process that Site sediments are not negatively impacted by the release of TPH in the uplands, the discussion of marine natural resources is brief.

5.4.1 UPLAND HABITAT

The upland portion of the Site was created by filling and has been used for commercial and industrial purposes since its creation, is almost entirely paved or covered by buildings, and consequently has no substantive natural resource value. The upland portion of the Site is considered unlikely to attract wildlife because most of the uplands portion the Site is covered with pavement or buildings, lacks vegetation or standing water, and has a relatively high level of industrial and commercial activity. The nearest potential terrestrial habitat is the Blaine Marina Park, approximately 1,000 ft northeast of the Site. The terrestrial ecological setting of the Site is not expected to change in the future based on plans for redevelopment. Based on the terrestrial ecological setting, the Site is exempt from the requirement of conducting a terrestrial ecological evaluation in accordance with WAC 173-340-7491(1) and terrestrial plants and animals are not considered potential receptors for the Site.

5.4.2 MARINE HABITAT

The potential Site boundary was extended into the marine aquatic area to the west of the Site in the RI Work Plan based on the potential that contamination associated with petroleum hydrocarbon releases at the Site could have impacted marine sediment and/or surface water. Based on the results of the RI in the marine portion of the Site as discussed in Section 7, it does not appear that marine sediments have been impacted by Site releases. However, a discussion of the marine habitat is provided herein based on the close proximity of marine waters to the Site.

The most significant features of the marine area are the bulkhead and riprap along the shoreline, and a dock supported on wooden piling extending approximately 110 ft into the harbor, as shown on Figure 3. Some sedimentation within the riprap was documented during the sediment investigation, although aquatic habitat along the western Site boundary primarily consists of a moderately steep (3H:1V) riprap-covered slope in the intertidal zone, with a vertical bulkhead face bordering much of the upper intertidal zone above approximately elevation 8 ft MLLW. Figure 3 shows the bathymetry of the marine area near the Site as surveyed in 2011 for the RI.

5.4.3 PLANT AND ANIMAL SPECIES

Although the Site does not provide a high quality upland or aquatic habitat, some animal species may frequent the Site, potentially drawn to the Site by nearby fish-processing activity. The significant plant and animal species are summarized below.

5.4.3.1 Plants

As previously mentioned, the Site is essentially devoid of vegetation. Small patches of grasses or weeds may occasionally populate unpaved portions of the Site, although no significant coverage has been observed. At the Blaine Marina Park approximately 1,000 ft northeast of the Site, grasses and small shrubs are present in landscaped portions of the park near the shoreline. The park is known to attract waterfowl and other birds.

5.4.3.2 Terrestrial Wildlife

Wildlife that may be present at the Site and in the vicinity is limited to those species typically observed along the urban waterfront including various songbirds, gulls, crows, and ravens. It is unlikely that the Site is frequented by other terrestrial wildlife, which are probably common in the Blaine, Washington area such as squirrels, raccoons, or opossums. These species are potential visitors, but unlikely to be found frequently due to the industrial activity at the Site, the relative isolation of the upland area which can be accessed only from the mainland by Sigurdson Avenue, and the lack of suitable habitat. Terrestrial wildlife near the Site is likely to be attracted toward the higher quality habitat of the Blaine Marina Park, away from the Site.

5.4.3.3 Aquatic Wildlife

Based on the close proximity of the Site to Blaine Harbor, a general discussion of aquatic wildlife is provided for this region of Puget Sound based on resources located in Bellingham Bay, approximately 20 miles to the south. Threatened, endangered, and sensitive species in this region of the Puget Sound include the bald eagle, peregrine falcon, marbled murrelet, Pacific salmon, bull trout, and orca whales.

Fish and Marine Invertebrates

Documented fisheries resources potentially present in the Site area include the following:

- **Surf Smelt and Sand Lance:** Surf smelt and Pacific sand lance are common fish that spawn in the high intertidal portions of coarse sand and gravel beaches.
- **Pacific Herring:** Pacific herring spawn in inland marine waters of Puget Sound between January and June in specific locations. There is typically a 2-month peak within the overall spawning season. Herring, which deposit their eggs on marine vegetation such as eelgrass and algae in the shallow subtidal and intertidal zones between 1 ft above and 5 ft below MLLW, are known to congregate in the deeper waters in the area.

- **Salmonids:** Anadromous salmonid species, including coho, chum, Chinook, pink, and sockeye salmon, steelhead, cutthroat, and bull trout likely frequent the Site vicinity, and nearby rivers and streams that discharge to Puget Sound.
- **Groundfish:** Several species of groundfish occur in both shallow and deep waters in the northern Puget Sound area for part or all of their life.

A variety of marine invertebrates, ranging from infauna (worms, clams, and small ghost shrimp that penetrate benthic sediments) to epibenthic plankters (organisms such as very small crustaceans that move off the substrate surface) to larger invertebrates such as oysters, crabs, and shrimp may additionally be supported in the Site area.

Sea Birds and Marine Mammals

The greater Bellingham Bay area and its shallow estuarine habitats support a number of birds in all seasons. Although Bellingham Bay is approximately 20 miles south of the Site, it is likely to support similar types of sea birds and marine mammals as the marine waters near the Site. Waterfowl sited in Bellingham Bay include brant, snow geese, mallard, widgeon, green-winged teal, and pintail. The area also serves as an overwintering area for diving birds such as scoter and golden eye. Western Washington is also within a large bird migration route (the Pacific Flyway) extending from Alaska to Patagonia.

Limited information is available on the presence and residence time of marine mammals in the area. Several species have been reported in the northern Puget Sound area, including the harbor seal, sea lion, orca whale, gray whale, and harbor porpoise. The local population of orca whale is listed as endangered under the Endangered Species Act (ESA) and the Steller sea lion is listed by Washington State as a threatened species. The other marine mammals are not threatened or endangered species under the ESA, but they are protected from hunting under the Marine Mammal Protection Act. Seals and sea lions have been noted in the area and migrating gray whales have been noted to feed in subtidal areas of Puget Sound. Orca whales are occasionally observed in and near Rosario Strait and near the San Juan Islands.

5.5 HISTORIC AND CULTURAL RESOURCES

No known archaeologically significant cultural or historic resources are present at the Site. As discussed in Section 2.1, prior to development of the uplands in the late 1940s, the Site area was undeveloped aquatic lands of Drayton Harbor. Since the 1940s, the Site area has been used for commercial and light industrial activities in support of the marine trades. Because the native ground surface was originally subtidal and located some distance from the original shoreline, the potential for Native American archaeological material to be present at the Site beneath the dredge fill is low.

5.6 LAND AND NAVIGATION USES

The Site is currently used for the storage and sale of gasoline and diesel fuel to support the commercial marine industry and recreational boaters, and also as a used furniture repair and retail outlet. The land is owned by the Port and DNR as discussed in Section 1.0, and is zoned for commercial use with surrounding properties zoned for commercial or industrial use with limited public access. Based on the Blaine Marina Industrial Area Plan (Makers et al. 2013), no significant changes to local zoning or land use are planned or anticipated in the immediate vicinity of the Site as a result of the Port's planned redevelopment activities. No changes to navigation and marine uses are planned or anticipated.

6.0 SITE SCREENING LEVELS

Site SLs were developed in the RI Work Plan (Landau Associates 2012a). This section presents a summary of the SLs, which are used to evaluate RI data. The section presents a summary of the COPCs and their likely sources, potentially affected media, migration pathways, and potential contaminant exposure routes to human or ecological receptors. SLs are developed for COPCs to be protective of the potential receptors and exposure pathways in accordance with MTCA requirements.

6.1 POTENTIAL CONTAMINANT SOURCES, MIGRATION PATHWAYS, AND MEDIA OF POTENTIAL CONCERN

The primary sources of contamination at the Site are related to the storage and dispensing of fuel products. The reported contaminant release in 1990 during a fuel transfer operation from delivery trucks to the ASTs is a confirmed source of contamination. Additionally, based on the age of the ASTs and associated infrastructure, the current distribution of petroleum hydrocarbons in soil and groundwater, and because system components (the ASTs and fuel transfer piping) were installed in direct contact with soil, the ASTs and piping system are also considered potential primary sources of contamination. Releases from these confirmed or potential contaminant sources have entered Site soil as LNAPL.

Upon reaching groundwater, which has a greater density than gasoline or diesel, LNAPL can spread laterally on top of the groundwater and generally migrates with the groundwater flow direction. Residual LNAPL generally remains in soil along the path of LNAPL migration from the ground surface to the groundwater, and is typically distributed vertically within the upper portion of water table aquifers in a “smear zone” caused by groundwater-level fluctuations. The LNAPL (both residual and free-phase) acts as a secondary source of contamination that can migrate to other media by dissolution, convection, diffusion, or volatilization.

Based on groundwater at the Site being relatively shallow and the close proximity of the Site to marine surface water, the potential pathways for contaminant migration at the Site could include:

- Leaching of contaminants from LNAPL or affected soil to groundwater
- Volatilization of contaminants from LNAPL, soil, and groundwater to indoor or outdoor air
- Transport of contaminants adsorbed to soil to outdoor air via wind or fugitive dust
- Transport of contaminants in groundwater, or as LNAPL, to adjacent marine surface water and sediment.

Based on our understanding of Site conditions and these migration pathways, the media of potential concern consist of:

- Soil
- Groundwater

- Surface water
- Sediment
- Air.

6.2 POTENTIAL RECEPTORS AND EXPOSURE PATHWAYS

This section identifies potential receptors and the potential exposure pathways for the receptors based on the current and future land uses expected for the Site.

6.2.1 POTENTIAL RECEPTORS

Potential receptors of Site contaminants could be humans, terrestrial ecological receptors (i.e., wildlife, soil biota, and plants), or benthic and aquatic biota. Each of these was evaluated based on the current and anticipated future land use of the Site, as follows:

- **Humans:** Because the Site is used for marine industrial purposes (commercial and light industrial use), employees working at the Site, construction workers conducting intrusive activities, and visitors or patrons of the local businesses are considered potential human receptors.
- **Terrestrial Ecological Receptors:** As previously discussed in Section 5.4.1, the Site meets the requirements for an exclusion under WAC 173-340-7491(1) for conducting a terrestrial ecological assessment, and, consequently, terrestrial plants and animals are not considered potential receptors for the Site.
- **Marine Benthic and Aquatic Organisms:** Due to the Site's proximity to marine surface water, benthic and aquatic organisms in Blaine Harbor are considered to be potential receptors, as well as humans that ingest benthic or aquatic organisms affected by Site releases.

Based on this evaluation, potential receptors for Site contaminants consist of:

- Humans
- Marine benthic and aquatic organisms.

6.2.2 POTENTIAL EXPOSURE PATHWAYS

Potential exposure pathways may be present that would allow Site releases to affect human health or aquatic ecological receptors. These potential exposure pathways are presented by medium below. It has not yet been determined whether these exposure pathways are complete.

Soil:

- Direct contact (including incidental ingestion) by Site workers or visitors. Currently, direct contact with affected soil is considered unlikely since most of the Site is paved or covered with buildings. During construction or intrusive activities, workers could dig into affected soil and could be exposed to affected soil or soil vapor.

- Leaching to groundwater and subsequent migration to marine surface waters and/or sediment where marine benthic or aquatic biota could be exposed.
- Erosion of potentially contaminated soil into the adjacent marine surface water and sediment. The interim action implemented by the Port to repair the failing bulkhead should effectively eliminate this potential exposure pathway.
- Inhalation of indoor or outdoor air that has been affected by volatilization and subsequent migration of gasoline-range petroleum hydrocarbons from contaminated soil.

Groundwater:

- Direct contact by Site workers. During construction or other intrusive activities that could encounter groundwater (between approximately 7 and 10 ft BGS), Site workers could be exposed to affected groundwater or vapors released from groundwater.
- Ingestion by visitors or Site workers. Based on the following considerations, ingestion of Site groundwater is not considered a potential exposure pathway:
 - Due to its close proximity to marine surface water, groundwater at the Site is likely highly saline and not considered a potable source of drinking water.
 - The Site is served by a municipal water supply.
 - The Site is hydrogeologically isolated from the mainland, and as a result, Site groundwater cannot affect any potential potable water supplies.
- Migration of groundwater to the adjacent marine surface water and/or sediment where marine benthic and aquatic biota could be exposed.
- Inhalation of indoor or outdoor air that has been affected by volatilization and subsequent migration of gasoline-range TPH from contaminated groundwater.

Sediment:

- Exposure of benthic organisms to contaminants released from the Site via groundwater discharge through the biologically active zone of sediment (the upper 10 cm below the mudline). This may result in the uptake of contaminants in these organisms.
- Human ingestion of marine organisms that were impacted by releases from the Site.

Surface Water:

- Exposure of aquatic organisms to contaminants released from the Site to surface water.
- Human ingestion of marine organisms that were impacted by releases from the Site.

6.2.3 SITE SCREENING LEVELS

SLs were developed for media of potential concern identified in Section 6.1 (i.e., soil, groundwater, surface water, indoor and outdoor air, and sediment) and presented in the RI Work Plan. COPCs were also presented in the RI Work Plan and include hazardous substances commonly associated with gasoline- and diesel-range petroleum hydrocarbon releases. Although surface water is a potentially affected medium, it is addressed through the development of groundwater SLs that are protective of surface water rather than developing surface water SLs directly. Groundwater SLs address the protection

of indoor air quality, and as discussed in the RI Work Plan, soil vapor SLs are developed herein for VOCs that were detected in soil vapor monitoring samples. A groundwater SL has been included for dissolved manganese based on detections of this constituent during monitoring for natural attenuation parameters, as described in Section 7.3.3. Tables 6 through 9 present a summary of screening level development.

MTCA provides three approaches for establishing cleanup levels for soil and groundwater: Method A, Method B, and Method C. The Method A approach is appropriate for sites that have few hazardous constituents. The Method B approach is applicable to all sites. The Method C approach is applicable for specific site uses and conditions. The Method B and Method C approaches use applicable state and federal laws and risk equations to establish cleanup levels. However, the Method B approach establishes cleanup levels using exposure assumptions and risk levels for unrestricted land uses, whereas the Method C approach uses exposure assumptions and risk levels for restricted land uses such as industrial properties. For practical purposes, MTCA requires cleanup levels developed using MTCA Method B and Method C approaches to be set at the practical quantitation limit (PQL) or natural background if the PQLs are greater than the calculated cleanup levels.

In general, the Method B approach was used for the development of the SLs for the Site. However, Method A cleanup levels were applied to certain constituents for which Method B cleanup levels have not been established, such as lead and petroleum hydrocarbons.

Sediment SLs were developed based on site-specific COPCs and the application of MTCA and SMS requirements. Two SMS criteria are promulgated by Ecology as follows:

- The marine sediment quality standards (SQS; WAC 173-204-320), the concentration above which adverse effects to benthic organisms may occur.
- The sediment cleanup screening levels [CSL; WAC 173-204-520)], the concentration above which adverse effects to benthic organisms are likely to occur.

The SL for lead was developed based on the SMS SQS and CSL values, although potential risks to human health would be evaluated if lead concentrations appeared to be elevated above natural background concentrations because lead is considered a potential persistent bioaccumulative toxin. The SQS are the most stringent SMS numeric criteria and represent the goal for sediment cleanups. The SQS and CSL for lead are listed in Table 8.

SQS and CSL values are not available for other sediment COPCs (i.e., TPH-D and TPH-G). For TPH-D and TPH-G, concentrations protective of benthic organisms were to be evaluated using toxicity tests (bioassays) if TPH-G, TPH-D, or TPH-O were detected at concentrations that indicated a release from the Site may have occurred.

Site SLs for VOCs in soil vapor were not developed in the RI Work Plan. Instead, SLs are developed herein for all VOCs detected in Site soil vapor samples. Table 9 presents soil vapor SLs for constituents detected in soil vapor. The soil vapor SLs identified in the table were calculated based the

MTCA Method C indoor air cleanup levels and a vapor attenuation factor of 0.03, based on recent guidance and direction from the EPA (2012) and Ecology (2009). Although SLs for other media at the Site were based on Method B cleanup levels, the SLs for soil vapor are based on establishing a soil vapor concentration protective of the vapor intrusion pathway to indoor air in an industrial setting. Method B indoor cleanup levels are also provided in the table for comparison purposes.

6.3 CONSTITUENTS OF POTENTIAL CONCERN

An evaluation of the prior investigation results was conducted in the RI Work Plan to identify a list of COPCs for soil and groundwater. Existing sediment quality data do not indicate the presence of any COPCs related to Site releases. In accordance with WAC 173-340-350, some additional constituents were selected to be included as COPCs based on historical operations and the confirmed presence of TPH-G in the subsurface. Dissolved manganese was added based on detection above the SL while evaluating natural attenuation. The following list summarizes COPCs by media type:

Groundwater:

- TPH: TPH-G, TPH-D, and TPH-O
- Metals: Lead (total, dissolved) and manganese (dissolved)
- VOCs: BTEX, EDB, EDC, MTBE
- PAHs: Naphthalenes

Soil:

- TPH: TPH-G, TPH-D, and TPH-O
- Metals: Lead
- VOCs: BTEX, EDB, EDC, MTBE
- PAHs: Naphthalenes

Sediment:

- TPH: TPH-G, TPH-D, and TPH-O
- Metals: Lead

Surface Water:

- TPH: TPH-G, TPH-D, and TPH-O
- Metals: Lead (total, dissolved)
- VOCs: BTEX, EDB, EDC, MTBE
- PAHs: Naphthalenes

Air:

- VOCs: BTEX, EDB, EDC, MTBE.

7.0 NATURE AND EXTENT OF CONTAMINATION

This section describes existing Site environmental conditions including soil, soil vapor, groundwater, marine sediment, and surface water quality. The nature and extent of contamination resulting from releases of petroleum hydrocarbons were characterized during historical investigations from 1990 through 2008, and more recently through the RI, which was conducted in 2012 and 2013. All RI data were evaluated for quality prior to use in accordance with the procedures identified in the RI Work Plan (Landau Associates 2012a). Laboratory analytical data for all media are summarized in Tables 10 through 15.

COPCs identified in various media include petroleum hydrocarbons in the gasoline and diesel ranges, VOCs, and naphthalenes. Figures 11 and 12 graphically illustrate where soil contamination was encountered on the geologic cross sections presented in Section 5.2. The alignments of cross sections A-A' and B-B' are shown on Figure 4. The vertical extent of contamination shown on those figures is based on laboratory analytical data and the results of field screening while advancing the borings. As illustrated on the cross sections, contamination extends to depth within the clay unit in the source area, but is limited to the saturated zone and primarily associated with the coarser-grained deposits outside of the source area.

Figures 13, 14, and 15 indicate the locations and depth intervals where COPCs [TPH, VOCs (benzene, ethylbenzene, xylenes, and EDB), and naphthalenes, respectively] were detected in soil at concentrations greater than the SLs. Figure 13, which shows the TPH exceedances in soil, indicates where LNAPL or LNAPL sheen was observed during the RI. Figure 16 provides a cumulative summary of Figures 13, 14, and 15, and indicates the locations and depth intervals of contamination for each of the COPCs. The boundary of the Site is presented on Figure 16 for reference. The Site boundary was established based on all RI results including groundwater quality. Figure 17 shows the soil vapor sampling locations and indicates where VOCs were detected. Figure 18 provides the groundwater quality results, Figure 19 shows the monitored natural attenuation (MNA) parameters, and Figure 20 provides the sediment and surface water quality data.

In general, the data indicate that the petroleum hydrocarbon contamination present at the Site originated near the ASTs and the supporting infrastructure (secondary containment system, filling valves, transfer piping, etc.). Concentrations of all COPCs are elevated in the vicinity of the ASTs and are found at decreasing concentrations away from this source area. The source area appears to coincide with the unpaved gravel area and associated groundwater mounding near the ASTs. The groundwater mounding in this area is consistent with the distribution of soil and groundwater contamination beyond the source area resulting from migration with groundwater. The lateral extent of soil and groundwater with

concentrations of COPCs greater than SLs appears to range in distance from about 50 to 100 ft from the source area.

The depth intervals where COPCs were detected at concentrations greater than SLs range from near the ground surface to approximately 15 ft BGS in the source area, from 7 to 17 ft BGS in the area west of the source area along Sigurdson Avenue, and approximately 9 to 15 ft BGS in the area east of the source area. This vertical distribution is consistent with contaminant migration away from the source along the water table.

7.1 SOIL QUALITY

Soil quality data developed during the RI are compared to the SLs developed in the RI Work Plan and summarized in Section 6.0. A total of 66 soil samples were analyzed from 32 soil boring or monitoring well locations. Soil quality analytical results are summarized in Table 10.

Exceedances of SLs for one or more COPCs were found in 33 soil samples from 17 locations. In general, COPCs are present at concentrations that exceed the SLs in soil near the ASTs from a very shallow depth (1 ft BGS) to a maximum depth of approximately 15 ft BGS, although the depth of contamination generally does not extend deeper than about 9 to 12 ft BGS. Moving outward in each direction from the ASTs, unimpacted soil overlies the interval of contaminated soil, which is consistent with contaminant migration along the water table surface outside of the source area. The following sections provide additional details regarding the TPH, VOC, and naphthalenes found in soil at the Site.

7.1.1 TOTAL PETROLEUM HYDROCARBONS

The extent of TPH contamination was delineated using field-screening and laboratory analytical results. Exceedances of the SLs observed in analytical data from direct-push borings correlate well with field observations for sheen, LNAPL, or PID readings that indicated the presence of petroleum hydrocarbon contamination. The field-screening results were used to locate borings, delineate the lateral extent of contamination, and determine where to collect samples with the highest potential for contamination within borings for laboratory analyses. It is apparent from review of the analytical data that both TPH-G and TPH-D have been released at the Site. The lateral extent of TPH-G is more extensive than TPH-D, and TPH-D exceedances were detected only at locations where TPH-G exceedances were also detected.

Figure 13 shows TPH analytical results in soil. Concentrations of TPH-G exceeding the SL were detected in 24 soil samples from 15 sample locations, whereas TPH-D exceedances occurred in only six samples at three locations (BMI-GP-5, BMI-GP-17, and BMI-GP-20). The vertical extent of TPH-G detections greater than the SL is also deeper than for TPH-D. The maximum concentrations of both

TPH-D (6,200 mg/kg) and TPH-G (17,000 mg/kg) occur in the same location (GP-17 from 2 to 3 ft BGS). The area with the highest concentrations of both TPH-D and TPH-G is located to the immediate west of the secondary fuel containment dike, extending south from BMI-GP-17 to BMI-GP-14, BMI-GP-15, and BMI-GP-20. SL exceedances at these locations occur in the shallow subsurface (1 to 2 ft BGS) and extend to depths of approximately 9.5 ft BGS. TPH soil contamination generally extends to 9 to 12 ft BGS, but extends down to 15 ft BGS at two locations (BMI-GP-20 and MW-7).

Additional TPH-G exceedances were detected at most sample locations near the shoreline to the west of the ASTs, between BMI-GP-9 and B-3-12. The depth of contamination near the bulkhead was generally between approximately 7.5 and 10 ft BGS. TPH exceedances were detected in soil to the east of the ASTs extending from BMI-GP-5 to the north and as far south as MW-9, but concentrations were lower than at locations with exceedances west of the ASTs. In addition to generally lower contaminant concentrations east of the ASTs, the lateral extent of contamination is more limited than to the west.

7.1.2 VOLATILE ORGANIC COMPOUNDS

Soil samples were analyzed for the VOCs commonly associated with gasoline fuel releases, including BTEX, EDB, EDC, and MTBE. Of these VOCs, there were only two exceedances of the SL for EDB, and no exceedances for EDC or MTBE, indicating these fuel additives were not substantially present in fuel released at the Site. Other VOC detections at concentrations greater than the SLs were limited to BTEX compounds, and were generally limited to within the area where TPH-G exceedances are also found at concentrations greater than the SL.

The concentrations of VOCs were greater than SLs in 17 samples from eight sample locations (B-1, B-2, B-3, BMI-GP-8, BMI-GP-14, BMI-GP-15, BMI-GP-17, and BMI-GP-20). All VOC exceedances occurred at sample locations also showing TPH-G exceedances with the exception of BMI-GP-8. The discrete depths of all but one VOC exceedance coincided with depths of TPH-G exceedances. Field observations of obvious contamination also coincided with VOC exceedances, with the exception of BMI-GP-8, which had no visual or olfactory indications of contamination. The locations and depth intervals of VOC exceedances in soil are shown on Figure 14.

The number and extent of VOC exceedances of SLs in soil are more limited than that of TPH-G. Detected VOC concentrations were highest in samples from geotechnical borings B-2-12 and B-3-12 with values as high as 120,000 micrograms per kilogram ($\mu\text{g}/\text{kg}$) for ethylbenzene and EDB. VOC detections in soil at nearby sampling locations MW-6, MW-7, and BMI-GP-13 were below SLs, indicating that VOC concentrations are lower along the bulkhead. One VOC exceedance was noted in a sample collected to the east of the ASTs at BMI-GP-8 where a comparatively low benzene concentration (10 $\mu\text{g}/\text{kg}$) was detected.

As observed with TPH-G, the VOC detections greater than SLs mostly occur to the west of the ASTs and the eastern extent of VOC contamination is more limited. Additionally, the depths of VOC exceedances were similar to those of TPH exceedances, with depths of 2 to 15 ft BGS in the vicinity of the ASTs (and associated equipment), depths of 7.5 to 9 ft BGS in the area along the bulkhead, and depths of 10 to 12 ft BGS at BMI-GP-8 to the southeast of the tanks. The similarities in the distribution of TPH and VOC contamination is consistent with the VOCs being a component of gasoline release(s) and not separate release(s) of VOCs.

7.1.3 NAPHTHALENES

Soil samples were analyzed for naphthalenes, which can be associated with TPH contamination. The term “total naphthalenes” refers to the sum of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene. The SL for total naphthalenes is 2,300 µg/kg for unsaturated soil (above the groundwater table) and 120 µg/kg for saturated soil (below the groundwater table). The locations and depths of total naphthalene exceedances in soil are shown on Figure 15. Total naphthalenes were detected at concentrations greater than the soil SL in 27 samples from 13 locations. All total naphthalene exceedances occurred at sample locations with TPH exceedances, with the exception of BMI-GP-8 and MW-6.

The discrete depths of all but five total naphthalene exceedances also coincided with depths of TPH exceedances; these five exceptions were observed in deeper soil samples (at depths of 13.5 to 17 ft BGS), as shown on Figure 14. At the locations where total naphthalenes were detected at concentrations greater than the SLs at the maximum boring depth, the concentrations are significantly lower than detections at shallower depths. These deeper exceedances largely result from the very low SL for total naphthalenes under saturated conditions (120 µg/kg), which is evidenced by the lack of exceedances of SLs for other COPCs and the lack of any visual or olfactory evidence of contamination in these samples. The vertical extent of contamination in these areas was estimated based on trending concentrations and detections of naphthalenes at nearby borings where concentrations are less than SLs at the maximum boring depth.

7.1.4 LEAD

Lead was not detected at concentrations greater than the soil SL in any of the 33 samples collected from 25 locations. The maximum lead detection during the RI was 12 mg/kg, far below the SL of 250 mg/kg for unsaturated soil or 81 mg/kg for saturated soil.

7.1.5 SOIL SUMMARY

Based on the soil data collected during the RI, it is apparent that soil impacts from Site activities originate from a release (or releases) associated with the ASTs or ancillary equipment. The lateral extent of COPCs exceeding the SLs is limited to the north (BMI-GP-22, BMI-GP-19, BMI-GP-18, and BMI-GP-21), to the east (MW-10 and BMI-GP-16), to the west by the bulkhead, and to the south (BMI-GP-2, BMI-GP-3, BMI-GP-4, and MW-8).

The vertical extent of soil contamination encountered during the investigation is consistent with the conceptual Site model discussed in the RI Work Plan, which indicates that TPH (and related COPCs) contamination originated near the ASTs or ancillary equipment, migrated down to the water table, and then migrated laterally along the groundwater table or less permeable layers of soil, such as clay. Observable soil contamination (soil exhibiting visual and/or olfactory evidence of contamination) is largely limited to the upper 12 ft of soil, although trace-level contamination, primarily naphthalene, was encountered to maximum depths of 17 ft BGS. Although the deepest samples in some borings exceed the SL for naphthalenes, the concentrations decrease rapidly compared to the overlying soil, and the maximum depth of exceedance can be estimated based on the decrease in concentrations, and samples from nearby borings. For example, based on data from the borings nearest the ASTs (BMI-GP-14, -15, -17, and -20), the average concentration of contamination, based on the sum of all COPCs, is approximately 3,900 mg/kg in the depth interval of 9 to 12 ft BGS, and drops to 240 mg/kg below 12 ft BGS. This is a decrease in concentration of approximately 94 percent and supports the conclusion, based on data from other nearby borings, that the depth of contamination is adequately delineated to develop and evaluate cleanup alternatives for the Site.

7.2 SOIL VAPOR QUALITY

Four soil vapor samples were collected at the Site as described in Section 4.3. The analytical results are provided in Table 13 and shown on Figure 17. As indicated in the table, trace concentrations of a number of VOCs were detected in soil vapor. Only 1,3-butadiene was detected at concentrations that exceed its soil vapor SL [28 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$)]. Related to TPH-G, 1,3-butadiene was detected at three of four soil vapor sampling locations. The detected concentrations ranged from 44 to 73 $\mu\text{g}/\text{m}^3$; 1,3-butadiene was not detected in the sub-slab soil vapor sample (or the associated duplicate sample). Benzene was detected in soil vapor at concentrations ranging from 17 to 35 $\mu\text{g}/\text{m}^3$, which are below the soil vapor SL of 110 $\mu\text{g}/\text{m}^3$.

The soil vapor SL exceedances fall within the Site boundary and coincide with soil exceedances discussed in the above section and shown on Figure 17. Based on the analytical results, it is likely that

soil vapor contamination is present where petroleum hydrocarbons in soil are above SLs at the Site but does not currently pose an unacceptable risk to workers in the Blaine Marina Inc. building.

7.3 GROUNDWATER QUALITY

Groundwater quality was evaluated based on analyzing samples collected from 12 temporary direct-push locations (BMI-GP-4, BMI-GP-5, BMI-GP-8, BMI-GP-9, BMI-GP-10, BMI-GP-11, BMI-GP-12, BMI-GP-16, BMI-GP-18, BMI-GP-19, BMI-GP-21, and BMI-GP-22) and the 8 monitoring wells installed during the RI activities (MW-4, MW-5, MW-6, MW-7, MW-8, MW-9, MW-10, and MW-11). Samples were analyzed for the COPCs discussed in the RI Work Plan and summarized in Section 6.3. Groundwater analytical results are provided in Table 11. Figure 18 shows the groundwater grab sample locations and groundwater monitoring well locations, and indicates where one or more COPCs were detected at concentrations greater than groundwater SLs during the RI.

Groundwater samples were not collected from existing monitoring wells (MW-1, MW-2, and MW-3) due to the presence of LNAPL during the sampling events, in accordance with the RI Work Plan.

7.3.1 GROUNDWATER SCREENING LEVEL EXCEEDANCES

Characterization of groundwater quality at the Site was conducted by analytical testing and was based on the observations of LNAPL in the source area near the ASTs. Where LNAPL free product was observed on the groundwater table, it was assumed that groundwater was contaminated by COPCs at concentrations greater than the SLs. Groundwater sample locations were selected based on a determination of the extent of groundwater impacts farther away from the source area. It was therefore assumed that groundwater in the vicinity of monitoring wells MW-1, MW-2, MW-3, and the pilot LNAPL recovery well RW-1 have concentrations of COPCs greater than SLs based on the presence of LNAPL. In general, concentrations of COPCs are highest in the area of the ASTs and heading west from that area toward monitoring wells MW-6 and MW-7.

The detected concentrations of COPCs were less than groundwater SLs at most sampling locations. Concentrations were greater than the SLs at 5 of the 20 monitoring locations. The following bullets summarize the groundwater results and indicate which COPCs were detected at concentrations above the SLs. For locations where a COPC was detected on multiple occasions, the maximum detection is shown.

- **TPH-D** (SL = 0.5 mg/L):
 - Concentrations in groundwater grab samples from BMI-GP-5 (5.3 mg/L) and BMI-GP-9 (34 mg/L) exceed the groundwater SL.
 - Concentrations at 18 other groundwater sample locations are less than the SL.

- **TPH-G** [SL = 0.8 or 1.0 microgram per liter ($\mu\text{g/L}$), depending on the presence of benzene]:
 - Concentrations in groundwater at BMI-GP-9 (1.2 $\mu\text{g/L}$), MW-6 (1.3 $\mu\text{g/L}$), and MW-7 (11 $\mu\text{g/L}$) exceed the SL.
 - Concentrations at 17 other groundwater sample locations are less than the SL.
- **VOCs** (Multiple SLs, depending on compound):
 - The concentration of benzene at one location, MW-7 (4.6 $\mu\text{g/L}$) exceeds the groundwater SL of 0.8 $\mu\text{g/L}$.
 - The concentrations of VOCs detected at MW-6 are less than groundwater SLs.
 - Concentrations of other VOCs in groundwater at the Site are generally orders of magnitude less than the SLs.
- **Total Naphthalenes** (SL = 83 $\mu\text{g/L}$):
 - The concentration of total naphthalenes in groundwater at one location, MW-7 (136 $\mu\text{g/L}$) is greater than the SL.
 - The concentrations of total naphthalenes at all other groundwater monitoring locations are less than the SL.
- **Total and Dissolved Lead** (SL = 8.1 $\mu\text{g/L}$):
 - Total lead in groundwater was detected at BMI-GP-22 at 19 $\mu\text{g/L}$. However, the dissolved lead concentration is less than the laboratory reporting limit of 1 $\mu\text{g/L}$, indicating that the elevated total lead concentration is related to sample turbidity (sample was a groundwater grab sample collected from an open Geoprobe boring).
 - Concentrations of total and dissolved lead are less than the SL at the remaining 19 sample locations.
- **Dissolved Manganese** (SL = 0.1 mg/L):
 - Concentrations in groundwater are less than the SL at all sampled locations except MW-2, where it was detected at a concentration of 0.537 mg/L.

The most significant impacts to groundwater quality were observed near the ASTs (where LNAPL was observed), and in wells and direct-push borings near the marine bulkhead. Lower concentrations of COPCs were detected north and east of the source area near the ASTs. All exceedances of groundwater SLs (discounting total lead at BMI-GP-22) are associated with locations where soil SLs were also exceeded for one or more contaminants, and thus the extent of groundwater contamination is similar to that discussed for soil COPCs. This indicates that groundwater contamination has primarily migrated outward from the source area in a west to southwest direction, consistent with the direction of groundwater flow.

7.3.2 OCCURRENCE OF LIGHT NON-AQUEOUS PHASE LIQUID

The presence of free-phase LNAPL on the groundwater surface was observed in the three existing monitoring wells (MW-1, MW-2, and MW-3) and recovery well RW-1. This finding indicates that an

area of free-phase LNAPL exists between MW-1 near the northwest corner of the Blaine Marina furniture building and MW-3 to the northwest of the ASTs. The maximum apparent LNAPL thickness at MW-3 (3.13 ft) was significantly less at MW-2 (0.59 ft) and MW-1 (0.46 ft), indicating that the thickness decreases toward the southwest from MW-3. LNAPL thickness was less than anticipated at RW-1 (0.35 ft), which is located nearest to MW-3, likely as a result of the localized clay layer in this area impacting the migration and accumulation of LNAPL. LNAPL product thicknesses measured during measurement of groundwater elevations are shown in Table 5. It should also be noted that the product thickness that accumulates over time in a monitoring well is typically greater than the actual product thickness on the water table, so these product thickness values likely overestimate product thickness.

LNAPL sheen was also observed in soil samples collected from several locations across the Site. Observations for LNAPL were aided by the use of hydrophobic dye. LNAPL sheen was observed on soil samples collected at BMI-GP-5, BMI-GP-7, BMI-GP-9, MW-7, BMI-GP-14, BMI-GP-15, and BMI-GP-20, as indicated on Figure 13.

7.3.3 MONITORED NATURAL ATTENUATION PARAMETERS

Additional groundwater samples were collected from four locations in October 2013 to evaluate the extent to which natural attenuation was occurring at the Site. Natural attenuation of petroleum hydrocarbons occurs primarily through biological processes, during which available electron acceptors are chemically reduced in the order of greatest energy yield (oxygen, nitrate, manganese, iron, and sulfate) during the consumption of the hydrocarbon (electron donor). Sequential consumption of electron acceptors during natural attenuation of hydrocarbons results in increasingly reducing aquifer conditions reflected by a negative oxidation reduction potential (ORP).

To assess the potential for natural attenuation across the Site, groundwater samples were collected from areas generally upgradient of the source area (MW-4, which is more accurately crossgradient of the source area, but due to groundwater mounding in the source area collecting a sample from a true upgradient location was not feasible), within the source area (MW-2), two locations in the plume area (MW-6 and MW-7), and downgradient of the plume (MW-11). Samples were tested for MNA parameters measured in the field (dissolved oxygen, ORP, and ferrous iron), and by the laboratory (dissolved manganese, nitrate, and sulfate). The field and laboratory analytical results for MNA parameters are summarized in Table 12, which also includes MNA parameters from other wells collected during the RI.

The results suggest that aquifer conditions are nitrate to iron-reducing across the Site, as indicated by low to depleted dissolved oxygen (<0.49 mg/L) and nitrate (<1.2 mg/L) concentrations at all sampled locations, as well as the presence of low to moderate concentrations of ferrous iron (0.2 to 1.4 mg/L) and

moderate to very negative ORP values (−169.2 to −588.3 millivolts). Elevated dissolved manganese concentrations indicate that conditions are most reducing at MW-2 (537 mg/L) and the aquifer becomes less reducing with distance downgradient, as indicated by results from MW-11 to the southwest (12 mg/L) and IW-4 (87 mg/L) to the north. However, sulfate concentrations may not be a useful indicator of sulfate reduction at wells MW-11 (1,900 mg/L) and MW-6 (389 mg/L) along the marine bulkhead where values are likely influenced by infiltration of sulfate-rich marine water. Additionally, sulfate concentrations at MW-7 (120 mg/L), MW-2 (126 mg/L), and MW-4 (<0.1 mg/L) were not consistent with the expectation of more highly reducing conditions (i.e., lower sulfate concentrations) near the source area. ORP values vary across all wells sampled for groundwater and do not show a clear correlation to other redox parameters or the presence of contaminants. Matrix interferences are understood to affect the accurate measurement of ORP and, as a result, ORP results are not used solely to assess reducing or oxidizing conditions, but are considered in conjunction with other MNA parameters.

The overall results of the natural attenuation monitoring indicate that natural attenuation is occurring at the Site, including in downgradient locations. Aquifer conditions are more reducing in the vicinity of the source area, which suggests that natural attenuation is occurring through anaerobic biological processes. Selected MNA parameters are shown on Figure 19, providing an overview of the observed MNA conditions upgradient, within the source area, in the plume area, and downgradient of the plume on October 9, 2013.

7.3.4 LIGHT NON-AQUEOUS PHASE LIQUID TRANSMISSIVITY

In order to comply with the MTCA requirement to perform source control and remove LNAPL product to the maximum extent practicable, a recoverability evaluation (baildown test) was conducted to determine if it is practicable to recover LNAPL from the Site subsurface, as discussed in Section 4.4. LNAPL transmissivity is a Site-specific parameter that can be used to evaluate the recoverability of LNAPL. The value of LNAPL transmissivity describes the degree of lateral mobility of LNAPL on the groundwater table at the Site, and correlates to LNAPL recoverability based on the impact of availability on mobility.

The Bouwer and Rice (B&R) method (Bouwer 1989) was identified in the RI Work Plan Addendum (Landau Associates 2013b) as the preferred approach to estimating transmissivity using the baildown test data based on the method's simplicity. The B&R method is commonly used to evaluate aquifer transmissivity for slug test evaluations. However, the American Petroleum Institute (API) spreadsheet calculator used in this evaluation estimates LNAPL transmissivity using the Cooper and Jacob (C&J) method, which includes a parameter related to storage capacity in the well filter pack, which is not considered in the B&R method. API indicates this inclusion results in a more accurate estimate of

LNAPL transmissivity (API 2012) and, as a result, the C&J method was used for this evaluation (Cooper and Jacob 1946).

As discussed in Section 4.4, during the baildown test, LNAPL is quickly removed from a well casing and changes in the observed depth to water and depth to LNAPL in the well are recorded as the system returns to the static condition. The elapsed time, depth to LNAPL, depth to water, and other parameters measured during the drawdown test are used as input to the API spreadsheet model. The model uses the rate of recovery and the relationships between the groundwater recharge and LNAPL recharge into the well to estimate an effective well radius and, ultimately, LNAPL transmissivity.

The baildown test data collected on April 23 and August 20, 2013 are shown on Figures C-1 and C-2 in Appendix C, as input to the API spreadsheet models. The observed LNAPL thickness during the recovery portion of the test is plotted over time for the two events in Figures C-3 and C-4. The following paragraphs summarize how the LNAPL transmissivity was estimated by the C&J method using these field-collected data as input. The C&J model evaluates data using the following equation:

$$V_n(t_i) = \sum_j^i \frac{4\pi T_n s_j}{\ln\left(\frac{2.25T_n t_j}{r_e^2 S_n}\right)} \Delta t_j$$

Where:

V_n = Volume inflow to the well

T_n = LNAPL transmissivity

t_j = Elapsed time to measurement j

s_j = Drawdown (difference in depth to LNAPL from time zero to t_j)

S_n = Storage parameter

r_e = Effective well radius (estimated within the spreadsheet tool using baildown test data)

t = Time.

The analysis using the C&J method produced transmissivity values of 1.34 and 1.19 ft²/day. The relative percent difference between these calculated values is 11.2 percent, indicating a consistent reproducibility between events. According to the Interstate Technology & Regulatory Council, LNAPL hydraulic recovery systems are reported to effectively reduce LNAPL transmissivity down to 0.8 ft²/day (ITRC 2009). As such, LNAPL transmissivity values greater than 0.8 ft²/day are indicative of conditions where LNAPL recovery is feasible. As such, it appears feasible that hydraulic recovery methods could be used to remove LNAPL from the Site at monitoring well MW-3 based on the results from the C&J method.

Monitoring well MW-3 was the only Site monitoring well where sufficient LNAPL accumulated to conduct a baildown test, so it does not appear feasible to recover LNAPL at other nearby locations,

including the pilot LNAPL recovery well RW-1. This is likely due to the presence of the clay layer observed in the AST area, which appears to limit recoverability (transmissivity) at other locations. It was not practicable to install wells within the AST secondary containment area, so it is possible that recoverable LNAPL is present in this area, depending on the nature of the underlying fill materials.

7.4 SEDIMENT QUALITY

Marine sediment quality in Blaine Harbor near the upland portion of the Site was evaluated based on the analytical results of three sediment samples collected as part of the RI. The marine sediment quality data, in conjunction with the marine sediment SLs, are provided in Table 14 and sediment collection locations are shown on Figure 20. Analytical results of the sediment investigation are summarized as follows:

- Gasoline-range organics or volatile petroleum hydrocarbon fractions were not detected in the samples.
- Diesel-range organics, lube oil-range organics, and some extractable petroleum hydrocarbon fractions were detected in each of the samples at low concentrations ranging from 30 mg/kg to 76 mg/kg for diesel, 42 mg/kg to 77 mg/kg for lube oil, and 5 mg/kg to an estimated 58 mg/kg.
- Naphthalene was detected in sample BMI-SS-3 and the duplicate sample of BMI-SS-3. The naphthalene concentrations detected (0.081 mg/kg and 0.073 mg/kg, respectively) were slightly greater than the reporting limit of 0.062 mg/kg.

The TPH concentrations detected in the three surface sediment samples were quite low and not indicative of a point source release. The consistency in concentrations between the samples regardless of location relative to the shoreline and the Site upland source area is not indicative of an upland source emanating from the Site. Additionally, the constituents detected in surface sediment are not consistent with the Site upland source. Specifically, TPH-O was detected in sediment at concentrations similar to TPH-D, and neither naphthalenes nor TPH-G were detected, even though these are the primary COPCs detected in the uplands. Based on these results, the Port, in coordination with Ecology, determined that the sediment near the Site did not appear to be impacted from Site releases.

7.5 SURFACE WATER QUALITY

As discussed in Section 4.6, a marine surface water quality sample was collected as part of the RI. One sample was collected from near sample location BMI-SS-2 (Figure 20) and the analytical results are provided in Table 15. No Site COPCs were detected in the surface water sample. The absence of Site COPCs in the surface water supports the conclusion that surface water is not impacted by Site releases. This finding is consistent with the results of the marine sediment evaluation.

8.0 CONTAMINANT FATE AND TRANSPORT

This section addresses contaminant fate and transport processes, including source control, transport, and natural attenuation. The discussion in this section is focused on general fate and transport processes associated with affected media.

8.1 SOURCE CONTROL

Limited source control measures have been implemented to address releases from Site operations that resulted in contamination of affected media. Source control measures included the repair of leaking fuel pipe connections in 1986 (Section 2.1.2), LNAPL removal from monitoring wells from 1997 to 2011 (Section 2.3), and the bulkhead and sheetpile wall installation conducted during the Interim Action (Section 3.0). Because the secondary containment for the AST tanks does not have an impermeable base, the potential remains for releases to occur due to leakage or spills in the AST area.

8.2 TRANSPORT AND ATTENUATION PROCESSES

Attenuation and transport processes are generally media- and contaminant-specific. Exceedances of screening criteria for soil and groundwater contaminants include TPH-D, TPH-G, VOCs, naphthalenes, and dissolved manganese. Attenuation and transport processes associated with these contaminants are discussed for each affected medium in the following section.

8.2.1 SOIL

The transport of petroleum hydrocarbon contamination in soil can occur through multiple mechanisms and multiple phases. The most direct transport mechanism is the migration of LNAPL downward through the unsaturated zone until the groundwater table is intersected. Because petroleum hydrocarbon LNAPL is primarily lighter than water, the LNAPL that reaches groundwater tends to migrate on top of the water table surface in the downgradient direction until the driving force for migration is eliminated. During its downward migration, layers of relatively fine-grained soils may affect the transport pathway and distribution. Once in the subsurface, petroleum hydrocarbon LNAPL often releases dissolved-phase contamination to groundwater either through direct contact with groundwater or as the result of stormwater infiltration through the affected soil. LNAPL can be present in residual interstitial spaces in the soil and can release contaminants to soil vapor. The transport of TPH from soil to soil vapor and groundwater can continue for many years if the LNAPL source material is not removed, though petroleum hydrocarbon contamination in soil generally attenuates rapidly with distance from the source.

There were 48 occurrences of clay observations in the borings having a thickness greater than 1 ft. Sheen or NAPL occurrence was observed in 6 of the 48 locations with clay present with a thickness greater than 1 ft. Five of 6 these occurrences were either within the source area, or immediately adjacent to more hydraulically-conductive materials (i.e., adjacent to sand or decaying organics). Additionally, 23 soil samples were analyzed that were described in the field as clay. Of these 23 samples, only the sample from GP-13 had concentrations of COPCs above the SLs in a location outside of the immediate vicinity of the ASTs and was not identified as having sheen or NAPL. Based on observations for sheen or NAPL, and the distribution of COPCs determined using laboratory analysis, most clay soil observed at the Site outside the source area has not been penetrated deeply by Site releases.

8.2.2 GROUNDWATER

As discussed in Section 5.3, groundwater mounding in the source area results in groundwater flowing outward from that area. It is apparent that groundwater migrating outward from the source area transports both LNAPL and dissolved-phase petroleum hydrocarbons downgradient from the source area. The transport of petroleum hydrocarbon contamination in groundwater is affected by various processes, including the amount of LNAPL released, and absorption, dispersion, and biological decomposition of dissolved-phase groundwater contamination. The biological attenuation factors are most effective in an aerobic (oxygen-rich) environment, which is present only beyond the limits of LNAPL.

The attenuation of groundwater COPCs at the Site appears to effectively reduce contaminant concentrations to less than SLs within approximately 50 to 100 ft of the area over which LNAPL is present as free-phase product. The attenuation of COPCs in the bulkhead area may be heavily influenced by hydrodynamic dispersion in a tidally influenced groundwater. Hydrodynamic dispersion in groundwater subjected to tidal fluctuations is greatly increased due to the mixing of surface water and groundwater in the vicinity of the shoreline. In addition to direct mixing of groundwater and surface water, the fluctuation in groundwater elevation causes “tidal pumping” of soil vapor in the unsaturated zone. Tidal pumping results in greater air/soil vapor exchange and a more oxygen-rich subsurface environment, which in turn supports greater aerobic decomposition of petroleum hydrocarbons. These enhanced aerobic conditions are evidenced by the natural attenuation data collected from the Site and discussed in Section 7.3.3.

Dissolved manganese concentrations were observed to be greater than the SL within the source area, where reducing conditions are prevalent, but less than the SL in all other sampled locations. Manganese was not released at the Site, but is naturally occurring in the soil and dissolves into groundwater under reducing conditions. As a result, when dissolved manganese is transported away from areas where natural attenuation is occurring, it will precipitate and return to the soil matrix as a solid.

Groundwater discharges to surface water at the Site, with the western side of the Site appearing to be the only area where contaminated groundwater may be discharging to surface water. As previously discussed, the recently installed steel sheetpile bulkhead significantly impedes groundwater flow and appears to redirect most groundwater discharge around the ends of the bulkhead. The lack of groundwater contamination in either boring BMI-GP-12 or monitoring well MW-11, located within 5 and 10 ft of the south end of the bulkhead, respectively, supports the conclusion that significant groundwater contamination is not being discharged to surface water from the Site.

9.0 DISCUSSION OF CLEANUP STANDARDS

This section identifies regulatory cleanup requirements through the development of Site-specific preliminary cleanup levels (PCLs) based on the results of the RI and consideration of potentially applicable laws and regulations. PCLs are refined from the SLs for soil, groundwater, sediment, and soil vapor COPCs provided in Tables 6 through 9. Based on the frequency of detection and exceedance of SLs, this section revises the list of COPCs and media of potential concern, develops a list of indicator hazardous substances (IHS), and proposes PCLs for Site soil and groundwater. Final Site cleanup levels will be established by Ecology in the Cleanup Action Plan following completion of the RI/FS process.

9.1 FREQUENCY OF DETECTION AND SCREENING LEVEL EXCEEDANCES

This section presents a summary of the frequency of detection for Site COPCs and a discussion of COPCs that were detected at concentrations greater than the SLs. Tables 16 and 17 present summary statistics used in this evaluation. The tables show the number of samples collected, the number of detections, minimum and maximum detections, and reporting limits. The summary statistics provided in the tables includes Site data collected during historical investigations and the RI beginning in 2012. COPCs that were not detected at concentrations greater than SLs for a given medium, or do not have a frequency of detection greater than 5 percent will not be carried forward as IHS.

As discussed in Section 7, COPCs were not found to exceed SLs in sediment or surface water at the Site. As a result, these will not be carried forward as media of concern. Soil vapor samples were collected at four locations and analyzed for 75 VOCs. Only one VOC was detected at a concentration greater than its SL (1,3-butadiene). Based on the low frequency of VOC exceedances in soil vapor, and because the groundwater PCLs were developed to protect the soil vapor pathway, VOCs in soil vapor are not carried forward as IHS.

9.1.1 INDICATOR HAZARDOUS SUBSTANCES – SOIL

The following list summarizes soil COPCs that were detected with a frequency of greater than 5 percent, or with at least one detection greater than SLs in samples collected during previous investigations or the RI:

- TPH-D
- TPH-G
- VOCs:
 - Benzene

- Ethylbenzene
- Xylenes
- Total naphthalenes.

TPH-O, MTBE, EDB, EDC, toluene, and lead were not carried forward as IHS. None of these compounds were detected at concentrations greater than the SLs. MTBE, EDB, and EDC were also not detected at a frequency greater than 5 percent.

9.1.2 INDICATOR HAZARDOUS SUBSTANCES – GROUNDWATER

The following list summarizes groundwater COPCs that were detected with a frequency of greater than 5 percent, or at concentrations greater than SLs during previous investigations or the RI:

- TPH-D
- TPH-G
- VOCs:
 - Benzene (only)
- Total naphthalenes.

TPH-O, ethylbenzene, xylenes, MTBE, EDB, EDC, toluene, lead, and dissolved manganese were not carried forward as IHS. None of these compounds were detected at concentrations greater than the SLs except a single detection of total lead in groundwater collected from the direct-push boring GP-22, and dissolved manganese at MW-2. As discussed in Section 7.3, dissolved lead was not detected in this sample, and the total lead exceedance was likely associated entrained particles in the sample. Dissolved manganese was analyzed for to evaluate whether natural attenuation is occurring. Ecology and the EPA view manganese as a secondary contaminant for aesthetic considerations, but it is not likely to present a risk to human health. Dissolved manganese is not carried forward as an IHS. MTBE, EDB, and EDC were not detected at a frequency greater than 5 percent. Total naphthalenes are carried forward as IHS although they were detected at a concentration greater than the SL in only one groundwater sampling location, MW-7.

9.2 PRELIMINARY CLEANUP LEVELS

Soil SLs were developed for the COPCs discussed in Section 6.1 to be protective of human health and groundwater in accordance with MTCA requirements. For each soil IHS, we propose to carry forward the SL as a PCL. Table 18 provides a summary of soil IHSs and the PCLs for both saturated and unsaturated conditions. Similarly, groundwater PCLs are based on the groundwater SLs for the groundwater COPCs that are identified as groundwater IHS for the Site, with one exception. The groundwater SL for benzene was based on protection of the vapor intrusion pathway, but as noted in

Section 7.2, benzene in soil vapor at the Site was below SLs. As a result, the SL for benzene in groundwater was adjusted to eliminate the vapor migration pathway. The three relevant human health SLs, as presented in Table 7 are:

- 23 µg/L (MTCA Method B surface water cleanup level)
- 71 µg/L [National Toxics Rule; applicable or relevant and appropriate requirement (ARAR)]
- 51 µg/L (Clean Water Act; ARAR).

Toxicity testing has shown that a benzene concentration of 80 µg/L in groundwater is protective of aquatic species (Verbruggen et al. 2008). Each of the three SLs is less than this value and is expected to be protective of aquatic species, so none of these SLs is rejected for this consideration. The MTCA Method B value and the two ARARs are each based on a 1×10^{-6} cancer risk, with the difference in value attributable to assumptions regarding the fish consumption rates in the calculation. Since both of the ARARs listed above are at or below (meaning more protective than) the 1×10^{-5} cancer risk based on the MTCA Method B calculated value, Ecology considers these values sufficiently protective under MTCA and in accordance with MTCA Focus Sheet 01-09-050, which states:

“For hazardous substances for which sufficiently protective, health-based concentrations have been established under applicable state and federal laws, the most stringent of those concentrations is used. A concentration established under applicable state and federal laws is sufficiently protective if the excess cancer risk does not exceed 1 in 100,000 (1×10^{-5}) and the hazard quotient does not exceed one (1).”

Since both of the ARARs listed above are sufficiently protective, the Method B value is not selected, and per WAC 173-340-730(3)(b), the most protective ARAR (51 µg/L) is proposed as the PCL for benzene in groundwater.

9.3 POINTS OF COMPLIANCE

The point(s) of compliance under MTCA are the point or points at a site where the cleanup levels must be attained to achieve cleanup standards for each environmental medium. The proposed point(s) of compliance will be considered in the development and evaluation of cleanup alternatives during the FS.

The proposed point of compliance for Site soil is throughout the Site. The proposed point of compliance for Site groundwater is also throughout the Site.

9.4 CONCEPTUAL SITE MODEL

Historical Site activities, environmental data, and the physical processes that control the fate and transport of contaminants were used to develop the conceptual Site model (CSM). The CSM describes the Site contaminant sources, fate and transport processes, migration pathways, and potential receptors.

The CSM includes elements that address releases associated with the former and current use of the Site for gasoline and diesel fuel storage and dispensing. Figure 21 illustrates the CSM for the Site.

Contamination associated with releases from activities related to the storage or dispensing of diesel and gasoline fuel has affected soil, groundwater, and soil vapor. LNAPL is present in the vicinity of the ASTs and remains an ongoing source of groundwater contamination. Contamination consists of TPH-D, TPH-G, and associated VOCs and naphthalenes. Free-phase LNAPL occurrence appears limited to the area near the ASTs, although residual LNAPL, characterized by sheen in soil samples, extends up to about 60 ft downgradient from the source area exhibiting free-phase LNAPL.

As shown on the CSM (Figure 21), LNAPL migrated downward and outward through the extensive clay deposits in the vicinity of the ASTs. Once the LNAPL reached groundwater, it migrated laterally through the sand deposits with only limited penetration into the less extensive clay lenses present outside of the source area. The LNAPL ceased migrating once the release(s) were sufficiently distributed to eliminate the driving force for ongoing migration. The extent of LNAPL is not expected to expand farther unless additional releases occur.

Groundwater contamination originating from free-phase LNAPL and soil containing residual LNAPL migrate with groundwater flowing outward from the source area near the ASTs due to groundwater mounding in that area. Based on the distribution of LNAPL and groundwater contamination, the predominant groundwater flow direction appears to be toward the shoreline to the west-southwest.

Natural attenuation appears to be occurring and concentrations of IHSs appear to be less than PCLs within about 50 to 100 ft of the source area near the ASTs. Biodegradation is likely enhanced in the shoreline vicinity by the frequent recharge of atmospheric oxygen to the unsaturated zone caused by “tidal pumping”; tidal pumping results from the displacement and replacement of soil vapor in the unsaturated zone through alternating high and low tides.

Due to the volatile nature of gasoline-range petroleum hydrocarbons and associated VOCs, contamination also likely migrates via the soil vapor pathway. Soil vapor generally migrates upward, but also moves laterally if it encounters a low permeability barrier to upward migration. Soil vapor ultimately discharges to the atmosphere.

Potential receptors for contamination originating from the former gasoline UST include construction workers that contact contaminated soil, groundwater, or soil vapor during intrusive activities, and aquatic organisms potentially affected by the discharge of contaminated groundwater to surface water. Contaminant concentrations in soil vapor below the Blaine Marina Furniture and Appliance retail building are less than SLs, indicating that the soil vapor does not pose an unacceptable exposure risk to current Site workers.

9.4.1 CURRENT AND ANTICIPATED SITE ACTIVITIES

The Site is currently occupied by Blaine Marina Inc., a company that operates a retail used furniture sales and repair outlet, and stores and dispenses diesel and gasoline fuel for boaters at Blaine Harbor. The Port is in the planning phase for redevelopment of the entire Blaine Harbor Industrial Area, including the Site. Redevelopment will be guided by the Port's 2007 Blaine Wharf District Master Plan (Development Plan; Port of Bellingham 2007), development regulations in the City of Blaine's Land Use Code (BMC 17.23), and Design Standards, BMC 17.121 for the Wharf District. The Development Plan is intended to provide for a variety of recreational, commercial, marine, industrial, and residential activities. The Site is located in Wharf District Planning Area 6, referred to in the Development Plan as the Shipyard Industrial Park. The Site area will be preserved for marine-related commercial and industrial use, serving primarily the commercial fishing, boat building, and boat-repair and marine service industry.

10.0 REMEDIAL INVESTIGATION CONCLUSIONS

In summary, data gaps that were identified prior to implementation of the RI have been filled and the Site has been characterized sufficiently to develop and evaluate cleanup alternatives for the Site. The nature and extent of contamination has been adequately delineated. Contamination at the Site appears to have been caused primarily by the release of gasoline fuel, and to a lesser extent, diesel fuel, in the vicinity of the ASTs. Contamination has spread outward from this area roughly 50 to 100 ft as indicated by the Site boundary shown on Figure 16 and subsequent figures of this report. Additional data may be needed to support design or implementation of the final cleanup action selected by Ecology. If necessary, those data would be collected during the remedial design phase following completion of the FS and selection of the final cleanup action in the cleanup action plan (CAP).

11.0 FEASIBILITY STUDY

The purpose of the FS is to develop and evaluate cleanup alternatives for addressing contamination at the Site. This evaluation and the selection of a preferred cleanup alternative were conducted in accordance with the procedures specified in Chapter 173-340 WAC, and is organized into the following sections:

- Section 11.1: Future land use considerations
- Section 11.2: Remedial action objectives (RAOs) and potentially applicable laws
- Section 11.3: Summary of remedial technologies considered for the FS
- Section 11.4: Description of the remedial alternatives
- Section 11.5: Description of the evaluation criteria
- Section 11.6: Evaluation of the remedial alternatives and disproportionate cost analysis (DCA)
- Section 12.0: Summary and conclusions; description of the preferred alternative.

11.1 FUTURE LAND USE CONSIDERATIONS

The Site is currently used for commercial and light-industrial purposes, including operation of the fueling facility. Current structures include two buildings used for furniture and appliance repair and retail, two small buildings used for marine industry storage, and several aboveground tanks and ancillary equipment used for the storage and dispensing of gasoline and diesel fuel at the nearby fueling dock. The Site will be redeveloped in the coming years to upgrade aging infrastructure and better support the marine industry. According to current land use planning (Makers et al. 2013), the Site is anticipated to be used after cleanup and redevelopment for expanded upland boatyard operations, including boat storage and repair. The existing fueling facility will be decommissioned and a new fueling facility will be constructed either at the Site following construction of the cleanup action, or elsewhere on the upland industrial area peninsula.

11.2 REMEDIAL ACTION OBJECTIVES

RAOs define the goals of the cleanup that must be achieved to adequately protect human health and the environment. RAOs must address all affected media, and a cleanup alternative must achieve all RAOs to be considered a viable cleanup action. RAOs can be either action-specific or media-specific. Based on the preliminary cleanup standards developed in Section 9.0 and the CSM presented in Section 9.4, the action-specific and media-specific RAOs identified for the Site consist of:

- RAO-1:** Remove the fuel storage and dispensing system and recoverable LNAPL to eliminate any ongoing sources of contamination
- RAO-2:** Prevent human or terrestrial ecological receptors from being exposed to hazardous substances through direct contact with contaminated media (soil and groundwater)
- RAO-3:** Prevent hazardous substances in soil from leaching to groundwater at concentrations that exceed the groundwater PCLs
- RAO-4:** Prevent hazardous substances in soil from migrating (by erosion) to marine sediment at concentrations that exceed marine sediment PCLs
- RAO-5:** Prevent hazardous substances in groundwater from migrating to surface water and marine sediment at concentrations that exceed the groundwater PCLs
- RAO-6:** Prevent use of shallow Site groundwater for drinking.

The cleanup action alternatives described in Section 11.5 must achieve all of the above RAOs to be considered a viable remedy for Site cleanup.

11.3 POTENTIALLY APPLICABLE LAWS

In accordance with MTCA, all cleanup actions must comply with applicable state and federal laws [WAC 173-340-710(1)]. MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate. Collectively, these requirements are referred to as applicable or relevant and appropriate requirements (ARARs). The starting point for ARARs is the MTCA cleanup levels and regulations that address implementation of a cleanup under MTCA (Chapter 173.105D RCW; Chapter 173-340 WAC). Other potential ARARs include the following:

- Washington State SMS (Chapter 173-204 WAC)
- State Water Pollution Control Act (Chapter 90.48 RCW)
- EPA National Recommended Water Quality Criteria – Section 304 Clean Water Act
- EPA Water Quality Standards (National Toxics Rule) – 40 CFR 131
- Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 RCW)
- Washington Pollution Control Act and the implementing regulations, Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC)
- Washington Hazardous Waste Management Act and the implementing regulations, Dangerous Waste Regulations (Chapter 173-303 WAC), to the extent that any dangerous wastes are discovered or generated during the cleanup action
- Washington’s Shoreline Management Act, with respect to construction activities conducted near the shoreline during the cleanup action
- Endangered Species Act
- Washington Clean Air Act (Chapter 70.94 WAC)
- Occupational Safety and Health Act, 29 CFR Subpart 1910.120

- Washington Industrial Safety and Health Act.

11.4 SCREENING OF REMEDIAL TECHNOLOGIES

The purpose of the FS is to develop and evaluate cleanup action alternatives to enable an appropriate cleanup action to be selected for the Site. Cleanup action alternatives are an assemblage of one or more cleanup activities that, taken as a whole, will achieve all the RAOs for the Site. This section discusses the breadth of remedial technologies considered for implementation and identifies the remedial technologies that are carried forward for development of the cleanup action alternatives in Section 11.5. The following remedial technologies or response actions were screened for consideration in development of cleanup action alternatives for the Site, including comparison to the applicable RAOs.

11.4.1 CAPPING/CONTAINMENT

Engineered caps are commonly implemented to contain contaminated materials and prevent human and terrestrial ecological exposure to contaminated materials. Caps prevent migration of soil via erosion or mechanical disturbance by covering contaminated soil with a physical protective barrier. The use of low-permeable materials to construct the cap minimizes the potential for precipitation and surface water to infiltrate and potentially cause leaching of contaminants from soil or LNAPL to groundwater in an affected area. At the Site, a surface cap constructed of paving material would provide an effective and easy-to-implement containment system that would prevent direct contact and minimize surface water infiltration.

An asphalt layer and building slabs currently cover most of the Site, except in an area near the ASTs where the surface is gravel. Roof drainage in this area currently discharges to the gravel surface area. Although the asphalt pavement and building slabs are not considered engineered caps, they do provide soil containment by limiting human exposure to contaminated soil and groundwater. The existing asphalt pavement and slabs also minimize infiltration and, accordingly, minimize the rate of groundwater recharge by acting as low-permeable layers. In order to effectively contain contaminated soil at the Site, an engineered cap would need to cover the entire Site, including the gravel area around the ASTs. Roof drainage and surface runoff would need to be diverted from infiltrating to the subsurface in the gravel area by providing for overland flow to the nearby surface water, or by capture, conveyance, and treatment/discharge via a new stormwater system. It is anticipated that a new stormwater system would be constructed in conjunction with Site redevelopment, and Site stormwater would be managed using this new system.

A vertical barrier functions to laterally contain contaminated material and/or redirect groundwater flow. A sheetpile bulkhead was installed as an interim action at the Site to limit the migration of

contaminated soil into Blaine Harbor by erosion. The installation has successfully stabilized the shoreline, and as discussed in Section 5.3.1, does affect westerly groundwater flow toward the harbor. However, the sheetpile bulkhead is not considered a complete hydraulic barrier since water can seep through the sheetpile panel interlocks. A vertical hydraulic barrier designed for groundwater containment typically includes the use of sealed sheet piles, a bentonite slurry cutoff wall, or similar technologies to prevent the lateral migration of groundwater. Vertical hydraulic barriers are typically designed to achieve a hydraulic conductivity less than 1×10^{-7} cm/sec in the horizontal direction, and groundwater extraction is typically required in conjunction with a vertical hydraulic barrier to achieve complete hydraulic containment.

Soil containment with a paved surface would achieve RAO-2 and RAO-6 by preventing direct contact with contaminated soil. This technology would assist in achieving RAO-3 and RAO-5 by reducing groundwater recharge and reducing the amount of Site groundwater discharge to surface water. A vertical barrier could assist in achieving RAO-4 and RAO-5 by preventing soil (via erosion) or groundwater from migrating toward the surface water. To ensure that the RAOs continue to be met, this technology would need to be paired with institutional controls (see Section 11.4.10) and possibly groundwater extraction. Based on the ability to achieve several RAOs, containment technology is carried forward for further consideration.

