Feasibility Study

Former USG Taylor Way Plant Site
2301 Taylor Way
Tacoma, Washington
Cleanup Site ID 5003

PUBLIC REVIEW DRAFT

USG Corporation
550 W. Adams St.
Chicago, Illinois 60661-36761

May 5, 2021

CDM Smith

A Report Prepared For:

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Chicago, Illinois 60661-36761

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Table of Contents

CDM Smith

List of Tables

List of Figures

List of Exhibits

Appendices

Acronyms

<	less than
≤	less than or equal to
AGI	AGI Technologies Inc. or Applied Geotechnology Inc.
ARARs	Applicable or Relevant and Appropriate Requirements
ADP	anthropogenic density plume
AST	Above-ground storage tank
bgs	below ground surface
BLM	Bureau of Land Management
CBN/T	Commencement Bay Nearshore/Tideflats
CCA	chromated copper arsenate
CD	Consent Decree
CDM	Camp Dresser & McKee Inc. (Now CDM Smith)
CFR	Code of Federal Regulations
CIPP	cured in place pipe
COC	contaminants of concern
cy	cubic yards
DCA	disproportionate cost analysis
DPT	direct push technology
Ecology	Washington State Department of Ecology
EMP	Electron microprobe
EPA	Environmental Protection Agency
FRTR	Federal Remediation Technologies Roundtable
FS	feasibility study
ft	feet
ft/d	feet per day
ft/ft	feet per foot
GRA	general response actions
HDPE	high density polyethylene
hr	hours
IA	interim action
IC	institutional control
ISCO	in situ chemical oxidation
KJC	Kennedy Jenks Consultants
mg/kg	milligrams per kilogram
µg/L	micrograms per liter
mg/L	milligrams per liter
POC	point of compliance
POTW	publicly owned treatment works
ppm	parts per million
NBA	north boundary area (Arkema Property)
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
MLLW	mean lower low water

MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
OCC	Occidental Chemical Corporation
O&M	operation and maintenance
OMMP	Operations Maintenance and Monitoring Plan
PCS	petroleum contaminated soil
Port	Port of Tacoma
ppm	parts per million
RBSR	Relative benefit score ratio
RAG	Remedial action goal
RAO	Remedial action objective
RI	remedial investigation
ROD	Record of Decision
SOD	soil oxidant demand
S/S	solidification/stabilization
su	standard units
TBC	To be considered
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons quantified as diesel
TPH-O	total petroleum hydrocarbons quantified as oil
USEPA	United States Environmental Protection Agency
USG	United States Gypsum Corporation
USGI	USG Interiors, LLC.
WAC	Washington Administrative Code
XRF	X-Ray fluorescence
ZVI	zero valent iron

Executive Summary

This report presents the results of a Feasibility Study (FS) for the former USG Taylor Way Plant site (Cleanup Site ID 5003) generally located at 2301 Taylor Way, Tacoma, Washington (the Site). This FS was performed to satisfy one of the requirements of Agreed Order DE3405 (current Order) between the Washington State Department of the Ecology (Ecology) and USG Interiors, LLC (USGI) and the Port of Tacoma (the Port).

Project Description

The Site includes a property herein referred to as the Taylor Way Property and, to the extent that contaminants originating from the Taylor Way Property are causing an impact, the adjacent former Murray Pacific Property to the north and an area to the south on 2901 Taylor Way. The Taylor Way Property is a roughly L-shaped 9.4-acre parcel. The property is currently owned by the Port of Tacoma and leased and occupied by Carlile Transportation (Carlile). The Taylor Way Property is developed with a large dock high concrete tilt-up warehouse and an open-sided I-beam supported metal-roofed structure. The rest of the Taylor Way Property is asphalt-paved with a few landscaped islands. The former Murray Pacific Property is surfaced with gravel and is used by Carlile for trailer parking. At 2901 Taylor Way to the south is a grassy undeveloped area that is part of the property where the former Arkema manufacturing facility was located.

USGI formerly owned the Taylor Way Property which was previously developed as a mineral fiber manufacturing facility where mineral fiber insulation products were produced between 1946 and 2002. Slag obtained from ASARCO's copper smelter in Ruston, Washington was used as raw material from at least 1959 to 1973. ASARCO slag was later found to typically contain high concentrations of metals, including arsenic, copper, lead, cadmium, zinc, antimony, and silver. However, arsenic and lead are typically the metals that drive cleanups at sites contaminated by ASARCO slag, with arsenic being the primary driver due to its relatively greater toxicity and mobility. These metals were also present in some of the waste products produced at the Taylor Way facility (baghouse dust, a sand-sized cylindrical material called "shot," cupola bottom material, and off-spec product) and therefore became a source of contamination on the Taylor Way Property.

The Site is located in the Commencement Bay industrial area in the Puyallup Valley near the mouth of the Puyallup River. Historically, the Puyallup River discharged to Commencement Bay through tidal marshes laced by a network of channels. In the early part of the 1900s, waterways were constructed along the Puyallup River and major streams by dredging and hydraulically filling the intervening marsh and tideflat sediments. The Site abuts the Hylebos Waterway on the northeast. A zone of perched water, referred to as the "surface aquifer" occurs in the fill on top of the tideflat sediments. The second aquifer, which is tidally influenced, occurs in the deltaic sediments below the tideflat sediments.

The Taylor Way Property has been the subject of numerous environmental assessments, beginning in the early 1990s. Various interim actions (IAs) were subsequently completed as conditions were identified that required such actions. As the phased environmental assessments identified the locations of arsenic-contaminated soils and residual source materials (and also two areas with petroleum hydrocarbon contamination), a series of interim actions involving soil removal were subsequently conducted. Over 32,000 tons of contaminated soils and source material were removed from the Taylor Way Property during these IAs. In September 2016, an Agency-Review Final Draft Supplemental Remedial Investigation (RI) was completed for the Site. Additional field investigations were subsequently conducted to fill data gaps identified during the RI and to support the FS.

The results of the RI determined that multiple IAs completed for the Site resulted in significant mass removal of source material and contaminated soil, as well as substantial natural attenuation of contaminants. The preponderance of soil data, combined with the groundwater data, indicate the most highly leachable source material (baghouse dust) has been substantially removed throughout the Taylor Way Property. However, arsenic concentrations in soils throughout the Taylor Way Property still commonly exceed the Model Toxics Control Act (MTCA) Method A soil cleanup level of 20 milligrams per kilogram (mg/kg). Arsenic concentrations close to or exceeding 1,000 mg/kg occur in three areas on the Taylor Way Property and are associated with the presence of residual source material. Elevated lead concentrations (i.e., exceeding industrial land use MTCA Method A standards) are only associated with the presence of ASARCO-related source material.

Before the initiation of the IAs in the early 1990s, arsenic concentrations in groundwater were as high as 19,000 micrograms per liter (µg/L). Between 2006-2014 arsenic concentrations throughout the Site ranged between 1.6 µg/L and 1,040 µg/L. The groundwater standard currently considered protective of surface water is 5 µg/L. The distribution of arsenic in groundwater is very complex. Arsenic concentrations in groundwater are not strictly correlative with arsenic concentrations in soils. Other factors such as the leachability of the residual source material, the subsurface-specific chemistry, presence of organics (i.e., wood, petroleum hydrocarbon metabolites) and seasonal gradients factor into the arsenic concentrations at any given location. The RI determined that iron and arsenic concentrations are attenuated by ferric and ferrous phosphates, ferrous carbonates, and ferric oxyhydroxides.

Total petroleum hydrocarbon concentrations exceed the MTCA Method A cleanup level at the USGI/Murray Pacific property line adjacent to the Hylebos Waterway, just downgradient of the historical Bunker C above-ground storage tank remedial excavation area. However, the plume is highly weathered, concentrations are relatively low, and the cleanup level exceedance is limited to a very narrow area. This weathered hydrocarbon plume appears to be enhancing the solubility of residual arsenic within this area.

Except for one well at the south end of the property, metals concentrations in the second aquifer have similarly declined over time subsequent to the completion of IAs and current concentrations are below or only slightly above surface water and human health-based standards.

The storm drain system on the Taylor Way Property has a low rate of flow during dry weather; a camera survey found that the source of dry weather flow is related to unsealed areas in the system. Additionally, there is potential for contaminated groundwater to infiltrate the City of Tacoma storm drain system in the vicinity of the south corner of the Taylor Way Property. The Department of Ecology previously sampled dry weather flow at three locations along this storm drain line. Samples from all three locations, including one manhole approximately 1,000 feet upgradient from the Taylor Way Property, contained elevated arsenic concentrations, indicating that there are other sources of arsenic to the Taylor Way storm drain system.

As is explained in Section 1.2 of this document, a separate Focused Feasibility Study report will be prepared to evaluate cleanup alternatives for a portion of 2901 Taylor way, known as the North Boundary Area. This document does not address that area.

FS Remedial Alternatives

Five remedial alternatives were developed to address soil, groundwater and the storm drain system(s). Four remedial alternatives (Alternatives1 through 4) were developed to address the three areas determined to require remedial actions due to: 1) arsenic concentrations in soil exceeding the risk-based acute remediation level developed for the Site, and/or 2) the proximity of the area to the point of compliance (POC), which is surface water receptors – the Hylebos Waterway adjacent to the Site and the storm drain system in Taylor Way. The three focus areas are referred to as the South Corner Area, Railroad Spur Area, and Hylebos Waterway Area. The fifth remedial alternative is a full soil removal alternative that is consistent with the MTCA definition of a permanent cleanup action for an industrial property.

The following elements are common to all the remedial alternatives:

- Institutional Controls (ICs)
- Groundwater Quality Monitoring
- Post-Construction Cap Maintenance
- Onsite Storm Drain Repair

Alternative 1

Alternative 1 generally consists of the following elements:

- South Corner Area: Soil excavation will occur in the South Corner Area with a twofold intent: 1) remove soils exceeding the acute criteria, and 2) to minimize the leachability of arsenic in soil with the intent of reducing arsenic concentrations in the surface aquifer. Reduction of arsenic concentrations in the surface aquifer may also result in the reduction of arsenic concentrations in the second aquifer and from impacting the storm drain line. The proposed excavation will extend for approximately 230 feet and approximately 10 feet on either side of the gas utility line. The depth of the excavation will range from approximately 4 to 6 feet and likely average about 5 feet deep. This area is targeted as it appears that relatively high arsenic concentrations are located along the utility line and may be acting as an ongoing source of groundwater contamination. Natural attenuation of arsenic in groundwater would be promoted both in the surface and second aquifers because saturated soils containing higher arsenic concentrations would be removed.

- Railroad Spur Area: Soil excavation will occur in three areas to remove soils found to exceed the acute-based soil remediation level for arsenic. One of the excavations will also be extended to remove soil exceeding Method A industrial soil cleanup level for lead. Groundwater impact in this area is relatively minimal and natural attenuation has served to diminish arsenic concentrations to less than the 5 µg/L before reaching the Hylebos Waterway, so no further actions will occur in this area.

- Hylebos Waterway Area: Excavation will occur in two areas to remove soils exceeding the acute-based soil remediation level. Elevated arsenic and hydrocarbon concentrations in groundwater in the Hylebos Waterway area would be addressed through in situ treatment using air sparging and/or an in situ chemical oxidation (ISCO) recirculation system. In situ treatment consists of actions that treat contaminants in place by facilitating chemical stabilization and immobilization. The in situ treatment may further promote degradation of the residual dissolved petroleum hydrocarbons.

Alternative 2

Alternative 2 generally consists of the following elements:

- South Corner Area: Limited soil excavation would occur at the singular borehole where a soil sample collected at 3.5 feet below ground surface (ft bgs) exceeded the acute-based arsenic soil remediation level of 1,060 mg/kg. In addition, soil with elevated arsenic concentrations along the utility corridor adjacent to the southeast property boundary and soil parallel to Taylor Way will be treated through solidification/stabilization (S/S). Natural attenuation of arsenic in groundwater would be promoted both in the surface and second aquifer because groundwater would no longer interact with soils containing higher arsenic concentrations due to the lower permeability.

- Railroad Spur Area: Alternative 2 uses the same soil excavation scenario as was described for Alternative 1.

- Hylebos Waterway Area: Alternative 2 uses the same soil excavation scenario as was described for Alternative 1. Instead of ISCO, elevated arsenic concentrations in groundwater in the Hylebos Waterway Area would be addressed through in situ treatment using a permeable reactive barrier (PRB) in a funnel and gate arrangement. A PRB entails subsurface placement of reactive materials across the natural flow path of a dissolved contaminant plume. Contaminated groundwater flows through the reactive wall and exits the other side as treated groundwater. The PRB can be combined with vertical barriers (e.g., slurry walls) in a funnel and gate arrangement in which the slurry walls, constructed on either side of the wall of reactive materials directs groundwater flow through the treatment zone. The treatment zone material is envisioned to contain zero valent iron (ZVI). The PRB would not directly address petroleum hydrocarbon concentrations in groundwater. However, the excavations that will occur in this area will also be removing soils with residual wood fibers. This may promote further reduction in hydrocarbon concentrations as a result of wood-based organics. Beyond this, monitored natural attenuation (MNA) is recommended.

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Alternative 3

Alternative 3 generally consists of the following elements:

- South Corner Area: Limited soil excavation would occur at the singular borehole where a soil sample collected at 3.5 ft bgs exceeded the acute-based arsenic soil remediation level of 1,060 mg/kg. For groundwater in the South Corner Area, a slip line will be installed in the storm drain line in Taylor Way.

- Railroad Spur Area: Alternative 3 would use the same soil excavation scenario as was described for Alternative 1.

- Hylebos Waterway Area: Alternative 3 would use the same soil excavation scenario as was described for Alternative 1. Similar to Alternative 2, elevated arsenic concentrations in groundwater in the Hylebos Waterway Area would be addressed through in situ treatment using a PRB in a funnel and gate arrangement. The only difference is that in the targeted soil excavation area that lies between the Hylebos Waterway and the PRB, ZVI would be placed in the bottom of the excavation to more quickly attenuate residual arsenic prior to backfilling.

Alternative 4

Alternative 4 generally consists of the following elements:

- South Corner Area: Alternative 4 would use the same soil excavation scenario as was described for Alternative 1. Slip lining may be implemented in the storm drain line in Taylor Way at a later date as a contingency.

- Railroad Spur Area: Alternative 4 would use the same soil excavation scenario as was described for Alternative 1.

- Hylebos Waterway Area: Alternative 4 would use the same soil excavation scenario as was described for Alternative 3.

Alternative 5

Alternative 5 was developed to be the “full removal” alternative, consistent with the MTCA definition of a permanent cleanup action for an industrial property. Soils with arsenic concentrations greater than 88 mg/kg would be removed, except for those below the existing buildings or in other inaccessible areas. During soil excavation, a certain amount of dewatering will need to occur in areas where excavation deeper into the water table is required. This will remove some groundwater that is presently impacted by arsenic. Further reduction of arsenic and petroleum hydrocarbons in groundwater will occur through MNA following the remedial action. However, in the short -term and to ensure that residual arsenic in soil with the potential to impact groundwater in the Site interior does not infiltrate the storm drain systems, the storm drain line in Taylor Way would be slip lined and the storm drain line on the Taylor Way Property would be either replaced or slip lined.

Preferred Remedial Alternative

Based on the evaluation presented in this FS, the preferred remedy is Alternative 4 which includes the following:

- Selective excavation of soils
- Funnel and Gate PRB for groundwater
- Supplemental iron addition in an excavation adjacent to the Hylebos Waterway
- Off-site storm drain line repair

This alternative also includes the common elements as follows:

- Institutional controls – e.g., use restrictions, soil management, site-specific health and safety plans if subsurface work is to be conducted.
- Groundwater monitoring
- Onsite cap (soil cover) maintenance
- Onsite storm drain repair

A disproportionate cost analysis was completed for the four alternatives. The calculated relative benefit score ratio (RBSR) ranged from 325 (Alternative 5) to 1,125 (Alternative 4). The RBSR for Alternative 4 was clearly greater than the other four alternatives. Alternative 4 would reliably contain Site impacts to the Hylebos Waterway in the shortest timeframe, while significantly reducing mass for the most reasonable cost. The contingency for slip lining of the storm drain line in Taylor Way allows for an added level of protection, should soil excavation in the South Corner area not result in the necessary reduction in arsenic concentrations in a timely manner. Alternative 4 is the most cost-effective combination of treatment, containment, and mass removal. Alternative 4 would protect human health and the environment in the short-term and long-term.

Section 1

Introduction

1.1 Purpose

This document presents the feasibility study (FS) completed for the site generally located at 2301 Taylor Way in Tacoma, Washington (the Site). This FS was performed to develop, evaluate, and provide recommendations for appropriate alternatives to remediate contamination in soil and groundwater in accordance with the Model Toxics Control Act (MTCA). The FS was completed to satisfy one of the requirements of Agreed Order DE3405 (current Order) between the Washington State Department of the Ecology (Ecology) and USG Interiors, LLC (USGI) and the Port of Tacoma (the Port). United Stated Gypsum Corporation (USG), on behalf of its subsidiary USGI, retained CDM Smith Inc. (CDM Smith) to conduct this FS.[1]

1.2 Site Description and Setting

The Site lies within the Commencement Bay Nearshore /Tideflats (CBN/T) Superfund Site of Tacoma, Washington, within the Head of Hylebos Waterway 'problem area' identified in the Record of Decision (ROD). **Figure 1** shows the Site location.

The 2301Taylor Way Property (Taylor Way Property) is a roughly L-shaped 9.4-acre parcel (parcel number 0321351006), located at Taylor Way. Taylor Way borders the southwest side and the Hylebos Waterway borders the northeast side of the property. The property is currently owned by the Port of Tacoma and leased and occupied by Carlile Transportation (Carlile). **Figure 2** and **Figure 3** show the current facility layout. Current structures on the property include a large dock high concrete tilt-up warehouse and an open-sided I-beam supported metal-roofed structure with a concrete slab floor where maintenance activities, such as welding, occur. The rest of the Taylor Way Property is asphalt-paved with a few landscaped islands. USGI formerly owned the Taylor Way Property and the property was previously developed with USGI's mineral fiber manufacturing facility. It is listed on Ecology's cleanup site database as the USG Taylor Way Plant site, with the Cleanup Site ID 5003.

1.2.1 Murray Pacific Property

North of the Taylor Way Property is an approximately 18-acre gravel-surfaced yard that is currently leased and used by Carlile for parking long haul trailers (**Figure 2** and **Figure 3**). This property was formerly occupied by the Murray Pacific Log Sort Yard #1 and is referred to in this FS as the Murray Pacific Property. The Site includes portions of the Murray Pacific Property, where groundwater and/or soil contamination are present near the Hylebos Waterway shoreline. The Murray Pacific Property is associated with the historical addresses of 2245 Taylor Way,

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[1] It should be noted that several predecessor companies of CDM Smith previously conducted remedial investigation and interim action activities at the Site. These include: Applied Geotechnology Inc. (AGI), AGI Technologies (AGI), and Camp Dresser & McKee Inc. (CDM). These predecessor companies are also referred to as CDM Smith throughout this FS, but the referenced documents are reported by the company's name in effect at the time.

3510 Lincoln Avenue, and 3502 Lincoln Avenue. The Murray Pacific property is listed on Ecology's cleanup site database as Murray Pacific #1, with the Cleanup Site ID 2318. Historical cleanup actions were conducted on that property, which removed ASARCO[2] slag containing arsenic and other metals that had been used instead of gravel throughout the property. Ecology issued a No Further Action determination for the Murray Pacific #1 site on August 15, 1997.

1.2.2 North Boundary Area

Bordering the southeast side of the Taylor Way Property is an approximately 45-acre property formerly occupied by a chemical manufacturing plant (chlor-alkali and arsenic pesticide/herbicide) with the address of 2901 Taylor Way (Arkema Property). The facility structures have been demolished from this property and it is currently vacant. The grassy area immediately adjacent to the Taylor Way Property is referred to in later sections of this report as the "North Boundary Area" in reference to the north boundary of the Arkema property (**Figure 2**). The North Boundary Area (NBA) is bound on the southeast by the former Salt Pad Storage area and to the northeast by the Hylebos Waterway. The Arkema Property is listed in Ecology's cleanup site database as Arkema Inc., with the Cleanup Site ID 3405. Arsenic contamination has been identified on the Arkema Property as a result of the historical manufacture of the arsenic pesticide called "Penite."

Arsenic and lead are present in soils and groundwater at the NBA. The source of this contamination has been a subject of disagreement between USGI and the Port of Tacoma. In response to a request from Ecology, USGI and the Port stated their agreement in a letter to Ecology dated June 14, 2013, that the property line between the Taylor Way Property and the former Arkema property would serve as the "functional boundary" between the two sites. With the functional boundary, contamination on the Taylor Way Property would be investigated and cleaned up separately from that which exists on the Arkema Property.

In 2020, Ecology determined that it would be beneficial to the USG and Arkema site cleanups to implement a new framework for the NBA. In a letter dated January 13, 2021, Ecology directed USGI and the Port that contamination in the NBA that is contiguous with current or previously existing areas of contamination on the former USGI property would be cleaned up under the current Order. Ecology further directed the Port to produce (1) a separate focused feasibility study (Focused FS) for the specified areas of the NBA, (2) an alternatives memo; and (3) prepare an NBA cleanup action chapter that will be incorporated into the Draft Cleanup Action Plan required under the current Order. In addition, if Ecology determines that additional data are necessary to complete the Focused FS, the Port must submit and implement a pre-FS investigation work plan and submit a data memo summarizing the same to Ecology.

1.3 Taylor Way Property History

1.3.1 Mineral Fiber Manufacturing

The Taylor Way Property was originally developed in the early 1940s to supply insulation material for the war effort. It was operated by Pacific Carbide Corp. from 1943 until

[2] ASARCO was organized in 1899 as **A**merican **S**melting **and R**efining **Co**mpany.

1946 (TLI Systems 1996). Mineral fiber insulation products were produced on the Taylor Way Property between 1946 and 2002. Between 1946 and 1959, Mineral Fiber Producing Company and Feltrock Insulation Manufacturing Company owned the Taylor Way Property (Kennedy Jenks Consultants [KJC 2002]). In 1959 United States Gypsum Company purchased the Taylor Way Property and continued the same manufacturing operations. Ownership was transferred in 1985 to USG Acoustical Products Company, created out of the former Acoustical Products Division of United States Gypsum Company. In 1987, USG Acoustical Products Company was renamed USG Interiors, Inc. and is now known as USG Interiors, LLC (USGI). In 1996 USGI sold the Taylor Way Property to Thermafiber who also manufactured mineral fiber insulation. Thermafiber sold the property to the Port of Tacoma in December 2002.

Figure 4 shows the historical plant layout. Prior plant structures included a laboratory, office, and manufacturing buildings (warehouse, production, storage); a block bin; 17,000-gallon Bunker C above-ground storage tank (AST), and vehicle garages. Two railroad spurs entered the Taylor Way Property from the west and aligned with the northeast and southwest sides of the manufacturing buildings. The northeast railroad spur, constructed on a berm and a trestle, was used to bring in raw materials.

Mineral fiber insulation was manufactured by mixing and heating raw materials (such as steel slag and basalt rock) to a molten state and extruding these materials under pressure to produce a mineral fiber (TLI Systems 1996). Slag obtained from ASARCO's copper smelter in Ruston, Washington was used by USG as a raw material from the time they began operating the plant in 1959 until June of 1973 (TLI Systems 1996). Prior mineral fiber insulation companies operating at the Site may have also used ASARCO slag as raw material. ASARCO slag was later found to typically contain high concentrations of metals, including arsenic, copper, lead, cadmium, zinc, antimony, and silver. However, arsenic and lead are typically the metals that drive cleanups at sites contaminated by ASARCO slag, with arsenic being the primary driver due to its relative toxicity and mobility.

These metals were also present in some of the waste products produced at the Taylor Way facility (i.e., baghouse dust, "shot," cupola bottom material, and off-spec product) and therefore became a source of contamination on the Taylor Way Property. These waste products are described below (KJC 2002, TLI Systems, Inc. 1996):

- Shot consisted of very small, rounded, glassy particles that were the broken ends of the mineral fibers extruded during the production process. Reportedly, the plant generated approximately 6,000 tons of shot per year. The shot could not be reintroduced into the furnace and was disposed of as waste. The shot consisted of about 0.4 percent arsenic by weight (TLI Systems, Inc. 1996). Electron microprobe (EMP) analyses on shot particles along the south border of the Site and within the NBA resulted in arsenic concentrations ranging from 0.029 to 0.77 weight percent with a median of 0.26% (based on 10 shot particles) (CDM Smith, 2013).

- Baghouse dust was generated after the baghouse was installed in 1970 to control air particulate emissions. Baghouse dust consisted of small particles generated from the manufacturing process and had the consistency of dry, loose silt. During the time ASARCO slag was used as a raw material, arsenic and other metals were concentrated in the dust, which reportedly contained about 23% arsenic and about 8.5% lead, by weight. The baghouse was reported to produce up to 30,000 pounds of dust, per week (TLI Systems Inc. 1996).

- Cupola bottoms consisted of heavier materials, mainly iron, that accumulated during the melting process. These materials were knocked out of the bottoms of the cupolas when cooled. During the time ASARCO slag was used as a raw material, cupola bottoms were sold back to ASARCO to be reintroduced into the smelting process for metals reclamation.

- Off-spec product is, as the name implies, product that did not meet the required specifications and was typically reintroduced into the production process.

Raw material and waste management practices at the Site are not well documented. Several historical operations or practices that resulted in source areas of contamination at the Site were ascertained during phases of initial site assessments and interim actions (IAs). Some of these material management practices and source areas included the following:

- Temporary stockpiles of raw material (ASARCO slag, steel slag and blast furnace slag, metallurgical coke, basalt rock) and waste material (mixture of shot, slag fines, baghouse dust, off-spec product, cupola bottoms) were located on mostly unpaved surfaces at the back (northeastern) side of the property and southeastern side of the production building.

- Shot and other waste products, some of which were derived from the ASARCO slag, had been used as fill throughout the material stockpile area and southeastern truck passageway to raise the grade.

- The baghouse area where baghouse dust settled and accumulated.

- A soil/waste material berm that divided the Taylor Way and the Murray Pacific Properties. The berm was constructed to protect employees from the risk posed by unstable log piles. It was found to contain slag and waste products derived from the use of ASARCO slag in material production.

- The Hylebos Waterway embankment, which apparently had been extended with fill; some of the fill used included USGI plant waste, such as shot.

- The railroad berm, which contained slag and industrial waste products.

In approximately 1973 USGI removed visible source material[3] (i.e., primarily shot) that existed as a surface layer across the material stockpile area (**Figure 4**) and transported this material to an offsite landfill.

Between 1996 and 1999, USGI undertook a series of source control actions to reduce metals concentrations (primarily arsenic) and petroleum hydrocarbons (associated with the removed 17,000-gallon Bunker C AST) in the Taylor Way Property soil and groundwater. These included removal of residual source materials and contaminated soils, replacement of the leaky storm drain system, and installation of pavement across the temporary material stockpile area between the plant facilities and the Hylebos Waterway. In 2005, USGI also undertook an additional independent IA to remove arsenic-contaminated soils from an area near the new Carlile warehouse building that was being constructed on the property. These actions are summarized in Section 3.2.

1.3.2 Redevelopment into the Carlile Facility

The Thermafiber facility was closed in August 2002 and the Port of Tacoma purchased the property for redevelopment in December 2002. Demolition of the plant apparently occurred in early 2003. During late 2004/early 2005 the area of the proposed new facility had a soil preload.[4] Construction of the Carlile facility occurred in 2005. During construction, two underground storage tanks (USTs) were discovered adjacent to the southern corner of the new warehouse building. One 4,000- gallon and one 5,000-gallon tank were removed, each of which had apparently been used to store diesel fuel. The USTs were below asphalt and concrete layers, indicating they were installed before the property was occupied by USGI. Additional IAs were conducted in association with the redevelopment, including removal of arsenic-impacted soils under the area where the new Carlile warehouse was to be constructed and disposal of soil excavated to allow for the UST removal, as summarized in Section 3.2.The property did not require significant grade changes as a result of the redevelopment. The configuration of buildings and pavement, which completely cover the property except for the few small planter areas has been the same since 2006. The existing gravel surfacing on the adjacent Murray Pacific Property remained essentially unchanged. The Carlile facility was opened for business in 2006.

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[3] Source material is used herein to mean ASARCO slag and ASARCO slag-derived manufacturing waste product with the potential to adversely impact soil, stormwater, groundwater or sediment. Source materials were identified based on visual observation and/or laboratory analyses.

[4] The application of a surcharge load (i.e., a temporary soil stockpile) prior to construction of the permanent structure until most of the primary settlement has occurred.

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Section 2

Physical Site Setting

2.1 Regional Geology

The Site is located in the Commencement Bay industrial area in the Puyallup Valley near the mouth of the Puyallup River. Historically, the Puyallup River discharged to Commencement Bay through tidal marshes laced by a network of channels. In the early part of the 1900s, waterways were constructed along the Puyallup River and major streams by dredging and hydraulically filling the intervening marsh and tideflat sediments. Imported fill and waste material were also used as fill material.

2.2 Site Geology

Approximately 1 to 4 feet of surficial fills (gravelly sand, gravelly silty sand, gravel, gravelly sandy clay) underlie the Taylor Way Property, but is thicker in some areas, such as where significant remedial actions (i.e., soil excavation) have occurred.

The surficial fill is typically underlain by hydraulically placed fill (i.e. dredged material from the waterway). The hydraulic fill is up to 12 feet thick at the northeast side (Hylebos Waterway) of the Taylor Way Property and becomes very thin to nonexistent along the southwest side. The hydraulic fill grades from fine/medium-grained sand at the east end closest to the Hylebos Waterway, to sandy silt and clayey silt along the southwest side. The hydraulic fill thickness ranges between 8 and 12 feet. Finer grained fill soils, suggesting placement by means other than hydraulically, is prevalent on the southwestern side of the Site.

The fill is underlain by approximately 1 to 8 feet of clayey silt tidal marsh sediments that represent an aquitard. The upper 1 to 5 feet of the clayey silt aquitard contains abundant undecomposed marsh grasses and other organics that are less abundant with depth. The underlying deltaic sediments consist of a complex sequence of interbedded sand, silt, and clayey silt. The Deltaic sediments are coarser near the Hylebos Waterway and become finer grained toward Taylor Way.

Subsurface conditions on the Murray Pacific Property and the NBA are generally similar. Remedial actions on the Murray Pacific Property have generally resulted in placement of about 2 to 4 feet of recent fill across the entire property, with some thicker layers of fill mostly along the waterway. The tideflat layer was encountered at depths of 7.5 to 10.5 feet below ground surface (ft bgs). In the NBA, the tideflat layer appears to be generally shallower, ranging from about 2 to 7 ft bgs. Based on the historical aerial photographs reviewed, the NBA area was also used as a fill site for many decades. Fill containing bark, wood chips, asphalt, concrete, and/or brick debris was commonly observed in borings drilled in the NBA, ranging up to six feet thick. EMP analyses showed the presence of raw slag[5] containing 0.32 to 2.0 weight percent arsenic with a median of

[5] Raw slag is a non-uniform, angular material as opposed to the spherical shot, which has a uniform composition and appearance. Slag also tends to have other minerals enclosed within in it which can be seen by the EMP.

0.73% (based on analysis of 8 slag grains). Arsenic trioxide, containing approximately 60 weight percent arsenic, was also found in the NBA. Shot was identified in the NBA, but was rare, occurring in only 7 of the approximately 1,000 arsenic-bearing grains identified within the 7 NBA samples analyzed (CDM Smith, 2013).

2.3 Site Hydrogeology

Groundwater occurs under water table conditions in the fill. The fill contains the uppermost water-bearing zone, which is referred to herein as the "surface aquifer." Marsh sediments are referred to as the first aquitard. The deltaic sediments contain the next water-bearing zone (referred to as the "second aquifer"), which occurs under confined conditions and is tidally influenced.

Ultimately, all groundwater discharges to the Hylebos Waterway. To greater or lesser extents Site hydrogeology is influenced by tides of the Hylebos Waterway, surface water features, paved and unpaved surfaces, underground utilities, fill type, geologic sediments, and perhaps other undetermined conditions.

CDM Smith completed tidal influence monitoring, slug testing, and several synoptic rounds of water level measurements, the results of which are presented and summarized in the Draft Supplemental Remedial Investigation (RI) (CDM Smith 2016) and a May 15, 2017 memo (**Appendix A**). The results of these studies are summarized below.

2.3.1 Surface Aquifer

2.3.1.1 Depth to Groundwater and Water Level Fluctuation

Depth to groundwater across the Taylor Way Property is the shallowest at the south end (MW1) and is also where the greatest seasonal fluctuation occurs, ranging from approximately 1.8 feet bgs to 5 feet bgs. It is deepest at the northeast corner (MW5) next to the Hylebos Waterway and much less fluctuation is observed at this location, where water levels range from approximately 9.9 to 10.5 feet bgs.

The surface aquifer is only slightly affected by tidal fluctuation (0.1 to 0.18 ft) and this effect is only observed at wells situated next to the Hylebos Waterway., where the tideflat daylights along the embankment and surface aquifer seeps occur at approximately 0 feet MLLW.

Water level fluctuation in the surface aquifer is primarily seasonally-based. Seasonal water level variation in the surface aquifer generally varies by less than 1 foot. The exception to this is the area along the southern half of the southeast property line where it appears that groundwater recharge is occurring from the unpaved areas of the NBA.

2.3.1.2 Groundwater Flow Direction

Water levels on the Site have been monitored over the years since the early 1990s. Sometimes water level monitoring occurred only on the Taylor Way Property, at other times comprehensive water level measurements occurred on the Murray Pacific, Arkema and Taylor Way Properties concurrently. The monitoring well network has also changed over the years as new wells have been added and a few wells abandoned. To some degree this has influenced the interpretation of the groundwater contours and flow direction.

With few exceptions groundwater is indicated to be entering the Taylor Way Property from the south-southeast and migrating under the property in a north to northwesterly direction. **Figure 5** is the potentiometric surface map for March 17, 2017. A distinct groundwater mound is indicated to occur in the NBA, about 225 feet northeast of the Taylor Way Property's south corner. From this mound, groundwater is flowing north-northwest into the Taylor Way Property and northeast across the NBA. Groundwater flows in a northerly direction through the Taylor Way Property. On the Murray Pacific Property, groundwater flows in an easterly direction. The groundwater flow on the Murray Pacific and Taylor Way Properties converges at about the property line, which appears to be the discharge to the Hylebos Waterway. This "convergence" is more evident during some monitoring events. This may be caused by an artifact of the predevelopment tideflat configuration, the existing storm drain line, or both.

2.3.1.3 Hydraulic Properties

The gradient between MW9 (located mid-way on the southeastern property line) and the Hylebos Waterway has been found to range from about 0.0007 and 0.009 feet per foot (ft/ft) and averages about 0.0034 ft/ft.

Slug testing in a group of wells located near the Hylebos Waterway found a group of three wells (Group 1) with relatively high hydraulic conductivity (MW6, MW37, and MW38, see **Figure 5**). The Group 1 wells are generally southeast of a group of two wells (Group 2) with lower hydraulic conductivity (MW29 and MW31). The average hydraulic conductivity for these wells was 4.6 feet per day (ft/d) and 0.51 ft/d, respectively. The calculated groundwater velocity for the Group 1 wells was 0.063 ft/d and for the Group 2 wells 0.0069 ft/d.

2.3.2 Second Aquifer

2.3.2.1 Water Level Fluctuation

The tidal effect in the second aquifer is far greater than the surface aquifer. The amount of fluctuation in the second aquifer wells depends on both the amount of tidal fluctuation and the distance from the waterway. To date, the greatest observed difference between water levels due to tidal effect is 9.26 feet. This occurred at MW28, located next to the Hylebos Waterway, in August 2008, at which time there was a 13.2-foot difference between the high and low tide water levels in the Hylebos Waterway. On the same date in August 2008, well 1C2-2, located in the NBA and farthest from the Hylebos Waterway, had an observed fluctuation of only 1.55 ft.

The lag time between the fluctuating tide and the water level observed in the well depends upon the distance from the Hylebos Waterway. For example, in MW18 (approximately 150 ft from the Hylebos Waterway) a 7.7-ft response was observed with a lag time of only 1 hour, while at MW14 (approximately 300 away) a 1.7-ft response was observed with a 3-hour lag time.

2.3.2.2 Groundwater Flow Direction

Figure 6 and **Figure 7** show the high and low tide potentiometric surfaces of the second aquifer in August 2008. The gradient during low tide is generally northeasterly toward the Hylebos Waterway. At high tide there is a gradient reversal that extends approximately 175 to 300 feet inland before it equalizes with the groundwater flow from the other direction. This creates a valley, or bowl-like, effect centrally across the Site.

2.4 Seeps

Prior to completion of interim actions along the Hylebos Waterway embankment in 1997 and 1998 there were visible seeps. The embankment was observed for the presence of seeps during the groundwater and stormwater sampling events conducted between April 1998 and February 2007. Seeps were observed and sampled in April 1998 and April 1999. No seeps were observed between 2000 and 2007. The embankment was inspected for seeps at low tide on May 6, 2019. The tide inspection occurred at 1300 hr. The low tide was -1.64 mean lower low water (MLLW) at 1244 hr. At this time, a line of seeps was observed along the embankment, at approximately 0 MLLW. The seeps begin just southeast of the stormwater outfall and extend along the embankment for about 60 feet.

Seeps are not currently evident northwest of the stormwater outfall and along the Murray Pacific Property embankment. Following the 1996 remedial excavation and subsequent 2005 Hylebos waterway cleanup, the embankment was regraded, a layer of geotextile and sand placed over it, and then surfaced with quarry spalls (Conestoga-Rovers & Associates 2015).

2.5 Stormwater

2.5.1 Taylor Way Property

The Taylor Way Property has always had a stormwater conveyance system. The areas captured by the original stormwater system were limited to paved portions of the Site. However, direct discharge to the Hylebos Waterway via overland flow was never substantial due, collectively, to the stormwater system, the porous nature of soils in previously unpaved areas which allowed for direct infiltration, and the topography at the facility. In 1998, the majority of the original stormwater system was replaced and expanded under an Agreed Order with Ecology. The system was constructed with the goal of preventing dry weather flow from entering the system. The lines were pressure tested to ensure they were sealed and controlled density fill was used to fill the trench near the outfall instead of granular fill to prevent a preferential pathway to the Hylebos.

When the Taylor Way Property was redeveloped with the Carlile facility, an oil/water separator was installed off the north corner of the Carlile warehouse. The section of storm drain line between the oil/water separator and the outfall was not replaced. Upstream of the oil/water separator, existing manholes were reused, some of which were retrofitted to serve a dual purpose as catch basins, but it is believed that the remainder of the catch basins and the storm drain lines were replaced. **Figure 8** shows the pre- and post-Carlile development storm drain configurations.

While a 2007 dry weather inspection did not identify dry weather flow, dry weather flow was observed and sampled in May 2015. During a dry weather inspection on May 6, 2019, when rain had not occurred for over a week, a consistent flow of about 0.5 to 1 gallon per minute was observed at the outfall. The total arsenic concentration in the outfall water was 23 micrograms per liter (µg/L). In September 2015 CDM Smith conducted a camera inspection of portions of the storm drain system. The results of this survey indicated the source of dry weather flow is related to unsealed areas in the storm drain system (i.e., groundwater inflow).

2.5.2 Offsite

2.5.2.1 Taylor Way

A 30-inch storm drain line and a 21-inch sanitary sewer line extend along Taylor Way parallel to the southwestern property line (**Figure 8**). The storm line appears to run approximately 60 feet from the property line and the sewer line runs approximately 12 feet from the property line. Drawings indicate there are three storm system manholes situated along the length of the Taylor Way Property. One exists at the south corner at the first Carlile entrance and a catch basin exists within a few feet of the manhole. The drawings indicate there is a second catch basin in the Carlile driveway, but this was not observed. It is possible that such a catch basin exists, but that it has been overgrown by the junipers, or was paved over during the redevelopment.

At the south corner of the Taylor Way property, the depth of the sewer line is approximately 10 feet deep. The depth of the storm line is a little over 7 feet deep. Based on the depths, both of these utilities are submerged (i.e., within the groundwater). While the Site is generally downgradient of these utility lines, the mounding that occurs at 1B4-1 may cause reversal in the groundwater flow direction at times.

Ecology sampled dry weather flow in the storm manhole at the south corner of the Site in May 2015. Total arsenic was detected in this sample at a concentration of 32. 6 µg/L. However, the sample was turbid and much of the arsenic may have been present within the suspended solids. In addition, the sample collected contained flow from both the upstream main line and the line originating in front of the Taylor Way Property. Based on these factors, this sampling is inconclusive.

2.5.2.2 Murray Pacific Property

Following remedial actions in 1996, a stormwater detention pond was constructed on the Murray Pacific Property adjacent to the Hylebos Waterway to capture surface water runoff (**Figure 3**). From this detention pond, stormwater reportedly passes through an oil/water separator and then discharges to the Hylebos Waterway.

2.5.2.3 North Boundary Area

The NBA is unpaved except for the former salt pad areas. The Arkema stormwater collection system has been plugged so that stormwater that collects on unpaved surfaces generally infiltrates into the ground surface instead of flowing offsite as surface runoff.

In prior years some stormwater from Arkema (i.e., the NBA) reportedly entered the south end of the Taylor Way Property and would flow across the truck/trailer parking area to stormwater catch basins near the office building (TLI Systems 1996).

2.6 Underground Utilities

As was indicated above, the current/past storm drain system configuration on the Taylor Way Property is shown on **Figure 8**, as are the sewer and storm main lines located in Taylor Way. **Figure 8** also shows the location of two other underground utilities – a water line and natural gas line – which enter the Taylor Way Property at the south corner. These underground utilities are key features that need to be considered as a part of remedial actions discussed in the FS.

Section 3

Summary of Remedial Investigations and Interim Actions Completed

3.1 RI Summary

On September 16, 2016, CDM Smith submitted the Final Draft Supplemental RI for the Site. The Supplemental RI was the culmination of numerous investigations dating back to the early 1990s with various interim actions completed to address conditions identified. Each of these investigations is briefly summarized below.

- 1991, 1994/1995 – Phase 1 and II Remedial Investigation: Tasks included: collection and analysis of surface soil samples across the material stockpile area; installing nine shallow monitoring wells; locating and sampling seeps along the waterway embankment; and sampling the stormwater outfall. The primary findings were the presence of shot and high arsenic concentrations at MW9, located near the baghouse and high arsenic concentrations in groundwater, seep water, and dry weather flow from the stormwater outfall. (AGI 1991, 1994, 1995).

- 1996 – Berm Evaluation: A soil berm existed along the property between the Taylor Way Property and the Murray Pacific Property. The berm extended in a southwest to northeast alignment between the railroad siding trestle and the Hylebos Waterway. The berm was approximately 520 feet long, 6 to 12 feet high, and 20 to 25 feet wide at its base. Total arsenic concentrations in the berm soils were found to be high throughout. Cadmium and lead concentrations generally correlate with the arsenic concentrations. Arsenic concentrations in all soil samples collected from the northern half of the berm exceeded the dangerous waste characteristic leaching criteria of 5 milligrams per liter (mg/L). (AGI 1996).

- 1996 – Tide Bank Investigation: The material makeup of the embankment was investigated in three phases. Source material (i.e., shot) was found at several locations on the bank top and within the bank slope. (AGI, 1997).

- 1993 - Hydrocarbon Assessment: A test pit investigation was conducted to explore the presence of petroleum contamination associated with the removed Bunker C AST. This investigation determined that hydrocarbon contamination was present in soil, which had migrated to groundwater at 4 ft bgs. (AGI, 1993).

- 1998 - MW9 Area Investigation: This investigation involved hand augering 26 borings and drilling five borings using a hollow-stem auger drill rig to evaluate the nature and extent of source material and contamination in the area of MW9. This investigation identified an area with high arsenic concentrations, a portion of which also had a 0.6 to 2.4-foot layer of shot, that extended along the access road between the plant building and the fence, beginning at the dry filter and extending northeastward past the railroad spur by about 60 or 70 feet. It also extended into the waste material off-loading area between the baghouse and the railroad spur. (AGI, 1998).

- 2000-2001 – Groundwater and Stormwater Monitoring: For a two-year period, CDM Smith conducted quarterly groundwater monitoring. The results of this sampling showed significant decreases in arsenic concentrations at several of the surface aquifer wells in response to interim actions completed. Possible dry weather flow at the stormwater outfall was observed twice and was sampled both times following replacement of the storm drain system (April 1999 and April 2000). Arsenic concentrations in both dry weather flows was approximately 60 µg/L. (CDM 2002).

- 2002 – Phase 1 and Limited Phase II Environmental Site Assessment: Kennedy Jenks Chilton (KJC) conducted due diligence assessments on behalf of the Port prior to acquisition. As expected, during the Phase II ESA arsenic was detected at elevated concentrations in soil and groundwater samples collected throughout the Taylor Way Property. In addition, an area of petroleum hydrocarbon contamination not previously identified was discovered behind the production building. The most likely source was attributed to the piping that extended between the former AST and the boiler used to heat the facility buildings. (KJC 2002).

- 2004 – Building Pre-Load Sampling: KJC conducted soil sampling within the proposed new building footprint (location of demolished mineral fiber plant and current location of the Carlile building) where soil preloading was planned to occur. Arsenic concentrations were variable, ranging from 20 to 1,100 milligrams per kilogram (mg/kg). Limited areas with arsenic contamination in the upper 2 to 3 feet were identified for removal prior to emplacement of the preload.

- 2005 – Former Railroad Spur Investigation: CDM Smith conducted a test pit investigation under the former railroad berm after its removal. Similar to other investigations, arsenic concentrations were variable, ranging from 8 to 890 mg/kg. A small area of residual shot was observed in one test pit. (CDM 2005a).

- 2005 – B13 and B23 Borings: CDM Smith investigated arsenic and lead concentrations in soils in the vicinity of KJC's borings B13 and B23. Eight test pits (B13-1 through B13-8, and B23-1 through B23-8) were excavated throughout each area. These borings were in the vicinity of the MW9 area investigation described above and in close proximity to the former baghouse and material storage area. Results of this investigation identified the need to expand upon the MW9 area interim actions.

Most of the investigations summarized above resulted in interim actions, which are described in Section 3.2 below. Additional investigations were conducted as a part of the Supplemental RI in an effort to complete a comprehensive characterization of contamination in soil and groundwater originating from the Taylor Way Property. The Supplemental RI also evaluated the relationship between contamination originating on the Taylor Way Property and offsite properties, if any, and thus define the boundaries of contamination associated with the Taylor Way Property. These supplemental investigations occurred in three phases between 2006 and 2014. The work completed generally consisted of the following:

- Replacement of monitoring wells destroyed during the redevelopment.
- Installation of additional monitoring wells within the Murray Pacific Property and along the property line between the Taylor Way Property and the Murray Pacific Property.
- Collection of groundwater samples from newly installed and existing monitoring wells.
- Synoptic water level measurements at high and low tides.
- Dry and wet weather inspections and sampling of the storm drain outfall.
- 24-hour continuous water level monitoring and slug testing on selected wells.
- Extended a series of boreholes using drive-point sampling methods in selected areas of concern in an effort to identify the extent of arsenic-contaminated soil and presence of arsenic-containing source material.
- Collection of groundwater samples from selected monitoring wells for further chemical evaluation and confirmation of earlier results.
- Camera survey of the storm drain system.

3.2 Historical Interim Actions Completed

As the phased environmental assessments identified arsenic (and other metals)-contaminated soil, residual source materials, and petroleum hydrocarbon contaminated soil, a series of interim actions were subsequently conducted by CDM Smith and KJC. Not counting the initial source material removal conducted by USGI in 1973, over 32,360 tons of soils and source material have been removed from the Taylor Way Property during the IAs during the course of 11 different removal actions conducted between 1996 and 2005.

Individual IAs completed on the Taylor Way Property are summarized and on **Table 3-1**. For IAs involving soil excavation, **Figure 9** shows the excavation limits and depths.

3.3 Pre-FS Site Investigations

In 2017, CDM Smith conducted a series of pre-FS investigations/studies in an effort to fill data gaps identified during the Supplemental RI. The work was conducted in accordance with our Final Work Plan entitled “Pre-FS Supplemental Investigation, 2301 Taylor Way, Tacoma WA” dated March 1, 2017. The objectives of this work were two-fold: 1) to investigate RI data gaps, and 2) support evaluation of some of the technologies that will be considered in the FS. More specifically these were:

Objective 1: Investigate RI Data Gaps

- Verify the anomalous arsenic concentration at MW13R obtained in 2012.
- Evaluate residual arsenic concentrations in soils along the former railroad spur in areas not previously investigated.
- Define the extent of unusually elevated arsenic concentrations in soil and groundwater surrounding boring DPT10.

Objective 2: Support of Remedial Technology Evaluation

Two remedial technologies that will be evaluated during the FS include a permeable reactive barrier (PRB) and in situ chemical oxidation (ISCO). The following tasks were developed to enable an appropriate level of evaluation of these technologies during the FS.

- Determine the presence or absence of the tideflat layer in the area of the proposed PRB between existing monitoring wells MW37 and MW28 located next to the Hylebos Waterway.
- Develop an estimate of the groundwater velocity in the immediate area of the proposed PRB.
- Confirm groundwater flow directions to support the design of the PRB by conducting a full round of water level measurements at shallow groundwater monitoring wells located throughout the Taylor Way Property, Murray Pacific Property and the Arkema North Boundary Area.
- Evaluate in situ ISCO remedial technologies by conducting an oxidant demand bench-scale study on Site soil and groundwater.

The investigations were presented in four technical memoranda, which are included in **Appendix A** and summarized below, with the exception of the hydraulic conditions study, which was summarized in Section 2.3.

3.3.1 MW13R Sampling

On March 15, 2017, CDM Smith sampled monitoring well MW13R (second aquifer well) at the Taylor Way property in Tacoma, Washington to confirm the dissolved arsenic concentration reported for this well in May 2012, which was considered to be anomalous because concentrations were significantly higher than samples from prior years. The sample was collected by low-flow sampling techniques, utilizing a peristaltic pump fitted with silicone tubing. The groundwater sample was submitted for analysis of total and dissolved arsenic and lead. Lead was not detected above the method reporting limit in either sample analyzed on the total or dissolved basis. Total and dissolved arsenic were detected, and the concentrations were similar (116 μg/L, total versus 119 μg/L, dissolved). Although the dissolved arsenic concentration in the

2017 sample is less than the dissolved arsenic concentration reported in 2012 (188 µg/L), the results are of the same magnitude, which confirms the prior data.

3.3.2 Soil Sampling Investigation

Soil sampling was conducted in three general areas using direct-push sampling methods. The investigation scope and results are summarized below. Boring locations are shown on **Figure 10**, which also provides a compilation of all boring and excavation limit locations for the Site.

3.3.2.1 DPT10 Area

Boring DPT10 was located near the entrance to the original plant facility, southeast of the plant office and west of the manufacturing plant facility. At the DPT10 boring location a black lens of material with an elevated arsenic concentration (960 mg/kg) was noted at a depth of 6 ft bgs. This concentration was close to the proposed acute-based remediation level of 1,060 mg/kg. The lead concentration was also elevated (1,494 parts per million [ppm] as screened using X-Ray Fluorescence [XRF]), suggesting a slag or shot-related source. The dissolved arsenic concentration in the groundwater sample collected at this location of 2,360 µg/L was higher than usual for this Site, which suggested an undefined source of groundwater impact at this location.

Four borings were extended in the area surrounding DPT10 (DPT20-DPT23). Soils were screened during drilling using an XRF and one soil sample from each boring, and a groundwater sample collected from DPT20, DPT21, and DPT23 were submitted for analysis.

The fill in this area was determined not to be dredge fill as exists closer to the Hylebos waterway, but rather fill soil with some demolition debris. The relatively higher arsenic concentrations in soils within the DPT10 area appear to be related to small amounts of slag intermixed with the fill that also contains demolition construction-type debris. None of the soil samples exceeded the proposed chronic-based remediation level of 400 mg/kg (see Section 4.5.2 for a discussion of acute and chronic risk-based remediation levels).

Dissolved arsenic concentrations in the groundwater samples ranged from 55.1 µg/L to 358 µg/L. The groundwater data confirmed earlier conclusions that arsenic attenuates significantly within a very short distance downgradient of areas containing residual source materials as these samples, collected only 15 to 35 feet away from DPT10, contained arsenic concentrations that are one to two orders of magnitude lower than in DPT10.

Based on these findings, CDM Smith concluded that this area should not require further interim remedial actions.

3.3.2.2 Railroad Spur Area

The railroad spur berm located to the west of the former manufacturing facility was removed by Kennedy/Jenks Consultants for the Port of Tacoma in 2003. These berm materials contained slag and various USG-process arsenic-containing waste materials. Previously, borings and test pits were extended within the area of the former railroad spur berm and further west along the rail spur to verify the adequacy of interim actions; what appeared to be sporadic pockets of shot and slag were identified. Because soil excavation is being considered for this area, further investigation was conducted to evaluate arsenic contamination in soils between the furthest west boring, DPT2, and the western corner.

A total of 11 borings (DPT24-DPT34) were completed using direct push technology methods (DPT) within the railroad spur area, mostly along the path of the former track. The salient findings from this investigation are summarized in the bullets below:

- Similar to the investigation around DPT10, the fill in this area is not dredge fill as exists closer to the Hylebos. The upper 3 to 4 feet contains some demolition debris.
- Within the upper 2 to 4 feet, there appears to be residual slag and/or shot scattered in the area between borings DPT27 on the west and DPT5 on the east.
- The elevated concentration of arsenic previously found at DPT5A (20,700 mg/kg) appears to be a one-time anomalous occurrence.
- No new areas with soils containing arsenic greater than the proposed acute-based remediation level of 1,060 mg/kg were discovered and all soils tested during this investigation were less than the proposed chronic-based remediation level of 400 mg/kg (see Section 4.5.2).
- Three relatively small areas were found to exceed the acute-based remediation level of 1,060 mg/kg as were discovered during the previous RI investigations. Contamination is limited to the upper 2 to 4 feet.

3.3.2.3 Hylebos Waterway Area

Three borings (DPT35, DPT36, and DPT36b) were drilled downgradient of the historical hydrocarbon remedial excavation. The primary purpose of these borings was to collect soil for bench scale testing. Two borings (DPT37 and DPT38) were drilled adjacent to the Hylebos Waterway on either side of DPT6. The primary purpose of these borings was to ascertain the presence and depth of the historical tideflat. DPT39 was not a planned boring and was drilled for additional stratigraphic and arsenic information.

This investigation confirmed that the tideflat layer is present in the area between MW37 and MW28, but is slightly deeper, about 12 to 13 ft bgs, as opposed to the 10 to 11 ft bgs as usually observed.

At DPT37 a silty sand with scattered natural organics was encountered at a depth of 10 to 12.5 ft bgs and a soft, fibrous organic silt was encountered at 12.5 ft bgs (tideflat layer). At 12 ft bgs and just above the tideflat layer, concentrations of arsenic and lead in the laboratory-analyzed samples were 594 mg/kg and 40.5 mg/kg, respectively. The relatively low lead concentration, as compared to the arsenic concentration, combined with the presence of significant plant-based organics, and potentially the residual hydrocarbon plume associated with the former Bunker C AST (residual petroleum hydrocarbons were detected in groundwater in nearby wells MW29, MW37, and MW38), further suggested that arsenic in this area is being mobilized by the reducing conditions created by the natural decomposition of residual organics, consistent with previous interpretation of the data in this area.

3.3.3 Bench Scale Study

CDM Smith completed a bench-scale treatability study to evaluate the potential effectiveness of the ISCO treatment technology to decrease arsenic concentrations in groundwater. The study used soil collected during the DPT sampling described in section 3.3.2.3 and groundwater collected from monitoring well MW-37. Three different soil conditions were tested (soil from each of two individual borings, and a soil mix from two borings). Permanganate was used as the oxidant as similar studies performed with persulfate and peroxide showed a significant pH decrease and were ineffective in removing arsenic.

The salient findings from the bench-scale treatability study were as follows:

- ISCO appears to be effective at removing fairly high concentrations of arsenic; however, achieving concentrations as low as the MTCA Method A cleanup level of 5 µg/L appears difficult to achieve using ISCO alone.
- In all soil samples tested, increased oxidant concentrations produced only minor additional reduction in arsenic concentrations. Therefore, an oxidant concentration equal to or less than the soil oxidant demand (SOD) should be considered for ISCO if implemented in the field.
- No significant changes in pH were observed at any oxidant dosages and in any of the test conditions.
- Iron limitation is likely not a concern at the Site. Increasing iron doses from 5,000 µg/L to 10,000 µg/L resulted in no additional arsenic removal. The inability to achieve an arsenic concentration below 5 µg/L in groundwater is likely due to aqueous complexing of arsenic into forms that are not readily coprecipitated with iron.

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Section 4

Conceptual Site Model

This section presents a summary of the contaminant characterization of the Site that was used in the development and analysis of applicable remedial technologies and alternatives. The following sections present and discuss:

- The contaminants of concern (COC) identified for the Site.
- A summary of the COC distribution by affected media.
- Fate and transport mechanisms.
- Exposure pathways and receptors.
- Cleanup and remediation levels developed for the Site
- Points of compliance.
- An evaluation of areas requiring remedial actions based on the conceptual site model.

4.1 Contaminants of Concern

Contaminants of potential concern at this Site include metals associated with the historical use of ASARCO slag, and petroleum hydrocarbons associated with releases from the historical Bunker C AST and its associated underground fuel line that extended to the facility. The following sections discuss the contaminants determined to be of concern to the Site.

4.1.1 Metals

ASARCO slag contains relatively high concentrations of a variety of metals, but most particularly arsenic and lead. Indeed, high arsenic and lead concentrations were found throughout the Taylor Way Property and were the target of IAs completed to date. Under certain conditions, arsenic has a high propensity to leach. For example, in the presence of wood debris, arsenic in ASARCO slag becomes highly leachable due to the acidic and reducing conditions created by the wood debris. This is why arsenic contamination was so prevalent in the area log sort yards where ASARCO slag was used as ballast. USG's two most prevalent wastes were shot and baghouse dust. Shot, while it contains high concentrations of arsenic when derived from ASARCO slag, does not readily leach arsenic. Arsenic in baghouse dust, however, is highly leachable and was the primary cause of arsenic impacts to groundwater. Lead, unlike arsenic, is not highly leachable, except under highly acidic conditions (e.g., such as at battery recycling facilities where acid and lead are released). For this reason, lead has not been identified in groundwater at concentrations considered to be a concern (i.e., neither drinking water or surface water standards are exceeded).

During the early assessments various soil and groundwater samples were analyzed for additional metals besides arsenic and lead, including: antimony, barium, cadmium, chromium, copper, lead, nickel, mercury, selenium, silver, and zinc. From these analyses it was determined that concentrations of the other metals in soils were either not elevated or were not particularly elevated as compared to arsenic and lead concentrations in those same samples. Therefore, remedial actions that would address arsenic and lead in soil would concurrently address these secondary metals. Concentrations of these secondary metals in groundwater also were either never elevated or were not particularly elevated in the first place and have generally declined over the years following implementation of IAs.

For these reasons, arsenic was determined to be a contaminant of concern in soil and groundwater, as well as surface water due to the proximity of the Hylebos Waterway and nearby storm drain lines that discharge to the Hylebos Waterway. Lead is a contaminant of concern in soil, but not in groundwater or surface water.

4.1.2 Petroleum Hydrocarbons

Heavy end petroleum hydrocarbons were historically confirmed in soil, having resulted from releases associated with the former Bunker C tank and underground piping. IAs completed have removed petroleum hydrocarbon-impacted soils exceeding the MTCA Method A unconditional land use soil cleanup levels in effect at the time. The cleanup level was 200 mg/kg when the Bunker C AST remediation occurred. By the time the piping remediation occurred the cleanup level had been increased to 2,000 mg/kg. Therefore, petroleum hydrocarbons are no longer a contaminant of concern in soil from the aspect of direct contact. However, groundwater data indicate that shallow groundwater within and downgradient of the former Bunker C remediation area has some impact by very weathered heavy end petroleum hydrocarbons (**Table B-1**, **Appendix B**). Considering the proximity of the hydrocarbon groundwater plume to the Hylebos Waterway, petroleum hydrocarbons are also considered a contaminant of concern to groundwater and surface water. In addition, residual hydrocarbons may increase the mobility of arsenic in the area by creating reducing conditions within the groundwater.

4.2 Affected Media and Contaminant Distribution

4.2.1 Soil

Total arsenic and lead data generated throughout the Taylor Way and Murray Pacific Property that represent current soil metals concentrations (i.e., data on previously excavated soils are not included) are summarized in **Table B-2** in **Appendix B**. **Figure 10** presents a compilation of total arsenic concentrations by sample location and depth. This includes confirmation samples collected at the conclusion of interim actions and at locations where no interim actions have been complete. The figure provides soil arsenic data individually by depth except at the base of excavations, where average arsenic concentrations are provided. The data shown on **Figure 10** are a mix of laboratory and XRF data.[6] Analytical laboratory data were used where available; otherwise, the total arsenic data shown are by XRF.

[6] The XRF provides data in parts per million while laboratory analytical data are in mg/kg, which are approximately the same. For the purposes of this report, they should be considered interchangeable. Typically, when only XRF are being discussed, the values will be referred to in units of ppm. When both XRF and laboratory or just laboratory data are being discussed, the values will be referred to in units of mg/kg.

4.2.1.1 Arsenic

Arsenic concentrations vary widely throughout the Site, ranging from less than the method reporting limit (4 to 13 mg/kg) to as much as 20,700 mg/kg. The distribution of high arsenic concentrations also varies widely. For example, the greatest observed arsenic concentration occurred at sample location DPT5A next to the former railroad spur on the west side of the Taylor Way Property at a depth of 3 ft bgs, but by 4 ft bgs the arsenic concentration declined to 1,700 ppm and by 6 ft bgs (DPT5B and DPT32), arsenic was not detected. Next to the Hylebos Waterway at MW29, arsenic concentrations ranged between 24 and 185 mg/kg at depths between 1.5 and 6.5 ft bgs, but at 7 ft bgs, the arsenic concentration was measured at 2,708 ppm. In both instances, residual source material was observed in the samples with high arsenic concentrations. In the south corner, while we see relatively higher arsenic concentrations at shallower depths due to the presence of scattered residual source material, concentrations seen at lower depths are sometimes even greater than in the shallow soils, which appear to be the result of leaching and redeposition. For example, at DPT13, an arsenic concentration of 1,130 mg/kg was observed concurrent with a lens of suspected source material at 3.5 ft bgs, the arsenic concentration declined to 30 ppm in silt fill at 5.5 ft bgs but increased to 155 ppm at the top of the tideflat layer at 8 ft bgs.