11.4.2 SOIL VAPOR EXTRACTION / AIR SPARGING

Soil vapor extraction (SVE) and air sparging (AS) are common technologies for remediation of hydrocarbons and VOCs in groundwater and vadose zone soils, both in the dissolved phase and as LNAPL. By injecting compressed air below the groundwater table (AS), volatile contaminants are stripped out of groundwater and removed from the subsurface by extraction (SVE). These technologies can be implemented individually, but are more effective when implemented together. The advantage of using this technology at the Site is the inherently volatile nature of most constituents in gasoline-range petroleum hydrocarbons. SVE and AS could provide a mechanism for phase change and product removal and also help to stimulate biological degradation by increasing dissolved oxygen levels in groundwater. As a result, SVE/AS could help to address RAO-3, RAO-4, and RAO-5 by removing volatile contaminants from the soil and groundwater.

However, this technology has shown limited success at treating sites with high quantities of LNAPL and sites with poor soil permeability. To prevent LNAPL from limiting the effectiveness, these technologies could be implemented after LNAPL removal. But the fine-grained soils and clay layers observed at the Site remain a significant impediment to successfully achieving RAOs in a reasonable timeframe, and would also be expensive to operate over the long term since the efficiency and

effectiveness of SVE and/or AS would be very low. The technology may appear to operate effectively in the short term while readily accessible VOCs are removed. Afterward, the removal rate and cost efficiency become poor if significant quantities of contaminants are trapped in pockets of clayey soil and inaccessible to the imparted soil vapor flow. The rate of contaminant diffusion from these pockets can be very slow, which leads to system inefficiency in terms of cost per unit of contaminant removal and a very long restoration timeframe.

Based on the low permeability of the soils observed at the Site, implementation of AS/SVE is anticipated to be ineffective and will not be carried forward for further consideration.

11.4.3 BIOSPARGING / BIOVENTING

Biosparging/bioventing involves the slow introduction of air into groundwater and/or soil to stimulate aerobic microbial degradation of contaminants, typically paired with the removal of soil vapor by extraction similar to AS/SVE as described above, but with typically much lower flow rates. The potential limitations of AS/SVE described in Section 11.4.2 are also relevant to applications of this technology. The amount of equipment and infrastructure (and consequently cost) required for biosparging/bioventing is similar to that of AS /SVE; and since biosparging/bioventing is a less aggressive technology than AS/SVE, the benefits are expected to be realized over longer periods of time and the cost effectiveness is expected to be even less than for AS/SVE. As such, this technology is not likely to be an effective Site-wide remedial approach and will not be carried forward for further consideration.

11.4.4 MULTI-PHASE EXTRACTION

A multi-phase extraction system could be used to extract soil vapor, groundwater, and LNAPL from the subsurface for *ex situ* treatment. Based on the prevalence of fine-grained soils (including clay) at the Site, which would restrict recovery rates, and the limited area of the Site where LNAPL recovery is feasible, implementation would be focused only in the source area. Multi-phase extraction systems operate with high efficiency when LNAPL is being recovered. When recoverable LNAPL is depleted, the remedial benefits would be similar to a groundwater pump-and-treat system, but with poorer efficiency. The long-term treatment of large quantities of groundwater and exhaust air would require significant capital investment in equipment, infrastructure, and operations and maintenance (O&M). Consequently, this technology is not carried forward in the FS as an option for implementation in the manner traditionally employed.

Although traditional multi-phase extraction is not being considered further, it is possible to implement this technology for intermittent LNAPL recovery, while retaining the added benefit of some

soil vapor and groundwater contaminant removal. With this approach, a vector truck would periodically extract LNAPL (and as a consequence of this approach, would also remove soil vapor and groundwater) from extraction wells installed in the source area. This allows intermittent implementation, scheduled based on the observed recovery rates. This approach prevents many of the operating inefficiencies that would hamper a permanent traditional system based on poor and unpredictable LNAPL recovery rates by extracting only when LNAPL is available for recovery.

Using an intermittent approach is both economical and labor-efficient, since each extraction session removes the maximum LNAPL volume possible while also removing some of the most impacted groundwater and soil vapor at the Site in areas coinciding with the presence of free-phase LNAPL. This technology could be used to address RAO-1 and RAO-3 by removing LNAPL and volatile contaminants from soil and groundwater, RAO-5 by removing groundwater contamination and its source, and, to a limited degree, RAO-6 by removal of contaminated soil vapors and their source. Based on these considerations, intermittent dual-phase extraction is carried forward for consideration for LNAPL removal, and will be referred to herein as intermittent LNAPL recovery.

11.4.5 SOIL FLUSHING

In situ soil flushing introduces a liquid to contaminated soil to mobilize contaminants (including LNAPL). Contaminants are mobilized by solubilization, emulsification, or by chemical reactions with the flushing solutions, which can include surfactants. Surfactants are discussed further in Section 11.4.6.

The purpose of soil flushing is to enhance mobilization of contaminants, making them more available to remediation. This can reduce the restoration timeframe at sites where contaminants are relatively immobile under typical hydrological conditions. At the Site, it is anticipated that soil flushing could be employed along Sigurdson Avenue to increase the mobility of contaminants that would be difficult to access by other remedial approaches such as excavation. Although the extensive fine-grained soils present in the AST vicinity would likely make this approach ineffective in the source area, the approach could be applied in downgradient areas where the clay deposits are less extensive to increase contaminant mobility and assist in the achievement of RAO-5. As a result, soil flushing is carried forward for additional consideration.

11.4.6 BIOREMEDIATION

In situ bioremediation typically consists of enhancing or stimulating naturally occurring aerobic or anaerobic biological processes in saturated subsurface soil and groundwater through the introduction of oxidizing reagents, oxygen sources, nitrates, sulfates, and/or macro/micro nutrients into the treatment area. The introduction of these reagents can increase the rate of degradation of petroleum constituents in

soil and groundwater when the natural metabolic biological processes are limited by the depletion or limited availability of these compounds.

Reagent introduction can be accomplished by direct injection into wells or infiltrated to the subsurface using infiltration trenches. This technology has demonstrated effectiveness at sites with similar IHS and environmental settings (near marine surface water) as the Site and is therefore carried forward for further consideration.

The anaerobic conditions observed at the Site are typical of other marine shoreline sites contaminated by petroleum hydrocarbons. Although oxidizing reagents or oxygen sources could theoretically be applied to change the aquifer conditions from anaerobic to aerobic to enhance biodegradation, the cost would be prohibitively expensive due to the high concentrations of natural organic matter present in most dredge fills adjacent to marine water. Experience at similar sites has demonstrated that a more efficient bioremediation strategy under these conditions is to further stimulate anaerobic degradation by the injection of nitrates, sulfates, and nutrients, since these reagents are not quickly consumed by competing reactions with naturally occurring organic matter and have much greater solubility in water than oxygen. The reagents used for anaerobic bioremediation also tend to be much less expensive than those used for aerobic bioremediation, so anaerobic bioremediation is much more economical provided the site exhibits naturally anaerobic conditions.

Through the use of infiltration trenches, the reagents can be introduced to the subsurface in large batches under gravity flow. Unlike treatment technologies that require a constant input of energy (such as running an extraction or injection blower), the limitations in the rate of infiltration would not result in the types of process efficiencies that would significantly affect the cost of long-term operations. Instead, the limitations in the rate of infiltration would be addressed by the installation of multiple large infiltration trenches designed to seep bioremediation reagents into permeable zones. Reagent application would be adjusted based on performance monitoring to maintain elevated nitrate concentrations throughout the aquifer at the Site. It is anticipated that TPH concentrations in groundwater would be reduced to achieve cleanup standards soon after the aquifer is saturated with the bioremediation solutions, and would remain suppressed until the nitrate is depleted. Continued injections would maintain the low TPH concentrations in groundwater and as a result, potential exposure to or migration of contaminated groundwater is mitigated *during* the active remediation process rather than relying on its *completion*.

Based on the ability to address RAO-3 through RAO-5 by the direct reduction in the concentration of groundwater contaminants, bioremediation is carried forward for additional consideration. However, the effectiveness of bioremediation is limited in areas containing free-phase LNAPL, so bioremediation would need to be combined with LNAPL removal to achieve cleanup in a reasonable restoration timeframe.

11.4.7 SURFACTANT FLUSHING

Surfactants could also be used to increase the solubility of petroleum hydrocarbons by selectively transferring LNAPL from soil surfaces and areas of accumulation into the aqueous dissolved phase. This technology could increase the effectiveness of biological treatment. Biodegradable, non-ionic surfactants are available that are demonstrated to be useful in enhancing the effectiveness of other remedial technologies. Application would be limited to areas under hydraulic control to ensure that contamination mobilized into groundwater could not migrate off site. Based on the potential for use in enhancing other remedial technologies such as LNAPL removal, bioremediation, enhanced natural attenuation, or soil flushing, the use of surfactants will be carried forward for further consideration during development of the remedial alternatives.

11.4.8 EXCAVATION AND OFFSITE DISPOSAL/TREATMENT

Excavation and offsite disposal or treatment of contaminated soil is a permanent remedial technology for physically removing contamination from a site. Excavation could focus on source removal if used in conjunction with other remedial technologies to address remaining residual contamination. Or, excavation could be implemented Site-wide to remove all contamination from the Site. Either excavation scenario would first require the removal of the AST system and adjacent buildings to allow access to the subsurface.

During implementation of all excavation scenarios, free-phase LNAPL would be removed from the Site using sorbent pads, or with the assistance of a vector truck skimming LNAPL from the exposed groundwater surface. Contaminated media could be disposed of off site at a solid waste landfill designed and permitted in accordance with state and federal regulations. Because soil at the Site is not contaminated by metals or other contaminants not effectively remediated by thermal treatment, offsite treatment of contaminated soil by thermal desorption may be a practicable alternative to disposal at a solid waste facility. However, because of the significant amount of fine-grained soil present at the Site, it is unlikely that most of the treated soil could be reused as structural or general fill and would likely require disposal at a limited purpose landfill. As a result, the evaluation of the practicability of thermal treatment as an alternative to disposal at a solid waste facility would require consideration of disposal as well as treatment costs.

Based on the ability of excavation to potentially address all RAOs, excavation and offsite disposal or treatment is carried forward for further consideration.

11.4.9 MONITORED NATURAL ATTENUATION

This technology reduces concentrations of contaminants in groundwater by natural processes such as dilution, dispersion, sorption, and biodegradation. Application of this technology includes monitoring the progress of these natural processes to verify contaminant concentrations are reducing at a sufficient rate to meet project goals. These natural processes can limit the extent of the petroleum plume to achieve RAO-3 and RAO-5. Groundwater quality would be monitored for IHS and geochemical parameters to confirm its effectiveness in accordance with Ecology's *Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation* (Ecology 2005). Additional Site monitoring data would need to be collected during remedial design to confirm the effectiveness of natural attenuation processes at the Site. However, MNA parameters were evaluated during the RI that indicate natural attenuation processes are occurring, as discussed in Section 7.3.3. We anticipate that if contaminant sources are removed as part of the cleanup action, this technology could be an effective complementary remedial technology and is therefore carried forward for further consideration.

11.4.10 INSTITUTIONAL CONTROLS

Institutional controls are measures undertaken to limit or prohibit activities that may interfere with the integrity of a cleanup action and could thereby cause exposure to hazardous substances. Institutional controls may include physical measures, such as fences, documented use restrictions such as deed restrictions or restrictive covenants, maintenance requirements, and/or educational programs. For the Site, institutional controls would include restrictive covenants limiting activities that could lead to potential human contact with hazardous substances. If paired with capping, institutional controls could help in achieving RAO-2 and RAO-3. Cleanup actions cannot rely primarily on institutional controls and monitoring where it is technical possible to implement a more permanent cleanup action [WAC 173-340-440(6)]. However, institutional controls are carried forward for additional evaluation as a potential measure to be applied in conjunction with capping, containment, and long-term compliance monitoring.

11.4.11 COMPLIANCE MONITORING

Compliance monitoring is not considered a stand-alone remedial alternative, but is a required element of any cleanup action conducted under MTCA. Compliance monitoring would be conducted to verify that cleanup standards for affected media are achieved, and once achieved, are maintained. Compliance monitoring could be applied to all affected media (soil, groundwater, soil vapor), and could also be applied to the performance of certain cleanup technologies (e.g., physically monitoring the integrity of a containment cap). Compliance monitoring is carried forward as a remedial technology for further evaluation.

11.5 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section provides a detailed evaluation of the remedial technologies considered applicable for use at the Site and packages these technologies into Site-wide remedial alternatives. The remedial alternatives account for current conditions at the Site and each alternative is anticipated to meet all RAOs by a combination of technologies. A description of the following alternatives is presented in the sections below along with a discussion of the conceptual approach for implementation.

Alternative 1: Limited Source Removal with LNAPL Recovery and Bioremediation

Alternative 2: Source Removal and Bioremediation

Alternative 3: Source Removal, Bioremediation, and Soil Flushing with a Downgradient Hydraulic Barrier

Alternative 4: Expanded Source Removal, Bioremediation Along Shoreline

Alternative 5: Expanded Source Removal, Soil Flushing with a Downgradient Hydraulic Barrier

Alternative 6: Mass Excavation and MNA.

11.5.1 COMMON ELEMENTS OF EACH ALTERNATIVE

Some elements of the cleanup remedy are common to all alternatives and will be implemented regardless of which alternative is selected. Any cleanup alternative implemented at the Site will include the following actions:

- Remove the AST system and adjacent buildings to ensure that the system is not an ongoing source of contamination and to provide access to the source area for implementation of the cleanup action
- Install and maintain a pavement cover to reduce stormwater infiltration, limit contaminant migration, and prevent direct contact with contamination (not applicable for Alternative 6).
- Conduct monitoring to assess compliance with cleanup standards
- Implement institutional controls to ensure the long-term integrity of the containment system and prevent the use of Site groundwater as a drinking water source (not applicable for Alternative 6).

The estimated costs for the activities listed above are included in the remedial alternative cost estimates provided in Appendix D. The scope and cost for some of these common cleanup elements may differ slightly between the alternatives.

11.5.2 ALTERNATIVE 1: LIMITED SOURCE REMOVAL WITH LIGHT NON-AQUEOUS PHASE LIQUID RECOVERY AND BIOREMEDIATION

In addition to implementing the common elements discussed in Section 11.5.1, this alternative includes removing soil and LNAPL from the source area in the vadose zone, then implementing Site-wide bioremediation until cleanup standards are achieved. Figure 22 provides an illustrative summary of the

actions included as part of this alternative. The following list summarizes how each of the RAOs would be addressed by this cleanup alternative:

- RAO-1:** Ongoing sources of contamination would be removed by decommissioning/removal of the fueling system and removal of LNAPL.
- RAO-2:** Humans would be protected from direct contact with contaminated soil and groundwater by the removal of shallow contaminated soil and the installation and maintenance of a paved cover surface.
- RAO-3:** Groundwater would be protected from contaminants leaching from soil by paving the Site surface to limit surface water infiltration, removing contaminated soil by excavation, and by directly reducing contaminant concentrations through bioremediation to achieve groundwater PCLs.
- RAO-4:** Marine sediment in the adjacent Blaine Harbor would be protected from hazardous substances migrating (by erosion) by removing shallow soil contamination, paving all unpaved areas, and extending the sheetpile bulkhead to stabilize the shoreline to the north of the existing sheetpile bulkhead.
- RAO-5:** Aquatic organisms would be protected from exposure to groundwater or surface water that exceeds the groundwater PCLs by installing a paved surface to reduce surface water infiltration, by removing the source of contamination (AST system, contaminated soil, and LNAPL), and by reducing contaminant concentrations in saturated soil and groundwater through bioremediation to achieve groundwater PCLs.
- RAO-6:** Institutional controls will prevent the use of shallow Site groundwater as a drinking water source.

The primary cleanup elements are discussed in the following sections.

11.5.2.1 Excavation and Offsite Treatment/Disposal

After removal and decommissioning of the AST system, approximately 1,700 tons of soil would be excavated from the approximate location indicated on Figure 22, in the source area, from surface to the groundwater table (an approximate depth of 10 ft BGS). The excavation is intended to remove contamination in the unsaturated zone that cannot be effectively treated by bioremediation or other *in situ* treatment technologies.

The actual dimensions of the excavation may vary from what is presented on Figure 22 based on the results of pre-design investigation and conditions encountered during construction. Existing data indicate significant vadose-zone contamination exists in this area, including LNAPL, which may be present from near the surface to the groundwater table. Based on the RI data, removal of this affected soil and the LNAPL present in the source area could result in reducing the contaminant mass by approximately 35 tons, or approximately 55 percent of the Site contamination by mass. Contaminated soil removed from the Site would be potentially treated by thermal desorption prior to disposal, if practicable, and then disposed of at a licensed disposal facility.

11.5.2.2 Light Non-Aqueous Phase Liquid Recovery

While the excavation is open and the groundwater table is exposed across the floor of the excavation, a vactor truck and/or sorbent pads would be used to skim LNAPL from the exposed groundwater table. The excavation would remain open to facilitate LNAPL removal until recovery becomes impracticable. For the purpose of estimating cost, we assume a vactor truck would visit the Site on four occasions to remove LNAPL and would remove approximately 4,000 gallons of liquid waste (groundwater and LNAPL) on each visit. Sorbent pads could also be used to adsorb LNAPL, as needed, and could be disposed of along with the contaminated soil. The soil at the bottom of the excavation would be mixed using the excavator bucket to release residual LNAPL trapped by capillary forces between the soil particles to enhance removal of contamination with the sorbent pads or vactor truck. Soil samples from the sidewalls and floor of the excavation would be collected and analyzed for IHS to establish the concentrations associated with residual contamination in soil, although it is not anticipated that cleanup levels would be achieved.

11.5.2.3 Sheetpile Bulkhead Extension

As part of Alternative 1, the sheetpile bulkhead installed as an interim action at the Site would be extended north to the timber bulkhead that extends west beneath the fish processing building. The extended bulkhead would reduce the near-shore tidal exchange in the affected upland area and extend the residence time for the bioremediation solutions in this area. The interlocking panels of the new bulkhead would be sealed to provide a more complete hydraulic barrier.

11.5.2.4 Bioremediation

After the removal of the contaminated soil and recoverable LNAPL, the excavation would be backfilled with a granular backfill material, and three bioremediation injection points would be installed within the limits of the excavation. The injection points would be installed to an approximate depth of 12 to 15 ft BGS, and would include a section of perforated pipe near the bottom, a fill port at the top, and a flush-mounted vault or protective monument at the ground surface. These injection points would be used to inject bioremediation solutions into the former source area.

Bioremediation would focus on enhancing the activity of naturally occurring anaerobic microbes to degrade petroleum hydrocarbons in the soil and groundwater. Solutions of ammonium nitrate (AN) and monoammonium phosphate (MAP) would be introduced to the subsurface to act as electron acceptors to stimulate rapid growth of the microbes and thereby increase the contaminant degradation rate.

The AN and MAP solutions would be injected in the former source area using injections wells, raising the groundwater level in that area and causing the solutions to flow outward from the source area

along similar pathways followed historically by the TPH contamination. In addition to injecting these solutions into the former source area after it is backfilled with granular backfill, infiltration trenches would be constructed outside of the excavation area, as indicated on Figure 22, to facilitate delivery of the bioremediation solutions throughout the Site aquifer. As indicated on Figure 22, the conceptual plan includes three injection wells, and six infiltration trenches totaling approximately 170 linear ft in length. A cross section showing the conceptual infiltration trench details is provided on Figure 23. As indicated on the figure, the trenches would be approximately 9 to 15 ft in depth, depending on the depth of nearby contamination. The trenches would be backfilled with gravel and would include a horizontal section of perforated pipe, a vertical PVC pipe to be used as an injection port, and a traffic-rated flush-mount vault constructed over the injection port for equipment protection and security. The actual trench design details and installation locations would be developed based on the observed contamination and Site hydrogeology during the remedial design phase.

The conceptual plan includes filling the infiltration trenches to near the ground surface with bioremediation reagents, then allowing the solutions to migrate into the groundwater flow system. For preliminary planning purposes, we have assumed that for each injection event, up to approximately 40,000 gallons of injection solution would be prepared on Site from pelletized bulk AN and MAP in onsite mixing tanks, and would be pumped into the infiltration trenches and the former source area through the injection ports. Performance monitoring would be conducted during the injection events and would include observing groundwater elevations during and after injection to evaluate solution infiltration rates around the Site. Groundwater quality monitoring conducted between injection events would include monitoring for petroleum hydrocarbons, nitrate, and additional parameters related to the microbial degradation pathway of petroleum hydrocarbons to develop an understanding of the fate and transport characteristics unique to the Site, and to further refine the injection program to maximize efficiency.

For FS cost estimating purposes, it was assumed that 15 Site-wide injection events over a 5-year period (3 injection events per year) would be conducted to achieve cleanup standards. It is possible that in the later years of the bioremediation program, injections would not be required at a frequency of three per year if performance monitoring indicated that residual nitrate concentrations remain sufficiently elevated between events.

Based on the heterogeneity of the Site soils and the importance of effectively introducing the bioremediation solutions into target areas, supplemental bioremediation injection may be needed if some locations are not effectively treated by the infiltration trenches and source area injections. Three supplemental injection locations are shown on Figure 22 to conceptually illustrate the application of supplemental bioremediation injection. The need for, location, and number of supplemental injection points would be determined during implementation of the cleanup action if performance monitoring

indicates additional injection points are necessary. If needed, supplemental bioremediation injection would be conducted by either installing additional injection wells or using a direct-push probe rig outfitted with an injection pump, or similar equipment, to pressure-inject bioremediation solutions into limited target areas to accelerate the remediation process. Supplemental direct injection treatment is considered an integral part of Alternative 1, although the need for and location of the supplemental treatment would be determined during the cleanup action implementation.

For cost estimating purposes, it was assumed that one supplemental injection would be conducted during each year of bioremediation after the first year, occurring during the same mobilization as one of the three annual injection/infiltration events. For FS cost estimating purposes, we assumed that the supplemental injections would include installing up to three permanent injection points within Sigurdson Avenue.

11.5.2.5 Monitored Natural Attenuation

When cleanup standards are achieved along the shoreline, and it has been demonstrated that risks of exposure to aquatic species based on groundwater discharge to Blaine Harbor have been mitigated, the bioremediation program will transition to MNA. MNA would be conducted to monitor the continued decline of contaminant concentrations until Site-wide cleanup is demonstrated. For the purpose of estimating cost, we assumed that MNA would include semiannual groundwater monitoring, conducted for an additional 5 years after the 5 years of bioremediation. However, the actual timeframe for injection and MNA may vary, and bioremediation efforts would be conducted at the frequency necessary to prevent the discharge of groundwater exceeding the PCLs to surface water throughout the remediation process.

11.5.2.6 Capping

The capping system (paved surface across the Site) would prevent direct contact with contaminated media during Site remediation and minimize stormwater infiltration. Monitoring and maintenance of this system would continue until cleanup standards are achieved.

11.5.2.7 Compliance Monitoring

For the purpose of estimating costs, we have assumed quarterly groundwater monitoring would be conducted during the first 2 years of remediation, followed by semiannual groundwater monitoring for the following 8 years. Annual groundwater monitoring reports would be prepared to summarize Site conditions, remedial activities, and progress toward attaining Site cleanup, and submitted to Ecology.

11.5.3 ALTERNATIVE 2: SOURCE REMOVAL AND BIOREMEDIATION

Alternative 2 is similar to Alternative 1, but includes expanded source removal over that provided by Alternative 1. Each of the RAOs would be addressed by this cleanup alternative in the same manner described for Alternative 1, although RAO 2 through RAO 5 would be more extensively addressed through the removal of contaminated soil. In addition to implementing the common elements discussed in Section 11.5.1 and the cleanup elements associated with Alternative 1, Alternative 2 includes excavating approximately 3,000 tons of contaminated soil from the source, which is 75 percent more excavation of than included in Alternative 1. The additional soil mass results from excavating a larger area to a greater depth. The conceptual design for Alternative 2 is illustrated on Figure 24.

11.5.3.1 Excavation and Offsite Treatment/Disposal

Source removal would be conducted after removal of the AST system and adjacent buildings. The soil excavation would extend vertically to a depth of approximately 12 ft BGS, and would extend laterally to the extent of free-phase LNAPL, as shown on Figure 24. As shown on Figure 24, the excavation would be constrained on the west side by Sigurdson Avenue, which may result in a limited amount of free-phase LNAPL remaining in this area following excavation.

The goal for excavation in Alternative 2 is to remove all accessible significant contamination from the source area without compromising the existing utilities in Sigurdson Avenue. As discussed in Section 7.1, only trace levels of contamination were encountered below 12 ft BGS, so excavation to this depth would remove virtually all the contaminant mass from the source area. Soil samples would be collected from the floor and sidewalls of the excavation to document conditions remaining in-place.

Approximately 3,000 tons of contaminated soil would be removed for Alternative 2, resulting in a reduction of contaminant mass of approximately 44 tons, or approximately 70 percent of the total Site contamination by mass. Excavated soil would be managed in the same manner as described for Alternative 1.

11.5.3.2 Light Non-Aqueous Phase Liquid Recovery

While the excavation is open, free-phase LNAPL would be removed from the exposed groundwater surface using a vactor truck and/or adsorbent materials deployed into the open excavation, as discussed for Alternative 1 above. However, because the excavation would extend farther laterally and vertically, the amount of LNAPL requiring recovery is anticipated to be minimal for Alternative 2.

11.5.3.3 Bulkhead Extension

As with Alternative 1, the sheetpile bulkhead installed as an interim action at the Site would be extended north to the timber bulkhead that extends west beneath the fish processing building.

11.5.3.4 Bioremediation and Monitored Natural Attenuation

Bioremediation would be conducted in a similar manner to that described for Alternative 1. Because Alternative 2 includes more contaminant removal through excavation, it is anticipated that bioremediation would be shorter in duration. For the purpose of estimating cost, it was assumed that 12 injection events would be conducted over a period of 4 years (3 per year) before transitioning to MNA. The overall restoration timeframe for this alternative to achieve cleanup standards Site-wide was estimated to be between 5 and 8 years.

Similar to Alternative 1, it was assumed that one supplemental bioremediation direct injection event would be conducted during each year of bioremediation after the first year to treat any areas not adequately treated by the installed bioremediation system or otherwise determined to require more aggressive treatment. The location of the injection points, if needed, would be determined during cleanup implementation, but injection locations are shown on Figure 24 for illustrative purposes. The supplemental injections could be conducted through injection wells as indicated on the figure; or, direct-push methods or a soil lance could be used to target areas needing aggressive treatment with additional flexibility.

11.5.4 ALTERNATIVE 3: SOURCE REMOVAL, BIOREMEDIATION AND SOIL FLUSHING WITH A DOWNGRAIENT HYDRAULIC BARRIER

Alternative 3 includes all of the cleanup elements associated with Alternative 2. It also includes a groundwater flushing system to more aggressively treat the area between the excavated source area and the shoreline (i.e., beneath Sigurdson Avenue) and an extension of the sheetpile bulkhead to the south to ensure that soil flushing solutions are adequately contained. The area beneath Sigurdson Avenue was selected for more aggressive treatment because 1) it contains the highest concentrations of soil and groundwater contamination outside of the source area, and 2) contamination in this area extends to the immediate vicinity of the shoreline, and as such, poses the greatest threat to human health and the environment through potential release of Site contaminants to surface water. For Alternative 3, each of the RAOs would be addressed in a similar manner to Alternative 2, although the addition of the soil flushing system is anticipated to achieve the objectives in a shorter restoration timeframe.

As illustrated on Figure 25, the soil flushing system would include an injection system consisting of an extended infiltration trench on the east side of Sigurdson Avenue, an interceptor trench at the

shoreline, and a soil flushing system to recirculate groundwater and treatment solutions through the treatment area. This alternative also includes extending the bulkhead 10 ft to the south and modifying the existing bulkhead to create a hydraulic barrier system along the shoreline.

11.5.4.1 Soil Flushing

The soil flushing system would allow the bioremediation treatment described for Alternative 2 to be applied more aggressively because higher groundwater velocities through the treatment area are created by lowering groundwater elevations at the shoreline and consistently maintaining higher groundwater elevations at the upgradient injection point. Additionally, the installation of a hydraulic barrier system at the shoreline would allow the application of higher concentrations of electron acceptors (AN and/or MAP) and the application of soil flushing solutions (e.g., surfactants) without the risk of releases to surface water.

The soil flushing system interceptor trench would be installed along the shoreline, upland of the sheetpile bulkhead. Installation of the trench would likely to be difficult due to the proximity of subsurface utilities (see Figure 2), the potential for significant dewatering requirements due to the proximity to surface water, and the need to temporarily shore and protect the existing bulkhead during installation.

The western side of the interceptor trench adjacent to the existing sheetpile bulkhead would be lined with a flexible membrane liner and the joints of the new bulkhead sections would be sealed to provide a downgradient hydraulic barrier along the shoreline. The interceptor trench in combination with the bulkhead/flexible membrane liner barrier system would create a hydraulic control system to prevent the discharge of treatment chemicals to surface water, and to minimize marine water intercepted by the soil flushing system.

The trench would be filled with granular backfill to capture groundwater into a horizontal perforated pipe installed at the groundwater interface. Two riser pipes would be installed in the trench in the approximate locations shown on Figure 25. Figure 26 provides a conceptual cross section of the interceptor trench. Pumps would be installed in the risers to extract groundwater from the trench and convey it to the aboveground equipment for monitoring, limited treatment including oil/water separation, filtration, and dosing with nitrate and/or surfactants before re-injecting the groundwater to upgradient infiltration trenches. The extraction/injection flow rate that would be required to maintain circulation is anticipated to be low since the surface containment system sheetpile bulkhead and the downgradient hydraulic barrier would both act to limit groundwater recharge.

Aboveground treatment of the extracted groundwater would be limited, since the flushing system would control groundwater flow to prevent releases beyond the treatment area. The flushing system

would be adjusted to target areas determined during performance monitoring to require further treatment, and to amend the recirculated groundwater with solutions to enhance *in situ* bioremediation. The aboveground soil flushing equipment would include process piping, pump controls, system monitoring equipment, a compressor and compressed-air dryer, oil/water separator, physical filtration (if needed), and solution metering/dosing equipment. The system would be enclosed within security fencing.

Soil flushing would extract groundwater from along the shoreline, provide the limited treatment described above, and amend the water with added electron acceptors prior to re-injection. It is anticipated that higher concentrations of electron acceptors could be used because of the barrier system's ability to prevent discharge of the treatment chemicals to surface water. If flushing with electron acceptor solutions does not provide adequate treatment to support the conclusion that cleanup would be achieved within a reasonable restoration timeframe, the flushing solution would be amended with a surfactant to accelerate the bioremediation process.

The soil flushing system included in Alternative 3 is expected to result in a restoration timeframe of between 3 and 6 years. For cost estimating purposes, it was assumed that nine injection events would be conducted over a 3-year period, prior to transitioning to MNA for the remaining 3 years. It was also assumed that an electron acceptor solution would be applied for the first year of treatment and a solution containing both an electron acceptor and a surfactant would be applied during the second and third years.

Similar to Alternatives 1 and 2, supplemental direct injection treatment is considered an integral part of Alternative 3, although the need for and location of the supplemental treatment would be determined during the cleanup action implementation. The location of the injection points, if needed, would be determined during cleanup implementation, but three injection locations are shown on Figure 25 for illustrative purposes. It was assumed that one supplemental bioremediation direct injection event would be conducted during each year of bioremediation after the first year.

11.5.5 ALTERNATIVE 4: EXPANDED SOURCE REMOVAL, BIOREMEDIATION ALONG SHORELINE

Alternative 4 includes the cleanup elements in Alternative 2, but would have a larger excavation to remove all contaminated soil east of Sigurdson Avenue. As indicated on Figure 27, the excavation area for this alternative would encompass the entire Site, except for the area within Sigurdson Avenue. Similar to Alternatives 2 and 3, soil contamination underlying Sigurdson Avenue would not be excavated because the presence of subsurface utilities (see Figure 2) and the close proximity to the shoreline bulkhead make excavation in this area very difficult and disruptive to ongoing tenant operations. This alternative is anticipated to achieve the RAOs in the same manner as Alternatives 1 and 2.

Approximately 10,000 tons of contaminated soil would be removed for Alternative 4, resulting in a reduction of contaminant mass of approximately 56 tons, or approximately 85 percent of the total Site

contamination by mass. Excavated soil would be managed in the same manner as described for Alternative 1. As discussed in Section 11.4.8, outside of the vicinity of the ASTs, the contaminated zone is covered by 5 to 10 ft of soil that does not contain concentrations of IHS above cleanup standards. Although not contaminated, much of the cover soil would likely not be suitable for re-use on site because its fine-grained nature would make recompaction difficult. Approximately 8,000 tons of the soil removed would be contaminated and would be disposed of at a licensed solid waste or thermal desorption facility. It was assumed that the approximately 2,000 tons of uncontaminated cover soil would need to be disposed of at an inert waste landfill.

Based on an excavation depth ranging from 12 to 15 ft, and the large area of the excavation, this option would require significant dewatering and shoring to allow excavation of contaminated soil in dry conditions, maintain side-slope stability, and protect utilities and nearby structures.

Bioremediation would be implemented in a similar manner to other alternatives, except that bioremediation would be limited to the area beneath Sigurdson Avenue. As a result, only 80 linear ft of trenching would be required for infiltration of bioremediation solutions.

Similar to the preceding alternatives, supplemental direct injection treatment is considered an integral part of Alternative 4, although the need for and location of the supplemental treatment would be determined during the cleanup action implementation. Conceptual injection locations are shown on Figure 27 for illustrative purposes. For cost estimating purposes, it was assumed that one supplemental injection event would be conducted during each year of bioremediation after the first year, to treat areas not effectively treated by the installed bioremediation system or areas otherwise determined to require treatment that is more aggressive.

The restoration timeframe for Alternative 4 was estimated to be between 5 and 8 years. The estimated restoration timeframe is similar to Alternative 2 because treatment of the soil beneath Sigurdson Avenue is expected to be the time-limiting factor in achieving cleanup standards, and is likely to be similar for both of these alternatives. For the purpose of estimating cost, we assumed that 12 injection events would be conducted over a period of 4 years (3 per year) before transitioning to MNA.

11.5.6 ALTERNATIVE 5: EXPANDED SOURCE REMOVAL, SOIL FLUSHING WITH DOWNGRAIDENT HYDRAULIC BARRIER

Alternative 5 is a blend of Alternatives 3 and 4. It includes all the cleanup elements in Alternative 4, and the soil flushing and hydraulic barrier system described for Alternative 3. Each of the RAOs would be achieved by this alternative in the same manner described for Alternative 3.

As discussed for Alternative 4, the cleanup of the soil beneath Sigurdson Avenue is likely to require the most time, and as a result, is the determining factor when estimating the restoration timeframe.

Because the same remedial approach would be implemented beneath Sigurdson Avenue as included for Alternative 3, this alternative is anticipated to have a similar restoration timeframe, which was estimated to be between 3 and 6 years.

Supplemental direct injection treatment is considered an integral part of Alternative 5, although the need for and location of the supplemental treatment would be determined during the cleanup action implementation. Potential injection locations are shown on Figure 28 for illustrative purposes. For cost estimating purposes, it was assumed that one supplemental injection event would be conducted during each year of bioremediation after the first year.

11.5.7 ALTERNATIVE 6: MASS EXCAVATION AND MONITORED NATURAL ATTENUATION

Alternative 6 includes removal of existing Site structures and compliance monitoring discussed in Section 11.5.1, in conjunction with removal and offsite disposal/treatment of all contaminated soil and LNAPL. Each of the RAOs would be achieved by removing the contamination from the Site, though as described below, some residual contamination is likely to persist for a short period of time following excavation then naturally attenuate.

Excavation would extend vertically to depths between approximately 9 and 17 ft BGS, and would extend laterally to remove all contaminated soil from the Site, as indicated on Figure 29. For the purpose of estimating cost, it was estimated that approximately 15,000 tons of soil would be excavated to remove all contamination from the Site. As with the excavations described for Alternatives 4 and 5, contaminated soil would be managed separately from the clean overburden soil. For cost estimating purposes, it was assumed that clean and contaminated soil would be disposed of off site at inert waste and solid waste landfill facilities, respectively.

Compliance monitoring would include soil and groundwater monitoring for IHS to confirm that cleanup standards are achieved and maintained. For cost estimating purposes, it was assumed that minor residual contamination would remain following excavation, but that additional active remediation would not be required because the residual contamination would naturally attenuate rapidly following implementation of the removal action. As a result, 2 years of quarterly groundwater monitoring for MNA are included in the alternative.

Excavation along the shoreline and beneath Sigurdson Avenue is anticipated to be very difficult but technically feasible. Utilities in the area (water, sanitary sewer, electric, communications, and natural gas) will need to be temporarily or permanently rerouted so service can continue at nearby commercial businesses during the removal action. Significant disruption to tenant operation would occur during construction, potentially requiring temporary closure of some businesses.

Excavation along the shoreline bulkhead would be complicated by marine water intrusion through and around the bulkhead. To limit marine water intrusion, the sheetpile bulkhead installed during the interim action would be extended approximately 60 ft to the north to minimize marine water intrusion and provide shoreline stability during the excavation activities. Temporary sheetpile sections extending inland from the north and east ends of the shoreline bulkhead are anticipated to be required to minimize inflows of marine water around the ends of the excavation. Temporary shoring of the bulkhead would be required to maintain its structural stability during excavation.

Because of the depth and lateral extent of the excavation, and its proximity to the shoreline, construction dewatering is anticipated to be a significant construction element. Dewatering design would require groundwater modeling and related analyses. For the purposes of the FS, it was assumed that construction dewatering would require the combination of a well point system around the perimeter of the excavation in conjunction with localized sump dewatering.

After excavation, the Site would be backfilled with imported clean fill. The surface of the Site would be graded and paved with asphalt, consistent with existing conditions. The restoration timeframe for this alternative is anticipated to be up to 2 years after completion of remedial design and permitting.

11.6 FEASIBILITY STUDY EVALUATION CRITERIA

MTCA requires that cleanup alternatives be compared to a number of criteria to evaluate the adequacy of each alternative to achieve the intent of the regulations, and as a basis for comparing the relative merits of the cleanup alternatives developed. Consistent with MTCA, the cleanup alternatives were evaluated with respect to compliance with threshold requirements, permanence, restoration timeframe, and consideration of public concerns, as discussed in the following subsections.

11.6.1 MODEL TOXICS CONTROL ACT THRESHOLD REQUIREMENTS

As specified in WAC 173-340-360(2), all cleanup actions are required to meet the following threshold requirements:

- Protect human health and the environment
- Comply with cleanup standards specified under MTCA
- Comply with applicable state and federal laws
- Provide for compliance monitoring.

It is assumed that compliance with MTCA cleanup standards will ensure protection of human health and the environment and that any cleanup action performed in accordance with the requirements of MTCA will be in compliance with applicable state and federal laws. Compliance monitoring is a component of all cleanup alternatives.

11.6.2 REQUIREMENT FOR PERMANENT SOLUTION TO THE MAXIMUM EXTENT PRACTICABLE

WAC 173-340-200 defines a permanent solution as one in which cleanup standards can be met without further action being required at the original site or any other site involved with the cleanup action, other than the approved disposal site of any residue from the treatment of hazardous substances. Ecology recognizes that permanent solutions may not be practicable for all sites and provides criteria for determining whether a cleanup action is permanent to the “maximum extent practicable” in WAC 173-340-360(3)(f). These criteria include:

- **Overall protectiveness** of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce the existing risks and attain cleanup standards, risks from implementation, and improvement of overall environmental quality.
- **Permanence**, as the degree of reduction in toxicity, mobility, and volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of the waste treatment process, and the characteristics and quantity of treatment residuals generated.
- **Cost**, including capital costs and O&M costs.
- **Long-term effectiveness**, including the degree of certainty that the alternative will be successful, long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste.
- **Management of short-term risks**, including the protection of human health and the environment associated with the alternative during construction and implementation.
- **Implementability**, including consideration of whether the alternative is technically possible, availability of necessary offsite facilities, services, and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions.
- **Consideration of public concerns**, including the extent to which the alternative addresses such concerns. This process includes identifying and addressing concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

Ecology provides a procedure referred to as a disproportionate cost analysis [DCA; WAC 173-340-360(3)(e)] to determine whether a cleanup action is permanent to the maximum extent practicable. The purpose of the DCA is to determine if the incremental increase in cost of a cleanup alternative over that of a lower cost alternative is justified by the incremental increase in benefits to human health and the environment. If the incremental increase in cost is determined to be disproportionate to the benefits, the more expensive alternative is considered impracticable and the lower cost alternative is determined to be permanent to the maximum extent practicable. This process provides a mechanism for balancing the permanence of the cleanup action with its cost, while ensuring that human health and the environment are adequately protected.

11.6.3 REQUIREMENT FOR A REASONABLE RESTORATION TIMEFRAME

WAC 173-340-360(4)(b) specifies that the following factors be considered when determining whether a cleanup action provides for a reasonable restoration timeframe:

- Potential risks to human health and the environment
- Practicability of achieving a shorter restoration timeframe
- Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site
- Availability of alternative water supplies
- Likely effectiveness and reliability of institutional controls
- Ability to control and monitor migration of hazardous substances from the site
- Toxicity of the hazardous substances at the site
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

11.6.4 REQUIREMENT FOR CONSIDERATION OF PUBLIC CONCERNS

Consideration of public concerns is an inherent part of the site cleanup process under MTCA (see WAC 173-340-600). Ecology will publish a notice in the Site Register when the Draft Final RI/FS report is received [WAC 173-340-515(4)(d)]. There will be a formal public review and comment period of 30 days, during which time comments from the public may be submitted. Those comments will be considered and addressed as applicable in the Final RI/FS and CAP.

11.7 EVALUATION OF ALTERNATIVES

This section provides an evaluation of the cleanup alternatives with respect to the MTCA criteria discussed in Section 11.6. Each cleanup action alternative must achieve the RAOs and meet the MTCA threshold requirements discussed below to be considered a viable cleanup alternative.

11.7.1 MODEL TOXICS CONTROL ACT THRESHOLD REQUIREMENTS

Each cleanup alternative must meet the following threshold requirements: 1) protect human health and the environment; 2) comply with cleanup standards; 3) comply with applicable state and federal laws; and 4) provide for compliance monitoring. Compliance with the threshold requirements for a cleanup action under MTCA is presumed by definition to be protective of human health and the environment once the cleanup action meets the cleanup standards for all affected media. Also, any cleanup action performed in accordance with the requirements of MTCA is assumed to be in compliance with cleanup standards and applicable state and federal laws. The following sections identify how each cleanup alternative complies with the threshold requirements.

11.7.1.1 Protection of Human Health and the Environment

Through a combination of remedial technologies, each of the six alternatives will protect human health and the environment. Alternatives 1 through 6 include varying degrees of removal and offsite disposal of contamination, and implementing other measures to provide protection. Residual contamination left on site after excavation under each alternative will be addressed by implementing *in situ* bioremediation. MNA would be a component of each of these alternatives if any contamination remains after the other remedial actions are complete. The following sections describe how the cleanup alternatives meet each of the threshold requirements.

11.7.1.2 Compliance with Cleanup Standards

Alternatives 1 through 6 comply with MTCA cleanup standards by achieving cleanup levels at the points of compliance for soil and groundwater (throughout the Site).

11.7.1.3 Compliance with State and Federal Laws

Through compliance with identified ARARs (Section 11.3) and compliance with MTCA regulations, Alternatives 1 through 6 comply with state and federal laws.

11.7.1.4 Provisions for Compliance Monitoring

Compliance monitoring requirements [WAC 173-340-410(1)] include protection monitoring (during construction, operation, and maintenance of the cleanup action), performance monitoring (to confirm that cleanup standards have been attained), and confirmation monitoring (to confirm the long-term effectiveness of the cleanup action once cleanup standards have been attained). Protection monitoring would be provided for Alternatives 1 through 6 through appropriate health and safety protocols outlined under a Site-specific health and safety plan.

A compliance monitoring plan will be prepared during the design phase of the cleanup action to provide specific requirements for compliance monitoring based on the cleanup alternative selected for implementation. Performance and confirmation monitoring would include collecting and analyzing soil and groundwater samples for IHS for all alternatives, and the inspection of the surface pavement capping/containment system for Alternatives 1 through 5. Long-term compliance monitoring would be conducted for all alternatives where residual contamination is present following active remediation until cleanup standards are achieved.

11.7.2 REQUIREMENT FOR A REASONABLE RESTORATION TIMEFRAME

MTCA identifies a number of factors to be considered when establishing a reasonable restoration timeframe. A cleanup action is considered to have achieved restoration once cleanup standards have been met. An evaluation of the cleanup alternatives with regard to achieving a reasonable restoration timeframe is discussed below, except that the practicability of achieving a shorter restoration timeframe is addressed as part of the DCA evaluation presented in Section 11.8. Restoration timeframe estimates are interpreted to begin at the initiation of remedial construction. The six cleanup alternatives are anticipated to achieve restoration in a reasonable timeframe, ranging from approximately 2 to 10 years.

Alternative 1 is estimated to achieve cleanup standards in approximately 8 to 10 years. After removal of the contamination sources (AST system removal, source area soil and LNAPL removal), the residual contamination would be addressed through bioremediation, followed by MNA. The excavation of 1,700 tons of soil is expected to remove approximately 35 tons of contaminant mass, or approximately 55 percent of the Site contamination by mass in the early stages of remediation. Although longer than the other alternatives, the restoration timeframe for this alternative is considered reasonable given the low risk to human health and the environment during conduct of the cleanup action.

Alternative 2 is estimated to achieve cleanup standards in approximately 5 to 8 years. Excavation in the source area of approximately 3,000 tons of soil would remove approximately 44 tons of contaminant mass, or approximately 70 percent of Site contamination by mass in the early stages of remediation. Bioremediation would address most of the remaining soil and groundwater contamination, and MNA would address any residual contamination following bioremediation, if applicable. The restoration timeframe is considered reasonable given the low potential risk to human health and the environment during conduct of the cleanup action, particularly following removal of the source area.

Alternative 3 is estimated to achieve cleanup standards in approximately 3 to 6 years. Excavation in the source area would remove the same amount of contamination as Alternative 2. Bioremediation would include active soil flushing, possibly enhanced by surfactants or other soil flushing solutions that could shorten the restoration timeframe. As with the other alternatives, this restoration timeframe estimate includes MNA to address any residual contamination following active remediation, if needed. The restoration timeframe is considered reasonable given the low potential risk to human health and the environment during conduct of the cleanup action, particularly following removal of the source of contamination.

Alternative 4 is estimated to achieve cleanup standards in approximately 5 to 8 years, the same as for Alternative 2. The additional excavation conducted as part of this alternative in comparison to Alternative 2 is not anticipated to affect the restoration timeframe. As discussed for Alternative 2, this restoration timeframe is considered reasonable.

Alternative 5 is estimated to achieve cleanup standards in approximately 3 to 6 years, the same as Alternative 3. Similar to Alternative 4, the additional excavation for this alternative in comparison to Alternative 3 is not anticipated to affect the restoration timeframe. As discussed for Alternative 3, this restoration timeframe is considered reasonable.

Alternative 6 has an estimated restoration timeframe of 2 years, which is the shortest restoration timeframe and is considered reasonable.

11.7.3 PERMANENT SOLUTIONS TO THE MAXIMUM EXTENT PRACTICABLE

MTCA requires that cleanup actions be permanent to the maximum extent practicable, and identifies a number of criteria to evaluate whether this requirement is achieved. Evaluation of the practicability of a given alternative is based on the comparative evaluation of whether the incremental increase in cost associated with increasingly protective cleanup actions is substantial and disproportionate to the incremental increase in environmental benefit. If the incremental cost is determined to be substantial and disproportionate to the incremental increase in environmental benefit, the cleanup alternative is considered impracticable and eliminated from further consideration. The remainder of this section provides a comparison of the cleanup alternatives to the permanence criteria summarized in Section 11.6.2. The evaluation of practicability is addressed in Section 11.8 (Disproportionate Cost Analysis).

11.7.3.1 Overall Protectiveness

As indicated in Section 11.6.2, overall protectiveness of human health and the environment is a measure of the degree to which existing risks are reduced, the time required to reduce existing risks at the Site and attain cleanup standards, the onsite and offsite risks resulting from implementation, and the improvement of overall environmental quality. All six cleanup alternatives are protective of human health and the environment and reduce the risk of direct contact to human and ecological receptors and the potential risk of leaching to groundwater through a combination of contamination removal, *in situ* remediation, capping/containment, and implementation of institutional controls.

Each alternative has the potential to temporarily increase onsite and offsite risks (i.e., short-term risks); they have the potential of spreading contaminated soil during construction through windblown or mechanically spread dust or dirt, or spills during transportation. However, these risks can be appropriately managed through proper design, implementation, and monitoring.

11.7.3.2 Permanence

Permanence is the degree of reduction in toxicity, mobility, and volume of hazardous substances, including the adequacy of the alternative in destruction, reduction, or elimination of hazardous substances. All six alternatives provide a high degree of permanence through removal of contamination and/or destruction through *in situ* remediation. Alternatives 1 through 5 achieve permanence through a combination of excavation and offsite treatment or disposal, and *in situ* treatment. Alternative 6 achieves permanence through excavation and offsite treatment or disposal.

11.7.3.3 Cost Estimates

Cost estimates are presented in the FS for the purpose of comparing the costs associated with the cleanup alternatives. A more detailed breakdown of the cost estimates and associated assumptions for each alternative are provided in Appendix D. These estimates were prepared using generally accepted cost estimating techniques for FS cost estimates, including cost estimating guides for civil construction, experience with similar projects, tasks, equipment, materials, and best professional judgment. Costs do not include specific quotes from subcontractors, vendors, or suppliers. An updated and more detailed cost estimate will be developed for the selected cleanup action during the design phase. Estimated costs are summarized as follows:

Alternative 1: \$1,960,000

Alternative 2: \$2,190,000

Alternative 3: \$3,030,000

Alternative 4: \$3,690,000

Alternative 5: \$4,020,000

Alternative 6: \$4,710,000

These estimated cleanup costs are consistent with an order of magnitude cost estimate, which means that actual costs are anticipated to be within –30 percent to +50 percent of the estimated cost. These costs are used as the cost basis for the DCA presented in Section 11.8.

11.7.3.4 Long-Term Effectiveness

Long-term effectiveness includes the degree of certainty that the alternative will be successful, long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste. All six of the alternatives are expected to be effective over the long term as they all have a relatively high certainty in the success and reliability of removing and/or preventing risk of exposure to human or ecological receptors.

Under WAC 3-340-360(3)(e)(iv), MTCA states that the “following types of cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: Reuse or recycling; destruction or detoxification; immobilization or solidification; onsite or offsite disposal in an engineered line and monitored facility; onsite isolation or containment with attendant engineering controls; and institutional controls and management.” By this standard, all the alternatives rely on cleanup action components with moderate long-term effectiveness. While all of the alternatives are anticipated to be effective in the long term, the level of certainty for long-term effectiveness is somewhat higher for alternatives that remove greater contaminant mass from the Site through excavation and offsite treatment/disposal, or provide greater hydraulic control along the shoreline.

11.7.3.5 Management of Short-Term Risks

Management of short-term risks includes the protection of human health and the environment associated with the alternative during construction and implementation. The degree of short-term risk for the six alternatives varies due primarily to risks associated with construction activities for the cleanup action. The short-term risks associated with implementing Alternatives 1, 2, and 3 are moderate, but easily managed. The risks are primarily related to potential accidents, worker exposure to hazardous substances during excavation of contaminated soil, damage to utilities or other infrastructure, and the transport of contaminated soil for treatment or disposal.

The short-term risks associated with Alternatives 4, 5, and 6 are higher than for Alternatives 1, 2, and 3 due to the larger volume of contaminated soil excavation and/or the complexities and uncertainties associated with excavation in close proximity to the shoreline. Excavation along the shoreline (Alternative 6) increases the short-term risks based on the presence of utilities, the potential for surface water intrusion into the excavation, and the potential for instability of the bulkhead. However, short-term risks for all alternatives are manageable with proper design, health and safety procedures, planning, and effective construction quality control during implementation.

11.7.3.6 Technical and Administrative Implementability

Implementability includes consideration of whether the alternative is technically possible; the availability of necessary offsite facilities, services, and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing facility operations and other current or potential remedial actions. The challenges related to implementability of the six alternatives vary due to differences between

the construction and/or implementation techniques, how Site conditions specifically impact those techniques, and different permitting and Site access requirements.

The relative difficulty of implementability increases from Alternative 1 to Alternative 6 based on technical implementability challenges and increasingly greater complexity in design and construction. Alternative 6 is considered far more difficult to implement technically than the other alternatives because of the higher level of complexity in excavating to greater depths, in areas with multiple utilities, and adjacent to the shoreline. Alternative 6 is also the only alternative with significant administrative implementability issues because excavation immediately adjacent to the shoreline may require a federal permit for conducting in-water work.

11.8 DISPROPORTIONATE COST ANALYSIS

MTCA regulations for remedy selection include the requirement to use permanent solutions to the maximum extent practicable. MTCA defines permanent cleanup actions as those in which cleanup standards are met without further action being required. MTCA specifies that the evaluation of whether a cleanup action uses permanent solutions to the maximum extent practicable be based on a DCA consistent with the requirements of WAC 173-340-360(3)(e). In that analysis, cleanup alternatives are arranged from most to least permanent based on the criteria specified in WAC 173-340-360(3)(f).

The DCA then compares the relative environmental benefits of each alternative to those provided by the most permanent alternative evaluated. Costs are disproportionate to benefits if the incremental cost of the more permanent alternative exceeds the incremental benefits achieved by the lower cost alternative [WAC 173-340-360(3)(e)(i)]. Alternatives that exhibit disproportionate costs are considered “impracticable.” Where the benefits of two alternatives are equivalent, MTCA specifies that the least costly alternative shall be selected [WAC 173-340-360(3)(e)(ii)(C)].

The benefits of each alternative are ranked under the criteria of the DCA [WAC 173-340-360(3)(f)] in Section 11.8.1. The costs are then compared to these benefits and the relationship between the costs and benefits determined in Section 11.8.2. This analysis then defines which alternative is permanent to the maximum extent practicable, as summarized in Table 19.

The relative rankings for the alternatives were determined by assigning a value on a scale of 1 to 10, where 10 is the highest benefit/value, for each criterion, multiplying each value by a weighting factor, and summing the weighted values to determine an overall alternative benefit ranking score. The weighting factors were developed by the Port in consultation with Ecology in 2008 as part of the RI/FS for the Central Waterfront cleanup in Bellingham Bay (ENSR Corporation 2008) to ensure an appropriate weighting is applied to each of the evaluation criteria. These weighting factors have since been used with

Ecology's approval at several waterfront cleanup sites in Bellingham and have been adopted for use in this FS. The six evaluation criteria and associated weighting factors are:

- Overall protectiveness: 30 percent
- Permanence: 20 percent
- Long-term effectiveness: 20 percent
- Short-term risk management: 10 percent
- Implementability: 10 percent
- Considerations of public concerns: 10 percent

11.8.1 COMPARATIVE EVALUATION OF ALTERNATIVES

The DCA is based on a comparative analysis of the alternatives against the six evaluation criteria identified in the previous section and discussed below. All alternatives include excavation and offsite disposal as an integral part of the cleanup action. The amount of contaminant mass removed relative to the total mass of soil excavated is a measure of the efficacy of soil removal versus *in situ* treatment for a given alternative. Figure 30 provides a plot of soil volume excavated versus the mass of contamination removed. As illustrated by the figure, the efficacy of removal decreases greatly from the first three alternatives to Alternatives 4 and 5, and again between Alternatives 4 and 5, and Alternative 6. Although not a direct measure of practicability, the significant increase in excavated soil volume relative to the mass of contaminants removed for some alternatives is reflected in both the cost for those alternatives and the relative benefits score for some of the permanence criteria.

11.8.1.1 Overall Protectiveness

Alternative 6 is ranked highest for protectiveness with a score of 10 based on the relative certainty that protectiveness will be achieved and maintained by Site-wide removal of contaminated soil and because potential future exposure risks are negligible. Alternatives 1 through 5 are progressively more protective due to the progressively increasing amount of contamination removed from the Site and increased remedial efforts that reduce the restoration timeframe.

The alternatives are ranked as follows for overall protectiveness:

Alternative 1: 4

Alternative 2: 6

Alternative 3: 7

Alternative 4: 7

Alternative 5: 8

Alternative 6: 10.

11.8.1.2 Permanence

All alternatives have a high level of permanence because all alternatives achieve cleanup standards through removal and/or *in situ* destruction of contamination. However, removal generally provides a higher level of certainty that permanence will be achieved within a reasonable restoration timeframe because heterogeneities present in geologic systems can affect the time required for *in situ* treatment to achieve treatment goals. Based on these considerations, Alternative 6 provides the greatest certainty in reducing toxicity or volume of hazardous substances at the Site and receives a ranking of 10.

Alternative 2 is considered more permanent than Alternative 1 because it removes a significantly greater mass of contamination by expanding the size of the excavation in the source area, and the presence of the large clay deposit increases the level of uncertainty in the source area. Alternative 3 is considered somewhat more permanent than Alternative 2 because it provides for more aggressive treatment in the shoreline area. The larger excavations included for Alternatives 4 and 5 are not considered substantially more permanent than Alternatives 2 and 3, respectively, because it is likely that the bioremediation included in Alternatives 2 and 3 would adequately treat the lower level of contamination present in the expanded excavation area outside of the source area in advance of achieving cleanup standards near the shoreline. Alternative 5 is considered more permanent than Alternative 4 based on the same rationale as to why Alternative 3 is considered more permanent than Alternative 2.

The alternatives are ranked as follows for permanence:

Alternative 1: 5

Alternative 2: 7

Alternative 3: 8

Alternative 4: 7

Alternative 5: 8

Alternative 6: 10.

11.8.1.3 Long-Term Effectiveness

Long-term effectiveness includes the degree of certainty that the alternative will be successful, long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste. All six alternatives are expected to be effective over the long term as they all have a relatively high certainty in the success and reliability of removing and/or preventing risk of exposure to human or ecological receptors.

Alternative 6 is given the highest long-term effectiveness score of 10 because it relies on offsite treatment/disposal as the primary mechanism for compliance with the cleanup standards, which provides for the greatest certainty that cleanup standards would be achieved throughout the Site. Alternative 2 is

more effective than Alternative 1 because it removes a significantly greater mass of contamination by expanding the size of the excavation in the source area where the presence of the large clay deposit creates the greatest level of uncertainty regarding the effectiveness of *in situ* treatment. Alternative 3 is somewhat more effective than Alternative 2 because it provides for more aggressive treatment in the shoreline area. The larger excavations included for Alternatives 4 and 5 are not anticipated to have a significant increase in long-term effectiveness over Alternatives 2 and 3, respectively, because it is likely that the bioremediation included in Alternatives 1, 2, and 3, would be effective in treating the lower level of contamination present outside of the source area in advance of achieving cleanup standards near the shoreline. Alternative 5 is somewhat more certain to achieve cleanup standards than Alternative 4 based on the same rationale as to why Alternative 3 is considered more effective in the long term than Alternative 2.

The alternatives are ranked as follows for long-term effectiveness:

Alternative 1: 5

Alternative 2: 7

Alternative 3: 8

Alternative 4: 7

Alternative 5: 8

Alternative 6: 10.

11.8.1.4 Management of Short-Term Risks

The short-term risks for remedial activities generally increase with increased excavation size, increased construction complexity, and with construction in the shoreline area. Short-term risks associated with Alternative 1 are relatively low based on the shallower excavation depth and smaller area of excavation compared to the other alternatives. The excavation volume for Alternative 2 is about 75 percent larger than Alternative 1, but is of a similar magnitude and complexity, so the short-term risks are similar. Excavation along the shoreline to install the interceptor trench for Alternative 3 significantly increases the short-term risks relative to Alternatives 1 and 2 because of the proximity of surface water and the shoring difficulties in constructing the trench immediately adjacent to the bulkhead. Alternative 4 increases the size of the excavation almost 500 percent relative to Alternative 1, which significantly increases the short-term risks associated with excavation and related activities. Alternative 5 provides the same increase in excavation volume relative to Alternative 3 and, as a result, exhibits a similar increase in short-term risk as between Alternatives 2 and 4. Alternative 6 provides the greatest level of short-term risk based on its 800 percent increase in excavation volume over Alternative 1 and the need to excavate in the immediate vicinity of the shoreline.

The alternatives are ranked as follows for short-term risk:

Alternative 1: 9

Alternative 2: 9

Alternative 3: 7

Alternative 4: 7

Alternative 5: 6

Alternative 6: 4.

11.8.1.5 Technical and Administrative Implementability

Alternative 1 was given the highest score of 10 for technical and administrative implementability based on its limited construction scope. Alternative 2 is similar in scope to Alternative 2 and was given an equivalent ranking. Alternative 3 would be more difficult to implement from a technical perspective because of the challenges associated with constructing the interceptor trench along the shoreline, and could be subject to some administrative implementability issues associated with the use of surfactants to enhance LNAPL mobility and treatment. The significantly larger excavation associated with Alternative 4 increases the technical implementability difficulty of Alternative 4 relative to Alternatives 1 and 2. Similarly, the larger excavation increases the technical implementability difficulty of Alternative 5 relative to Alternative 3. Alternative 6 provides the greatest level of technical and administrative implementability challenges due to the large size and complexity of the excavation, the proximity of surface water, and the disruption of tenant operations during construction.

The alternatives are ranked as follows for technical and administrative implementability:

Alternative 1: 10

Alternative 2: 10

Alternative 3: 7

Alternative 4: 8

Alternative 5: 5

Alternative 6: 3.

11.8.1.6 Consideration of Public Concerns

Public concerns regarding the cleanup are not yet known, but will be solicited and responded to during the draft RI/FS public comment period. For the purposes of this FS, all alternatives are given a ranking of 10 for consideration of public concerns. The evaluation of alternatives against the Consideration of Public Concerns criterion is subject to change based on public comments received on this document.

11.8.2 COMPARISON OF OVERALL BENEFITS (RELATIVE BENEFIT SCORES)

Based on receiving the highest score in the areas of overall protectiveness, Alternative 4 has the highest weighted overall benefit score. The six alternatives received similar scores for the other categories of permanence, long-term effectiveness, management of short-term risk, and implementability. The rank and relative benefit scores for each alternative are presented in Table 19, and are as follows:

Alternative 1: 6.1

Alternative 2: 7.5

Alternative 3: 7.7

Alternative 4: 7.4

Alternative 5: 7.7

Alternative 6: 8.7.

11.8.3 CONCLUSIONS AND SUMMARY OF THE DISPROPORTIONATE COST ANALYSIS

As required by MTCA for remedy selection, the costs and benefits associated with the evaluated remedial alternatives were compared using a DCA. The DCA compares the relative environmental benefits of each alternative to those provided by the most permanent alternative evaluated. Costs are disproportionate to benefits if the incremental cost of the most permanent alternative exceeds the incremental degree of benefits achieved over a lower cost alternative [WAC 173-340-360(3)(e)(i)]. Alternatives that exhibit such disproportionate costs are considered “impracticable.” Where the benefits of two alternatives are equivalent, MTCA specifies that the lower cost alternative shall be selected [WAC 173-340-360(3)(e)(ii)(C)].

The estimated costs and benefits are summarized for each alternative in Table 19. Figure 31 provides a graphical comparison between the costs of each alternative and the relative benefits. Alternative 6 provides the highest comparative overall benefit but at the highest cost. Alternative 1 could be implemented at the lowest cost, but has the lowest comparative overall benefit. The DCA provides a mechanism to determine which of the alternatives provides a permanent remedy to the maximum extent practicable by evaluating the incremental increase in cost to achieve greater overall benefits, to determine the most effective use of funding for remedial efforts, with the understanding that each of the alternatives is capable of meeting the RAOs and threshold requirements.

Because the DCA indicates that Alternative 6 yields the greatest overall benefit of the alternatives evaluated for the Site, it is considered the most permanent. Because Alternative 6 is the most permanent alternative, the relative benefits and costs for the other alternatives are compared to Alternative 6 to determine which alternative is permanent to the maximum extent practicable. As shown on Figure 31 and in Table 19, Alternative 6 has a benefit score of 8.7, and is estimated to cost approximately \$4,710,000 to

implement. The cost is approximately \$540,000 (13 percent) higher than the next most permanent alternative (Alternative 5), and the benefit to cost ratio [relative benefit / (Cost / \$1M)] for Alternative 6 (1.8) is the same as for Alternative 5. Because the cost associated with Alternative 6 is substantially more than Alternative 5 and the two alternatives have the same cost to benefit ratio, the incremental cost to implement Alternative 6 is considered substantial and disproportionate to the incremental benefit and Alternative 6 is considered impracticable in comparison to the Alternative 5. As a result, Alternative 6 is eliminated from further consideration.

Alternative 5 has a comparative benefit score of 7.7 and is estimated to cost approximately \$4,170,000. The cost is approximately \$480,000 (9 percent) higher than the next most permanent alternative (Alternative 4), and the benefit to cost ratio for Alternative 5 is 1.8 compared to 2.0 for Alternative 4. Because the cost associated with Alternative 5 is substantially more than Alternative 4, and Alternative 4 has a higher cost to benefit ratio, the incremental cost to implement Alternative 5 is considered substantial and disproportionate to the incremental benefit and Alternative 5 is considered impracticable in comparison to the Alternative 4. As a result, Alternative 5 is eliminated from further consideration.

Alternative 4 has a comparative benefit score of 7.4 and is estimated to cost approximately \$3,690,000. The cost is approximately \$660,000 (18 percent) higher than the next most permanent alternative (Alternative 3), and the benefit to cost ratio for Alternative 4 is 2.0 compared to 2.5 for Alternative 3. Because the cost associated with Alternative 4 is substantially more than Alternative 3, and this alternative has a lower benefit to cost ratio, the incremental cost to implement Alternative 4 is considered substantial and disproportionate to the incremental benefit and Alternative 4 is considered impracticable in comparison to the Alternative 3. As a result, Alternative 4 is eliminated from further consideration.

Alternative 3 has a comparative benefit score of 7.7 and is estimated to cost approximately \$3,030,000. The cost is approximately \$840,000 (38 percent) higher than the next most permanent alternative (Alternative 2), and the benefit to cost ratio for Alternative 3 is 2.5 compared to 3.4 for Alternative 2. Because the cost associated with Alternative 3 is substantially more than Alternative 2, and this alternative has a lower cost to benefit ratio, the incremental cost to implement Alternative 3 is considered substantial and disproportionate to the incremental benefit, and Alternative 3 is considered impracticable in comparison to the Alternative 2. As a result, Alternative 3 is eliminated from further consideration.