4.2.1.2 Lead

Total lead concentrations are also summarized in **Table B-2** in **Appendix B**. Total lead concentrations ranged from less than the method reporting limit (1.5 to 13 mg/kg) to as much as 3,900 ppm. Relatively speaking lead concentrations are, overall, much less than arsenic. Of the 406 samples analyzed around the Site, 302 samples (74%) had concentrations less than or equal to the Puget Sound Area background concentration of 24 mg/kg (San Juan 1994). High lead concentrations are only observed in association with samples containing relatively higher arsenic concentrations and in conjunction with the presence of source material (i.e., shot, slag).

4.2.2 Groundwater

Surface and second aquifer metals concentrations measured over the years are summarized in **Table B-3** and **Table B-4** in **Appendix B** and summarized below.

4.2.2.1 Surface Aquifer

Figure 11 presents a compilation of the most recent arsenic concentration data for groundwater in the surface aquifer. The greatest arsenic concentration (2,360 µg/L) was observed at DPT10, located in the central western side of the Site, near Taylor Way. However, as was observed during the subsequent DPT investigation, arsenic concentrations attenuate quickly within a short distance from DPT10.

The next highest arsenic concentration is observed at MW1R (1,100 µg/L). Similar to DPT10, arsenic concentrations are observed to attenuate within a fairly short distance from MW1R. Calculations presented in the RI using a conservatively low arsenic K_d of 3.26 L/kg, a groundwater velocity of 0.033 ft/d, a soil bulk density of 1.65 L/kg, and a porosity of 0.2 showed that a transit time of 730 years would be required for arsenic to travel the 315 feet between well MW-1R and well MW-9.

Next to the Hylebos Waterway, arsenic concentrations on the Taylor Way Property, between the property line with the Arkema Property and the storm drain system are low – less than the cleanup level – with arsenic concentrations between 1.7 and 3.5 µg/L. However, around the property line with the former Murray Pacific site, arsenic concentrations range between 203 and 876 µg/L. Arsenic concentrations decline, but are variable and still elevated further in the Murray Pacific Property along the edge of the Hylebos Waterway, with arsenic concentrations ranging between 15 and 97 µg/L.

In other areas of the Site, arsenic concentrations are lower, but variable. In the central area of the Murray Pacific Property, arsenic concentrations were as low as 1 µg/L. On the western side of the Taylor Way property, the arsenic concentration was 3 µg/L at MW27, which is situated in the former railroad spur area where the greatest arsenic concentrations in soil were observed. Similarly, at B8, which is located on the property line with Taylor Way at the western entrance to the facility, the arsenic concentration was only 3.88 µg/L. At MW9, located at the Arkema property line and near the former baghouse where extensive interim actions occurred, arsenic concentrations have shown the greatest decline over the years, beginning with as much as 19,000 µg/L in 1998 but was only 40 µg/L as of the most recent sampling round (May 2012).

4.2.2.2 Second Aquifer

Arsenic concentrations in the second aquifer are generally low (**Figure 12**), ranging from ≤1µg/L near the Hylebos Waterway, to 4-9 µg/L in the interior of the Site. The exception is at MW13R, located in the South Corner Area, where the arsenic concentrations have been variable over the years, ranging from 5 to 69 µg/L between 1994 and 2006, but increasing by an order of magnitude to 188 µg/L in 2012. This higher, yet still variable, concentration was confirmed during a resampling event in March 2017 where the arsenic concentration was reported at 119 µg/L.

4.2.2.3 Stormwater

Taylor Way Property System

The results of the RI indicate that the stormwater system on the Taylor Way Property was compromised during the redevelopment and groundwater impacted by arsenic is entering the system and discharging to the Hylebos Waterway. The section of the storm drain line that extends between the oil/water separator near the corner of the Carlile building and the outfall is one continuous section that was not replaced. This is the section that extends through the residual hydrocarbon plume. Based on this, petroleum hydrocarbons sometimes detected in stormwater samples are considered to be associated with dissolved hydrocarbons that pass through the oil/water separator.

City-Owned System in Taylor Way

The results of Ecology's dry weather storm drain system sampling in Taylor Way were inconclusive with regard to whether the Taylor Way Property is a contributing source of arsenic found in the City's system located in the road. Given the prevalence of dry weather flow in this system, it cannot be considered competent (i.e., groundwater inflow to the storm drain via cracks and joints in the piping is likely). Based on this, and the apparent groundwater flow directions, the possibility of groundwater from the Taylor Way property impacting the storm drain system in Taylor Way cannot be ruled out.

4.3 Fate and Transport

As indicated in prior sections, sources of contamination at the Site include:

- ASARCO slag;
- Byproducts of manufacturing operations that used ASARCO slag, including shot, baghouse dust, and off-spec product; and
- Petroleum contamination associated with a former Bunker C AST.

Interim actions have substantially removed source material and high concentration contaminated soils that resulted from the past use of ASARCO slag, although, as noted in prior sections, relatively small areas with residual source material and high concentration soils exist. Interim actions have also removed petroleum hydrocarbon-contaminated soils, which no longer presents an ongoing source of contamination to groundwater. Petroleum hydrocarbons present in groundwater are a highly weathered artifact of the prior contaminant source.

Arsenic and metals are released from source material by partial dissolution of source materials which causes the release of arsenic and metals to soil and groundwater. Attenuation of arsenic and metals in groundwater occurs in response to precipitation of iron minerals, such as iron carbonate, iron phosphates, and iron oxyhydroxides. Adsorption of arsenic and metals onto the aquifer sediments likely occurs to some extent but is less important than coprecipitation with iron-bearing minerals. In effect, iron dissolves from the source materials resulting in increases in aqueous iron concentrations in the groundwater until the solubility limits of the iron carbonate and phosphate phases is reached. PHREEQC modeling conducted during the RI demonstrated that both iron carbonate and iron phosphates are at equilibrium, which is a strong indication that these phases are forming within the aquifer at the Site.

According to calculated attenuation times presented in the RI, the net result of the attenuation processes is that arsenic is transported a minimum of 28 times slower than the groundwater. For example, the time for arsenic to travel from well MW9 to MW5 (437 ft.) was estimated at 372 years. However, under certain conditions, the solubility (and leachability) of source materials are enhanced. The mechanisms that appear to be most important in enhancing the migration of arsenic in groundwater in certain areas at the Site appear to be:

- ***Reducing conditions:*** Under reducing conditions, the solubility of arsenic is enhanced. Reducing conditions can be driven by the presence of hydrocarbons and/or organic acids, which can leach from wood waste. This condition is apparent at the property line between the Taylor Way and Murray Pacific Properties where weathered petroleum hydrocarbons were detected in groundwater and residual wood waste was observed in one boring. The residual wood waste is likely a small wedge of soil/wood waste left in place between the two separate events of upland and bank cleanup that occurred on the Murray Pacific Property. Along the boundary with the NBA, the fraction of the reduced form of arsenic (arsenite) is higher, and to some extent the Eh[7] is lower. The more mobile form of arsenic predominates at low Eh. Two of the three wells along the former berm and between the

[7] Eh is a measure of the redox (oxidation-reduction) state of a solution.

former Bunker C tank and the Hylebos had percentages of arsenite of 85% or greater (MW25, 87% As(III), MW36, 85% As(III), MW37, 75% As(III)). The only wells with comparable or higher percentages of arsenite were MW42 (in a wood waste area near the Hylebos Waterway with 87% As(III)) and MW1R in an area where boring logs indicate the presence of organics in the south corner of the site (95% As(III)).

- ***High ionic strength groundwater:*** At the OCC site, metals concentrations and migration in groundwater were found to be influenced by several mechanisms. One of the most important of these was the limitation of the sorption of metals due to the ion-ion interactions associated with the high ionic strength anthropogenic density plume (ADP) (i.e., competition for sorption sites, which was keeping the metals in solution (CRA 2014). The term ADP refers to a plume of elevated groundwater density due to releases of high density materials from historical operations (i.e., with regard to the Site, salt from salt pads at the NBA). This may be an influencing factor in the south corner of the Taylor Way Property at MW1R. While minor localized ASARCO slag and organic material were noted in borings in this area, CDM Smith previously noted a correlation between arsenic concentrations and conductivity measurements. Arsenic concentrations were notably higher when conductivity values have been higher. Arkema's former salt pads are situated only about 300 feet to the east and, as noted in Section 2.3, groundwater mounding in the NBA is apparently causing groundwater flow into the south corner of the Taylor Way Property from the NBA. Higher ionic strength when groundwater flow is from the NBA to the south corner has the potential to increase the mobility of arsenic.

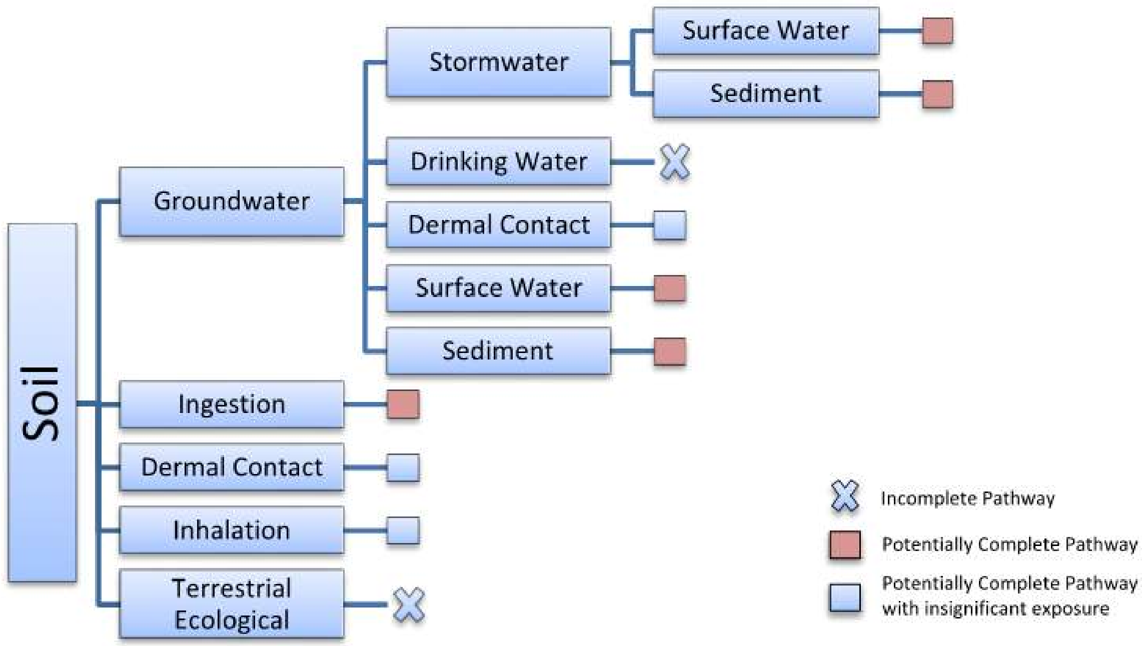
- Another potential arsenic source to groundwater in the south corner is dissolution or desorption of arsenic from the shallow soil due to consistently elevated groundwater levels in this area.

4.4 Exposure Pathway Assessment

In 1940 the Port established its Industrial Development District, stretching from the Hylebos Waterway where the Site is situated, to the Milwaukee Waterway (Port of Tacoma website). The Site, which is currently owned by the Port of Tacoma, will continue to be used for industrial purposes in the future. Any future redevelopment is likely to similarly consist of the property being entirely covered by buildings with surrounding asphalt/concrete/gravel parking lots and minimal islands of landscaping, or rail lines. The Site meets the industrial criteria specified in WAC 173-340-200 in that it: 1) has been consistently used for traditional industrial manufacturing purposes and 2) is zoned industrial by the City of Tacoma. Therefore, current and future exposure scenarios and chemical-specific remediation levels were developed based on industrial land use.

Exhibit 4-1 below summarizes the conceptual exposure pathways for contaminants originating on the Taylor Way property.

Exhibit 4-1 Source and Exposure Medium Summary – Taylor Way Property



4.4.1 Receptors

4.4.1.1 Soil

There is no significant complete exposure pathway for the current industrial worker. Potential future human exposures for the Site include such activities as new construction (e.g., to install a new building foundation) or to repair or install new underground utilities. Such activities are likely to be infrequent and of short duration. Therefore, onsite contact with soil is considered a potentially complete exposure pathway for future utility/construction workers.

The risk for the terrestrial ecological organisms was ended because the Site is industrial, and all hazardous substances are covered by physical barriers that will prevent plants or wildlife from being exposed.

As discussed below, the groundwater to surface water pathway is a potential concern. Therefore, the cleanup needs to consider actions that minimize the potential for arsenic in soil to leach into groundwater. The standard Method B soil cleanup levels for protection of groundwater (2.9 mg/kg for vadose soils and 0.15 mg/kg for saturated soils, based on standard defaults and assumptions) are less than natural background concentrations, and would be impracticable to implement. Therefore, remedial actions need to minimize contact of arsenic contaminated soil with groundwater to the extent practicable and to remediate/minimize discharges of contaminated groundwater to surface water.

4.4.1.2 Groundwater

The surface and second aquifer groundwater at the Site are not suitable potential drinking water sources, regardless of the arsenic concentrations, based on secondary water quality criteria. Human exposures to groundwater would only likely ever occur via direct contact and this is even less likely to occur than for contaminated soils. Therefore, no potential human receptors for groundwater were identified.

4.4.1.3 Surface Water

Groundwater discharges to surface water, whether directly or via discharge into the onsite storm drain system, and potentially into the storm drain system in Taylor Way. Marine water is not a potential source of drinking water, and neither is direct contact a likely significant exposure mechanism. However, aquatic biota and humans through consumption of aquatic biota are likely receptors as a result of surface water impacts.

4.3.1.4 Sediment

Similar to surface water, aquatic biota and humans through consumption of aquatic biota are likely receptors as a result of sediment impacts.

4.5 Cleanup and Remediation Levels

4.5.1 Cleanup Levels

4.5.1.1 Arsenic and Lead

Soil

The current MTCA Method A unconditional land use and industrial cleanup levels for arsenic are the same at 20 mg/kg. The Method A unconditional land use cleanup level for lead is 250 mg/kg and its Method A industrial cleanup level is 1,000 mg/kg. The Method C cleanup levels (based on standard defaults and assumptions) for arsenic are 1,050 mg/kg (noncancer risk) and 87.5 mg/kg (cancer risk). No Method C cleanup levels for lead have been established.

The Site meets the definition of an industrial site and therefore industrial Method A and Method C cleanup levels may be applicable. The RI established preliminary soil cleanup levels for arsenic and lead at 87.5 mg/kg (rounded up to 88 mg/kg) and 1,000 mg/kg respectively.

Groundwater

The current MTCA Method A cleanup level for arsenic in groundwater for drinking water beneficial uses is 5 µg/L. However, drinking water cleanup levels are not considered applicable as it is considered that Site groundwater is non-potable per WAC 173-340-720(2) (a), (b), (c) and (d). To demonstrate the non-potability of the Site groundwater, groundwater in wells close to the Hylebos Waterway, as well as MW1, are all saline, as evidenced by the high specific conductance and chloride concentrations. In addition, it would be difficult, or impossible, to achieve sustainable production of 0.5 gallons per minute from most wells due to the minimal saturated interval (i.e., 2 – 3 feet near the Hylebos) or the low hydraulic conductivity due to the tight silt soils (western side of the property). The second aquifer underlying the Site is also non-potable as it is highly influenced by saltwater intrusion. Further, in March 2015 Ecology issued a determination of non-potability for the Occidental Chemical Corporation (OCC) facility at 605 Alexander Avenue (San Juan, 2015). The OCC facility is only 1.1 mile to the northwest of the Taylor Way Property and also adjacent to the Hylebos Waterway. As was noted in the memorandum, the OCC property is situated on a manmade peninsula that extends into Commencement Bay, which was constructed by placement of fill on historic tideflats. As such, the historic hydrogeology was tidal marsh/estuary and Puyallup River deltaic deposits. Therefore, the natural state of the underlying groundwater is brackish and unfit for human consumption without costly treatment. Ecology therefore granted the determination of non-potability for the OCC facility. The same hydrogeologic conditions exist at the Taylor Way Property as for the OCC facility.

Because groundwater discharges to the Hylebos Waterway, surface water becomes the next most sensitive receptor; therefore, groundwater cleanup levels are set to be protective of surface water.

Marine water standards are based on protection of aquatic organisms and human health (i.e., ingestion of marine organisms). The most stringent marine water arsenic standard is based on protection of human health due to consumption of marine organisms (0.14 µg/L),[8] which is less than the practical quantitation limit and also less than background. In these instances, the standards default to background, which for arsenic in marine water Ecology considers to be 5 µg/L.[9] Site remedial actions for groundwater will need to focus on protection of the surface water standards, which would then be 5 µg/L for arsenic.

4.5.1.2 Petroleum Hydrocarbons

The MTCA Method A groundwater cleanup level (drinking water standard) for both total petroleum hydrocarbons (TPH) quantified as diesel (TPH-D) and oil (TPH-O) is 500 µg/L, However, as was noted for arsenic, Site remedial actions for petroleum hydrocarbons in groundwater will need to focus on protection of surface water.

For protection of surface water, cleanup levels are based on the highest beneficial uses and the reasonable maximum exposure expected to occur under both current and potential future site use and conditions per WAC 173-340-730 (1), which for this site, is ecological and human health based. Ecology recently completed a study to develop a weathered diesel range total petroleum hydrocarbon ecological-based cleanup standard for protection of aquatic life in marine water (Ecology, 2020). This value was determined to be 2,000 µg/L. WAC 173-340-730(3)(b)(iii)(C) establishes that, as an alternative to calculating a site specific cleanup level for total petroleum hydrocarbons for human health protection, the total petroleum hydrocarbon cleanup level in Table 720-1 (Method A cleanup level for groundwater) may be used. Based on this, the lowest applicable cleanup level for TPH with regard to protection of surface water defaults to the Method A cleanup level of 500 µg/L.

Finally, per Ecology's Implementation Memorandum #4, *Determining Compliance with Method A Cleanup Levels for Diesel and Heavy Oil*, the reported result for the diesel and oil range TPH in groundwater will need to be summed together as the source of petroleum is Bunker C, which spans both ranges of the TPH spectrum (Ecology, 2004).

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[8] National Recommended Water Quality Criteria, Human Health for Consumption of Organisms, published pursuant to Section 304(a) of the Clean Water Act. https://www.epa.gov/wqc/national-recommended-water-quality-criteria.

[9] WAC 173-340-900, Table 720-1, Method A Cleanup Levels for Ground Water, footnote b.

4.5.2 Remediation Levels

CDM Smith developed Site-specific risk-based remediation levels for use in developing remedial alternatives for the Site in addition to the full cleanup alternative. Following a series evaluations and negotiations, in an April 8, 2016 email Ecology approved a soil arsenic chronic remediation level of 400 mg/kg, based on a utility worker exposure scenario. Ecology further acknowledged that it may not be possible to meet the chronic remediation level at every location throughout the Site and agreed that it would be appropriate to use the upper 95% confidence level of the mean when evaluating compliance with that level (**Appendix C**)

Further, Ecology also agreed that the upper bound acute risk-based acceptable arsenic concentration to leave onsite, if not feasible to remove all soils above the chronic remediation level, is 1,060 mg/kg (short-term/acute health effect) (**Appendix C**).

4.6 Points of Compliance

4.6.1 Soil

The point of compliance for soil is the point or points where the soil cleanup level is established. For soil cleanup levels based on protection of groundwater, the point of compliance is throughout the site. For soil cleanup levels based on human exposure, the point of compliance is throughout the site from ground surface to fifteen feet below ground surface (WAC 173 340-740(6)(a)(b)(d)). However, in instances where the selected cleanup actions involve containment, soil cleanup levels will typically not be met at the points of compliance. In these instances, compliance is determined if: (1) the selected remedy is permanent to the extent practicable, (2) protective of human health, (3) protective of ecological receptors, (4) institutional controls are implemented, and (5) compliance monitoring and periodic reviews are implemented to ensure the long-term integrity of the containment system (WAC 173-340-740(6)(f)). The following presents the proposed points of compliance for soil assuming application of WAC 173-340-740(6)(f) for arsenic.

- Arsenic: At a minimum, achievement of remediation levels, as discussed in Section 4.4, throughout the Site. Additionally, achievement of arsenic concentrations less than the 400 mg/kg chronic-based remediation level is considered in this FS at selected areas, should such action potentially result in a greater likelihood of achieving the desired outcome in another media (i.e., groundwater).

- Lead: The Method A industrial soil cleanup level of 1,000 mg/kg throughout the Site to a depth of 15 feet below ground surface.

4.6.2 Groundwater

The standard point of compliance for groundwater is the attainment of groundwater cleanup levels throughout the site to the outer boundary of the hazardous substance plume from the uppermost level of the saturated zone, extending vertically to the lowest depth which could be affected (WAC 173-340-720(8)(a)(b)). However, MTCA allows the use of conditional points of compliance in instances where such a cleanup is not feasible (WAC 173-340-720(8)(c)).

- Arsenic: Conditional points of compliance will be the points where groundwater may enter the surface water (i.e., embankment) and conveyance systems that may carry groundwater to surface water (i.e., storm drain systems). (WAC 173-240-730(6)(a))
- Petroleum Hydrocarbons: Conditional point of compliance where groundwater may enter the surface water (i.e., embankment).

The actual points of compliance will be determined by Ecology. In the absence of accurate estimates of natural attenuation, shoreline wells will likely be used to establish the points of compliance.

4.7 Contaminant Distribution Compared to Cleanup and Remediation Levels

4.7.1 Soil – Method A Industrial Cleanup Levels

Currently, soil arsenic concentrations are quite variable across the Taylor Way Property and exceedances of the Method C cleanup level of 88 mg/kg can occur sporadically nearly anywhere on the property. While such exceedances typically occur within about the upper 4 feet, it is not uncommon to see arsenic concentrations exceeding the Method C cleanup level at depths up to 10 ft bgs. **Figure 13** shows the locations where arsenic concentrations exceed 88 mg/kg.

Total lead concentrations exceeded the Method A industrial cleanup level of 1,000 mg/kg at five borings clustered within the former railroad spur. The cleanup level was also exceeded at singular locations at DPT13 (south corner) and DPT10 (west, middle western side of property at 6 ft bgs). Residual source material was observed at each of these locations. At these same locations the Method C cleanup level for arsenic is exceeded.

4.7.2 Soil – Remediation Levels

The acute-based arsenic remediation level of 1,060 mg/kg was exceeded at three locations: 1) the former railroad spur area where this concentration was exceeded at multiple locations (similar to lead); 2) DPT13 in the south corner, where the soil lead concentration also exceeded its cleanup level; and 3) at MW29 and DPT17 next to the Hylebos Waterway. These areas are shown on **Figure 13.**

To evaluate compliance with the soil remediation level of 400 mg/kg for arsenic, CDM Smith conducted a preliminary statistical evaluation. Soil samples exceeding the acute-based remediation level of 1,060 mg/kg were first removed from the data set as, at a minimum, remedial actions will target these areas. Results of the statistical analysis are summarized in **Exhibit 4-2** and the summary statistical data sheets are included in **Appendix C**.

Exhibit 4-2 Preliminary Statistical Analysis of Arsenic Concentrations in Soil

Depth (ft)	No. of Samples	UCL95	Type	% Exceeding Chronic (400 ppm)	Decision
0-3	186	178.2	95% Chebyshev (Mean, Sd) UCL	5.91	Pass
0-6	291	147.6	95% Chebyshev (Mean, Sd) UCL	4.81	Pass
0-9	337	140.5	95% Chebyshev (Mean, Sd) UCL	4.45	Pass

This statistical analysis concluded that, following removal of soils exceeding 1,060 mg/kg arsenic, the UCL95 concentrations range between 140 and 178 mg/kg – well below the remediation level of 400 mg/kg. Based on this, with regard to protection based on the utility worker exposure scenario, further remedial actions beyond removal of soils exceeding the acute-based arsenic remediation level would not be necessary. However, this does not preclude consideration of additional soil remedial actions in certain areas in an effort to reduce further potential impacts to groundwater. A final statistical analysis will be conducted after remedial actions are completed.

4.7.3 Groundwater

4.7.3.1 Arsenic

The arsenic concentration in the surface aquifer exceeds the Method A cleanup level of 5 µg/L throughout the Taylor Way Property with the exception of the western tip of the property where virtually no industrial activities are known to have occurred and at the property line adjacent to the Hylebos Waterway, east of the storm drain line. The greatest arsenic concentrations occur at DPT10 (2,360 µg/L), the area next to the Hylebos Waterway between MW29 and MW37 (203 to 876 µg/L), and in the south corner at MW1R (1,100 µg/L).

At DPT10, the arsenic concentrations in groundwater were found to attenuate by one to two orders of magnitude within about 15 to 35 feet of DPT10. This, and the continued attenuation of arsenic found in further downgradient wells, show that arsenic concentrations are not a threat to surface water. While DPT10 poses no apparent threat of impacting surface water, the same is not true for the area of high arsenic concentrations next to the Hylebos Waterway, or at MW1R, which is situated close to the storm drain system in Taylor Way.

In the second aquifer, arsenic concentrations are ≤1 µg/L adjacent to the Hylebos Waterway. In the central/northern property line areas of the Taylor Way Property, arsenic concentrations are in the single digits (< 10 µg/L), while at the southern corner, at MW13R next to MW1R, the arsenic concentration has increased from 22 µg/L (1994) to 119 µg/L (2017). The exact cause of the increased arsenic concentrations has not been ascertained.

MW13R is too far from the Hylebos Waterway to be a threat of impact. The second aquifer begins at a depth between about 15 and 18 ft bgs, which is deeper than the sewer line in Taylor Way (7 to 7.5 feet bgs). The second aquifer is artesian and the static water level averages about 6 ft bgs, so there is some possibility that leakage occurs through the confining tideflat layer. Regardless, arsenic concentrations in the second aquifer are less, by an order of magnitude than in the surface aquifer at this location.

4.7.3.2 Petroleum Hydrocarbons

The downgradient edge of the residual and highly weathered hydrocarbon plume coincides with that of the area of high concentration arsenic next to the Hylebos Waterway. There was, however, only one monitoring well where the expected surface water cleanup level of 500 µg/L TPH was exceeded. This was MW37 (~1,300 µg/L); TPH concentrations in wells upgradient and on either side of MW37 (i.e., MW6, MW36, MW38, and MW29) had concentrations of <250 µg/L to 500 µg/L.

It should be noted that the TPH analysis is non-specific and the results can therefore be biased high for several reasons. For example, wood waste leachate can be reported as part of the TPH-Dx analysis when silica gel cleanup is not used by the analytical laboratory (RI samples were not analyzed with silica gel cleanup). Residual wood fibers that exist from the prior Murray Pacific Log Yard operations are present in the saturated zone in the immediate vicinity of MW37 as they were observed in nearby borings MW28 and MW29. In addition, historical RI sampling has shown detections of petroleum hydrocarbons in groundwater sampled from as many as five other monitoring well locations that are well outside of the hydrocarbon plume, including two offsite second aquifer wells. The cause of these detections was not determined but may be due to leachate from naturally occurring organics, such as the residual organics associated with original tideflat marsh, which were frequently observed in the boreholes. The presence of organics, whether naturally occurring or as residual wood waste may be biasing the actual petroleum hydrocarbon concentration high at MW37.

4.7.4 Summary

Based on the evaluation presented in Sections 4.7.1 through 4.7.3 three areas were identified as requiring remedial actions, aside from a full cleanup scenario. The common name that each area will be referred to throughout the rest of this FS, a description of each area, and the factors ultimately that require implementation of remedial actions are described below and depicted on **Figure 14.**

1) **South Corner Area**: This area is situated in the south corner of the Taylor Way Property next to the south driveway entrance into the Carlile facility. Soil at a depth of 3.5 ft bgs in DPT13 exceeds the arsenic acute soil remediation level of 1,060 mg/kg. The lead concentration at this same depth at DPT13 also exceeds the industrial Method A cleanup level. The arsenic concentration in monitoring well MW1/MW1R exceed 5 µg/L. Groundwater mounding, which occurs on the adjacent NBA based on the water level elevations at well 1B4-1, appears to cause a reversal in the groundwater flow whereby the groundwater through the south corner Area migrates towards Taylor Way. Contaminated groundwater originating in the south corner Area may leak into the City storm drain line in Taylor Way, which ultimately discharges to the Hylebos Waterway. In addition, arsenic concentrations in second aquifer well MW13/MW13R have increased over the years, the cause of which has not been determined (see Section 4.7.3.1). Remedial actions implemented in this area may help to reduce arsenic concentrations in the second aquifer at this location.

2) **Railroad Spur Area**: This area is situated on the western side of the Taylor Way Property along a section of the former railroad spur that previously serviced the plant facility. Three relatively small areas were found where arsenic concentrations exceed the arsenic acute soil remediation level. Lead also exceeded its industrial Method A cleanup level within one of these areas. These soil remediation/cleanup level exceedances occur within approximately the upper 3.5 feet. Groundwater is not significantly impacted in this area.

3) **Hylebos Waterway Area**: This area is situated generally parallel to the top of the embankment of the Hylebos Waterway. It extends northwestward from approximately the storm drain line in the Taylor Way property to MW31 on the Murray Pacific Property. While groundwater is known to be impacted further northwestward on the Murray Pacific Property, Ecology agreed that analysis of cleanup alternatives considered under this FS would include the area extending from the property boundary up to and including MW31 (Ecology, 2015) and no further (**Appendix C**).[10] In this area, arsenic concentrations in groundwater exceed the surface water standard of 5 µg/L at wells MW37, MW29, and MW31, which lie adjacent to the Hylebos Waterway. TPH also exceeds the groundwater standard of 500 µg/L at MW37. In addition, relatively deep soil (7 to 8 ft bgs) at MW29 and DPT7 exceed the arsenic acute soil remediation level. Relatively high concentrations of arsenic in soil at MW28 and DPT37 are also a concern and targeted for remediation. While the arsenic concentrations at these two locations do not exceed the acute soil remediation level, there is a concern that the concentrations observed at depth (7.5-12 ft bgs) are a contributing source of groundwater contamination. The conditions in this area are much different than for any other area of the Site. The highly weathered, residual hydrocarbon plume and sporadic presence of residual wood debris in this area appears to be causing geochemical conditions that increase the mobility of arsenic as discussed in Sections 4.1.1 and 4.3.

[10] However, long-term groundwater monitoring would need to include the entire Murray Pacific Shoreline to MW33.

Section 5

ARARs and Remedial Action Objectives and Goals

5.1 Applicable or Relevant and Appropriate Requirements (ARARs)

Identification and evaluation of ARARs are integral components of the FS process to determine whether remedial alternatives can protect human health and the environment. MTCA discusses requirements for identifying applicable local, state, and federal laws. The requirements in Washington Administrative Code (WAC) 173-340-710 are similar to the ARAR approach of the federal superfund law.

5.1.1 ARAR Identification Process

ARARs are designated as either "applicable" or "relevant and appropriate," according to Environmental Protection Agency (EPA) guidance and may stem either from federal or state law. ARARs must be identified on a site-specific basis and involve a two-part analysis. A determination must first be made on whether a given requirement is applicable. If it is not applicable, then a second determination must be made on whether it is both relevant and appropriate. When the analysis determines that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable. According to WAC 173-340-710(2) Ecology will make the final interpretation on whether the requirements presented have been correctly identified and are legally applicable or relevant and appropriate.