Alternative 2 has a comparative benefit score of 7.5 and is estimated to cost approximately \$2,190,000. The cost is approximately \$230,000 (12 percent) higher than the next most permanent alternative (Alternative 1), and the benefit to cost ratio for Alternative 2 is 3.4 compared to 3.1 for

Alternative 1. Alternative 2 has a higher comparative overall benefit score of 7.5, compared to 6.1 for Alternative 1, which represents a 23 percent greater relative benefit. This indicates that the increase in relative benefit of Alternative 2 over Alternative 1 (23 percent) is about twice the increase in cost (12 percent). Based on these considerations, the additional cost to implement Alternative 2 is not considered substantial and disproportionate to the incremental increase in benefit relative to Alternative 1. As a result, Alternative 2 is considered permanent to the maximum extent practicable.

12.0 FEASIBILITY STUDY SUMMARY AND CONCLUSIONS

The Site RI defined and documented physical characteristics, source areas, the nature and extent of impacted media, and the migration pathways for contaminants. Data from the RI were used in the FS process to develop and evaluate remedial alternatives for the Site.

The FS developed six remedial alternatives for the Site to clean up contaminated media delineated in the RI, evaluated the alternatives against criteria defined by MTCA, provided a comparative analysis of the alternatives to determine the relative environmental benefits of each, and compared the relative benefits of each against their costs to determine the alternative that uses the most permanent solutions to the maximum extent practicable.

12.1 PREFERRED ALTERNATIVE

The preferred alternative for a site is an assemblage of the most practicable alternatives for each area or medium of concern. Based on the DCA, Alternative 2 (Source Removal and Bioremediation) uses permanent solutions to the maximum extent practicable and has been identified as the preferred remedial alternative for the Site. Alternative 2 consists of the following elements:

- **Removal of the AST system** as a potential ongoing source of contamination.
- **Removal of the buildings** adjacent to the AST system to allow access to the subsurface to implement Site cleanup.
- **Construction of a sheetpile bulkhead** along 60 ft of shoreline to increase the effectiveness of bioremediation near the shoreline and prevent shoreline erosion.
- **Excavation** of approximately 3,000 tons of contaminated soil and the LNAPL present in the source area. The soil and LNAPL removed will be treated at an offsite thermal desorption facility or disposed of offsite at an appropriate solid waste management facility.
- **Installation and maintenance of a paved surface** to prevent direct contact with contaminated media, limit inhalation exposure to contaminated vapors (if present), and reduce surface water infiltration. The reduction of surface water infiltration reduces contamination leaching from soil or LNAPL surfaces to groundwater, where it could discharge to marine surface water, and increases the effectiveness of bioremediation treatment. The paved surface is expected to provide short-term containment during cleanup, but will likely remain intact based on the anticipated future land use as a boat yard.
- **Implementation of bioremediation** to achieve soil and groundwater cleanup levels in affected areas outside the source removal area. Bioremediation will include injection of treatment fluids into the excavated source area, infiltration via multiple infiltration trenches, and supplemental direct-injection events, if needed.
- **MNA**, if needed, to address any low-level residual contamination remaining at the conclusion of active bioremediation.
- **Compliance monitoring** to ensure cleanup standards are achieved and maintained.

12.2 IMPLEMENTATION OF SITE CLEANUP

The selected cleanup action will be presented in the Site CAP, which will describe the cleanup action and specify cleanup standards and compliance monitoring requirements. Following public review of the CAP, the cleanup will progress in a series of implementation phases, including engineering and design, permitting, construction, and long-term compliance monitoring and maintenance (as applicable).

13.0 USE OF THIS REPORT

This document has been prepared for the use of the Port of Bellingham and the Washington State Department of Ecology for specific application to the Blaine Marina Inc. Site. None of the information, conclusions, and recommendations included in this document can be used for any other project without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the Pacific Northwest under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff:

LANDAU ASSOCIATES, INC.

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Senior Project Engineer

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Principal

LDB/JMD/ccy

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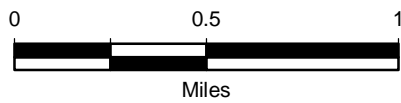
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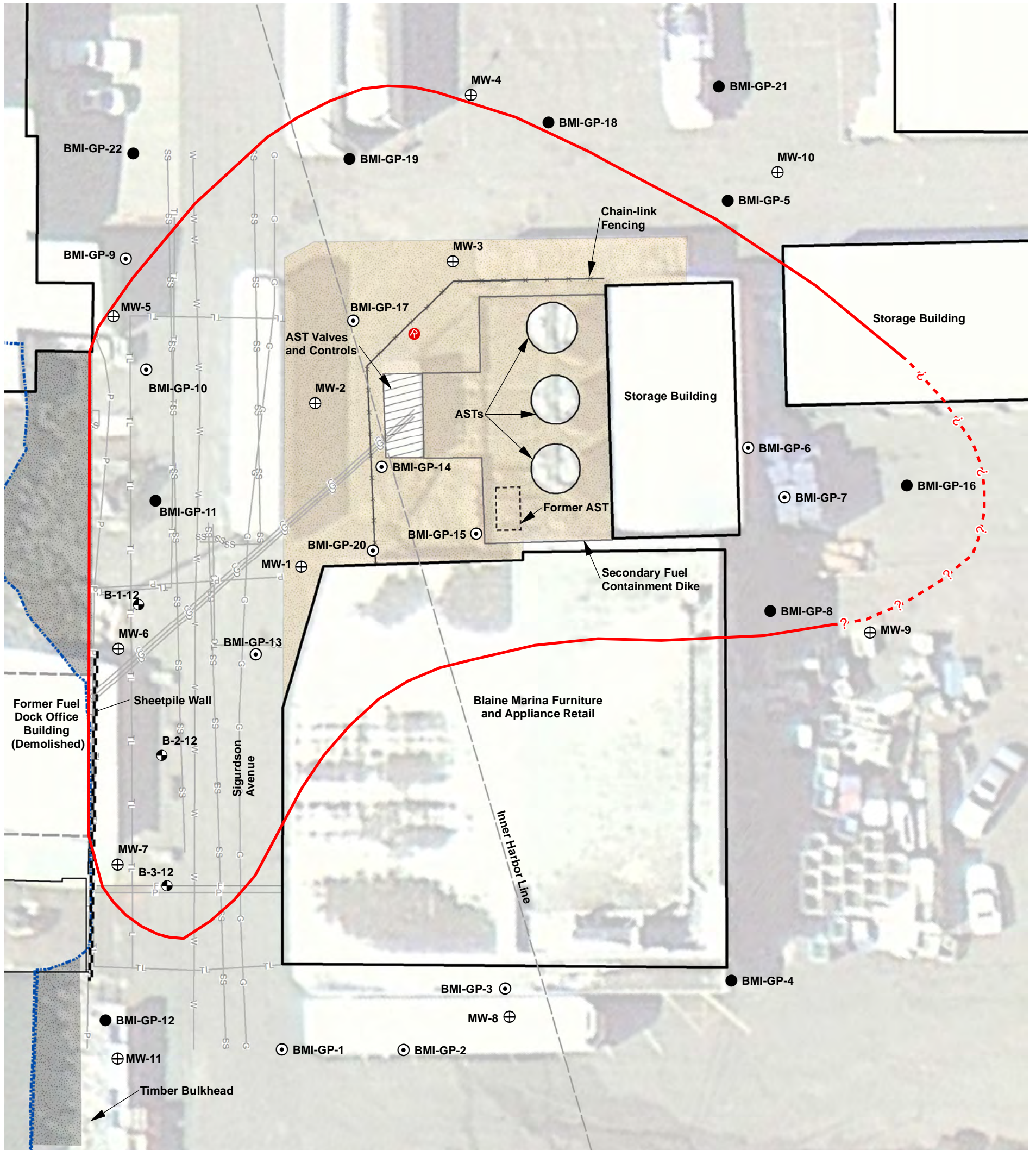
Data Source: Esri 2012

Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

Vicinity Map

Figure
1





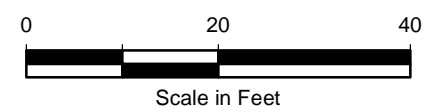
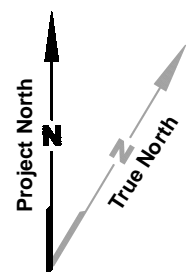
Legend

- ⊕ Groundwater Monitoring Well Location
- Soil Sample and Groundwater Grab Sample Location
- ⊙ Soil Sample Location
- ⊕ Geotechnical Boring Location
- Ⓡ Pilot LNAPL Recovery Well
- MHHW - 9.5 ft Above MLLW
- Gravel Area
- Riprap Slope
- Preliminary Site Boundary (Developed Pre-R1)

- SS— Sanitary Sewer Line
- W— Water
- F— Fire Booster Line
- IR— Irrigation Line
- F— Fuel Line
- G— Old Fuel Line
- V— Vault Line
- P— Power Line
- TC— HTCI
- TL— Telephone Line

Abbreviations

- LNAPL = Light Non-Aqueous Phase Liquid
- MHHW = Mean Higher High Water
- MLLW = Mean Lower Low Water



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

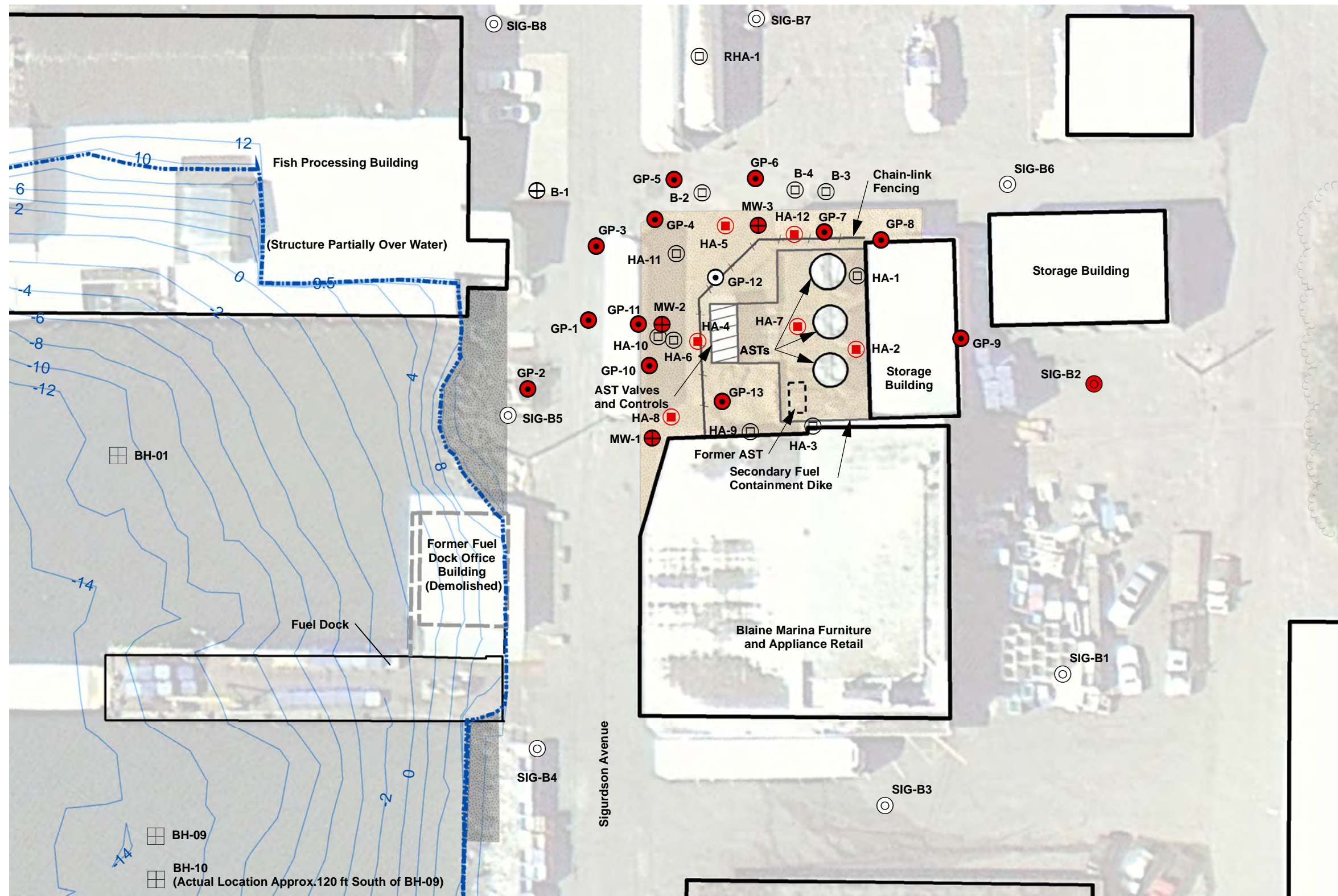


Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

Site Plan

Figure
2

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Legend

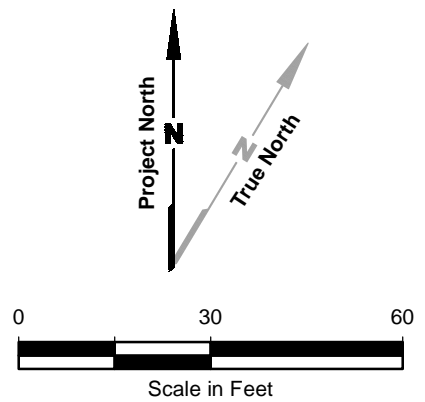
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|--|---|--|--|--|--------------------------------------|
| | Geotechnical Boring Location (Soil Sampling, Landau Associates 2012c) | | Hand Auger Location (Soil Sampling, SEACOR 1990) | | Gravel Area |
| | Surface Sediment Sample Location | | Geoprobe Location (Groundwater Sampling and Sheen Testing, RETEC 1996) | | Riprap Slope |
| | Boring Location | | Geoprobe Location (Soil Sampling, Farallon Consulting 2008) | | Mean Higher High Water - 9.5 ft MLLW |
| | Groundwater Monitoring Well Location | | 2011 Bathymetry Contours | | |

Abbreviations

MLLW = Mean Lower Low Water
COPCs = Constituents of Potential Concern

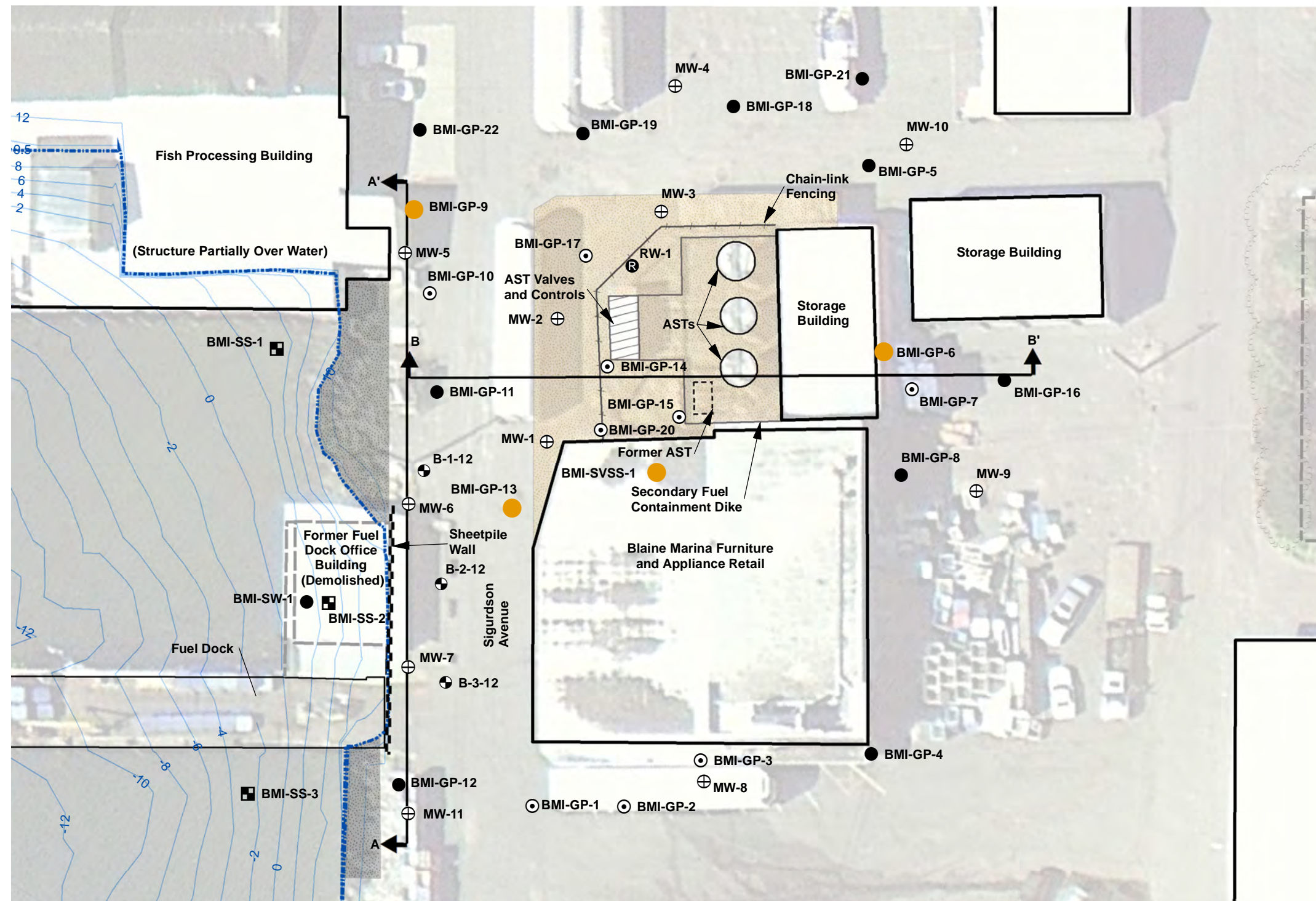
Notes

- Explorations shown in Red indicate contaminant levels exceed preliminary screening levels.
- Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Historical Investigations	Figure 3
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Legend

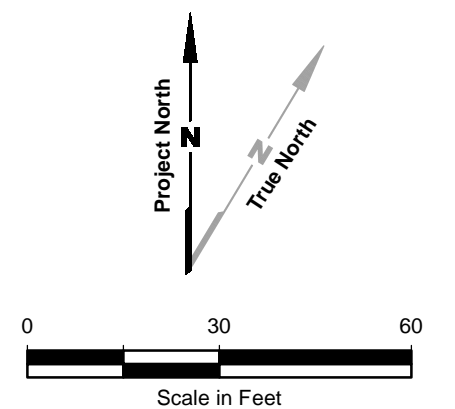
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|--|--|
| ● Soil Vapor Sample Location | ▨ Gravel Area |
| ● Grab Sample Location | ▨ Riprap Slope |
| ⊙ Soil Sample Location | ⋯ Mean Higher High Water - 9.5 ft MLLW |
| ▣ Surface Sediment Sample Location | — Bathymetry Contours |
| ⊕ Geotechnical Soil Boring | ↕ Cross-Section Location |
| Ⓡ Pilot LNAPL Recovery Well | |
| ⊕ Groundwater Monitoring Well Location | |

Abbreviations

LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

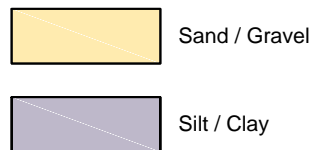


Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

LANDAU ASSOCIATES, INC. | G:\Projects\0010340101018\F5\F6 Sections.dwg (A) - Figure 5 - 4/7/2015

Legend

- B-1-12 — Project Exploration Designation
- (Offset 2' N) — Offset Distance in Feet and Direction
- Top of Exploration
- SM — USCS Letter Symbol (See Appendix B for Definitions)
- Interpreted Geological Contact
- Approximate Groundwater Table
- Bottom of Exploration

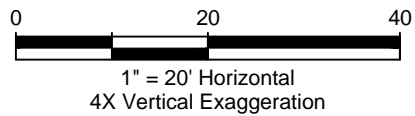
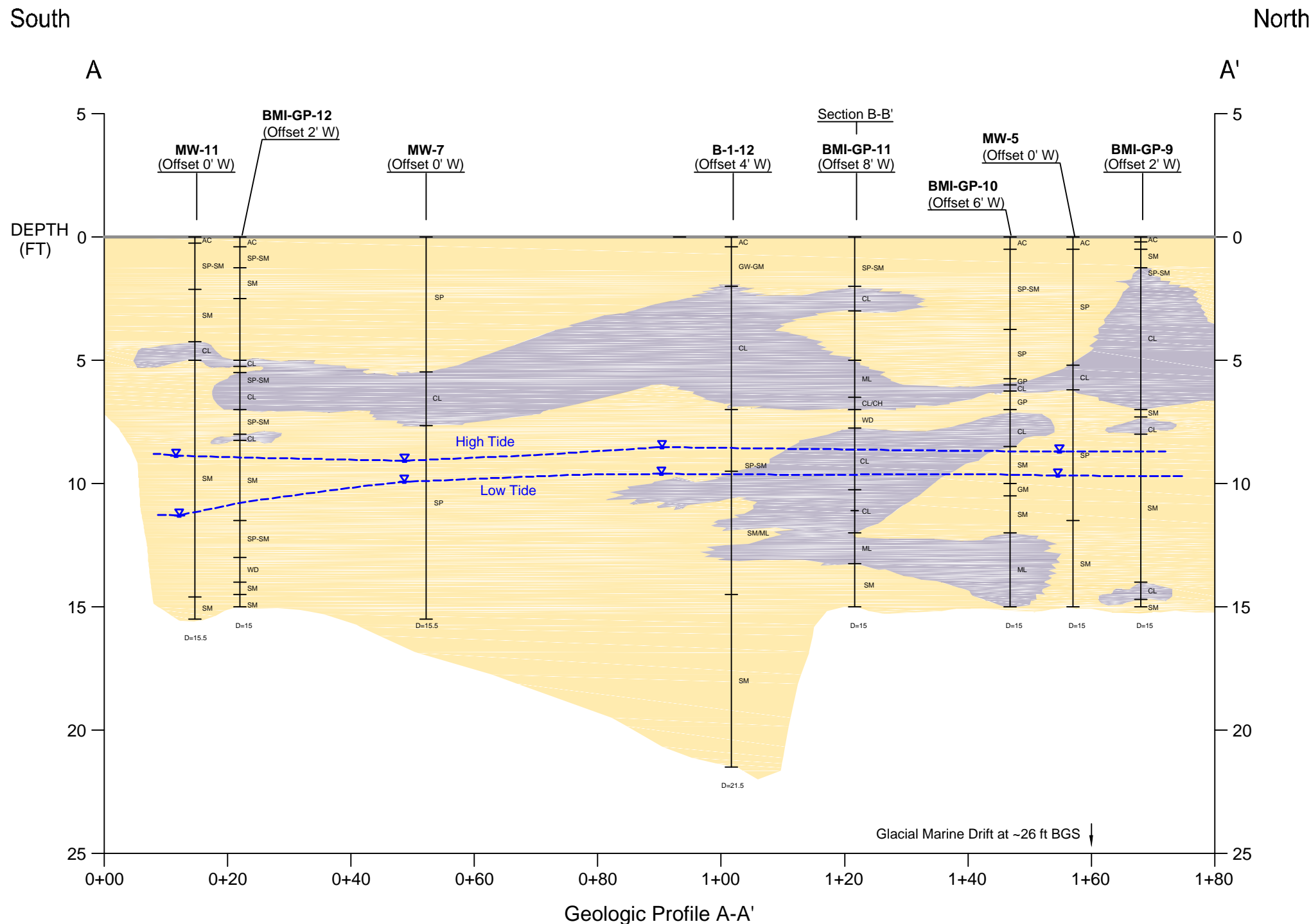


Abbreviations

USCS = Unified Soil Classification System

Notes

1. Soil descriptions are generalized based on interpretation of field and laboratory data.
2. Stratigraphic contacts are interpolated between borings and actual conditions may vary.
3. See Appendix B for boring logs and descriptions of geologic units.
4. For cross-section location, see Figure 4.
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



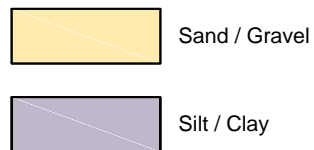
Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Geologic Cross-Section A-A'	Figure 5
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LANDAU ASSOCIATES, INC. | G:\Projects\0010340101018\F5\F6 Sections.dwg (A) - Figure 6 - 4/7/2015

Legend

- B-1-12 — Project Exploration Designation
- (Offset 2' N) — Offset Distance in Feet and Direction
- Top of Exploration
- SM — USCS Letter Symbol (See Appendix B for Definitions)
- Interpreted Geological Contact
- Approximate Groundwater Table
- Bottom of Exploration

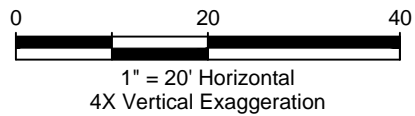
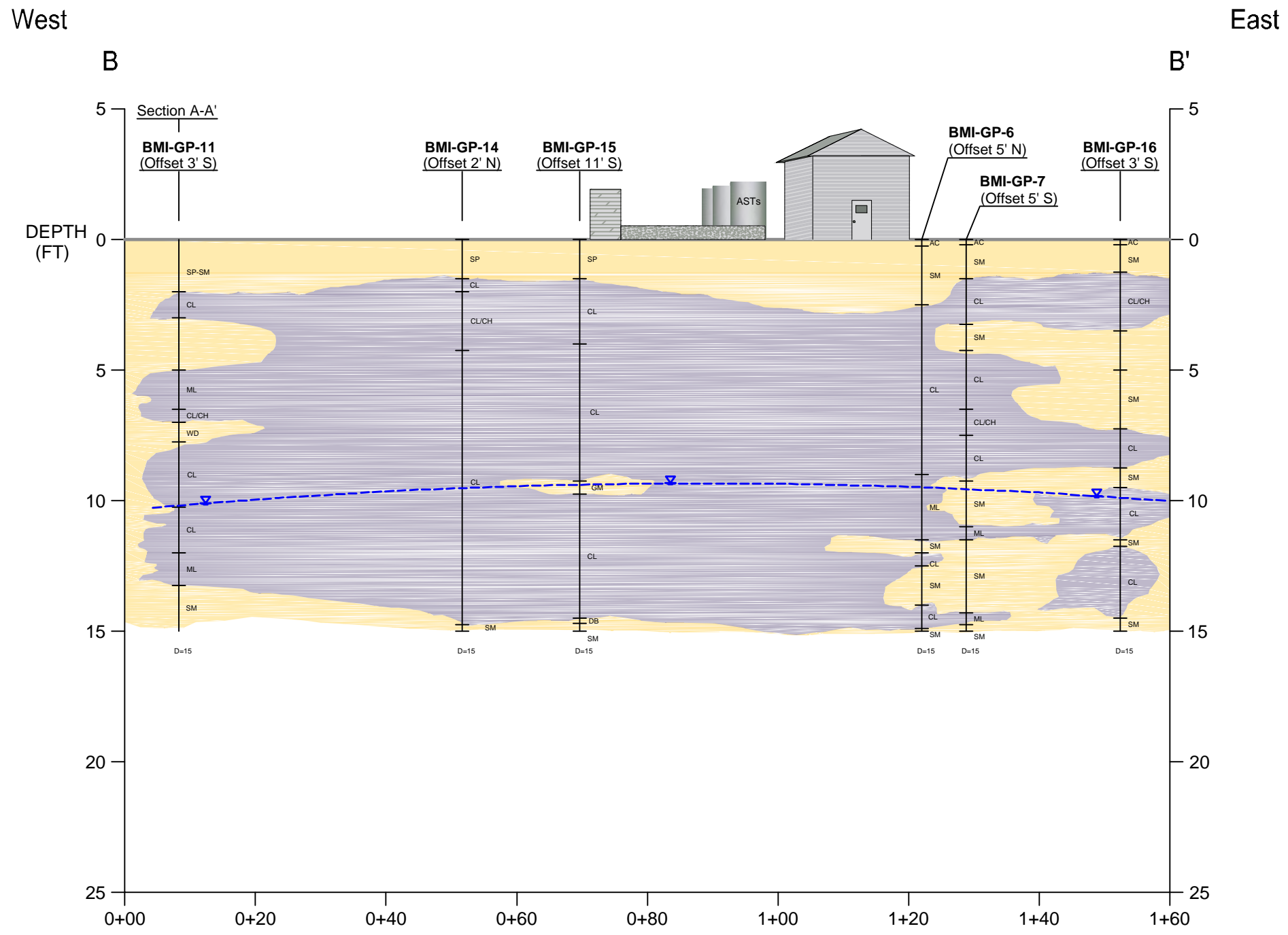


Abbreviations

USCS = Unified Soil Classification System

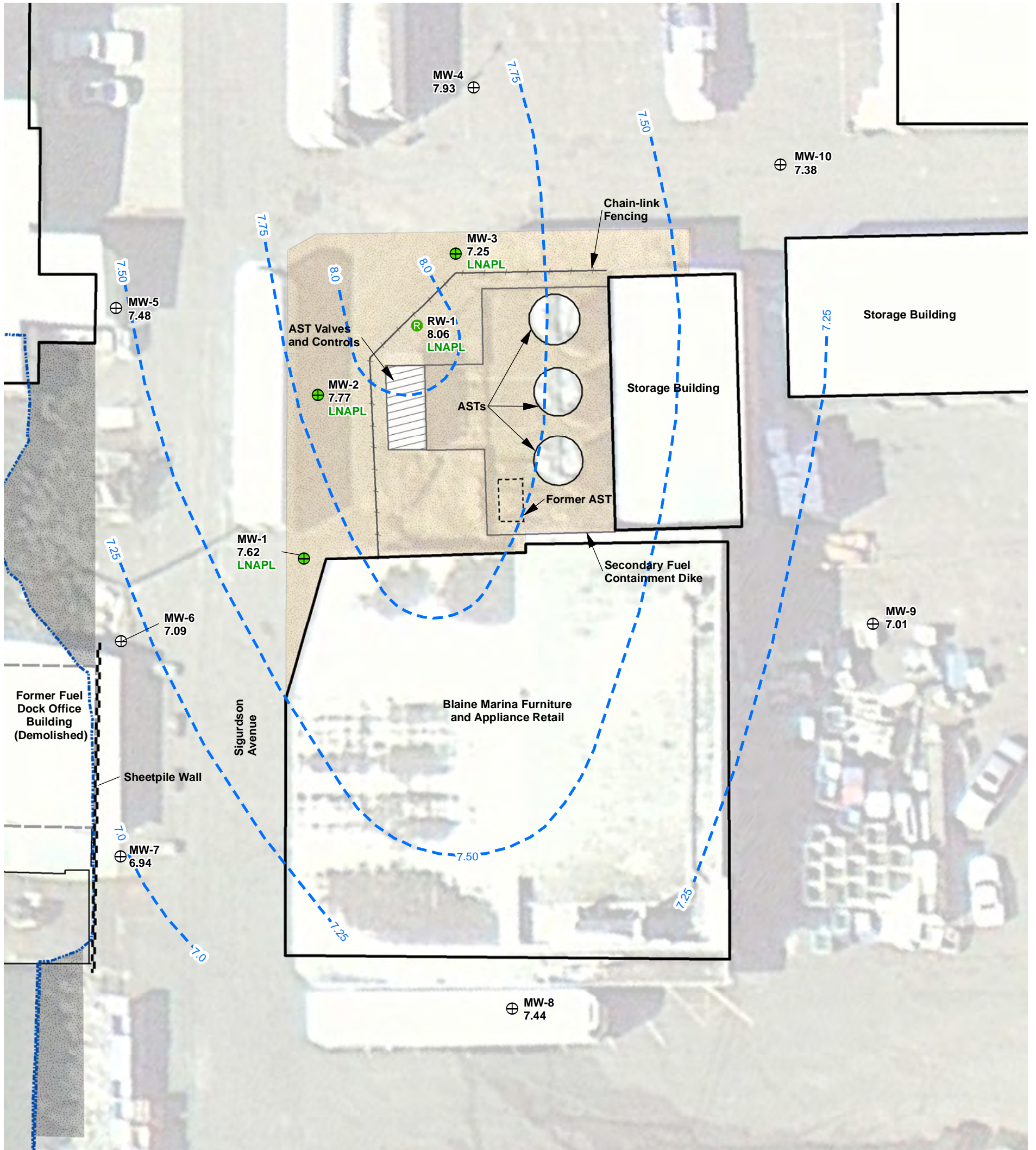
Notes

1. Soil descriptions are generalized based on interpretation of field and laboratory data.
2. Stratigraphic contacts are interpolated between borings and actual conditions may vary.
3. See Appendix B for boring logs and descriptions of geologic units.
4. For cross-section location, see Figure 4.
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Geologic Cross-Section B-B'	Figure 6
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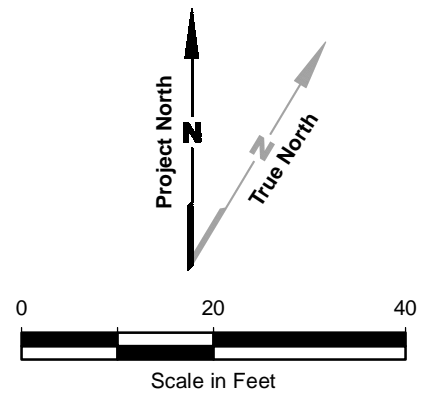


Legend

- ⊕ Groundwater Monitoring Well Location
- 6.94 Groundwater Elevation in ft
- Groundwater Elevation in ft
- LNAPL Corrected for Presence of LNAPL
- Ⓡ Pilot LNAPL Recovery Well
- Approximate Groundwater Elevation Contour (ft above MLLW)
- Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Riprap Slope

Abbreviations

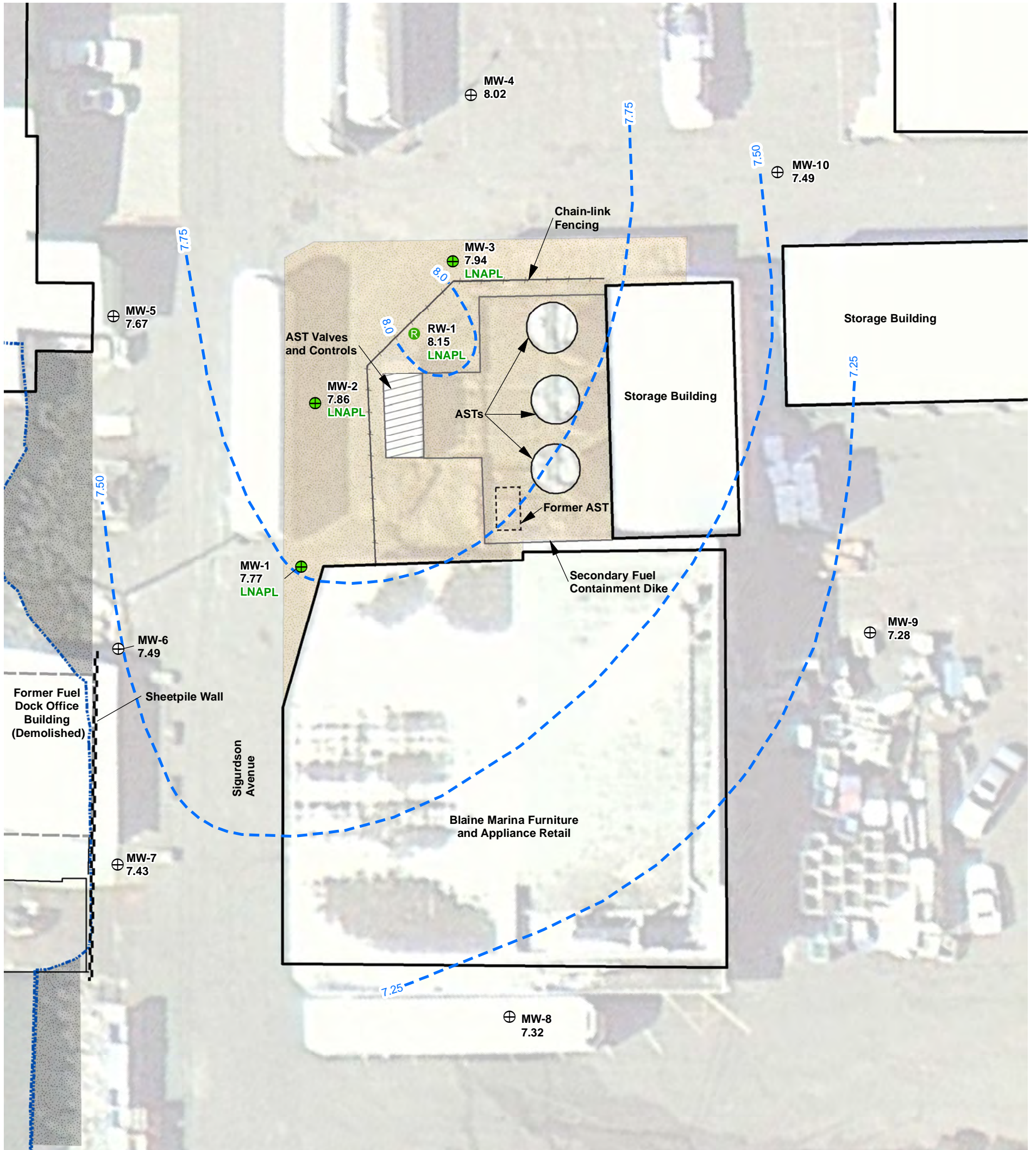
LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water



Notes

1. Groundwater elevations measured on April 24, 2013 at low tide.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



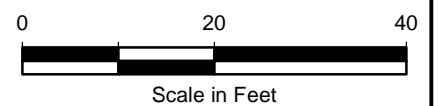
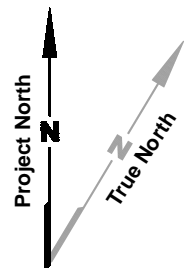
Legend

- ⊕ Groundwater Monitoring Well Location
- 7.93 Groundwater Elevation in ft
- Groundwater Elevation in ft
- LNAPL Corrected for Presence of LNAPL
- Ⓡ Pilot LNAPL Recovery Well

- - - Approximate Groundwater Elevation Contour (ft above MLLW)
- - - Mean Higher High Water - 9.5 ft MLLW
- ▨ Gravel Area
- ▨ Riprap Slope

Abbreviations

LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water



Notes

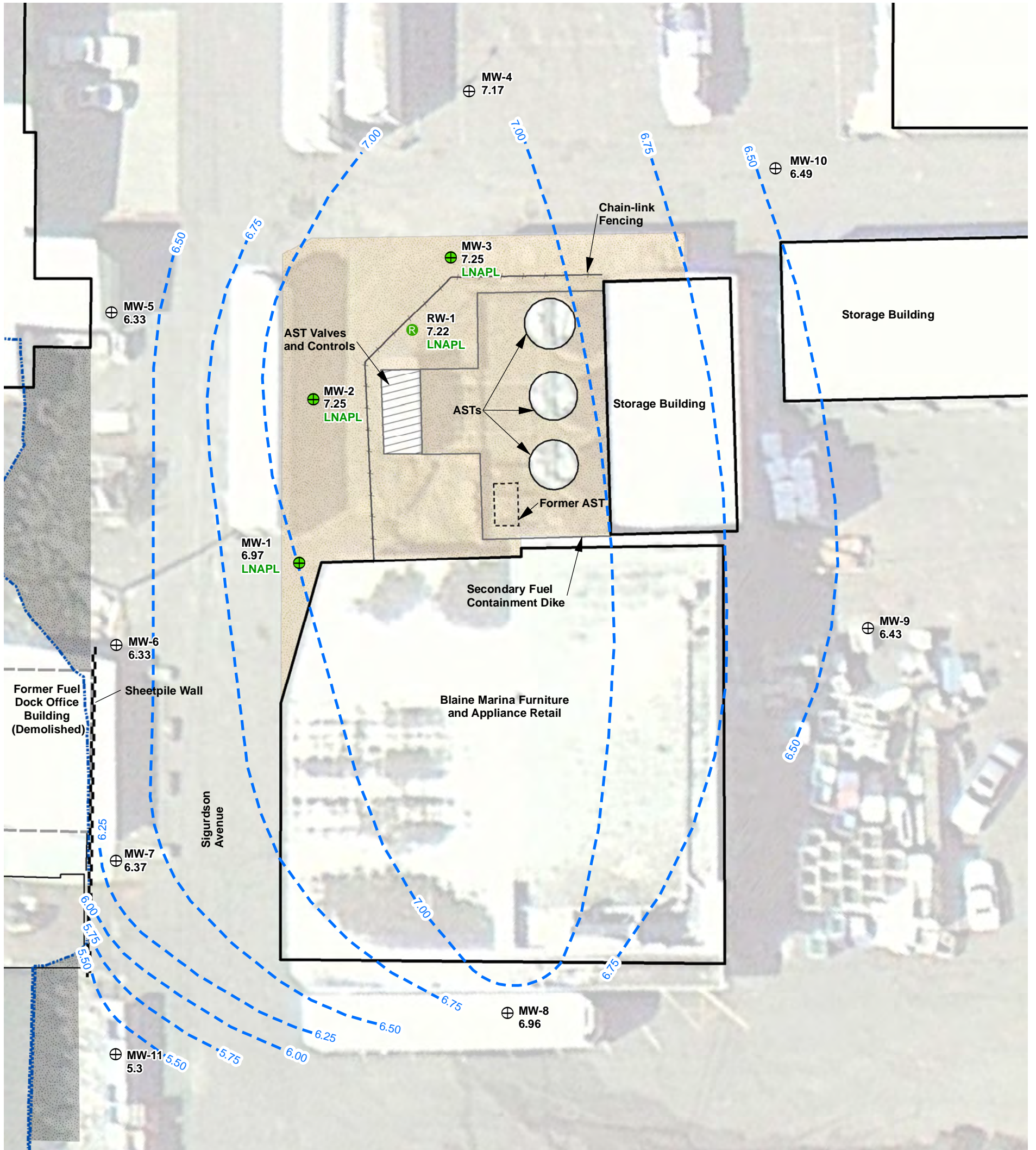
1. Groundwater elevations measured on April 24, 2013 at high tide.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Blaine Marina Inc. Site
 Blaine Harbor
 Blaine, Washington

**Groundwater Elevation Contours
 Wet Season - High Tide**

Figure
8

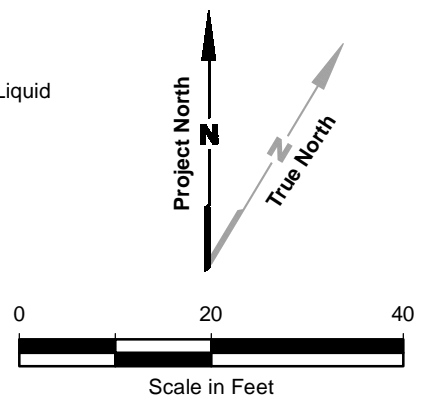


Legend

- ⊕ Groundwater Monitoring Well Location
- 7.93 Groundwater Elevation in ft
- Groundwater Elevation in ft
- LNAPL Corrected for Presence of LNAPL
- Ⓡ Pilot LNAPL Recovery Well
- Approximate Groundwater Elevation Contour (ft above MLLW)
- Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Riprap Slope

Abbreviations

- LNAPL = Light Non-Aqueous Phase Liquid
- MLLW = Mean Lower Low Water



Notes

1. Groundwater elevations measured on August 29, 2013 at low tide.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

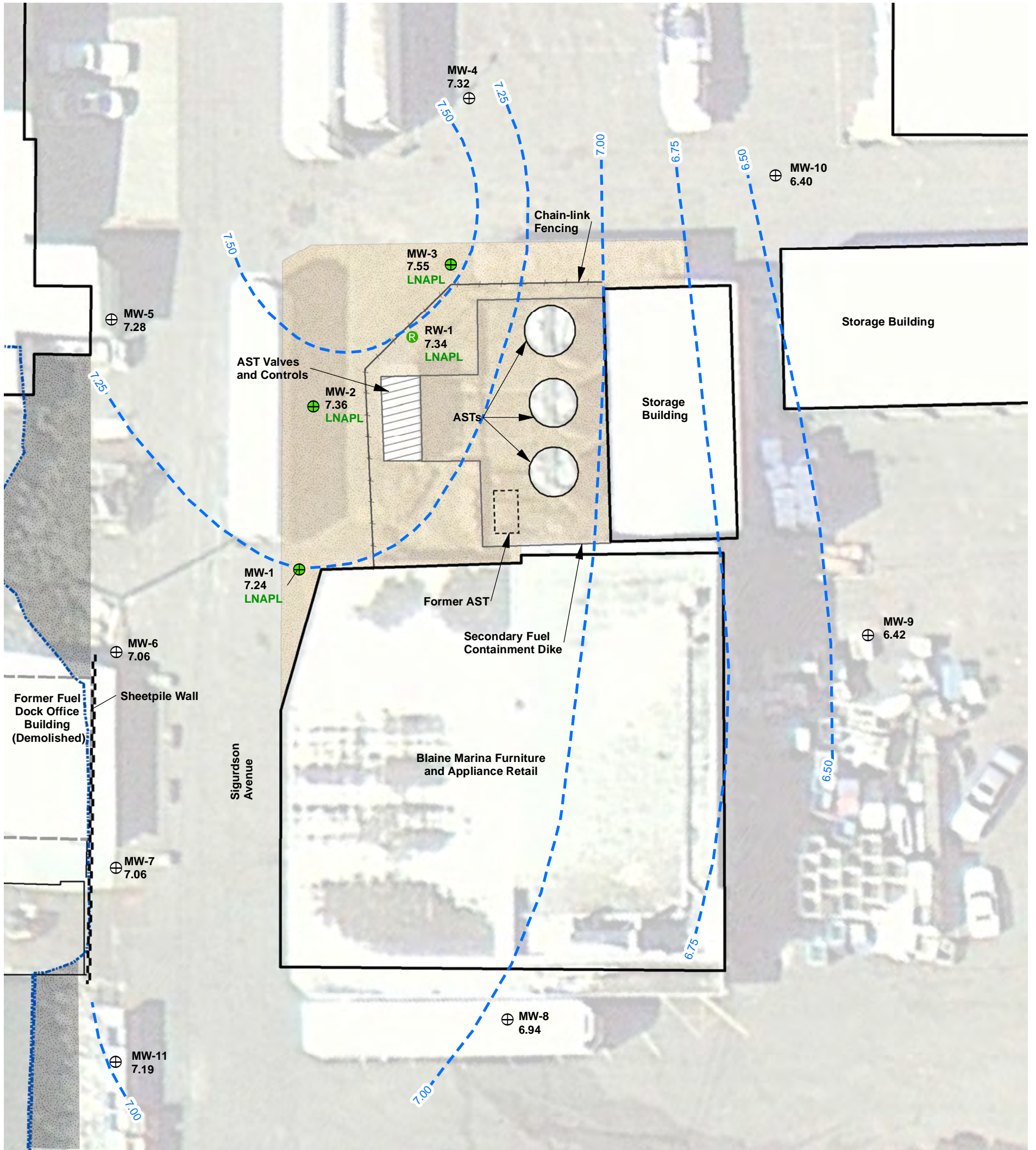
Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

Groundwater Elevation Contours
Dry Season - Low Tide

Figure
9

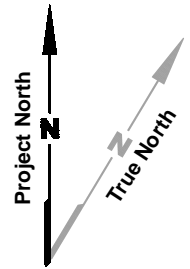


Legend

- ⊕ Groundwater Monitoring Well Location
- 7.19 Groundwater Elevation in ft
- Groundwater Elevation in ft
- LNAPL Corrected for Presence of LNAPL
- Ⓡ Pilot LNAPL Recovery Well
- Approximate Groundwater Elevation Contour (ft above MLLW)
- Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Riprap Slope

Abbreviations

LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water



Notes

1. Groundwater elevations measured on August 28, 2013 at near high tide.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

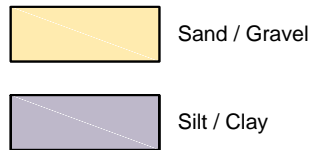


Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Groundwater Elevation Contours Dry Season - High Tide	Figure 10
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LANDAU ASSOCIATES, INC. | G:\Projects\0010340101018\F11 F12 Sections.dwg (A) "Figure 11" 4/7/2015

Legend

- B-1-12 — Project Exploration Designation
- (Offset 2' N) — Offset Distance in Feet and Direction
- Top of Exploration
- SM — USCS Letter Symbol (See Appendix B For Definitions)
- Interpreted Geological Contact
- Approximate Groundwater Table
- Vertical Extent of Observed Contamination Based on Field Observations and Laboratory Analytical Data
- Bottom of Exploration



Abbreviations

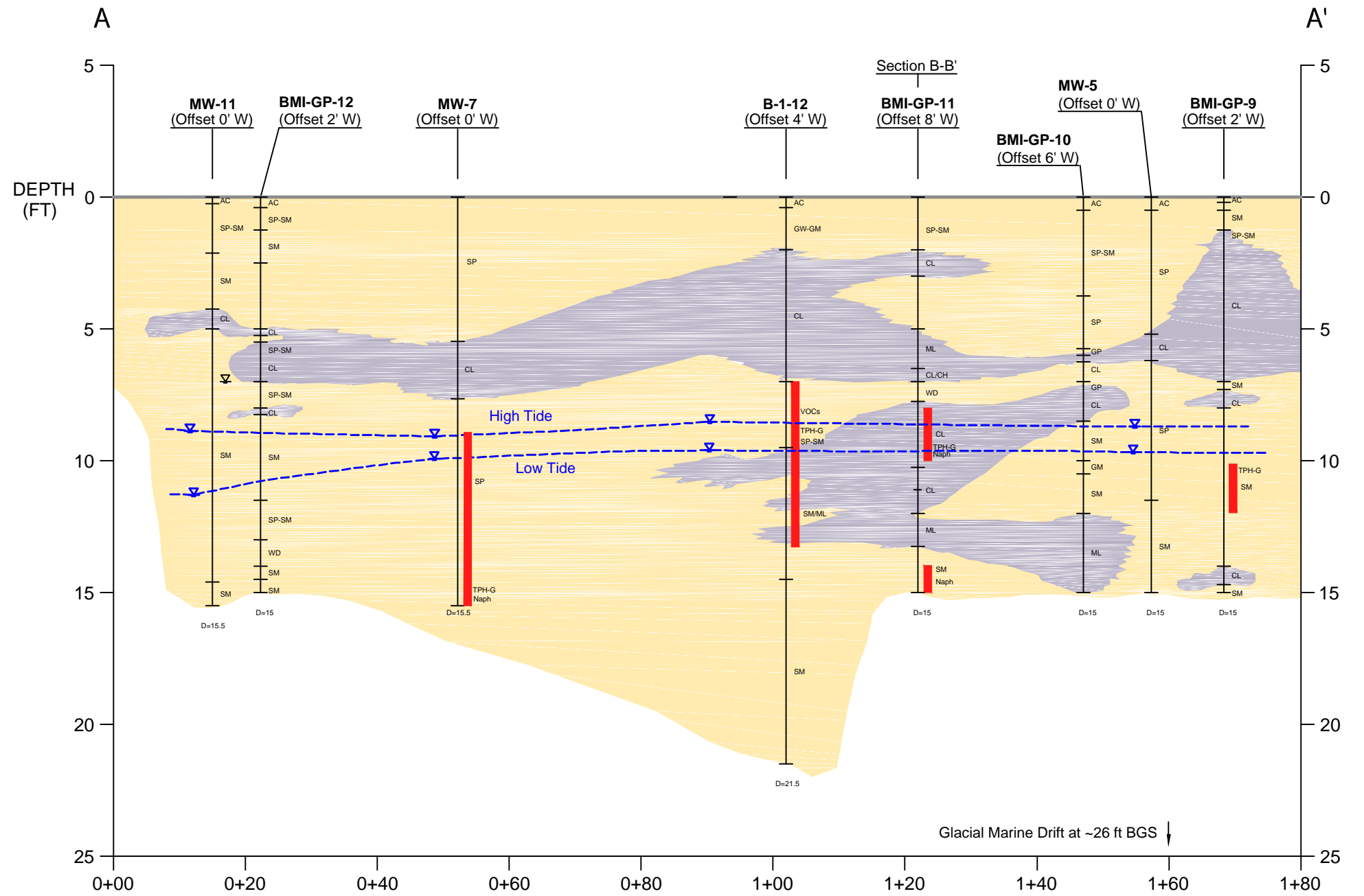
- Naph = Naphthalenes Exceed Site Screening Levels
- VOCs = Volatile Organic Compounds Exceed Site Screening Levels
- TPH-G = Gasoline-Range Organics Exceed Site Screening Levels
- USCS = Unified Soil Classification System
- BGS = Below Ground Surface

Notes

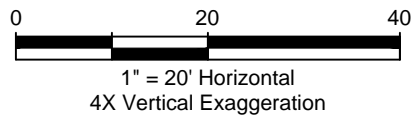
1. Soil descriptions are generalized based on interpretation of field and laboratory data.
2. Stratigraphic contacts are interpolated between borings and actual conditions may vary.
3. See Appendix B for boring logs and descriptions of geologic units.
4. For cross-section location, see Figure 4.
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

South

North



Geologic Profile A-A'



Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

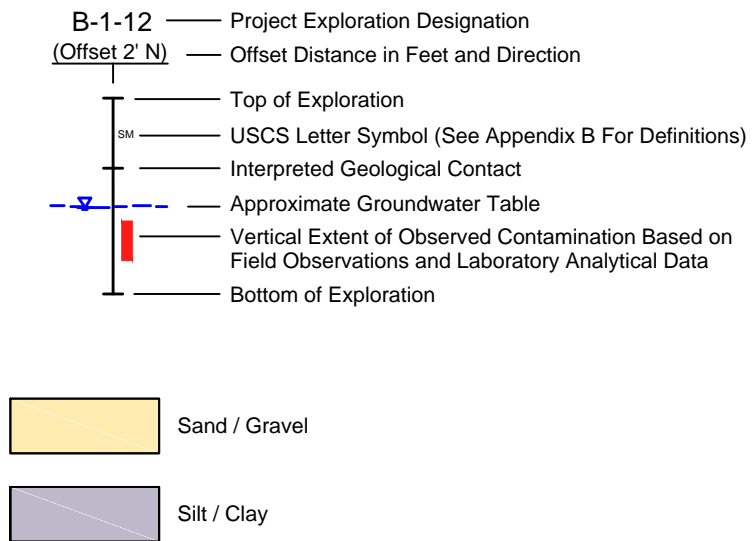
Soil Contamination

Figure
11



LANDAU ASSOCIATES, INC. | G:\Projects\001034\01018\F11 F12 Sections.dwg (A) "Figure 12" 4/7/2015

Legend

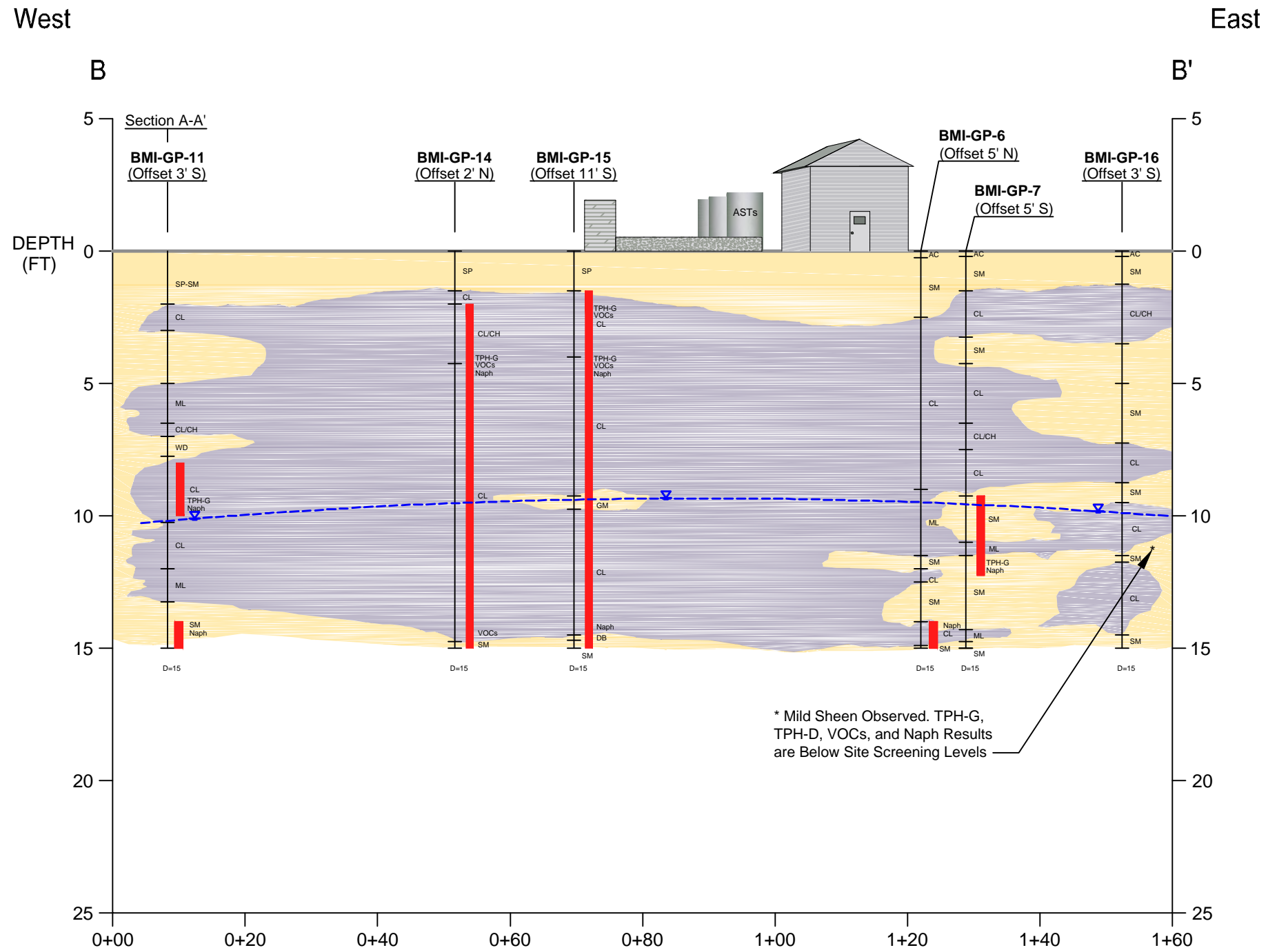


Abbreviations

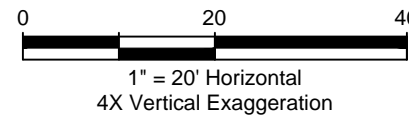
Naph = Naphthalenes Exceed Site Screening Levels
 VOCs = Volatile Organic Compounds Exceed Site Screening Levels
 TPH-G = Gasoline-Range Organics Exceed Site Screening Levels
 TPH-D = Diesel-Range Organics
 USCS = Unified Soil Classification System

Notes

1. Soil descriptions are generalized based on interpretation of field and laboratory data.
2. Stratigraphic contacts are interpolated between borings and actual conditions may vary.
3. See Appendix B for boring logs and descriptions of geologic units.
4. For cross-section location, see Figure 4.
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Geologic Profile B-B'

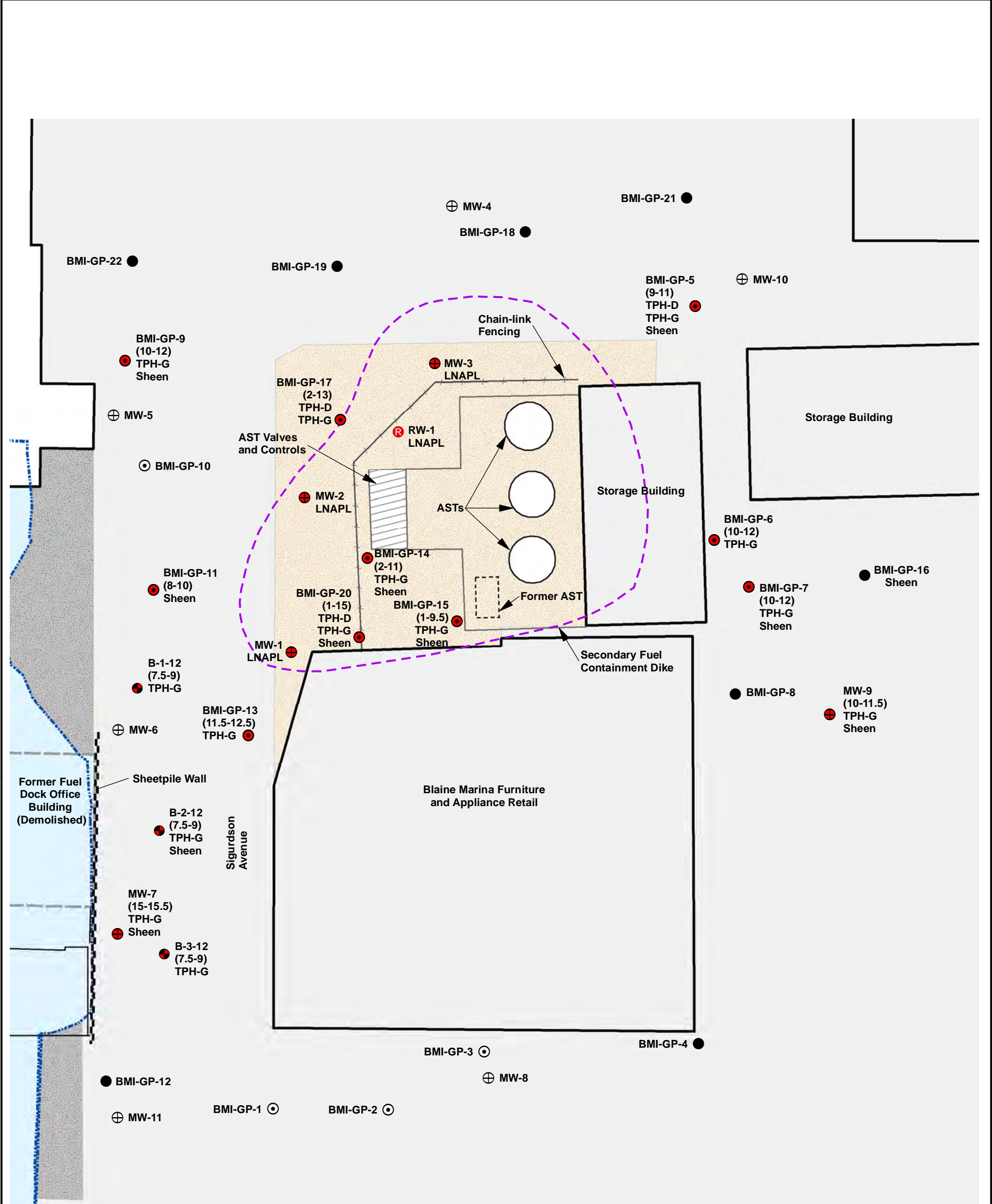


Blaine Marina Inc. Site
 Blaine Harbor
 Blaine, Washington

; Yc`c [JW7 f cgg! GYW]cb`6`!6 fi
Soil Contamination

Figure
12





Legend

- ⊕ Groundwater Monitoring Well Location
- (8-10) Depth Interval in ft of Screening Level Exceedance
- Soil and Groundwater Grab Sample Location
- ⊙ Soil Sample Location
- ⊕ Geotechnical Boring Location
- Ⓡ Pilot LNAPL Recovery Well
- - - Approximate Extent of Accumulated Free Product on Groundwater Surface
- - - Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Paved Surface
- Riprap Slope
- Water

Notes

1. Observations of sheen aided by hydrophobic dye testing. No measurable thickness of free product observed at these locations.
2. Where LNAPL is indicated, a measurable thickness was observed accumulated on the groundwater surface. Soil is assumed to be contaminated at these locations.
3. Explorations shown in Red indicate detected concentrations exceed the screening level.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

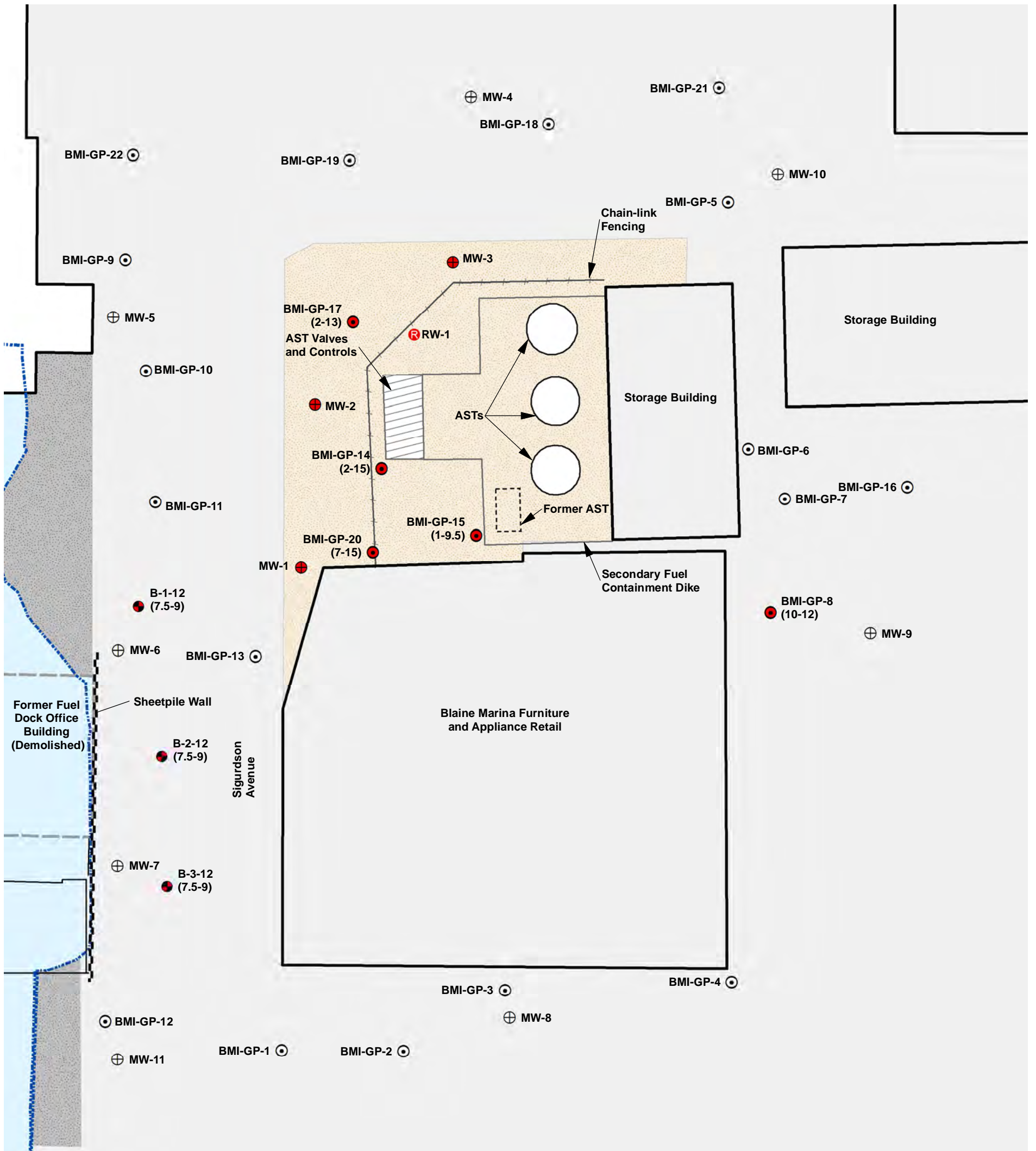
Abbreviations

ft = Feet
 LNAPL = Light Non-Aqueous Phase Liquid
 TPH = Total Petroleum Hydrocarbons
 TPH-D = Diesel Range TPH
 TPH-G = Gasoline Range TPH
 MLLW = Mean Lower Lower Water