5.1.1.1 Applicable Requirements

WAC 173-340-710(3) defines "applicable requirements" as cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations promulgated under federal or state environmental laws that specifically address a hazardous substance, pollutant, contaminant, removal action, location, or other circumstances at the site.

5.1.1.2 Relevant and Appropriate Requirements

According to WAC 173-340-710(4) relevant and appropriate requirements specifically refer to cleanup standards, standards of control, and other environmental requirements, criteria, or limitations promulgated under federal or state environmental law. These requirements are not directly applicable to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at a site but address problems or situations sufficiently similar (relevant) to those encountered at the site such that their use is well suited to the particular site.

5.1.1.3 Information to be Considered (TBC)

In addition to ARARs, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) states that where ARARs do not exist, agency advisories, criteria, or guidance are to be considered useful "in helping to determine what is protective at a site or how to carry out certain actions or requirements" (55 Federal Register 8745). These sources of information are referred to as TBCs.

The NCP preamble states, however, that provisions in the TBC category "should not be required as cleanup standards because they are, by definition, generally neither promulgated nor enforceable, so they do not have the same status as do ARARs." Although not enforceable requirements, these documents are important sources of information that EPA and the state may consider during selection of the remedy, especially regarding the evaluation of public health and environmental risks, or which will be referred to, as appropriate, in selecting and developing cleanup actions (40 Code of Federal Regulations [CFR] § 300.400(g)(3), 40 CFR § 300.415(I)).

5.1.1.4 Other Regulatory Requirements Not Considered ARARs

There are other laws and regulations that do not constitute ARARs for the Site because they are not specifically related to environmental cleanup. One example would be the U.S. Department of Transportation regulations for transport of hazardous and nonhazardous materials or wastes; another would be Occupational Safety and Health Administration general construction safety regulations.

5.1.2 Categories of ARARs

Environmental laws and regulations fit (more or less) into three categories:

- Those that pertain to the management of certain chemicals;
- Those that restrict activities at a given location; and
- Those that control specific actions.

Thus, there are three primary types of ARARs: chemical-, location-, and action-specific. An ARAR can be one or a combination of all three types of ARARs.

Chemical-specific requirements address chemical or physical characteristics of compounds or substances on sites. These values establish acceptable amounts or concentrations of contaminants that may be found in, or discharged to, the ambient environment.

Location-specific requirements are restrictions placed on the concentrations of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location-specific ARARs relate to the geographical or physical positions of sites rather than the nature of contaminants at sites.

Action-specific requirements are usually technology-based or activity-based requirements or limitations on actions taken with respect to hazardous substances, pollutants, or contaminants. A given cleanup activity will trigger an action-specific requirement. Such requirements do not themselves determine the cleanup alternative but define how chosen cleanup methods should be performed.

5.1.3 Permit Exemption

WAC 173-340-710(9) states, "remedial actions conducted under a consent decree (CD), order, or agreed order, and the department when it conducts a remedial action are exempt from the procedural requirements of certain laws." The activities must, however, comply with substantive permit requirements. Substantive requirements of the specific local and state permits that are determined to apply to the selected cleanup action will be identified in the Cleanup Action Plan.

5.1.4 Identification of Potential ARARs for Remedial Alternatives

Table 5-1 lists potential ARARs. The ARARs are organized by whether they are federal, State of Washington, or local ARARs. The ARARs or group of related ARARs included in **Table 5-1** are identified by a statutory or regulatory citation, followed by a brief description of the ARAR and explanation of how, and to what extent, the ARAR is expected to apply to potential activities to be conducted. The table also identifies whether the ARAR is chemical-, location-, and/or action-specific.

5.2 Remedial Action Objectives and Goals

Remedial action objectives (RAOs) are media-specific and source-specific goals to be achieved through completion of a remedy that is protective of human health and the environment. The RAOs developed for the Site are as follows:

1. Remove residual source material and contaminated soil or reduce the leachability of arsenic in these media, which contribute to groundwater contamination.

2. Protect surface water by reducing discharges of groundwater that contain arsenic and/or TPH at concentrations in excess of chemical-specific ARARs.

3. Protect workers from short-term (acute) and long-term (chronic) exposure to COC in source material and contaminated soils containing arsenic and lead.

Remedial action goals (RAGs) are defined as the average concentration of a chemical in an exposure unit associated with a target risk level such that concentrations at or below the RAGs do not pose an unacceptable risk. The RAGs are typically presented as chemical- and media-specific values that directly address the RAOs. These values are typically used as a preliminary value in the FS to guide evaluations of remedial alternatives. Identification and selection of the RAGs are typically based on RAOs, the current and anticipated future land uses, and the tentatively identified ARARs. The RAGs developed for the Site are as follows:

1. Removal of soils exceeding the acute risk-based remediation level of 1,060 mg/kg for total arsenic.

2. Removal of soils exceeding the Method C cleanup level of 1,000 mg/kg for total lead.

3. Attain compliance with the risk-based chronic remediation level developed for the Site such that the upper 95% confidence level of the mean soil arsenic concentration throughout the Site does not exceed 400 mg/kg.

4. Maintain soil caps at the Site to prevent day to day exposure of arsenic concentrations in soil that exceed the industrial cleanup level.

5. Protection surface water by eliminating discharges of groundwater exceeding 5 µg/L arsenic and 500 µg/L total petroleum hydrocarbons at the established conditional points of compliance.

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Section 6

Identification and Screening of Remedial Technologies

This section identifies general response actions (GRAs), remedial technologies, and process options that are potentially useful to address the MCTA requirements and remedial action objectives and goals presented in Section 5.2 for the affected soils, groundwater, and stormwater at the Site that pose a potential threat to human health and the environment. This section presents screening of GRAs, remedial technologies, and process options in accordance with MTCA to retain representative technologies and process options that can be assembled into remedial alternatives.

The identification and screening process consisted of the following general steps:

- Identify the contaminants and affected media that pose risks to human health and the environment and group these into a category or categories of affected media for FS evaluation. (Section 4.2)
- Develop GRAs for the affected media that will satisfy the RAOs identified in Section 5.2. (Section 6.1)
- Compile remedial technologies and process options for each GRA that are potentially viable for remediation of the affected media. (Section 6.2)
- Screen the remedial technologies and process options with respect to technical implementability for the affected media at the Site. Technologies and process options that are not technically implementable relative to the affected media are eliminated from further consideration in this FS. (Section 6.3)
- Evaluate and screen the retained remedial technologies and process options with respect to effectiveness, ease of implementability, and relative cost. Technologies and process options that have low effectiveness, low implementability, or high cost to address the affected media are eliminated from further consideration in this FS. (Section 6.4)
- Present the retained technologies and process options for the affected media, which are developed into remedial alternatives as presented in Section 7. (Section 6.5)

The remainder of this section evaluates GRAs, technologies, and process options that are potentially viable for addressing them to meet the RAOs and ARARs discussed in Section 5.

6.1 General Response Actions

General response actions are broad classes of actions that may satisfy MTCA requirements for the site. General response action categories for the site are assembled based on the nature and extent of contamination, as described in Section 4. The general response actions identified for the Site include the following:

- Institutional Controls
- Monitoring
- Monitored Natural Attenuation (MNA)
- Containment
- Treatment
- Removal, Transport, and Disposal

Monitoring involves physical and/or chemical measures applied to affected media to determine if there is contaminant migration. Monitoring is not intended to substitute for any engineering aspect of a selected remedy and does not physically address contaminants.

MNA involves the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The processes, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, and/or concentration of contaminants in soil and/or groundwater

Institutional controls involve administrative, informational, and/or physical measures intended to control or prevent present and future use or access to affected media and inform and warn of dangers associated with these media. Institutional controls often involve deed restriction or covenants, use restrictions and/or CDs. These controls are not intended to substitute for engineering aspects of a selected remedy and do not physically address contaminants; however, they are implemented to prohibit activities that may interfere with the integrity of the remedial action or result in exposure to affected media at the Site.

Containment involves physical measures applied to affected media to control the release of contaminants and/or prevent direct contact or exposure to the contaminants.

Treatment involves biological, chemical, thermal, and/or physical measures applied to the contaminated media that reduce toxicity, mobility, and/or volume of the contaminants present

Removal, transport, and disposal involves a complete or partial removal of affected media, followed by transportation and disposal at an onsite or offsite location.

6.2 Identification of Remedial Technologies and Process Options

In this step of the FS process, remedial technology types and process options that are capable of addressing affected media are identified and organized under each GRA listed in Section 6.1. The term “technology” refers to general categories of technologies, the term “process option” refers to

CDM Smith

specific alternative process' within each technology family. This section describes potentially viable remedial technologies and process options for the affected media.

Remedial technologies and process options were assembled using the Federal Remediation Technologies Roundtable (FRTR) Remediation Technologies Screening Matrix and Reference Guide, Version 4.0 (EPA 2007), the Abandoned Mine Site Characterization and Cleanup Handbook (EPA 2000a), Presumptive Remedy Guidance for Metals-in-Soil Sites (EPA 1999), the Bureau of Land Management (BLM) Abandoned Mine Land Program Policy Handbook (BLM 2007), Abandoned Mine Waste Repositories – Site Selection, Design, and Cost (BLM 2003), published literature and vendor information, and engineering judgment based on experience from other remediation projects.

Potentially viable remedial technologies and associated process options identified for remediation of affected soil and groundwater media are presented in **Table 6-1** and **Table 6-2**, respectively.

6.3 Screening of Remedial Technologies and Process Options for Technical Implementability

The remedial technologies and process options presented on **Table 6-1** and **Table 6-2** were first evaluated and screened based on technical implementability. A wide range of potential remedial technologies and process options for the Site were reviewed to evaluate the suitability of a technology for addressing the affected soil media (**Table 6-1**) and groundwater and storm drain systems (**Table 6-2**). The references identified in Section 6.2 were also used to perform the screening.

A given technology or process option was eliminated from further consideration on the basis of technical implementability if site conditions or site characterization data indicated that the technology or process option is incompatible with the contaminants or cannot be implemented effectively because of physical limitations or constraints at the Site. Factors that commonly influence this step of the screening process include, but are not limited to, the type of contaminants and extent of contaminated materials.

The process options eliminated from further consideration in this FS (with the rationale for elimination) are indicated on **Table 6-1** and **Table 6-2** using shading. Retained technologies and process options were then carried forward to the second step of the evaluation process as discussed in Section 6.4. The screening resulted in the following general conclusions:

- Remedial technologies/process options exist that should be eliminated and have no further consideration, because they are unable to remediate the affected soil and groundwater media.
- Remedial technologies/process options exist that have substantial potential and applicability as a stand-alone remedy for affected soil and groundwater media.

- Remedial technologies/process options exist that could provide remedial benefits in combination with other remedial technologies but would likely only have cost-effective application for specific site elements and particular conditions and will likely be retained for further evaluation.

6.4 Evaluation of Remedial Technologies and Process Options for Effectiveness, Implementability, and Relative Cost

Each of the technically implementable remedial technologies and process options retained from the preliminary screening process presented in Section 6.3 were further evaluated to determine whether they should be eliminated from further consideration in the FS or retained for inclusion within remedial alternatives.

6.4.1 Evaluation Criteria

Each remedial technology or process option was qualitatively evaluated for effectiveness, implementability, and relative cost. The criteria used, as defined in this step of the FS process, are as follows:

Effectiveness: The evaluation of the effectiveness of a remedial technology or process option focuses on:

- Potential effectiveness of each technology or process option in remediating the affected soil and groundwater and meeting the objectives identified in RAOs.
- Potential effectiveness of a given process option or technology in remediating the affected soil and groundwater contamination, given the nature and extent (volumes, concentrations, depths, locations, etc.).
- Potential impacts to human health and the environment during construction and implementation.
- Evaluation of the success of the remedial technology and process option at other sites with similar contaminants and site conditions, including the maturity of the technology (i.e. proven "mature" technology versus innovative or experimental)

Implementability: This criterion focuses on the relative degree of technical and administrative feasibility of implementing a given technology or process option. This criterion focuses on:

- Ability to obtain permits
- Administrative/institutional feasibility
- Availability and capacity of treatment, storage, materials, and disposal services
- Availability of necessary equipment and skilled workers
- Physical constraints (e.g., presence of site infrastructure such as utilities, buildings, etc.)

Relative Cost: Cost plays a limited role in the screening of technologies and process options. Relative capital and operation and maintenance (O&M) costs are used. The evaluation of cost is based on engineering judgement and considered relative to other process options in the same technology type. Since remedial alternatives and associated quantities are not defined during technology and process option screening, relative cost is presented qualitatively rather than quantitatively.

Based on the evaluation of effectiveness, implementability, and relative cost, each of the technologies or process options are then either retained or eliminated from further evaluation. The following subsections further describe and summarize the screening results for each general response action.

6.4.2 Screening Evaluation

Each of the remedial technologies and process options retained from the first screening step for the affected soil and groundwater were evaluated against the three criteria identified in Section 6.4.1 to determine whether they should be eliminated from further consideration in the FS or retained for assembly into remedial alternatives. The results of this second screening step are presented on **Table 6-3** and **Table 6-4**. **Exhibit 6-1** presents the qualitative rating system used in conjunction with the stated rationale to justify the ratings with respect to each criterion.

Exhibit 6-1 Qualitative Rating System for Screening of Remedial Technologies and Process Options

Effectiveness and Implementability		Relative Cost	
⓿	None	⓿	None
❶	Low	$	Low
❷	Low to moderate	$$	Low to moderate
❸	Moderate	$$$	Moderate
❹	Moderate to high	$$$$	Moderate to high
❺	High	$$$$$	High

The evaluation and screening process is inherently qualitative. The evaluation criteria described in Section 6.4.1 are specified by EPA RI/FS guidance (EPA 1988); however, the degree to which the criteria are weighted against each other is not specified. Determination of how the individual evaluation criterion should influence the overall rankings is subjective and based on site-specific considerations and professional judgment. The factors considered for each of the three criteria that justify retention or elimination are rated using the qualitative rating system. For the effectiveness and implementability criteria, a "low" rating was the least preferable and a "high" rating was the most preferable. For relative cost criteria, a "low" rating indicated a relatively low cost (most preferable) while a "high" rating indicated a relatively high cost (least preferable).

Remedial technologies or process options deemed to have low effectiveness, low implementability, and/or high relative cost for affected soil and groundwater media are eliminated from further consideration in the FS for development of remedial alternatives and are indicated in **Table 6-3** and **Table 6-4** using shading. The factors considered for each of the three criteria that provide justification for retention or elimination are also summarized. The applicable locations for implementation of a retained process option (either for site-wide application or for particular remediation subareas on the site) is also considered during screening of the process options, and as appropriate, the site-specific applicability is clarified in the process option description.

6.5 Retained Remedial Technologies, and Process Options

Based on the results of the two-step screening process described in Sections 6.3 and 6.4, a reduced number of remedial technologies and process options for affected soil and groundwater media were retained for further evaluation and the development of remedial action alternatives as discussed further in Section 7. These retained remedial technologies and process options are presented in **Exhibit 6-2**.

Exhibit 6-2 Retained Remedial Technologies and Process Options for Development of Remedial Alternatives

Affected Media	Remedial Technology	Process Option
Soil	Physical and/or chemical monitoring	Non-intrusive visual inspection
	Administrative controls	Governmental controls, proprietary controls, and informational devices
	Community awareness	Informational and educational programs
	Access controls	Access restrictions
	Surface source controls	Engineering cover, exposure barriers
	Removal	Excavation (mechanical, pneumatic, or hydraulic)
	Transport	Mechanical transport (hauling/conveying)
	Disposal	Disposal at offsite facility
	Ex-situ treatment	Stabilization/solidification
	In-situ treatment	Stabilization/solidification
Groundwater	Physical and/or chemical monitoring	Sample collection and analysis
	MNA	MNA
	Administrative controls	Governmental controls, proprietary controls, and informational devices
	Community awareness	Informational and educational programs
	Physical Barriers	Slurry wall/grout curtain/sheet piling
	Hydraulic isolation, diversion and separation	Passive and active water control measures to limit or redirect groundwater flow.

Affected Media	Remedial Technology	Process Option
Groundwater (continued)	Removal, transport, disposal	Collection/extraction, discharge to POTW, haul to waste treatment facility
	In situ Treatment	Funnel and Gate Permeable Reactive Barrier Air sparging Placement of iron in the saturated zone of the excavation backfill. In-situ Chemical Oxidation (ISCO)
	Ex situ Treatment	Water treatment to meet discharge requirements
Stormwater	Storm Drain Repair	Slip lining Replacement

Remedial technologies and process options identified to address affected soil and groundwater are retained because they either have substantial potential and applicability as a stand-alone remedy or have remedial benefits in combination with other remedial technologies but would only have cost-effective application for specific site elements and particular conditions.

It is unlikely that using or applying a single remedial technology/process option to the affected soil and groundwater materials will solely be able to achieve the RAOs or comply with ARARs. Thus, using various remedial technologies/process options in combination is likely to be necessary. Remedial technologies/process options for affected soil and groundwater media are used in various combinations for assembly of remedial alternatives as discussed in Section 7.

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Section 7

Development of Alternatives

7.1 Overview

In this section, remedial action alternatives (herein referred to as remedial alternatives) are developed by combining the retained remedial technologies and process options presented in Section 6. Remedial alternatives are developed from either stand-alone process options or combinations of the retained process options.

Five remedial alternatives were developed to address soil, groundwater and the storm drain system. Four remedial alternatives (Alternatives 1 through 4) were developed to address the three areas described in Section 4.7.4 (South Corner Area, Railroad Spur Area, Hylebos Waterway Area) to provide a representative range of potentially applicable remedial technologies for evaluation purposes. The fifth remedial alternative is a full soil removal alternative that is consistent with the MTCA definition of a permanent cleanup action for an industrial property.

The final design for the selected alternative may differ from the alternative description presented in this FS based on agency decisions, input from stakeholders and public, supplemental data that may be collected to support the design, and other factors. The assumptions affecting development of remedial alternatives, the derivation of quantities and costs for each alternative are conceptual level and based on current knowledge of site conditions and engineering judgment.

7.2 Assumptions Affecting Development of Remedial Alternatives

Several fundamental assumptions affect the development of remedial alternatives evaluated in this FS. These assumptions are driven by requirements of the RAOs and ARARs identified in Section 5 and site limitations and constraints that cannot be overcome by using one or more remedial technology/process options as described in Section 6. These fundamental assumptions were taken into consideration during development of remedial alternatives for this FS and include the items listed in **Exhibit 7-1**.

Exhibit 7-1 Assumptions Affecting Development of Remedial Alternatives

Fundamental Assumption	Rationale
Contaminated soil and protection of surface water are the focus of remedial alternative development.	The RAOs and related RAGs for soils and surface water are identified in Section 5.2 and are focused on preventing risks from direct exposure to contaminants for humans and for preventing contaminants in groundwater from migrating to surface water, causing risks to human and ecological receptors. The RAOs will be achieved by addressing the soil and groundwater contamination that result in unacceptable human health risks and prevent contaminated groundwater from migrating to surface water. Thus, soil contaminated with arsenic and/or lead and groundwater contaminated with arsenic and/or petroleum hydrocarbons as identified in Section 4 are the focus of remedial alternative development and evaluation using a range of GRAs and the retained remedial technologies and process options.
No direct remedial actions are developed for surface water	Protection of surface water will be achieved by preventing contaminated groundwater from migrating to surface water and via source removal that will further attenuate groundwater contamination.
Surface water cleanup level for arsenic is 5 µg/L, which is the same as the MTCA Method A groundwater cleanup level.	The groundwater at the Site is considered non-potable per WAC 173-340-720(2)(b)(i)&(ii) and (d). But Site groundwater ultimately discharges to marine surface water. The most stringent marine water standard is based on protection of human health-based on consumption of marine organisms, which is less than the practical quantitation limit and also less than background. In these instances, the standard defaults to background, which Ecology considers to be 5 µg/L, which is what the MTCA Method A groundwater cleanup level is based upon.
Groundwater cleanup level for TPH is 500 µg/L, which is the same as the Method A groundwater cleanup level.	The most stringent marine water standard is based on protection of human health-based on consumption of marine organisms, which have not been formally studied or established. As an alternative to calculating a site specific cleanup level for total petroleum hydrocarbons for human health protection in marine water, the total petroleum hydrocarbon cleanup level in Table 720-1 (Method A cleanup level for groundwater), which is the Method A cleanup level of 500 µg/L, may be used. .
Four out of fiver of the alternatives will ensure that, at a minimum, the acute-based soil remediation level is achieved at all locations throughout the Site and the chronic-based remediation level is statistically achieved throughout the Site.	The fifth alternative will consider the full-scale soil remediation to meet the MTCA Method C soil cleanup level (direct contact). Since there are no viable technologies to destroy arsenic, remediation is limited to removal in some form or another. Therefore, removal actions were developed using a risk-based approach. Additional limited soil removal will occur in areas to further enhance natural attenuation of arsenic in groundwater, even though arsenic concentrations do not exceed remediation levels.
With one exception, soil remedial actions will not specifically target lead exceeding its Method A industrial soil cleanup level.	For the most part, lead is co-located with arsenic and remedial actions for arsenic will remove lead concentrations exceeding the Method A industrial soil cleanup level. At one boring in the Railroad Spur Area (DPT4) the lead concentration, analyzed by XRF, was indicated to exceed the cleanup level. While the arsenic concentration did not exceed the acute remediation level in this sample, the soil excavation in this area will be extended to include this boring.
Maximum depth of any excavation for contaminated soil removal will be the tideflat layer.	Protection of the second aquifer, besides which, arsenic migration is indicated to be impeded by the tideflat layer.
Excavations will not extend under buildings.	Prior to development, the Port of Tacoma had attempted to remove all soils exceeding the Method C industrial soil cleanup level under proposed building areas. At this point, it would be obviously cost prohibitive to remove and replace the buildings to go after the minor amount of soil known to exceed cleanup and/or remediation levels.

CDM Smith

Fundamental Assumption	Rationale
The remedial alternative for the Hylebos Waterway Area will extend into the former Murray Property starting at the property boundary and extending to MW31. There are no administrative or legal hurdles to implement a cleanup action that crosses this former property boundary.	Ecology has established that FS includes evaluation of cleanup alternatives specifically of this area. The Port currently owns both parcels and is named on the Agreed Order.
Long-term monitoring of groundwater will be implemented on the Murray Pacific Property in addition to the Taylor Way Property	Required by Ecology
For costing purposes, contaminated soils are assumed not to profile as dangerous/hazardous waste.	The extensive prior interim actions completed on the Site appear to have removed soil and source materials that exceed dangerous waste limits for arsenic based on leachability. No additional soils exceeding dangerous waste limits are anticipated at this time.
Thirty-year period of evaluation for all remedial alternatives.	It is likely that all remedial alternatives would require an indefinite duration of O&M. However, evaluation of long durations of O&M is cumbersome and is generally not necessary for comparative evaluation between alternatives because of the effects of cost discounting in later years under present value analysis. The period of analysis for the FS is assumed to be 30 years, because the increase of present value cost due to small periodic expenditures for maintenance and monitoring after 30 years is minimal relative to the accuracy range of the estimates.

7.3 Common Elements to the Remedial Alternatives

The following elements are common to all the remedial alternatives.

- Institutional Controls (ICs)
- Groundwater Quality Monitoring
- Post-Construction Cap Maintenance
- Onsite Storm Drain Repair

7.3.1 Institutional Controls

All remedial alternatives will incorporate ICs. ICs are measures undertaken to limit or prohibit activities that interfere with the integrity of a remedy or that might result in exposure to hazardous substances at a site. In most cases, ICs are recorded as part of the property deed to warn future property owners of the condition and to restrict activities or use of the property that could result in exposure to hazardous substances. Tenants must also be notified of the restrictions in any lease agreement.

The circumstances where institutional controls are required as part of a cleanup action include the following (WAC 173-340-440):

- Sites where contamination remains at concentrations that exceed the established cleanup levels.
- Sites where cleanup levels are established representing concentrations that are protective of human health and the environment for specified site uses and conditions.
- Sites where cleanup levels are established based on industrial land use (soil) or a site-specific risk assessment (groundwater).
- Sites where a conditional point-of-compliance is used.
- Any time an institutional control is required under WAC 173-340-7490 through 173-340-7494 (ecological concerns).
- Where the department determines such controls are required to assure the continued protection of human health and the environment or the integrity of the interim or cleanup action.

Types of ICs include:

- Proprietary controls: include property use restrictions based on private property laws (easements and covenants).
- Governmental controls: include local laws or permits (zoning; building codes; state, tribal, or local groundwater use regulations; and commercial fishing bans and sports/recreational fishing limits posed by federal, state, and/or local resources and/or public health agencies).
- Enforcement tools: include documents that require individuals or companies to conduct or that prohibit specific actions (administrative orders, permits, and CDs, or unilateral orders).
- Informational devices: include notices in deeds or public advisories that alert and educate public about the site.

ICs for the Site will include an environmental covenant that will, at a minimum:

- Restrict certain activities that may impact or interfere with the remedial action(s) and any operation, maintenance, monitoring, or inspection of monitoring wells, capped areas, or groundwater barrier systems.
- Restrict any activities that may threaten continued protection of human health and environment.
- Prohibit non-industrial land use.
- Prohibit groundwater extraction for any water supply purpose.
- Require adherence to a contaminated materials management plan for future activities that would result in soil disturbance.

Where ICs are required, Ecology will conduct five-year reviews to evaluate whether human health and environment are being protected, including review of groundwater use and groundwater and cap monitoring results.

7.3.2 Groundwater Quality Monitoring

The purpose of a groundwater quality monitoring program is to verify that plumes are not migrating to non-impacted areas, to verify reduction in overall contaminant concentrations in groundwater over time, and to ensure that the contaminated groundwater is not reaching the Hylebos Waterway. Groundwater quality monitoring will be conducted as part of the performance and confirmation monitoring per WAC 173-340-410(1)(b) and (c) to ensure the remedy is performing as intended, as well as the long term effectiveness of the remedy. A groundwater quality sampling and analysis plan will be developed and submitted to Ecology with the O&M plan (WAC 173-340-400) for review and approval during the implementation of the remedial action. The plan will specify the groundwater samples to be collected, the handling of the samples, and the analysis procedures to be performed per WAC 173-340-820.

7.3.3 Post-Construction Cap Maintenance

The term "cap" is used broadly here, in that the "cap" is defined as, singularly or any combination of, clean fill soils, landscaping, gravel, pavement, and/or buildings that are placed on the site or left in place after the final remedy is implemented. The primary purpose of the "cap" at the site is to contain contamination (e.g., mitigate dust control) and mitigate risk of direct human contact with affected soils that exceed MTCA Method A unconditional land use soil cleanup levels that may remain onsite. The cap will not be designed to minimize infiltration; it is not considered necessary. A Cap Inspection and Maintenance Plan, included as part of the Operations Maintenance and Monitoring Plan (OMMP), subject to review and approval by Ecology, will be developed for the Taylor Way Property. Any activities that will disturb the capped area will comply with this plan. Periodic inspection of the cap will be performed to evaluate the condition and performance of the cap. Detailed provisions of periodic inspections will be included in the Cap Inspection and Maintenance Plan. Existing buildings and paved areas would remain; potential future disturbance of soil under these areas will be addressed in the Cap Inspection and Maintenance Plan.

7.3.4 Storm Drain Repair

As discussed in Section 4, the Taylor Way Property stormwater system was compromised during redevelopment and groundwater impacted by arsenic is entering the drain and discharging to the Hylebos Waterway. All five alternatives include a component to repair the onsite storm drain system to ensure it is watertight and not a conduit for groundwater discharge to surface water. The length of the storm drain line believed to require repair is indicated on **Figure 14**.

Storm drains can be repaired in place through slip lining or cured in place pipe (CIPP) technology (also called "trenchless" technology). Alternatively, if the pipe is too damaged, or if only a small section of pipe needs to be repaired, the old pipe can be removed using conventional excavation and trenching and rebuilt to be watertight.

With slip lining, a smaller diameter pipe (typically high density polyethylene [HDPE]) is threaded through the existing pipe and the annulus between the old and new pipe is grouted to provide a seal. Thus, slip lining effectively installs an entirely new pipe within the old pipe; however, the new pipe diameter will be smaller, which can be an issue if the resulting capacity is insufficient.

For the CIPP technology, a flexible felt liner soaked in epoxy resin is threaded through the pipe to be lined. The felt ensures good contact with the interior of the pipeline and conforms to any irregularities in the shape of the pipe. The liner material is then "inflated" and cured in place using hot air. This creates a new, continuous, smooth, intact pipe interior.

Both slip lining and CIPP storm drain repair technologies would be considered equally protective, so the final selection in design will be based on cost.

Additionally, dry weather flow occurs in the City's storm drain system under Taylor Way; there is a possibility that groundwater attributable to the Taylor Way Property could be entering the City's system and affecting water quality. Two out of five of the alternatives include a component to repair the storm drain line in Taylor Way, as is described in Section 7.4 and a third alternative provides this as a contingency. Given the diameter of this line, and its location in the road, slip lining, instead of replacement, was determined be the most cost effective approach. Slip lining would need to occur throughout the length of the storm drain line between manholes. Beginning at the manhole at the south corner entrance to the Site, slip lining would occur approximately 425 feet to the northwest and 400 feet to the southeast (see **Figure 14**).

Similar to the cap, the Site's storm drain system and the repaired storm drain line in Taylor Way, if applicable, would require long term inspection and maintenance.

7.4 Description of Alternatives

As described above, five remedial alternatives were developed to address soil and groundwater. Alternatives #1 through #4 focus on the three areas identified that require remedial actions due to potential impacts to surface water (either directly or indirectly) and/or exceedance of the acute-based remediation level for arsenic in soil.

Table 7-1 provides a matrix summary of the components of the five alternatives, including the elements common to all of them. Variation among the first four alternatives for soil and groundwater occurs in the South Corner Area and the Hylebos Waterway area. The scope of the soil removal and groundwater remediation in the Railroad Spur area is the same among Alternatives 1 through 4. Alternative 5 is a full soil removal alternative of soils exceeding 88 mg/kg arsenic, which is consistent with the MTCA definition of a permanent cleanup action for an industrial property. The alternatives are described in further detail in the subsections below.

7.4.1 Alternative 1 – Selective Excavation of Soils, Air Sparging and/or ISCO for Groundwater, Onsite Storm Drain Repair/Replacement

7.4.1.1 Soils

Alternative 1 was developed to evaluate excavation of soils exceeding the acute-based remediation levels for arsenic, as well as selective excavation of soils with elevated arsenic concentrations to facilitate groundwater remediation through natural attenuation with the purpose of protecting surface water. The approximate extents of the excavations are shown on **Figure 15** through **Figure 17** and are described as follows:

- South Corner Area: The intent of soil excavation in the South Corner Area will be not only to remove soils exceeding the acute criteria, but also to minimize the leachability of arsenic in soil in an effort to reduce arsenic concentrations in the surface aquifer. Decreasing arsenic concentrations in the surface aquifer may also result in the reduction of arsenic concentrations in the second aquifer and limit impacts to the storm drain line. As depicted on **Figure 15**, soil excavation will occur generally along the current/former gas utility line, extending from approximately NB-45 to just past NB-27 (a distance of approximately 230 feet) approximately 10 feet on either side of the gas utility line. The depth of the excavation will range from approximately 4 to 6 feet and likely average about 5 feet deep. This area is targeted as it appears that relatively high arsenic concentrations are situated along the utility line and may be acting as an ongoing source of groundwater contamination. For planning purposes, the total estimated volume of soil removed is 900 cubic yards (cy).

- Railroad Spur Area: Excavation will occur in three areas to remove soils found to exceed the acute-based soil remediation level at DPT2, DPT5A, and TP9/MW27. Excavation at DPT4 will also occur to remove soil exceeding the Method A industrial soil cleanup level for lead, which is 1,000 mg/kg. For planning purposes, three excavations are estimated with dimensions of approximately 19 ft by 14 ft and 5 ft deep (DPT5A), 22 ft by 18 ft and 3 ft deep (DPT2), and 36 ft by 50 ft and 3 ft deep (TP9/MW27/DPT4), as indicated on **Figure 16**. Based on these dimensions, approximately 300 cy of soil would be removed.

- Hylebos Waterway Area: Soil excavation will occur in two areas. Within the area of DPT7 and MW29, soil excavation will target removal of soils exceeding the acute-based soil remediation level. Due to the close proximity of MW28, with arsenic concentrations exceeding the chronic-based remediation level and presence of wood fibers in the saturated zone, the excavation would extend to just past MW28 as well. Additionally, soil with elevated arsenic concentrations found at 12 ft bgs at DPT37 immediately next to the Hylebos Waterway would also be excavated. The areas of excavation not only target soils exceeding the chronic-based remediation level, but also remove higher arsenic concentrations in soils with the intent of further mitigating arsenic in groundwater close to the Hylebos Waterway. The soil at DPT37 would be excavated rather than relying on ISCO (Alternative 1 groundwater treatment method, see Section 7.4.1.2) because of the close proximity to the Hylebos where control of injected chemical reagents would be difficult. The conceptual excavation areas are shown on **Figure 17**. Based on these dimensions, approximately 567 cy of soil would be removed. Due to the depths of the excavations, it is assumed that sheet-pile shoring will be used to maintain the integrity of the excavation area. Because soil will be excavated below the water table, it is also assumed that bentonite or a similar absorbent material will be used to absorb water in the soils to be excavated using mechanical means. This will allow a more complete capture of contaminated soil below the water table.

All contaminated excavated soils, following appropriate profiling, would be transported to a Subtitle D landfill for disposal. After excavation of these soils, clean fill would be placed in the excavation, compacted, and the areas would be returned to their original grade and surfacing (e.g., gravel, pavement).

In the South Corner area, coordination with the utilities and temporary shutoff of the gas line is assumed for reasons of safety. For this extent of excavation near utility lines, hydro excavation (utilizing pressurized water followed by vacuum excavation of the slurry generated) could be used. Hydro excavation is a method to excavate around utility lines without damaging the lines. Because the cost difference between mechanical and hydraulic excavation is nominal, mechanical excavation is assumed in the cost estimate. The exact excavation method would be specified in the design.

7.4.1.2 Groundwater

For the South Corner Area and the Railroad Spur Areas, continued reduction in arsenic concentrations in groundwater would occur via MNA after removal of soils. For groundwater in the Railroad Spur Area, the point of compliance has already been met as it has already been demonstrated that arsenic concentrations in groundwater in the Murray Pacific Property downgradient of this area currently meet the surface water standard. For the South Corner Area, MNA following soil removal is proposed to address potential infiltration of groundwater in the storm drain system in Taylor Way.

Elevated arsenic and petroleum hydrocarbon concentrations in groundwater in the Hylebos Waterway area would be addressed through in situ treatment using air sparging and/or ISCO recirculation. In situ treatment consists of actions that treat contaminants in place by facilitating chemical stabilization and immobilization. The approach would promote in situ attenuation of arsenic to prevent it from migrating to the Hylebos Waterway. The extent of groundwater envisioned for air sparging/ISCO recirculation in the Hylebos Waterway Area is depicted on **Figure 17**, spanning an area of approximately 18,000 square feet.

Three “tiers” of in situ treatment with degrees of chemical reagent addition are conceptualized for Alternative 1; the final approach can be determined with pilot testing and design. For costing purposes in the FS, the most reagent-intensive, third tier was assumed.

In areas with higher concentrations of iron in a primarily reduced and soluble form, pressurized air can be injected by sparging into the aquifer to oxidize the existing soluble ferrous iron to form solid ferric iron oxyhydroxides. These iron oxyhydroxides will co-precipitate arsenic (and other metals) from solution and create a solid phase with a highly sorptive surface area. Air sparging will also enhance the degradation of residual hydrocarbons. In this first tier, no supplemental reagents other than air would be necessary.

If existing iron concentrations in groundwater are insufficient, supplemental dissolved iron can be added. In this second tier, ferrous sulfate solution would be injected into the groundwater, followed by air sparging to oxidize the ferrous iron to ferric iron. Formation of iron oxyhydroxides, coprecipitation and adsorption of arsenic would follow.

If air sparging is an insufficient oxidant, chemical oxidants can be used as a third tier. A similar geochemical process can be achieved by injecting or introducing an oxidant into the subsurface (with or without supplemental iron). Chemical oxidation is a technology that is potentially effective on both the residual organic contaminants at the Site, as well as the arsenic. For organics, chemical oxidation converts organic materials to carbon dioxide and water. For arsenic, chemical oxidation converts the relatively mobile trivalent form of arsenic (As III) to the less mobile (As V) form. In addition, ISCO converts ferrous iron present within the aquifer to ferric iron, producing arsenic-bearing ferric iron oxyhydroxide. Chemical oxidants include sodium permanganate ($NaMnO_4$), hydrogen peroxide (H_2O_2), sodium persulfate ($Na_2S_2O_8$) and others. Previous studies for another USG site impacted by the same sources of arsenic have shown sodium permanganate to be superior to the other oxidants in terms of effectiveness and minimal adverse effects. Persulfate was found to result in unacceptably low pH values (~3 standard units [su]), while hydrogen peroxide was not as specific to iron and arsenic, compared to permanganate. However, an alkaline-activated persulfate chemical oxidant has recently been developed to address the low pH values. Any of these oxidants may be appropriate at the Site.

Because of the use of strong chemical oxidants, for this third tier, it is assumed that a groundwater recirculation system will be necessary to contain and recirculate oxidant chemicals and prevent unreacted chemicals from migrating into the Hylebos Waterway. This recirculation system would require the pipes to be buried below the ground surface to minimize disruption to the current business. Because the saturated interval near the Hylebos Waterway is only about 1.5 to 3 feet thick, the recirculation system envisioned would consist of an extraction trench and an upgradient infiltration trench.

For the purposes of cost estimation, it is assumed that the representative chemical reagent to be used for ISCO is permanganate. Furthermore, because ISCO often takes multiple applications to ensure complete oxidation, for the purposes of cost estimation, it is assumed that ISCO will take three applications over the course of the first 2 years and then one application every 5 years thereafter.

7.4.2 Alternative 2 – Selective Excavation of Soils, Soil Solidification/Stabilization, Funnel and Gate PRB for Groundwater, Onsite Storm Drain Repair/Replacement

7.4.2.1 Soils

Alternative 2 was developed to evaluate a combination of selective excavation and treatment of soils exceeding the acute-based remediation level for arsenic, as well as selective excavation of soils with elevated arsenic concentrations to facilitate groundwater remediation through natural attenuation with the purpose of protecting surface water. Additional soils with elevated arsenic concentrations will undergo solidification/stabilization to facilitate groundwater remediation with the purpose of protecting surface water. These areas and the approximate extents of excavation are shown on **Figure 15** through **Figure 17** and are described as follows:

- South Corner Area: Soil excavation will center on DPT13 where a soil sample collected at 3.5 ft bgs exceeded the acute-based arsenic soil remediation level of 1,060 mg/kg. For planning purposes, the excavation is estimated to be 10 ft by 20 ft and 4 ft deep, centered on either side of the gas utility line as indicated on **Figure 15**. Based on these dimensions, approximately 30 cy of soil would be removed. It is assumed that coordination with the utility for temporary shut off and hydro excavation (using pressurized water to wash soils from around utility lines, followed by vacuum excavation) or excavation with hand tools will be necessary to remove the contaminated soils safely. In addition, soil with elevated arsenic concentrations along the utility corridor (generally between NB45 and NB29) and soil parallel to Taylor Way will be treated through solidification/stabilization (S/S) as indicated on **Figure 15** (see further discussion below).

- Railroad Spur Area: Alternative 2 uses the same soil excavation scenario as was described for Alternative 1.

- Hylebos Waterway Area: Alternative 2 uses the same soil excavation scenario as was described for Alternative 1. Soil excavation at DPT37 will similarly occur as described in Alternative 1 as it is expected to lie between the PRB and the Hylebos Waterway.

All contaminated excavated soils, following appropriate profiling, would be transported to a subtitle D landfill for disposal. The South Corner Area and the Railroad Spur Area excavations will be backfilled with clean fill, compacted and the areas returned to their original condition (e.g., gravel, pavement). In the Hylebos waterway area, the excavated area between DPT7 and MW28 would be incorporated into the funnel and gate PRB (described further in the next section under groundwater). The DPT37 excavation area is downgradient of the PRB alignment and thus would be backfilled with clean fill and returned to its original grade and surfacing (gravel).

For this alternative, S/S in the South Corner Area is expected to further minimize the leachability of arsenic in soil with the intent of reducing arsenic concentrations in the surface aquifer. Reduction of arsenic concentrations in the surface aquifer may also result in the reduction of arsenic concentrations in the second aquifer and limiting impacts to the storm drain line. S/S is a well-accepted technology. *Solidification* is typically carried out using a cement of some type, while *stabilization* is provided by addition of chemical reagents either before or during the solidification process. Bentonite is typically added to Portland cement in concentrations of 1 to 2 percent to reduce the permeability of the solidified material. Bentonite is a type of clay that swells when water is added, which can be effective in filling pore spaces and connections between pores, even at low doses, thereby reducing groundwater flow through the contaminated material. S/S in which iron solutions are used in conjunction with cement, is referred to as the "iron flood" method. The iron flood method has been used successfully for stabilizing arsenic-bearing treatment sludge (Palfy et al. 1999) and in chromated copper arsenate (CCA)-treated wood, mine tailings, and smelter-impacted soil (Randall 2012).

S/S involves the in-place mixing of agents into the soil using backhoe/excavator, mixing injector, horizontal rotary mixer, vertical auger mixing, or jet grouting. S/S would immobilize and encapsulate arsenic contaminated soils and create a low permeability zone forcing groundwater to flow around the contaminated zone instead of through it.

For this alternative it is assumed that contaminated soil along the South Corner Area between NB-45 and NB-29 would undergo S/S. Additional soil parallel to Taylor Way would also under go S/S to reduce potential groundwater migration from the Taylor Way property toward the storm drain and further isolate and control leaching to groundwater. The approximate area of S/S is shown on **Figure 15**.

7.4.2.2 Groundwater

For the South Corner Area and the Railroad Spur areas, continued reduction in arsenic concentrations in groundwater would occur via MNA after removal of soils and S/S. For groundwater in the Railroad Spur Area, the point of compliance has already been met as it has already been demonstrated that arsenic concentrations in groundwater in the Murray Pacific Property downgradient of this area currently meet the surface water standard. For groundwater in the South Corner Area, MNA would be further promoted both in the surface and second aquifer because groundwater would no longer interact with soils containing higher concentrations of arsenic due to the lower permeability.

Elevated arsenic concentrations in groundwater in the Hylebos Waterway Area would be addressed through in situ treatment using a PRB in a funnel and gate arrangement. A PRB entails subsurface placement of reactive materials across the natural flow path of a dissolved contaminant plume. Contaminated groundwater flows through the reactive wall and exits the other side as treated groundwater. The PRB can be combined with vertical barriers (e.g., slurry walls, sheet piling, etc.) in a funnel and gate arrangement in which the slurry walls, constructed on either side of the wall of reactive materials, directs groundwater flow through the treatment zone.

This feature would be constructed perpendicular to groundwater flow, for a length of approximately 230 feet parallel to the Hylebos Waterway (generally between wells MW8 and MW31), as indicated on **Figure 17**. The PRB treatment zone (gate), is estimated to be about 60 feet long (generally between MW37 and MW28, targeting the low point in the tideflat). The funnel and gate PRB would be keyed into the low permeability tideflat layer. A conceptual cross section of the funnel and gate PRB is depicted in **Figure 18**.

Slurry walls are constructed of a mixture of soil, bentonite, and water. Bentonite is a type of clay that swells when water is added, which can be effective in filling pore spaces and connections between pores, even at low doses. To construct the slurry wall, a bentonite slurry is used for wall stabilization during excavation. A soil-bentonite backfill material is then placed into the trench, displacing the slurry, to create the low permeability wall. It is assumed that the onsite soil excavated from the trench could be incorporated into the slurry wall mixture, with the exception of the areas of contaminated soil excavation described above.

Slurry walls of this composition provide a barrier with low permeability (typically 10^{-7} centimeters/second) and chemical resistance at low cost. Other wall compositions may be used if greater structural strength is required, or if chemical incompatibilities exist. Other critical factors include acceptability of the site soil for use as part of the backfill mixture, trench stability, chemical compatibility, available work area, water availability, longevity, and availability of off-site backfill materials, if needed.

Slurry walls can be constructed at depths up to 100 feet and are generally 2 to 4 feet thick. The most effective application of a slurry wall is to base (or key) the slurry wall 2 to 3 feet into a low-permeability layer at depth such as clay or bedrock. This "keying-in" provides an effective foundation with minimum potential for leakage or short-circuiting under the slurry wall. In the Hylebos Waterway area, the slurry wall would be tied into the relatively impermeable tideflat layer at about 10 to 15 ft bgs.

The materials used for PRBs are contaminant-specific. For arsenic, PRBs are constructed out of materials that have a high adsorption capacity for arsenic, such as ZVI or other proprietary compounds. Groundwater with dissolved arsenic comes into contact with the ZVI (or other compound), which corrodes (rusts), forming a high surface area material that has a high adsorption capacity for arsenic. As the groundwater passes through the wall, arsenic is removed, resulting in much lower arsenic concentrations on the down-gradient end of the wall.

For the purposes of the FS, the reactive zone would consist of a mixture of 80 percent sand and 20 percent ZVI. To ensure groundwater flows through the PRB, a medium to very coarse grain size (approximately 8 to 50 mesh U.S. standard sieve size) will be assumed for both sand and ZVI to provide an average hydraulic conductivity of about 5×10^{-2} centimeters per second (142 ft/day) (ITRC 2011). The cross-sectional width would be about 1.5-2 feet, typical of the width of the bucket on an excavator. The cross-sectional thickness and composition of the PRB would be refined in design.

The PRB would not directly address petroleum hydrocarbon concentrations in groundwater. However, the excavations that will occur in this area will also be removing soils with residual wood fibers, particularly as was seen in the area of MW28/MW29. This may promote further reduction in the TPH concentrations as a result of wood-based organics. Beyond this, MNA is recommended.

7.4.3 Alternative 3 – Selective Excavation of Soils, Funnel and Gate PRB for Groundwater, Supplemental in Excavation Iron Addition, On- and Off-site Storm Drain Line Repair/Replacement

7.4.3.1 Soils

Alternative 3 was developed to evaluate excavation of soils exceeding the acute-based remediation level for arsenic, as well as selective excavation of soils elevated arsenic concentrations. The excavations would facilitate groundwater remediation through natural attenuation with the purpose of protecting surface water, the same as was outlined for Alternative 2. As was indicated in Alternative 2, excavation of arsenic-contaminated soils at depth along the Hylebos, but downgradient of the proposed PRB alignment will occur, but in addition, prior to backfilling, ZVI will be placed at the base of the excavation to further mitigate residual arsenic contamination in groundwater that will not be treated by the PRB. These areas and the approximate extents of excavation are shown on **Figure 15** through **Figure 17**. The extents of excavation are described as follows:

- South Corner Area: Soil excavation would center on DPT13 where a soil sample collected at 3.5 feet below ground surface (ft bgs) exceeded the acute-based soil remediation level of 1,060 mg/kg. For planning purposes, the excavation is estimated to be 10 ft by 20 ft and 4 ft deep, centered on either side of the gas utility line as indicated on **Figure 15**. Based on these dimensions, approximately 30 cy of soil would be removed (Same as Alternative 2). It is assumed that coordination with the utility for temporary shut off and hydro excavation (using pressurized water to wash soils from around utility lines, followed by vacuum excavation) or excavation with hand tools will be necessary to remove the contaminated soils safely.

- Railroad Spur Area: Alternative 3 uses the same soil excavation scenario as was described for Alternative 1.

- Hylebos Waterway Area: Alternative 3 uses the same soil excavation scenario as was described for Alternative 2.

All contaminated excavated soils, following appropriate profiling, would be transported to a Subtitle D landfill for disposal. After excavation of these soils in the South Corner Area and the Railroad Spur Area, clean fill would be placed in the excavation, compacted, and the areas would be returned to their original grade and landscaping (e.g., gravel, pavement).

In the Hylebos waterway area, the excavated area between DPT7 and MW28 will be incorporated into the funnel and gate PRB (as previously described for Alternative 2). The DPT37 excavation area is downgradient of the PRB alignment. Prior to backfilling ZVI would be added to the saturated zone in the excavation to attenuate residual arsenic in groundwater downgradient of the PRB. The area would then be backfilled to its original grade and gravel surfacing.

7.4.3.2 Groundwater

For the South Corner Area and the Railroad Spur Areas, continued reduction in arsenic concentrations in groundwater would occur via MNA after removal of soils. For groundwater in the area of the Railroad Spur, the point of compliance has already been met as it has already been demonstrated that arsenic concentrations in groundwater in the Murray Pacific Property downgradient of this area currently meet the surface water standard. For groundwater in the South Corner Area, the point of compliance will be met by installing a slip line in the Taylor Way storm drain line as indicated in Section 7.3.4.

Similar to Alternative 2, elevated arsenic concentrations in groundwater in the Hylebos Waterway Area would be addressed through in situ treatment using a PRB in a funnel and gate arrangement. As described above, the area around DPT37 would be excavated to remove the contaminated soils at depth that would be on the downgradient side of the PRB. Additional ZVI would be placed in the bottom of the excavation as a means to more quickly attenuate residual arsenic prior to backfilling.

Also, as for Alternative 2, MNA would be recommended for the residual petroleum hydrocarbon plume following soil excavation and implementation of the PRB.

7.4.4 Alternative 4 – Selective Excavation of Soils, Funnel and Gate PRB for Groundwater, Supplemental in Excavation Iron Addition, Onsite Storm Drain Line Repair/Replacement

7.4.4.1 Soils

Similar to the first three alternatives, Alternative 4 was developed to evaluate excavation of soils exceeding the acute-based remediation levels for arsenic, as well as selective excavation of soils with elevated arsenic concentrations to facilitate groundwater remediation through natural attenuation with the purpose of protecting surface water. Alternative 4 uses features of both Alternatives 1 and 3. As was indicated in Alternative 3, excavation of arsenic-contaminated soils at depth along the Hylebos downgradient of the proposed PRB alignment will occur, but in addition, prior to backfilling, ZVI will be placed at the base of the excavation to further mitigate residual arsenic contamination in groundwater that will not be treated by the PRB. These areas and the approximate extents of excavation are shown on **Figure 15** through **Figure 17**. The extents of excavation are described as follows:

- South Corner Area: Alternative 4 uses the same soil excavation scenario as was described for Alternative 1, which is the greater soil excavation area than proposed for Alternatives 2 and 3.
- Railroad Spur Area: Alternative 4 uses the same soil excavation scenario as was described for Alternatives 1 through 3.
- Hylebos Waterway Area: Alternative 4 uses the same soil excavation scenario as was described for Alternative 2.

All contaminated excavated soils, following appropriate profiling, would be transported to a Subtitle D landfill for disposal. After excavation of these soils in the South Corner Area and the Railroad Spur Area, clean fill would be placed in the excavation, compacted, and the areas would be returned to their original grade and landscaping (e.g., gravel, pavement).

The same as for Alternative 3, in the Hylebos waterway area, the excavated area between DPT7 and MW28 will be incorporated into the funnel and gate PRB (as previously described for Alternative 2). The DPT37 excavation area is downgradient of the PRB alignment. Prior to backfilling ZVI would be added to the saturated zone in the excavation to attenuate residual arsenic in groundwater downgradient of the PRB. The area would then be backfilled to its original grade and gravel surfacing.

7.4.4.2 Groundwater

For the South Corner Area and the Railroad Spur Areas, continued reduction in arsenic concentrations in groundwater would occur via MNA after removal of soils. For groundwater in the area of the Railroad Spur, the point of compliance has already been met as it has already been demonstrated that arsenic concentrations in groundwater in the Murray Pacific Property downgradient of this area currently meet the surface water standard. For the South Corner Area, MNA following soil removal is proposed to address potential infiltration of groundwater in the storm drain system in Taylor Way.

Similar to Alternative 2, elevated arsenic concentrations in groundwater in the Hylebos Waterway area would be addressed through in situ treatment using a PRB in a funnel and gate arrangement. As described above, the area around DPT37 would be excavated to remove the contaminated soils at depth that would be on the downgradient side of the PRB. Additional ZVI would be placed in the bottom of the excavation as a means to more quickly attenuate residual arsenic prior to backfilling.

Also, as for Alternative 2, MNA would be recommended for the residual petroleum hydrocarbon plume following soil excavation and implementation of the PRB.

7.4.5 Alternative 5 - Full Soil Excavation to Method C Soil Cleanup Level, MNA for Groundwater, On- and Off-site Storm Drain Line Repair/Replacement

7.4.5.1 Soils

Alternative 5 was developed to be the "full removal" alternative, consistent with the MTCA definition of a permanent cleanup action for an industrial property. Soils with arsenic concentrations greater than 88 mg/kg would be removed, except for those below the existing buildings and other infrastructure. The maximum excavation depth of any removal would be the tideflat layer, to protect the second aquifer. The estimated excavation extents are depicted on **Figure 19**, the estimated volume of which is 22,321 cy. All contaminated excavated soils, following appropriate profiling would be transported to a Subtitle D landfill for disposal. It is assumed that all monitoring wells (approximately 12) located within the excavation areas would need to be abandoned, approximately 10 of which would need to be reinstalled afterward.

Because soils will be excavated below the water table, it is assumed that some hydraulic excavation (slurry pumping) will be necessary, followed by dewatering of the slurried soils, containment of that water, treatment, and disposal at a POTW.

Hydro excavation (pressurized water and vacuum excavation or slurry pumping) or hand tools would be used in difficult-to-excavate areas around utilities.

7.4.5.2 Groundwater

During soil excavation, a certain amount of dewatering will need to occur in areas where excavation deeper into the water table is required. This will remove some groundwater that is presently impacted by arsenic. Further reduction of arsenic in groundwater will occur through MNA following the remedial action. This has been previously been observed at the Site and is expected to be an adequate approach in the long-term. However, in the short -term and to ensure that residual arsenic in soil with the potential to impact groundwater in the Site interior does not infiltrate the storm drain systems, the storm drain line in Taylor Way would be slip lined and the storm drain line in on the Taylor Way Property would be either replaced or slip lined as indicated in Section 7.3.4.

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Section 8

Evaluation of Remedial Action Alternatives

This section evaluates the remedial action alternatives according to the process described in WAC 173-340-360.

8.1 Threshold Requirements

Remedial actions performed under MTCA must comply with threshold requirements. Remedial alternatives that do not comply with the threshold requirements are not considered suitable remedial alternatives under MTCA. As provided in WAC 173-340-360(2)(a), remedial alternatives shall meet the following four threshold requirements:

- protect human health and the environment
- comply with cleanup standards
- comply with applicable state and federal laws
- provide for compliance monitoring

In addition, MTCA requires that remedial actions:

- use permanent solutions to the maximum extent practical
- provide for a reasonable restoration time frame
- consider public concerns

8.1.1 Protection of Human Health and the Environment

Overall protectiveness of human health and the environment includes the degree to which existing risks are reduced, time required to reduce risk at the site and attain cleanup standards, and improvement of the overall environmental quality.

Four of the alternatives remove contaminated soil with arsenic concentrations greater than the acute-based remediation level within all three areas identified: Hylebos Waterway, South Corner Area, and Railroad Spur. They will also meet the chronic-based remediation level for the Site. Direct contact with soil is prevented by maintaining the existing pavement/landscape/buildings. Alternative 5 removes contaminated soils with arsenic concentrations exceeding the MTCA Method C industrial cleanup level; which is still a conditional land use. All five of the remedial alternatives require institutional controls, including Environmental Covenants prohibiting the use of groundwater for drinking water purposes and an Ecology-approved OMMP to protect future workers who may come in contact with contaminated soils.

The groundwater to surface water pathway is prevented for all five alternatives, although the level of protection and time period to achieve the desired protectiveness will vary between the alternatives. Alternatives 3 and 5 are likely to achieve the most immediate and highest degree of protectiveness for arsenic at the point of compliance, followed by Alternative 4, Alternative 2, and then Alternative 1. However, Alternative 1 will likely achieve a more immediate reduction for residual petroleum hydrocarbons in groundwater. With that said, residual hydrocarbons are already highly degraded and the one, relatively minor, cleanup level exceedance is limited to a very narrow area. As discussed in Section 4.7.3.2, there is a high likelihood that the existing hydrocarbon concentrations are biased high due to residual wood fibers and naturally occurring organics. With the soil excavation that occurs in this area for Alternatives 2 through 5, some reduction of hydrocarbon concentrations should be seen immediately and MNA should be suitable thereafter.

8.1.2 Compliance with Cleanup Standards

Cleanup standards, as defined by MTCA, consist of cleanup levels for hazardous substances present at the Taylor Way Property, the location, or points of compliance where the cleanup levels must be met, and any regulatory requirements that may apply to a site due to the type of action being implemented or the location of the site.

Alternatives 1-4 do not meet the soil cleanup level throughout the Site to the 15 foot deep point of compliance specified in MTCA. However, WAC 173-340-740(6)(f) recognizes that cleanup actions involving containment of hazardous substances may be deemed to comply with cleanup standards if the remedy is permanent to the maximum extent practicable; protective of human health and ecological receptors; and institutional controls and monitoring provisions are in place. As indicated above, Alternatives 1 through 4 comply with risk-based soil remediation levels developed for the Site for both protection of human health under the short-term exposure scenario (e.g., utility worker) and protection of human health in the long-term under the current land use scenario. Alternative 5 provides a greater degree of protection for long-term exposure by meeting the Method C cleanup level; however, the exposure scenario that would make it necessary to meet these lower concentrations is unlikely, considering the current and long-term land use and existing site conditions. All five alternatives require that the remaining soil (with a mean concentration less than the chronic criteria) would be managed via the landscaping/asphalt cover, consistent with WAC 173-340-740(6)(f).

All remedial alternatives were developed with the ultimate goal of achieving the groundwater cleanup level for arsenic and petroleum hydrocarbons at the points of compliance (POCs). All remedial alternatives should achieve groundwater cleanup levels at the POCs; however, the level of effort (e.g., ongoing ISCO for Alternative 1) and the length of time (i.e., the amount of time required to see the reduction in arsenic concentrations as a result of soil excavation) will vary.

8.1.3 Compliance with State and Federal Laws

Remedial actions conducted under MTCA must comply with applicable state and federal laws and local regulations. The term “applicable state and federal laws” includes legally applicable requirements and those requirements that Ecology determines to be relevant and appropriate as described in WAC 173-340-710. State and federal laws and local regulations are detailed in **Table 5-1** and consist of chemical-specific ARARs applicable to the contamination type at the

Taylor Way Property, location-specific ARARs that apply to the physical location of the site, and action-specific ARARs that apply to the construction components of the remedy. All of the alternatives will comply with the laws and regulations outlined in **Table 5-1**.

8.1.4 Compliance Monitoring

MTCA requires that all selected cleanup alternatives provide for compliance monitoring as described in WAC 173-340-410. Compliance monitoring consists of protection monitoring, performance monitoring, and confirmation monitoring. Protection monitoring is performed during remedial implementation to monitor short-term risk and confirm protection of human health and the environment during construction activities. Performance monitoring is conducted to confirm that the remedial action has attained cleanup standards, remediation levels and/or other performance standards. Confirmational monitoring is conducted to confirm the long-term effectiveness of the remedial action once cleanup standards, remediation levels and/or other performance standards have been attained.

All five alternatives provide for compliance monitoring. Protection monitoring would be conducted during implementation of the remedy through compliance with the site-specific health and safety plan. Performance monitoring would be conducted during the excavation to confirm that the target soil remediation levels have been met. For Alternative 1, performance monitoring would be conducted within the ISCO treatment area to determine whether adequate treatment is occurring throughout the target zone. For Alternative 2, performance monitoring would be conducted to ensure that the necessary specifications to achieve proper S/S have been met. For Alternatives 2 through 4, performance monitoring would be conducted to ensure that the necessary specifications to achieve the desired mixes and thicknesses for the slurry wall and permeable reactive barriers have been met and that the wall is performing adequately to remove arsenic and achieve cleanup levels. Long-term groundwater monitoring would meet the objectives of confirmation monitoring to ensure the system continues to work and to detect breakthrough if it occurs.

8.1.5 Use Permanent Solution to the Maximum Extent Practicable

MTCA requires that when selecting a remedial alternative, preference shall be given to permanent solutions to the maximum extent practicable (WAC 173-340-360(2)(b)(i). MTCA specifies that the permanence of remedial alternatives shall be evaluated by balancing the costs and benefits of each of the alternatives using a “disproportionate cost analysis” in accordance with WAC 173-340-360(3)(e). The criteria for conducting this analysis are described in Section 8.2 below. The disproportionate cost analysis was completed and is presented in Section 8.3.

8.1.6 Provide for a Reasonable Restoration Time Frame

Restoration time frame is defined in MTCA as “the period of time needed to achieve the required cleanup levels at the point of compliance established at the site.” Preference is given to an alternative that provides for a reasonable restoration time frame. According to MTCA, the following factors shall be considered to determine whether a remedial alternative provides for a reasonable restoration timeframe:

- Potential risks posed by the site to human health and 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;
- Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;
- Availability of alternative water supply;
- 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; and
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

Unlike organic contaminants, there are no natural processes or remedial technologies that destroy arsenic and lead. Soil excavation will provide an immediate benefit with regard to reducing the potential for direct exposure. Institutional controls will also show an immediate benefit with regard to reducing the potential for direct exposure. As was noted previously, institutional controls will be required regardless of which alternative is selected when a Method C industrial cleanup is implemented.

For Alternatives 1,2, and 4 the effect of soil removal/treatment in reducing arsenic concentrations in groundwater near the storm drain system is estimated to be on the order of 5 years, based on the estimated time for clean groundwater to travel from the area of excavation to the storm drain line, assuming the same groundwater flow velocity as was estimated in the RI. This also assumes that the source is accurately depicted as being confined to the areas of treatment. For Alternative 3, slip lining will show an immediate and long-term benefit; however, because the amount of soil excavation/treatment will be much less than any of the other alternatives, the restoration timeframe to reduce arsenic concentrations in groundwater will be much longer than any of the other alternatives For Alternative 5, the effect of soil removal will similarly take some number of years (estimated 3 to 5) in reducing arsenic concentrations in groundwater near the storm drain system. However, slip lining will show an immediate benefit as for Alternative 3.

With regard to the Hylebos Waterway Area, the effect of soil removal and groundwater treatment for Alternatives 1 through 4 in reducing arsenic concentrations in groundwater discharging to the Hylebos Waterway is estimated to be on the order of 5 years, based on the estimated time for clean groundwater to travel from the treatment areas to the Hylebos Waterway, assuming the same groundwater flow velocity as was estimated in the RI. The effects of the soil removal in reducing arsenic groundwater concentrations for Alternative 5 is estimated to be on the order of 1 to 2 years.