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Total Petroleum Hydrocarbons in Soil	Figure 13
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Legend

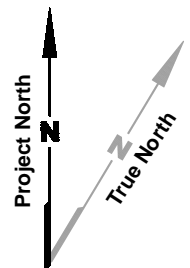
- ⊕ Groundwater Monitoring Well Location
- (7-15) Depth Interval in ft of Screening Level Exceedance
- ⊙ Soil Sample Location
- ⊕ Geotechnical Boring Location
- Ⓡ Pilot LNAPL Recovery Well
- Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Paved Surface
- Riprap Slope
- Water

Abbreviations

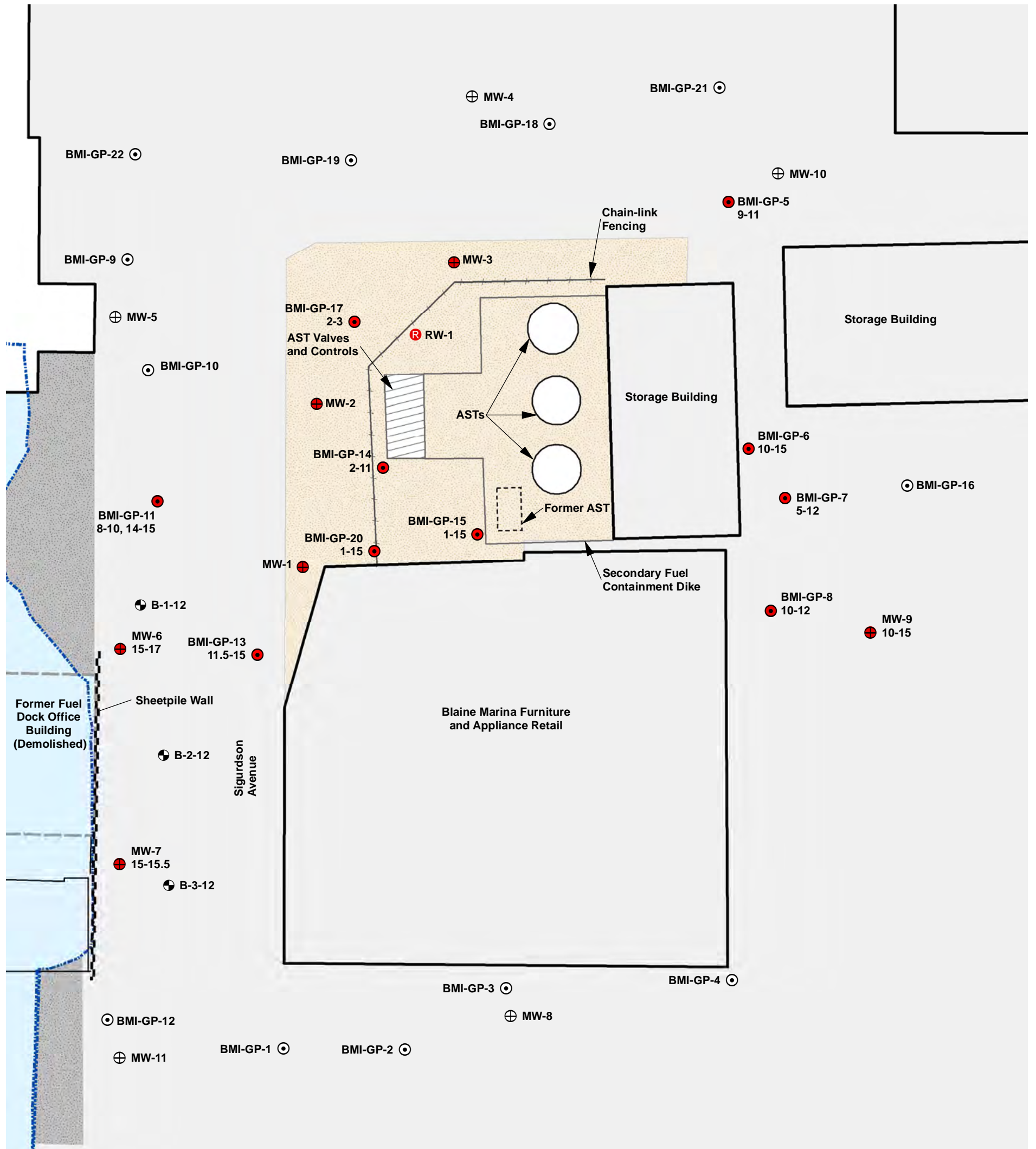
ft = Feet
 LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water
 VOCs = Volatile Organic Compounds

Notes

1. Explorations shown in Red indicate detected concentrations exceed the screening level.
2. Where LNAPL is indicated, a measurable thickness was observed accumulated on the groundwater surface. Soil is assumed to be contaminated at these locations.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



Legend

- ⊕ Groundwater Monitoring Well Location
- (8-10) Depth Interval in ft of Screening Level Exceedance
- ⊙ Soil Sample Location
- ⊕ Geotechnical Boring Location
- Ⓡ Pilot LNAPL Recovery Well
- - - Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Paved Surface
- Riprap Slope
- Water

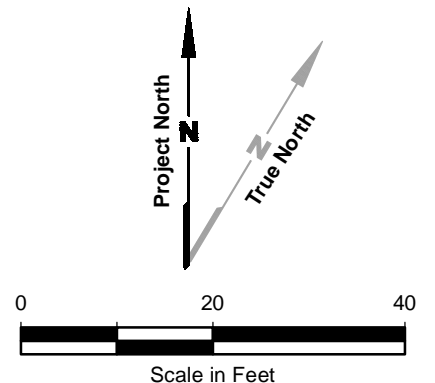
Notes

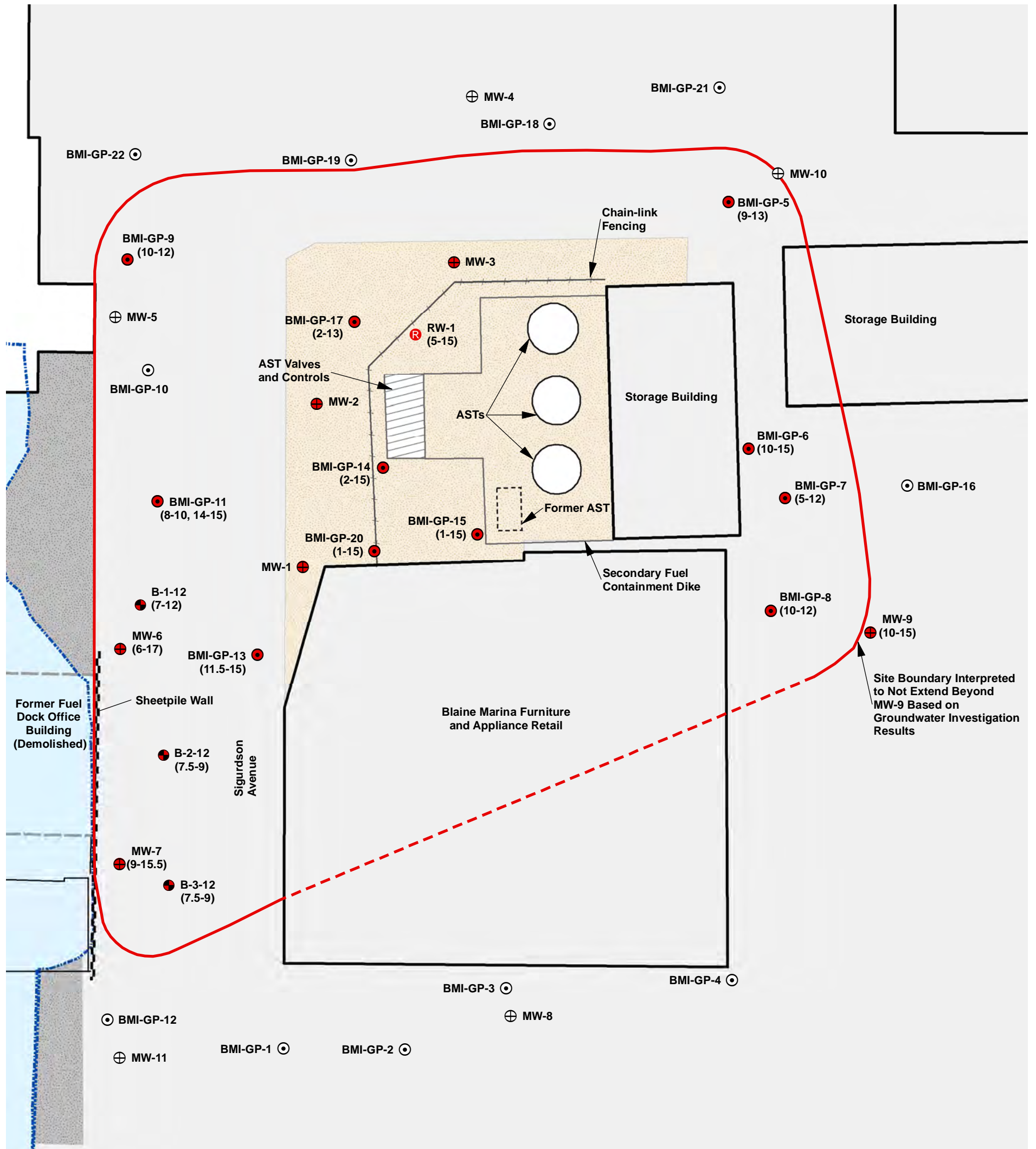
1. Explorations shown in Red indicate detected concentrations exceed the screening level.
2. Where LNAPL is indicated, a measurable thickness was observed accumulated on the groundwater surface. Soil is assumed to be contaminated at these locations.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Abbreviations

ft = Feet
 LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



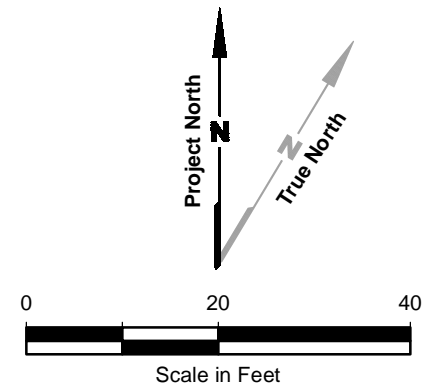


Legend

- ⊕ Groundwater Monitoring Well Location
- (8-10) Depth Interval of Impacts Based on Screening Level Exceedances and/or Field Screening Results
- ⊙ Soil Sample Location
- ⊕ Geotechnical Boring Location
- Ⓡ Pilot LNAPL Recovery Well
- Mean Higher High Water - 9.5 ft MLLW
- Site Boundary
- Gravel Area
- Paved Surface
- Riprap Slope
- Water

Notes

1. Explorations shown in Red indicate detected concentrations exceed the screening level.
2. Where LNAPL is indicated, a measurable thickness was observed accumulated on the groundwater surface. Soil is assumed to be contaminated at these locations.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



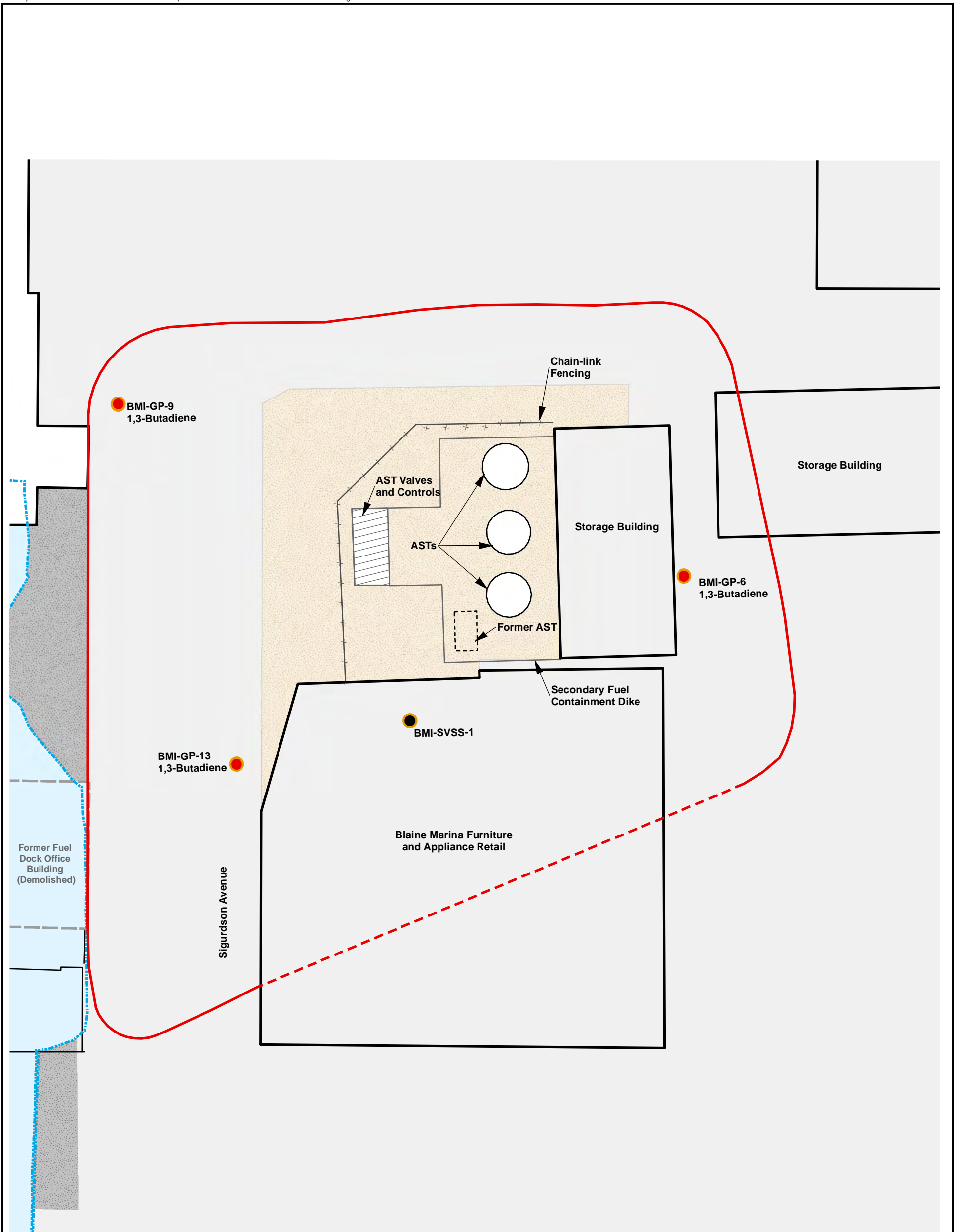
Abbreviations

ft = Feet
 LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water

Blaine Marina Inc. Site
 Blaine Harbor
 Blaine, Washington

Extent of Soil Contamination

Figure
16

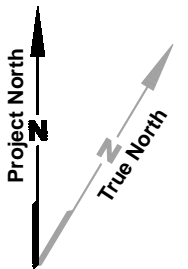
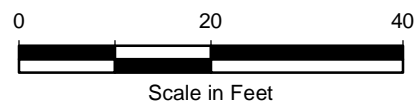


Legend

- Soil Vapor Sample Location
- Concentration Exceeds Screening Level
- Concentration Below Screening Level
- Site Boundary
- Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Paved Surface
- Riprap Slope
- Water

Abbreviations

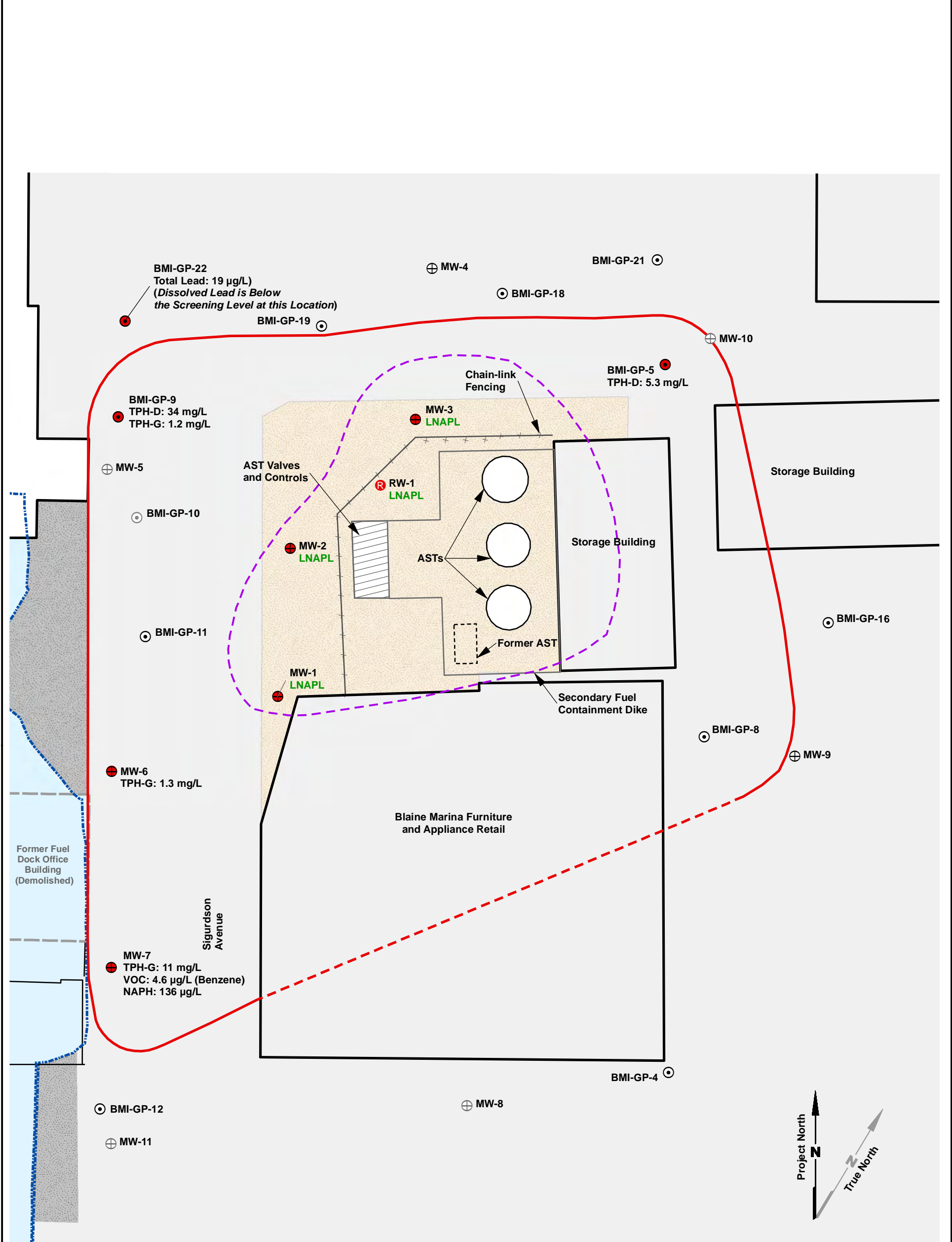
MLLW = Mean Lower Low Water



Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



Legend

- Groundwater Grab Sample Location
- Groundwater Monitoring Well
- Pilot LNAPL Recovery Well
- Site Boundary
- Approximate Extent of Accumulated Free Product on Groundwater Surface
- Mean Higher High Water - 9.5 ft MLLW
- Gravel Area
- Paved Surface
- Riprap Slope
- Water

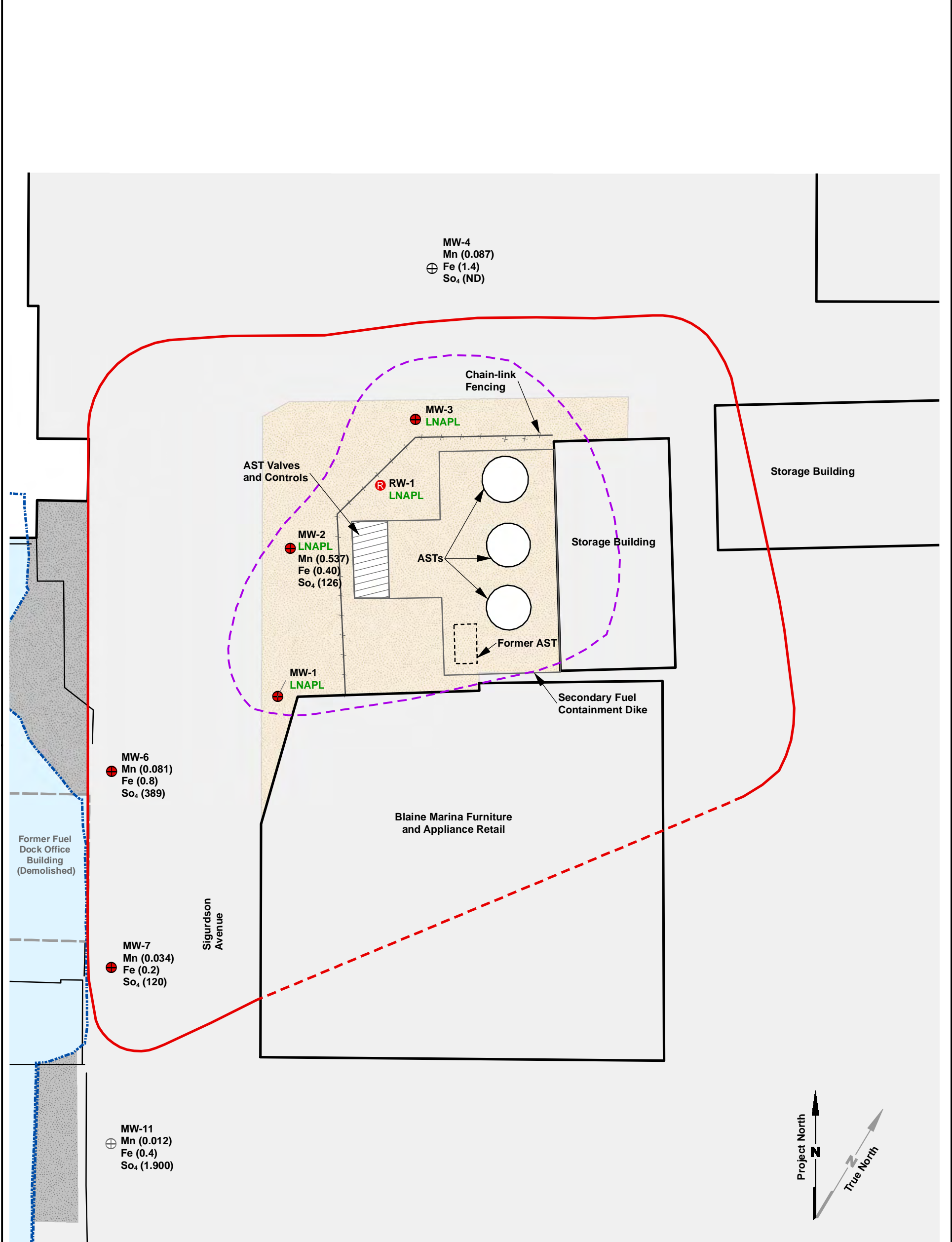
Abbreviations

COPCs = Constituents of Potential Concern
 TPH-D = Diesel
 TPH-G = Gasoline
 LNAPL = Light Non-Aqueous Phase Liquid
 NAPH = Naphthalenes
 VOC = Volatile Organic Compounds
 MLLW = Mean Lower Low Water
 mg/L = Milligrams per Liter
 µg/L = Micrograms per Liter

Notes

- Explorations shown in **Red** indicate detected concentrations exceed screening levels.
- Explorations shown in **Black** indicate detected concentrations are below screening level.
- Explorations shown in **Gray** indicate COPCs were not detected.
- Where LNAPL is indicated, a measurable thickness was observed accumulated on the groundwater surface.
- Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



Legend

- ⊕ Groundwater Monitoring Well
- Ⓡ Pilot NAPL Recovery Well
- Site Boundary
- - - Approximate Extent of Accumulated Free Product on Groundwater Surface
- · - · - Mean Higher High Water - 9.5 ft MLLW

- Gravel Area
- Paved Surface
- Riprap Slope
- Water

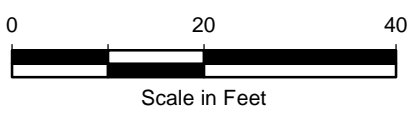
Abbreviations

- Fe = Dissolved Iron
- LNAPL = Light Non-Aqueous Phase Liquid
- MLLW = Mean Lower Low Water
- mg/L = Milligrams Per Liter
- Mn = Dissolved Manganese
- ND = Not Detected
- SO₄ = Sulfate

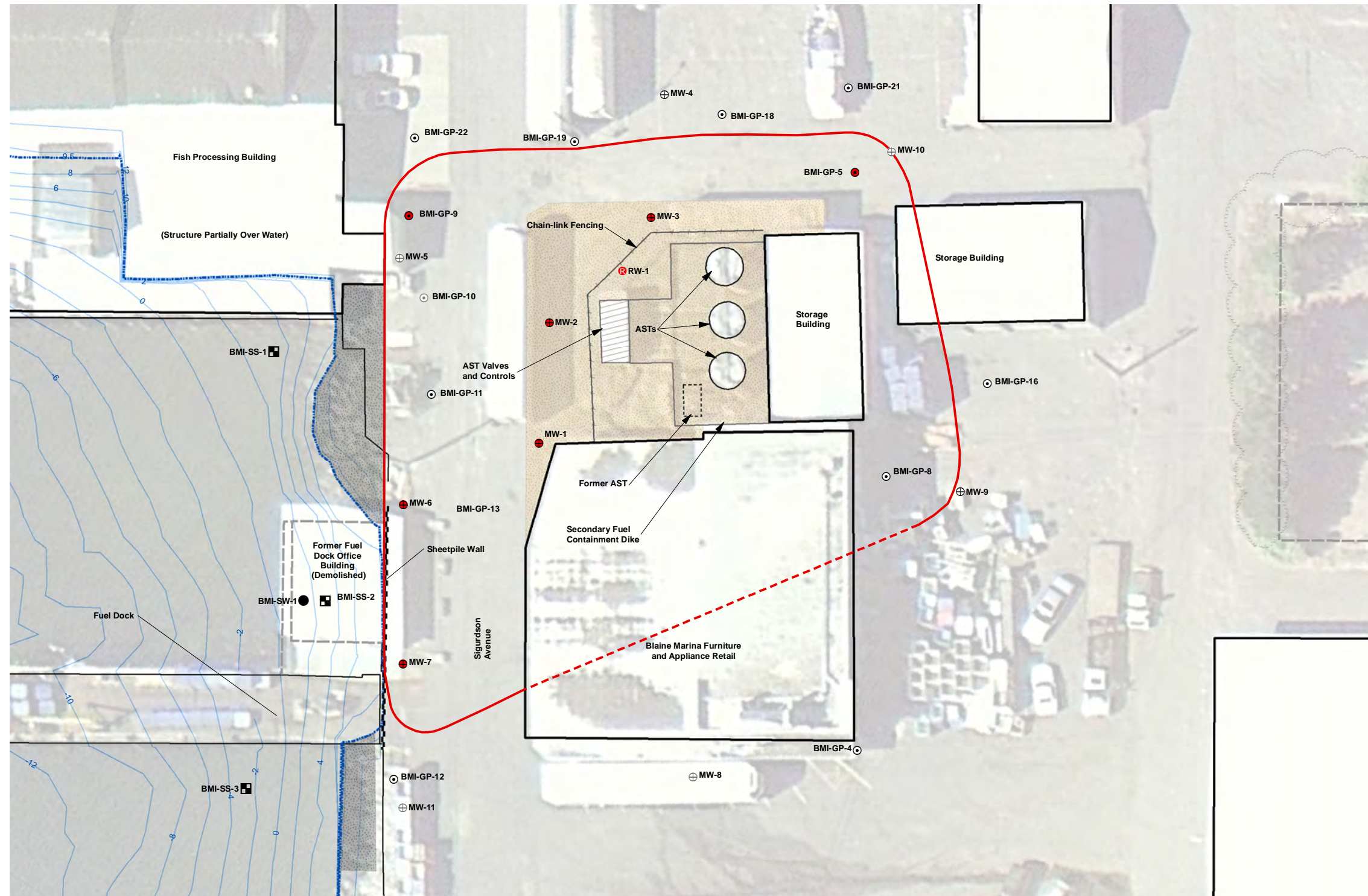
Notes

1. Where LNAPL is indicated, a measurable thickness was observed accumulated on the groundwater surface.
2. All results reported in mg/L.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.



Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Monitored Natural Attenuation Parameters October 9, 2013	Figure 19
--	---	---------------------



Legend

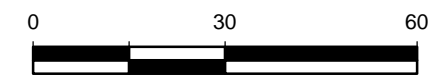
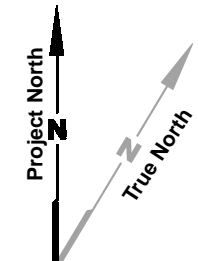
- Surface Sediment Sample Location
- Surface Water Sample Location
- Groundwater Grab Sample Location
- ⊕ Groundwater Monitoring Well Location
- Ⓡ Pilot LNAPL Recovery Well
- Site Boundary
- Mean Higher High Water - 9.5 ft MLLW
- Bathymetry Contours
- ▨ Gravel Area
- ▨ Riprap Slope

Abbreviations

COPCs = Constituents of Potential Concern
 LNAPL = Light Non-Aqueous Phase Liquid
 MLLW = Mean Lower Low Water

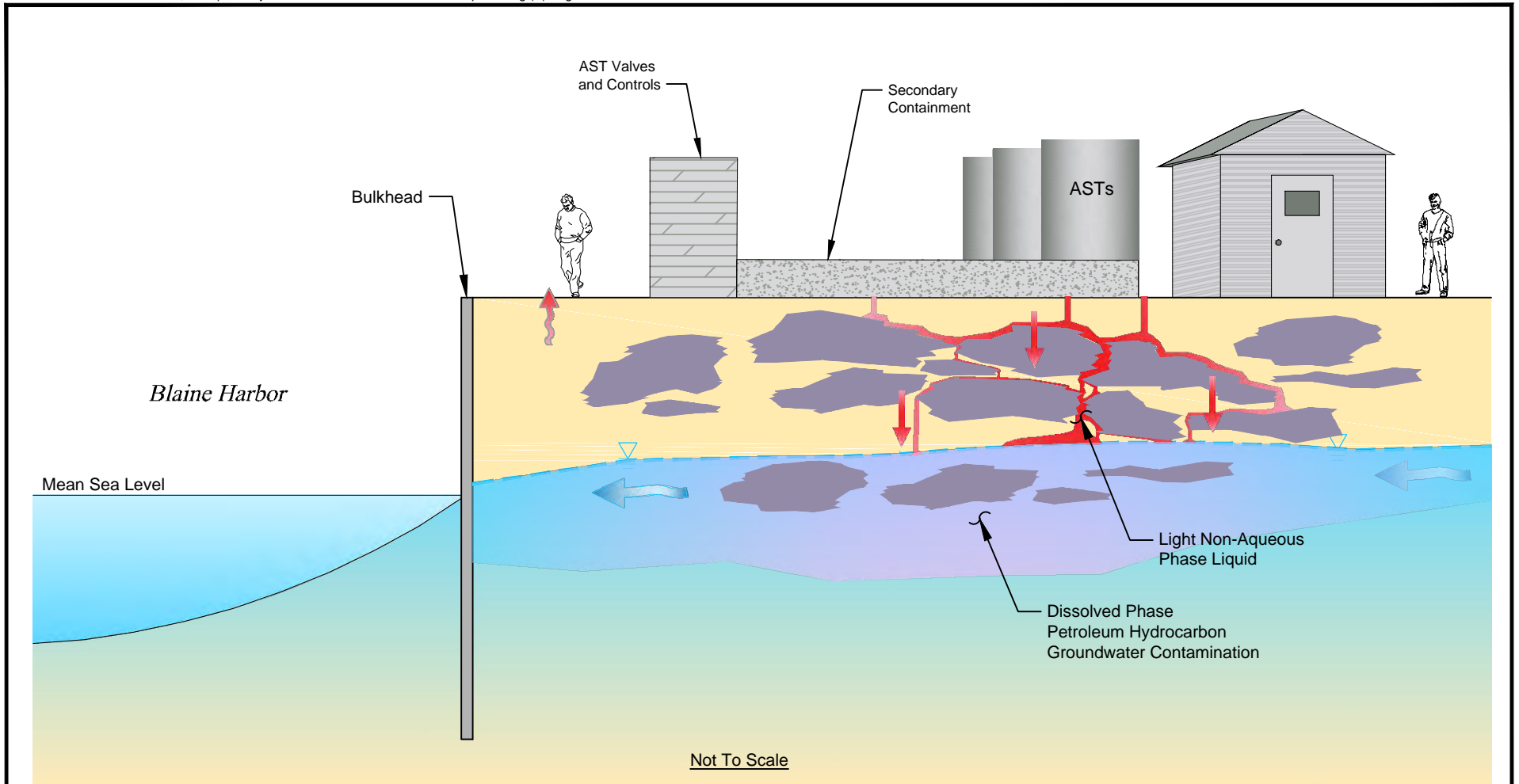
Notes

1. Explorations shown in **Red** indicate detected concentrations exceed screening levels.
2. Explorations shown in **Black** indicate detected concentrations are below screening level.
3. Explorations shown in **Gray** indicate COPCs were not detected.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.






Scale in Feet


Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.




Legend

 Silt/Clay

 Groundwater Level
 Groundwater Flow

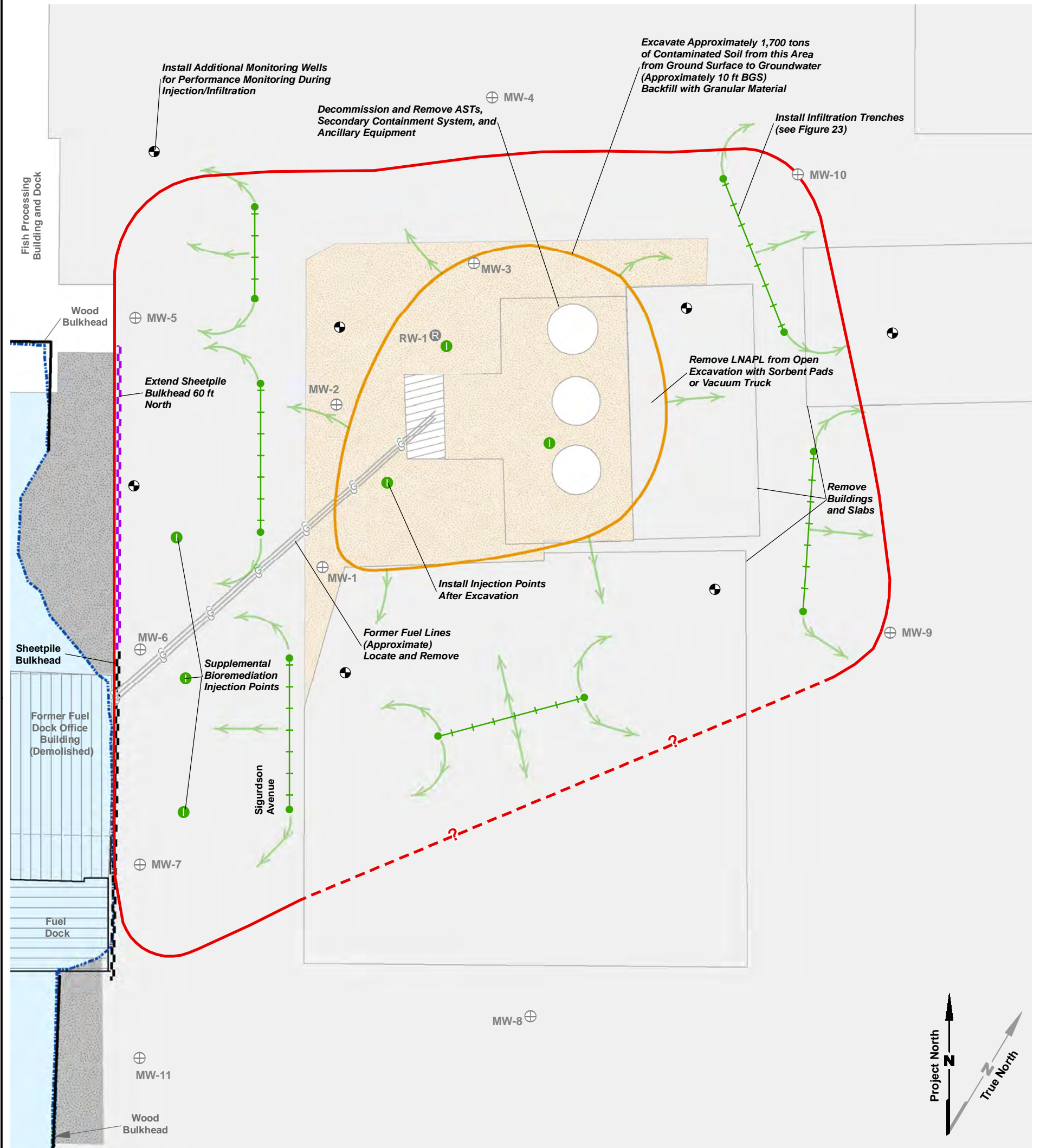
 Soil/LNAPL Leaching to Groundwater Pathway

 Potential Direct Soil Contact, Vapor Inhalation, or Dust Inhalation for Site Workers

Blaine Marina Inc. Site
 Blaine Harbor
 Blaine, Washington

Conceptual Site Model

Figure
21



Legend

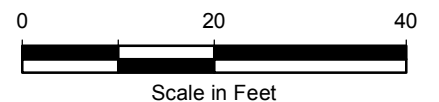
- Bioremediation Injection Point
- Bioremediation Infiltration Trench
- Nitrate Flow Direction
- ⊕ Proposed Groundwater Monitoring Well
- ⊕ Existing Groundwater Monitoring Well
- Ⓡ Recovery Well
- Site Boundary
- Existing Sheetpile Bulkhead
- Proposed Sheetpile Bulkhead
- Mean Higher High Water
- Old Fuel Line
- Paved Surface
- Riprap Slope
- Water
- Gravel Surface

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

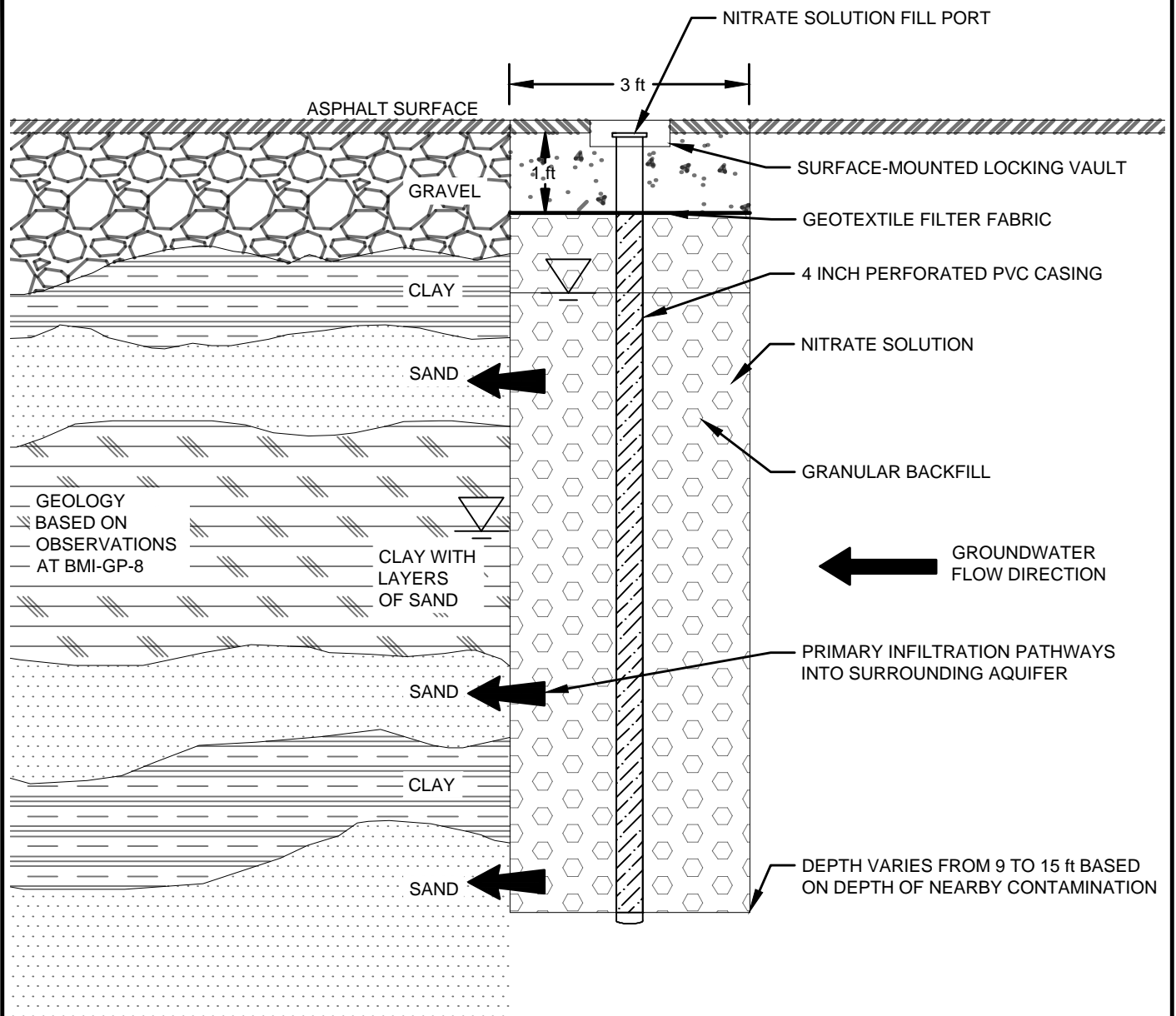
Remedial Alternative 1 Includes the Following Actions

1. Remove AST system and adjacent buildings.
2. Excavate contaminated soil and LNAPL from source area to an approximate depth of 10 ft BGS.
3. Extend sheetpile bulkhead to the north 60 ft.
4. Implement bioremediation program by injecting nutrients and electron acceptors.
5. Construct and maintain a paved surface (containment system) to limit migration by reducing stormwater infiltration and to prevent direct contact with contamination.
6. Implement institutional controls to ensure the long-term integrity of the containment system.
7. Conduct compliance monitoring until cleanup standards are achieved.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

LANDAU ASSOCIATES, INC. | G:\Projects\001\034\01\001\8\F\F\F23 TrenchDetail.dwg (A) *Figure 23* 4/7/2015



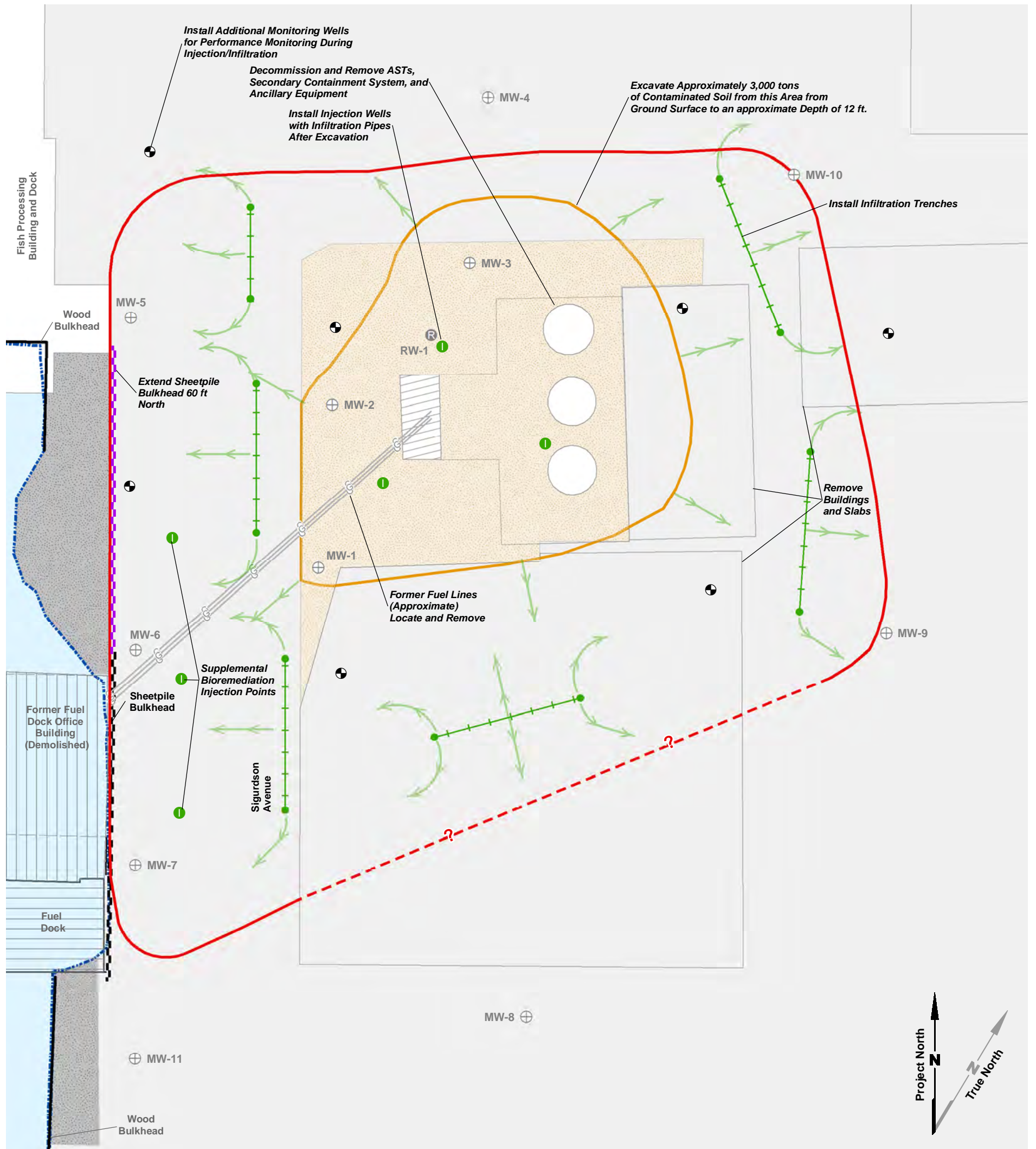
Not to Scale



Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

**Infiltration Trench
Conceptual Cross Section**

Figure
23



Legend

- Supplemental Bioremediation Injection Point
- Bioremediation Infiltration Trench
- Nitrate Flow Direction
- Proposed Monitoring Well
- ⊕ Existing Groundwater Monitoring Well
- Ⓡ Recovery Well
- Old Fuel Line
- Existing Sheetpile Bulkhead
- Proposed Sheetpile Bulkhead
- Mean Higher High Water
- Paved Surface
- Riprap Slope
- Water
- Gravel Surface

Abbreviations

- AST = Above Ground Storage Tank
- BGS = Below Ground Surface
- ft = Feet
- LNAPL = Light Non-Aqueous Phase Liquid

Remedial Alternative 2 Includes the Following Actions

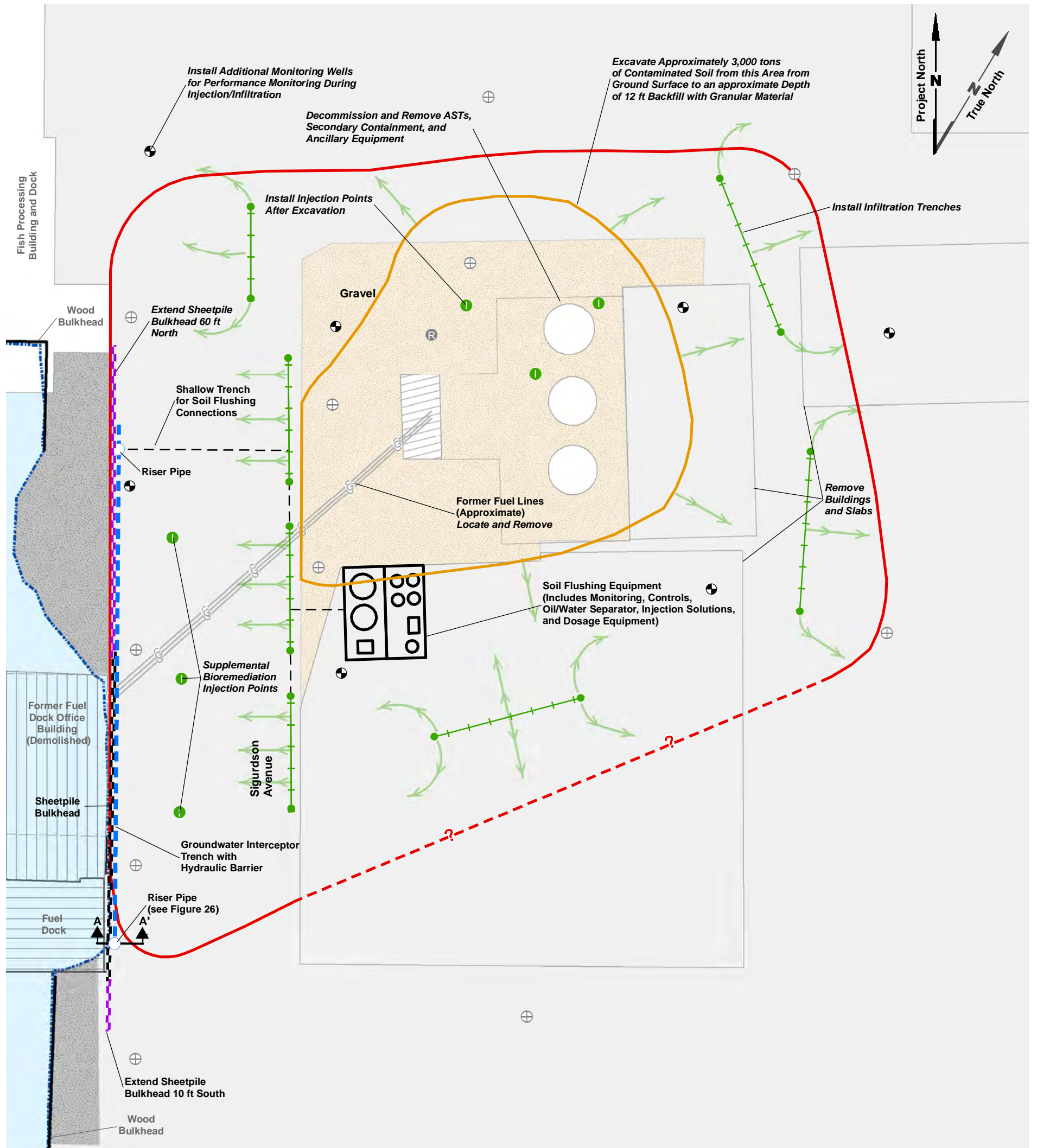
1. Remove AST system and adjacent buildings.
2. Excavate contaminated soil (and LNAPL) from source area to a maximum depth of 12 ft BGS. Export material for offsite treatment and/or disposal.
3. Extend sheetpile bulkhead to the north 60 ft.
4. Implement bioremediation program by injecting nutrients and electron acceptors.
5. Construct and maintain a paved surface (containment system) to limit migration by reducing stormwater infiltration and to prevent direct contact with contamination.
6. Implement institutional controls to ensure the long-term integrity of the containment system.
7. Conduct compliance monitoring until cleanup standards are achieved.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Legend

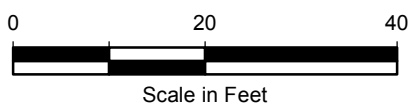
- Bioremediation Injection Point
- Bioremediation Infiltration Trench
- ← Nitrate Flow Direction
- Proposed Groundwater Monitoring Well
- Existing Groundwater Monitoring Well
- Recovery Well
- Riser Pipe
- Trench
- Site Boundary
- Old Fuel Line
- Existing Sheetpile Bulkhead
- Proposed Sheetpile Bulkhead
- Mean Higher High Water
- Paved Surface
- Riprap Slope
- Water
- Gravel Surface

Abbreviations

- AST = Above Ground Storage Tank
- BGS = Below Ground Surface
- ft = Feet
- LNAPL = Light Non-Aqueous Phase Liquid

Remedial Alternative 3 Includes the Following Actions

1. Remove AST system and adjacent buildings.
2. Excavate contaminated soil (and LNAPL) from source area to an approximate depth of 12 ft BGS. Export material for offsite treatment and/or disposal.
3. Extend sheetpile bulkhead to the north 60 ft and south 10 ft.
4. Implement bioremediation program site-wide.
5. Construct and maintain a paved surface (containment system) to limit migration by reducing stormwater infiltration and to prevent direct contact with contamination.
6. Construct interceptor trench along shoreline to capture and treat groundwater. System includes hydraulic barrier to limit discharge to Blaine Harbor and increase capture efficiency, groundwater treatment, and automated dosing of bioremediation reagents prior to reinjection.
7. Implement institutional controls to ensure the long-term integrity of the containment system.
8. Conduct compliance monitoring until cleanup standards are achieved.

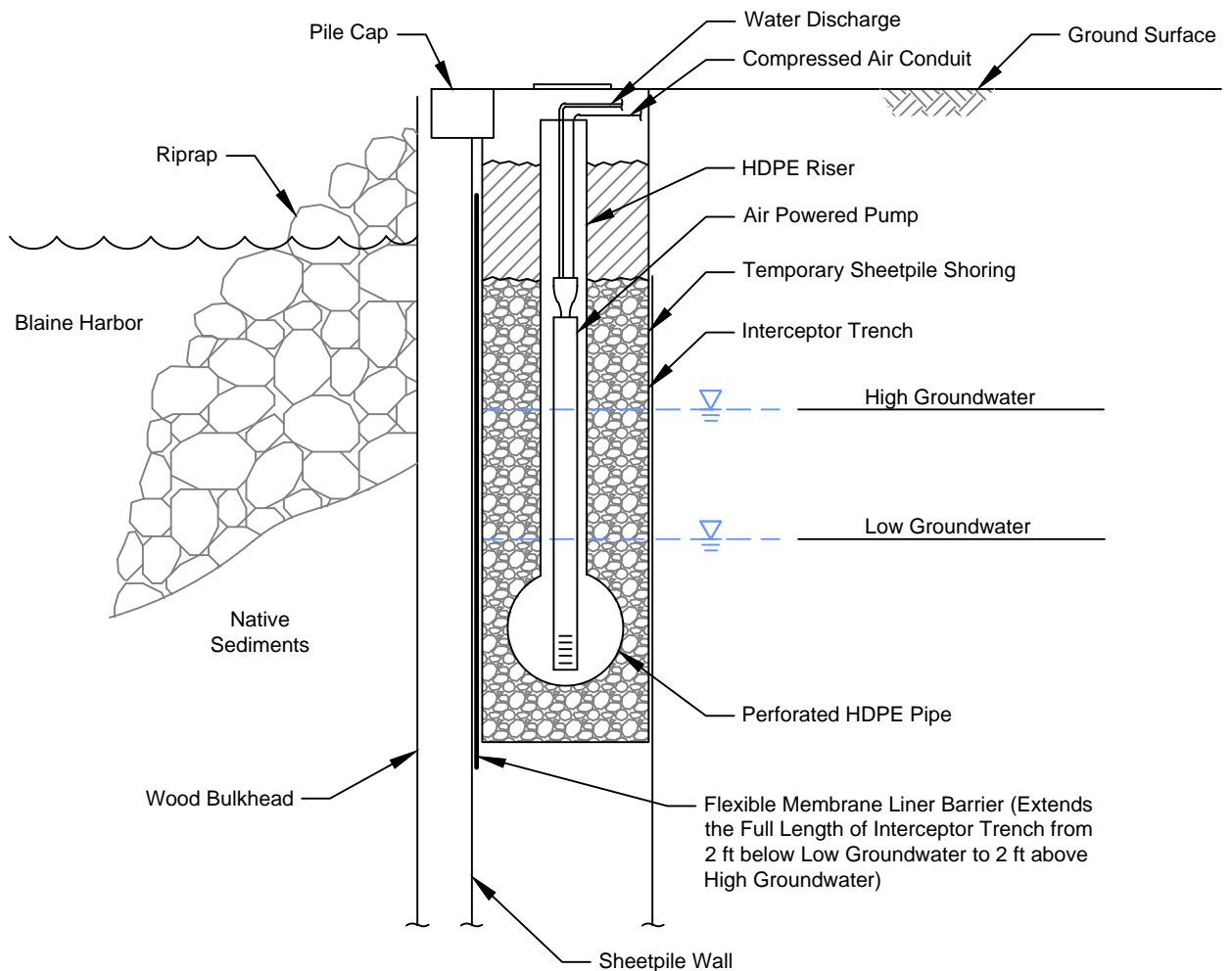


Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES, INC. | G:\Projects\001\034\101\001\8\F\SI\F26 ConceptualSectionA.dwg (A) "Figure 26" 4/7/2015



Conceptual Cross-Section A-A'

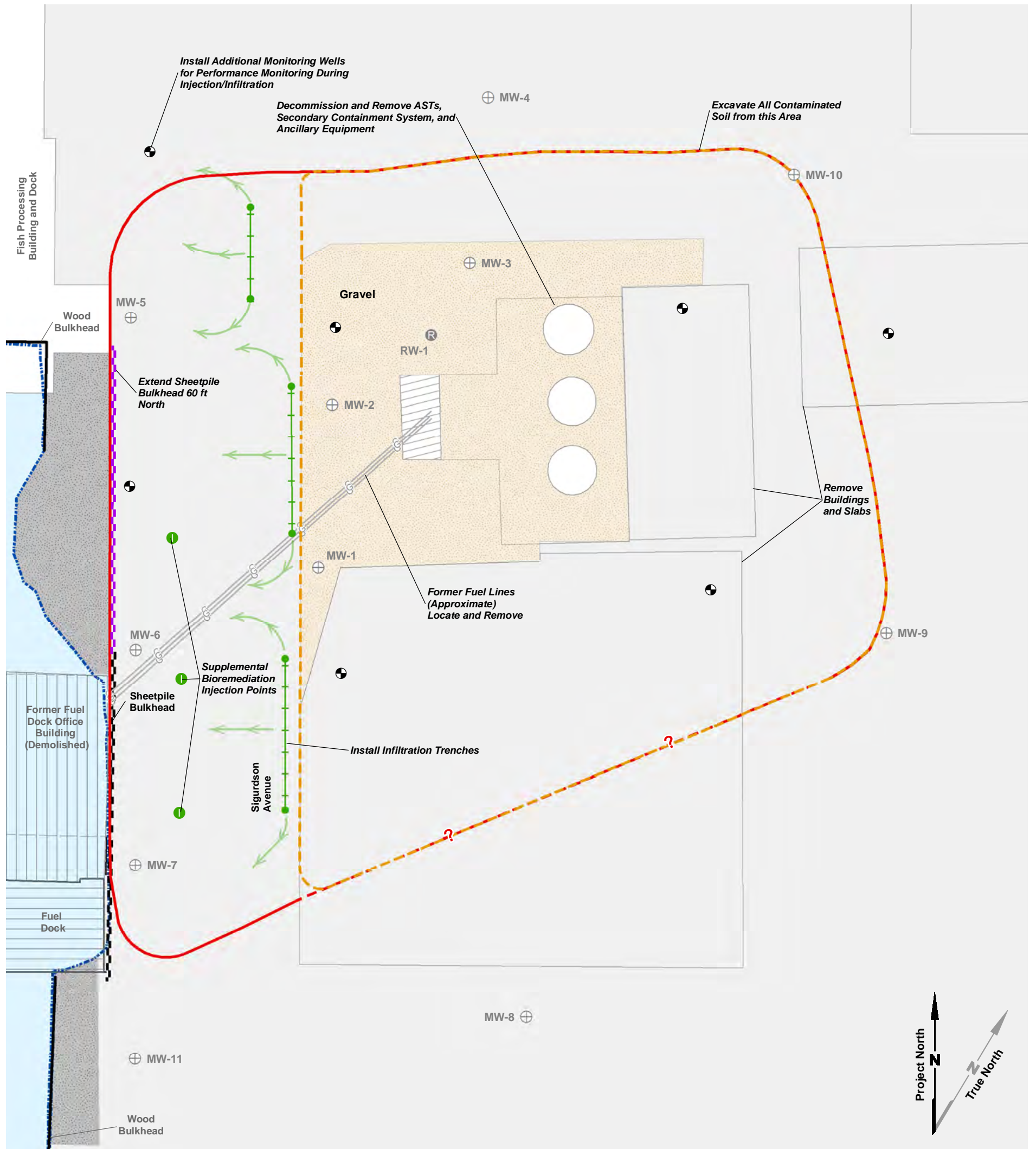
Not to Scale



Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

Conceptual Cross-Section A-A'

Figure
26



Legend

- Supplemental Bioremediation Injection Point
- Bioremediation Infiltration Trench
- ← Nitrate Flow Direction
- Proposed Monitoring Well
- Existing Groundwater Monitoring Well
- R Recovery Well
- Excavation Area
- Site Boundary
- Old Fuel Line
- Existing Sheetpile Bulkhead
- Proposed Sheetpile Bulkhead
- Mean Higher High Water
- Paved Surface
- Riprap Slope
- Water
- Gravel Surface

Abbreviations

AST = Above Ground Storage Tank
 BGS = Below Ground Surface
 ft = Feet

Remedial Alternative 4 Includes the Following Actions

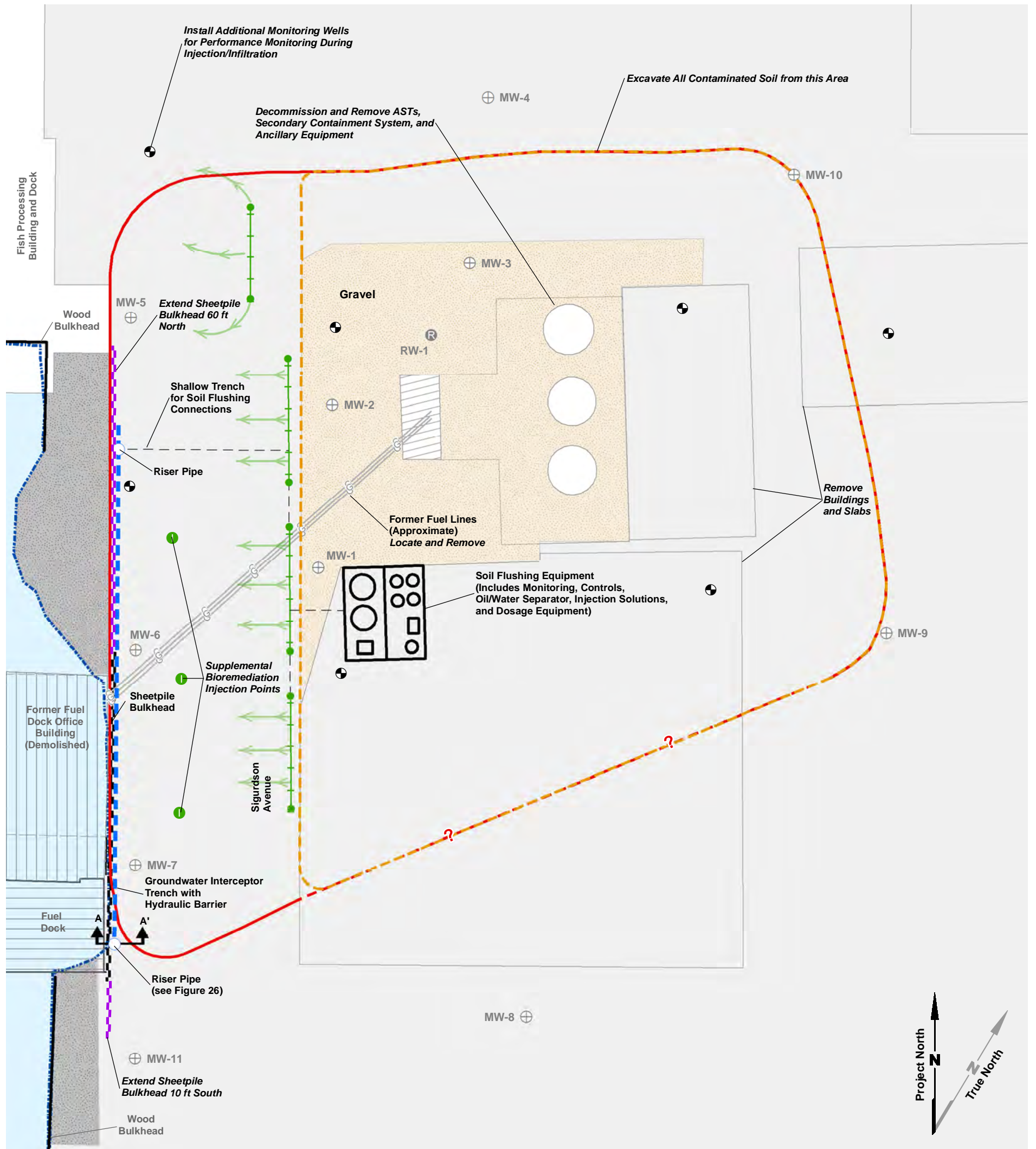
1. Remove AST system and adjacent buildings.
2. Excavate contaminated soil east of Sigurdson Avenue. Export material for offsite treatment and/or disposal.
3. Extend sheetpile bulkhead to the north 60 ft.
4. Implement bioremediation program by injecting nutrients and electron acceptors.
5. Construct and maintain a paved surface (containment system) to limit migration by reducing stormwater infiltration and to prevent direct contact with contamination.
6. Implement institutional controls to ensure the long-term integrity of the containment system.
7. Conduct compliance monitoring until cleanup standards are achieved.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Note
 1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Alternative 4 Expanded Source Removal, Bioremediation Along Shoreline	Figure 27
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Legend

- | | |
|--------------------------------------|-----------------------------|
| Bioremediation Injection Point | Existing Sheetpile Bulkhead |
| Proposed Monitoring Well | Proposed Sheetpile Bulkhead |
| Existing Groundwater Monitoring Well | Mean Higher High Water |
| Recovery Well | Old Fuel Line |
| Riser Pipe | Excavation Area |
| Trench | Paved Surface |
| Bioremediation Infiltration Trench | Riprap Slope |
| Nitrate Flow Direction | Water |
| Site Boundary | Gravel Surface |

Abbreviations

AST = Above Ground Storage Tank
ft = Feet

Remedial Alternative 5 Includes the Following Actions

1. Remove AST system and adjacent buildings.
2. Excavate contaminated soil east of Sigurdson Avenue. Export material for offsite treatment and/or disposal.
3. Extend sheetpile bulkhead to the north 60 ft.
4. Implement bioremediation program by injecting nutrients and electron acceptors.
5. Construct and maintain a paved surface (containment system) to limit migration by reducing stormwater infiltration and to prevent direct contact with contamination.
6. Implement institutional controls to ensure the long-term integrity of the containment system.
7. Conduct compliance monitoring until cleanup standards are achieved.