Repair of the onsite storm drain system will show an immediate benefit for the storm drain system to surface water pathway.

8.1.7 Consider Public Concerns

Public participation is an integral part of Ecology's responsibilities under MTCA. Ecology's goal is to provide the public with timely information and meaningful opportunities for participation. As the Taylor Way Property is under an Agreed Order, a public participation plan is in place and a Public Coordinator has been assigned to the Site. Published documents are posted to Ecology's web site and public notices providing opportunities for review of project documents and comment are provided at appropriate time periods. Additional information may be communicated to the public by other means such as published Fact Sheets, Notice in the *Site Register*, and/or public meetings, as appropriate.

Typically, public concerns are considered and addressed following the comment period for the Draft FS and draft Cleanup Action Plan when the public's specific concerns become known. It is expected that the public's primary concern is protection of the Hylebos Waterway. All of the alternatives will ultimately meet RAO # 2 *Protect surface water by reducing discharges of groundwater that contain arsenic and/or TPH at concentrations in excess of chemical-specific ARARs* to varying degrees.

8.2 Disproportionate Cost Analysis (DCA) Methodology

The MTCA DCA is used to further evaluate which of the alternatives that meet the threshold requirements are permanent to the maximum extent practicable. This analysis involves comparing the costs and benefits of alternatives and selecting the alternative whose incremental costs are not disproportionate to the incremental benefits. As presented in WAC 173-340-360(3)(f), the evaluation criteria are as follows:

- Protectiveness
- Permanence
- Long-term effectiveness
- Management of short-term risks
- Technical and administrative implementability
- Consideration of public concerns
- Cost

8.2.1 Protectiveness

Each alternative is assessed to determine whether it can provide appropriate protection of human health and the environment from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the Taylor Way Property. Evaluation of this criterion focuses on how site risks are eliminated, reduced, or controlled through containment, removal/disposal, treatment, and/or institutional controls and whether an alternative poses any unacceptable cross-media impacts.

8.2.2 Permanence

MTCA specifies that when selecting a cleanup action alternative, preference shall be given to actions that are "permanent solutions to the maximum extent practicable." Evaluation criteria include the degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances. Factors to be considered, as appropriate, include the following:

- The treatment processes the alternatives use and materials they will treat.
- The amount of hazardous substances, pollutants, or contaminants that will be destroyed or treated, including how the principal threat(s) will be addressed.
- The degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment.
- The degree to which the treatment is irreversible.
- The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate such hazardous substances and their constituents.
- Whether the alternative would satisfy the statutory preference for treatment as a principal element of the remedial action.

8.2.3 Long-Term Effectiveness

Long-term effectiveness is a parameter that expresses the degree of certainty that the alternative will be successful in maintaining compliance with cleanup standards over the long-term performance of the cleanup action. MTCA contains a specific preference ranking for different types of technologies that is to be considered as part of the comparative analysis. The ranking places the highest preference on technologies such as reuse/recycling, treatment, immobilization/solidification, and disposal in an engineered, lined, and monitored facility. Lower preference rankings are applied for technologies such as on-site isolation/containment with attendant engineered controls, and institutional controls and monitoring.

8.2.4 Management of Short-Term Risks

This criterion reviews the effects of each alternative during the construction and implementation phase of the remedial action until remedial response objectives are met. The short-term impacts of each alternative are assessed, considering the following factors, as appropriate:

- Short-term risks that might be posed to the community during implementation of an alternative.
- Potential impacts on workers during the remedial action and the effectiveness and reliability of protective measures.

- Potential adverse environmental impacts resulting from construction and implementation of an alternative and the reliability of the available mitigation measures during implementation in preventing or reducing the potential impacts.
- Time until protection is achieved.

8.2.5 Implementability

The technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation is evaluated under this criterion. The ease or difficulty of implementing each alternative will be assessed by considering the following factors detailed in **Exhibit 8-1**.

8.2.6 Consideration of Public Concerns

The public involvement process under MTCA is used to identify potential public concerns regarding remedial alternatives. The extent to which an alternative address those concerns is considered as part of the evaluation process. This includes concerns raised by individuals, community groups, local governments, tribes, federal and state agencies, and other organizations that may have an interest in or knowledge of the site.

Exhibit 8-1 Implementability Factors to be Considered during Alternative Evaluation

Criterion	Factors to be Considered
Technical feasibility	▪ Technical difficulties and unknowns associated with the construction and operation of a technology ▪ Reliability of the technology, focusing on technical problems that will lead to schedule delays ▪ Ease of undertaking additional remedial actions, including what, if any, future remedial actions would be needed and the difficulty to implement additional remedial actions ▪ Ability to monitor the effectiveness of the remedy, including an evaluation of risks of exposure should monitoring be insufficient to detect a system failure
Administrative feasibility	▪ Activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for offsite actions)
Availability of services and materials	▪ Availability of adequate offsite treatment, storage capacity, and disposal capacity and services ▪ Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources ▪ Availability of services and materials, plus the potential for obtaining competitive bids, which is particularly important for innovative technologies ▪ Availability of prospective technologies

8.2.7 Cost

The analysis of remedial action alternative costs under MTCA includes the costs associated with implementing an alternative, such as the pre-design work, design, construction, long-term monitoring and institutional controls. Costs are intended to be comparable among different alternatives to assist in the overall analysis of relative costs and benefits of the alternatives. The costs to implement an alternative include the cost of construction, the net present value of any long-term costs and agency oversight costs. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs and the cost of maintaining institutional controls.

8.2.8 Criteria Priorities and Score Calculations

In the DCA process, each alternative was assigned a rank (score) for each criterion using a scale of 1 to 6 (6 being the best) that represent a judgement of how well an alternative satisfies a criterion. Since each criterion is not considered equal by the Ecology, each rank is multiplied by a weighting factor or percentage representative of the criterion before the ranks are added up to produce a total that is referred to as a "total weighted benefit" and then divided by the relative cost to come up with a relative benefit score to cost ratio (see equation below). These ratios are compared and the higher the ratio the more beneficial the alternative is.

The weighting percentages for the Taylor Way Property, as accepted by Ecology, are summarized below:

- Protectiveness - 30%
- Permanence - 20%
- Long-term effectiveness - 20%
- Management of short-term risks - 10%
- Technical and administrative implementability - 10%
- Consideration of public concerns - 10%

After each criterion is assigned a value between 1 and 6 and appropriately weighted using the factors above the overall relative benefit score ratio is calculated as follows:

RBSR = 1000 * ((Prot*0.3) + (Perm*0.2) + (LTE*0.2) + (STR*0.1) + (Imp*0.1) + (PC*0.1))/C

Where,

RBSR	=	Relative benefit score ratio
Prot	=	Protectiveness score (1 through 6)
Perm	=	Permanence score (1 through 6)
LTE	=	Long-term effectiveness score (1 through 6)
STR	=	Management of short-term risks score (1 through 6)
Imp	=	Technical and administrative implementability score (1 through 6)
PC	=	Consideration of public concerns score (1 through 6)
C	=	Cost in millions

A remedy cost in the millions generally results in an RBSR on the order of hundreds, allowing differences between alternatives to be easily discerned.

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8.3 MTCA Disproportionate Cost Analysis

The following sections provide a discussion regarding differences between the alternatives for each of the evaluation criteria in the DCA, with the exception of cost. The scoring for each alternative is then presented, based on this evaluation. The scoring of the benefit of each metric for each remedial alternative is somewhat subjective and based on professional judgement.

8.3.1 Overall Protectiveness

Soil: All of the alternatives, at a minimum, will meet the acute and chronic-based remediation levels. All of the alternatives will also require institutional controls and maintenance of the asphalt/landscaping cover. Given the industrial nature of the Site, whereby the existing asphalt cover is maintained to allow for the constant ingress and egress of trucks, there is virtually no risk of exposure to site soils on a day-to-day basis. Actions that would breach the existing cover, such as to repair underground utilities or redevelopment would be rare; institutional controls would ensure that appropriate protections are implemented if and when these events occur. Therefore, none of the alternatives have a strongly greater or lesser overall protection for human health and the environment with regard to soil exposure. Alternative 3 would likely have the greatest length of time to see reduction in concentrations of arsenic in groundwater due to the least amount of soil removal in the South Corner Area, followed by Alternative 1, due to the treatment methodology next to the Hylebos Waterway. Alternatives 2 and 4 would likely be comparable. Based on the extensive soil removal, the fastest reduction in arsenic concentrations in groundwater would likely be observed with Alternative 5.

Groundwater, Hylebos Waterway: While Alternative 5 relies solely on MNA following extensive soil removal, Alternatives 3 and 4 utilize a combination of the funnel and gate PRB and soil excavation, with the addition of ZVI in the one soil excavation location (DPT37) between the PRB and the tidebank. It is possible that groundwater cleanup levels at the POC would be realized sooner for Alternatives 3 and 4 than for Alternative 5. Alternative 2 is very similar to Alternatives 3 and 4, but is slightly less protective since this alternative does not include the addition of ZVI in the DPT37 excavation. Alternative 1 is the only alternative to directly address petroleum hydrocarbons in groundwater. However, drawbacks to the ISCO treatment method are the degree of certainty in meeting the treatment goals, the likelihood of needing to repeat treatments for the long-term, and the potential discharge of residual oxidant to surface water (i.e., water which may potentially escape the recirculation system). All the other alternatives include excavation of soils that will remove a substantial amount of soils containing residual wood fibers, which may result in an immediate reduction in hydrocarbon concentrations. Finally, considering that the hydrocarbons are very weathered, and the one, relatively minor, cleanup level exceedance is limited to a very narrow area, the actual risks posed by residual petroleum hydrocarbons in groundwater are minimal.

Groundwater, South Corner Area: Alternatives 3 and 5 provide the most immediate protections at the POC as these two alternatives include slip lining the Taylor Way storm drain system, which will immediately mitigate any contaminated groundwater entering the storm drain system and discharging to surface water; however with the lesser amount of soil excavation, it is likely that, in the long-term, groundwater cleanup levels will not be achieved. In addition, slip lining will require ongoing monitoring to ensure that it is maintained in good repair. Alternatives 1 and 4 rely on MNA following the most extensive soil removal for this area, besides that of Alternative 5. Alternative 2 also relies on MNA following S/S, which would decrease leachability of arsenic. Alternatives rely most heavily on soil excavation or S/S may ultimately further reduce arsenic concentrations in the second aquifer.

Based on these considerations in total, Alternatives 1, 2, 3, 4, and 5 were ranked respectively, as follows: 3, 4, 3, 5, 6.

8.3.2 Permanence

With the exception of the weathered petroleum hydrocarbons in the Hylebos Waterway Area, the COCs are nondestructive (i.e., arsenic and lead). The only alternative that actively addresses the petroleum hydrocarbons is Alternative 1 (ISCO recirculation system), which has the potential to destroy dissolved organics. However, due to the relatively low hydrocarbon cleanup level exceedances that are limited to narrow area of the site, MNA is a viable option. The residual hydrocarbon plume is shown to be degrading, which is ultimately permanent.

The effectiveness of Alternative 1 ISCO groundwater treatment for arsenic could be relatively short-term due to the lack of reliable source control. Dissolved iron within the aquifer can coat grains of impacted soil or solid source materials (shot, slag, etc.) when oxidized by the ISCO treatment, but the coatings are typically only partial even after multiple treatments. Furthermore, the iron oxyhydroxide coatings can potentially re-dissolve under iron-reducing conditions. The failure to provide effective source control and the potential of dissolution of the coatings usually requires multiple treatment cycles to reliably meet groundwater standards.

Funnel and gate PRBs tend to provide more permanent treatment because the groundwater is treated as it flows through the treatment media. The system is effective until the media becomes passivated (the arsenic adsorption capacity of the media is reached), typically after about 10 years. At some point leachable arsenic will be exhausted and eventually the groundwater that reaches the PRB will no longer need treatment. Considering the soil excavation that will be a part of remedial action, the PRB treatment, the arsenic concentrations in the surrounding area, and natural attenuation that is observed across the site, the need for use of the PRB could very well be discontinued within the 30 year period that is assumed for the FS cost estimate.

Natural attenuation of arsenic in groundwater occurs at the Site mainly via precipitation reactions which can occur indefinitely compared to adsorption processes, which are limited by the available adsorption sites within the aquifer. Due to the much greater soil removal that would occur for Alternative 5, MNA would occur faster than for Alternatives 1 through 4. However, soil removal actions for Alternatives 1 through 4 will assist in the natural attenuation of arsenic, particularly in the Hylebos Waterway Area. In the South Corner Area, the level of permanence would be greater for Alternatives 1, 2 and 4 due to the greater area of excavation/treatment.

Based on these considerations in total, Alternatives 1, 2, 3, 4, and 5 were ranked respectively, as follows: 3, 5, 4, 5, 6.

8.3.3 Effectiveness Over the Long Term

The ISCO recirculation system within Alternative 1 would likely have poor long-term performance for treatment of arsenic without periodic retreatment. Eventually, the impacted soil and waste particles could become coated, providing source control and longer intervals between retreatments. It may also be difficult for ISCO to overcome the organics for treatment of the residual hydrocarbons. Alternatives 2 through 4 would have better long-term performance in terms of groundwater treatment for arsenic due to the use of a funnel and gate PRB instead of ISCO. For the reasons discussed previously, MNA is a viable option for the residual, weathered petroleum hydrocarbons and it is permanent. Soil removal will also be effective, as demonstrated by the water quality improvements realized following previous removal actions but varies by the degree of removal for each individual alternative.

Where Alternatives 1 and 4rely on soil removal and 2 on S/S to reduce arsenic concentrations in the South Corner Area, achievement of the 5 µg/L groundwater cleanup level may not be realized at the POC for decades, whereas the proposed slip lining for Alternatives 3 and 5 will be very effective immediately and during the design life of the system (approx. 30 years). In the long-term, however, the effectiveness in removing arsenic concentrations would be greatest for Alternatives 1, 2, and 4 over that of Alternative 3. With the greatest volume of soil removal, Alternative 5 presents the greatest likelihood that natural attenuation will effectively reduce arsenic and petroleum concentrations permanently in groundwater over the long-term.

Based on these considerations in total, Alternatives 1, 2, 3, 4 and 5 were ranked respectively, as follows: 2, 3, 3, 4, 5.

8.3.4 Management of Short-Term Risks

Alternatives 1 through 5 all have risks associated with excavation, handling and transport of contaminated soils and work around heavy equipment. For Alternatives 1 through 4, an added risk will be in working around an operating trucking business. However, Alternative 5 has the greatest risks of traffic accidents associated with much greater volume soil that will be transported over public roadways. Alternative 1 has an added risk with the handling of caustic chemicals (ISCO), as well as the potential discharge of residual oxidant to surface water.

Site work will require work under a health and safety plan, which will address appropriate personal protective equipment, best management practices, training, cordoning off construction areas, and other appropriate protective measures to manage risks.

Based on these considerations in total, Alternatives 1, 2, 3, 4, and 5 were ranked respectively, as follows: 2, 4, 4, 4, 4.

8.3.5 Technical and Administrative Implementability

8.3.5.1 Technical Implementability

All of the alternatives are technically implementable but will have challenges. Alternatives 1 through 3 would require employing careful excavation practices in the South Corner Area to avoid utilities. For Alternative 2, S/S near utilities could represent a challenge. Deep soil excavation at DPT37 for Alternatives 1 through 3 will necessitate the use of sheet piling to maintain the excavation sidewalls next to the Hylebos, as well as an additive to soak up water in order to capture solids at the base of the excavation. Bench scale, pilot, and further hydrologic studies would be necessary before ISCO could be implemented for Alternative 1

For Alternative 4, excavation around existing utilities (storm drain, power, water, sewer, natural gas, electricity) will be even more problematic as the excavation includes a much larger area which is very likely to encounter all types of underground utilities. In addition, transfer stations are often limited as to how much volume of soil they can take at any one time, particularly during the construction season. This can and does often lead to significant delays. An alternative when this occurs is to truck the soil directly to the landfills, which are located in Oregon and eastern Washington, but the additional trucking fees can be costly.

8.3.5.2 Administrative and Regulatory Requirements

Substantive requirements for a grading permit would need to be met for each of the alternatives. Alternative 1 would also need an Underground Injection Control (UIC) permit for the ISCO portion of the remedial action. Slip-lining the storm drain line in Taylor Way requires communication with and permission from the City of Tacoma.

8.3.5.3 Site Access for Construction and Monitoring

The Site is an active trucking facility (Carlile). Alternatives 1 through 4 would have a moderate to high impact on the business. Access to one of the entrances would need to be blocked during the period that treatment in the South Corner Area is implemented. Storm drain line replacement would have a greater impact to business operations than slip lining. Alternative 5 would have a major impact on operation of the business, requiring relocating the business temporarily until the remedial action could be completed and the Site is restored.

8.3.5.4 Integration with Existing Site Operations or Other Potential Future Remedial Action

Long-term and short-term integration of Alternatives 1 through 4 is expected to be possible, as long as the work can be completed in stages. The short-term integration would represent a major problem for Alternative 5, due to the necessary relocation of the business. Finding temporary facilities and relocating a large, active trucking business twice over a relatively short period of time would be time-consuming and costly.

Based on these considerations in total, Alternatives 1, 2, 3, 4, and 5 were ranked respectively, as follows: 3, 3, 4, 3, 1.

8.3.6 Consideration of Public Concerns

As noted previously, public concerns are typically considered and addressed following the comment period for the Draft FS when the public's specific concerns become known. However, it is expected that the public will have the following concerns regarding the Site:

- Potential exposure to contaminated soil
- Potential loading of arsenic and/or hydrocarbons to the Hylebos Waterway via groundwater discharge
- Potential loading of arsenic to the Hylebos Waterway via storm drain discharge

Each of the alternatives would address the anticipated public concerns to varying degrees.

Based on the anticipated expectations of the public, Alternatives 1, 2, 3, 4, and 5 were ranked respectively, as follows: 2, 4, 3, 5, 6.

8.3.7 Costs

Cost estimates were developed for each Alternative in accordance with "*A Guide to Developing and Documenting Cost Estimates during the Feasibility Study*" (EPA 2000b). Types of costs that were assessed for each alternative include: capital costs, annual O&M costs, periodic costs, and present value of capital and annual O&M costs. Each of these cost types are described further below.

- Capital costs are expenditures that are required to construct a remedial action. They are exclusive of costs required to operate or maintain the action throughout its lifetime. Capital costs consist primarily of expenditures initially incurred to build or install the remedial action. Capital costs include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with activities, such as mobilization/demobilization, site work, excavation and disposal of contaminated soil, and groundwater remediation. Capital costs also include expenditures for professional/technical services that are necessary to support construction of the remedial action.

- Annual O&M costs are post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action. These costs are estimated mostly on an annual basis. Annual O&M costs include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with activities, such as monitoring, Annual O&M costs also include expenditures for professional/technical services necessary to support O&M activities.

- Periodic costs are costs that occur only once every few years (e.g., 5-year reviews and PRB replacement or additional ISCO application). These costs may be either capital or O&M costs, but because of their periodic nature, it is more practical to consider them separately from other capital or O&M costs in the estimating process.

- The present value of each alternative provides the basis for the cost comparison. The present value cost represents the amount of money that, if invested in the initial year of the remedial action at a given rate, would provide the funds required to make future payments to cover all costs associated with the remedial action over its planned life. Future O&M and periodic costs are included and reduced by the appropriate present value discount rate as outlined in A Guide to Developing and Documenting Cost Estimates during the Feasibility Study (EPA 2000b). Per the guidance, the present value analysis was performed on remedial alternatives using a 7 percent discount (interest) rate over the period of evaluation for each alternative. Inflation and depreciation were not considered in preparing the present value costs.

The cost development for each alternative is provided in **Appendix D**. For each alternative there is a sheet that lists the assumptions used in developing the cost estimate, a second sheet with the breakdown of capital, O&M, and periodic costs, and third sheet for the present value analysis. The levels of detail employed in making these estimates are conceptual but are considered appropriate for making choices between alternatives. The information provided in the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Unit costs were derived using a combination of online cost estimating software (Gordian 2019), construction cost estimates solicited from applicable vendors and contractors; review of actual costs incurred during similar applicable projects; and professional judgment. It is likely that all remedial alternatives would require an indefinite duration of O&M. However, evaluation of long durations of O&M is cumbersome and is generally not necessary for comparative evaluation between alternatives because of the effects of cost discounting in later it would years under present value analysis. The period of analysis for the FS was assumed to be 30 years, because the increase of present value to small periodic expenditures for maintenance and monitoring after 30 years is minimal relative to the accuracy range of the estimates.

Table 8-1 provides a summary of the cost estimates developed for Alternatives 1 through 4. The level of accuracy (including contingency) was deemed to be between -30 percent and +50 percent and these ranges are also included in **Table 8-1**. Percentages used for contingency and professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," (EPA 2000b). The preliminary estimate applies contingency (after subtotaling the costs for major work activities). Scope contingency was applied to account for changes between the FS and final design submittals, such as unforeseen circumstances, or unanticipated conditions that cannot be quantified, based on available data at the time the estimate is prepared. Bid contingency reflects the unknown costs associated with constructing a given project, such as adverse weather conditions, materials costs, or unfavorable market conditions.

8.3.8 Results of the DCA

The DCA summary table is provided in **Table 8-2**. Based on the rankings for each alternative discussed in Sections 8.3.1 through 8.3.6, the total weighted benefit scores for Alternatives 1 through 5 were 2.6, 3.9, . 3.4, 4.5, and 5.1, respectively. Calculating in the cost for each alternative, the RBSR for each alternative is as follows:

Alternative 1 - 441

Alternative 2 - 1,054

Alternative 3 - 944

Alternative 4 - 1,125

Alternative 5 - 325

The RBSR for Alternative 4 is about 2.6 to 3.5 times greater than for Alternatives 1 and 5. The RBSR for Alternative 4 is about 19% greater than for Alternative 3 and about 7% greater than for Alternative 2. In all, the RBSR for Alternative 4 is significantly greater than Alternatives 1, 3 and 5, and somewhat higher than Alternative 2.

Section 9

Preferred Remedial Alternative

Based on the evaluation presented in this FS, the preferred remedy is Alternative 4 which includes the following:

- Selective excavation of soils
- Funnel and Gate PRB for groundwater
- Supplemental iron addition in an excavation adjacent to the Hylebos Waterway

This alternative also includes the common elements as follows:

- Institutional controls – e.g., use restrictions, soil management, site-specific health and safety plans if subsurface work is to be conducted.
- Groundwater monitoring
- Onsite cap (soil cover) maintenance
- Onsite storm drain repair

Alternative 4 would reliably contain Site impacts to the Hylebos Waterway in the shortest timeframe, while significantly reducing mass for the most reasonable cost. The contingency for slip lining of the storm drain line in Taylor Way allows for an added level of protection, should soil excavation in the South Corner Area not result in the necessary reduction in arsenic concentrations in a timely manner. Alternative 4 is the most cost-effective combination of treatment, containment, and mass removal. Alternative 4 would protect human health and the environment in the short-term and long-term.

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Section 10

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Tables

Table 3-1 Summary of Completed Interim Actions
Taylor Way Property Feasibility Study
Tacoma, Washington

Year	Action	Summary	Soil Removed (tons)
1996	Soil Berm Removal	Removal of the soil berm at the USG/Murray Pacific property line, which protected workers from potential collapse of log piles. Subsurface soils excavated in limited sections to achieve a cleanup level of 200 milligrams per kilogram (mg/kg)	4,420
1996	AST Petroleum Hydrocarbon Cleanup	Excavation of petroleum-contaminated soil associated with the above ground Bunker C oil tank. Excavation extended northward under the removed berm and approximately 30 feet into the Murray Pacific Property. Soil excavated down to the tideflat layer.	5,000
1997	Intertidal Bank Excavation	Excavation of shot used as fill to extend the intertidal bank with removal of 1,072 tons of upland soils and 2,062 tons of intertidal bank sediment.	2,062 1,072
1998	Additional Bank Top Cleanup	Excavation of additional source material from the bank top to the north of the intertidal bank excavation.	87
1998/1999	Stormwater System Replacement and Paving	Replacement of the entire stormwater system over two phases. Areas where process by-products and raw products were temporarily stored or handled were paved with asphalt.	-
1999	MW9 Area Excavation	Excavated soils from around monitoring well MW9 located on the easterly side of the production building. Laterally, the excavation was limited by the buildings on the westerly side and the Arkema Property on the easterly side.	4,144
2003	Rail Berm Removal	Removal of an approximately 265-foot stretch of railroad spur berm soils down to pre-existing grade.	2,500
2003	Hydrocarbon Remediation	Removal of petroleum hydrocarbon-contaminated soils on the northeastern side of the plant building apparently from a leaking underground piping associated with the previously removed Bunker C above ground storage tank.	4,400
2004	Building Preload Excavation	Removal of soils containing arsenic concentrations greater than 87.5 mg/kg under the area where the new Carlile warehouse building was to be constructed. Two areas excavated at either end of the proposed building, one to 2 feet bgs and the other to 3 feet bgs.	Included in totals for 2005 actions
2005	UST Removal	Soil disposed of in association with the removal of one 4,000- gallon and one 5,000-gallon tank discovered during construction activities. No petroleum release was discovered, but soils removed to allow for the tank removal that contained greater than 20 mg/kg were disposed of at a landfill.	500
2005	B13 and B23 Soil Excavations	Excavation of arsenic-contaminated soils under the former baghouse (B13) and from under a former concrete pad used for material storage (B23). The B13 excavation ranged between 4 and 8 ft deep and the B23 excavation ranged between 2 and 5 ft deep. These excavavations abutted the MW9 excavation. Soils removed during the preload excavation were also disposed of at the time.	8,176
		Total Tons Removed from the Taylor Way Property	**32,361**

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
FEDERAL						
National Historic Preservation Act (NHPA) and Implementing Regulations 16 United States Code (U.S.C.) 470 36 CFR Part 800	Applicable	This statute and implementing regulations require federal agencies to take into account the effect of this response action upon any district, site, building, structure, or object that is included in or eligible for the National Register of Historic Places (generally, 50 years old or older).	If cultural resources on or eligible for the national register are present, it will be necessary to determine if there will be an adverse effect and if so how the effect may be minimized or mitigated. The unauthorized removal of archaeological resources from public or Indian lands is prohibited without a permit, and any archaeological investigations at a site must be conducted by a professional archaeologist. If any are found, consultation with the State Historic Preservation Office (SHPO) and the NHPA will be addressed during remedial design.		✓	
Archaeological and Historic Preservation Act and Implementing Regulations 16 U.S.C. 469 43 CFR 7	Applicable	This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data.			✓	
Fish and Wildlife Coordination Act and Implementing Regulations 16 U.S.C. 662, et seq., 50 CFR 83 33 CFR 320-330	Applicable	This statute and implementing regulations require coordination with federal and state agencies for federally funded projects to ensure that any modification of any stream or other water body affected by any action authorized or funded by the federal agency provides for adequate protection of fish and wildlife resources.	If the remedial action involves activities that affect wildlife and/or non-game fish, federal agencies must first consult with the U.S. Fish and Wildlife Service and the relevant state agency with jurisdiction over wildlife resources.		✓	
Bald and Golden Eagle Protection Act 16 USC §§ 668 et seq.	Applicable	This requirement establishes a federal responsibility for protection of bald and golden eagles and requires continued consultation with the appropriate program within the USFWS during remedial design and remedial construction to ensure that any cleanup of the facility does not unnecessarily adversely affect the bald and golden eagle.	If bold or golden eagle are identified within the remedial areas, activities must be designed to conserve the species and their habitat.		✓	

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
Endangered Species Act and Implementing Regulations, 16 U.S.C. 1531 50 CFR 17 and 402	Applicable	This statute and implementing regulations provide that federal activities not jeopardize the continued existence of any threatened or endangered species. Endangered Species Act, Section 7 requires consultation with the U.S. Fish and Wildlife Service to identify the possible presence of protected species and mitigate potential impacts on such species.	If threatened or endangered species are identified within the remedial areas, activities must be designed to conserve the species and their habitat.		✓	
Migratory Bird Treaty Act and Implementing Regulations, 16 U.S.C. 703, et seq. 50 CFR 10.13	Applicable	This requirement establishes a federal responsibility for the protection of the international migratory bird resources and requires continued consultation with the U.S. Fish and Wildlife Service during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	The selected remedial actions will be carried out in a manner to avoid adversely affecting migratory bird species, as defined in federal regulations, including individual birds or their nests.		✓	
Clean Water Act/Water Pollution Control Act (33 U.S.C. 1251) Effluent Limitations (Sections 301-302) Water Quality Standards (Section 303) Federal Water Quality Criteria (Section 304) National Performance Standards (Section 306) Toxic and Pre-Treatment Standards (Section 307) State Certification of Water Quality (Section 401) National Pollutant Discharge Elimination System (NPDES) Section 402	Applicable	These regulations govern water quality, including water discharged as part of a remedial process. Section 307—Pretreatment regulations under 40 CFR Part 403 provide for limits on discharge to a sanitary sewer system, protecting the municipal system from accepting wastewater that would cause it to exceed its NPDES permit discharge limits. Section 401—Water Quality Certification requires that EPA receive a water quality certification from a state that a given project requiring a federal permit that may result in a discharge to navigable water will comply with the state's water quality standards. Section 402—The NPDES program establishes a comprehensive framework for addressing processing water and stormwater discharges under the program. Requires that point-source discharges not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 CFR 122.26 for point-source discharge of stormwater from construction sites to surface water and provides for Best Management Practices such as erosion control for removal and management of sediment to prevent run-on and runoff.	The selected remedial actions will be carried out in a manner to avoid adversely affecting surface water		✓	✓

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
Clean Water Act / Water Pollution Control Act Discharge of Dredge and Fill Materials 33 USC 26-IV § 1344; 33 CFR 323.1 et seq.	Relevant and Appropriate	Regulates the discharge of dredge and fill material into waters of the United States, including wetlands.	Relevant and Appropriate during excavation and fill activities next to the Hylebos Waterway. The selected remedial action will be carried out in a manner to avoid the discharge of excavation and fill materials into waters of the United States.			✓
Clean Air Act (CAA) and Implementing Regulations 42 U.S.C. 7401, et seq.	Applicable	National Ambient air quality standards (NAAQS) may be applicable	The selected remedial actions will be carried out in a manner that will comply with NAAQS. The CAA establishes the National Ambient Air Quality Standards (NAAQS) in 40 C.F.R. § 50.4–50.12. NAAQS are not enforceable in and of themselves; they are translated into source-specific emissions limitations by the state (U.S. EPA 1990).	✓	✓	✓
Floodplain Management Regulations Executive Order No. 11988 (referenced in 40 CFR Part 35, Appendix A to Subpart H).	Not an ARAR	These require that actions be taken to avoid, to the extent possible, adverse effects associated with direct or indirect development of a floodplain, or to minimize adverse impacts if no practicable alternative exists.	No jurisdictional floodplains are delineated within areas designated for remediation, these standards would not be applicable.		✓	
Protection of Wetlands Regulations Executive Order No. 11990 (referenced in 40 CFR Part 35, Appendix A to Subpart H). 33 U.S.C. § 1344(b)(1)	Not an ARAR	This ARAR requires federal agencies and the potentially responsible parties (PRPs) to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. 33 U.S.C. § 1344(b)(1) also prohibits the discharge of dredged or fill material into waters of the United States. Together, these requirements create a “no net loss” of wetlands standard.	No jurisdictional wetlands are delineated within areas designated for remediation, these standards would not be applicable.		✓	✓