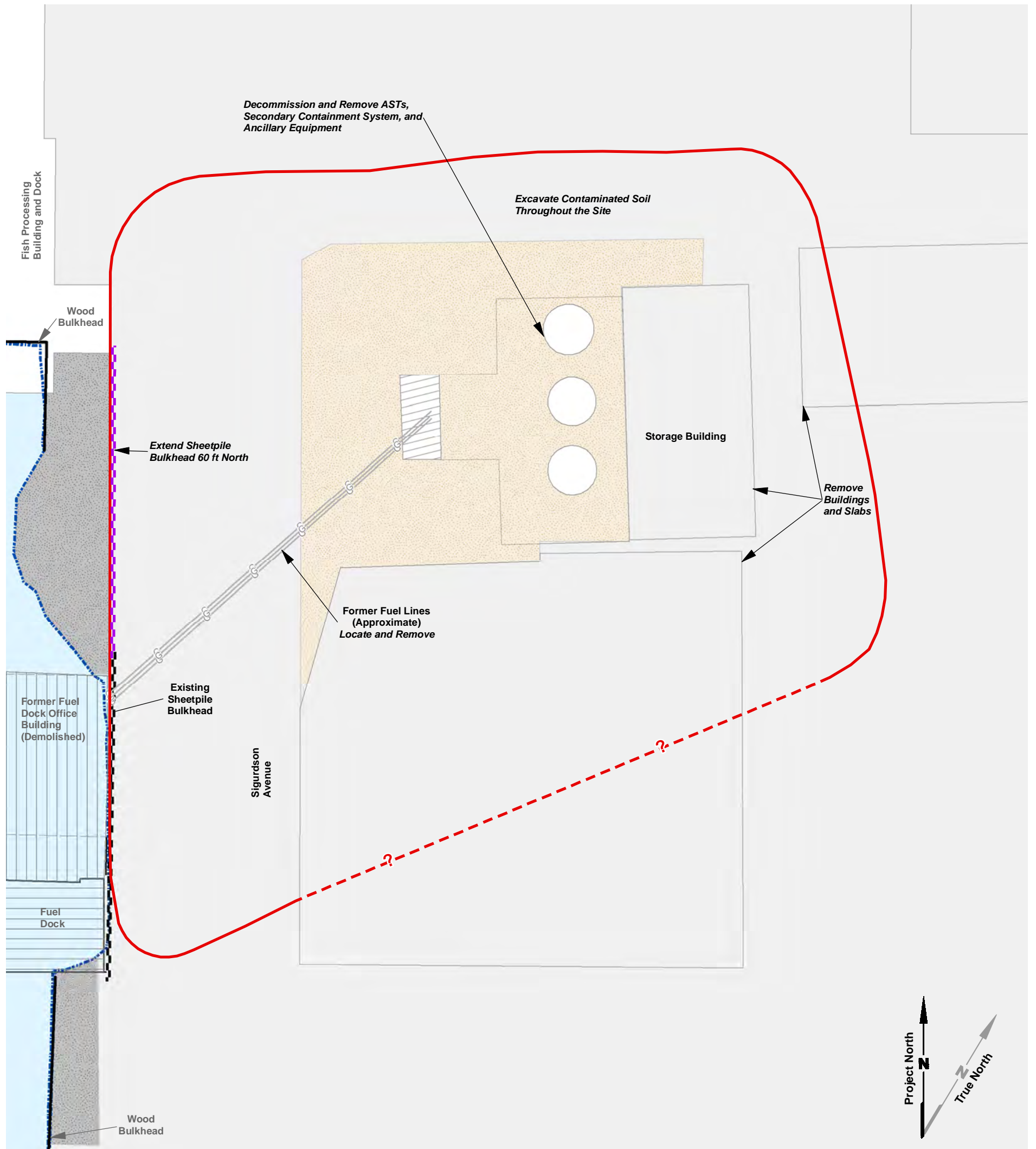


Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Blaine Marina Inc. Site Blaine Harbor Blaine, Washington	Alternative 5 Expanded Source Removal, Soil Flushing with Downgradient Hydraulic Barrier	Figure 28
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Legend

- Site Boundary
- Sheetpile Bulkhead
- Mean Higher High Water
- Old Fuel Line
- Paved Surface
- Riprap Slope
- Water
- Gravel Surface

Abbreviations

AST = Above Ground Storage Tank
ft = Feet

Remedial Alternative 6 Includes the Following Actions

1. Remove AST system and adjacent buildings.
2. Temporarily re-route utilities located beneath Sigurdson Avenue to facilitate excavation.
3. Extend sheetpile bulkhead 60 ft north.
4. Excavate contaminated soil throughout the site.
5. Implement monitored natural attenuation program site-wide until cleanup standards are achieved.



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

Alternative 6
Mass Excavation and
Monitored Natural Attenuation

Figure
29

TABLE 1
CHRONOLOGY OF HISTORICAL SITE INVESTIGATION ACTIVITIES
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

Activity Description	Date of Investigation
SEACOR investigation for total petroleum hydrocarbons: Hand-auger borings (HA-1 through HA-11)	1990
RETEC investigation for the presence of non-aqueous phase liquid petroleum hydrocarbons: Evaluation at MW-1, MW-2, MW-3; reports do not indicate RETEC installed these wells	1996
RETEC investigation for petroleum hydrocarbons in soil and groundwater: Direct-push borings GP-1 through GP-13	1996
Landau Associates investigation of sediment quality	2001
Farallon investigation for total petroleum hydrocarbons in soil and groundwater: Direct-push borings SIG-B1 through SIB-B8	2008

**TABLE 2
SUMMARY OF HISTORICAL INVESTIGATION RESULTS – SOIL
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

Location/ Sample ID	Data Source	Sample Date	Sample Depth	TPH	Gasoline-Range Organics	Diesel-Range Organics	Motor Oil	Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	Xylenes
Preliminary Screening Level (all units mg/kg)													
				2,000	100 (c) 30 (c)	2,000	2,000	0.014 (d) 0.005 (e)	110 (d) 6.4 (e)	18 (d) 1 (e)	-	-	9.1 (d) 0.52 (e)
B-1	1	Unknown	Unknown	34									
HA-1	2	5/8/1990	5.5	1,600									
HA-2	2	5/8/1990	5.7	16,000									
HA-3	2	5/8/1990	3.5	1,400									
HA-4	2	5/8/1990	3.0	12,000									
HA-5	2	5/8/1990	3.0	11,000									
HA-6	2	5/8/1990	3.0	10									
HA-7	2	5/8/1990	9.5		389								
HA-8	2	5/8/1990	6.0		407								
HA-9	2	5/8/1990	5.0	183									
HA-10	2	5/8/1990	9.5	217									
HA-11	2	5/8/1990	9.0	10									
HA-12	2	5/8/1990	7.0			732							
SIG-B1	3	1/7/2008	7.5		3.5 U	27 U	68	0.02 U	0.35 U	0.35 U	0.35 U	0.35 U	
SIG-B2	3	1/7/2008	10.8		8.4 U	3,300	68 U	0.02 U	0.084 U	0.084 U	0.084 U	0.084 U	
SIG-B3	3	1/7/2008	9.0		4.1 U	33 U	70	0.02 U	0.041 U	0.041 U	0.041 U	0.041 U	
SIG-B4	3	1/7/2008	9.0		5.4 U	32 U	64 U	0.02 U	0.054 U	0.054 U	0.054 U	0.054 U	
SIG-B5	3	1/7/2008	10.0		4.1 U	34 U	68 U	0.02 U	0.041 U	0.041 U	0.041 U	0.041 U	
SIG-B6	3	1/7/2008	15.0		4.2 U	34 U	68 U	0.02 U	0.042 U	0.042 U	0.042 U	0.042 U	
SIG-B7	3	1/7/2008	10.8		4 U	34 U	210	0.02 U	0.04 U	0.04 U	0.04 U	0.04 U	
SIG-B8	3	1/7/2008	10.0		4.3 U	33 U	66 U	0.02 U	0.043 U	0.043 U	0.043 U	0.043 U	
B-1 S-3 7.5'	4	1/5/2012	7.5		680	140	50 U	0.3 U	0.89	1.6			2.0 U
B-2 S-3 7.5'	4	1/5/2012	7.5		6,100	510	50 U	3.4 U	5.7 U	120			120
B-3 S-3 7.5'	4	1/5/2012	7.5		1,800	330	150	3.0 U	5.0 U	31			42

Bold = Detected compound.
 Boxed value = Concentration exceeds screening level.
 U = Compound was undetected at the reported concentration.

Data sources:
 1. RETEC 1996a.
 2. SEACOR 1990.
 3. Farallon Consulting 2008.
 4. Landau Associates 2012b.

- (a) Screening levels developed in Table 6.
- (b) Historical data do not distinguish between gasoline-, diesel-, or motor oil-range total petroleum hydrocarbons.
- (c) MTCA Method A cleanup level is 100 mg/kg if benzene is not present and the total of ethylbenzene, toluene, and xylene is less than 1 percent of the gasoline mixture; otherwise the cleanup level is 30 mg/kg.
- (d) Unsaturated soil - see Table 6 for development of screening levels.
- (e) Saturated soil - see Table 6 for development of screening levels.

TABLE 3
SUMMARY OF HISTORICAL INVESTIGATION RESULTS – GROUNDWATER
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

Sample ID	Sample Date	Diesel-Range Organics (mg/L)
		Screening Level 0.5 (a)
GP-1	7/19/1996	55
GP-2	7/19/1996	1.4
GP-3	7/19/1996	160.5
GP-4	7/19/1996	27.5
GP-5	7/19/1996	0.2 (b) U
GP-6	7/19/1996	54.7
GP-7	7/19/1996	0.2 (b) U
GP-8	7/19/1996	11.4
GP-9	7/19/1996	13.4
GP-10	7/19/1996	251
GP-11	7/19/1996	85.6
GP-12	7/19/1996	LNAPL
GP-13	7/19/1996	33.5
MW-1	7/19/1996	0.1 U
MW-2	7/19/1996	LNAPL
MW-3	7/19/1996	LNAPL

Bold = Detected compound.

Boxed value = Concentration exceeds screening level.

U = Compound was undetected at the reported concentration.

LNAPL = Non-aqueous phase liquid

(a) Screening level developed in Table 6.

(b) Results were boxed due to sheen or LNAPL observed in the boring.

Data Source: RETEC 1996a.

TABLE 4
SUMMARY OF HISTORICAL INVESTIGATION RESULTS – SEDIMENT
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

Sample ID Sample Date	SQS (a)	CSL (b)	BH-01 9/27/2001	BH-09 9/27/2001	BH-10 9/27/2001
Metals (mg/kg)					
Arsenic	57	93	6 U		
Cadmium	5.1	6.7	1.1		
Chromium	260	270	28.4		
Copper	390	390	76.8 J		
Lead	450	530	13 J		
Mercury	0.41	0.59	0.09 J		
Silver	6.1	6.1	0.3		
Zinc	410	960	103		
PCBs (mg/kg OC) (c)					
Aroclor 1016	NA	NA	1.2 U		
Aroclor 1242	NA	NA	1.2 U		
Aroclor 1248	NA	NA	1.2 U		
Aroclor 1254	NA	NA	1.2 U		
Aroclor 1260	NA	NA	1.2 U		
Aroclor 1221	NA	NA	2.4 U		
Aroclor 1232	NA	NA	1.2 U		
Total PCBs (d)	12	65	2.4 U		
PAHs (mg/kg OC) (c)					
Naphthalene	99	170	1.2 U	1.3 U	
Acenaphthylene	66	66	6.1	2.8	
Acenaphthene	16	57	1.7	1.4 M	
Fluorene	23	79	2.9	2.1	
Phenanthrene	100	480	28.1	25.3	
Anthracene	220	1,200	17.5	7.3	
2-Methylnaphthalene	38	64	1.2 U	1.3 U	
LPAH (d)(e)	370	780	56.3	39.0	
Fluoranthene	160	1,200	87.5	47.3	
Pyrene	1,000	1,400	87.5	46.0	
Benzo(a)anthracene	110	270	35.0	20.0	
Chrysene	110	460	68.8	34.7	
Benzo(b)fluoranthene	NA	NA	55.0	24.0	
Benzo(k)fluoranthene	NA	NA	55.0	24.0	
Total Benzofluoranthenes (f)	230	450	110.0	48.0	
Benzo(a)pyrene	99	210	28.8	20.7	
Indeno(1,2,3-c,d)pyrene	34	88	19.4	13.3	
Dibenz(a,h)anthracene	12	33	3.2	2.8	
Benzo(g,h,i)perylene	31	78	9.4	12.0	
HPAH (d)(g)	960	5,300	449.4	244.8	
SVOCs (mg/kg OC) (c)					
1,2-Dichlorobenzene	2.3	2.3	1.2 U	1.3 U	
1,3-Dichlorobenzene	NA	NA	1.2 U	1.3 U	
1,4-Dichlorobenzene	3.1	9	1.2 U	1.3 U	
1,2,4-Trichlorobenzene	0.81	1.8	1.2 U (h)	1.3 U (h)	
Hexachlorobenzene	0.38	2.3	0.06 U	1.3 U (h)	
Dimethylphthalate	53	53	1.8	2.5	
Diethylphthalate	61	110	1.2 U	1.3 U	
Di-n-Butylphthalate	220	1,700	1.2 U	1.3 U	
Butylbenzylphthalate	4.9	64	1.2 U	1.3 U	
bis(2-Ethylhexyl)phthalate	47	78	81.3	16.0	
Di-n-octyl phthalate	58	4,500	1.2 U	1.3 U	

TABLE 4
SUMMARY OF HISTORICAL INVESTIGATION RESULTS – SEDIMENT
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

Sample ID Sample Date	SQS (a)	CSL (b)	BH-01 9/27/2001	BH-09 9/27/2001	BH-10 9/27/2001
Dibenzofuran	15	58	1.4	1.3 U	
Hexachlorobutadiene	3.9	6.2	0.06 U	1.3 U	
N-Nitrosodiphenylamine	11	11	1.2 U	1.3 U	
SVOCs (µg/kg)					
Phenol	420	1,200	19 U	20 U	
2-Methylphenol	63	63	19 U	20 U	
4-Methylphenol	670	670	19 U	64	
2,4-Dimethylphenol	29	29	19 U	20 U	
Pentachlorophenol	360	690	120	99 U	
Benzyl Alcohol	57	73	19 U	20 U	
Benzoic Acid	650	650	190 U	200 U	
Organotins (µg/kg)					
Tributyltin (as chloride)	NA	NA	35		24
Tributyltin (as TBT ion)	73 (i)	NA	31		21
Conventionals					
Total Organic Carbon (percent)	NA	NA	1.6	1.5	
Total Solids (percent)	NA	NA	44.6	61.5	
Preserved Total Solids (percent)	NA	NA	41.2		
N-Ammonia (mg-N/kg)	NA	NA	38		
Sulfide (mg/kg)	NA	NA	310		
Fecal Coliform (CFU/g)	NA	NA	49 U		

OC = Organic Carbon

NA = Not available.

U = Compound was analyzed for, but was not detected at the given detection limit.

J = Estimated value.

M = An estimated value of analyte detected and confirmed by analyst with low spectral match parameters.

CFU = Colony-forming units.

Boxed results exceed the SQS.

Shaded results exceed the CSL.

(a) SMS sediment quality standard (Chapter 173-204 WAC).

(b) SMS cleanup screening level (Chapter 173-204 WAC).

(c) Where chemical criteria in this table represent the sum of individual compounds or isomers, the following methods shall be applied:

(i) Where chemical analyses identify an undetected value for every individual compound/isomer, then the single highest detection limit shall represent the sum of the respective compounds/isomers.

(ii) Where chemical analyses detect one or more individual compounds/isomers, only the detected concentrations will be added to represent the group sum.

(d) All organic data (except phenols, benzyl alcohol, and benzoic acid) are normalized to total organic carbon; this involves dividing the dry weight concentration of the constituent by the fraction of total organic carbon present.

(e) The LPAH criterion represents the sum of the following "low molecular weight polycyclic aromatic hydrocarbon" compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. The LPAH criterion is not the sum of the criteria values for the individual LPAH compounds listed.

(f) The total benzofluoranthenes criterion represents the sum of the concentrations of the "B," "J," and "K" isomers.

(g) The HPAH criterion represents the sum of the following "high molecular weight polynuclear aromatic hydrocarbon" compounds: fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. The HPAH criterion is not the sum of the criteria values for the individual HPAH compounds as listed.

(h) Method detection limits exceed the SQS or CSL criteria.

(i) TBT bulk sediment screening level established by Ecology, which is conceptually equivalent to the SQS.

TABLE 5
GROUNDWATER ELEVATIONS AND LIGHT NON-AQUEOUS PHASE LIQUID THICKNESS
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

Location	x (Northing, NAVD88)	y (Easting, NAVD88)	Elevation Top of Pipe/TOC (ft MLLW)	Date Measured	Time	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water Level Elevation (ft, MLLW)
RW-1	732595.1	1176945.5	17.10	4/24/2013	9:27	9.19	9.03	0.16	7.91
	732595.1	1176945.5							
RW-1			17.10	4/24/2013	18:30	9.23	9.08	0.15	7.87
RW-1	732595.1	1176945.5	17.10	8/28/2013	14:14	10.06	9.74	0.32	7.04
RW-1	732595.1	1176945.5	17.10	8/29/2013	7:05	10.2	9.85	0.35	6.90
MW-1	732545.7	1176949.9	16.48	4/24/2013	9:15	9.25	8.79	0.46	7.23
MW-1	732545.7	1176949.9	16.48	4/24/2013	18:01	9.10	8.64	0.46	7.38
MW-1	732545.7	1176949.9	16.48	8/28/2013	14:05	9.55	9.22	0.33	6.93
MW-1	732545.7	1176949.9	16.48	8/29/2013	7:00	9.81	9.46	0.35	6.67
MW-2	732573.9	1176936.1	16.65	4/24/2013	9:20	9.00	8.86	0.14	7.65
MW-2	732573.9	1176936.1	16.65	4/24/2013	18:04	9.02	8.75	0.27	7.63
MW-2	732573.9	1176936.1	16.65	8/28/2013	14:08	9.75	9.27	0.48	6.90
MW-2	732573.9	1176936.1	16.65	8/29/2013	6:55	9.90	9.31	0.59	6.75
MW-3	732610.8	1176944.7	16.71	4/24/2013	9:24	11.26	8.40	2.86	5.45
MW-3	732610.8	1176944.7	16.71	4/24/2013	18:07	10.97	8.42	2.55	5.74
MW-3	732610.8	1176944.7	16.71	8/28/2013	0:59	12.13	9.00	3.13	4.58
MW-3	732610.8	1176944.7	16.71	8/29/2013	6:50	11.26	9.14	2.12	5.45
MW-4	732639.9	1176931.3	16.67	4/24/2013	9:10	8.74	---	---	7.93
MW-4	732639.9	1176931.3	16.67	4/24/2013	17:43	8.65	---	---	8.02
MW-4	732639.9	1176931.3	16.67	8/28/2013	13:59	9.35	---	---	7.32
MW-4	732639.9	1176931.3	16.67	8/29/2013	6:48	9.50	---	---	7.17
MW-5	732568.3	1176894.3	15.61	4/24/2013	9:33	8.13	---	---	7.48
MW-5	732568.3	1176894.3	15.61	4/24/2013	17:48	7.94	---	---	7.67
MW-5	732568.3	1176894.3	15.61	8/28/2013	13:43	8.33	---	---	7.28
MW-5	732568.3	1176894.3	15.61	8/29/2013	6:22	9.28	---	---	6.33
MW-6	732514.1	1176928.0	15.63	4/24/2013	9:36	8.54	---	---	7.09
MW-6	732514.1	1176928.0	15.63	4/24/2013	17:50	8.14	---	---	7.49
MW-6	732514.1	1176928.0	15.63	8/28/2013	13:45	8.58	---	---	7.05
MW-6	732514.1	1176928.0	15.63	8/29/2013	6:18	9.30	---	---	6.33
MW-7	732478.6	1176949.2	15.77	4/24/2013	9:40	8.83	---	---	6.94
MW-7	732478.6	1176949.2	15.77	4/24/2013	17:52	8.34	---	---	7.43
MW-7	732478.6	1176949.2	15.77	8/28/2013	13:48	8.71	---	---	7.06
MW-7	732478.6	1176949.2	15.77	8/29/2013	6:20	9.40	---	---	6.37
MW-8	732492.3	1177028.6	15.98	4/24/2013	9:43	8.54	---	---	7.44
MW-8	732492.3	1177028.6	15.98	4/24/2013	17:54	8.66	---	---	7.32
MW-8	732492.3	1177028.6	15.98	8/28/2013	13:54	9.04	---	---	6.94
MW-8	732492.3	1177028.6	15.98	8/29/2013	6:32	9.02	---	---	6.96
MW-9	732591.1	1177049.9	15.61	4/24/2013	9:45	8.6	---	---	7.01
MW-9	732591.1	1177049.9	15.61	4/24/2013	17:57	8.33	---	---	7.28
MW-9	732591.1	1177049.9	15.61	8/28/2013	13:55	9.19	---	---	6.42
MW-9	732591.1	1177049.9	15.61	8/29/2013	6:38	9.18	---	---	6.43
MW-10	732657.5	1176989.3	16.12	4/24/2013	9:50	8.74	---	---	7.38
MW-10	732657.5	1176989.3	16.12	4/24/2013	17:59	8.63	---	---	7.49
MW-10	732657.5	1176989.3	16.12	8/28/2013	13:57	9.72	---	---	6.40
MW-10	732657.5	1176989.3	16.12	8/29/2013	6:43	9.63	---	---	6.49
MW-11	732446.7	1176968.3	15.62	8/28/2013	13:50	8.43	---	---	7.19
MW-11	732446.7	1176968.3	15.62	8/29/2013	6:45	10.32	---	---	5.30

Notes: All well elevations and coordinates except MW-11 surveyed May 2, 2013. MW-11 surveyed August 28, 2013.

**TABLE 6
SITE SCREENING LEVELS – SOIL
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

ANALYTE (BY GROUP)	Most Stringent Unrestricted Land Use Value from Groundwater Screening Level Table (refer to Tab 3, Table 1) (µg/L)	APPLICABLE SOIL VALUES										Soil Screening Level (mg/kg)			
		Groundwater Protection					Direct Contact (d)					Natural Background Concentrations (Ecology 1994) (mg/kg) (g)	Applicable Practical Quantitation Level (PQL) for RI Analyses (mg/kg) (h)	Unsaturated Soil	Saturated Soil
		Constants and Coefficients (a)			Calculated Values										
		K _{oc} (Soil Organic Carbon-Water Partitioning Coefficient) (L/kg)	K _d (Distribution Coefficient for metals) (L/kg)	Henry's Law Constant (H _{cc} ; unitless)	Unsaturated Soil Concentration Protective of Leachability to Groundwater for Unrestricted Land Use (mg/kg) (b)	Saturated Soil Concentration Protective of Leachability to Groundwater for Unrestricted Land Use (mg/kg) (c)	Soil, Method A, Unrestricted Land Use, Table Value (mg/kg) (a,e)	Soil, Method B, Most-Restrictive Standard Formula Value, Direct Contact (ingestion only), Unrestricted Land Use (mg/kg) (a,f)	(back)	(pql)					
Total Petroleum Hydrocarbons (mg/kg)															
Gasoline Range Hydrocarbons (with benzene)	800							30			5	30	(mA)	30	(mA)
Gasoline Range Hydrocarbons (without benzene)	1,000							100				100	(mA)	100	(mA)
Diesel Range Hydrocarbons	500							2,000			25	2,000	(mA)	2,000	(mA)
Oil Range Hydrocarbons								2,000			100	2,000	(mA)	2,000	(mA)
Heavy Metals (mg/kg)															
Lead	8.1		10,000	0	1,600	81	250			24	0.1	250	(mA)	81	(gwl-s)
Volatile Organic Compounds (including BTEX) (mg/kg)															
1,2-Dibromoethane (EDB)	2	66			0.011	0.00071	0.005	0.5			0.02	0.02	(pql)	0.02	(pql)
1,2-Dichloroethane (EDC)	4.2	38		0.04	0.02	0.0014		11			0.005	0.02	(gwl-u)	0.005	(pql)
Benzene	2.4	62		0.23	0.014	0.00084	0.03	18			0.005	0.014	(gwl-u)	0.005	(pql)
Ethylbenzene	2,100	200		0.32	18	1	6	8,000			0.005	18	(gwl-u)	1	(gwl-s)
Methyl-Tert-Butyl Ether	610	110		180	190	0.24	0.1				0.05	190	(gwl-u)	0.24	(gwl-s)
Toluene	15,000	140		0.27	110	6.4	7	6,400			0.005	110	(gwl-u)	6.4	(gwl-s)
Xylenes (total)	1,000	230		0.28	9.1	0.52	9	16,000			0.02	9.1	(gwl-u)	0.52	(gwl-s)
Polycyclic Aromatic Hydrocarbons (PAHs)															
Total Naphthalenes	83	1,200		0.02	2.3	0.12	5	1,600			0.005	2.3	(gwl-u)	0.12	(gwl-s)

- (a) Values from Ecology's CLARC Database May 2012 (Ecology website 2012), except as noted.
- (b) Calculated values from 3-phase model, per MTCA Equation 747-1, with groundwater value (Cw) as most stringent value from groundwater screening level process (Table 1), and Dilution Factor = 20.
- (c) Calculated values from 3-phase model, per MTCA Equation 747-1, with groundwater value (Cw) as most stringent value from groundwater screening level process (Table 1), and Dilution Factor = 1.
- (d) Direct contact criteria applicable for soils to 15-ft depth.
- (e) Because groundwater at this Site not a practicable source of drinking water in accordance with MTCA, many Method A soil cleanup levels are not applicable. Method A unrestricted cleanup levels used only if they are based on background or ARARs, or there are no corresponding Method B direct contact values. Soil leachability to groundwater is addressed separately. Method A values for diesel- and oil-range TPH based on accumulation of free product, not direct contact.
- (f) Method B values are most restrictive of carcinogenic or non-carcinogenic values presented in Ecology's CLARC Database (Ecology website 2012).
- (g) Values are from Ecology's Natural Background Soil Metals Concentrations in Washington State (Ecology 1994).
- (h) From Columbia Analytical Services, Inc. (Kelso, WA) and Analytical Resources, Inc. (Tukwila, WA) published method reporting PQLs will be laboratory-specific, thus site-specific, and are the lowest concentration of an analyte that can be accurately measured.

- µg/L = Micrograms per liter.
- ARAR = Applicable or relevant and appropriate requirement.
- CLARC = Cleanup Levels and Risk Calculation.
- Ecology = Washington State Department of Ecology.
- gwl-u = Groundwater leachability - unsaturated.
- gwl-s = Groundwater leachability - saturated.
- K_d = Distribution coefficient.
- K_{oc} = Soil organic carbon water partitioning coefficient.
- L/kg = Liters per kilogram.
- mA = MTCA Method A.
- mB = MTCA Method B.
- mg/kg = Milligrams per kilogram.
- MTCA = Washington State Model Toxics Control Act.
- TPH = Total petroleum hydrocarbons.
- PAH = Polycyclic aromatic hydrocarbon.
- PQL = Practical quantitation limit.

Note: Blank cells are intentional.

**TABLE 7
SITE SCREENING LEVELS – GROUNDWATER
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

ANALYTE (BY GROUP)	APPLICABLE GROUNDWATER VALUES													Applicable PQL for RI Analyses (f) (pql)	Groundwater Screening Level	
	Marine Surface Water Criteria						Protection of Marine Sediment Recontamination			Tier 1 Vapor Intrusion Groundwater Screening Levels (d, g)						
	Surface Water ARAR Aquatic Life - Marine/Chronic - Ch. 173-201A WAC (ma-wac)	Surface Water ARAR Aquatic Life - Marine/Chronic - Clean Water Act §304 (ma-cwa)	Surface Water ARAR Aquatic Life - Marine/Chronic National Toxics Rule, 40 CFR 131 (ma-ntr)	Surface Water ARAR - Human Health – Marine – Clean Water Act §304 (hh-cwa)	Surface Water ARAR - Human Health – Marine – National Toxics Rule, 40 CFR 131 (hh-ntr)	Surface Water, Method B, Most-Restrictive, Standard Formula (a) (sw-b)	K _{oc} (Soil Organic Carbon-Water Partitioning Coefficient) (L/kg)	K _d (Distribution Coefficient for metals) (L/kg)	WAC 173-204 Marine SQS (mg/kg organic carbon)	WAC 173-204 Marine SQS (mg/kg dry weight)	Calculated Porewater Concentration Protective of Marine Sediment (c) (sed)	Method B, Unrestricted Land Use (vi-b)	Method C, Industrial Land Use (vi-c)			Method A Cleanup Levels (e) (vi-d)
Total Petroleum Hydrocarbons (µg/L)																
Gasoline-Range Hydrocarbons (with benzene)														800	250	800 (vi-d)
Gasoline-Range Hydrocarbons (without benzene)														1,000	250	1,000 (vi-d)
Diesel-Range Hydrocarbons														500	250	500 (vi-d)
Metals																
Lead (µg/L)	8.1	8.1	8.1					10,000		450	45			15	0.1	8.1 (ma-wac)
Manganese (mg/L)				0.1											0.00005	0.1 (hh-cwa)
Volatile Organic Compounds (µg/L)																
1,1,1,2-Tetrachloroethane														7.4	74	0.5 7.4 (vi-b)
1,1,1-Trichloroethane						930,000	140							11,000	25,000	0.5 11,000 (vi-b)
1,1,2 - Trichlorotrifluoroethane														1,100	2,400	0.5 1,100 (vi-b)
1,1,2,2-Tetrachloroethane				4	11	6.5	79							6.2	62	0.5 4 (hh-cwa)
1,1,2-Trichloroethane				16	42	25	75							7.9	79	0.5 7.9 (vi-b)
1,1-Dichloroethane							53							2,300	5,000	0.5 2,300 (vi-b)
1,1-Dichloroethene				7,100	3.2	23,000	65							130	280	0.5 3.2 (hh-ntr)
1,1-Dichloropropene																0.5
1,2,3-Trichlorobenzene																2
1,2,3-Trichloropropane																0.5
1,2,4-Trichlorobenzene				70		2	1,700		0.81		0.48		3,900	8,400	0.2 0.48 (sed)	
1,2,4-Trimethylbenzene														24	52	2 24 (vi-b)
Volatile Organic Compounds (Including BTEX) (µg/L)																
1,2-Dibromoethane (EDB)							66							0.74	7.4	0.01 2 2 (pql)
1,2-Dichloroethane (EDC)				37	99	59	38							4.2	42	5 0.5 4.2 (vi-b)
Benzene				51	71	23	62							2.4	24	5 0.5 2.4 (vi-b)
Ethylbenzene				2,100	29,000	6,900	200							2,800	6,100	700 0.5 2,100 (hh-cwa)
Methyl-Tert-Butyl Ether														610	6,100	20 0.5 610 (vi-b)
Toluene				15,000	200,000	19,000	140							15,000	33,000	1,000 0.5 15,000 (hh-cwa)
Xylenes (Total)							230									1,000 2 1,000 (vi-d)
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/L)																
Total Naphthalenes						4,900	1,200		99		83	170	360	160	0.01	83 (sed)

TABLE 7
SITE SCREENING LEVELS – GROUNDWATER
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

ARAR = Applicable or relevant and appropriate requirement
Ch = Chapter
CFR = Code of Federal Regulations
COPC = Constituent of potential concern
Ecology = Washington State Department of Ecology
K_d = Distribution coefficient
K_{oc} = Soil organic carbon water partitioning coefficient
PQL = Practical quantitation limit
RI = Remedial investigation
SQS = Sediment Quality Standards
WAC = Washington Administrative Code

Note: Blank cells are intentional.

- (a) Method B values are most restrictive of carcinogenic or non-carcinogenic values presented in Ecology's Cleanup Levels and Risk Calculation (CLARC) Database (Ecology website 2012).
- (b) Values from Ecology's CLARC Database May 2012 (Ecology website 2012), except as noted.
- (c) Calculated assuming equilibrium partitioning: C_w (porewater) = Sediment Quality Standard (SQS; WAC 173-204-320) / K_d.
- (d) From Table B-1 (Appendix B) of Ecology's Guidance for Evaluation of Soil Vapor Intrusion (Ecology 2009).
- (e) MTCA Method A Cleanup Levels from WAC 173-340-900, Table 720-1.
- (f) From ALS Laboratories, Inc. (Kelso, WA) and Analytical Resources, Inc. (Tukwila, WA) published method reporting limits. PQLs will be laboratory-specific, thus, site-specific, and are the lowest concentration of an analyte that can be accurately measured. PQLs are always above the method detection limit (MDL).
- (g) Values protective of vapor intrusion from Table B-1 of Ecology's Guidance for Evaluating Soil Vapor Intrusion (Ecology's Guidance for Evaluating Soil Vapor Intrusion (Ecology 2009).

TABLE 8
SITE SCREENING LEVELS – SEDIMENT
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

<i>ANALYTE (BY GROUP)</i>	<i>APPLICABLE SEDIMENT VALUES</i>			
	<i>Protection of Benthic Toxicity</i>			
	WAC 173-204 Sediment Management Standards (SMS)		WAC 173-204 Dry Weight Equivalents of SMS Criteria (a)	
	SMS SQS	SMS CSL/MCUL	Dry Weight SQS	Dry Weight CSL
Heavy Metals	mg/kg-dry wt	mg/kg-dry wt	mg/kg-dry wt	mg/kg-dry wt
Lead	450	530	450	530
Petroleum Hydrocarbons (b)				
Diesel-Range Petroleum Hydrocarbons	-	-	-	-
Gasoline-Range Petroleum Hydrocarbons	-	-	-	-

CSL = Cleanup screening level.
 MCUL = Maximum cleanup level.
 mg/kg = Milligrams per kilogram.
 MTCA = Washington State Model Toxics Control Act.
 OC = Organic carbon.
 RI/FS = Remedial Investigation/Feasibility Study.
 SMS = Sediment Management Standards.
 WAC = Washington Administrative Code.
 wt = Weight.

- (a) In some cases, it may be appropriate to use dry weight-based Apparent Effects Threshold (AET) sediment quality values in place of the Total Organic Carbon (TOC)-based sediment quality criteria contained in the SMS. The use of the dry weight-based AET sediment quality values should be done only on a case-by-case basis in consultation with Ecology.
- (b) No SMS numeric criteria are promulgated for protection of benthic toxicity. If petroleum hydrocarbons are detected in sediment samples at elevated concentrations, bioassay will be evaluated in the RI/FS to determine potential impacts to benthic organisms as per WAC 173-204-320.

TABLE 9
SITE SCREENING LEVELS – SOIL VAPOR
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Site Soil Vapor Screening Levels	
	MTCA Method B	MTCA Method C
VOCs Detected in Site Soil Vapor Samples		
Propene	--	--
Dichlorodifluoromethane (CFC-12)	3,000	6,700
1,3-Butadiene	2.8	28
Ethanol	--	--
Acetone	--	--
Trichlorofluoromethane	11,000	23,000
2-Propanol (Isopropyl Alcohol)	--	--
Carbon Disulfide	11,000	23,000
n-Hexane	11,000	23,000
Tetrahydrofuran (THF)	--	--
Benzene	11	110
Cyclohexane	90,000	200,000
n-Heptane	--	--
Toluene	77,000	170,000
n-Octane	--	--
Ethylbenzene	15,000	200,000
m, p-Xylenes	--	--
o-Xylene	--	--
n-Nonane	--	--
Cumene	6,000	13,000
n-Propylbenzene	15,000	33,000
4-Ethyltoluene	--	--
1,3,5-Trimethylbenzene	--	--
1,2,4-Trimethylbenzene	110	230
Naphthalene	47	100

MTCA = Washington State Model Toxics Control Act
VOC = Volatile organic compound.

**TABLE 10
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SOIL
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

Site Screening Levels (a)	B-1 S-3	B-2 S-3	B-3 S-3	BMI-GP-1	BMI-GP-2	BMI-GP-3	BMI-GP-4	BMI-GP-5	BMI-GP-5	BMI-GP-5	BMI-GP-5	BMI-GP-5	BMI-GP-5	BMI-GP-6	BMI-GP-6	BMI-GP-6	BMI-GP-7	BMI-GP-7	BMI-GP-7
	7.5' 1201032-01 01/05/2012	7.5' 1201032-02 01/05/2012	7.5' 1201032-03 01/05/2012	9-11 VQ78AJ 10/30/2012	9-11 VQ78AA 10/30/2012	9-11 VQ78X 10/30/2012	9-11 VQ78U 10/30/2012	2-3 VQ78A 10/29/2012	4-5 VQ78B 10/29/2012	9-11 VQ78C 10/29/2012	15-16 VQ78D 10/29/2012	19-20 VQ78E 10/29/2012	2-3 VR91J/VV57I 10/31/2012	10-12 VQ79X 10/31/2012	14-15 VR91KVV57M 10/31/2012	2.5-3.5 VV57O 11/01/2012	5-6 VQ79AD 11/01/2012	10-12 VQ79AE 11/01/2012	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)																			
NWTPH-Dx																			
Diesel Range Organics	2,000/2,000 (b)	140	510	330	21	6.0 U	6.4 U	26	33	3,900	12		1,500				52	1,700	
Lube Oil	2,000/2,000 (b)	50 U	50 U	150	80	18	13 U	190	170	390	13 U		180				91	33	
NWTPH-Gx																			
Gasoline Range Organics	30/100 (c)	680	6,100	1,800	8.1 U	15	5.4 U	6.7 U	10	6.1 U	1,400	11 U	8.2 U	6.4 U	340	23	6.3 U	1,800	
VOLATILES (µg/kg)																			
Method SW8260C/8021																			
1,2-Dichloroethane (EDC)	20/5 (b)				1.3 UJ	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
Benzene	14/5 (b)	300 U	3,400 U	3,000	1.3 U	2.1 U	2.1	2.6 U	1.5 U	1.2 U	240 U	1.6 U	2.8					1.1 U	290 U
Toluene	110,000/6,400 (b)	890	5,700 U	5,000	1.3 UJ	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
Ethylbenzene	18,000/1,000 (b)	1,600	120,000	31,000	1.3 UJ	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
m, p-Xylene					1.3 UJ	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
o-Xylene					1.3 UJ	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
Total Xylenes	9,100/520 (b,d)				ND	ND	ND	ND	ND	ND	ND	ND	ND					ND	ND
Ethylene Dibromide (EDB)	20/20 (b)	2,000 U	120,000	42,000	1.3 UJ	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
Methyl tert-Butyl Ether (MTBE)	190,000/240 (b)				1.3 U	2.1 U	1.2 U	2.6 U	1.5 U	1.2 U	240 U	1.6 U	1.2 U					1.1 U	290 U
TOTAL METALS (mg/kg)																			
Method EPA200.8/6020/SW7471A																			
Lead	250/81 (b)				6.0	3.0	3.3	2.0		4.8	11.6	3.2		8.5				8.0	3.6
SEMIVOLATILES (µg/kg)																			
Methods SW8270D/SW8270D-SIM																			
1-Methylnaphthalene	---				60 U	64 U	64 U	60 U		60 U	6,400	64 U		4.6 U	990	60	4.7 U	130	4,300
2-Methylnaphthalene	---				60 U	64 U	64 U	60 U		60 U	3,300	64 U		4.6 U	780	78	4.7 U	240	3,900
Naphthalene	---				60 U	64 U	64 U	60 U		60 U	1,200	64 U		4.6 U	130	210	4.7 U	66	250
Total Naphthalenes	2,300/120 (b)				ND	ND	ND	ND		ND	10,900	ND		ND	1,900	348	ND	436	8,450
GRAINSIZE (%)																			
Particle/Grain Size, Gravel	---																		
Particle/Grain Size, Sand	---																		
Particle/Grain Size, Silt/Clay	---																		

**TABLE 10
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SOIL
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

Site Screening Levels (a)	BMI-GP-7	BMI-GP-8	BMI-GP-8	BMI-GP-8	BMI-GP-9	BMI-GP-9	BMI-GP-9	BMI-GP-10	BMI-GP-11	BMI-GP-11	BMI-GP-11	BMI-GP-12	BMI-GP-13	BMI-GP-13	BMI-GP-13	BMI-GP-14	BMI-GP-14	BMI-GP-14	
	13-14 VQ79AF 11/01/2012	3-4 VR91L/VV57N 11/01/2012	10-12 VQ79AA 11/01/2012	14-15 VR91M 11/01/2012	6.5-7.5 VQ79P 10/31/2012	10-12 VQ79Q 10/31/2012	13-14 VQ79R 10/31/2012	9-11 VQ78AG 10/30/2012	2-3 VR91H/VV57J 10/31/2012	8-10 VQ79U 10/31/2012	14-15 VR91I/VV57K 10/31/2012	10-12 VQ78AD 10/30/2012	6.5-7.5 VR91C/VV57E 10/30/2012	11.5-12.5 VQ79F 10/30/2012	14-15 VR91D/VV57F 10/30/2012	2-3 VR91F/VV57H 10/31/2012	5-7 VQ79L 10/31/2012	10-11 VQ79M 10/31/2012	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)																			
NWTPH-Dx																			
Diesel Range Organics	2,000/2,000 (b)	6.0 U		10	6.1	360 J	6.1 U	6.2 U		9.5		6.1 U		18			1,400	880	
Lube Oil	2,000/2,000 (b)	12 U		13 U	60	12 U	12 U	32		13 U		12 U		71			32	27	
NWTPH-Gx																			
Gasoline Range Organics	30/100 (c)	7.3 U		10 U	18 U	160 J	7.0 U	7.2 U	7.4 U	170	7.1 U	7.4 U	10	140	20	7,200	1,100	1,300	
VOLATILES (µg/kg)																			
Method SW8260C/8021																			
1,2-Dichloroethane (EDC)	20/5 (b)	1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	1.5 U		1.3 U		1.5 U		1.6 U		72 U	84 U	89 U
Benzene	14/5 (b)	1.2 U	1.1 U	10	1.6 U	1.7	1.7	1.1 U	2.9		3.6		1.2 J		1.9		670	620	360
Toluene	110,000/6,400 (b)	1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	0.8 J		1.8		1.5 U		3.4		72 U	84 U	89 U
Ethylbenzene	18,000/1,000 (b)	1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	1.5 U		5.6		1.5 U		3.3		2,000	1,000	790
m, p-Xylene		1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	1.5 U		6.1		1.5 U		6.4		150	210	400
o-Xylene		1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	1.5 U		2.7		1.5 U		1.6 U		72 U	84 U	89 U
Total Xylenes	9,100/520 (b,d)	ND	ND	ND	ND	ND	ND	ND	ND		8.8		ND		6.4		150	210	400
Ethylene Dibromide (EDB)	20/20 (b)	1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	1.5 U		1.3 U		1.5 U		1.6 U		72 U	84 U	89 U
Methyl tert-Butyl Ether (MTBE)	190,000/240 (b)	1.2 U	1.1 U	1.4 U	1.6 U	1.5 U	1.4 U	1.1 U	1.5 U		1.3 U		1.5 U		1.6 U		72 U	84 U	89 U
TOTAL METALS (mg/kg)																			
Method EPA200.8/6020/SW7471A																			
Lead	250/81 (b)	2.5		4.3	5.5	2.1	1.7	3.2		7.3		1.8		6.3			8.4	7.5	
SEMIVOLATILES (µg/kg)																			
Methods SW8270D/SW8270D-SIM																			
1-Methylnaphthalene	---	64 U	4.8 U	410	63 U	62 U	61 U	60 U	4.9 U	260	43	64 U	6.4	590	39	1,900	2,200	1,300	
2-Methylnaphthalene	---	64 U	4.8 U	640	63 U	62 U	61 U	60 U	4.9 U	180	53	64 U	8.8	140	40	2,800	2,500	1,500	
Naphthalene	---	64 U	5.5	110	63 U	62 U	61 U	60 U	4.9 U	200	92	64 U	5.1	200	120	730	810	510	
Total Naphthalenes	2,300/120 (b)	ND	5.5	1,160	ND	ND	ND	ND	ND	640	188	ND	20.3	930	199	5,430	5,510	3,310	
GRAINSIZE (%)																			
Particle/Grain Size, Gravel	---																		
Particle/Grain Size, Sand	---																		
Particle/Grain Size, Silt/Clay	---																		

**TABLE 10
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SOIL
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

Site Screening Levels (a)	BMI-GP-14	BMI-GP-15	BMI-GP-15	BMI-GP-15	BMI-GP-16	BMI-GP-17	BMI-GP-17	BMI-GP-17	BMI-GP-17	BMI-GP-17	BMI-GP-18	BMI-GP-18	BMI-GP-18	BMI-GP-18	BMI-GP-19	BMI-GP-19	BMI-GP-19	BMI-GP-20
	14-15 VR91G/VV57I 10/31/2012	1-3 VQ79H 10/31/2012	8.5-9.5 VQ79I 10/31/2012	14-15 VR91E/VV57G 10/31/2012	11-13 VQ79AI 11/01/2012	2-3 VQ78L/VV57A 10/29/2012	5-6 VQ78M 10/29/2012	9-11 VQ78N 10/29/2012	12-13 VQ78O 10/29/2012	14-15 VQ78P/VV57B 10/29/2012	4-5 VQ78I 10/29/2012	9-11 VQ78J 10/29/2012	14-15 VQ78K 10/29/2012	4-5 VQ78Q 10/29/2012	9-11 VQ78R 10/29/2012	14-15 VQ78S 10/29/2012	1-2 VR91A/VV57C 10/30/2012	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)																		
NWTPH-Dx																		
Diesel Range Organics	2,000/2,000 (b)	1,500	640		240	6,200	5,100	4,800	580		18				48			5,300
Lube Oil	2,000/2,000 (b)	220	200		12 U	93	68	99	15		59			200				1,700
NWTPH-Gx																		
Gasoline Range Organics	30/100 (c)	20	1,200	130	28	7.3 U	17,000	650	5,800	510	7.0 U	14	8.0 U	8.2 U	8.7	4.6 U	4.7 U	7,000
VOLATILES (µg/kg)																		
Method SW8260C/8021																		
1,2-Dichloroethane (EDC)	20/5 (b)	1.6 U	240 U	1.6 U	1.2 U	1.4 U	640 U	620 U	820 U	120 U	1.2 U	1.2 U	1.4 U	1.5 U	1.5 U	0.6 U	0.7 U	84 U
Benzene	14/5 (b)	69	480	47	1.2 U	1.4 U	400 J	320 J	3,200	450	5.3	1.2 U	3.3	1.5 U	1.5 U	0.6 U	0.7 U	84 U
Toluene	110,000/6,400 (b)	1.6 U	300	8.6	1.2 U	1.4 U	640 U	620 U	610 J	120 U	1.2 U	0.7 J	1.4 U	1.5 UJ	1.5 U	0.6 U	0.7 U	84 U
Ethylbenzene	18,000/1,000 (b)	1.6 U	970	270	1.2 U	1.4 U	4,900	1,500	10,000	620	1.2 U	1.2 U	1.4 U	1.5 UJ	1.5 U	0.6 U	0.7 U	84 U
m, p-Xylene		1.6 U	3,900	310	1.2 U	1.4 U	24,000	5,300	21,000	270	1.2 U	1.2 U	1.4 U	1.5 UJ	1.5 U	0.6 U	0.7 U	84 U
o-Xylene		1.6 U	2,000	64	1.2 U	1.4 U	7,600	1,400	2,600	62 J	1.2 U	1.2 U	1.4 U	1.5 UJ	1.5 U	0.6 U	0.7 U	84 U
Total Xylenes	9,100/520 (b,d)	ND	5,900	374	ND	ND	31,600	6,700	23,600	270	ND	ND	ND	ND	ND	ND	ND	ND
Ethylene Dibromide (EDB)	20/20 (b)	1.6 U	240 U	1.6 U	1.2 U	1.4 U	640 U	620 U	820 U	120 U	1.2 U	1.2 U	1.4 U	1.5 UJ	1.5 U	0.6 U	0.7 U	84 U
Methyl tert-Butyl Ether (MTBE)	190,000/240 (b)	6.1	240 U	1.6 U	1.2 U	1.4 U	640 U	620 U	820 U	120 U	1.0 J	1.2 U	1.4 U	1.5 U	1.5 U	0.6 U	0.7 U	84 U
TOTAL METALS (mg/kg)																		
Method EPA200.8/6020/SW7471A																		
Lead	250/81 (b)		7.0	6.5		3.2		8.4	8.3	5.8			4.9			8.7		
SEMIVOLATILES (µg/kg)																		
Methods SW8270D/SW8270D-SIM																		
1-Methylnaphthalene	---	24	2,800	1,300	49	63 U	4,400	5,400	8,800	1,000	26		63 U			100		240
2-Methylnaphthalene	---	18	3,000	1,600	40	63 U	5,400	2,800	9,400	1,000	20		63 U		62 U			47 U
Naphthalene	---	15	770	380	96	63 U	1,500	80 U	3,600	310	25		63 U		62 U			200
Total Naphthalenes	2,300/120 (b)	57	6,570	3,280	185	ND	11,300	8,200	21,800	2,310	71		ND		100			440
GRAINSIZE (%)																		
Particle/Grain Size, Gravel	---																	
Particle/Grain Size, Sand	---																	
Particle/Grain Size, Silt/Clay	---																	

**TABLE 10
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SOIL
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

Site Screening Levels (a)	BMI-GP-20	BMI-GP-20	BMI-GP-20	BMI-GP-21	BMI-GP-21	BMI-GP-21	BMI-GP-22	MW-6	MW-7	MW-8	MW-9	MW-9	MW-10	MW-10	RW-1
	7-9 VQ79C 10/30/2012	11-12 VR29A 10/30/2012	14-15 VR91B/VV57D 10/30/2012	4-5 VQ78F 10/29/2012	9-11 VQ78G 10/29/2012	15-16 VQ78H 10/29/2012	10-12 VQ79AL 11/01/2012	15-17 WK89G 04/04/2013	15-15.5 WK89F 04/04/2013	10-10.5 WK89E 04/04/2013	10-11.5 WK89H 04/04/2013	13.5-15 WK89K 04/04/2013	9-10.5 WK89A 04/03/2013	14.5-16 WK89B 04/03/2013	8-8.5 WK89C 04/03/2013
TOTAL PETROLEUM HYDROCARBONS (mg/kg)															
NWTPH-Dx															
Diesel Range Organics	2,000/2,000 (b)	3,800	830		43		6.2 U						6.9 U	14	
Lube Oil	2,000/2,000 (b)	120	49		180		12 U						14 U	13 U	
NWTPH-Gx															
Gasoline Range Organics	30/100 (c)	6,300	710	31	8.3 U	8.0 U	8.5 U	7.5 U	16	200		240	29	7.4 U	8.8 U
VOLATILES (µg/kg)															
Method SW8260C/8021															
1,2-Dichloroethane (EDC)	20/5 (b)	1,100 U	82 U	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
Benzene	14/5 (b)	3,500	310	33	1.2 U	1.0 U	1.3 U	1.3 U				1.4	1.2 U		
Toluene	110,000/6,400 (b)	1,100 U	82 U	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
Ethylbenzene	18,000/1,000 (b)	3,200	1,100	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
m, p-Xylene		1,100 U	120	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
o-Xylene		1,100 U	82 U	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
Total Xylenes	9,100/520 (b,d)	ND	120	ND	ND	ND	ND	ND				ND	ND		
Ethylene Dibromide (EDB)	20/20 (b)	1,100 U	82 U	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
Methyl tert-Butyl Ether (MTBE)	190,000/240 (b)	1,100 U	82 U	1.6 U	1.2 U	1.0 U	1.3 U	1.3 U				1.2 U	1.2 U		
TOTAL METALS (mg/kg)															
Method EPA200.8/6020/SW7471A															
Lead	250/81 (b)	6.1	5.8		5.9		6.3								
SEMIVOLATILES (µg/kg)															
Methods SW8270D/SW8270D-SIM															
1-Methylnaphthalene	---	9,300	1,200	220		63 U		64 U	110	450		540	100	62 U	65 U
2-Methylnaphthalene	---	9,800	1,400	250		63 U		64 U	65	560		600	120	62 U	65 U
Naphthalene	---	870	370	41		63 U		64 U	310	520		110	210	62 U	100
Total Naphthalenes	2,300/120 (b)	19,970	2,970	511		ND		ND	485	1,530		1,250	430	ND	100
GRAINSIZE (%)															
Particle/Grain Size, Gravel	---											4.1	4.8	3.2	49.4
Particle/Grain Size, Sand	---											84.3	75.4	84.2	41.4
Particle/Grain Size, Silt/Clay	---											11.8	20.0	12.6	9.1

Notes:

- (a) Site screening levels for soil.
- (b) First value is for unsaturated soil; second value is for saturated soil.
- (c) For gasoline, the soil screening level is 30 mg/kg when benzene is present, and 100 mg/kg when benzene is not present and the total of ethylbenzene, toluene, and xylenes is less than 1 percent of the gasoline mixture.
- (d) Value is for total xylenes.
- U = Indicates the compound was not detected at the reported concentration.
- UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.
- J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
- Box = Exceedance of screening level.

**TABLE 11
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – GROUNDWATER
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

	Site Screening Levels (a)	BMI-GP-4	BMI-GP-5	BMI-GP-8	BMI-GP-9	BMI-GP-10	BMI-GP-11	BMI-GP-12	BMI-GP-16	BMI-GP-18	BMI-GP-19	Dup of BMI-GP-19		BMI-GP-21	BMI-GP-22	MW-2	MW-4	MW-4	MW-4	MW-5
		VQ82E VQ67F VQ67R 10/30/2012	VQ82A VQ67B VQ67N 10/29/2012	VQ82I VQ67J VQ67V 11/01/2012	VQ82G VQ67H VQ67T 10/31/2012	VQ82N 10/30/2012	VQ82H VQ67I VQ67U 10/31/2012	VQ82F VQ67G VQ67S 10/30/2012	VQ82J VQ67K VQ67W 11/01/2012	VQ82C VQ67D VQ67P 10/29/2012	VQ82D VQ67E VQ67Q 10/29/2012	BMI-GP-DUP VQ82L VQ67A VQ67M 10/29/2012	VQ82B VQ67C VQ67O 10/29/2012	VQ82K VQ67L VQ67X 11/01/2012	XJ53B 10/10/2013	WN48G WN48P 04/24/2013	XD12H XD12R 08/29/2013	XJ53A 10/10/2013	WN48A WN48J 04/24/2013	
TOTAL PETROLEUM HYDROCARBONS (mg/L)																				
NWTPH-Dx																				
Diesel Range Organics	0.5	0.10 U	5.3	0.10 U	34	NA	0.12	0.10 U	0.23	0.10 U	0.10 U	0.10 U	0.18	0.10 U			0.10 U	0.10 U		0.10 U
Lube Oil	---	0.20 U	1.0 U	0.20 U	0.43	NA	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
NWTPH-Gx																				
Gasoline Range Organics	0.8/1.0 (b)	0.25 U	0.30	0.25 U	1.2	0.25 U	0.30	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U			0.25 U	0.25 U		0.25 U
VOLATILES (µg/L)																				
Method SW8260C																				
1,2-Dichloroethane	4.2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
Benzene	2.4	0.20 U	0.20 U	1.8	0.20 U	0.20 U	0.21	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
Toluene	15,000	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
Ethylbenzene	2,100	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
m, p-Xylene	1,000 (c)	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U			0.40 U	0.40 U		0.40 U
o-Xylene	440	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
Ethylene Dibromide	2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U			0.20 U	0.20 U		0.20 U
Methyl tert-Butyl Ether	610	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.7	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U			0.50 U	0.50 U		0.50 U
METALS																				
Method EPA 200.8/6020																				
Lead, Dissolved (µg/L)	8.1	0.1 U	0.1 U	0.1 U	1 U	NA	1 U	1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1 U		0.1 U	0.1 U		0.5 U
Lead, Total (µg/L)	8.1	1.5	0.5	0.1 U	2	NA	1 U	2	0.3	2.1 J	6.0	6.7	0.9	19			0.1	0.2		0.5 U
Manganese Dissolved (mg/L)	0.1															0.537			0.087	
SEMIVOLATILES (µg/L)																				
Method SW8270D																				
1-Methylnaphthalene	---	1.0 U	14	2.6	1.0 U	NA	1.0 U	1.0 U	1.4	1.0 U	1.2	1.5	2.2	1.0 U			1.0 U	1.1 U		1.0 U
2-Methylnaphthalene	---	1.0 U	3.8	1.0 U	1.0 U	NA	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U			1.0 U	1.1 U		1.0 U
Naphthalene	---	1.0 U	5.0	1.0 U	1.0 U	NA	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U			1.0 U	1.1 U		1.0 U
Total Naphthalenes	83	ND	22.8	2.6	ND	NA	ND	ND	1.4	ND	1.2	1.5	2.2	ND			ND	ND		ND
CONVENTIONALS (mg/L)																				
Nitrate (EPA 300.0)	---															0.1 U	0.1 U	0.1 U		0.1 U
Sulfate (EPA 300.0)	---															126	94.7	114		0.1 U

**TABLE 11
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – GROUNDWATER
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON**

	Site Screening Levels (a)	MW-5	MW-6	Dup of MW-6	MW-6	Dup of MW-6	MW-6	MW-7	MW-7	MW-7	Dup of MW-7	MW-8	MW-8	MW-9	MW-9	MW-10	MW-10	MW-11	MW-7
		XD12B XD12L	WN48B WN48K	DUP-1 WN48H WN48Q	XD12C XD12M	DUP-1 XD12I XD12S	XJ38A	WN48C WN48L	XD12D XD12N	XJ38B	XJ38D	WN48D WN48M	XD12F XD12P	WN48E WN48N	XD12G XD12Q	WN48F WN48O	XD12A XD12K	XD12E XD12O	
		08/29/2013	04/24/2013	04/24/2013	08/29/2013	08/29/2013	10/10/2013	04/24/2013	08/29/2013	10/10/2013	10/09/2013	04/24/2013	08/29/2013	04/24/2013	08/29/2013	04/24/2013	08/28/2013	08/29/2013	10/10/2013
TOTAL PETROLEUM HYDROCARBONS (mg/L)																			
NWTPH-Dx																			
Diesel Range Organics	0.5	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U		0.27	0.35			0.10 U	0.10 U	0.42	0.34	0.10 U	0.10 U	0.10 U	
Lube Oil	---	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	
NWTPH-Gx																			
Gasoline Range Organics	0.8/1.0 (b)	0.25 U	0.41	0.36	1.3 J	1.0 J		11	8.6			0.25 U	0.25 U	0.65	0.26	0.25 U	0.25 U	0.25 U	
VOLATILES (µg/L)																			
Method SW8260C																			
1,2-Dichloroethane	4.2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U		0.20 U	1.0 U			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Benzene	2.4	0.20 U	0.46	0.44	2.1	2.0		4.6	3.6			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Toluene	15,000	0.20 U	1.1	1.0	1.9	2.0		13	5.6			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Ethylbenzene	2,100	0.20 U	3.5	3.2	7.6	7.6		360	73			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
m, p-Xylene	1,000 (c)	0.40 U	0.83	0.80	3.4	3.3		770	380			0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U
o-Xylene	440	0.20 U	0.35	0.33	0.20 U	0.20 U		59	45			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Ethylene Dibromide	2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U		0.20 U	1.0 U			0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Methyl tert-Butyl Ether	610	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U		0.50 U	2.5 U			0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
METALS																			
Method EPA 200.8/6020																			
Lead, Dissolved (µg/L)	8.1	0.2 U	0.1 U	0.1 U	0.1	0.1		0.5	0.3			0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.2 U	
Lead, Total (µg/L)	8.1	0.2 U	0.9	0.8	0.3	0.2		0.8	0.5			0.1 U	0.1 U	0.1	0.1	0.1 U	0.1 U	0.2 U	
Manganese Dissolved (mg/L)	0.1						0.081			0.034	33								0.012
SEMIVOLATILES (µg/L)																			
Method SW8270D																			
1-Methylnaphthalene	---	1.1 U	2.9	2.9	5.6	5.2		50	50			1.0 U	1.0 U	37	4.8	1.0 U	1.0 U	1.0 U	
2-Methylnaphthalene	---	1.1 U	1.0 U	1.0 U	1.0 U	1.0 U		10	16			1.0 U	1.0 U	25	1.0 U	1.0 U	1.0 U	1.0 U	
Naphthalene	---	1.1 U	1.2	1.0	1.0 U	1.0 U		76	50			1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	
Total Naphthalenes	83	ND	4.1	3.9	5.6	5.2		136	116			ND	ND	62	4.8	ND	ND	ND	
CONVENTIONALS (mg/L)																			
Nitrate (EPA 300.0)	---		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U			0.1 U	1.0 U	0.1 U	0.1 U	0.1 U	0.1 U				1.2 U
Sulfate (EPA 300.0)	---		407	407	446	400	389			120	120	47.1	30.2	137	253				1,900

Notes:

- (a) Site screening levels for groundwater are used for surface water samples.
- (b) For gasoline, the groundwater screening level is 0.8 mg/L when benzene is present, and 1.0 mg/L when benzene is not present.
- (c) Value is for total xylenes.
- NA = Not analyzed.
- ND = Not detected.
- U = Indicates the compound was not detected at the reported concentration.
- UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.
- J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
- Bold = Detected compound.
- Box = Exceedance of screening level.

TABLE 12
SUMMARY OF NATURAL ATTENUATION RESULTS
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

Well	Date	Natural Attenuation Parameters					
		DO (b) (mg/L)	ORP (b) (mV)	Nitrate (mg/L)	Iron II (c) (mg/L)	Sulfate (mg/L)	Dissolved Manganese (mg/L)
MW-2 (a) Source area	10/10/2013 (d)	2.14	-43.3	<0.1	0.40	126	0.537
MW-4 (a) Crossgradient	4/24/2013	0.23	-43.4	<0.1	1.7	94.7	
	8/29/2013	0.41	-263.9	<0.1	1.8	114	
	10/10/2013 (d)	2.55	-58.8	<0.1	1.4	<0.1	0.087
MW-5 Downgradient	4/24/2013	0.85	-99.5		0.0		
	8/29/2013	0.39	-71.4		3.2		
MW-6(a) Plume interior	4/24/2013	0.20	-231.2	<0.1	0.0	407	
	8/29/2013	0.36	-380.6	<0.1	0.0	446	
	10/9/2013 (d)	3.19	-243.8	<1.0	0.8	389	0.081
MW-7(a) Plume interior	4/24/2013	0.21	-250.8		0.0		
	8/28/2013	0.17	-378.2		0.0		
	10/9/2013 (d)	1.50	-320.4	<1.0	0.2	120	0.034
MW-8 Crossgradient	4/24/2013	0.30	-115.4	<0.1	1.1	47.1	
	8/29/2013	0.40	-293.9	<0.1	1.2	30.2	
MW-9 Downgradient	4/24/2013	0.35	-122.0	<0.1	2.0	137	
	8/29/2013	0.43	-312.0	<0.1	1.0	253	
MW-10 Downgradient	4/24/2013	0.25	-68.9		0.2		
	8/28/2013	0.76	-64.3		0.8		
MW-11 (a) Downgradient	8/29/2013	0.49	-272.5		0.3		
	10/9/2013 (d)	2.66	-169.2	1.2	0.4	1,900	0.012

Notes:

DO = Dissolved oxygen.

ORP = Oxidation reduction potential.

mg/L = Milligrams per liter.

mV = Millivolts.

= Analyte not sampled or measured.

< = The compound was not detected at the reported concentration.

(a) = Well sampled for evaluation of natural attenuation, location is relative to source area.

(b) = Field parameter collected from groundwater quality meter

(c) = Field parameter collected from field test kit.

(d) = Dissolved oxygen results may be biased high.

TABLE 13
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SOIL VAPOR
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Site Soil Vapor Screening Levels		BMI-GP-06 P1204604-003	BMI-GP-09 P1204604-002	BMI-GP-13 P1204604-001	BMI-SVSS-1 P1204604-005	Duplicate of BMI-SVSS-1 BMI-GP-DUP P1204604-004
	MTCA Method B	MTCA Method C	10/31/2012	10/31/2012	10/30/2012	10/31/2012	10/31/2012
VOLATILES (µg/m³)							
Method EPA-TO-15							
Propene	--	--	360	120	140	18 J	9.8 J
Dichlorodifluoromethane (CFC-12)	3,000	6,700	17	1.8	2.2	2.2	1.9
Chloromethane	1,400	3,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC-114)	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Vinyl Chloride	9.3	93	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,3-Butadiene	2.8	28	73	44	60	1.2 U	0.80 U
Bromomethane	77	170	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Chloroethane	150,000	330,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Ethanol	--	--	14	12 U	12 U	30	24
Acetonitrile	900	2,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Acrolein	0.30	0.67	3.4 U	4.8 U	4.7 U	4.6 U	3.2 U
Acetone	--	--	21	13	29	28 J	240 J
Trichlorofluoromethane	11,000	23,000	0.94	1.5	1.3	1.2 U	0.80 U
2-Propanol (Isopropyl Alcohol)	--	--	11	12 U	12 U	24	21
Acrylonitrile	1.2	12	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,1-Dichloroethene	3,000	6,700	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Methylene Chloride	180	1,800	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
3-Chloro-1-propene (Allyl Chloride)	15	33	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Trichlorotrifluoroethane	470,000	1,000,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Carbon Disulfide	11,000	23,000	8.5 U	29	46	12 U	8.0 U
Trans-1,2-Dichloroethene	900	2,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,1-Dichloroethane	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Methyl tert-Butyl Ether	47,000	100,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Vinyl Acetate	3,000	6,700	8.5 U	12 U	12 U	12 U	8.0 U
2-Butanone (MEK)	77,000	170,000	8.5 U	12 U	12 U	12 U	8.0 U
cis-1,2-Dichloroethene	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Ethyl Acetate	--	--	1.7 U	2.4 U	2.3 U	2.3 U	1.6 U
n-Hexane	11,000	23,000	32	52	110	230 J	180 J
Chloroform	3.7	37	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Tetrahydrofuran (THF)	--	--	2.9	1.2 U	2.1	3.7	3.2
1,2-Dichloroethane	3.2	32	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,1,1-Trichloroethane	77,000	170,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Benzene	11	110	21	25	17	35	30
Carbon Tetrachloride	14	140	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Cyclohexane	90,000	200,000	20	16	13	150	130
1,2-Dichloropropane	60	130	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Bromodichloromethane	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Trichloroethene	12	67	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,4-Dioxane	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Methyl Methacrylate	11,000	23,000	1.7 U	2.4 U	2.3 U	2.3 U	1.6 U
n-Heptane	--	--	17	18	3.4	81	70
cis-1,3-Dichloropropene	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
4-Methyl-2-pentanone	47,000	100,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
trans-1,3-Dichloropropene	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,1,2-Trichloroethane	5.3	53	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Toluene	77,000	170,000	14	13	1.2 U	7.2 J	44 J
2-Hexanone	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Dibromochloromethane	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,2-Dibromoethane	0.14	1.4	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
n-Butyl Acetate	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
n-Octane	--	--	7.2	7.6	1.2 U	6.1 J	6.6 J
Tetrachloroethene	320	1,300	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Chlorobenzene	770	1,700	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Ethylbenzene	15,000	200,000	2.4	1.7	1.2 U	3.2 J	11 J
m, p-Xylenes	--	--	6.5	4.7	3.5	54	63
Bromoform	77	7,700	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Styrene	15,000	33,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
o-Xylene	--	--	2.0	1.6	2.1	3.2 J	8.4 J

TABLE 13
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SOIL VAPOR
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Site Soil Vapor Screening Levels		BMI-GP-06	BMI-GP-09	BMI-GP-13	BMI-SVSS-1	Duplicate of BMI-SVSS-1 BMI-GP-DUP
	MTCA Method B	MTCA Method C	P1204604-003	P1204604-002	P1204604-001	P1204604-005	P1204604-004
			10/31/2012	10/31/2012	10/30/2012	10/31/2012	10/31/2012
n-Nonane	--	--	0.85 U	3.1	1.2 U	1.2 U	0.80 U
1,1,2,2-Tetrachloroethane	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Cumene	6,000	13,000	2.1	1.2 U	1.3	14 J	11 J
alpha-Pinene	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
n-Propylbenzene	15,000	33,000	2.7	1.2 U	1.2 U	24 J	19 J
4-Ethyltoluene	--	--	0.89	1.2 U	1.2 U	24	22
1,3,5-Trimethylbenzene	--	--	1.5	1.2 U	1.2 U	34	28
1,2,4-Trimethylbenzene	110	230	4.8	1.2 U	1.2 U	83	67
Benzyl Chloride	15	33	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,3-Dichlorobenzene	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,4-Dichlorobenzene	12,000	27,000	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,2-Dichlorobenzene	3,000	6,700	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
d-Limonene	--	--	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,2-Dibromo-3-chloropropane	0.014	0.14	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
1,2,4-Trichlorobenzene	30	67	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U
Naphthalene	47	100	3.4	1.2 U	1.2 U	1.8 J	2.0 J
Hexachlorobutadiene	3.7	37	0.85 U	1.2 U	1.2 U	1.2 U	0.80 U

Notes:

U = Indicates the compound was not detected at the reported concentration.

UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.

J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Box = Exceedance of MTCA Method B Screening Level.

Shaded and Boxed = Exceedance of MTCA Method C Screening Level.

TABLE 14
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SEDIMENT
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Sediment Management Standards (SMS)		BMI-SS-1	BMI-SS-2	BMI-SS-3	Dup of BMI-SS-3
	SQS (a)	CSL (b)	VP65A 10/26/2012	VK89A/VN78A 09/25/2012	VP65B 10/26/2012	Dup-1 VP65C 10/26/2012
TOTALS METALS (mg/kg)						
Method SW6010C						
Lead	450	530	8	6	8 U	8 U
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
NWTPH-Dx						
Diesel Range Organics	--	--	76	30	56	41
Lube Oil	--	--	77	74	63	42
NWTPH-Gx						
Gasoline Range Organics			9.2 U	6.7 U	16 U	14 U
EXTRACTABLE PETROLEUM HYDROCARBONS (mg/kg)						
Method NWEPH						
C8-C10 Aromatics	--	--	3.3 U	2.4 U	3.1 U	3.2 U
>C10-C12 Aromatics	--	--	3.3 U	2.4 U	3.1 U	3.2 U
>C12-C16 Aromatics	--	--	3.3 U	2.4 U	3.1 U	3.2 U
>C16-C21 Aromatics	--	--	9.8	5	10 J	31 J
>C21-C34 Aromatics	--	--	35	27	22 J	58 J
C8-C10 Aliphatics	--	--	3.3 U	6.8 U	3.1 U	3.2 U
>C10-C12 Aliphatics	--	--	3.3 U	2.4 U	3.1 U	3.2 U
>C12-C16 Aliphatics	--	--	3.3 U	2.4 U	3.1	3.2
>C16-C21 Aliphatics	--	--	12	10	14	14
>C21-C34 Aliphatics	--	--	51	42	50	54
VOLATILE PETROLEUM HYDROCARBONS (mg/kg)						
Method NWWPH						
Benzene	--	--	1.8 U	1.4 U	2.3 U	2.3 U
Toluene	--	--	1.8 U	1.4 U	2.3 U	2.3 U
Ethylbenzene	--	--	1.8 U	1.4 U	2.3 U	2.3 U
m, p-Xylene	--	--	3.5 U	2.8 U	4.7 U	4.7 U
o-Xylene	--	--	1.8 U	1.4 U	2.3 U	2.3 U
Methyl tert-Butyl Ether	--	--	1.8 U	1.4 U	2.3 U	2.3 U
n-Pentane	--	--	1.8 U	1.4 U	2.3 U	2.3 U
n-Hexane	--	--	1.8 U	1.4 U	2.3 U	2.3 U
n-Octane	--	--	1.8 U	1.4 U	2.3 U	2.3 U
n-Decane	--	--	1.8 U	1.4 U	2.3 U	2.3 U
n-Dodecane	--	--	1.8 U	1.4 U	2.3 U	2.3 U
C8-C10 Aromatics	--	--	18 U	14 U	23 U	23 U
>C10-C12 Aromatics	--	--	18 U	14 U	23 U	23 U
>C12-C13 Aromatics	--	--	18 U	14 U	23 U	23 U
C5-C6 Aliphatics	--	--	18 U	14 U	23 U	23 U
>C6-C8 Aliphatics	--	--	18 U	14 U	23 U	23 U
>C8-C10 Aliphatics	--	--	18 U	14 U	23 U	23 U
>C10-C12 Aliphatics	--	--	18 U	14 U	23 U	23 U
SEMIVOLATILES (mg/kg)						
Method SW8270D						
Naphthalene	2,100	2,100	0.064 U	0.061 UJ	0.081	0.073
2-Methylnaphthalene	670	670	0.064 U	0.061 UJ	0.062 U	0.062 U
1-Methylnaphthalene	--	--	0.064 U	0.061 UJ	0.062 U	0.062 U
CONVENTIONALS (%)						
Total Solids (SM2540B)	--	--	57.30	83.40	60.90	59.10
Total Organic Carbon (SW9060M)	--	--	2.99	2.49	3.39	3.24

TABLE 14
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SEDIMENT
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Sediment Management Standards (SMS)		BMI-SS-1	BMI-SS-2	BMI-SS-3	Dup of BMI-SS-3
	SQS (a)	CSL (b)	VP65A 10/26/2012	VK89A/VN78A 09/25/2012	VP65B 10/26/2012	Dup-1 VP65C 10/26/2012
GRAIN SIZE (%)						
ASTM D 422						
Particle/Grain Size, Gravel	--	--	21	56.3	10.3	11
Particle/Grain Size, Sand	--	--	62.3	40.8	72.9	72.8
Particle/Grain Size, Silt	--	--	10.8	1.2	10.4	9.7
Particle/Grain Size, Clay	--	--	5.7	1.7	6.5	6.4

Notes:

(a) Sediment Quality Standards.

(b) Cleanup screening level.

U = Indicates the compound was not detected at the reported concentration.

UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.

J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Bold = Detected compound.

TABLE 15
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SURFACE WATER
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Site Screening Levels (a)	BMI-SW-1 VK93A 09/25/2012
TOTALS METALS (µg/L)		
Method EPA200.8		
Lead	8.1	1 U
TOTAL PETROLEUM HYDROCARBONS (mg/L)		
NWTPH-Dx		
Diesel Range Organics	0.5	0.10 U
Lube Oil	0.5	0.20 U
NWTPH-Gx		
Gasoline Range Organics	0.8/1.0 (b)	0.25 U
VOLATILES (µg/L)		
Method SW8260C		
Chloromethane	5.2	0.50 U
Bromomethane	13	1.0 U
Vinyl Chloride	0.5	0.20 U
Chloroethane	12	0.20 U
Methylene Chloride	94	1.0 U
Acetone		5.0 U
Carbon Disulfide	400	0.20 U
1,1-Dichloroethene	3.2	0.20 U
1,1-Dichloroethane	2,300	0.20 U
trans-1,2-Dichloroethene	130	0.20 U
cis-1,2-Dichloroethene	160	0.20 U
Chloroform	1.2	0.20 U
1,2-Dichloroethane	4.2	0.20 U
2-Butanone	350,000	5.0 U
1,1,1-Trichloroethane	11,000	0.20 U
Carbon Tetrachloride	0.5	0.20 U
Vinyl Acetate	7,800	0.20 U
Bromodichloromethane	0.5	0.20 U
1,2-Dichloropropane	15	0.20 U
cis-1,3-Dichloropropene		0.20 U
Trichloroethene	0.5	0.20 U
Dibromochloromethane	0.5	0.20 U
1,1,2-Trichloroethane	7.9	0.20 U
Benzene	2.4	0.20 U
trans-1,3-Dichloropropene		0.20 U
2-Chloroethylvinylether		1.0 U
Bromoform	140	0.20 U
4-Methyl-2-Pentanone (MIBK)	11,000	5.0 U
2-Hexanone		5.0 U
Tetrachloroethene	0.5	0.20 U
1,1,2,2-Tetrachloroethane	4	0.20 U
Toluene	15,000	0.20 U
Chlorobenzene	100	0.20 U
Ethylbenzene	2,100	0.20 U
Styrene	78	0.20 U
Trichlorofluoromethane	120	0.20 U
1,1,2-Trichloro-1,2,2-trifluoroethane	1,100	0.20 U
m, p-Xylene	1,000 (c)	0.40 U
o-Xylene	440	0.20 U
1,2-Dichlorobenzene	6.1	0.20 U
1,3-Dichlorobenzene	960	0.20 U
1,4-Dichlorobenzene	5	0.20 U
Acrolein	20	5.0 U
Methyl Iodide		1.0 U
Bromoethane		0.20 U
Acrylonitrile	5	1.0 U
1,1-Dichloropropene		0.20 U
Dibromomethane		0.20 U

TABLE 15
SUMMARY OF REMEDIAL INVESTIGATION ANALYTICAL RESULTS – SURFACE WATER
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

	Site Screening Levels (a)	BMI-SW-1 VK93A 09/25/2012
1,1,1,2-Tetrachloroethane	7.4	0.20 U
1,2-Dibromo-3-chloropropane		0.50 U
1,2,3-Trichloropropane		0.50 U
trans-1,4-Dichloro-2-butene		1.0 U
1,3,5-Trimethylbenzene	25	0.20 U
1,2,4-Trimethylbenzene	24	0.20 U
Hexachlorobutadiene	0.2	0.50 U
Ethylene Dibromide	2	0.20 U
Bromochloromethane		0.20 U
2,2-Dichloropropane		0.20 U
1,3-Dichloropropane		0.20 U
Isopropylbenzene	720	0.20 U
n-Propylbenzene		0.20 U
Bromobenzene		0.20 U
2-Chlorotoluene		0.20 U
4-Chlorotoluene		0.20 U
tert-Butylbenzene		0.20 U
sec-Butylbenzene		0.20 U
4-Isopropyltoluene		0.20 U
n-Butylbenzene		0.20 U
1,2,4-Trichlorobenzene	0.48	0.50 UJ
Naphthalene	83	0.50 UJ
1,2,3-Trichlorobenzene		0.50 UJ
Methyl tert-Butyl Ether	610	0.50 U
SEMIVOLATILES (µg/L)		
Method SW8270D		
Naphthalene		1.0 U
2-Methylnaphthalene		1.0 U
1-Methylnaphthalene		1.0 U
Naphthalenes	83 (d)	ND

Notes:

- (a) Site screening levels for groundwater are used for surface water samples.
(b) For gasoline, the groundwater screening level is 0.8 mg/L when benzene is present, and 1.0 mg/L when benzene is not present.
(c) Value is for total xylenes.
(d) Value is total of naphthalene, 2-methylnaphthalene, and 1-methylnaphthalene.
U = Indicates the compound was not detected at the reported concentration.
UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.
ND = Not detected.

TABLE 16
SUMMARY STATISTICS – SOIL
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detection	SL(a)	Frequency Above SL	IHS?	Notes
NWTPH-Dx (mg/kg)								
Diesel Range Hydrocarbons	40	22	55%	16,000	2,000	6/40	Yes	
Motor Oil	40	26	65%	1,700	2,000	0/40	No	No Exceedances of SLs
NWTPH-Gx (mg/kg)								
Gasoline Range Hydrocarbons	63	35	56%	17,000	30/100 (b)	24/63	Yes	
VOCS/BTEX (µg/kg)								
Benzene	55	23	42%	3,500	14/5	12/55	Yes	
Ethylbenzene	55	16	29%	120,000	18,000/1,000	9/55	Yes	
m,p-Xylene	52	12	23%	24,000	--	--	-	(See total Xylenes)
o-Xylene	52	6	12%	7,600	--	--	-	(See total Xylenes)
Xylenes, Total	52	6	12%	120,000	9,100/520	4/52	Yes	
Methyl tert-Butyl Ether	52	1	2%	6.1	190,000/240	0/52	No	Low Frequency of Detection
Ethylene Dibromide	55	2	4%	120,000	20/20	2/55	No	Low Frequency of Detection
1,2-Dichloroethane	52	0	0%	No Detects	20/5	0/52	No	Low Frequency of Detection
Toluene	55	6	11%	890	110,000/6,400	0/55	No	No Exceedances of SLs
TOTAL METALS (mg/kg)								
Lead	33	33	100%	11.6	250/81	0/33	No	No Exceedances of SLs
SVOCs/SVOC-SIM (µg/kg)								
1-Methylnaphthalene	54	32	59%	9,300	--	--	-	(See Naphthalenes)
2-Methylnaphthalene	54	30	56%	9,800	--	--	-	(See Naphthalenes)
Naphthalene	54	32	59%	3,600	--	--	-	(See Naphthalenes)
Naphthalenes	54	32	59%	21,800	2,300/120	50%	Yes	

(a) First value is for unsaturated soil; second value is for saturated soil.

(b) For gasoline, the soil screening level is 30 mg/kg when benzene is present, and 100 mg/kg when benzene is not present and the total of ethylbenzene, toluene, and xylenes is less than 1 percent of the gasoline mixture.

TABLE 17
SUMMARY STATISTICS – GROUNDWATER
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON

	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detection	SL	Frequency Above SL	IHS?	Notes
NWTPH-Dx (mg/L)								
Diesel Range Hydrocarbons (a)	35	11	31%	251	0.5	8/35	Yes	
Motor Oil	29	1	3%	0.43	--	0/29	No	No Exceedances of SLs
NWTPH-Gx (mg/L)								
Gasoline Range Hydrocarbons (a)	36	17	47%	11	0.8	11/36	Yes	
VOCS (µg/L)								
Benzene	30	8	27%	4.6	2.4	2/30	Yes	
Ethylbenzene	30	6	20%	360	2,100	0/30	No	No Exceedances of SLs
m,p-Xylene	30	6	20%	770	1,000	0/30	No	No Exceedances of SLs
o-Xylene	30	6	20%	59	440	0/30	No	No Exceedances of SLs
Methyl tert-Butyl Ether	30	1	3%	1.7	610	0/30	No	No Exceedances of SLs
1,2-Dichloroethane	30	0	0%	No Detects	4.2	0/30	No	Low Frequency of Detection
Toluene	30	6	20%	13	15,000	0/30	No	No Exceedances of SLs
Ethylene Dibromide	30	0	0%	No Detects	2	0/30	No	Low Frequency of Detection
DISSOLVED METALS								
Lead (µg/L)	29	3	10%	0.5	8.1	0/29	No	No Exceedances of SLs
Manganese (mg/L)	5	5	100%	0.537	0.1	1/5	No	See Note (b)
TOTAL METALS (µg/L)								
Lead	31	16	52%	19	8.1	1/31	No	See Note (c)
SVOCS (µg/L)								
1-Methylnaphthalene	29	11	38%	50	--	--	-	(See Total Naphthalenes)
2-Methylnaphthalene	29	4	14%	25	--	--	-	(See Total Naphthalenes)
Naphthalene	29	4	14%	76	--	--	-	(See Total Naphthalenes)
Total Naphthalenes	29	11	38%	136	83	2/29	Yes	

(a) Number of samples and number of detections have been adjusted to account for free product observations at MW-1, -2, and -3 during two sampling events. All other fields show calculated values only from laboratory results.

(b) Ecology and the EPA view manganese as a secondary contaminant for aesthetic considerations such as taste, color, and odor.

It is not likely to present a risk to human health. Monitoring for manganese was conducted to evaluate natural attenuation processes at the Site.

(c) Total lead was detected above the SL only in groundwater grab sample. Dissolved sample from the same location had no detection of lead.

IHS = Indicator Hazardous Substance

SL = Screening Level

TABLE 18
INDICATOR HAZARDOUS SUBSTANCES AND PROPOSED CLEANUP LEVELS
BLAINE MARINA, INC. SITE
BLAINE, WASHINGTON

Indicator Hazardous Substance	Proposed Cleanup Level (Saturated Soil)	Proposed Cleanup Level (Unsaturated Soil)	Proposed Cleanup Level (Groundwater)
Total Petroleum Hydrocarbons			
TPH-D	2,000 mg/kg	2,000 mg/kg	0.5 mg/L
TPH-G	30 mg/kg	30 mg/kg	0.8 mg/L
VOCs			
Benzene	5 µg/kg	14 µg/kg	51 µg/L
Ethylbenzene	1,000 µg/kg	18,000 µg/kg	N/A
m, p-Xylene	520 µg/kg	9,100 µg/kg	N/A
Naphthalenes			
Total Naphthalenes	120 µg/kg	2,300 µg/kg	83 µg/L

Notes:

µg/kg = Micrograms per kilogram.

µg/L = Micrograms per liter.

mg/kg = Milligrams per kilogram.

mg/L = Milligrams per liter.

TPH-D = Diesel-range total petroleum hydrocarbons.

TPH-G = Gasoline-range total petroleum hydrocarbons.

VOCs = Volatile organic compounds.

N/A = Not applicable.

**TABLE 19
SUMMARY OF MODEL TOXICS CONTROL ACT OVERALL BENEFIT RANKINGS AND DISPROPORTIONATE COST ANALYSIS
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Alternative Name	Alternative 1: Limited Source Removal with LNAPL Recovery and Bioremediation	Alternative 2: Source Area Removal and Bioremediation	Alternative 3: Source Area Removal, Bioremediation, and Soil Flushing with a Downgradient Hydraulic Barrier																																																																																																
<p align="center">Description of Alternative ==>>></p> <p>Each of the alternatives will include the following:</p> <ul style="list-style-type: none"> Removal of the AST system and adjacent buildings Installation and maintenance of a pavement cover Compliance monitoring to include collecting soil, groundwater, and seep samples for comparison to cleanup levels <ul style="list-style-type: none"> Institutional controls 	<ul style="list-style-type: none"> Remove approximately 1,700 tons of heavily contaminated soil and LNAPL from upper 10 ft (vadose zone) in the source area Extend sheetpile bulkhead north 60 ft Bioremediation: Reagents introduced to subsurface through infiltration trenches totaling 170 LF in length Bioremediation: As needed, reagents introduced to subsurface through injection points in Sigurdson Avenue Possible MNA following bioremediation 	<ul style="list-style-type: none"> Remove contaminated soil and free-phase LNAPL from the upper 12 ft of soil in the source area Extend sheetpile bulkhead north 60 ft Bioremediation: Reagents introduced to subsurface through infiltration trenches totaling 170 LF in length Bioremediation: As needed, reagents introduced to subsurface through injection points in Sigurdson Avenue Possible MNA following bioremediation 	<ul style="list-style-type: none"> Remove contaminated soil and free-phase LNAPL from the upper 12 ft of soil in the source area Extend sheetpile bulkhead north 60 ft and south 10 ft Bioremediation: Reagents introduced to subsurface through infiltration trenches totaling 200 LF in length Soil flushing along Sigurdson Avenue: Extract, treat, and reinject groundwater; includes downgradient hydraulic barrier Possible MNA following bioremediation 																																																																																																
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<p>2 Compliance With MTCA Threshold Criteria [WAC 173-340-360(2)(a)]</p> <ul style="list-style-type: none"> Protect human health and the environment Comply with cleanup standards Comply with applicable state/federal laws Provide for compliance monitoring 	Yes Yes Yes Yes	Yes Yes Yes Yes	Yes Yes Yes Yes																																																																																																
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**TABLE 19
SUMMARY OF MODEL TOXICS CONTROL ACT OVERALL BENEFIT RANKINGS AND DISPROPORTIONATE COST ANALYSIS
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Alternative Name	Alternative 4: Excavation East of Sigurdson, Bioremediation Along Shoreline	Alternative 5: Excavation East of Sigurdson, Soil Flushing with Downgradient Hydraulic Barrier	Alternative 6: Mass Excavation and MNA																																																																																																
<p align="center">Description of Alternative ==>>></p> <p>Each of the alternatives will include the following:</p> <ul style="list-style-type: none"> Removal of the AST system and adjacent buildings Installation and maintenance of a pavement cover Compliance monitoring to include collecting soil, groundwater, and seep samples for comparison to cleanup levels <ul style="list-style-type: none"> Institutional controls 	<ul style="list-style-type: none"> Remove all contaminated soil and free-phase LNAPL upgradient of Sigurdson Avenue Extend sheetpile bulkhead north 60 ft Bioremediation: Reagents introduced to subsurface through infiltration trenches totaling 80 LF in length and three injection wells Bioremediation: As needed, reagents introduced to subsurface through injection points in Sigurdson Avenue Possible MNA following bioremediation 	<ul style="list-style-type: none"> Remove all contaminated soil and free-phase LNAPL upgradient of Sigurdson Avenue Extend sheetpile bulkhead north 60 ft, 10 ft south Bioremediation: Reagents introduced to subsurface through infiltration trenches totaling 80 LF in length and three injection wells Soil flushing along Sigurdson Avenue: Extract, treat, and reinject groundwater; includes downgradient hydraulic barrier Possible MNA following bioremediation 	<ul style="list-style-type: none"> Complete removal of approximately contaminated soil and LNAPL Extend sheetpile bulkhead north 60 ft Backfill excavation with clean fill and repave area Possible MNA following mass excavation 																																																																																																
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Historical Aerial Photographs



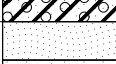









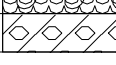
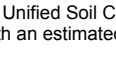
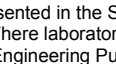





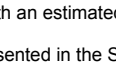




Boring Logs and Monitoring Well Construction Details

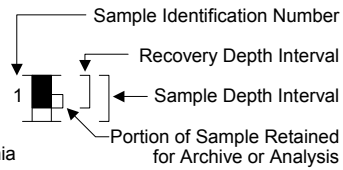
Soil Classification System



	MAJOR DIVISIONS	USCS GRAPHIC SYMBOL	LETTER SYMBOL ⁽¹⁾	TYPICAL DESCRIPTIONS ⁽²⁾⁽³⁾
COARSE-GRAINED SOIL <small>(More than 50% of material is larger than No. 200 sieve size)</small>	GRAVEL AND GRAVELLY SOIL <small>(More than 50% of coarse fraction retained on No. 4 sieve)</small>	CLEAN GRAVEL <small>(Little or no fines)</small>		GW Well-graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES <small>(Appreciable amount of fines)</small>		GP Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES <small>(Appreciable amount of fines)</small>		GM Silty gravel; gravel/sand/silt mixture(s)
	SAND AND SANDY SOIL <small>(More than 50% of coarse fraction passed through No. 4 sieve)</small>	CLEAN SAND <small>(Little or no fines)</small>		GC Clayey gravel; gravel/sand/clay mixture(s)
		SAND WITH FINES <small>(Appreciable amount of fines)</small>		SW Well-graded sand; gravelly sand; little or no fines
		SAND WITH FINES <small>(Appreciable amount of fines)</small>		SP Poorly graded sand; gravelly sand; little or no fines
FINE-GRAINED SOIL <small>(More than 50% of material is smaller than No. 200 sieve size)</small>	SILT AND CLAY <small>(Liquid limit less than 50)</small>		SM Silty sand; sand/silt mixture(s)	
			SC Clayey sand; sand/clay mixture(s)	
			ML Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity	
	SILT AND CLAY <small>(Liquid limit greater than 50)</small>		CL Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay	
			OL Organic silt; organic, silty clay of low plasticity	
			MH Inorganic silt; micaceous or diatomaceous fine sand	
		CH Inorganic clay of high plasticity; fat clay		
	OH Organic clay of medium to high plasticity; organic silt			
	PT Peat; humus; swamp soil with high organic content			

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

- Notes:
- USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
 - Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
 - Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:
 - Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
 - Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
 - > 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
 - Additional Constituents: > 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
 - ≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.
 - Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key		Field and Lab Test Data	
SAMPLER TYPE	SAMPLE NUMBER & INTERVAL	Code	Description
Code	Description		
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon	PP = 1.0	Pocket Penetrometer, tsf
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon	TV = 0.5	Torvane, tsf
c	Shelby Tube	PID = 100	Photoionization Detector VOC screening, ppm
d	Grab Sample	W = 10	Moisture Content, %
e	Single-Tube Core Barrel	D = 120	Dry Density, pcf
f	Double-Tube Core Barrel	-200 = 60	Material smaller than No. 200 sieve, %
g	2.50-inch O.D., 2.00-inch I.D. WSDOT	GS	Grain Size - See separate figure for data
h	3.00-inch O.D., 2.375-inch I.D. Mod. California	AL	Atterberg Limits - See separate figure for data
i	Other - See text if applicable	GT	Other Geotechnical Testing
1	300-lb Hammer, 30-inch Drop	CA	Chemical Analysis
2	140-lb Hammer, 30-inch Drop		
3	Pushed		
4	Vibrocore (Rotasonic/Geoprobe)		
5	Other - See text if applicable		



Groundwater	
	Approximate water level at time of drilling (ATD)
	Approximate water level at time other than ATD

B-1-12

SAMPLE DATA						SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Hollow-Stem Auger</u>	Water Level
								Ground Elevation (ft): <u>15</u>	
0	15	S-1	a2	5	0.4 W = 33	AC GW-GM		Approximately 5-inches of asphalt concrete pavement	<div style="text-align: center;"> ATD </div>
5	10	S-2A	b2	0	0.0 W = 38	CL	(FILL)	Brown, sandy GRAVEL with silt (medium dense, damp)	
10	5	S-3	b2	4	455	SP-SM		Gray, sandy CLAY with numerous jumbled pockets of clayey SAND (soft/loose to very soft/very loose, moist to damp) no odor	
15	0	S-4	b2	0	371	SM/ML		Gray, fine to medium SAND with silt and shell fragments, plus zones of sandy silt (loose, wet) strong gasoline and diesel odor	
20	-5	S-5	b2	2	4.1			Gray, sandy SILT with zones of silty fine to medium SAND (very soft/very loose, wet) strong gasoline and diesel odor	
		S-6	b2	4	0 W = 36	SM		-- moderate to weak diesel and gas odor, sulfur odor also present	
		S-7	b2	4	0			Gray, silty fine SAND with shells, occasional coarse wood fragments (very loose to loose, wet) weak sulfur odor (MARINE DEPOSITS)	

Boring Completed 01/05/12
Total Depth of Boring = 21.5 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034.01 4/8/15 N:\PROJECTS\01034.01\0.015.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring B-1-12

Figure
B-2

B-2-12

SAMPLE DATA		SOIL PROFILE				GROUNDWATER			
o	Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Hollow-Stem Auger</u> Ground Elevation (ft): <u>15</u> Drilled By: <u>Holocene Drilling Inc.</u>	Water Level
±	Elevation								
	5	S-1	b2	3	W = 34	AC GW-GM		Approximately 5-inches of asphalt concrete pavement	
	10	S-2	b2	0	2.5 W = 38	CL		Brown, sandy GRAVEL with silt (medium dense, damp) (FILL)	
	5	S-3	b2	2	452	CL		Gray, silty CLAY with pockets of silty sand, trace of gravel, occasional coarse wood fragments (very soft to soft, moist) no odor -- no gravel, no odor	
	10	S-4	b2	1	220	SM		-- color change to dark gray, strong diesel and gasoline odor, oil sheen in sampler	▽ ATD
	15	S-5	b2	4	47	SM		Dark gray, silty fine SAND (very loose, wet) very strong diesel and gasoline odor, sheen in sampler	
	20	S-6	b2	5	4.5 W = 27 GS	SM		Dark gray, silty fine SAND to SAND with silt, with scattered shells (very loose to loose, wet) (MARINE DEPOSITS) -- very strong diesel and gasoline odor, sheen in sampler	
	5	S-7	b2	4				-- color change to gray, moderate petroleum odor and sheen -- below 18 ft, weighted mud added to auger to help prevent heave -- occasional shells, no sheen, slight sulfur odor	
	10	S-8a S-8b	b2 b2	3		CL/CH		-- gray, silty fine SAND with shells, occasional wood fragments, no odor, no sheen	
	15							Gray, silty CLAY, occasional clayey sand pockets (very soft to medium stiff, moist) (GLACIOMARINE DRIFT)	
	20	S-9	b2	5	W = 45			-- trace of fine sand and shell fragments, no odor, no sheen	

- Notes:
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 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034.01 4/8/15 N:\PROJECTS\01034.01\0.015.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring B-2-12

Figure
B-3
(1 of 2)

B-2-12

SAMPLE DATA						SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Hollow-Stem Auger</u>	Water Level
35	-20	S-10	b2	1			CL/CH	Ground Elevation (ft): <u>15</u>	
40	-25	S-11	b2	5	W = 26			Drilled By: <u>Holocene Drilling Inc.</u>	
45	-30	S-12	b2	0				Gray, silty CLAY, occasional clayey sand pockets (very soft to medium stiff, moist) (GLACIOMARINE DRIFT) -- occasional partings of fine sandy silt	

Boring Completed 01/05/12
Total Depth of Boring = 46.5 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034.01 4/8/15 N:\PROJECTS\01034.01\0.015.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring B-2-12

Figure
B-3
(2 of 2)

B-3-12

SAMPLE DATA						SOIL PROFILE			GROUNDWATER
o Depth (ft)	± Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Hollow-Stem Auger</u>	Water Level
								Ground Elevation (ft): <u>15</u>	
5	10	S-1	b2	2	W = 27	AC GW- GM		Approximately 4-inches of asphalt concrete pavement	
		S-2	b2	2	10.8 W = 24	CL/ CH	(FILL)	Brown, sandy GRAVEL with silt (medium dense, damp)	
		S-3	b2	5	406	SM		Gray, sandy CLAY with sand pockets (very soft, moist) -- no odor	▽ ATD
10	5	S-4	b2	3	14.5 W = 27 GS	SM		Gray, silty, fine SAND to SAND with silt, numerous shell fragments (very loose to loose, wet) -- strong diesel and gasoline odor	
		S-5	b2	3	11.8	SM		Gray, silty fine SAND, no shells, faint bedding (very loose to loose, wet) faint petroleum odor (MARINE DEPOSITS)	
15	0	S-6	b2	5	3.1 W = 25			-- no odor	

Boring Completed 01/05/12
Total Depth of Boring = 16.5 ft.

1034.01 4/8/15 N:\PROJECTS\01034.01\0.015.GPJ SOIL BORING LOG W/ ELEV

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring B-3-12

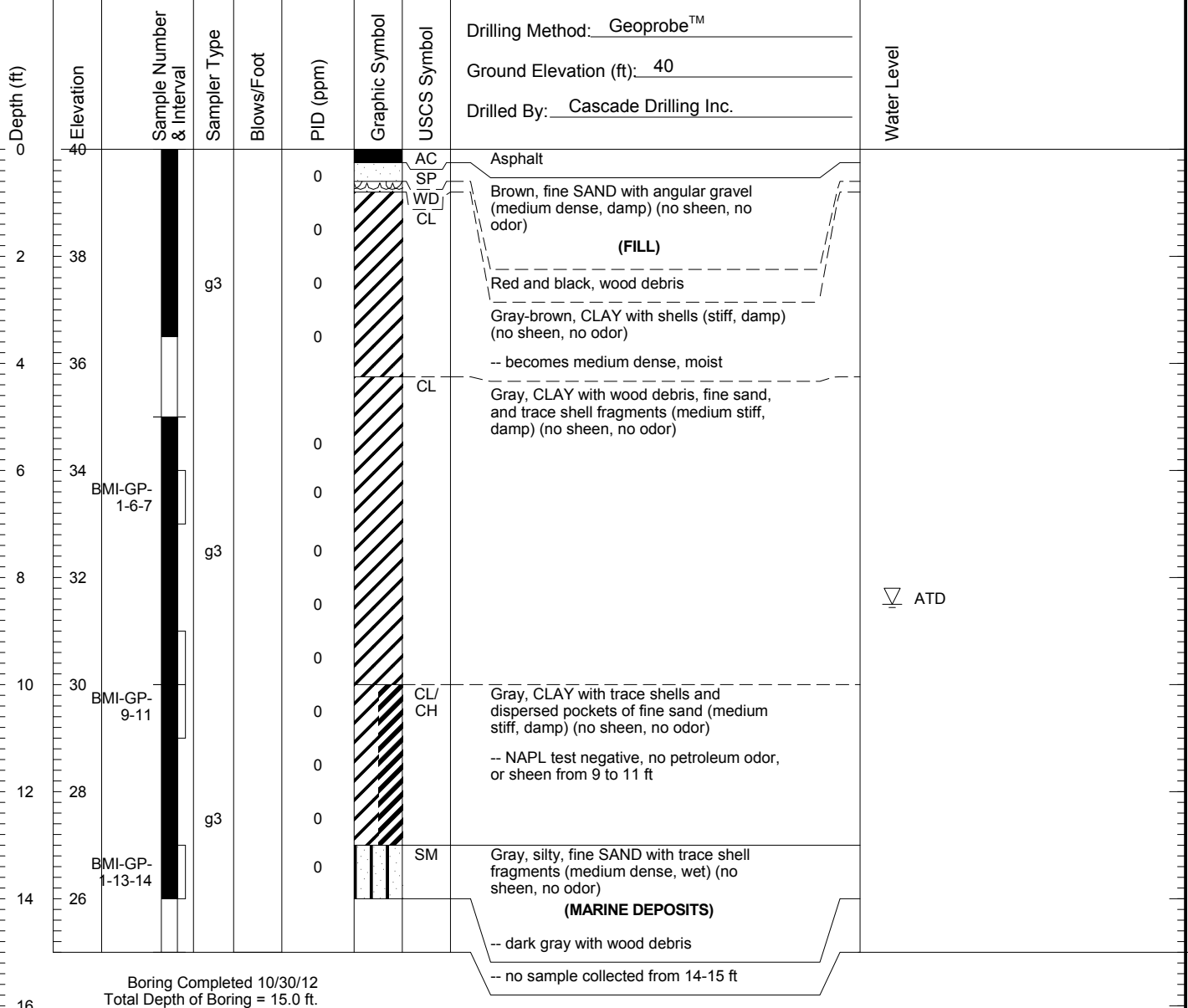
Figure
B-4

BMI-GP-1

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-1

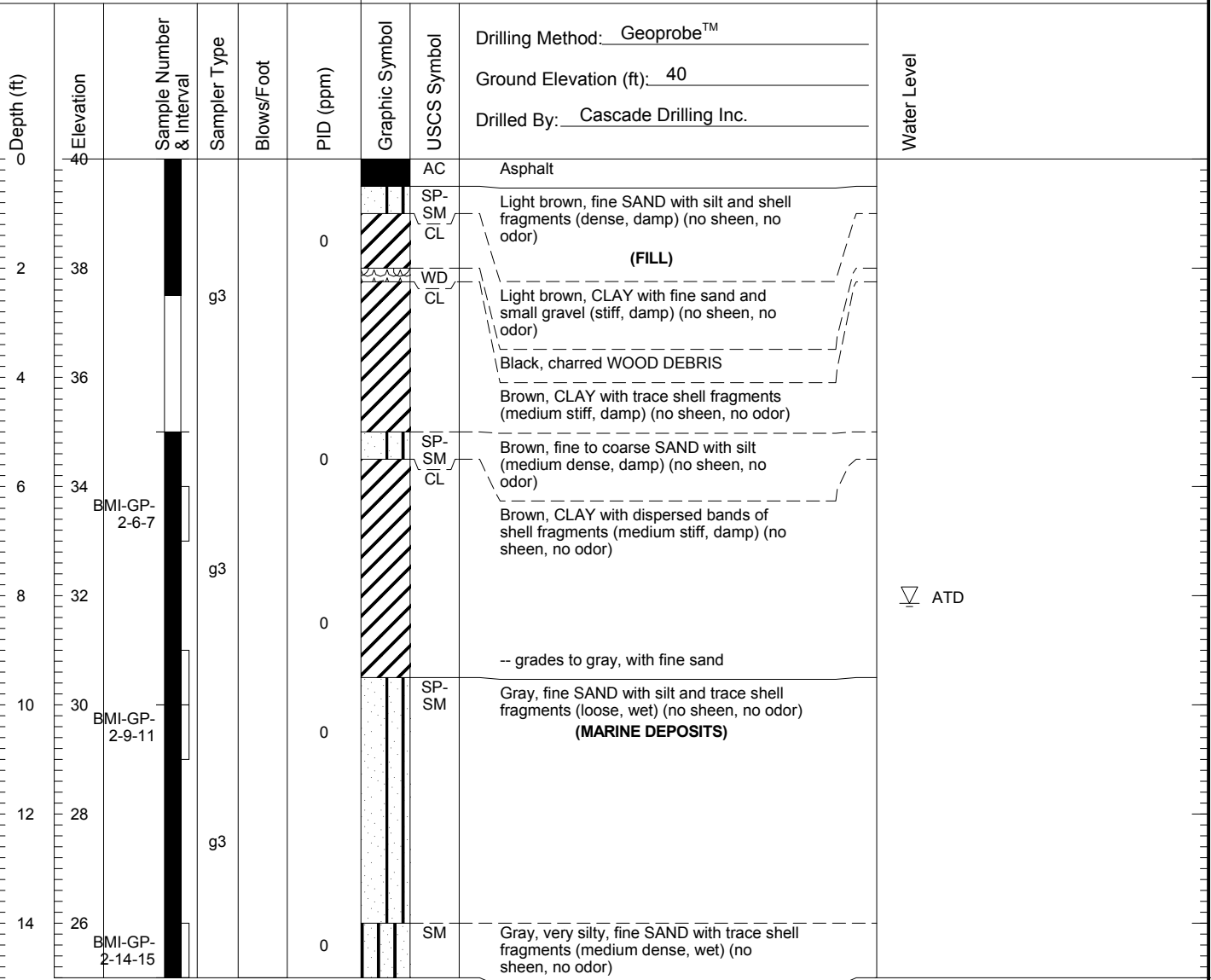
Figure
B-5

BMI-GP-2

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-2

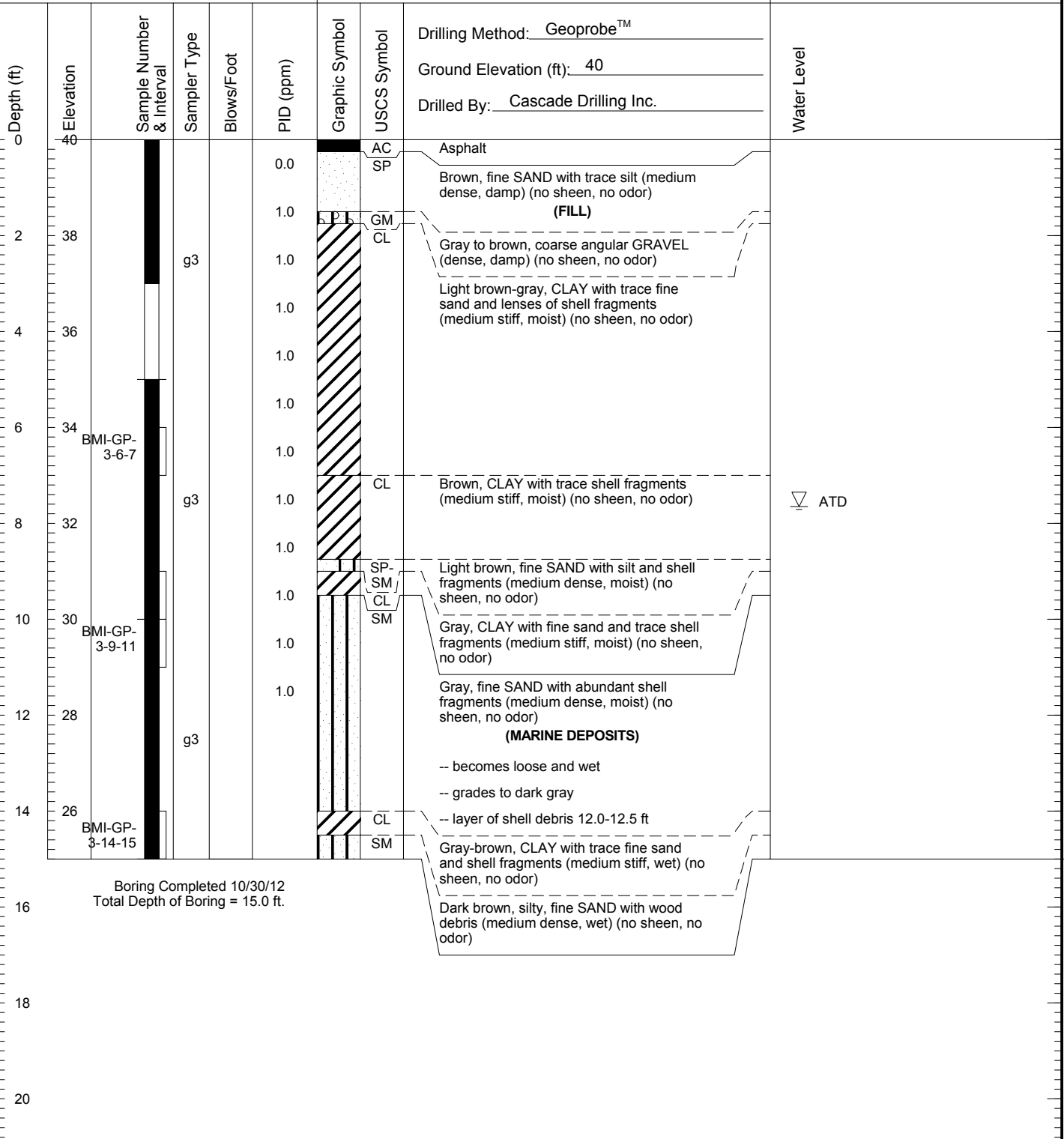
Figure
B-6

BMI-GP-3

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEVE

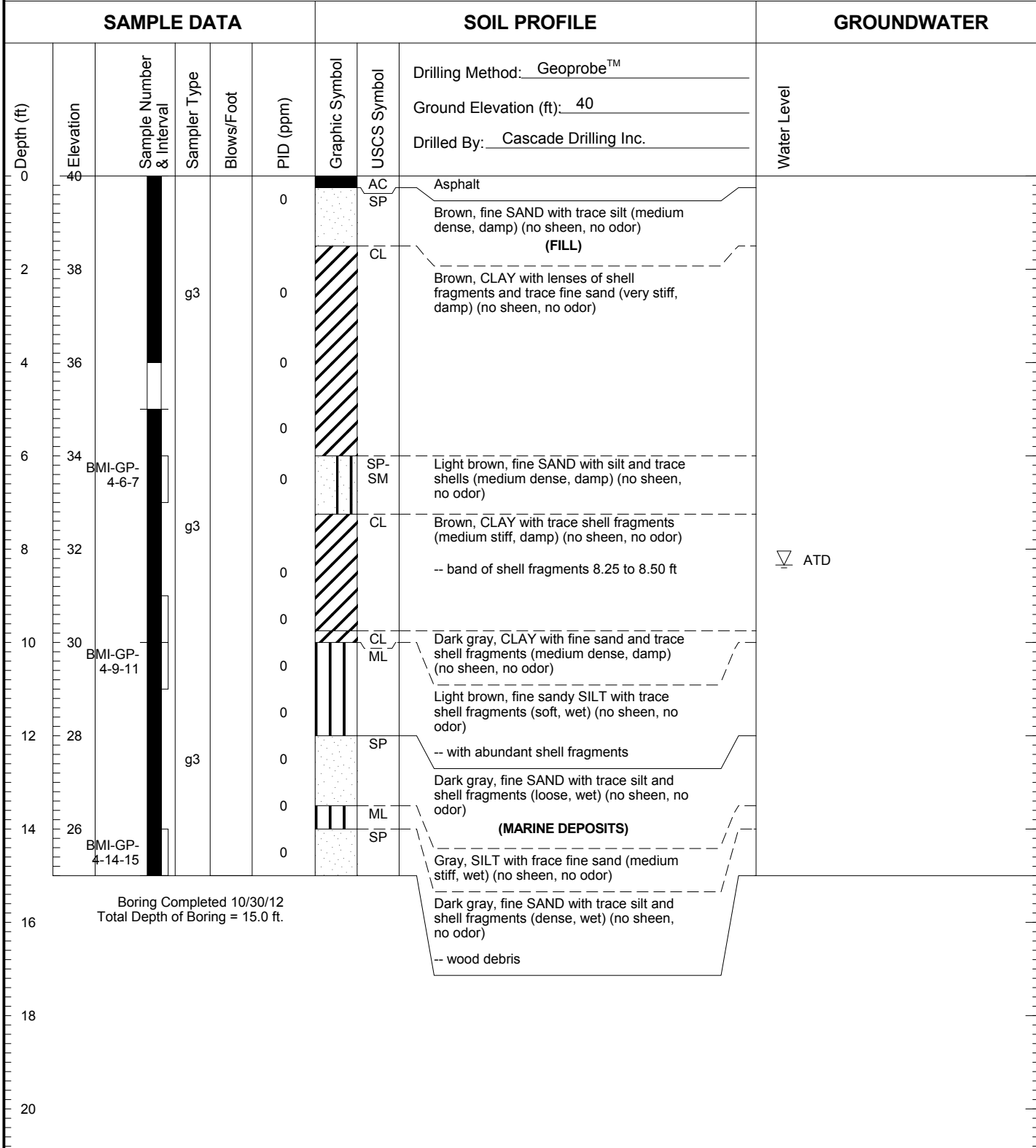


Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-3

Figure
B-7

BMI-GP-4



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

▽ ATD

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-4

Figure
B-8

BMI-GP-5

SAMPLE DATA			SOIL PROFILE			GROUNDWATER			
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Geoprobe™</u> Ground Elevation (ft): <u>40</u> Drilled By: <u>Cascade Drilling Inc.</u>	Water Level
0	40						AC	Asphalt and crushed rock	
0	0				0		SP	Brown, fine to coarse SAND with gravel and trace silt (med dense, moist) (no sheen, no odor)	
2	38	BMI-GP-5-2-3	g3		0.4		ML	(FILL) Gray, CLAY with abundant shell debris and trace fine to medium sand (medium stiff, moist) (no sheen, petroleum odor)	
4	36	BMI-GP-5-4-5							
6	34		g3		1.4			-- grades to gray -- strong petroleum odor, NAPL test negative, no sheen found from 9 to 11 ft	
8	32								
10	30	BMI-GP-5-9-11							▽ ATD
12	28		g3		1.3		ML	Brown-gray, sandy SILT (medium stiff, wet) (no sheen, no odor)	
14	26	BMI-GP-5-14-15					SM	-- NAPL, petroleum odor, and sheen found at 12 ft	
16	24						ML	Gray, fine, silty SAND with shells (loose, wet) (no sheen, no odor)	
16	24						SM	(MARINE DEPOSITS) Gray, SILT with trace fine sand (medium stiff, wet) (no sheen, no odor)	
18	22		g3					Dark gray, silty, fine SAND with trace shells (loose, wet) (no sheen, no odor)	
20	20	BMI-GP-5-19-20			0				

Boring Completed 10/29/12
Total Depth of Boring = 20.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_010.016.GPJ SOIL BORING LOG W/ ELEV

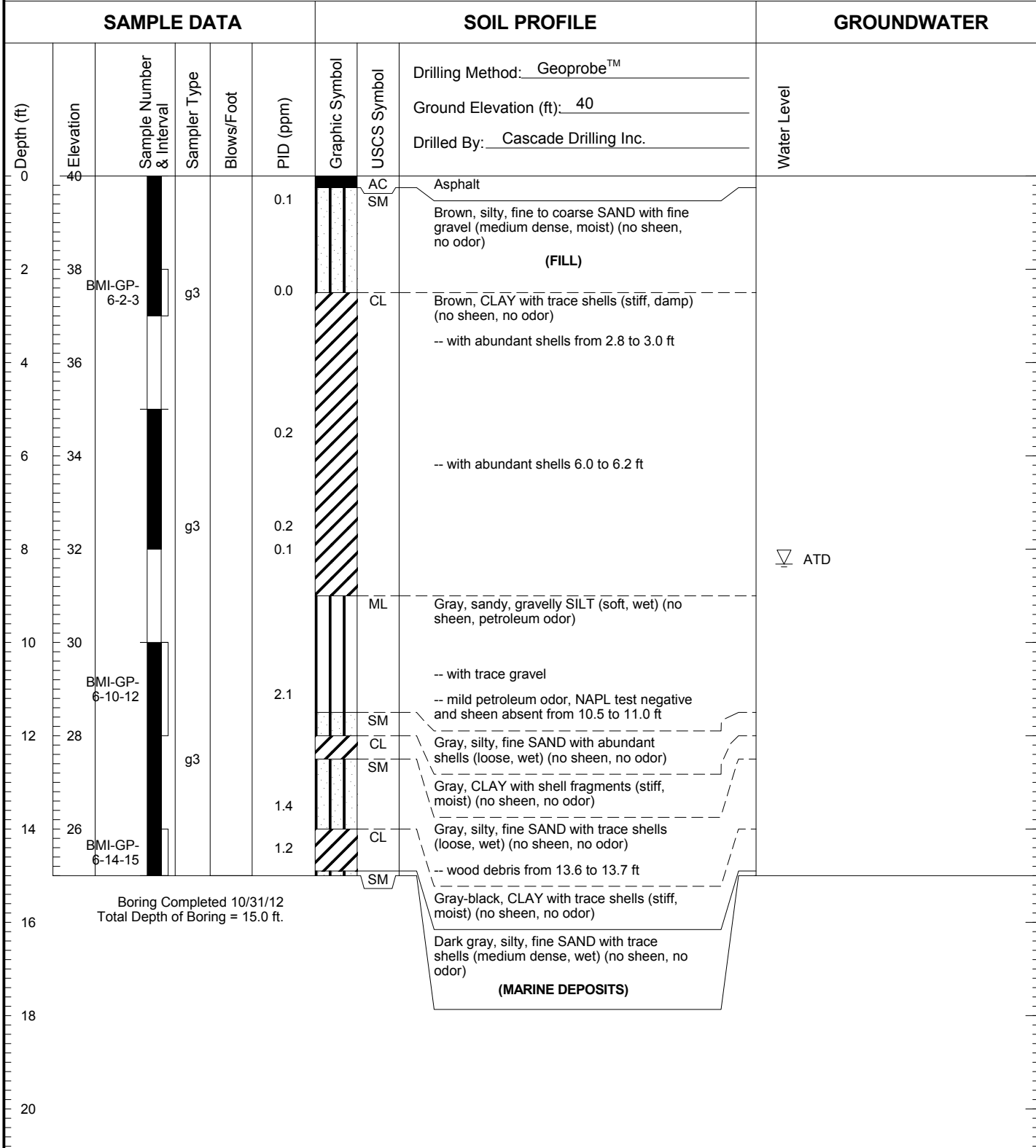


Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-5

Figure
B-9

BMI-GP-6



Boring Completed 10/31/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_010.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-6

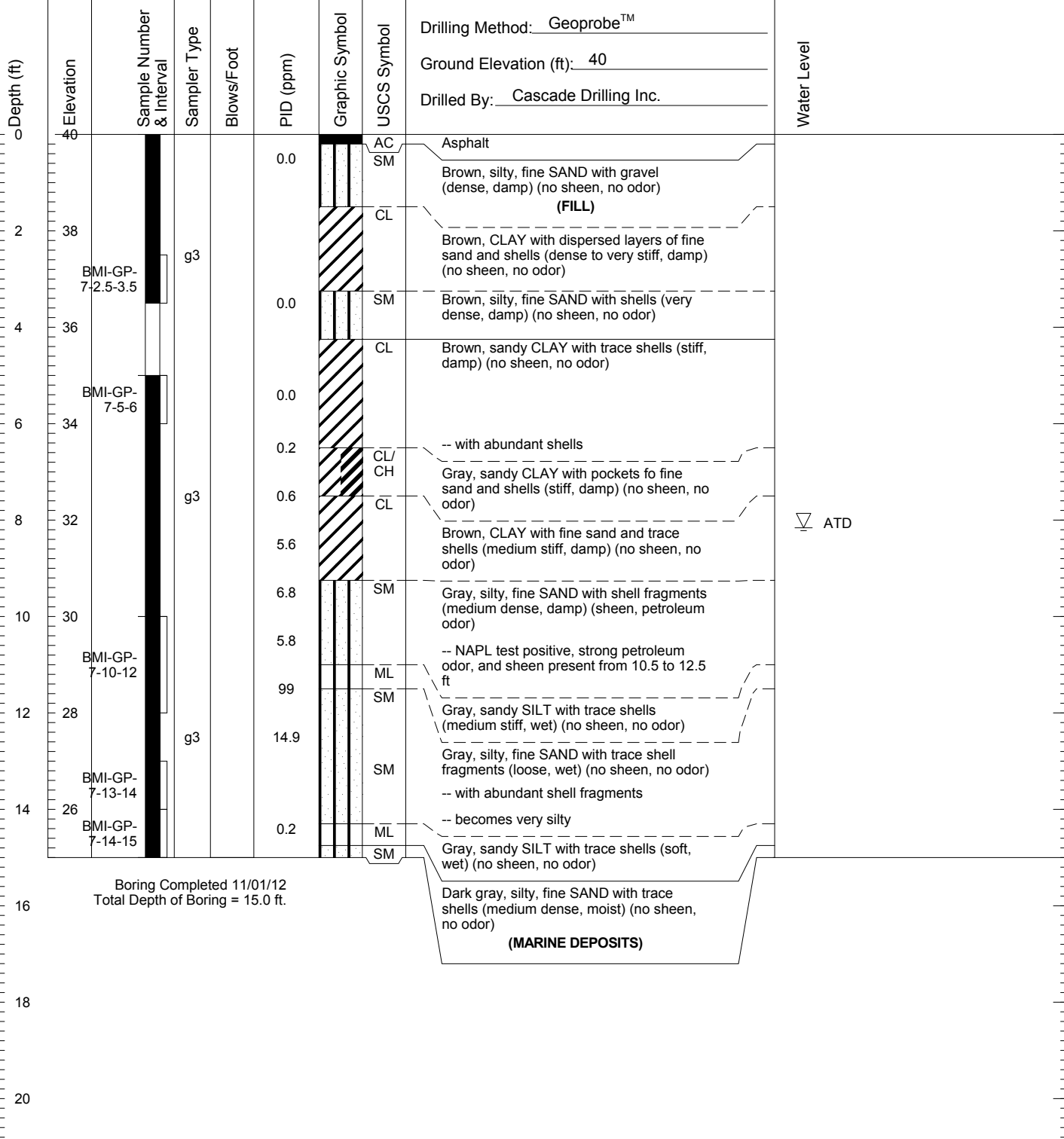
Figure
B-10

BMI-GP-7

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 11/01/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV

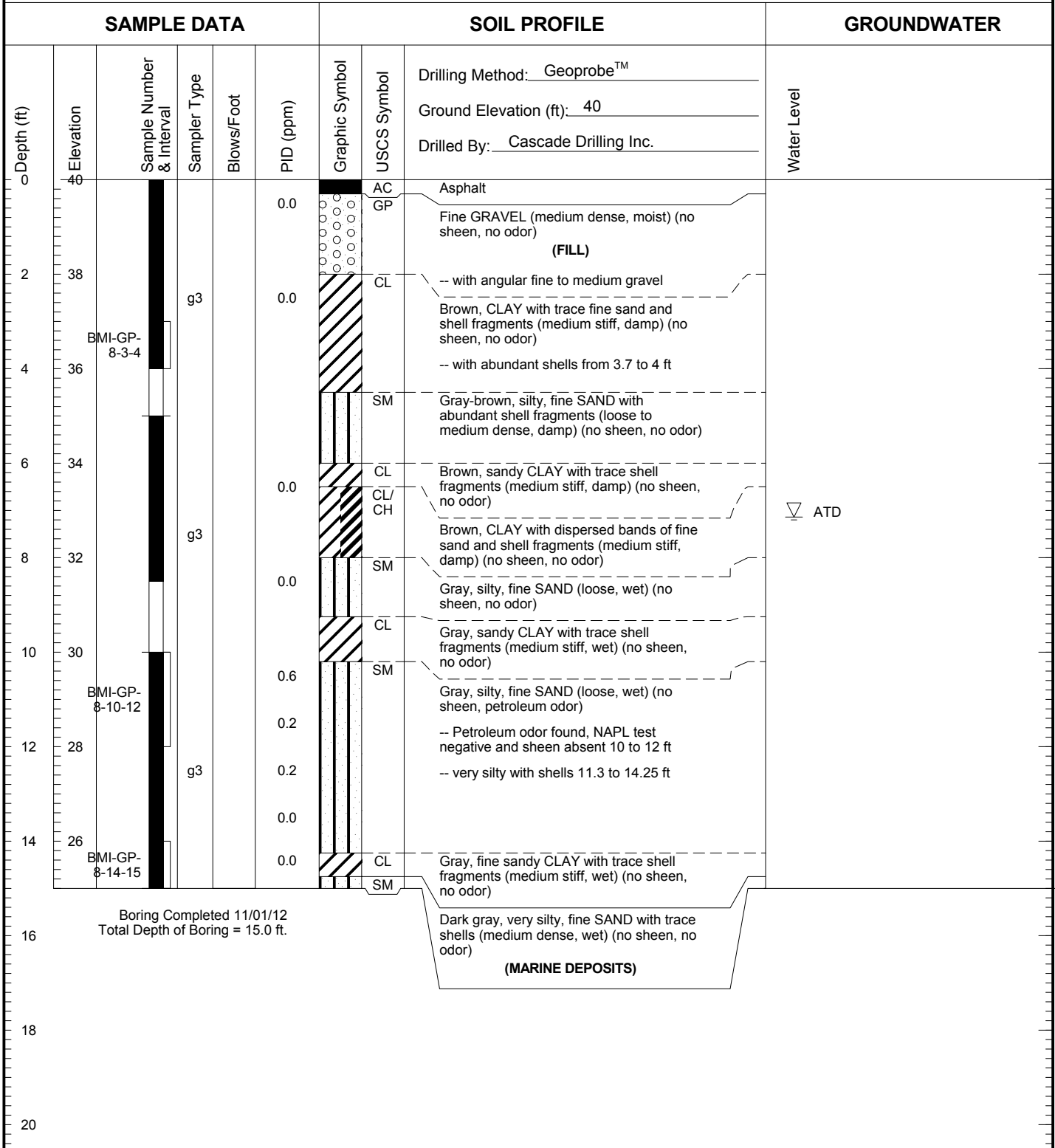


Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-7

Figure
B-11

BMI-GP-8



Boring Completed 11/01/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEVE

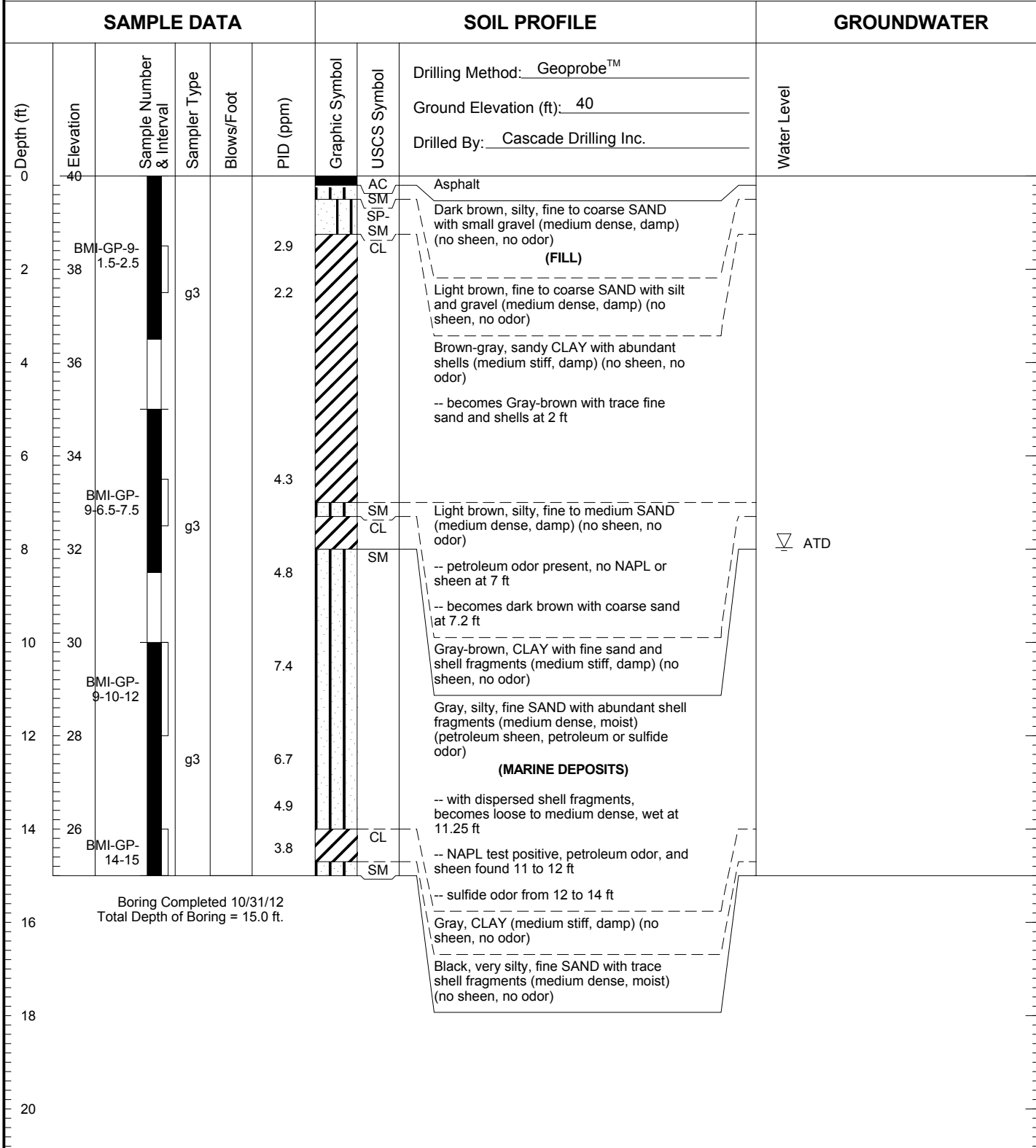


Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-8

Figure
B-12

BMI-GP-9



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-9

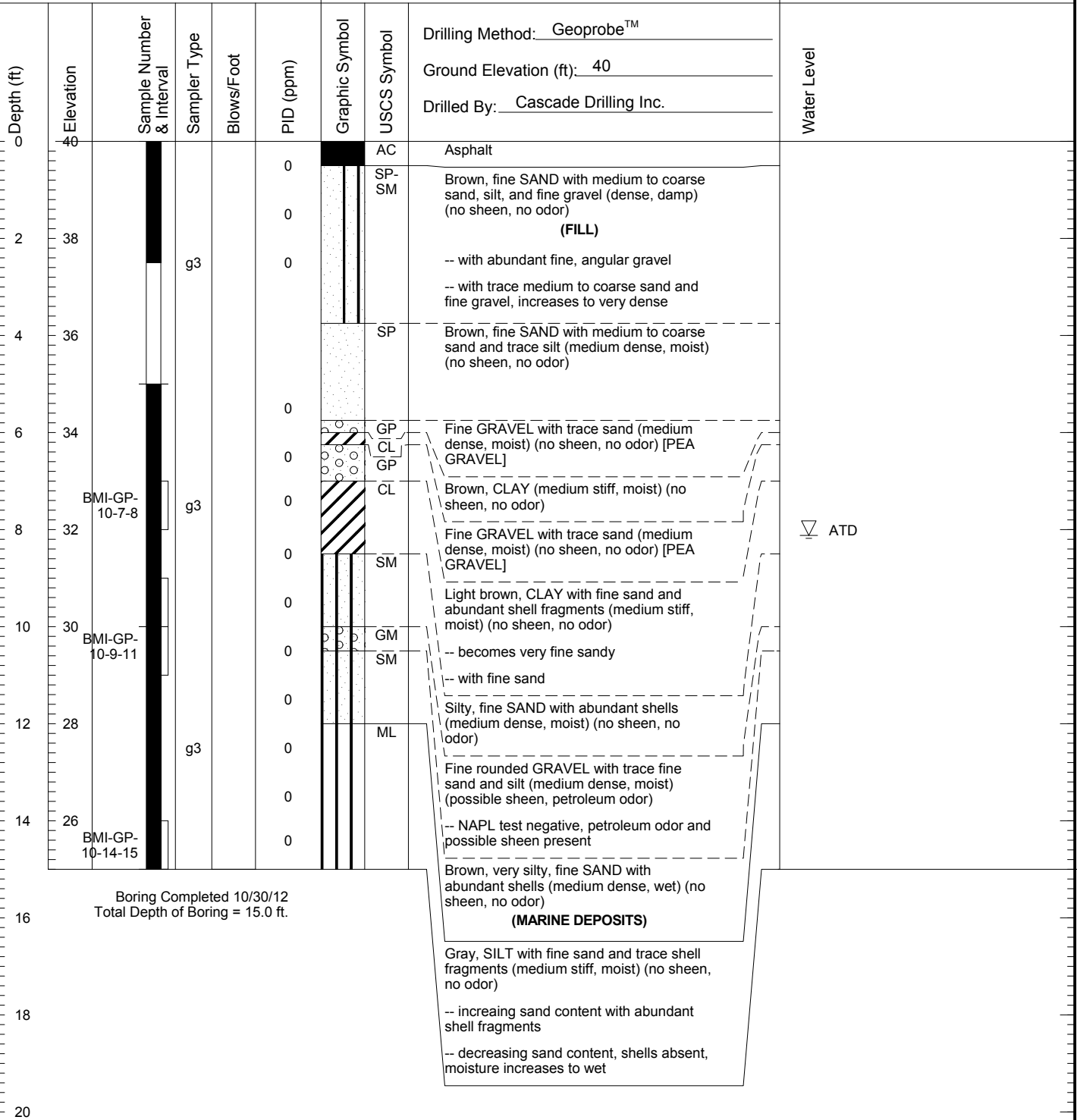
Figure
B-13

BMI-GP-10

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-10

Figure
B-14

BMI-GP-11

SAMPLE DATA			SOIL PROFILE			GROUNDWATER			
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™	Water Level
								Ground Elevation (ft): 40	
0	40						AC	Asphalt	
2	38	BMI-GP-11-2-3	g3		1.0	SP-SM		Brown, fine to coarse SAND with silt and fine gravel (medium dense, damp) (no sheen, no odor)	
					0.6	CL		(FILL) -- grades to gray -- becomes red -- with wood debris from 1.5 to 2.0 ft	
4	36				1.1			Gray-brown, sandy, CLAY (medium stiff, moist) (no sheen, no odor)	
					0.6	ML		No sample 3 to 5 ft Brown-gray, sandy, SILT (medium stiff, moist) (no sheen, no odor)	
6	34				0.3	CL/CH/WD		Gray, clay with dispersed layers of fine sand (soft, moist) (no sheen, no odor)	
8	32	BMI-GP-11-8-10	g3			CL		Brown, WOOD DEBRIS (medium dense, moist) (no sheen, organic odor) -- organic decomposition odor	▽ ATD
10	30				0.3			Gray, CLAY with trace fine sand (medium stiff, moist to wet) (sheen, petroleum odor) -- NAPL test negative, sheen, and petroleum odor found at 8 ft	
12	28				0.1	CL		-- rusty color 8.25 to 8.5 ft Gray, sandy, CLAY with trace wood debris (medium stiff, moist) (no sheen, no odor)	
					1.9	ML		Gray, sandy, SILT with trace shell fragments (medium stiff, wet) (no sheen, no odor)	
14	26	BMI-GP-11-14-15	g3		0.2	SM		Dark gray, silty, fine SAND with trace shell fragments (medium dense, wet) (no sheen, no odor)	
					0.3			(MARINE DEPOSITS)	