CDM Smith

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
National Primary Drinking Water Regulations 40 CFR 141	Not an ARAR	Establishes health-based standards, maximum contaminant levels (MCL) and maximum contaminant level goals (MCLG), for public water systems.	No potable surface water or groundwater at this site.	✓		
National Recommended Water Quality Criteria (NWQC) 33 USC 26-I § 1251 et seq.; 40 CFR 131	TBC	Establishes non-enforceable criteria for water quality based on toxicity to aquatic organisms and human health.	The State of Washington has been delegated this program. Recommended but not enforceable criteria.			
RCRA Subtitle D - Criteria for Classification of Solid Waste Disposal Facilities and Practices and for Municipal Solid Waste Landfills 40 CFR 257 and 258	Applicable	Establishes guidelines for the management of nonhazardous solid waste. Establish minimum national criteria under the RCRA for all municipal solid waste landfill (MSWLF) units for municipal solid waste landfills that are used to dispose of excavated soils and residual source material.	Applicable for excavated soils and residual source materials that are disposed of at an offsite facility.			✓
RCRA Subtitle C - Solid Waste Disposal: Identification and Listing of Hazardous Waste 42 USC 82-I § 6901 et seq.; 40 CFR 261	Applicable	Specifies hazardous waste identification, management, and disposal requirements.	Applicable to determining whether excavated soils and residual source materials are considered hazardous under RCRA.			✓
Solid Waste Disposal: Land Disposal Restrictions (LDRs) 42 USC 82-I § 6901 et seq.; 40CFR 268	Relevant and Appropriate	Restrictions (concentration or treatment) on RCRA hazardous wastes prior to their placement in a land disposal unit. Relevant and appropriate Land Disposal Restriction (LDR) requirements will be met by ex-situ treatment, if necessary, of excavated soils and source material prior to disposal.	Relevant and Appropriate if remedial activities generate and include land disposal of waste that is characterized as hazardous.	✓		
STATE						
Bald Eagle Protection Rules RCW77.12.655; WAC 232-12-292	Applicable	Establishes requirements for protecting the bald eagles	Taking or harming of eagles, their eggs, nests or young is prohibited; substantive requirements for the protection of bald eagle habitat including nesting, perching and roosting at the site will be met.			✓

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
Model Toxics Control Act (MTCA) RCW 70.105D; WAC 173 -340.	Applicable	Establishes processes and standards to identify, investigate, and clean up facilities where hazardous substances are located.	Facility is regulated under MTCA and must meet MTCA requirements.	✓		✓
Water Pollution Control Act. Water quality standards for groundwater of the State of Washington WAC 173-200	Relevant and Appropriate	Establishes groundwater quality standards, which together with technology-based treatment standards provide for protection of existing and future use of groundwater.	MTCA cleanup actions under and Agreed Order are exempt from the procedural requirements of this law, but will comply with the substantive requirements.	✓		✓
Hazardous Waste: Ecology Dangerous Waste Regulations WAC 173-303-141 to 270	Applicable	Establishes guidelines for treatment, storage and disposal and transportation of dangerous waste	Applicable to the extent that any dangerous wastes are discovered or generated during the cleanup action			✓
Hazardous Waste: Ecology Dangerous Waste Regulations WAC 173-303-080 to -100	Applicable	Establishes guidelines to determine dangerous waste lists, characteristics, criteria	Applicable to determining whether wastes are considered dangerous			✓
Hazardous Waste: Land Disposal Restriction WAC 173-303-140, 141	Applicable	Establishes standards for land disposal of Ecology dangerous waste.	Applicable if remedial activities include land disposal of dangerous waste.			✓
Solid Waste Management WAC 173-350	Applicable	Establishes standards for non-dangerous waste management	Substantive requirements for disposal of non-dangerous or non-hazardous waste generated during remedial activities, unless wastes meet recycling or other exemptions, will be complied with.			✓
Dredge Materials Management Program WAC 332-30-166(3)	Not Applicable	Establishes standards for dredge/fill and other in-water construction work	No in water construction work is planned.			✓

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
Shoreline Management Act RCW 90.58; WAC 173-14) Tacoma Municipal Code Chapter 13.10—Shoreline Management	Relevant and Appropriate	The Washington Shoreline Management Act, authorized under the federal Coastal Zone Management Act, establishes requirements for substantial development occurring within the waters of Washington State or within 200 feet of a shoreline.	Work will occur within 200 feet from the shoreline so the substantive requirements would apply.		✓	
Tacoma Municipal Code Chapter 13.11—Critical Areas Preservation	Applicable	Critical areas include critical aquifer recharge areas, fish and wildlife habitat conservation areas, flood hazard areas, geologically hazardous areas, stream corridors, wetlands, and any buffer zones. The criteria and standards provided in this chapter are intended to secure the public health, safety, and welfare by: ▪ protecting members of the public and public resources from damage or injury due to slope failures, erosion, landslides, and seismic or volcanic hazards, ▪ maintaining a healthy functioning ecosystem, ▪ preventing impacts to streams, fish and wildlife habitats, and water quality, ▪ providing open space and aesthetic value, ▪ providing migratory pathways for fish and birds, and ▪ giving special consideration to conservation efforts.	Substantive requirements may be applicable based on specific actions and locations. MTCA cleanup actions conducted under an Agreed Order are exempt from the procedural requirements of this law, but must comply with the substantive requirements.		✓	
Washington Floodplain Management Plan RCW 68.16; WAC 173-158)	Not an ARAR	An advisory standard pertaining to wetlands management that suggests local governments, with technical assistance from Ecology, institute a program that can identify and map critical wetland areas located within base floodplains.	No jurisdictional floodplains are delineated within areas designated for remediation, these standards would not be applicable.			

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
Drinking Water Standards—State Maximum Contaminant Levels RCW 70.119A; WAC 246-290-310	Not Applicable	Established health-based MCLs for public water supplies.	No drinking water supplies are impacted by the site, therefore, these standards are not applicable.			✓
Water Pollution Control Act WAC 173-201A; Aquatic Life Criteria (ALC) numeric criteria WAC 173-201A-240	Applicable	Establishes water quality standards for surface waters of the state. Waste discharge permits, whether issued pursuant to the NPDES or otherwise, shall be conditioned so that the discharge authorized will meet water quality standards.	Relevant to remedial actions impacting contaminant migration to surface water and groundwater. Applicable to remedial actions involving discharge to POTW. Substantive requirements will be applicable to any alternative that discharges effluent to surface water.	✓		✓
State Waste Discharge Program WAC 173-216	Applicable	Must meet pre-treatment regulations as revised for operations of the secondary sewage treatment plant.	Applicable if the option of discharge to the sanitary sewer (POTW) is chosen as part of the remedy. Substantive requirements must be met.	✓		✓
Washington Environmental Quality law WAC 173-400	Applicable	General Regulations for Air Pollution Sources	Some treatment alternatives may impact ambient air quality. Substantive requirements will be applicable if alternative results in emission from treatment processes.			✓
Washington Clean Air Act WAC 173-460	Applicable	Controls for New Sources of Toxic Air Pollutants	The selected alternative will require compliance with air quality regulations and best management practices for dust control.			✓
Washington Clean Air Act WAC 173-470	Applicable	Ambient air quality standards	The selected alternative will require compliance with air quality regulations and best management practices for dust control.			✓

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
State Environmental Policy Act (SEPA) WAC 192-11	Applicable	Requires a review of potential damage that occurs to the environment as a result of man's activities. SEPA checklist may be required prior to construction of the remediation system.	Applicable, implemented during design and permitting phase. Coordination with federal agencies may be necessary to ensure the SEPA process will to meet NEPA requirements. SEPA and MTCA are integrated processes per WAC 197-11-250 through 197-11-268			✓
Noise Control Act of 1974(RCW 70.107; WAC 173-60-040-050)	Applicable	Maximum levels at specified times for specified durations are WAC 173-60-040, subject to exemptions in WAC 173-60-050, including 050(3) (a) (sounds originating from temporary construction sites as a result of construction activity) and (3)(f) (sounds created by emergency equipment and work necessary in the interests of law enforcement or for health, safety or welfare of the community).	The selective alternative will need to comply with local and state noise pollution requirements. Construction and other activities will need to be limited to normal working hours.			✓
LOCAL						✓
Grading Activities under Tacoma Municipal Code (Chapters 13.11 and 13.12)	Applicable	Establishes restrictions of upland grading activities.	Substantive compliance required to minimize stormwater and other related impacts. MTCA cleanup actions are exempt from the procedural requirements of this law, but must comply with the substantive requirements.			✓
Tacoma Wastewater Treatment Requirements (Tacoma City Ordinance Chapter 12.08) and Shoreline Management (Chapter 13.10.130 for discharges to surface water in Port Industrial Area)	Applicable	Provides requirements for discharge to the POTW.	Applicable through NPDES permit.			✓

Table 5-1 Summary of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
Taylor Way Feasibility Study
Tacoma, Washington

Statute and Regulatory Citation	ARAR Determination	Description	Comment	Chemical	Location	Action
City of Tacoma Road Use Permit	Applicable	Any project that involves activities that impede the normal flow of vehicular traffic or pedestrian traffic requires a Road Use Permit, Right of Way Bond and Approved Traffic Control Plan				✓
City of Tacoma	Applicable	Lining the City's storm drain line would require communications, coordination, and compliance with any of the City's requirements				✓
Tacoma Power	Applicable	Permits required for temporary power connections and wiring for remediation systems.				✓

Table 6-1 Identification and Technical Implementability Screening of Potentially Applicable Remedial Technologies/Process Options for Affected Soil Media
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Action	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
No Action	None	None	No action would be taken. The affected soil remains under existing conditions.	No action alternative is not acceptable under MTCA.	No
Monitoring	Physical and/or Chemical Monitoring	Non-Intrusive Visual Inspection	A non-intrusive (surficial) visual inspection of covers or surface barriers to assess cover integrity. May also be used to identify the presence or absence of source materials, if visually recognizable.	Potentially implementable process option.	Yes
Institutional Controls	Administrative Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with affected soil would be controlled through legal instruments. Examples of governmental controls include, but are not limited to, local zoning, permits, codes, and/or regulations. Examples of proprietary controls include, but are not limited to, instruments such as Easement and Equitable Servitude (EES), Covenants, and Conditions and Restrictions (CCRs). Examples of informational devices include, but are not limited to, Notices of Environmental Contamination.	Potentially implementable process option.	Yes
	Community Awareness Activities	Informational and Educational Programs	Community informational and educational programs would be undertaken to enhance awareness of potential hazards and remedies for affected soil media.	Potentially implementable process option.	Yes
	Access Restrictions	Access controls, such as signage, fencing	Property access to the general public would be restricted	Potentially implementable process option.	Yes
Containment	Surface Controls	Engineered Cover	Affected soil media would be covered with relatively impervious layers (i.e., bentonite-amended soil cover, geosynthetic multi-layer cover or pavement cover) along with drainage to reduce infiltration of precipitation and eliminate surface exposure of affected soil media.	Potentially implementable process option.	Yes
		Exposure Barriers	Affected soil media would be covered with a gravel or asphalt cover to prevent surface exposure of affected soil media. Does not necessarily reduce infiltration of precipitation.	Potentially implementable process option.	Yes
		Vegetative Cover	Affected soil media would be covered with a layer of clean topsoil and revegetated to eliminate surface exposure of affected soil media.	Potentially implementable process option.	Yes
		Evapotranspiration Cover	Affected soil media would be covered with engineered layers of soil or rock, combined with select plant species to maximize evapotranspiration and eliminate surface exposure of contaminated soil.	Not technically implementable due to area's climate (the large amount of overall precipitation at the site and the percentage of that precipitation that occurs during the winter which is a period of low evapotranspiration potential). Also, the technology does not complement the current and future site industrial uses.	No
		Dust Suppression	Regular application of dust suppression chemicals to reduce generation of potentially contaminated dust from affected soil media.	Potentially implementable process option.	Yes
Removal, Transport, Disposal	Removal	Mechanical Excavation	Affected soil media would be excavated using mechanical methods.	Potentially implementable process option.	Yes
		Hydraulic Excavation (Slurry Pumping)	Affected soil media would be excavated in slurry form using a pipeline or other hydraulic conveyance systems. May be applicable for excavation of soils below the water table.	Potentially implementable process option.	Yes
		Pneumatic Excavation (Vacuum Extraction)	Affected soil media would be excavated using vacuum hoses, vacuum trucks, or other pneumatic conveyance system. May be applicable in and around utility corridor where conventional excavation is not feasible (such as hydro excavation - using pressurized water to wash soils from around utility lines followed by vacuum extraction of the soil slurry)	Potentially implementable process option.	Yes
	Transport	Mechanical Transport (Hauling/Conveying)	Excavated affected soil media would be transported by truck or other mechanical conveyance method to a disposal site.	Potentially implementable process option.	Yes
		Hydraulic Transport (Slurry Pumping)	Excavated affected soil media would be mixed with water and be transported via pipe in slurry form to a final disposal site.	Not readily implementable for small volumes over large distances without existing infrastructure. No disposal site nearby.	No
		Pneumatic Transport (Vacuum Extraction)	Excavated affected soil media would be transported using a vacuum system via pipe to a final disposal site.	Not readily implementable for small volumes over large distances without existing infrastructure. No disposal site nearby.	No
	Disposal	Disposal On-Site	Excavated affected soil media would be disposed at the on-site containment cell/repository	Potentially implementable process option.	Yes
		Disposal at an Offsite Facility	Excavated affected soil media would be disposed of in an existing (currently permitted) facility that is designed or authorized to accept the affected soil media.	Potentially implementable process option.	Yes

Table 6-1 Identification and Technical Implementability Screening of Potentially Applicable Remedial Technologies/Process Options for Affected Soil Media
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Action	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Treatment	Ex-Situ	Stabilization/Solidification	Affected soil media would be excavated and mixed onsite with a cement or other binding agent before disposal. Would be used in conjunction with other technologies and process options such as removal and disposal.	Potentially implementable process option.	Yes
		Chemical Oxidation	Affected soil media would be excavated and treated with chemicals to change oxidation state of arsenic and mineralize organic contaminants. Would be used in conjunction with other technologies and process options, such as removal and disposal.	Potentially implementable process option.	Yes
		Soil Washing	Affected soil media would be excavated, screened, and introduced into a washing process that uses a washing solution and mechanical agitation to remove surficial contaminants. Technology used in conjunction with several other technologies and process options, such as removal and disposal.	Not technically feasible for site application because technology does not remove contaminants such as metals and metalloids from affected contaminated soil. Technology is typically used for removal of organic contaminants from soils.	No
		Vitrification	Affected soil media would be excavated, screened, and stockpiled. An electrical current would be passed between electrodes inserted into soil media to cause melting. The melted matrix is then allowed to cool into a mass of vitrified glass. Technology would be used in conjunction with several other technologies and process options, such as removal and disposal.	Not technically feasible for site application because of large extent and volume of affected soil, large quantities of energy, and off gases from the process can contain arsenic posing safety concerns.	No
	In-Situ	Soil Flushing	A washing solution (as with soil washing) would be circulated through the affected soil media with the use of injection and extraction wells or trenches.	Not technically feasible for site application because of large extent and volume of solid source media, and the heterogeneous nature of the affected soil media matrix.	No
		In Situ Chemical Oxidation (ISCO)	Strong oxidizing agents and, in some instances, other reaction generating substances (catalysts) are injected into contaminated area of the subsurface to oxidize arsenic into the less mobile arsenate form,to destroy residual petroleum contamination, and organic acids leached from wood waste. Petroleum hydrocarbons and organic acids can both contribute to the mobilization of arsenic.	Potentially implementable process option.	Yes
		Ferrous Sulfate Stabilization	Contaminants in affected soil media are immobilized in situ with a ferrous sulfate or other iron binding agent, which is distributed throughout the affected area using augering, jet grouting, backhoe mixing, or rotary head mixing.	Potentially implementable process option.	Yes
		Stabilization/Solidification	Mix binder (cement), bentonite, and ferrous sulfate with soil through vertical auger mixing, in-place mixing, or pressure injection to reduce mobility of contaminants and/or flow of groundwater.	Potentially implementable process option.	Yes
		Electrochemical Treatment	In situ application of an electric current. Contaminants dissolve through the Induced Complexation (IC) process. Dissolved contaminants migrate to electrode in response to the electric field where they are concentrated. The concentrated contaminants are then removed via groundwater extraction.	The conditions at the site are generally unfavorable for the use of electrochemical treatment. Technology is not effective for soils with contaminants present as low solubility solids or tightly bound to the soil, due to the need for the contaminants to first dissolve into the water. The arsenic is present within solid phases (shot, secondary iron minerals, etc.) which are not easily mobilized. It is also not effective for the vadose zone because the soils must be saturated to conduct the electric current and much of the arsenic is present within the vadose zone	No
		Vitrification	An electrical current would be passed between electrodes inserted into affected soil to cause melting. The melted matrix is then allowed to cool into a mass of vitrified glass.	Not technically feasible for site application because of large extent and volume of affected soil, large quantities of energy, and off gases from the process can contain arsenic, posing safety concerns.	No

Note: Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of technical implementability. Remaining (unshaded) remedial technologies/process options have been retained for additional screening in Table 6-3.

Table 6-2 Identification and Technical Implementability Screening of Potentially Applicable Remedial Technologies/Process Options for Affected Groundwater
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Action	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
No Action	None	None	No action would be taken. The affected groundwater remains in its existing condition	No action alternative is not acceptable under MTCA.	No
Monitoring	Physical and/or Chemical Monitoring	Sample Collection and Analysis	Monitoring used to determine chemical and physical parameters of affected groundwater and migration of contaminants to surface water.	Potentially implementable process option.	Yes
Monitored Natural Attenuation	Monitored Natural Attenuation	Monitored Natural Attenuation	Natural subsurface processes (such as dilution, dispersion, biodegradation, adsorption, and chemical reactions) that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in the affected groundwater.	Potentially implementable process option.	Yes
Institutional Controls	Administrative Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with affected groundwater controlled through legal instruments. Examples of governmental controls include but are not limited to local zoning, permits, codes, or regulations. Examples of proprietary controls include but are not limited to instruments such as Easement and Equitable Servitude (EES) and Covenants, Conditions and Restrictions (CCRs). Examples of informational devices include but are not limited to Notices of Environmental Contamination.	Potentially implementable process option.	Yes
	Community Awareness Activities	Informational and Educational Programs	Community informational and educational programs undertaken to enhance awareness of potential hazards and remedies for affected groundwater.	Potentially implementable process option.	Yes
Containment and Hydraulic Isolation	Physical Barriers	Slurry Wall	Continuous trenches excavated and filled with a low permeability slurry to intercept and contain groundwater movement and limit contaminated groundwater migration to surface water.	Potentially implementable process option.	Yes
		Grout Curtain	Grout curtains used to intercept, contain, and or limit groundwater migration to surface water. Grout curtains are implemented by injecting grout into the subsurface at regular spacing patterns.	Potentially implementable process option.	Yes
		Sheet Piling	Sheet piling driven to intercept and contain groundwater movement and limit contaminated groundwater migration to surface water	Potentially implementable process option.	Yes
	Hydraulic isolation, diversion, and separation measures	Passive Water Control Measures	Water control measures (such as ditches, piping, intake or discharge structures, or earthen/synthetic barriers) used passively to limit or redirect groundwater flow	Potentially implementable process option.	Yes
		Active Water Control Measures	Water control measures (such as piping, intake, or discharge structures with pumps) used to limit or redirect groundwater flow.	Potentially implementable process option.	Yes
	Storm Drain Line Repair	Slip lining	A liner placed inside the storm drain to prevent affected groundwater from entering through existing cracks and breaks in the line.	Potentially implementable process option.	Yes
		Replacement	Construction of a new, water-tight storm drain to prevent affected groundwater from entering through existing cracks and breaks in the line	Potentially implementable process option.	Yes
Removal, Transport, Disposal	Removal	Collection/Extraction	Affected groundwater extracted for treatment	Potentially implementable process option.	Yes
	Transport	Hydraulic Transport (Pipeline)	Conveyance systems (such as ditches or piping) used to transport extracted groundwater for treatment and/or discharge.	Potentially implementable process option.	Yes
	Disposal	Discharge	Discharge of collected groundwater (with treatment) directly to a surface water body, groundwater, or to publicly owned treatment works (POTW).	Potentially implementable process option.	Yes
		Mechanical Transport (Hauling/Conveying)	Collected/extracted groundwater pumped into a tank and transported by truck or other mechanical conveyance method for treatment and disposal.	Potentially implementable process option.	Yes
Treatment	In Situ Treatment	Permeable Reactive Barrier (PRB)	A “wall” of permeable reactive material is installed in the subsurface perpendicular to groundwater flow to intercept and treat contamination as the groundwater flows through the barrier. Reactive materials can utilize abiotic or biotic methods to treat contaminants.	Potentially implementable process option.	Yes
		Funnel and Gate Permeable Reactive Barrier	Low conductivity walls installed in the subsurface, which are designed to funnel the flow of affected groundwater to a smaller section of a permeable reactive barrier or “gate.” The gate allows the passage of water while treating the contaminants, the same as a permeable reactive barrier. Allows better hydraulic control on the groundwater than a PRB alone.	Potentially implementable process option.	Yes
		Air sparging	Air injected into the affected groundwater to change the oxidation state of arsenic and oxidize ferrous iron (to hydrous ferric oxides [HFO]). HFO is an effective media for adsorbing As^{3+} and As^{5+}. May also oxidize organics.	Potentially implementable process option.	Yes

Table 6-2 Identification and Technical Implementability Screening of Potentially Applicable Remedial Technologies/Process Options for Affected Groundwater
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Action	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Treatment (continued)	In Situ Treatment (continued)	Hydrofracturing	A process of fracturing low permeability zones in aquifer materials to increase permeability. Reactive materials can then be injected into the fractured zones to increase distribution of reagents to these zones and improve treatment effectiveness. Would be used in combination with another in situ technology; the need would be determined during design.	Potentially implementable process option.	Yes
		In-situ Chemical Oxidation (ISCO)	A strong oxidizing agent injected in groundwater to mineralize organics, change the oxidation state of arsenic, and oxidize ferrous iron (to hydrous ferric oxides [HFO]). HFO is an effective media for adsorbing As3+ and As5+.	Potentially implementable process option.	Yes
		Placement of Iron in the Excavation Bottom.	Placement of iron media in excavated area. The iron particles become oxidized to HFO and through this process arsenic is adsorbed	Potentially implementable process option.	Yes
		Sulfide Precipitation	A polysulfide solution, lactate, emulsified vegetable oil, or other electron donor injected into the groundwater to create sulfate reducing conditions and in turn precipitate metals into metal sulfides.	Difficult to sustain reducing conditions over the long term, sulfide precipitates formed may not remain stable.	No
		Nanoscale Iron	Injection of iron particles that are small enough to move with groundwater. The iron particles become oxidized (through chemical oxidation or air sparging) to HFO and through this process arsenic is adsorbed.	Potentially implementable process option.	Yes
Treatment	Ex situ	Water Treatment Technologies Applicable to treatment of Chemicals of Concern	Contaminated groundwater is extracted and treated to meet disposal/discharge requirements. The facility could be temporary (such as for construction dewatering) or permanent (such as for pump and treat). There are numerous treatment processes that could be utilized such as separation, filtration, neutralization, precipitation, clarification, reverse osmosis, adsorption, and/or ion exchange.	Potentially implementable process option	Yes

Note: Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of technical implementability. Remaining (unshaded) remedial technologies/process options have been retained for additional screening in Table 6-4.

Table 6-3 Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Costs for Affected Soil Media
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness	Implementability	Relative Cost		Reason for Elimination of Process Option from Consideration
						Capital Cost	O&M Cost	
Monitoring	Physical and/or Chemical Monitoring	Non-Intrusive Visual Inspection	A non-intrusive (surficial) visual inspection of covers or surface barriers to assess cover integrity. May also be used to identify the presence or absence of source materials, if visually recognizable.	❶ Protects human receptors by ensuring integrity of remedy, enhancing awareness of potential site hazards in the event that the cover or surface barrier is compromised.	❺ Easily implemented using available technical and labor resources.	$	$	Retained
Institutional Controls	Administrative Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with affected soil media would be controlled through legal instruments. Examples of governmental controls include but are not limited to local zoning, permits, codes, or regulations. Examples of proprietary controls include but are not limited to instruments such as Easement and Equitable Servitude (EES) and Covenants, Conditions and Restrictions (CCRs). Examples of informational devices include but are not limited to Notices of Environmental Contamination.	❷ Enhances awareness of potential site hazards and remedies and restricts future uses of the site that are not protective of human health and the environment. Does not directly affect ecological receptors and does not physically address contamination.	❸ Implemented using legal instruments and labor resources; potential property owner and public resistance.	$$	$	Retained
	Community Awareness Activities	Informational and Educational Programs	Community informational and educational programs would be undertaken to enhance awareness of potential hazards and remedies for affected soil media.	❷ Protects human receptors by enhancing awareness of potential site hazards and remedies. Does not directly affect ecological receptors and does not physically address contamination.	❺ Easily implemented using available technical and labor resources.	$	$	Retained
	Access Controls	Access Restrictions	Property access to general public would be restricted.	❷ Protects human receptors by restricting access; however human receptors may choose to trespass. Lesser degree of protection to ecological receptors and does not physically address contamination.	❺ Easily implemented and resources readily available.	$	$	Retained
Containment	Surface Source Controls	Engineered Cover	Affected soil media would be covered with relatively impervious layers (i.e. bentonite-amended soil cover, geosynthetic multi-layer cover or pavement cover) along with drainage to reduce infiltration of precipitation and eliminate surface exposure of affected soil media.	❸ Protects receptors by eliminating surface exposure of contaminants. However, effectiveness of the cover may decrease over time due to longevity.	❹ Easily implemented using available construction resources. Requires maintenance for long-term protectiveness.	$$$	$$	Retained
		Exposure Barriers	Affected soils would be covered with a soil, gravel, or asphalt cover to prevent surface exposure.	❸ Protects receptors by eliminating surface exposure of contaminants. However, effectiveness of the cover may decrease over time without regular maintenance (e.g., repaving). Does not necessarily reduce infiltration of precipitation.	❺ Easily implemented and resources readily available. Requires maintenance for long-term protectiveness.	$$	$	Retained
		Vegetative cover	Affected soil would be covered with a layer of clean soil and organic amendment and revegetated to eliminate surface exposure.	❷ This technology would eliminate surface exposure of contaminants However, a vegetative cover would likely promote reducing conditions in the groundwater, which would likely mobilize rather than attenuate arsenic.	❸ Implementable using available construction resources. Requires maintenance for long-term protectiveness	$$$	$$	Effectiveness. Also, may not be compatible with current or future industrial land use
Removal, Transport, Disposal	Removal	Excavation (mechanical, pneumatic, or hydraulic removal)	Affected soil media would be excavated using mechanical, pneumatic, or hydraulic methods. Appropriate method for different areas would be determined during design.	❹ Protects receptors by eliminating exposure to contaminants. Must be combined with transport, disposal, and/or treatment technologies.	❹ Easily implemented using available construction resources.	$$$	⓿	Retained
	Transport	Mechanical Transport (Hauling/ Conveying)	Excavated affected soil media would be transported by truck or other mechanical conveyance method to disposal site.	❹ Protects receptors by eliminating exposure to contaminants. Transport of affected contaminated soil media on roads may cause adverse impacts to the public. Must be combined with removal, disposal, and/or treatment technologies.	❹ Easily implemented using available construction resources; efficient for all sizes of materials. Suitable road access or travel corridor required for mechanical transport.	$$$	⓿	Retained
	Disposal	Disposal On-Site	Excavated affected soil would be disposed at an onsite containment cell/repository constructed specifically for this purpose.	❹ Protects receptors by eliminating exposure to contaminants. Must be combined with removal, transport, containment, and/or treatment technologies.	❷ Implemented using available construction resources. Requires maintenance and monitoring for long-term protectiveness	$$$	$$	Implementability, Cost (not cost effective for smaller quantities)

Table 6-3 Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Costs for Affected Soil Media (continued)
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness	Implementability	Relative Cost		Reason for Elimination of Process Option from Consideration
						Capital Cost	O&M Cost	
Removal, Transport, Disposal (continued)	Disposal (continued)	Disposal at Offsite Facility	Excavated affected soil would be disposed of in an existing (currently permitted) offsite facility (landfill) that is designed or authorized to accept the affected soil.	❹ Protects receptors by eliminating exposure to contaminants. Must be combined with removal, transport, containment, and/or treatment technologies.	❹ Existing facilities are currently permitted to accept wastes; however, may require pre-treatment of affected soil to allow disposal. Future maintenance is performed by the disposal facility.	$$$	⓿	Retained
Treatment	Ex Situ	Stabilization/Solidification	Affected soil media would be excavated and mixed onsite with a ferrous sulfate and/or iron binding agent before disposal. Technology used in conjunction with several other technologies and process options such as removal and disposal.	❹ Protects receptors by eliminating exposure to contaminants by encapsulating them in a solid matrix. Useful for excavated soils that profile as a dangerous waste based on exceedance of leachable arsenic concentrations and therefore cannot be directly landfill disposed. Must be combined with removal, transport, containment, and/or treatment technologies.	❸ Implemented using available construction resources. Difficult to obtain and transport large quantities of binding agent and homogenize binding agent with soil. This process option will be most applicable on a smaller scale and for more homogeneous materials.	$$$$	⓿	Retained in the event that soil that profiles as a dangerous waste based on exceedance of leachable arsenic concentrations identified during excavation.
		Chemical Oxidation	Affected soil would be excavated and treated with chemicals to change oxidation state of arsenic and mineralize organic contaminants. Technology used in conjunction with several other technologies and process options, such as removal and disposal.	❸ Protects receptors by reducing the mobility of contaminants. Not effective for physical solidification. Chemical stabilization may be reversible.	❷ Implemented using available construction resources; however, more complex to implement than stabilization/solidification technology.	$$$$	⓿	Effectiveness, Implementability.
	In Situ	In Situ Chemical Oxidation (ISCO)	Strong oxidizing agent and, in some instances, other reaction generating substances (catalysts) is injected into contaminated area of the subsurface to change oxidation state of arsenic and iron resulting in coating of soil particles.	❷ Coprecipitation of dissolved iron and arsenic onto soil particles. Coating of impacted particles can inhibit leaching. ISCO treatment is designed for groundwater treatment but may provide some limited source control for soils. Protects receptors by reducing leachability. In lower permeability zones, limited contact between the soil and the ISCO solution can limit the effectiveness of the technology.	❸ Implemented using available construction resources.	$$$$$	$	Eliminated due to low effectiveness
		Ferrous Sulfate Stabilization	Affected soil media would be mixed in situ with a ferrous sulfate and/or iron binding agent using augering, jet grouting, backhoe mixing, or rotary head mixing to ensure arsenic remains immobile.	❷ Precipitation of iron onto impacted soil particles can inhibit leaching from soils and attenuate arsenic. Protects receptors by reducing leachability of arsenic to groundwater.	❸ Implemented using available construction resources.	$$$$$	$	Effectiveness
		Stabilization/Solidification	Mix binder (cement), bentonite, and ferrous sulfate with soil through vertical auger mixing, in-place mixing, or pressure injection to reduce mobility of contaminants and/or flow of groundwater.	❸ Solidification encapsulates contamination. Protects receptors by eliminating exposure of contaminants. Short term effectiveness may be impacted by high pH of cement which can mobilize arsenic	❸ Implemented using available construction resources. In areas containing infrastructure such as buried utilities, implementation of in-situ S/S is complicated, but still possible.	$$$$	⓿	Retained

Notes:

1. The screening process for effectiveness, implementability, and relative cost involves a qualitative assessment of the degree to which process options address evaluation criteria presented in Section 6. The numerical designations for the qualitative ratings system used in this table are not used to quantitatively assess process options (for instance, rankings for a process option are not additive).
2. Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of effectiveness, implementability, and/or disproportionate cost relative to other process options within the same GRA. Remaining (unshaded) remedial technologies/process options have been retained for assembly into remedial action alternatives as discussed in Section 7.
3. The following sources of technical information were used to identify and screen remedial technologies and process options:

Federal Remediation Technologies Roundtable (FRTR). 2007. Remediation Technologies Screening Matrix and Reference Guide, Version 4.0.