Boring Completed 10/31/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-11

Figure
B-15

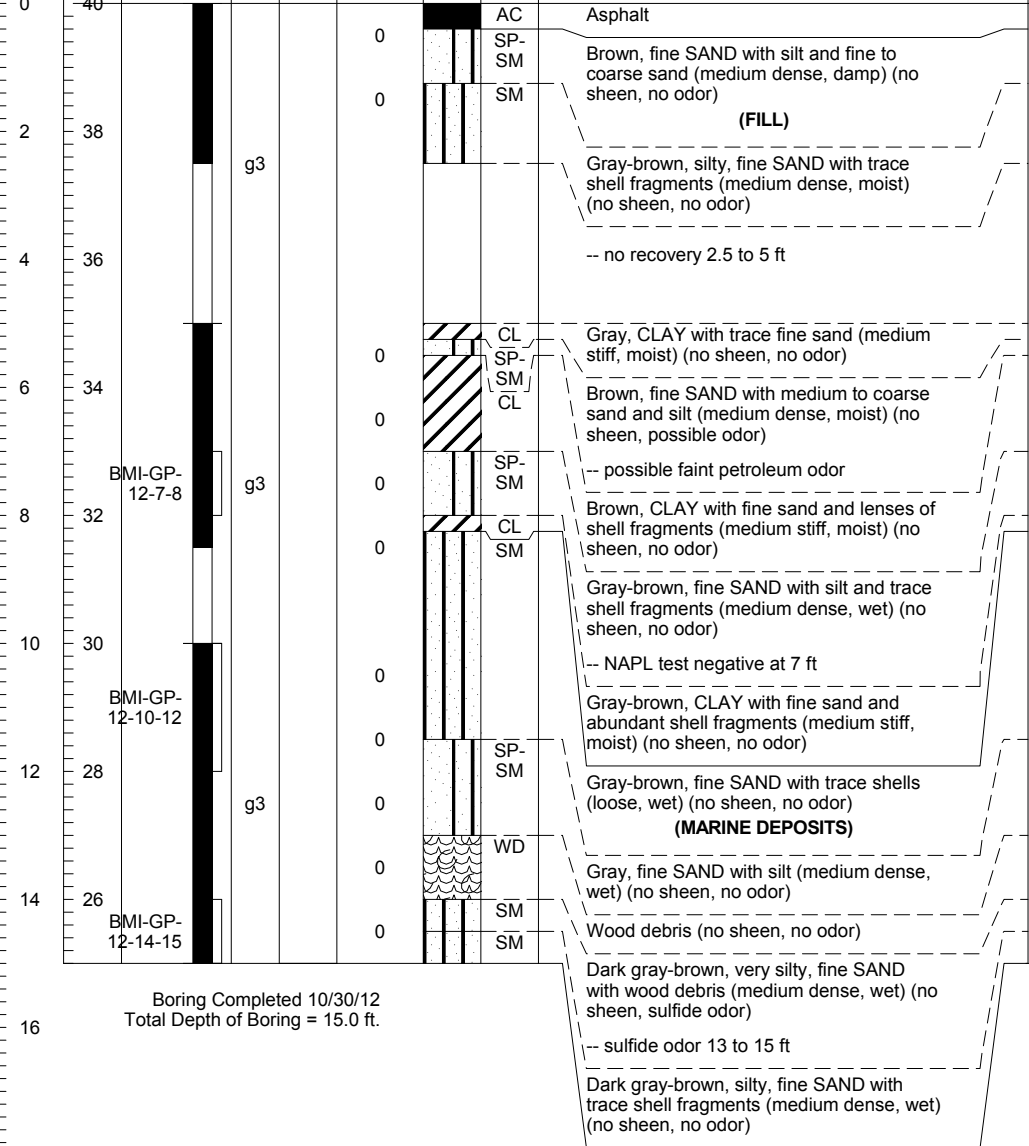
BMI-GP-12

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Geoprobe™</u>
								Ground Elevation (ft): <u>40</u>
								Drilled By: <u>Cascade Drilling Inc.</u>
								Water Level



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

▽ ATD

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-12

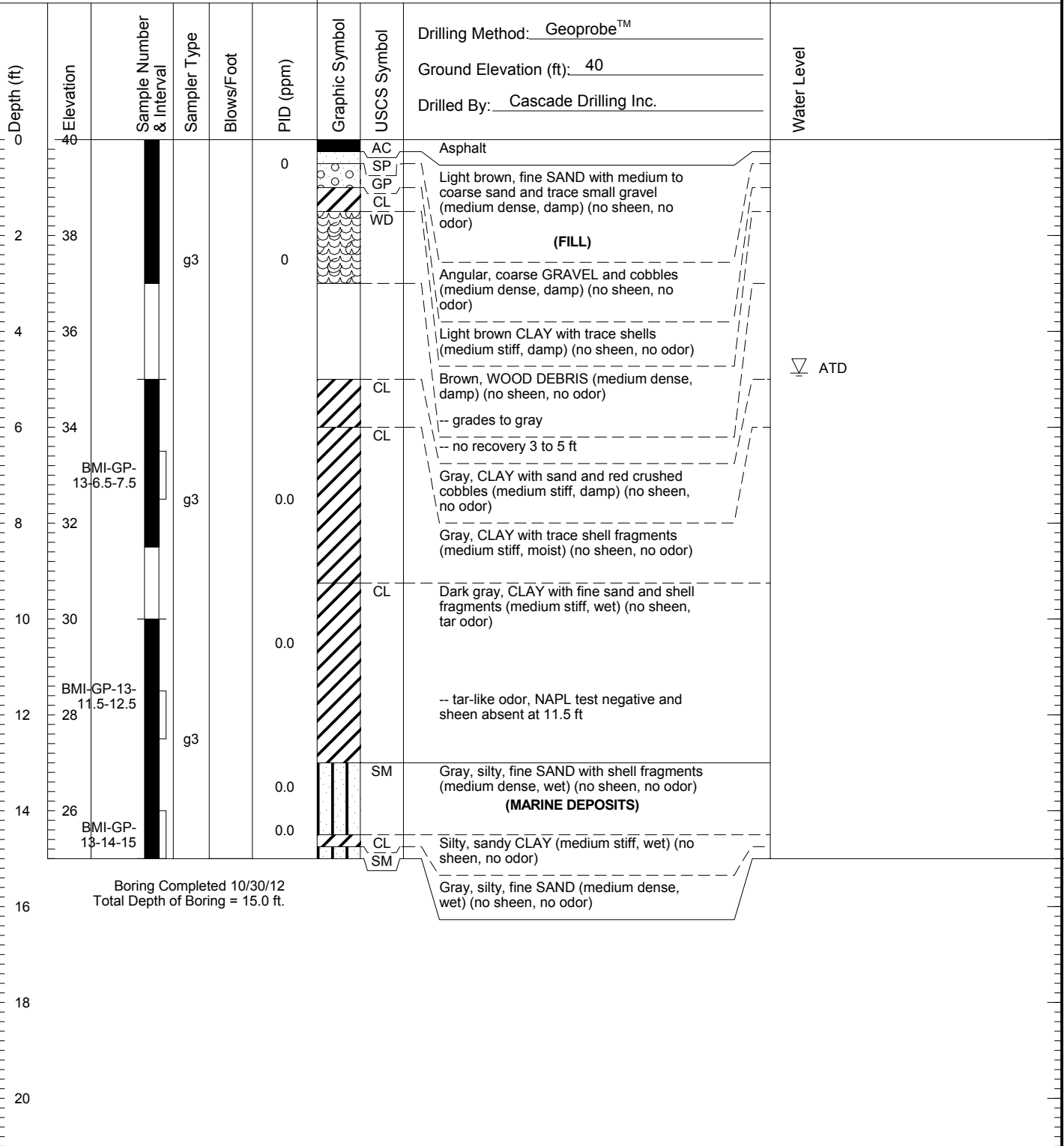
Figure
B-16

BMI-GP-13

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-13

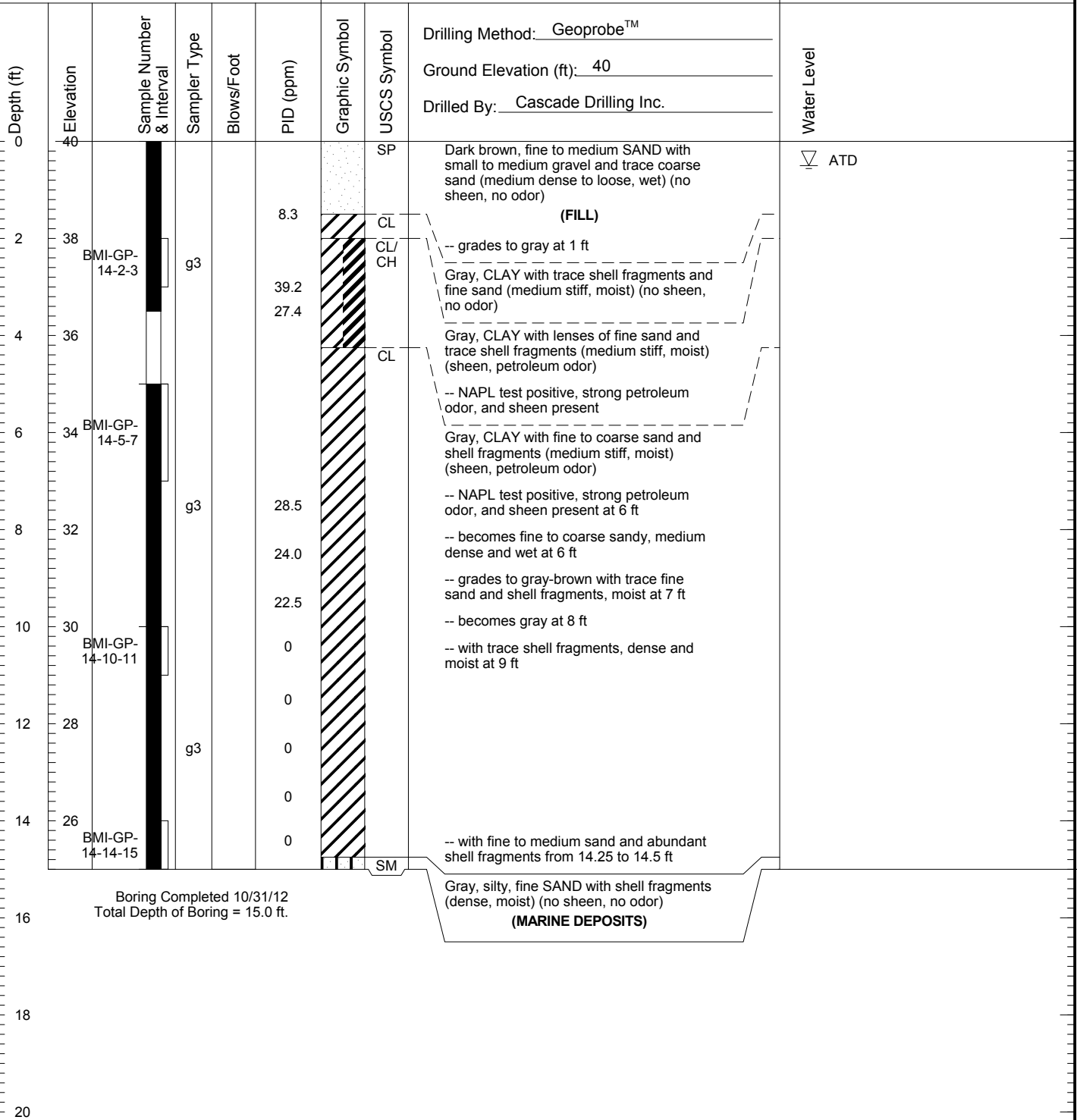
Figure
B-17

BMI-GP-14

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/31/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-14

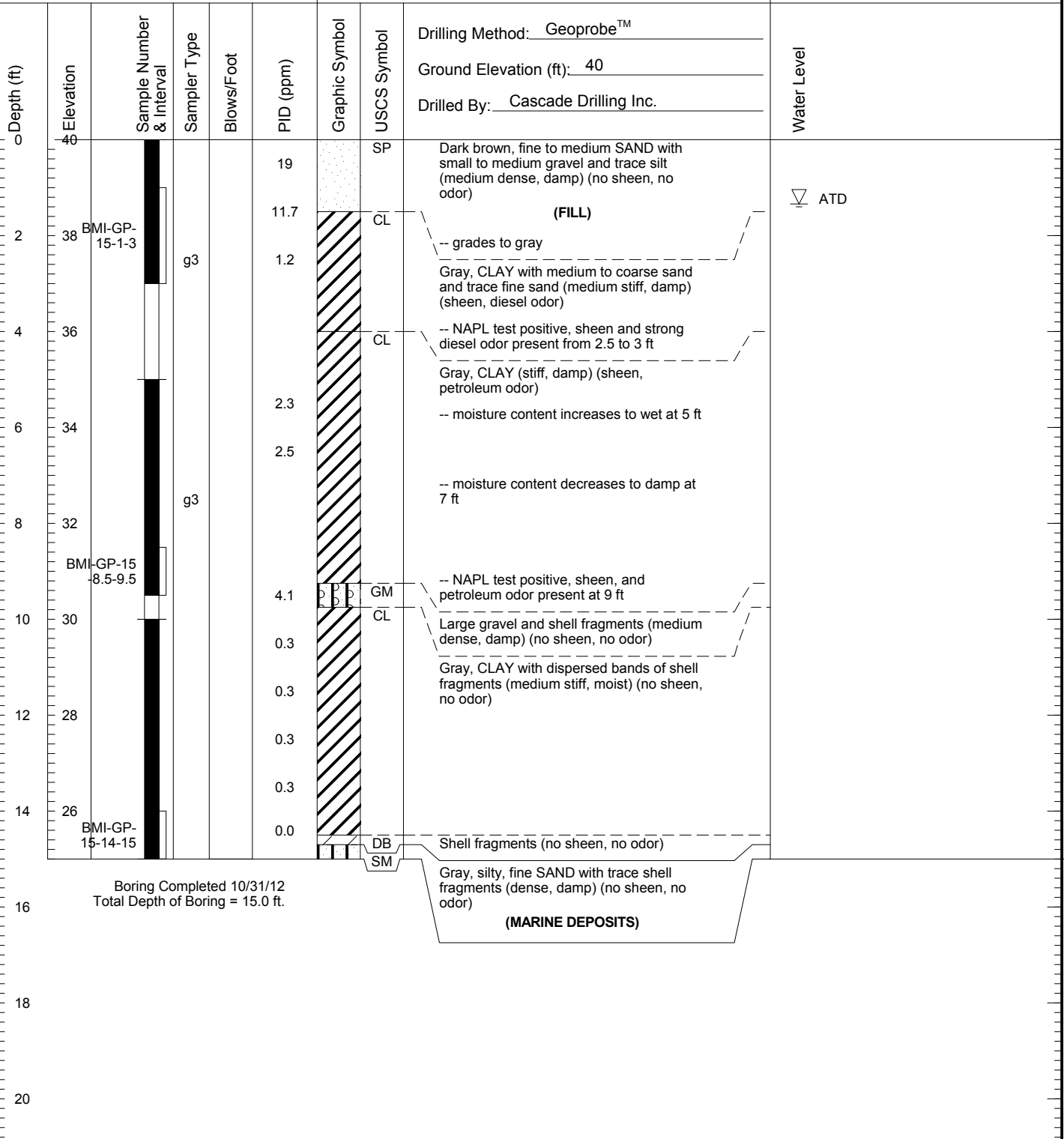
Figure
B-18

BMI-GP-15

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/31/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-15

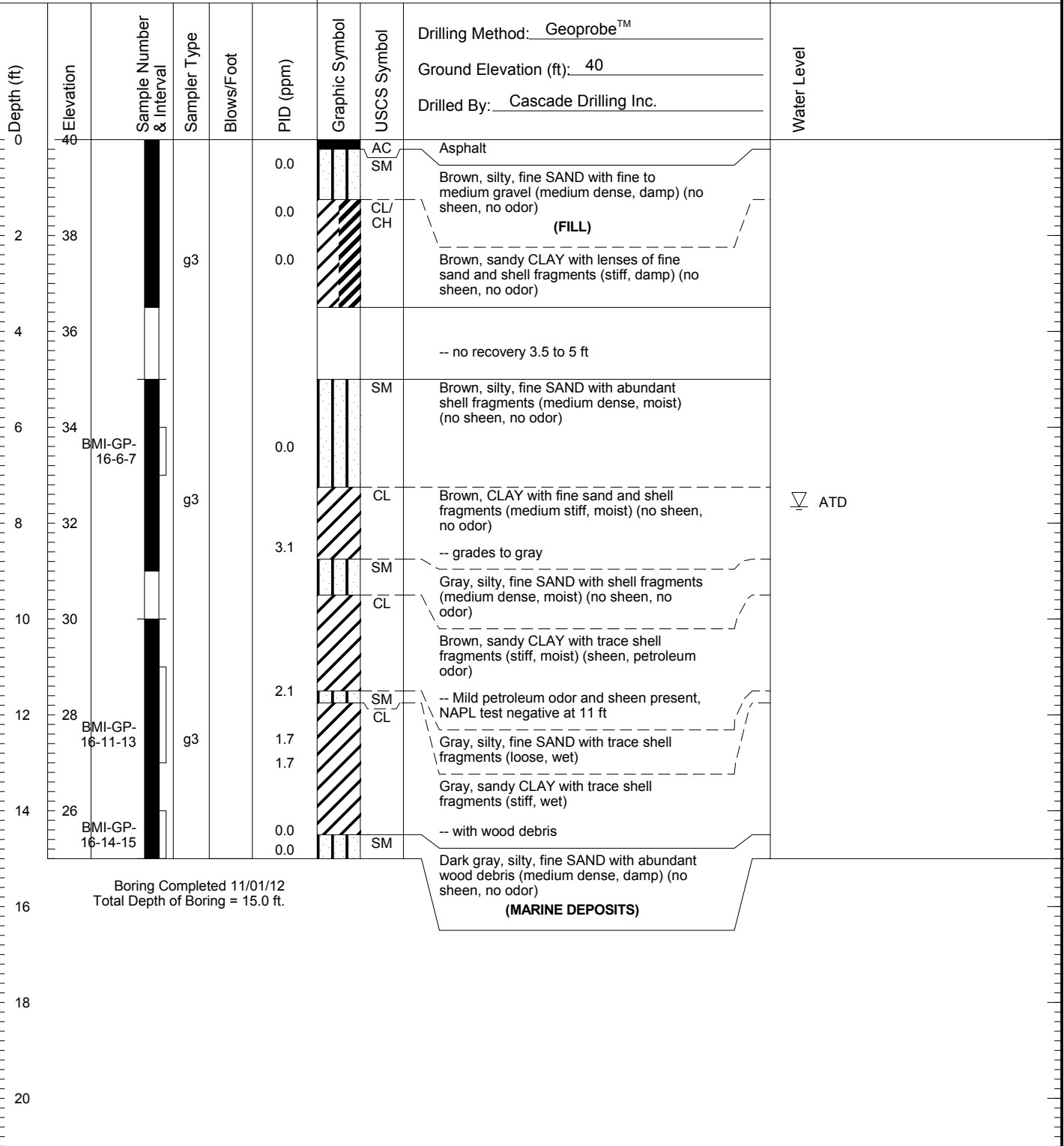
Figure
B-19

BMI-GP-16

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 11/01/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-16

Figure
B-20

BMI-GP-17

SAMPLE DATA			SOIL PROFILE				GROUNDWATER		
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Geoprobe™</u> Ground Elevation (ft): <u>40</u> Drilled By: <u>Cascade Drilling Inc.</u>	Water Level
0	40				0	(Circles)	GP	Medium to coarse sandy GRAVEL with trace silt (loose, moist) (no sheen, no odor) (FILL)	
2	38	BMI-GP-17-2-3	g3		7.2	(Dotted)	SP	Brown, fine to medium SAND with trace coarse sand (loose, moist) (no sheen, no odor)	
4	36				1.5	(Diagonal lines)	CL/CH	Gray CLAY with lenses of fine sand and trace shell fragments (stiff, moist) (no sheen, no odor)	
6	34	BMI-GP-17-5-6	g3		2.7	(Diagonal lines)			
8	32				6.2	(Diagonal lines)			▽ ATD
10	30	BMI-GP-17-9-11			2.6	(Vertical lines)	SM	Gray, silty, fine SAND (loose, wet) (sheen, petroleum odor) (no sheen, no odor) (MARINE DEPOSITS)	
12	28	BMI-GP-17-12-13	g3		7.4	(Diagonal lines)	CL	NAPL test negative, sheen, or odor found from 9-11 ft Gray, CLAY with trace fine sand and shell fragments (medium stiff to stiff, moist) (no sheen, no odor)	
14	26	BMI-GP-17-14-15			2.8	(Diagonal lines)			

Boring Completed 10/29/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-17

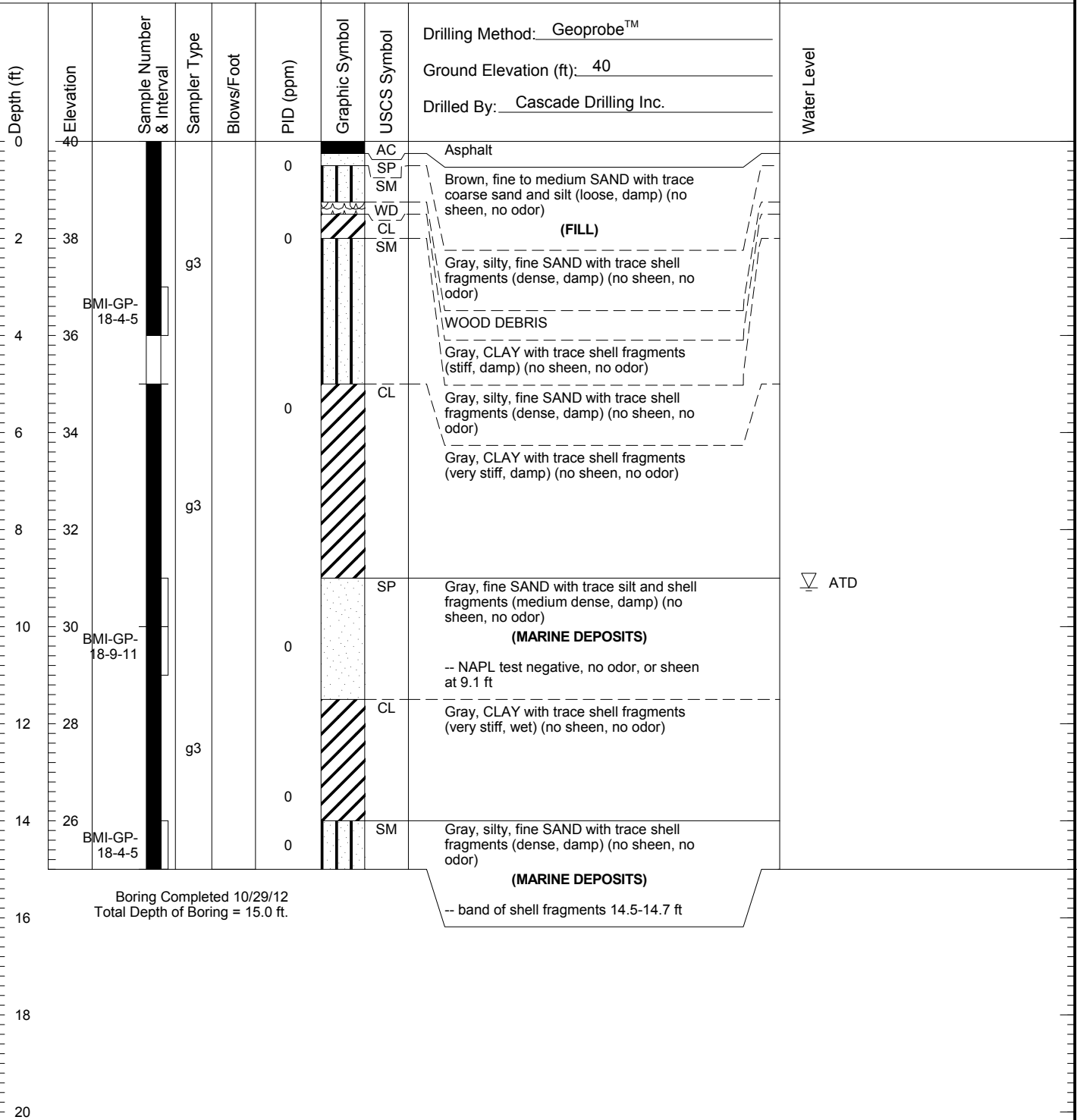
Figure
B-21

BMI-GP-18

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/29/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEVE



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-18

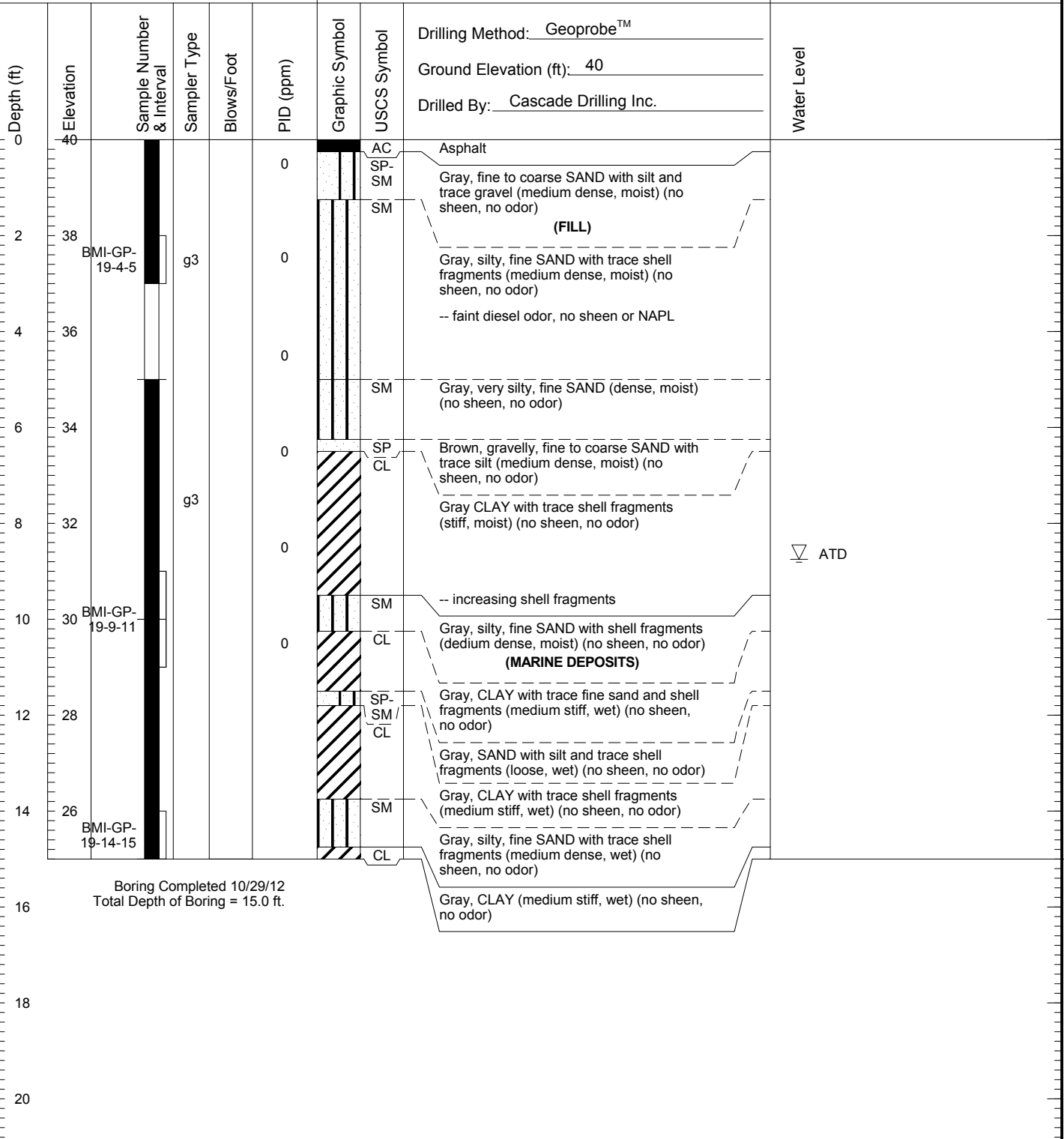
Figure
B-22

BMI-GP-19

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/29/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-19

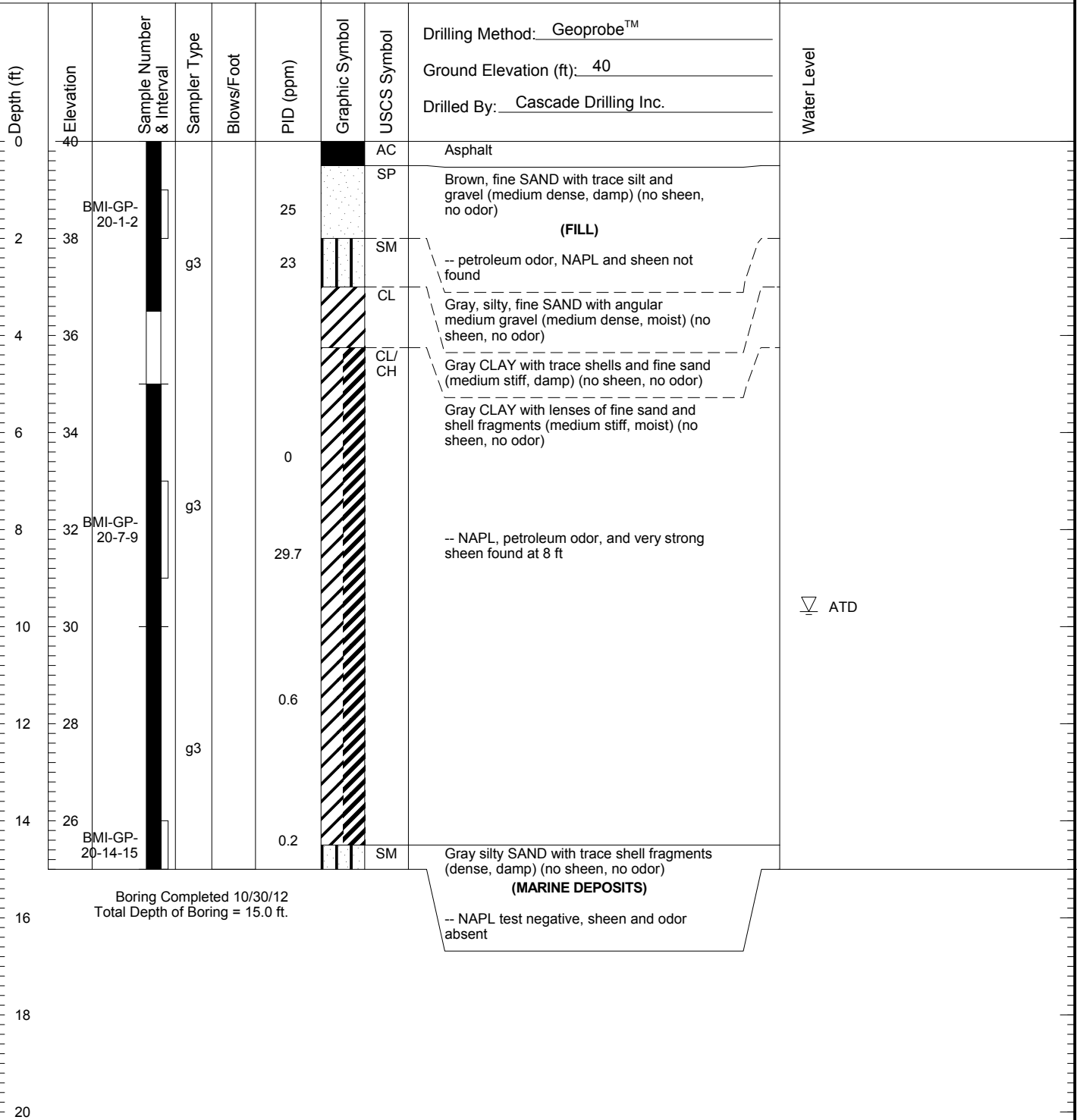
Figure
B-23

BMI-GP-20

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/30/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV



Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-20

Figure
B-24

BMI-GP-21

SAMPLE DATA		SOIL PROFILE				GROUNDWATER			
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™	Water Level
								Ground Elevation (ft): 40	
0	40				0	AC	SP	Asphalt	
2	38		g3		0		ML	Brown, fine to medium SAND with trace silt (loose, damp) (no sheen, no odor) (FILL)	
4	36	BMI-GP-21-4-5							
6	34		g3					-- with abundant shell fragments at 6 ft	
8	32								
10	30	BMI-GP-21-9-11			0			-- with trace shells, NAPL test negative no sheen or odor found at 9 ft -- grades to gray at 9.5 ft	▽ ATD
12	28		g3			SP-SM	SM	Brown, fine to medium SAND with silt (med dense, wet) (no sheen, no odor) (MARINE DEPOSITS)	
14	26							Gray, SILT with lenses of fine sand and shell fragments (med stiff to medium dense, damp) (no sheen, no odor)	
16	24	BMI-GP-12-15-16			0			Gray, silty, fine SAND with lenses of shell fragments (loose, wet) (no sheen, no odor)	
18	22		g3			SP-SM		Dark gray, fine SAND with silt and shell fragments (loose, wet) (no sheen, sulfide odor)	
20	20				0			-- grades to light gray at 18 ft	

Boring Completed 10/29/12
Total Depth of Boring = 20.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ SOIL BORING LOG W/ ELEV

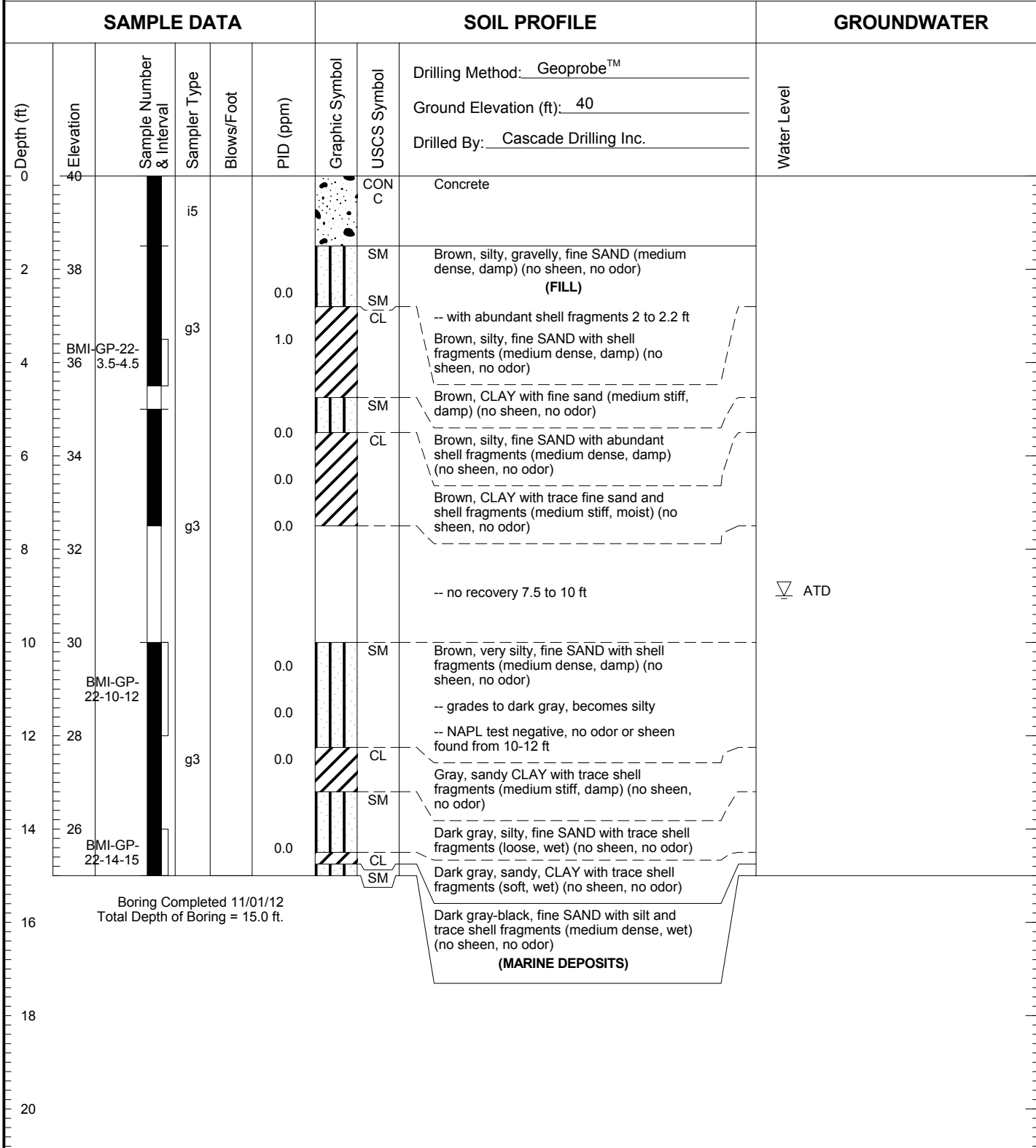


Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-21

Figure
B-25

BMI-GP-22



Boring Completed 11/01/12
Total Depth of Boring = 15.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_01\0.016.GPJ SOIL BORING LOG W/ ELEV

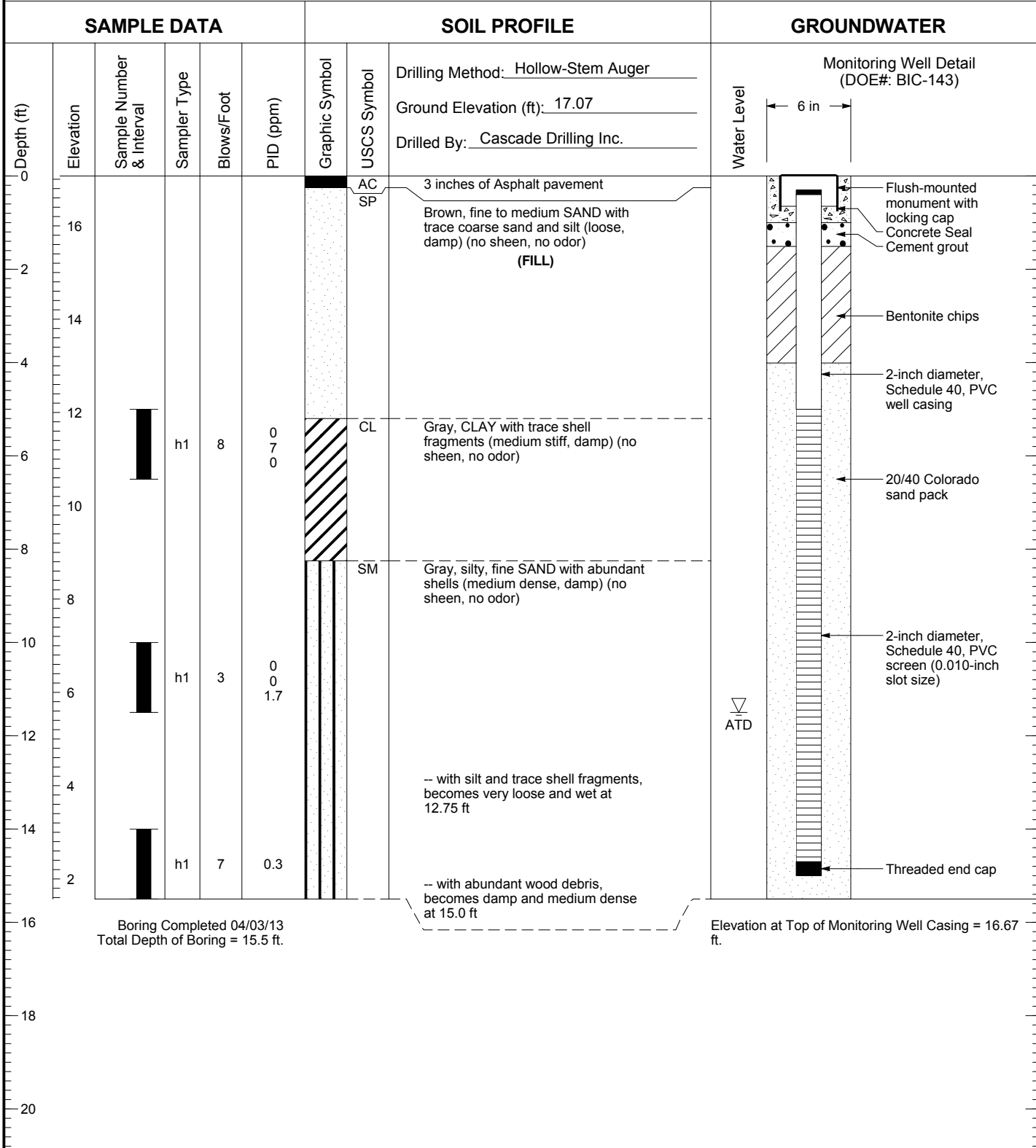


Blaine Marina Inc. Site
Blaine, Washington

Log of Soil Boring BMI-GP-22

Figure
B-26

MW-4



1034010016_4/8/15 N:\PROJECTS\001034_010_016.GPJ WELL LOG W/ ELEVATION

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

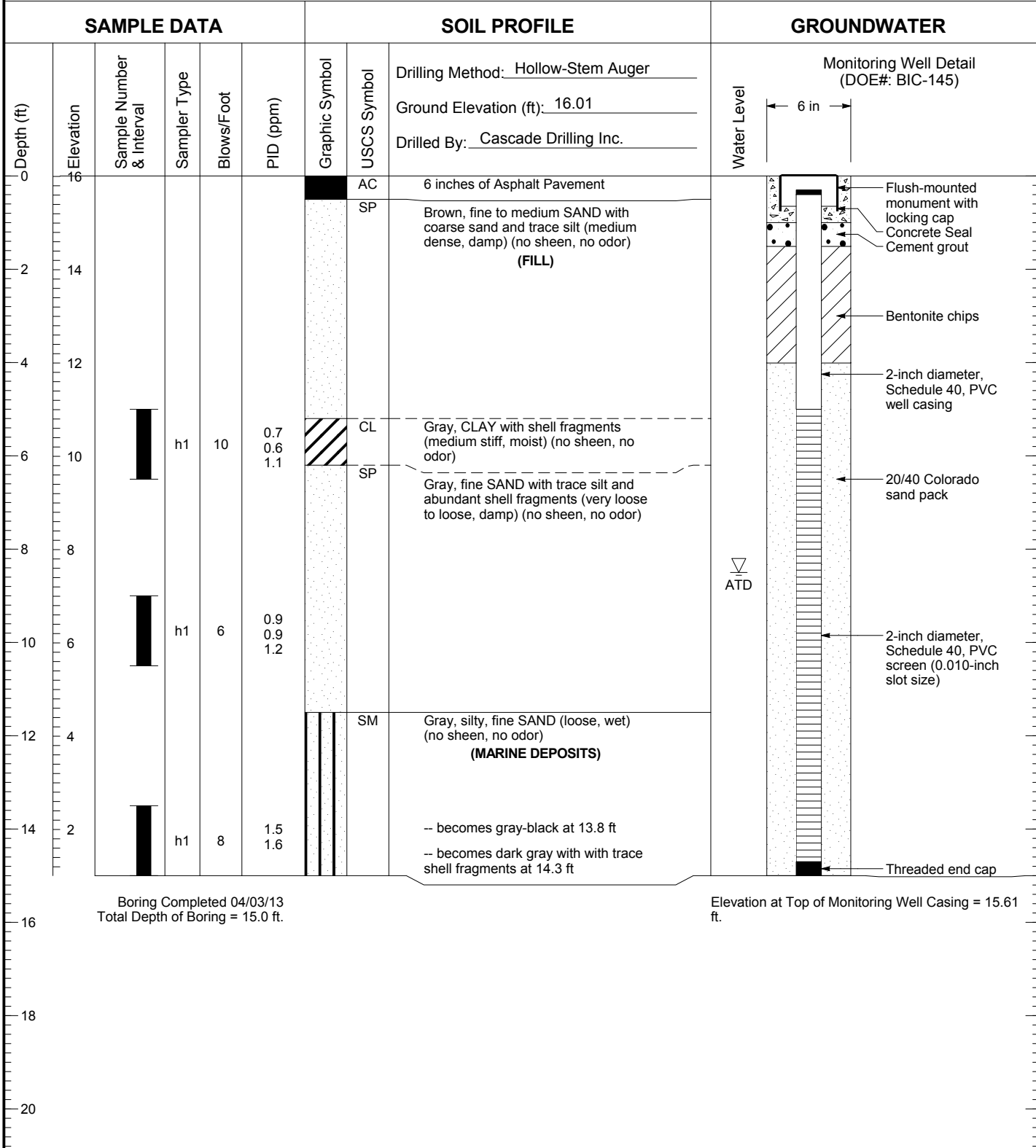


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-4

Figure
B-27

MW-5



Boring Completed 04/03/13
Total Depth of Boring = 15.0 ft.

Elevation at Top of Monitoring Well Casing = 15.61 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ WELL LOG W/ ELEVATION

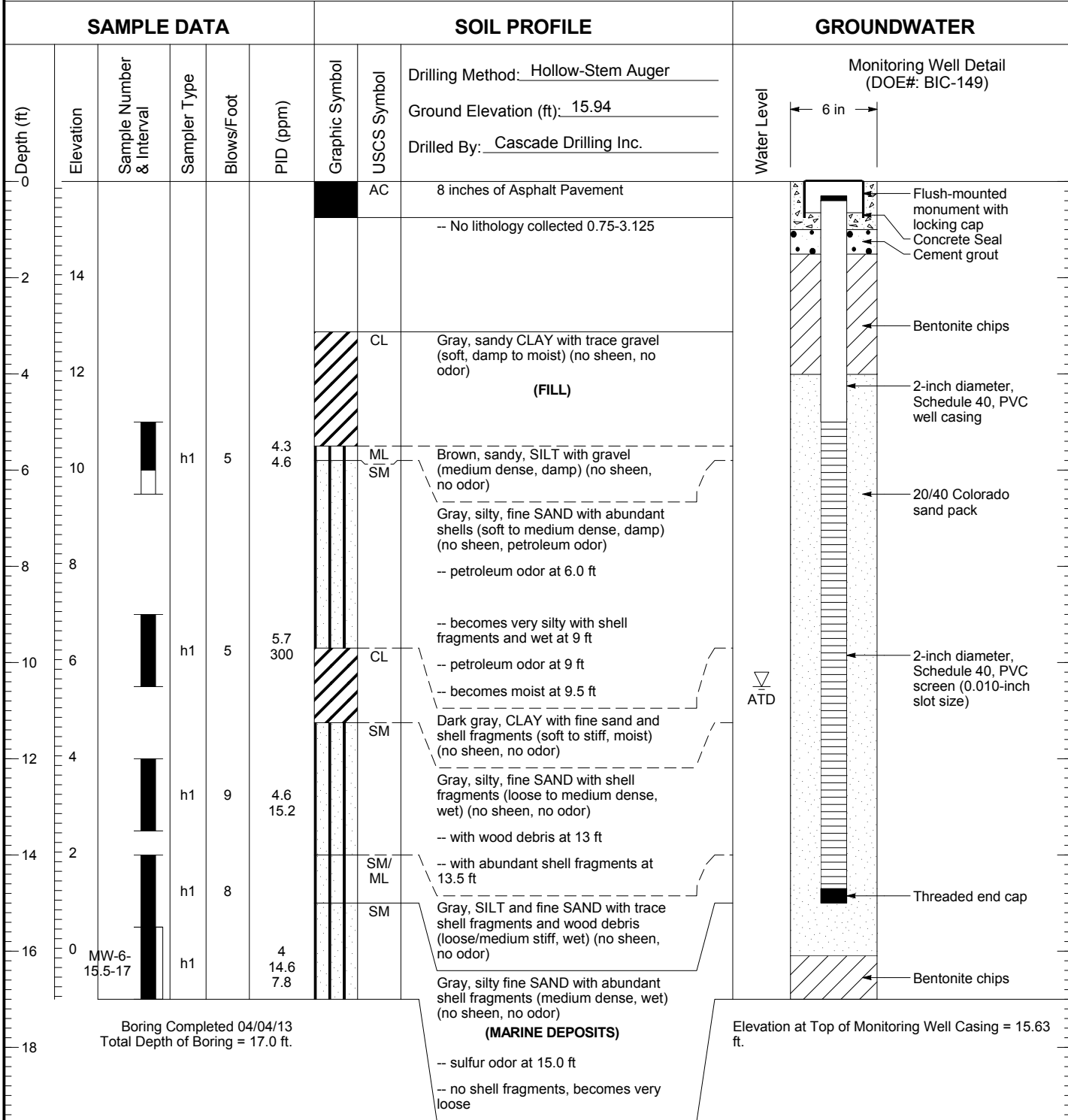


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-5

Figure
B-28

MW-6



Boring Completed 04/04/13
Total Depth of Boring = 17.0 ft.

Elevation at Top of Monitoring Well Casing = 15.63 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\016.GPJ WELL LOG W/ ELEVATION

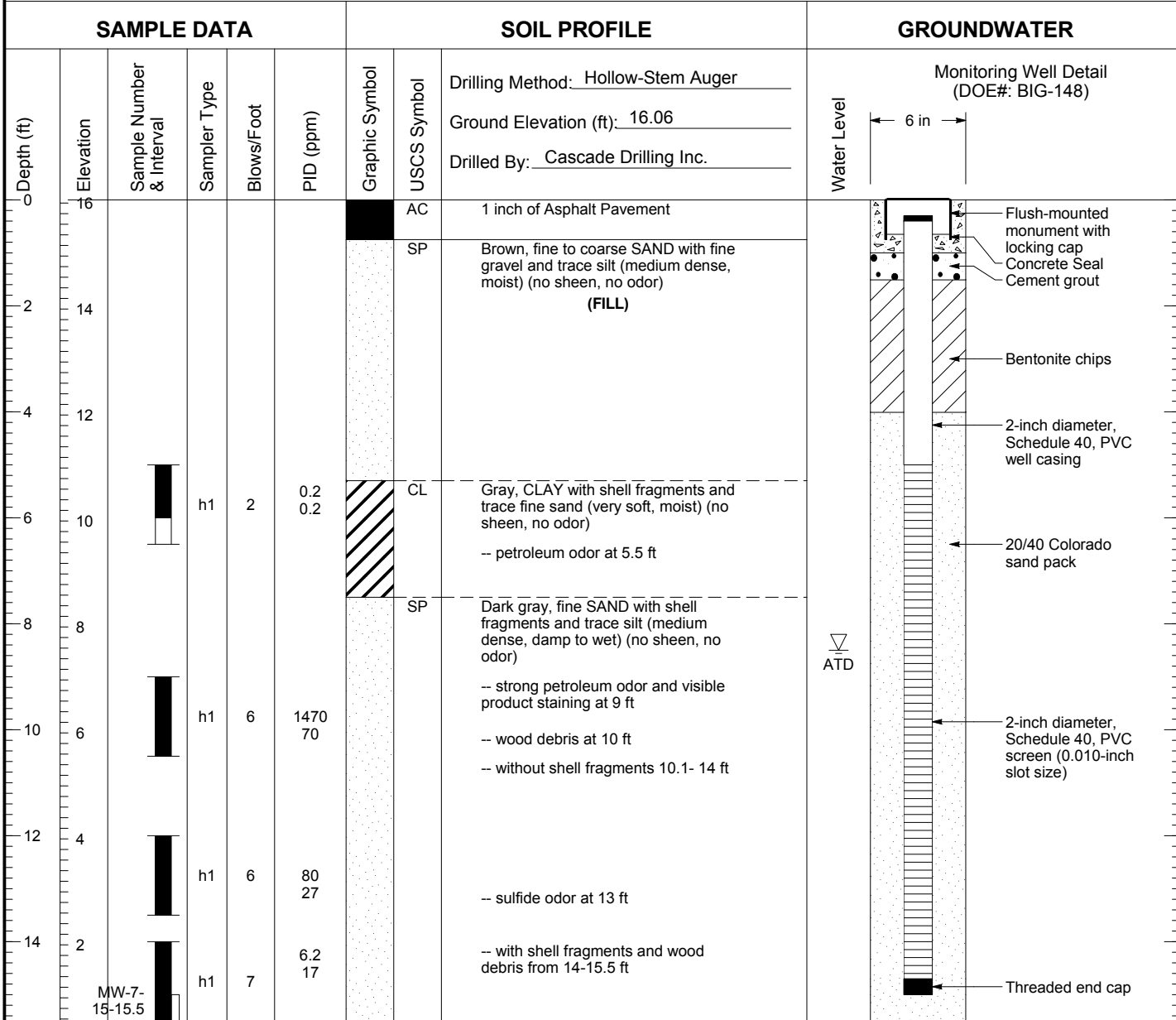


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-6

Figure
B-29

MW-7



Boring Completed 04/04/13
Total Depth of Boring = 15.5 ft.

Elevation at Top of Monitoring Well Casing = 15.77 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ WELL LOG W/ ELEVATION

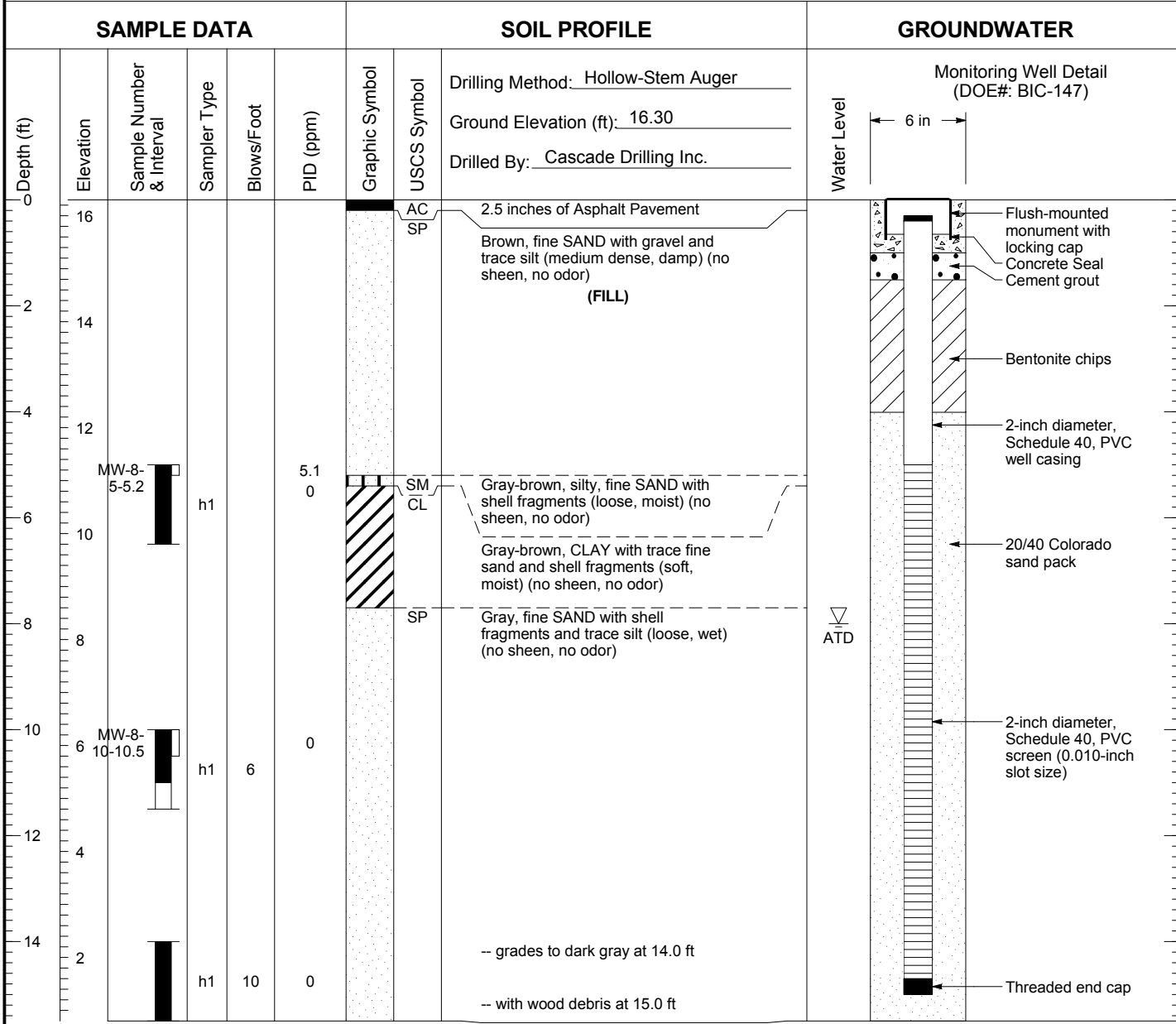


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-7

Figure
B-30

MW-8



Boring Completed 04/04/13
Total Depth of Boring = 15.5 ft.

Elevation at Top of Monitoring Well Casing = 15.98 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_010.016.GPJ WELL LOG W/ ELEVATION

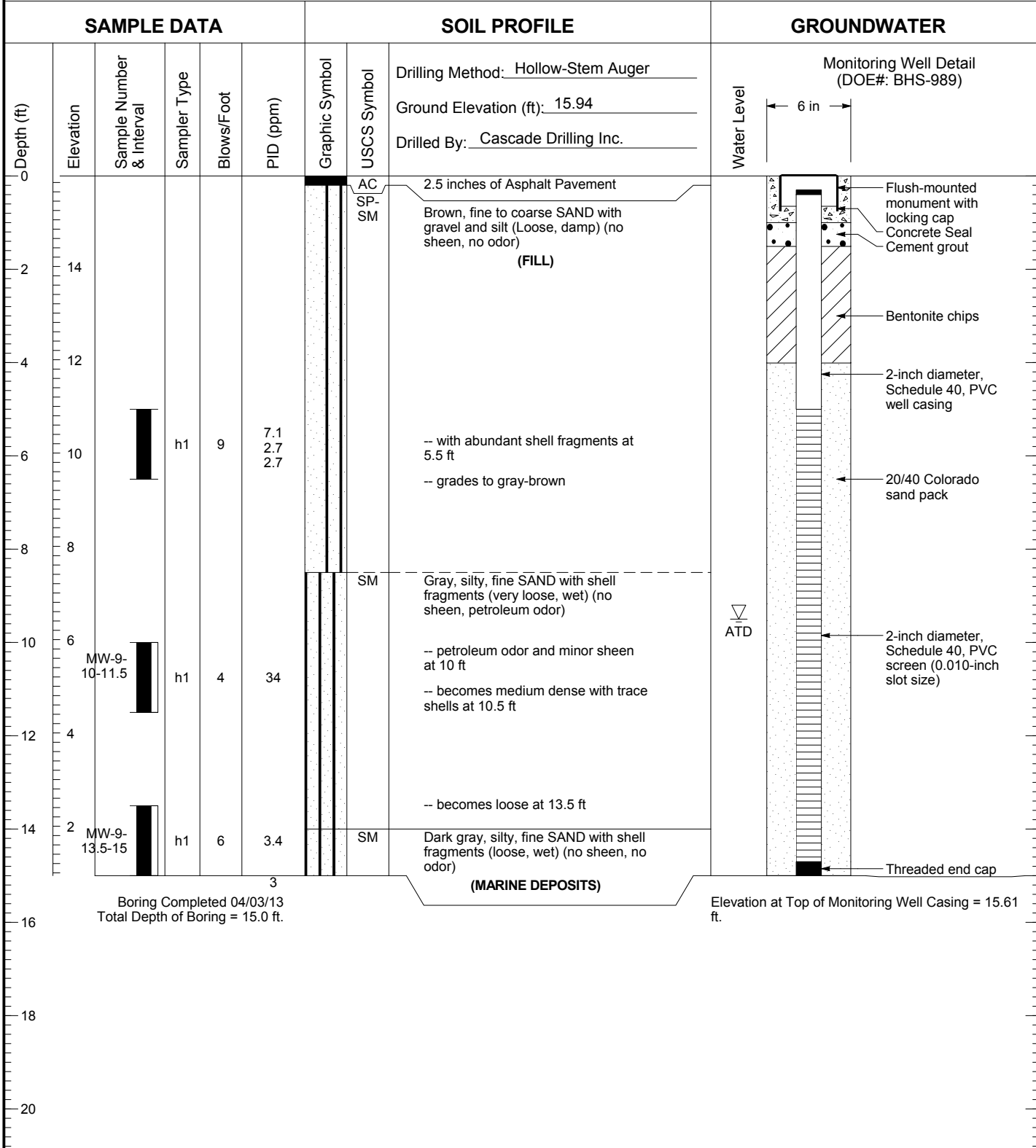


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-8

Figure
B-31

MW-9



1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ WELL LOG W/ ELEVATION

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

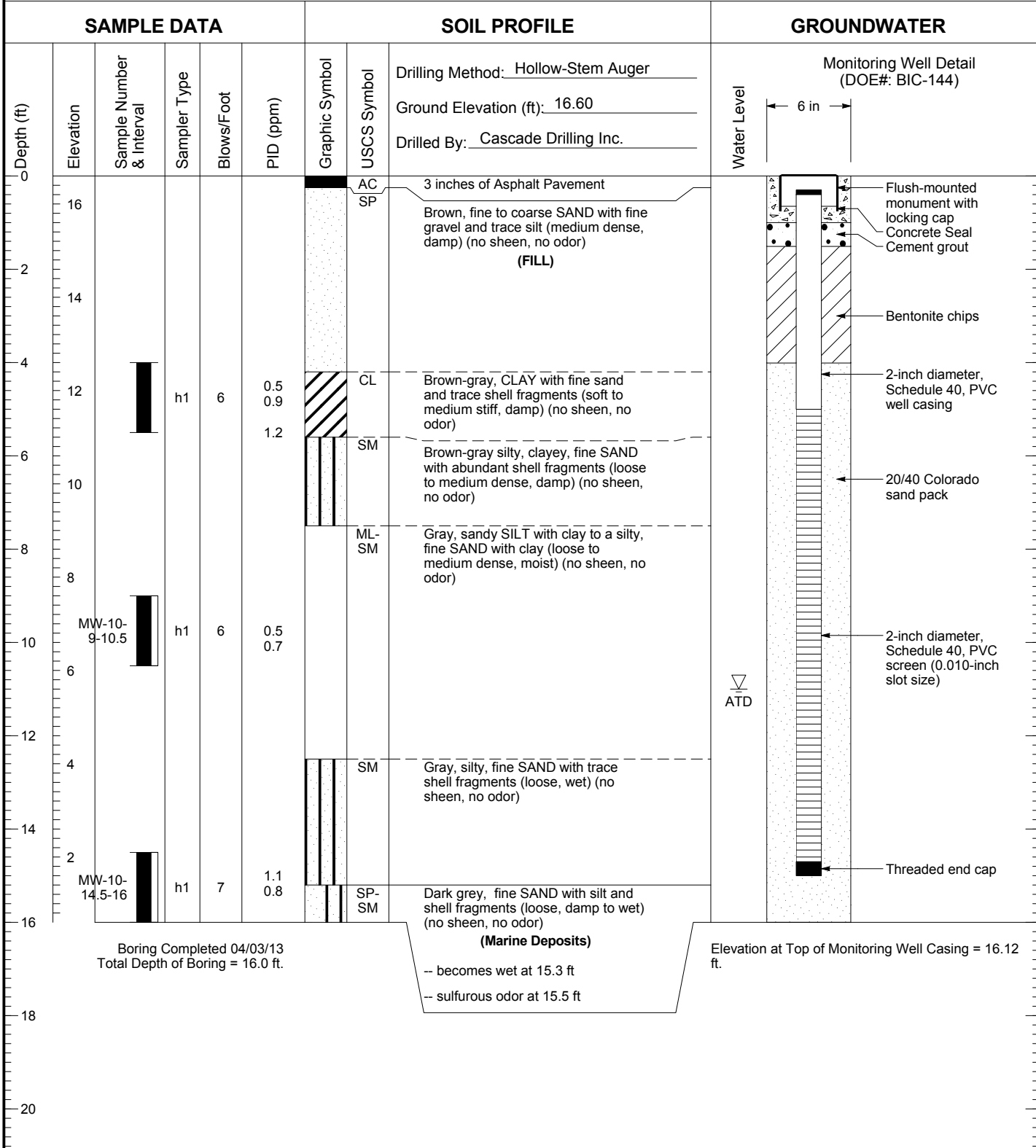


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-9

Figure
B-32

MW-10



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_010_016.GPJ WELL LOG W/ ELEVATION



Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-10

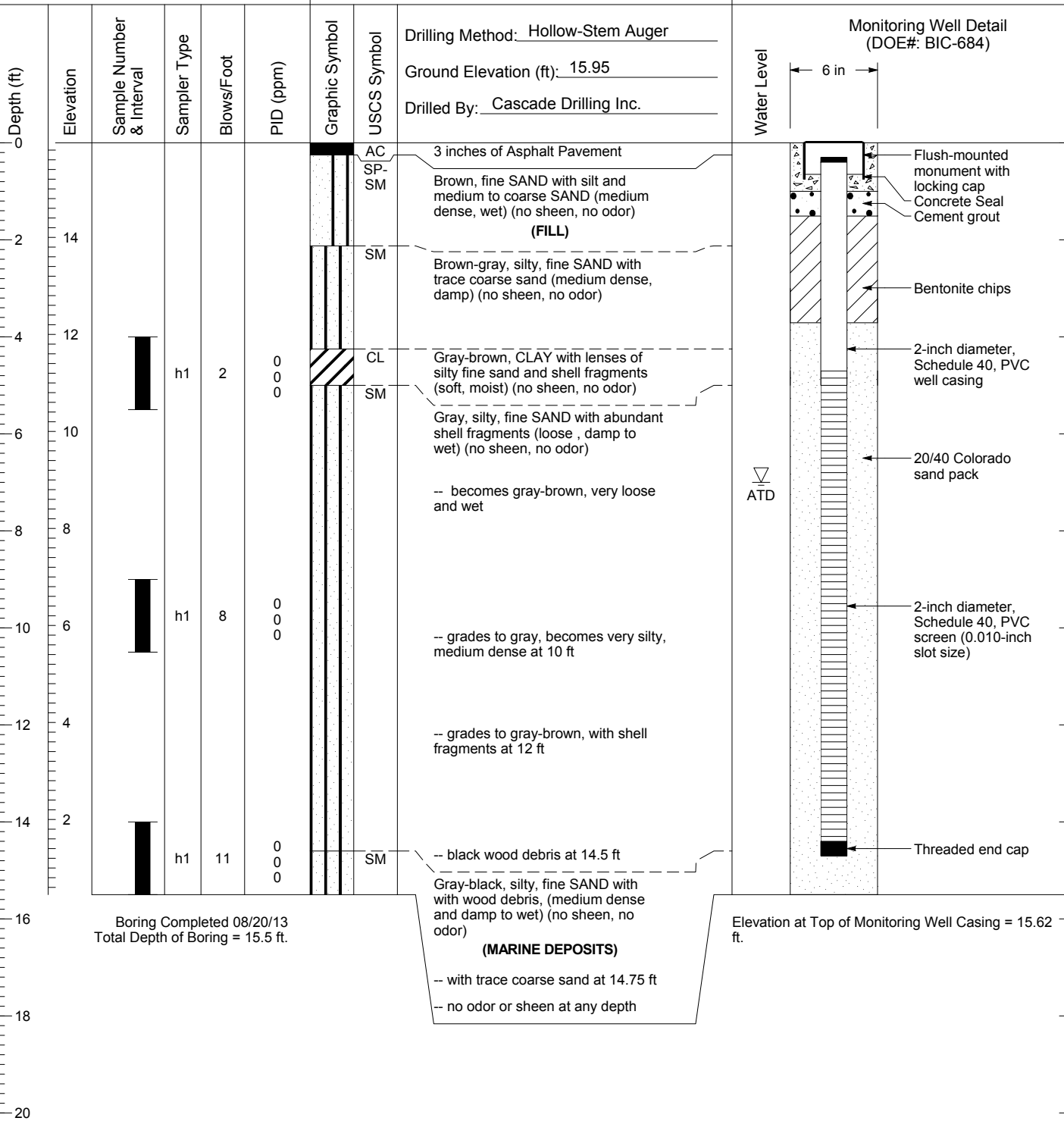
Figure
B-33

MW-11

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 08/20/13
Total Depth of Boring = 15.5 ft.

Elevation at Top of Monitoring Well Casing = 15.62 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016_4/8/15 N:\PROJECTS\001034_010.016.GPJ WELL LOG W/ ELEVATION

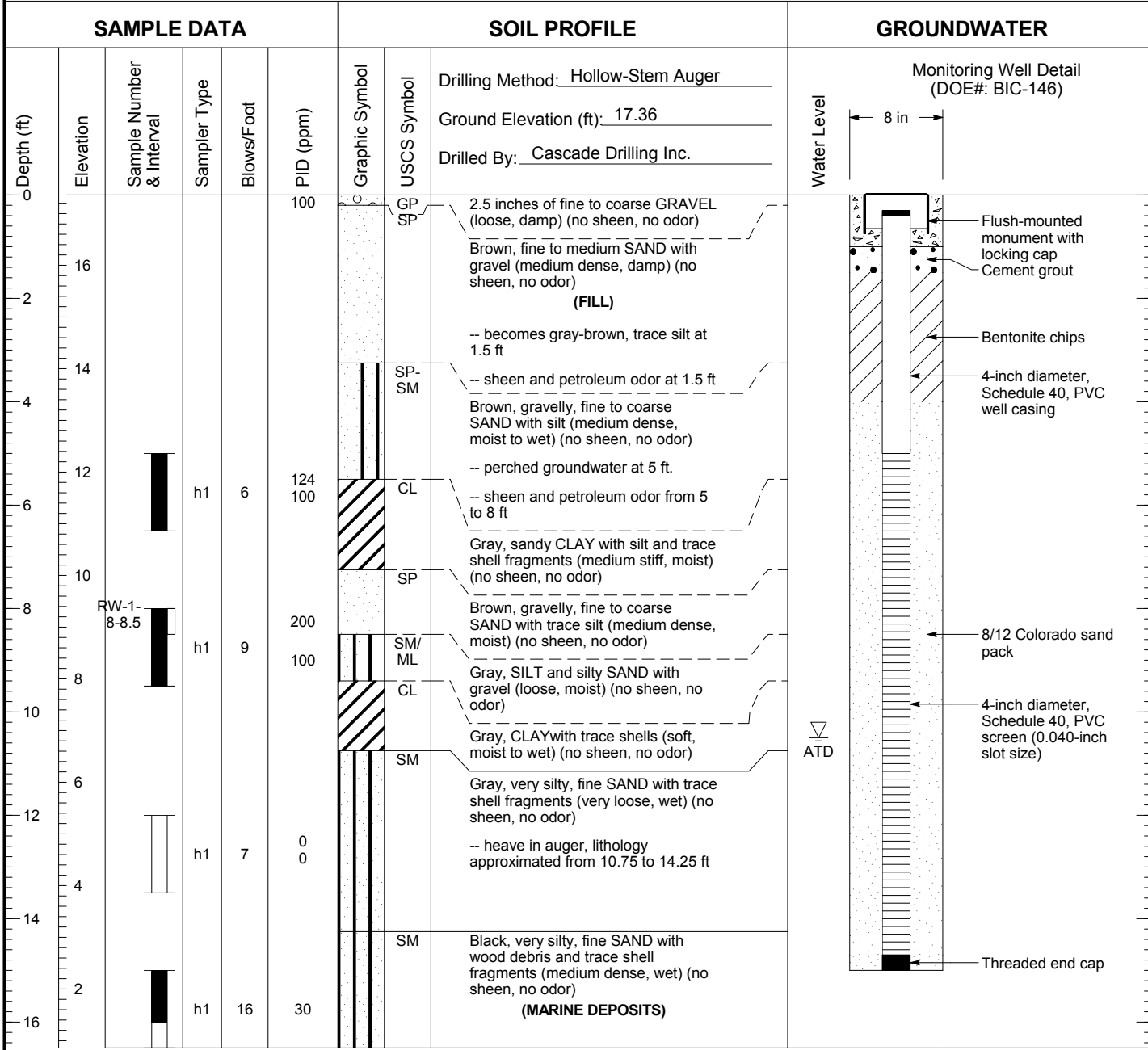


Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well MW-11

Figure
B-34

RW-1



Boring Completed 04/03/13
Total Depth of Boring = 16.5 ft.

Elevation at Top of Monitoring Well Casing = 17.10 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034010016. 4/8/15 N:\PROJECTS\001034.01\0.016.GPJ WELL LOG W/ ELEVATION



Blaine Marina Inc. Site
Blaine, Washington

Log of Monitoring Well RW-1

Figure
B-35

Light Non-Aqueous Phase Liquid Transmissivity Evaluation Data

Well Designation:	4/23/2013	Port of Blaine, Blaine Marina Inc. MW-1																			
Date:	date																				
Ground Surface Elev. (ft msl)	0.0	Enter These Data				Drawdown Adjustment															
Top of Casing Elev. (ft msl)	0.0						(ft)														
Well Casing Radius, r_c (ft):	0.083	r_c				0															
Well Radius, r_w (ft):	0.354																				
LNAPL Specific Yield, S_y :	0.175																				
LNAPL Density Ratio, ρ_p :	0.800																				
Top of Screen (ft bgs):	9.8																				
Bottom of Screen (ft bgs):	14.8																				
LNAPL Backdown Vol. (gal.):	1.2																				
Effective Radius, r_{eD} (ft):	0.166	Calculated Parameters																			
Effective Radius, r_{eS} (ft):	0.154																				
Initial Casing LNAPL Vol. (gal.):	0.46																				
Initial Filter LNAPL Vol. (gal.):	0.72																				
Enter Data Here																					
							Water Table	LNAPL													
							Depth	Drawdown			Average	Discharge	s_w	b_w	r_s						
							(ft)	s_w (ft)			Time (min)	Q_w (ft ³ /d)	(ft)	(ft)	(ft)						
Initial Fluid Levels:	0	8.43	11.27	8.43	11.27		9.00														2.84
Enter Test Data:	7	8.91	9.15	8.91	9.15		8.96	0.48													0.24
	16	8.8	9.3	8.80	9.30		8.90	0.37			11.5	0.908	0.43	0.50	0.083						
	31	8.65	9.9	8.65	9.90		8.90	0.22			23.5	5.361	0.30	1.25	0.154						
	48	8.64	10.01	8.64	10.01		8.91	0.21			39.5	0.757	0.22	1.37	0.154						
	62	8.61	10.1	8.61	10.10		8.91	0.18			55.0	0.919	0.20	1.49	0.154						
	80	8.65	10.25	8.65	10.25		8.97	0.22			71.0	0.655	0.20	1.60	0.154						
	108	8.6	10.43	8.60	10.43		8.97	0.17			94.0	0.881	0.20	1.83	0.154						
	125	8.6	10.5	8.60	10.50		8.98	0.17			116.5	0.442	0.17	1.90	0.154						
	167	8.58	10.73	8.58	10.73		9.01	0.15			146.0	0.638	0.16	2.15	0.154						
	222	8.61	10.88	8.61	10.88		9.06	0.18			194.5	0.234	0.17	2.27	0.154						
	282	8.55	10.98	8.55	10.98		9.04	0.12			252.0	0.286	0.15	2.43	0.154						
	325	8.52	11.08	8.52	11.08		9.03	0.09			303.5	0.324	0.11	2.56	0.154						
	369	8.48	11.02	8.48	11.02		8.99	0.05			347.0	-0.049	0.07	2.54	0.154						
	410	8.46	11.03	8.46	11.03		8.97	0.03			389.5	0.078	0.04	2.57	0.154						

Note: Outlier data points have been removed.



Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

**April 23, 2013 Baildown Test Well
Parameters and Field Data Input**

Figure
C-1

Well Designation:	8/20/2013	Part of Blaine, Blaine Marine Inc. MW-3											
Date:	date												
Ground Surface Elev (ft msl)	0.0	Enter These Data											
Top of Casing Elev (ft msl)	0.0												
Well Casing Radius, r_c (ft):	0.083	r_{ca}											
Well Radius, r_w (ft):	0.354												
LNAPL Specific Yield, S_y :	0.175												
LNAPL Density Ratio, ρ_r :	0.800												
Top of Screen (ft bgs):	9.8												
Bottom of Screen (ft bgs):	14.8												
LNAPL Baildown Vol. (gal.):	0.8												
Effective Radius, r_{es} (ft):	0.166	Calculated Parameters											
Effective Radius, r_{e2} (ft):	0.106												
Initial Casing LNAPL Vol. (gal.):	0.37												
Initial Filter LNAPL Vol. (gal.):	0.73												
Enter Data Here													
							Water Table	LNAPL					
							Depth	Drawdown		Average	LNAPL		
							(ft)	s_w (ft)		Time (min)	Discharge	s_w	b_w
										Q _w (ft ³ /d)	(ft)	r_e	
Initial Fluid Levels:	0	9.05	11.29	9.05	11.29		9.50					2.24	
Enter Test Data:	5	10.09	10.2	10.09	10.20		10.11	0.90				0.11	
	6	9.99	10.12	9.99	10.12		10.02	0.80		5.5	2.504	0.85	0.13
	7	9.92	10.06	9.92	10.06		9.95	0.73		6.5	1.252	0.77	0.14
	9	9.75	10	9.75	10.00		9.80	0.56		8.0	2.778	0.65	0.25
	10	9.71	9.99	9.71	9.99		9.77	0.53		9.5	1.515	0.55	0.28
	12	9.64	9.98	9.64	9.98		9.71	0.46		11.0	1.515	0.49	0.34
	14	9.57	9.97	9.57	9.97		9.65	0.39		13.0	1.515	0.42	0.40
	16	9.52	9.96	9.52	9.96		9.61	0.33		15.0	1.010	0.36	0.44
	18	9.46	9.96	9.46	9.96		9.56	0.28		17.0	1.515	0.30	0.50
	20	9.44	9.96	9.44	9.96		9.54	0.25		19.0	0.505	0.26	0.52
	24	9.38	9.96	9.38	9.96		9.50	0.20		22.0	0.758	0.22	0.58
	28	9.35	9.97	9.35	9.97		9.47	0.16		26.0	0.505	0.18	0.62
	32	9.31	9.99	9.31	9.99		9.45	0.13		30.0	0.758	0.14	0.68
	38	9.31	10.03	9.31	10.03		9.45	0.13		35.0	0.337	0.13	0.72
	44	9.27	10.03	9.27	10.03		9.42	0.08		41.0	0.337	0.10	0.76
	50	9.27	10.05	9.27	10.05		9.43	0.08		47.0	0.168	0.08	0.78
	56.0	9.27	10.07	9.27	10.07		9.43	0.08		53.0	0.168	0.08	0.80
	62.0	9.27	10.09	9.27	10.09		9.43	0.08		59.0	0.168	0.08	0.82
	68.00	9.26	10.11	9.26	10.11		9.43	0.07		65.0	0.253	0.08	0.85
	81.00	9.25	10.15	9.25	10.15		9.43	0.06		74.5	0.194	0.07	0.90
	90.00	9.25	10.16	9.25	10.16		9.43	0.06		85.5	0.056	0.06	0.91
	111.00	9.24	10.22	9.24	10.22		9.44	0.05		100.5	0.168	0.06	0.98
	123.00	9.25	10.25	9.25	10.25		9.45	0.06		117.0	0.084	0.06	1.00
	162.00	9.23	10.30	9.23	10.30		9.44	0.04		142.5	0.091	0.05	1.07
	181.00	9.23	10.37	9.23	10.37		9.46	0.04		171.5	0.186	0.04	1.14
	197.00	9.23	10.39	9.23	10.39		9.46	0.04		189.0	0.063	0.04	1.16
	219.00	9.21	10.41	9.21	10.41		9.45	0.03		208.0	0.092	0.03	1.20
	243.00	9.19	10.42	9.19	10.42		9.44	0.00		231.0	0.063	0.01	1.23

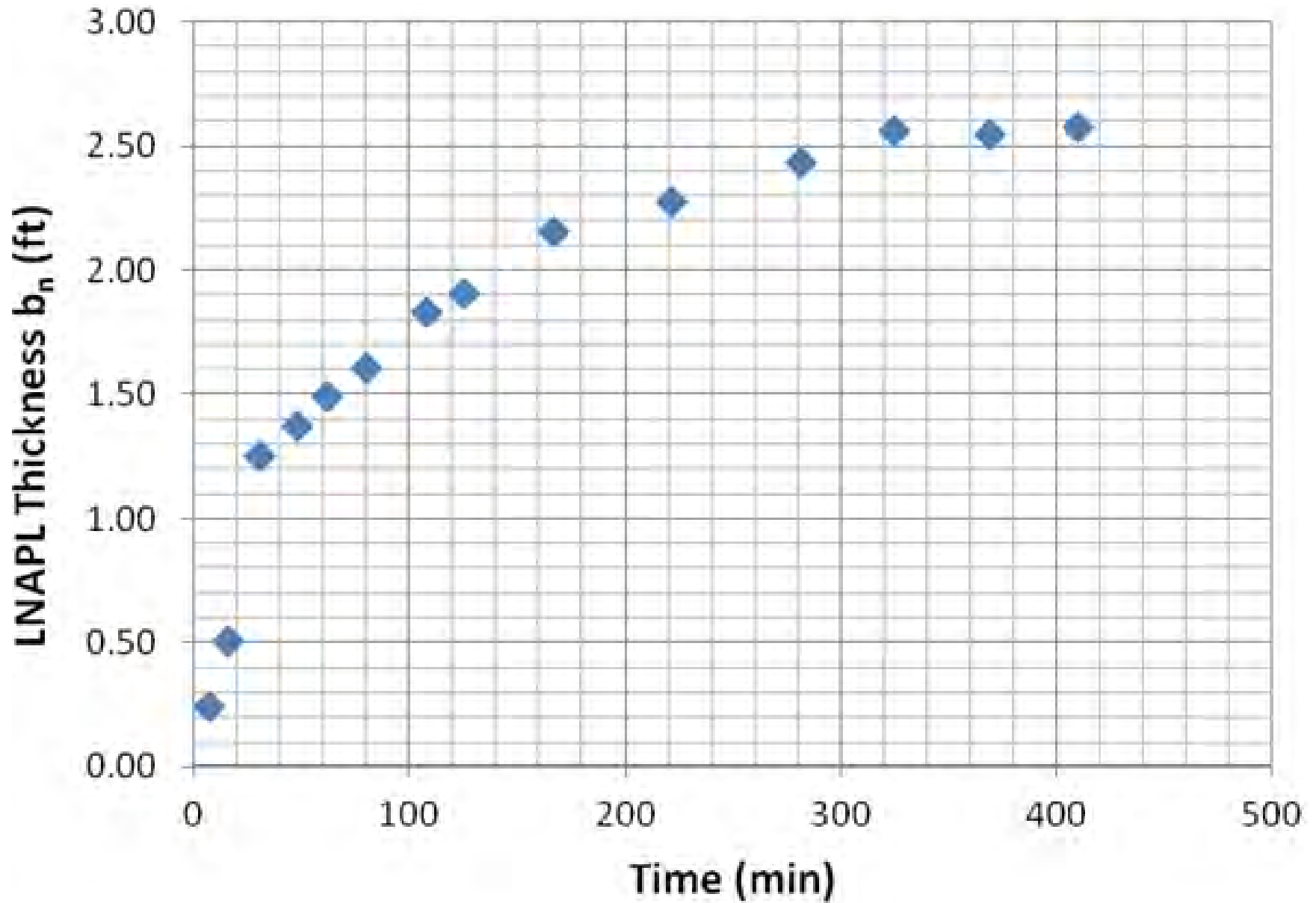
Note: Outlier data points have been removed.

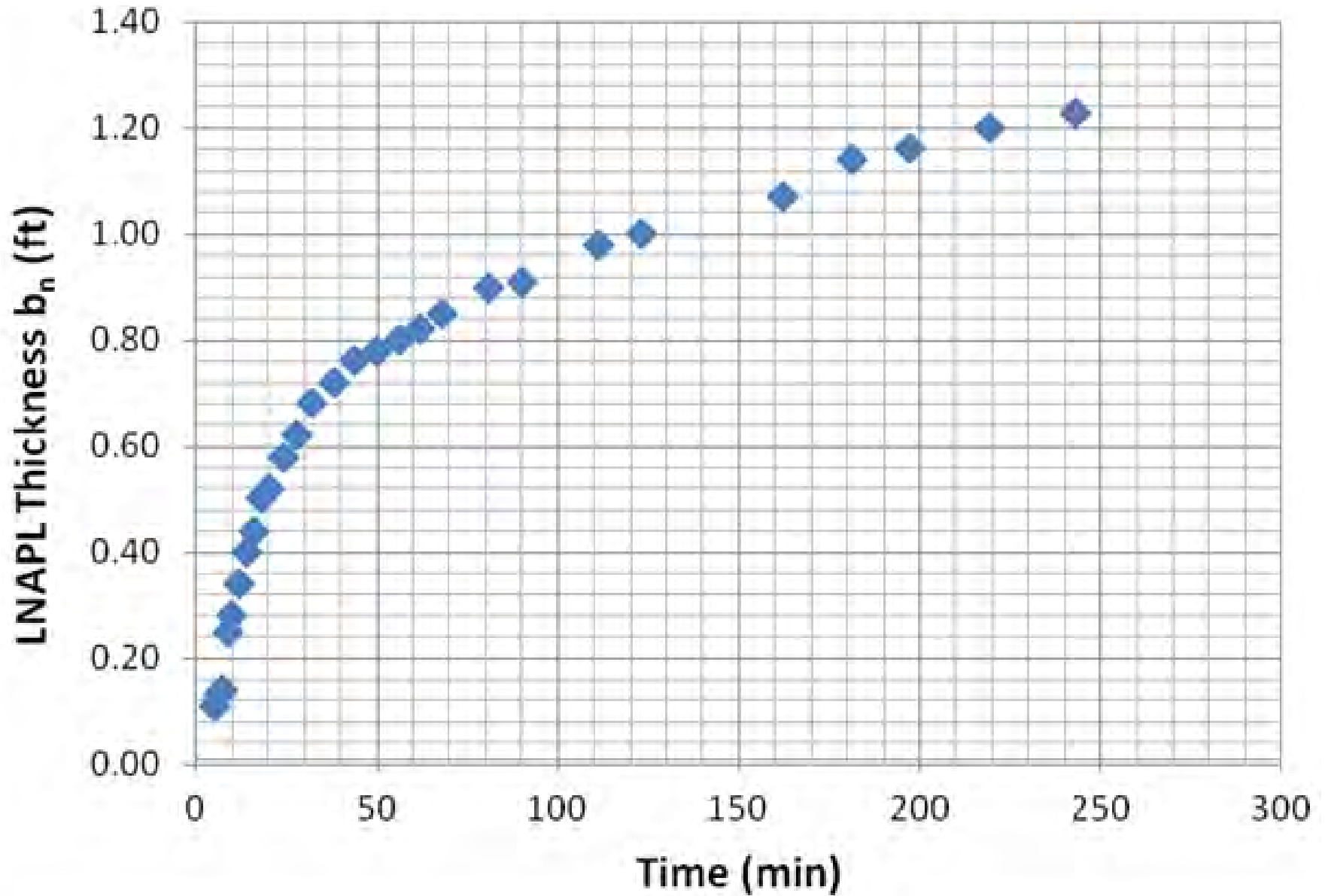


Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

**August 20, 2013 Baildown Test Well
Parameters and Field Data Input**

Figure
C-2





Cooper and Jacob (1946)

Well Designation:	41387
Date:	date

$$V_n(t_i) = \sum_j^i \frac{4\pi T_n S_j}{\ln\left(\frac{2.25 T_n t_j}{r_e^2 S_n}\right)} \Delta t_j$$

Enter early time cut-off for least-squares model fit

Time _{cut} (min):	31	<- Enter or change values here
Time Adjustment (min):	18.6	
Trial S _n :	d	<- Enter d for default or enter S _n value
Root-Mean-Square Error:	0.12417	<- Minimize this using "Solver"
	0.029	<- Working S _n
Trial T _n (ft ² /d):	1.3375	<- By changing T _n through "Solver"
		Add constraint T _n > 0.00001
Model Result:	T_n (ft²/d) = 1.34	

Cooper and Jacob (1946)

Well Designation:	41506
Date:	date

$$V_n(t_i) = \sum_j^i \frac{4\pi T_n S_j}{\ln\left(\frac{2.25 T_n t_j}{r_e^2 S_n}\right)} \Delta t_j$$

Enter early time cut-off for least-squares model fit

Time _{cut} (min):	12	<- Enter or change values here
Time Adjustment (min):	5.5	
Trial S _n :	0.025	<-- Enter d for default or enter S _n value
Root-Mean-Square Error:	0.01436	<-- Minimize this using "Solver"
	0.025	<-- Working S _n
Trial T _n (ft ² /d):	1.1900	<-- By changing T _n through "Solver"

Add constraint T_n > 0.00001

Model Result:

T_n (ft²/d) = **1.19**

Remedial Alternative Cost Estimates

**TABLE D-1
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 1
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 1: Limited Source Removal with LNAPL Recovery and Bioremediation

Item	Quantity	Unit	Unit Cost	Total	Notes
Capital Direct Costs -					
Contractor Mobilization					
Mobilize / Demobilize	1	LS	\$ 15,000	\$ 15,000	1,2
Contractor Work Plans	1	LS	\$ 5,000	\$ 5,000	1
			Task Subtotal	\$ 20,000	
Site Preparation / Demolition					
AST System Demolition / Disposal	1	LS	\$ 15,000	\$ 15,000	3
Building Demolition / Disposal	9,300	SF	\$ 12	\$ 111,600	1,4
			Task Subtotal	\$ 127,000	
Extend Sheetpile Bulkhead					
Extend Sheetpile Bulkhead to the North	60	LF	\$ 1,785	\$ 107,000	5
			Task Subtotal	\$ 107,000	
Source Area Excavation and Offsite Treatment/Disposal					
Excavation and Loading of Contaminated Soil (to 10 ft BGS)	1,100	CY	\$ 25	\$ 27,739	6
Transport and Disposal of Soil	1,650	TON	\$ 65	\$ 107,250	7
Backfill: Supply and Install Clean Imported Material	1,650	TON	\$ 20	\$ 33,000	3
Install Perforated Pipe and Riser for Bioremediation Infiltration	1	LS	\$ 3,500	\$ 3,500	1
LNAPL Removal From Open Excavation					
Extraction Costs - Vac Truck	4	EVENTS	\$ 1,000	\$ 4,000	8
Liquid Waste Disposal	16,000	GAL	\$ 0.45	\$ 7,200	9
Collect and Analyze Soil Confirmation Samples	1	LS	\$ -	\$ -	1
			Task Subtotal	\$ 183,000	
Surface Cover System (Asphalt Pavement)					
Site Grading	1,561	SY	\$ 3.50	\$ 5,464	1
Asphalt Paving	1,561	SY	\$ 37.90	\$ 59,200	1,3
			Task Subtotal	\$ 65,000	
Bioremediation					
Construct Infiltration Trenches					
Trench Excavation	170	LF	\$ 30	\$ 5,000	1,10
Soil Transport and Disposal	340	TON	\$ 65	\$ 22,000	7
Trench Backfill	340	TON	\$ 20	\$ 7,000	3
Dedicated Injection Equipment	1	LS	\$ 24,000	\$ 24,000	1,11
Injecting Bioremediation Solution (Year 1; see O&M for other years)	3	EA	\$ 19,500	\$ 58,500	1,12
			Task Subtotal	\$ 117,000	
Subtotal for Direct Capital Costs				\$ 619,000	

**TABLE D-1
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 1
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Capital Indirect Costs -					
Pre-Design Investigation/Evaluation	1	LS		\$ 40,000	1
Remedial Design	20	%		\$ 123,800	13
MTCA Engineering Design Report	1	LS		\$ 50,000	1
Project Management	6	%		\$ 37,140	13
Construction Management (Including CQA)	10	%		\$ 61,900	13
Construction Completion Report	1	LS		\$ 30,000	1
Permitting and Regulatory Compliance	3	%		\$ 18,570	1
Ecology Oversight	5	%		\$ 30,950	1
Estimate of Taxes	8.5	%		\$ 52,615	14
Subtotal for Capital Indirect Costs				\$ 445,000	
Subtotal for Capital Direct and Indirect Costs				\$ 1,064,000	
Contingency for Capital Direct and Indirect Costs				\$ 319,200	15
Total for Direct and Indirect Capital Costs				\$ 1,380,000	
O&M Costs (Present Worth)					
Discount Rate	3%				16
Containment system monitoring and maintenance	10	YR	\$ 1,000	\$ 9,000	17
Injecting Bioremediation Solution (Years 2 to 5; 3 injections per year)	4	YR	\$ 45,000	\$ 167,000	1,12
Quarterly Groundwater Monitoring	2	YR	\$ 36,440	\$ 70,000	18
Semiannual Groundwater Monitoring	8	YR	\$ 18,220	\$ 128,000	18
Annual Groundwater Reporting (Years 0-10)	10	YR	\$ 8,500	\$ 73,000	19
Subtotal for Operation and Maintenance Costs				\$ 447,000	
Contingency on Operation and Maintenance Costs				\$ 134,100	15
Total for Operation and Maintenance Costs				\$ 581,100	
ALTERNATIVE 1 PRESENT WORTH				\$ 1,960,000	

**TABLE D-1
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 1
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 1 NOTES

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

ABBREVIATIONS

CY = Cubic Yard	LS = Lump Sum	SF = Square Foot	DC = Direct Costs
EA = Each	O&M = Operation and Maintenance	SY = Square Yard	MNA = Monitored Natural Attenuation
LF = Linear Foot	QA = Quality Assurance	YR = Year	GAL = Gallons

COMMENTS

- 1 Cost estimates based on costs from similar projects and professional judgment.
- 2 Includes moving equipment and personnel on and off site, establishing work zones, temporary fencing, and temporary facilities.
- 3 Cost based on estimate from experienced contractor.
- 4 Unit costs based on similar project; includes HazMat abatement, concrete building slabs, dust control, disposal.
- 5 Based on bulkhead repair conducted during the Interim Action.
- 6 3,060 SF; 10 FT depth; unit costs based on in-place volume using costs for similar project marked up to account for difficulties excavating wet soil.
- 7 Assumes transport by truck to Everett and treatment by soil desorption and disposal in inert waste landfill.
- 8 Cost includes 5,000-gallon vac truck at \$100/hour x 10 hrs and site visit for engineering oversight.
- 9 4,000 gallons per event; unit disposal rate provided by disposal contractor.
- 10 170 LF of 3x10 FT trench).
- 11 Includes pumps, hoses, pipes, tanks, and miscellaneous equipment; installation of three additional monitoring wells for performance monitoring.
- 12 Labor, equipment, and product; 50% higher cost during Year 1 to conduct additional monitoring to develop injection program. Includes one supplemental injection event per year using a soil lance to inject solutions into locations needing more aggressive remediation.
- 13 Remedial design includes preparation of construction plans and specifications, preparation of engineer's estimate of probable cost, and bidding support. Project management includes bid/contract administration, cost and performance reporting, planning and coordination. Construction management includes submittal review, change order review, design modifications, construction schedule tracking. Estimated cost based on Remedial Design, Project Management and Construction Management based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- 14 Combined sales tax, Blaine, Washington.
- 15 Includes scope and bid contingency.
- 16 Based on an average return on investment of 6% with an assumed inflation rate of 3%.
- 17 Annual inspection of site cap. Assumes little to no repair will be required.
- 18 Sample eight wells plus duplicate; analyze groundwater for TPH-G/BTEX, TPH-D, PAHs, and MNA parameters.
- 19 Report of site conditions; comparison of water quality to cleanup standards; evaluate plume stability / MNA.

**TABLE D-2
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 2
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 2: Source Area Removal and Bioremediation					
Item	Quantity	Unit	Unit Cost	Total	Comments
Capital Direct Costs -					
Contractor Mobilization					
Mobilize / Demobilize	1	LS	\$ 15,000	\$ 15,000	1,2
Contractor Work Plans	1	LS	\$ 5,000	\$ 5,000	1
			Task Subtotal	\$ 20,000	
Site Preparation / Demolition					
AST System Demolition / Disposal	1	LS	\$ 15,000	\$ 15,000	3
Building Demolition / Disposal	9,300	SF	\$ 12	\$ 111,600	1,4
			Task Subtotal	\$ 127,000	
Extend Sheetpile Bulkhead					
Extend Sheetpile Bulkhead to the North	60	LF	\$ 1,785	\$ 107,000	5
			Task Subtotal	\$ 107,000	
Source Area Excavation and Offsite Treatment/Disposal					
Excavation and Loading of Contaminated Soil (to 10 ft BGS)	1,700	CY	\$ 25	\$ 42,870	1,6
Excavation, Stabilization and Loading of Contaminated Soil (10 to 12 ft BGS)	300	CY	\$ 29	\$ 8,646	1,6
Transport and Disposal of Soil	3,000	TON	\$ 65	\$ 195,000	7
Backfill: Supply and Install Clean Imported Material	3,000	TON	\$ 20	\$ 60,000	3
Install Perforated Pipe and Riser for Bioremediation Infiltration	1	LS	\$ 3,500	\$ 3,500	1
LNAPL Removal From Open Excavation					
Extraction Costs - Vac Truck	4	EVENTS	\$ 1,000	\$ 4,000	8
Liquid Waste Disposal	16,000	GAL	\$ 0.45	\$ 7,200	9
Collect and Analyze Soil Confirmation Samples	1	LS	\$ 14,000	\$ 14,000	1
			Task Subtotal	\$ 335,000	
Surface Cover System (Asphalt Pavement)					
Site Grading	1,561	SY	\$ 3.50	\$ 5,464	1
Asphalt Paving	1,561	SY	\$ 37.90	\$ 59,200	1,3
			Task Subtotal	\$ 65,000	
Bioremediation					
Construct Infiltration Trenches					
Trench Excavation	170	LF	\$ 30	\$ 5,000	1,10
Soil Transport and Disposal	340	TON	\$ 65	\$ 22,000	7
Trench Backfill	340	TON	\$ 20	\$ 7,000	3
Dedicated Injection Equipment	1	LS	\$ 24,000	\$ 24,000	1,11
Injecting Bioremediation Solution (Year 1; see O&M for other years)	3	EA	\$ 19,500	\$ 58,500	1,12
			Task Subtotal	\$ 117,000	
Subtotal for Direct Capital Costs				\$ 771,000	

**TABLE D-2
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 2
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Capital Indirect Costs -					
Pre-Design Investigation/Evaluation	1	LS		\$ 40,000	1
Remedial Design	20	%		\$ 154,200	13
MTCA Engineering Design Report	1	LS		\$ 65,000	1
Project Management	6	%		\$ 46,260	13
Construction Management (Including CQA)	10	%		\$ 77,100	13
Construction Completion Report	1	LS		\$ 30,000	1
Permitting and Regulatory Compliance	5	%		\$ 38,550	1
Ecology Oversight	5	%		\$ 38,550	1
Estimate of Taxes	8.5	%		\$ 65,535	14
Subtotal for Capital Indirect Costs				\$ 555,000	
Subtotal for Capital Direct and Indirect Costs				\$ 1,326,000	
Contingency for Capital Direct and Indirect Costs				\$ 397,800	15
Total for Direct and Indirect Capital Costs				\$ 1,720,000	
O&M Costs (Present Worth)					
Discount Rate	3%				16
Containment system monitoring and maintenance	8	YR	\$ 1,000	\$ 7,000	17
Injection of Nutrients and Electron Acceptors (Years 2 to 4; 3 injections per year)	3	YR	\$ 45,000	\$ 127,000	1,12
Quarterly Groundwater Monitoring	2	YR	\$ 36,440	\$ 70,000	18
Semiannual Groundwater Monitoring	6	YR	\$ 18,220	\$ 99,000	18
Annual Groundwater Reporting	8	YR	\$ 8,500	\$ 60,000	19
Subtotal for Operation and Maintenance Costs				\$ 363,000	
Contingency on Operation and Maintenance Costs				\$ 108,900	15
Total for Operation and Maintenance Costs				\$ 471,900	
ALTERNATIVE 2 PRESENT WORTH				\$ 2,190,000	

**TABLE D-2
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 2
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 2 NOTES

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

ABBREVIATIONS

CY = Cubic Yard	LS = Lump Sum	SF = Square Foot	DC = Direct Costs
EA = Each	O&M = Operation and Maintenance	SY = Square Yard	MNA = Monitored Natural Attenuation
LF = Linear Foot	QA = Quality Assurance	YR = Year	GAL = Gallons

COMMENTS

- 1 Cost estimates based on costs from similar projects and professional judgment.
- 2 Includes moving equipment and personnel on and off site, establishing work zones, temporary fencing, and temporary facilities.
- 3 Cost based on estimate from experienced contractor.
- 4 Unit costs based on similar project; includes HazMat abatement, concrete building slabs, dust control, disposal.
- 5 Based on bulkhead repair conducted during the Interim Action.
- 6 4,500 SF; 12 FT depth; unit costs based on in-place volume using costs for similar project marked up to account for difficulties excavating wet soil.
- 7 Assumes transport by truck to Everett and treatment by soil desorption and disposal in inert waste landfill.
- 8 5,000-gallon vac truck at \$100/hour x 10 hrs.
- 9 4,000 gallons per event; unit disposal rate provided by disposal contractor.
- 10 170 Lineal FT; 3 FT wide x 10 FT deep).
- 11 Includes pumps, hoses, pipes, tanks, and miscellaneous equipment; installation of three additional monitoring wells for performance monitoring.
- 12 Labor, equipment, and product; 50% higher cost during Year 1 to conduct additional monitoring to develop injection program. Includes one supplemental injection event per year using a soil lance to inject solutions into locations needing more aggressive remediation.
- 13 Remedial design includes preparation of construction plans and specifications, preparation of engineer's estimate of probable cost, and bidding support. Project management includes bid/contract administration, cost and performance reporting, planning and coordination. Construction management includes submittal review, change order review, design modifications, construction schedule tracking. Estimated cost based on Remedial Design, Project Management and Construction Management based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- 14 Combined sales tax, Blaine, Washington.
- 15 Includes scope and bid contingency.
- 16 Based on an average return on investment of 6% with an assumed inflation rate of 3%.
- 17 Annual inspection of site cap. Assumes little to no repair will be required.
- 18 Sample eight wells plus duplicate; analyze groundwater for TPH-G/BTEX, TPH-D, PAHs, and MNA parameters.
- 19 Report of site conditions; comparison of water quality to cleanup standards; evaluate plume stability / MNA.

**TABLE D-3
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 3
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 3: Source Area Removal and Bioremediation with Soil Flushing and Downgradient Hydraulic Barrier

Item	Quantity	Unit	Unit Cost	Total	Comments
Capital Direct Costs -					
Contractor Mobilization					
Mobilize / Demobilize	1	LS	\$ 25,000	\$ 25,000	1,2
Contractor Work Plans	1	LS	\$ 10,000	\$ 10,000	1
Task Subtotal				\$ 35,000	
Site Preparation / Demolition					
AST System Demolition / Disposal	1	LS	\$ 15,000	\$ 15,000	3
Building Demolition / Disposal	9,300	SF	\$ 12	\$ 111,600	1,4
Task Subtotal				\$ 127,000	
Source Area Excavation and Offsite Treatment/Disposal					
Excavation and Loading of Contaminated Soil (to 8 ft BGS)	1,300	CY	\$ 25	\$ 32,783	1,5
Excavation, Stabilization and Loading of Contaminated Soil (8 to 12ft BGS)	700	CY	\$ 29	\$ 20,174	1,5
Transport and Disposal of Soil	3,000	TON	\$ 65	\$ 195,000	6
Backfill: Supply and Install Clean Imported Material	3,000	TON	\$ 20	\$ 60,000	3
Install Perforated Pipe and Riser for Bioremediation Infiltration	1	LS	\$ 3,500	\$ 3,500	1
LNAPL Removal From Open Excavation					
Extraction Costs - Vac Truck	4	EVENTS	\$ 1,000	\$ 4,000	7
Liquid Waste Disposal	16,000	GAL	\$ 0.45	\$ 7,200	8
Compliance Monitoring (Soil Confirmation Samples)	1	LS	\$ 14,000	\$ 14,000	1
Task Subtotal				\$ 337,000	
Surface Cover System (Asphalt Pavement)					
Site Grading	1,561	SY	\$ 3.50	\$ 5,464	1
Asphalt Paving	1,561	SY	\$ 37.90	\$ 59,200	1,3
Task Subtotal				\$ 65,000	
Bioremediation					
Construct Infiltration Trenches					
Trench Excavation	200	LF	\$ 30	\$ 6,000	1,9
Soil Disposal	400	TON	\$ 65	\$ 26,000	6
Trench Backfill	400	TON	\$ 20	\$ 8,000	3
Dedicated Injection Equipment	1	LS	\$ 24,000	\$ 24,000	1,10
Injecting Bioremediation Solution (Year 1; see O&M for other years)	3	EA	\$ 19,500	\$ 58,500	1,11
Task Subtotal				\$ 123,000	
Soil Flushing and Downgradient Hydraulic Barrier					
Extend Sheetpile Bulkhead to the North and South	70	LF	\$ 1,785	\$ 125,000	12
Sheetpile shoring Parallel to Existing Bulkhead	3,240	SF	\$ 22.00	\$ 71,000	13
Temporary Utility Rerouting	1	LS	\$ 70,000	\$ 70,000	14
Interceptor Trench Excavation	105	LF	\$ 45	\$ 5,000	1,15
Dewatering Allowance	1	LS	\$ 50,000	\$ 50,000	
Soil Transport and Disposal	175	TON	\$ 65	\$ 11,000	16,6
Install Hydraulic Barrier	875	SF	\$ 8.00	\$ 7,000	17
Install Collection Pipe and Riser Pipe	1	LS	\$ 1,500	\$ 2,000	18
Riser Completion	2	EA	\$ 1,000	\$ 2,000	19

**TABLE D-3
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 3
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Backfill Gravel	175	TON	\$	20	\$	4,000	3
Supply and Install Pumps, Controls, Compressor, Filtration, Tanks, etc.	1	LS	\$	65,000	\$	65,000	1,20
				Task Subtotal	\$	412,000	
				Subtotal for Direct Capital Costs	\$	1,099,000	
Capital Indirect Costs -							
Pre-Design Investigation/Evaluation	1	LS			\$	75,000	1
Remedial Design	20	%			\$	219,800	21
MTCA Engineering Design Report	1	LS			\$	70,000	1
Project Management	5	%			\$	54,950	21
Construction Management (Including CQA)	10	%			\$	109,900	21
Construction Completion Report	1	LS			\$	35,000	1
Permitting and Regulatory Compliance	8	%			\$	87,920	1
Ecology Oversight	5	%			\$	54,950	1
Estimate of Taxes	8.5	%			\$	93,415	22
				Subtotal for Capital Indirect Costs	\$	801,000	
				Subtotal for Capital Direct and Indirect Costs	\$	1,900,000	
				Contingency for Capital Direct and Indirect Costs	\$	570,000	23
				Total for Direct and Indirect Capital Costs	\$	2,470,000	
O&M Costs (Present Worth)							
			Discount Rate	3%			24
Containment System Monitoring and Maintenance	6	YR	\$	1,000	\$	5,000	25
Injection of Nutrients and Electron Acceptors (Years 2 and 3; 3 injections per year)	2	YR	\$	45,000	\$	86,000	1,11
Quarterly Groundwater Monitoring	2	YR	\$	36,440	\$	70,000	26
Semiannual Groundwater Monitoring	4	YR	\$	18,220	\$	68,000	26
Annual Groundwater Reporting	6	YR	\$	8,500	\$	46,000	27
O&M for Soil Flushing System	2	YR	\$	65,000	\$	124,000	1
Sanitary Discharge - Permitting, monitoring, discharge fees	2	YR	\$	18,477	\$	35,000	1
				Subtotal for Operation and Maintenance Costs	\$	434,000	
				Contingency on Operation and Maintenance Costs	\$	130,200	23
				Total for Operation and Maintenance Costs	\$	564,200	
ALTERNATIVE 3 PRESENT WORTH					\$	3,030,000	

**TABLE D-3
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 3
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 3 NOTES

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

ABBREVIATIONS

CY = Cubic Yard	LS = Lump Sum	SF = Square Foot	DC = Direct Costs
EA = Each	O&M = Operation and Maintenance	SY = Square Yard	MNA = Monitored Natural Attenuation
LF = Linear Foot	QA = Quality Assurance	YR = Year	GAL = Gallons

COMMENTS

- 1 Cost estimates based on costs from similar projects and professional judgment.
- 2 Includes moving equipment and personnel on and off site, establishing work zones, temporary fencing, and temporary facilities.
- 3 Cost based on estimate from experienced contractor.
- 4 Unit costs based on similar project; includes HazMat abatement, concrete building slabs, dust control, disposal.
- 5 4,500 SF; 12 FT depth; unit costs based on in-place volume using costs for similar project marked up to account for difficulties excavating wet soil.
- 6 Assumes transport by truck to Everett and treatment by soil desorption and disposal in inert waste landfill.
- 7 5,000-gallon vac truck at \$100/hour x 10 hrs.
- 8 4,000 gallons per event; unit disposal rate provided by disposal contractor.
- 9 Five Infiltration trenches (3 x 30 LF + 2 x 40 LF; 3 FT wide x 8 FT deep).
- 10 Includes pumps, hoses, pipes, tanks, and miscellaneous equipment; installation of three additional monitoring wells for performance monitoring.
- 11 Labor, equipment, and product; 50% higher cost during Year 1 to conduct additional monitoring to develop injection program. Includes one supplemental injection event per year using a soil lance to inject solutions into locations needing more aggressive remediation.
- 12 Based on bulkhead repair conducted during the Interim Action.
- 13 Temporary sheetpile wall parallel to bulkhead; 12 FT x 135 FT; RS Means Heavy Const., 31.41.16.
- 14 Rerouting power and telecommunications.
- 15 105 LF trench adjacent to sheetpile bulkhead.
- 16 Assumes soil from 0 to 4 ft BGS is not contaminated and suitable for reuse as backfill; 1.5 tons per CY; 1.3 expansion factor after excavation.
- 17 60-mil HDPE; typical installation cost marked up for difficulty of vertical installation in wet conditions; assume four seams with 5 FT overlap.
- 18 8-inch HDPE SDR-17 collection, 4-inch HDPE SDR-17 riser.
- 19 Precast vaults (Oldcastle Enclosure Solutions); QED flange wellhead.
- 20 FRTR Cost estimate for small site soil flushing; experience similar remediation projects.
- 21 Remedial design includes preparation of construction plans and specifications, preparation of engineer's estimate of probable cost, and bidding support. Project management includes bid/contract administration, cost and performance reporting, planning and coordination. Construction management includes submittal review, change order review, design modifications, construction schedule tracking. Estimated cost based on Remedial Design, Project Management and Construction Management based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- 22 Combined sales tax, Blaine, Washington.
- 23 Includes scope and bid contingency.
- 24 Based on an average return on investment of 6% with an assumed inflation rate of 3%.
- 25 Annual inspection of site cap. Assumes little to no repair will be required.
- 26 Sample eight wells plus duplicate; analyze groundwater for TPH-G/BTEX, TPH-D, PAHs, and MNA parameters.
- 27 Report of site conditions; comparison of water quality to cleanup standards; evaluate plume stability / MNA.

**TABLE D-4
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 4
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 4: Excavation East of Sigurdson, Bioremediation Along Shoreline					
Item	Quantity	Unit	Unit Cost	Total	Comments
Capital Direct Costs -					
Contractor Mobilization					
Mobilize / Demobilize	1	LS	\$ 15,000	\$ 15,000	1,2
Contractor Work Plans	1	LS	\$ 10,000	\$ 10,000	1
			Task Subtotal	\$ 25,000	
Site Preparation / Demolition					
AST System Demolition / Disposal	1	LS	\$ 15,000	\$ 15,000	3
Building Demolition / Disposal	9,300	SF	\$ 12	\$ 111,600	1,4
			Task Subtotal	\$ 127,000	
Extend Sheetpile Bulkhead					
Extend Sheetpile Bulkhead to the North	60	LF	\$ 1,785	\$ 107,000	5
			Task Subtotal	\$ 107,000	
Excavation and Offsite Treatment/Disposal					
Dewatering Allowance	1	LS	\$ 100,000	\$ 100,000	1
Excavation and Loading of Contaminated Soil (to 8 ft BGS)	3,700	CY	\$ 25	\$ 93,305	1,6
Excavation, Stabilization and Loading of Contaminated Soil (8 to 15 ft BGS)	3,200	CY	\$ 29	\$ 92,224	1,6
Transport and Disposal of Contaminated Soil	8,194	TON	\$ 65	\$ 532,639	7
Transpot and Disposal of Clean Soil	2,222	TON	\$ 45	\$ 100,000	7
Backfill: Supply and Install Clean Imported Material	10,417	TON	\$ 20	\$ 208,333	3
Install Perforated Pipe and Riser for Bioremediation Infiltration	1	LS	\$ 2,000	\$ 2,000	1
LNAPL Removal From Open Excavation					
Extraction Costs - Vac Truck	4	EVENTS	\$ 1,000	\$ 4,000	8
Liquid Oily Waste Disposal	16,000	GAL	\$ 0.45	\$ 7,200	9
Compliance Monitoring (Soil Confirmation Samples)	1	LS	\$ 14,000	\$ 14,000	1
			Task Subtotal	\$ 1,154,000	
Surface Cover System (Asphalt Pavement)					
Site Grading	1,561	SY	\$ 3.50	\$ 5,464	1
Asphalt Paving	1,561	SY	\$ 37.90	\$ 59,200	1,3
			Task Subtotal	\$ 65,000	
Bioremediation					
Construct Infiltration Trenches					
Trench Excavation	80	LF	\$ 30	\$ 2,000	1,10
Soil Transport and Disposal	160	TON	\$ 65	\$ 10,000	7
Trench Backfill	160	TON	\$ 20	\$ 3,000	3
Dedicated Injection Equipment	1	LS	\$ 24,000	\$ 24,000	1,11
Injecting Bioremedation Solution (Year 1; see O&M for other years)	3	EA	\$ 19,500	\$ 58,500	1,12
			Task Subtotal	\$ 98,000	
			Subtotal for Direct Capital Costs	\$ 1,576,000	

**TABLE D-4
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 4
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Capital Indirect Costs -					
Pre-Design Investigation/Evaluation	1	LS		\$ 75,000	1
Remedial Design	15	%		\$ 236,400	13
MTCA Engineering Design Report	1	LS		\$ 65,000	1
Project Management	5	%		\$ 78,800	13
Construction Management (Including CQA)	8	%		\$ 126,080	13
Construction Completion Report	1	LS		\$ 30,000	1
Permitting and Regulatory Compliance	5	%		\$ 78,800	1
Ecology Oversight	5	%		\$ 78,800	1
Estimate of Taxes	8.5	%		\$ 133,960	14
Subtotal for Capital Indirect Costs				\$ 903,000	
Subtotal for Capital Direct and Indirect Costs				\$ 2,479,000	
Contingency for Capital Direct and Indirect Costs				\$ 743,700	15
Total for Direct and Indirect Capital Costs				\$ 3,220,000	
O&M Costs (Present Worth)					
Discount Rate	3%				16
Containment system monitoring and maintenance	8	YR	\$ 1,000	\$ 7,000	17
Injection of Nutrients and Electron Acceptors (Years 2 to 4; 3 injections per year)	3	YR	\$ 45,000	\$ 127,000	1,12
Quarterly Groundwater Monitoring	2	YR	\$ 36,440	\$ 70,000	18
Semiannual Groundwater Monitoring	6	YR	\$ 18,220	\$ 99,000	18
Annual Groundwater Reporting	8	YR	\$ 8,500	\$ 60,000	19
Subtotal for Operation and Maintenance Costs				\$ 363,000	
Contingency on Operation and Maintenance Costs				\$ 108,900	15
Total for Operation and Maintenance Costs				\$ 471,900	
ALTERNATIVE 4 PRESENT WORTH				\$ 3,690,000	

**TABLE D-4
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 4
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 4 NOTES

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

ABBREVIATIONS

CY = Cubic Yard	LS = Lump Sum	SF = Square Foot	DC = Direct Costs
EA = Each	O&M = Operation and Maintenance	SY = Square Yard	MNA = Monitored Natural Attenuation
LF = Linear Foot	QA = Quality Assurance	YR = Year	GAL = Gallons

COMMENTS

- 1 Cost estimates based on costs from similar projects and professional judgment.
- 2 Includes moving equipment and personnel on and off site, establishing work zones, temporary fencing, and temporary facilities.
- 3 Cost based on estimate from experienced contractor.
- 4 Unit costs based on similar project; includes HazMat abatement, concrete building slabs, dust control, disposal.
- 5 Based on bulkhead repair conducted during the Interim Action.
- 6 4,500 SF; 12 FT depth; unit costs based on in-place volume using costs for similar project marked up to account for difficulties excavating wet soil.
- 7 Contaminated soil: truck to Everett and treatment by soil desorption and disposal in inert waste landfill; Clean soil: no treatment.
- 8 5,000-gallon vac truck at \$100/hour x 10 hrs.
- 9 4,000 gallons per event; unit disposal rate provided by disposal contractor.
- 10 80 Lineal FT of trench; 3 FT wide x 10 FT deep).
- 11 Includes pumps, hoses, pipes, tanks, and miscellaneous equipment; installation of three additional monitoring wells for performance monitoring.
- 12 Labor, equipment, and product; 50% higher cost during Year 1 to conduct additional monitoring to develop injection program.
- 13 Remedial design includes preparation of construction plans and specifications, preparation of engineer's estimate of probable cost, and bidding support. Project management includes bid/contract administration, cost and performance reporting, planning and coordination. Construction management includes submittal review, change order review, design modifications, construction schedule tracking. Estimated cost based on Remedial Design, Project Management and Construction Management based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- 14 Combined sales tax, Blaine, Washington.
- 15 Includes scope and bid contingency.
- 16 Based on an average return on investment of 6% with an assumed inflation rate of 3%.
- 17 Annual inspection of site cap. Assumes little to no repair will be required.
- 18 Sample eight wells plus duplicate; analyze groundwater for TPH-G/BTEX, TPH-D, PAHs, and MNA parameters.
- 19 Report of site conditions; comparison of water quality to cleanup standards; evaluate plume stability / MNA.

**TABLE D-5
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 5
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 5: Excavation East of Sigurdson, Soil Flushing with Downgradient Hydraulic Barrier Along Shoreline						
Item	Quantity	Unit	Unit Cost	Total	Comments	
Capital Direct Costs -						
Contractor Mobilization						
Mobilize / Demobilize	1	LS	\$ 15,000	\$ 15,000	1,2	
Contractor Work Plans	1	LS	\$ 15,000	\$ 15,000	1	
			Task Subtotal	\$ 30,000		
Site Preparation / Demolition						
AST System Demolition / Disposal	1	LS	\$ 15,000	\$ 15,000	3	
Building Demolition / Disposal	9,300	SF	\$ 12	\$ 111,600	1,4	
			Task Subtotal	\$ 127,000		
Extend Sheetpile Bulkhead						
Extend Sheetpile Bulkhead to the North and South	70	LF	\$ 1,785	\$ 125,000	5	
			Task Subtotal	\$ 125,000		
Excavation and Offsite Treatment/Disposal						
Dewatering Allowance	1	LS	\$ 100,000	\$ 100,000	1	
Excavation and Loading of Contaminated Soil (to 10 ft BGS)	4,600	CY	\$ 25	\$ 116,001	1,6	
Excavation, Stabilization and Loading of Contaminated Soil (10 to 15 ft BGS)	2,300	CY	\$ 29	\$ 66,286	1,6	
Transport and Disposal of Contaminated Soil	8,194	TON	\$ 65	\$ 532,639	7	
Transport and Disposal of Clean Soil	2,222	TON	\$ 45	\$ 100,000	7	
Backfill: Supply and Install Clean Imported Material	10,417	TON	\$ 20	\$ 208,333	3	
Install Perforated Pipe and Riser for Bioremediation Infiltration	1	LS	\$ 2,000	\$ 2,000	1	
LNAPL Removal From Open Excavation						
Extraction Costs - Vac Truck	2	EVENTS	\$ 1,000	\$ 2,000	8	
Liquid Oily Waste Disposal	8,000	GAL	\$ 0.45	\$ 3,600	9	
Compliance Monitoring (Soil Confirmation Samples)	1	LS	\$ 14,000	\$ 14,000	1	
			Task Subtotal	\$ 1,145,000		
Surface Cover System (Asphalt Pavement)						
Site Grading	1,561	SY	\$ 3.50	\$ 5,464	1	
Asphalt Paving	1,561	SY	\$ 37.90	\$ 59,200	1,3	
			Task Subtotal	\$ 65,000		
Bioremediation Trenches (To Be Used For Flushing System)						
Construct Infiltration Trenches						
Trench Excavation	80	LF	\$ 30	\$ 2,000	1,10	
Soil Transport and Disposal	160	TON	\$ 65	\$ 10,000	7	
Trench Backfill	160	TON	\$ 20	\$ 3,000	3	
Supplemental Bioremediation Injections	3	EA	\$ 10,000	\$ 30,000	1,12	
			Task Subtotal	\$ 45,000		
Soil Flushing and Downgradient Hydraulic Barrier						
Sheetpile shoring Parallel to Existing Bulkhead	3,240	SF	\$ 22.00	\$ 71,000	13	
Temporary Utility Rerouting	1	LS	\$ 70,000	\$ 70,000	14	
Interceptor Trench Excavation	105	LF	\$ 45	\$ 5,000	15	
Dewatering Allowance	1	ls	\$ 50,000	\$ 50,000	1	
Soil Transport and Disposal	210	TON	\$ 65	\$ 14,000	7	

**TABLE D-5
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 5
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Install Hydraulic Barrier	875	SF	\$	8.00	\$	7,000	16
Install Collection Pipe and Riser Pipe	1	LS	\$	1,000	\$	1,000	17
Riser Completion	2	EA	\$	990	\$	2,000	18
Backfill Gravel	210	TON	\$	20	\$	4,000	3
Supply and Install Pumps, Controls, Compressor, Filtration, Tanks, etc.	1	LS	\$	65,000	\$	65,000	1
				Task Subtotal	\$	289,000	
				Subtotal for Direct Capital Costs	\$	1,826,000	
Capital Indirect Costs -							
Pre-Design Investigation/Evaluation	1	LS			\$	100,000	1
Remedial Design	15	%			\$	273,900	19
MTCA Engineering Design Report	1	LS			\$	65,000	1
Project Management	5	%			\$	91,300	19
Construction Management (Including CQA)	8	%			\$	146,080	19
Construction Completion Report	1	LS			\$	50,000	1
Permitting and Regulatory Compliance	5	%			\$	91,300	1
Ecology Oversight	5	%			\$	91,300	1
Estimate of Taxes	8.5	%			\$	155,210	20
				Subtotal for Capital Indirect Costs	\$	1,064,000	
				Subtotal for Capital Direct and Indirect Costs	\$	2,890,000	
Contingency for Capital Direct and Indirect Costs	30	%			\$	867,000	21
				Total for Direct and Indirect Capital Costs	\$	3,760,000	
O&M Costs (Present Worth)							
Discount Rate	3%						22
Containment system monitoring and maintenance	6	YR	\$	1,000	\$	5,000	23,24
O&M for soil flushing system	2	YR	\$	65,000	\$	124,000	1
Quarterly Groundwater Monitoring	2	YR	\$	36,440	\$	70,000	25
Semiannual Groundwater Monitoring	4	YR	\$	18,220	\$	68,000	25
Annual Groundwater Reporting	6	YR	\$	8,500	\$	46,000	26
				Subtotal for Operation and Maintenance Costs	\$	313,000	
Contingency on Operation and Maintenance Costs	30	%			\$	93,900	21
				Total for Operation and Maintenance Costs	\$	406,900	
				ALTERNATIVE 5 PRESENT WORTH	\$	4,170,000	

**TABLE D-5
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 5
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 5 NOTES

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

ABBREVIATIONS

CY = Cubic Yard	LS = Lump Sum	SF = Square Foot	DC = Direct Costs
EA = Each	O&M = Operation and Maintenance	SY = Square Yard	MNA = Monitored Natural Attenuation
LF = Linear Foot	QA = Quality Assurance	YR = Year	GAL = Gallons

COMMENTS

- 1 Cost estimates based on costs from similar projects and professional judgment.
- 2 Includes moving equipment and personnel on and off site, establishing work zones, temporary fencing, and temporary facilities.
- 3 Cost based on estimate from experienced contractor.
- 4 Unit costs based on similar project; includes HazMat abatement, concrete building slabs, dust control, disposal.
- 5 Based on bulkhead repair conducted during the Interim Action.
- 6 4,500 SF; 12 FT depth; unit costs based on in-place volume using costs for similar project marked up to account for difficulties excavating wet soil.
- 7 Contaminated soil: truck to Everett and treatment by soil desorption and disposal in inert waste landfill; Clean soil: no treatment.
- 8 5,000-gallon vac truck at \$100/hour x 10 hrs.
- 9 4,000 gallons per event; unit disposal rate provided by disposal contractor.
- 10 80 Lineal FT of trench; 3 FT wide x 10 FT deep).
- 11 Includes pumps, hoses, pipes, tanks, and miscellaneous equipment; installation of three additional monitoring wells for performance monitoring.
- 12 Labor, equipment, and product; 50% higher cost during Year 1 to conduct additional monitoring to develop injection program.
- 13 Temporary sheetpile wall parallel to bulkhead; 12 FT x 135 FT; RS Means Heavy Const., 31.41.16.
- 14 Rerouting power and telecommunications.
- 15 105 LF trench adjacent to sheetpile bulkhead.
- 16 60-mil HDPE; typical installation cost marked up for difficulty of vertical installation in wet conditions; assume four seams with 5 FT overlap.
- 17 8-inch HDPE SDR-17 collection, 4-inch HDPE SDR-17 riser.
- 18 Precast vaults (Oldcastle Enclosure Solutions); QED flange wellhead.
- 19 Remedial design includes preparation of construction plans and specifications, preparation of engineer's estimate of probable cost, and bidding support. Project management includes bid/contract administration, cost and performance reporting, planning and coordination. Construction management includes submittal review, change order review, design modifications, construction schedule tracking. Estimated cost based on Remedial Design, Project Management and Construction Management based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- 20 Combined sales tax, Blaine, Washington.
- 21 Includes scope and bid contingency.
- 22 Based on an average return on investment of 6% with an assumed inflation rate of 3%.
- 23 FRTR Cost estimate for small site soil flushing; experience similar remediation projects.
- 24 Annual inspection of site cap. Assumes little to no repair will be required.
- 25 Sample eight wells plus duplicate; analyze groundwater for TPH-G/BTEX, TPH-D, PAHs, and MNA parameters.
- 26 Report of site conditions; comparison of water quality to cleanup standards; evaluate plume stability / MNA.

**TABLE D-6
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 6
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 6: Mass Excavation and MNA						
Item	Quantity	Unit	Unit Cost	Total	Comments	
Capital Direct Costs -						
Contractor Mobilization						
Mobilize / Demobilize	1	LS	\$ 20,000	\$ 20,000	1,2	
Contractor Work Plans	1	LS	\$ 10,000	\$ 10,000	1	
			Task Subtotal	\$ 30,000		
Site Preparation / Demolition						
AST System Demolition / Disposal	1	LS	\$ 15,000	\$ 15,000	3	
Building Demolition / Disposal	9,300	SF	\$ 12	\$ 111,600	1,4	
			Task Subtotal	\$ 127,000		
Extend Sheetpile Bulkhead						
Extend Sheetpile Bulkhead to the North	60	LF	\$ 1,785	\$ 107,000	5	
			Task Subtotal	\$ 107,000		
Site Wide Excavation and Offsite Treatment/Disposal						
Asphalt Demolition/Recycling	50	CY	\$ 55	\$ 2,750	1,5	
Excavation and Loading of Contaminated Soil (<8ft, E. of roadway)	3,700	CY	\$ 25	\$ 93,240	1,6	
Excavation and Loading of Contaminated Soil (>8ft or in roadway)	6,400	CY	\$ 29	\$ 184,320	1,6	
Additional Shoring Allowance	1	LS	\$ 100,000	\$ 100,000	7	
Dewatering Allowance	1	LS	\$ 150,000	\$ 150,000	1	
Reroute Utilities Site-Wide	1	LS	\$ 200,000	\$ 200,000	8	
Transport and Disposal of Contaminated Soil	10,528	TON	\$ 65	\$ 684,306	9	
Transport and Disposal of Clean Soil	4,622	TON	\$ 45	\$ 208,000	9	
Backfill: Supply and Install Clean Imported Material	15,150	TON	\$ 20	\$ 303,000	3	
Compliance Monitoring (Soil Confirmation Samples)	1	LS	\$ 21,000	\$ 21,000	10	
			Task Subtotal	\$ 1,947,000		
Site Restoration (Asphalt Pavement)						
Site Grading	1,900	SY	\$ 3.50	\$ 6,650	1	
Asphalt Paving	1,900	SY	\$ 37.90	\$ 72,000	1,3	
			Task Subtotal	\$ 79,000		
Subtotal for Direct Capital Costs				\$ 2,290,000		

**TABLE D-6
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 6
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

Capital Indirect Costs -							
Pre-Design Investigation/Evaluation	1	LS		\$	75,000		1
Remedial Design	15	%		\$	343,500		11
MTCA Engineering Design Report	1	LS		\$	80,000		1
Project Management	5	%		\$	114,500		11
Construction Management (Including CQA)	8	%		\$	183,200		11
Construction Completion Report	1	LS		\$	35,000		1
Permitting and Regulatory Compliance	6	%		\$	137,400		1
Ecology Oversight	5	%		\$	114,500		1
Estimate of Taxes	8.5	%		\$	194,650		12
					Subtotal for Capital Indirect Costs	\$ 1,278,000	
Subtotal for Capital Direct and Indirect Costs					\$ 3,568,000		
Contingency for Capital Direct and Indirect Costs				30	%	\$ 1,070,400	13
Total for Direct and Indirect Capital Costs					\$ 4,640,000		
O&M Costs (Present Worth)							
			Discount Rate	3%			14
Quarterly Groundwater Monitoring (MNA)	2	YR		\$ 21,165	\$ 40,000		15
Annual Groundwater Reporting	2	YR		\$ 8,500	\$ 16,000		16
Subtotal for Operation and Maintenance Costs					\$ 56,000		
Contingency on Operation and Maintenance Costs				30	%	\$ 16,800	13
Total for Operation and Maintenance Costs					\$ 72,800		
ALTERNATIVE 6 PRESENT WORTH					\$ 4,710,000		

**TABLE D-6
FEASIBILITY STUDY COST ESTIMATE – ALTERNATIVE 6
BLAINE MARINA INC. SITE
BLAINE, WASHINGTON**

ALTERNATIVE 6 NOTES

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

ABBREVIATIONS

CY = Cubic Yard	LS = Lump Sum	SF = Square Foot	DC = Direct Costs
EA = Each	O&M = Operation and Maintenance	SY = Square Yard	MNA = Monitored Natural Attenuation
LF = Linear Foot	QA = Quality Assurance	YR = Year	GAL = Gallons

COMMENTS

- 1 Cost estimates based on costs from similar projects and professional judgment.
- 2 Includes moving equipment and personnel on and off site, establishing work zones, temporary fencing, and temporary facilities.
- 3 Cost based on estimate from experienced contractor.
- 4 Unit costs based on similar project; includes HazMat abatement, concrete building slabs, dust control, disposal.
- 5 Assumes \$35/CY demolition/loading and \$20/CY transport and recycling.
- 6 Unit costs based on in-place volume using costs for similar project marked up to account for difficulties excavating wet soil. Assuming higher cost per CY for work below 8 ft BGS, and for soil beneath Sigurdson Ave along shoreline.
- 7 Shoring allowance for excavation along the shoreline bulkhead.
- 8 Temporary rerouting of electrical, gas, water, communications, and sanitary sewer and reinstallation.
- 9 Contaminated soil: truck to Everett and treatment by soil desorption and disposal in inert waste landfill; Clean soil: no treatment.
- 10 Collect 30 soil samples from excavation floor and sidewalls; analyze for TPH/BTEX and PAHs.
- 11 Remedial design includes preparation of construction plans and specifications, preparation of engineer's estimate of probable cost, and bidding support. Project management includes bid/contract administration, cost and performance reporting, planning and coordination. Construction management includes submittal review, change order review, design modifications, construction schedule tracking. Estimated cost based on Remedial Design, Project Management and Construction Management based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- 12 Combined sales tax, Blaine, Washington.
- 13 Includes scope and bid contingency.
- 14 Based on an average return on investment of 6% with an assumed inflation rate of 3%.
- 15 Install three GW monitoring wells; sample three wells plus duplicate; analyze groundwater for TPH-G/BTEX, TPH-D, PAHs, and MNA parameters.
- 16 Report of site conditions; comparison of water quality to cleanup standards; evaluate plume stability / MNA.