U. S. Environmental Protection Agency (EPA). 1994. Superfund Innovative Technology Evaluation (SITE) Technology Capsule, Geosafe Corporation, In Situ Vitrification Technology. November.

U. S. Environmental Protection Agency (EPA). 1999. Presumptive Remedy for Metals-in-Soil Sites. September

Legend for Qualitative Ratings System: The following ratings were used for evaluation and presentation of effectiveness, implementability, and relative cost:

Effectiveness and Implementability		Relative Cost	
⓿	**None**	$	**Low**
❶	**Low**	$$	**Low to Moderate**
❷	**Low to Moderate**	$$$	**Moderate**
❸	**Moderate**	$$$$	**Moderate to High**
❹	**Moderate to High**	$$$$$	**High**
❺	**High**		

Table 6-4 Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Costs for Affected Groundwater
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness	Implementability	Relative Cost		Reason for Elimination of Process Option from Consideration
						Capital Cost	O&M Cost	
Monitoring	Physical and/or Chemical Monitoring	Sample Collection and Analysis	Monitoring used to determine chemical and physical parameters of affected groundwater and migration of contaminants to surface water.	❶ Does not directly affect receptors and does not physically mitigate contamination. However, monitoring contaminant concentrations may indicate contaminant migration has occurred and/or that a remedy component has failed.	❺ Easily implemented using available technical and labor resources.	$	$	Retained
Monitored Natural Attenuation	Monitored Natural Attenuation	Monitored Natural Attenuation	Natural subsurface processes (such as dilution, dispersion, biodegradation, adsorption, and chemical reactions) that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in the affected groundwater.	❷ Protects human and ecological receptors by allowing natural subsurface processes to reduce concentrations of contaminants in affected groundwater without human intervention. Progress of attenuation of contaminants would be monitored. There are limited situations on the Site where attenuation could be a viable remedy due to the type of contaminants.	❺ Easily implemented using available technical labor resources. Requires long-term monitoring, which depends on rate of reduction and type of affected groundwater.	$	$	Retained
Institutional Controls	Administrative Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with affected groundwater as controlled through legal instruments. Examples of governmental controls include but are not limited to local zoning, permits, codes, or regulations. Examples of proprietary controls include but are not limited to instruments such as Easement and Equitable Servitude (EES) and Covenants, Conditions and Restrictions (CCRs). Examples of informational devices include but are not limited to Notices of Environmental Contamination.	❷ Enhances awareness of potential site hazards and remedies and restricts future uses of the Site that are not protective of human health and the environment. Does not directly affect ecological receptors and does not physically address contamination.	❺ Implemented using legal instruments and labor resources; potential public resistance.	$$	$	Retained
	Community Awareness Activities	Informational and Educational Programs	Community informational and educational programs undertaken to enhance awareness of potential hazards and remedies of Site contaminants.	❷ Protects human receptors by enhancing awareness of potential site hazards and remedies. Does not directly affect ecological receptors and does not physically address contamination.	❺ Easily implemented using available technical and labor resources.	$	$	Retained
Containment and Hydraulic Isolation	Physical Barriers	Slurry Wall	Continuous trenches excavated and filled with a low permeability slurry to intercept and contain groundwater movement and limit contaminated groundwater migration to surface water.	❸ Protects receptors by containing groundwater and/or controlling flow path. Effectiveness of slurry wall highly dependent on ability to trench wall into an impermeable base layer to prevent short circuiting. Effectiveness of slurry wall may decrease over time if wall cracks or otherwise degrades.	❸ Implementable using available construction resources. Requires significant quantity of material to create the slurry wall. Difficult to implement slurry wall over an irregular surface, such as the existing tideflat layer. At a depth of only 10-12 feet, excavation to the tideflat layer would be not be a problem. The tideflat has a low permeability and is thick enough (1-8 ft) to tie in a slurry wall. Monitoring and potential maintenance would be required for long-term protectiveness.	$$$$	$$	Retained
		Grout Curtain	Grout curtains used to intercept, contain, and or limit groundwater migration to surface water. Grout curtains would be implemented by injecting grout into the subsurface at regular spacing patterns.	❸ Protects receptors by containing groundwater and/or controlling flow path. Effectiveness of slurry wall highly dependent on ability to connect into low permeability base layer to prevent short circuiting. Effectiveness of slurry wall may decrease over time if wall cracks or otherwise degrades.	❸ Implementable using available construction resources, considering the relatively shallow depth of the tideflat layer at approximately 10 to 12 feet bgs. Requires significant quantity of grout. Requires monitoring and potential maintenance for long-term protectiveness.	$$$$	$$	Retained

Table 6-4 Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Costs for Affected Groundwater (continued)
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost		Reason for Elimination of Process Option from Consideration
								Capital Cost	O&M Cost	
Containment and Hydraulic Isolation (continued)	Physical Barriers (continued)	Sheet Piling	Sheet piling driven to intercept and contain groundwater movement and limit contaminated groundwater migration to surface water	❸	Protects receptors by containing groundwater and/or controlling flow path. Effectiveness of sheet piling may decrease over time due to degradation of materials (e.g., corrosion) or development of cracking. Effectiveness of sheet piling is highly dependent on the uniformity of the underlying low permeability layer to prevent short circuiting. May be more applicable for temporary dewatering than for a long-term barrier.	❸	Sufficient space is required for equipment needed to drive sheet piling. Requires maintenance for long-term protectiveness; however, it may be difficult to determine where maintenance is required. Sheet pile material would require testing for and/or treatment for corrosion resistance.	$$$$	$$	Retained
	Hydraulic isolation, diversion, and separation measures	Passive Water Control Measures	Water control measures (such as ditches, piping, intake or discharge structures, or earthen/synthetic barriers) used passively limit or redirect groundwater flow	❷	Protects receptors by containing groundwater and/or controlling flow path. May not be as effective where groundwater fluctuates with tidal influences.	❷	Groundwater collected by the passive control system would need to be discharged, and thus would need to be accompanied by treatment.	$$$	$$	Retained, but only for short term or temporary measures such as dewatering.
		Active Water Control Measures	Water control measures (such as piping, intake, or discharge structures with pumps) used to limit or redirect groundwater flow.	❸	Allows water to be extracted and transported as needed. Effectiveness can decrease over time as pumps wear or clog.	❸	Easily implemented using available construction resources. Requires a power source for the pumps.	$$	$$	Retained, but only for short term or temporary measures such as dewatering
	Storm Drain Repair	Slip lining	A liner placed inside the storm drain to prevent affected groundwater from entering through existing cracks and breaks in the line. Could be smaller diameter pipe threaded through existing pipe and grouted or cured in place pipe ("trenchless") technology.	❹	Slip lining would make storm drains watertight and would be effective in preventing affected groundwater from infiltrating into the storm drains and being conveyed directly to the Hylebos.	❹	Implemented using available construction resources.	$$	$$	Retained
		Replacement	Construction of a new, water-tight storm drain to prevent affected groundwater from entering through existing cracks and breaks in the line.	❹	Replacing storm drains would be effective in preventing affected groundwater from infiltrating into the storm drains and being conveyed directly to the Hylebos.	❹	Implemented using available construction resources.	$$	$$	Retained
Removal, Transport, Disposal	Removal	Collection/Extraction	Affected groundwater collected/extracted for treatment	❷	Protects receptors by removing affected groundwater for treatment. Removal/transport/disposal must be combined with treatment technologies. Would be effective for temporary applications such as construction dewatering. Pump and treat is an inefficient technology. Given the distribution of arsenic throughout the property, the aquifer is unlikely to clean up, resulting in operating the system in-perpetuity. Effectiveness of the mechanical systems may decrease over time without maintenance due to pump wear or clogging.	❸	Easily implemented using available construction resources. Requires some maintenance for long-term protectiveness due to pump wear and clogging. A power source is required for the pumps.	$$$	$$$$	Retained only for short term or temporary measures such as dewatering. Otherwise screened out based on long-term effectiveness and cost
	Transport	Hydraulic Transport (Pipeline)	Conveyance systems (such as ditches or piping) used to transport extracted groundwater for treatment and/or discharge.							
	Disposal	Discharge	Discharge of collected groundwater (with treatment) directly to a surface water body, groundwater, or to POTW							
		Mechanical Transport (hauling/conveying)	Collected/extracted groundwater would be pumped into a tank and transported by truck or other mechanical conveyance for treatment and disposal.							
Treatment	In Situ Treatment	Permeable Reactive Barrier (PRB)	A "wall" of permeable reactive material is installed in the subsurface perpendicular to groundwater flow to intercept and treat contamination as the groundwater flows through the barrier. Reactive materials can utilize abiotic or biotic methods to treat contaminants.	❷	Protects receptors from contaminants and provides low to high reduction of contaminant concentrations through treatment. Effectiveness of permeable reactive barrier may decrease over time if reactive materials are not recharged over time. Effectiveness of a permeable reactive barrier is also dependent on flow velocity, which affects retention time for treatment of the contaminants.	❸	Implemented using available construction resources. Permeable reactive materials required for treatment. Requires maintenance and monitoring for long-term protectiveness.	$$$$	$$	PRB technology is retained for consideration only in a funnel and gate configuration

Table 6-4 Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Costs for Affected Groundwater (continued)
Taylor Way Property Feasibility Study
Tacoma, Washington

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost		Reason for Elimination of Process Option from Consideration
								Capital Cost	O&M Cost	
Treatment (continued)	In Situ Treatment (continued)	Funnel and Gate Permeable Reactive Barrier	Low conductivity walls would be installed in the subsurface, which are designed to funnel the flow of affected groundwater to a smaller section of a permeable reactive barrier or "gate." The gate allows the passage of water while treating the contaminants, the same as a permeable reactive barrier. Allows better hydraulic control on the groundwater than a PRB alone.	❹	Protects receptors from contaminants and provides moderate to high reduction of contaminant concentrations through treatment. Utilizing funnel and gate configuration would allow the direction of groundwater flow to be better controlled, and the smaller cross section would increase groundwater velocities to prevent excessively long residence times and stagnation within the wall.	❸	Implemented using available construction resources. Permeable reactive materials required for treatment. Requires maintenance and monitoring for long-term protectiveness.	$$$$	$$	Retained
		Air sparging	Air injected into the affected groundwater to change the oxidation state of arsenic and oxidize ferrous iron (to hydrous ferric oxides [HFO]). HFO is an effective media for adsorbing As3+ and As5+. May also oxidize organics.	❸	Protects receptors from contaminants and provides moderate to high reduction of contaminant concentrations through treatment. Suitable in locations where iron oxidation and/or oxidation of organics is desired. It would not be suitable in areas where stronger oxidizing conditions are needed. Oxidation of As3+ to As5+ using air alone is kinetically slow, and thus air injection alone may not be effective in oxidizing arsenic to its less mobile form.	❸	Implemented using available construction resources. Requires maintenance and monitoring for long-term protectiveness.	$$$$	$$	Retained
		Hydrofracturing	A process of fracturing low permeability zones in aquifer materials to increase permeability. Reactive materials can then be injected into the fractured zones to increase distribution of reagents to these zones and improve treatment effectiveness. Would be used in combination with another in situ technology; the need would be determined during design.	❸	Protects receptors from contaminants and provides moderate to high reduction of contaminant concentrations through treatment.	❷	Implemented using available construction resources. Challenging to implement in the areas of existing infrastructure.	$$$$	$	Implementability, Cost
		In-situ Chemical Oxidation (ISCO)	A strong oxidizing agent injected in groundwater to mineralize organics, change the oxidation state of arsenic, and oxidize ferrous iron (to hydrous ferric oxides [HFO]). HFO is an effective media for adsorbing As3+ and As5+.	❹	Protects receptors from contaminants and provides moderate to high reduction of contaminant concentrations through treatment. Highly effective in oxidizing residual organic contamination, such as the residual petroleum and wood waste.	❷	Implemented using available construction resources. However, the Bunker C area is relatively close to the Hylebos waterway. Permanganate is toxic to aquatic organisms. If implemented in this area a pump-back or recirculation system (e.g., hydraulic containment) would be considered to prevent entry of permanganate to surface water.	$$$$$	$	Retained
		Nanoscale Iron	Iron particles that are small enough to move in groundwater are injected into groundwater to oxidize (through chemical oxidation, air sparging, etc.) the iron to HFO, which in turn adsorbs the arsenic.	❸	Protects receptors from contaminants and provides reduction of contaminant concentrations through treatment. Injection of nanoscale iron would be expected to be effective if injected into a suitable aquifer formation (e.g., one with large enough porosity)	❷	Nanoscale iron is costly to produce and highly reactive. It is difficult to keep the iron stable until the particles are delivered to the desired location in the subsurface.	$$$$$	$	Implementability, Cost
	Ex situ Treatment	Water treatment technologies applicable to treat chemicals of concern	Contaminated groundwater would be extracted and treated to meet disposal/discharge requirements. The facility could be temporary (such as for construction dewatering) or permanent (such as for pump and treat). There are numerous treatment processes that could be utilized such as separation, filtration, neutralization, precipitation, clarification, reverse osmosis, adsorption, and/or ion exchange.	❹	Protects receptors from contaminants and provides reduction of contaminant concentrations through treatment. Water treatment technologies are well developed and available to treat arsenic, metals, and/or organics to very low concentrations.	❸	Water treatment is readily implementable. Continuous monitoring and maintenance are required, often with skilled labor. Requires continuous supply of reagents and other consumables as part of treatment process. Requires power. Treatment residuals (e.g., sludges, spent media, brine, etc.) are created requiring appropriate disposal.	$$$$$	$$$$	Retained if needed for short term or temporary measures such as dewatering. Otherwise screened out based on cost and implementability

Notes:

1. The screening process for effectiveness, implementability, and relative cost involves a qualitative assessment of the degree to which process options address evaluation criteria presented in Section 6. The numerical designations for the qualitative ratings system used in this table are not used to quantitatively assess process options (for instance, rankings for a process option are not additive).
2. Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of effectiveness, implementability, and/or disproportionate cost relative to other process options within the same GRA. Remaining (unshaded) remedial technologies/process options have been retained for assembly into remedial action alternatives as discussed in Section 7.
3. The following sources of technical information were used to identify and screen remedial technologies and process options:

   Federal Remediation Technologies Roundtable (FRTR). 2007. Remediation Technologies Screening Matrix and Reference Guide, Version 4.0.

   U. S. Environmental Protection Agency (EPA). 1994. Superfund Innovative Technology Evaluation (SITE) Technology Capsule, Geosafe Corporation, In Situ Vitrification Technology. November.

   U. S. Environmental Protection Agency (EPA). 1999. Presumptive Remedy for Metals-in-Soil Sites. September

Legend for Qualitative Ratings System: The following ratings were used for evaluation and presentation of effectiveness, implementability, and relative cost:

Effectiveness and Implementability		Relative Cost	
⓿	**None**	$	**Low**
❶	**Low**	$$	**Low to Moderate**
❷	**Low to Moderate**	$$$	**Moderate**
❸	**Moderate**	$$$$	**Moderate to High**
❹	**Moderate to High**	$$$$$	**High**
❺	**High**		

Table 7-1 Remedial Alternatives Matrix
Taylor Way Property Feasibility Study
Tacoma, Washington

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
Alternatives Based on Focus Areas					
South Corner Area					
SOIL	Excavate soil with arsenic concentrations exceeding chronic-based remediation level, at minimum (target possible source soils in utility corridor).	Excavate soil with arsenic concentrations exceeding acute-based remediation level and Solidification/ Stabilization for additional soils.	Excavate soil with arsenic concentrations exceeding acute-based remediation level.	Excavate soil with arsenic concentrations exceeding chronic-based remediation level, at minimum (target possible source soils in utility corridor).	
GW	MNA	MNA	Slipline storm drain line in Taylor Way	MNA/Slipline storm drain in Taylor Way as Contingency	
Hylebos Waterway Area					
SOIL	Limited soil excavation (acute/chronic for arsenic)	Limited soil excavation (acute/chronic for arsenic)	Limited soil excavation with iron placement in excavated area (acute/chronic for arsenic)	Limited soil excavation with iron placement in excavated area (acute/chronic for arsenic)	
GW	Air sparging and/or ISCO	Funnel and Gate PRB	Funnel and Gate PRB	Funnel and Gate PRB	
Railroad Spur Area					
SOIL	Limited soil excavation (Acute - arsenic, Method A Industrial - lead)	Limited soil excavation (Acute - arsenic, Method A Industrial - lead)	Limited soil excavation (Acute - arsenic, Method A Industrial - lead)	Limited soil excavation (Acute - arsenic, Method A Industrial - lead)	
GW	MNA	MNA	MNA	MNA	
					Full Property
SOIL					Excavate all soil with concentrations exceeding arsenic Method C cleanup level (maximum depth tideflat layer), replace excavated soil with clean fill
GW					MNA/Slipline in Taylor Way
Site Wide					
Storm Drains - Onsite System	Replace or Slipline				
Institutional Controls	√	√	√	√	√
O&M	√	√	√	√	√
Monitoring	√	√	√	√	√

Notes:

Arsenic Acute-Based Remediation Level - 1,060 milligrams per kilogram (mg/kg)

Arsenic Chronic-Based Remediation Level - 400 mg/kg

Arsenic Method C Industrial Soil Cleanup Level - 87.5 mg/kg

Lead Method A Industrial Soil Cleanup Level - 1,000 mg/kg

MNA - Monitored Natural Attenuation

Table 8-1 Cost Estimate Summary - Alternatives 1 through 5

Feasibility Study - Taylor Way Property
Tacoma, Washington

Alternative 1	Estimated	Low End (-30%)	High End (+50%)
Capital Cost (year 0)	$ 4,491,100	$ 3,143,770	$ 6,736,650
OM&M Cost (years 1 through 2) (per year)	$ 74,360	$ 52,052	$ 111,540
OM&M Cost (years 3 through 30) (per year)	$ 31,460	$ 22,022	$ 47,190
Periodic Cost - ISCO application (years 1, 6, 11, 16, 21, 26)	$ 320,330	$ 224,231	$ 480,495
Periodic Cost - 5 year review (years 5, 10, 15, 20, 25, 30)	$ 28,600	$ 20,020	$ 42,900
NPV	$ 5,927,000	$ 4,148,900	$ 8,890,500
Alternative 2	**Estimated**	**Low End (-30%)**	**High End (+50%)**
Capital Cost	$ 3,129,500	$ 2,190,650	$ 4,694,250
OM&M Cost (years 1 through 2) (per year)	$ 74,360	$ 52,052	$ 111,540
OM&M Cost (years 3 through 30) (per year)	$ 31,460	$ 22,022	$ 47,190
Periodic Cost - 5 year review (years 5, 10, 15, 20, 25, 30)	$ 28,600	$ 20,020	$ 42,900
Periodic Cost - PRB replacement (years 10, 20, 30)	$ 87,459	$ 61,221	$ 131,188
NPV	$ 3,738,000	$ 2,616,600	$ 5,607,000
Alternative 3	**Estimated**	**Low End (-30%)**	**High End (+50%)**
Capital Cost	$ 3,008,000	$ 2,105,600	$ 4,512,000
OM&M Cost (years 1 through 2) (per year)	$ 74,360	$ 52,052	$ 111,540
OM&M Cost (years 3 through 30) (per year)	$ 31,460	$ 22,022	$ 47,190
Periodic Cost - 5 year review (years 5, 10, 15, 20, 25, 30)	$ 28,600	$ 20,020	$ 42,900
Periodic Cost - PRB replacement (years 10, 20, 30)	$ 87,459	$ 61,221	$ 131,188
NPV	$ 3,616,000	$ 2,531,200	$ 5,424,000
Alternative 4	**Estimated**	**Low End (-30%)**	**High End (+50%)**
Capital Cost	$ 3,410,300	$ 2,387,210	$ 5,115,450
OM&M Cost (years 1 through 2) (per year)	$ 74,360	$ 52,052	$ 111,540
OM&M Cost (years 3 through 30) (per year)	$ 31,460	$ 22,022	$ 47,190
Periodic Cost - 5 year review (years 5, 10, 15, 20, 25, 30)	$ 28,600	$ 20,020	$ 42,900
Periodic Cost - PRB replacement (years 10, 20, 30)	$ 87,459	$ 61,221	$ 131,188
NPV	$ 4,019,000	$ 2,813,300	$ 6,028,500
Alternative 5	**Estimated**	**Low End (-30%)**	**High End (+50%)**
Capital Cost	$ 15,136,200	$ 10,595,340	$ 22,704,300
OM&M Cost (years 1 through 2) (per year)	$ 74,360	$ 52,052	$ 111,540
OM&M Cost (years 3 through 30) (per year)	$ 31,460	$ 22,022	$ 47,190
Periodic Cost - 5 year review (years 5, 10, 15, 20, 25, 30)	$ 28,600	$ 20,020	$ 42,900
NPV	$ 15,666,000	$ 10,966,200	$ 23,499,000

Note:
FS-level cost accuracy (including contingency) is deemed to be between -30 percent and +50 percent. Therefore, cost range is provided for budgeting purposes
Percentages used for contingency and professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," (EPA 2000b).

Table 8-2 Disproportionate Cost Analysis
Taylor Way Property Feasibility Study
Tacoma, Washington

Alternative #	Description[1]	Disproportionate Cost Analysis Criteria [2]	Protectiveness	Permanence	Long-Term Effectiveness	Management of Short-Term Risks	Tehnical and Administrative Implementability	Consideration of Public Concerns	Total Weighed Benefit	Cost (in millions)	Relative Benefit Score Ratio (RBSR)	Overall Recommendation
	Weighting Criteria		**30%**	**20%**	**20%**	**10%**	**10%**	**10%**				
1	Selective Excavation of Soils, Air Sparging and/or ISCO for Groundwater, Onsite Storm Drain Repair/Replacement		3	3	2	2	3	2	2.6	5.9	441	No
2	Selective Excavation of Soils, Soil Solidification/Stabilization, Funnel and Gate PRB for Groundwater, Onsite Storm Drain Repair/Replacement		4	5	3	4	3	4	3.9	3.7	1054	No
3	Selective Excavation of Soils, Funnel and Gate PRB for Groundwater, Supplemental in Excavation Iron Addition, On- and Off-site Storm Drain Line Repair/Replacement		3	4	3	4	4	3	3.4	3.6	944	No
4	Selective Excavation of Soils, Funnel and Gate PRB for Groundwater, Supplemental in Excavation Iron Addition, Onsite Storm Drain Line Repair/Replacement		5	5	4	4	3	5	4.5	4.0	1125	Yes
5	Full Soil Excavation to Method C Soil Cleanup Level, MNA for Groundwater, On- and Off-site Storm Drain Line Repair/Replacement		6	6	5	4	1	6	5.1	15.7	325	No

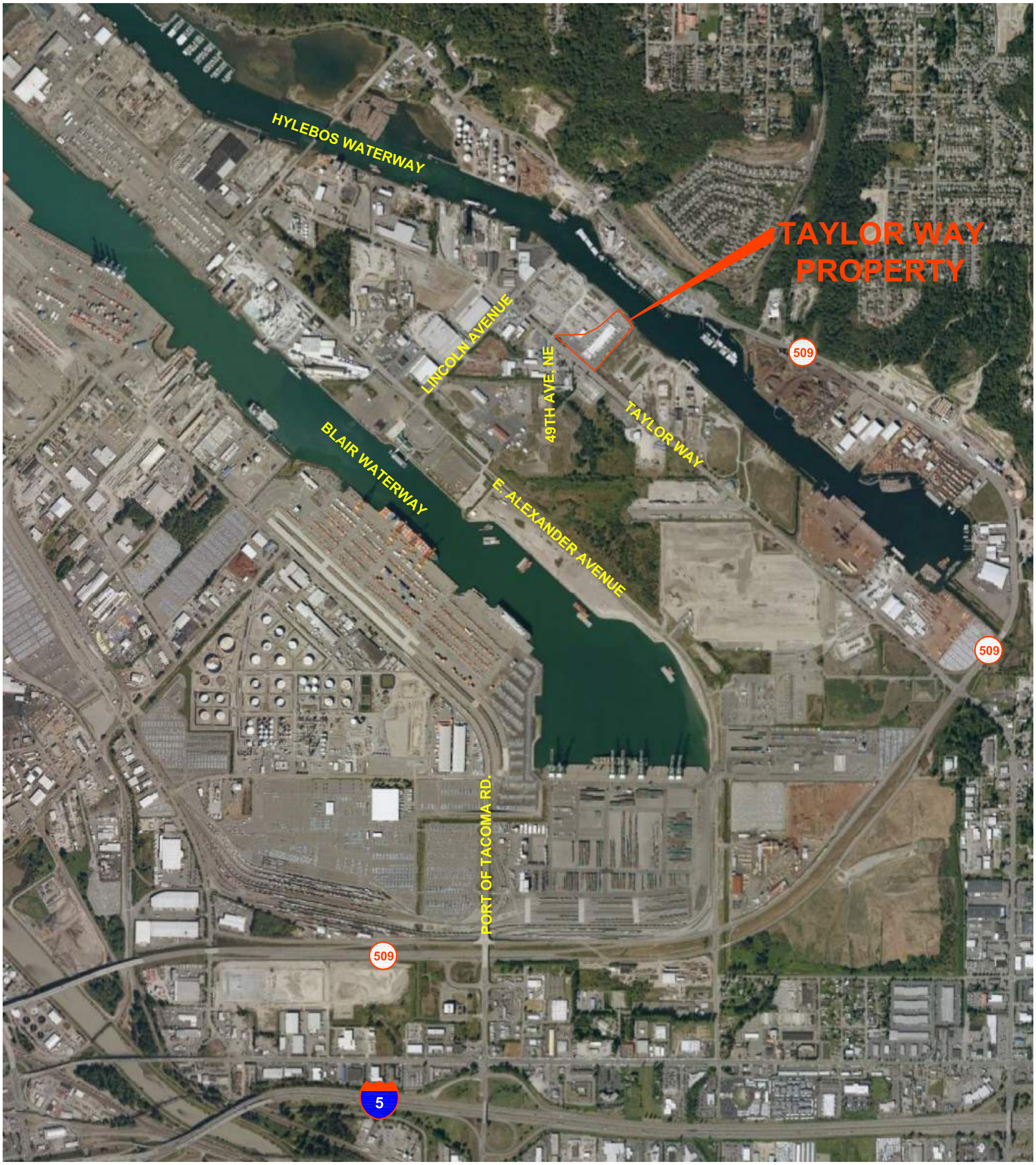
Notes:

1) All of the alternatives will include the following: Limited soil excavation (soils exceeding acute remediation levels) in the Railroad Spur Area, Institutional Controls, O&M, and Monitoring, as described in the FS.

2) Disproportionate Cost Analysis Criteria Scoring:

6 Ideal/Excellent Favorability
5 High Benefit/Very Favorable
4 Reasonable Benefit/Favorable
3 Some Benefit/Moderate Favorability
2 Slight Benefit/Low Favorability
1 Virtually No Benefit/Not Favorable

Figures



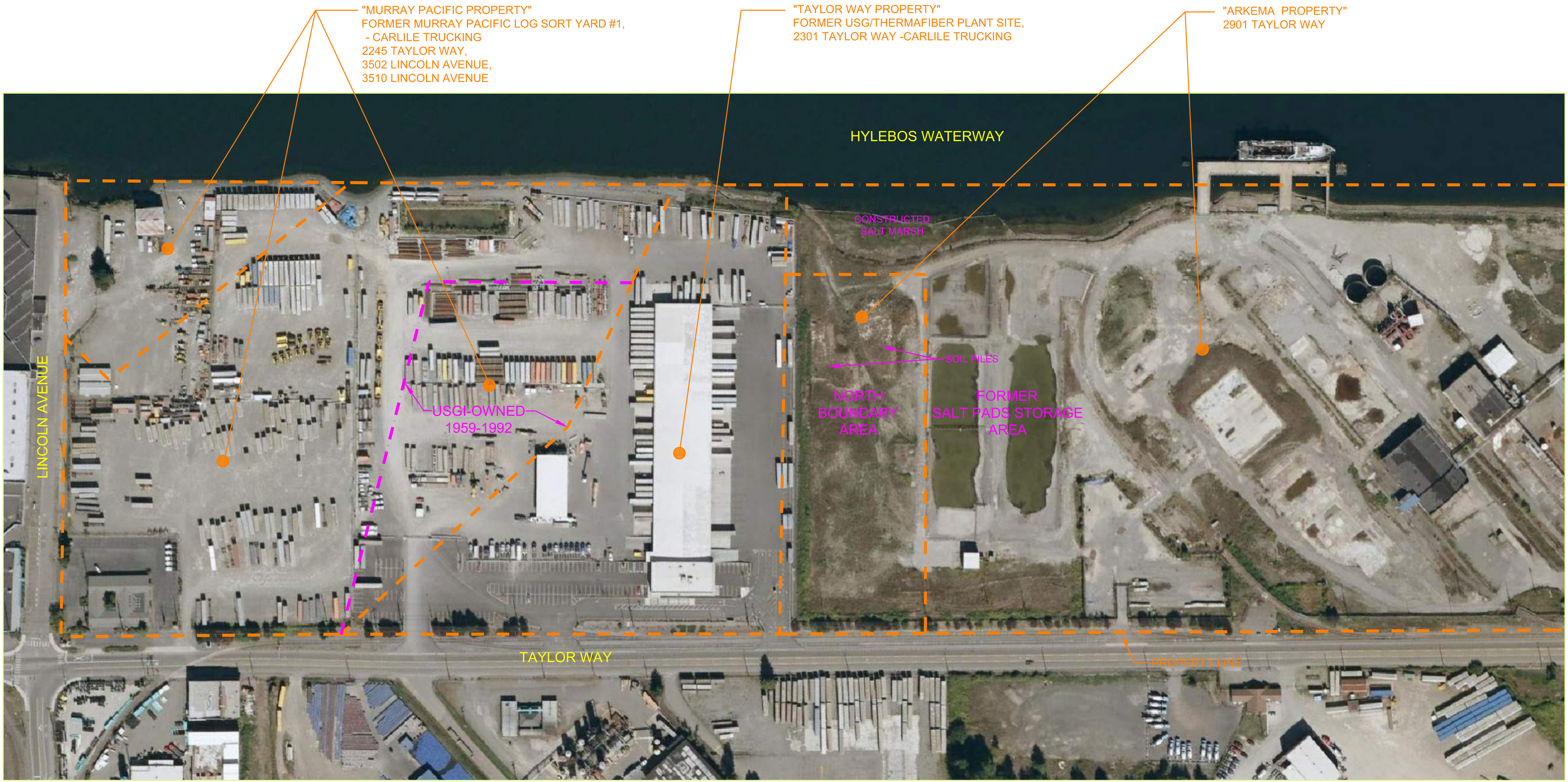
Source: GOOGLE EARTH PRO, 2009

N

0 2000
Scale in Feet

FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 1
Vicinity Map



SOURCE: GOOGLE EARTH PRO, 2009

N

1" = 200'

100 0 200

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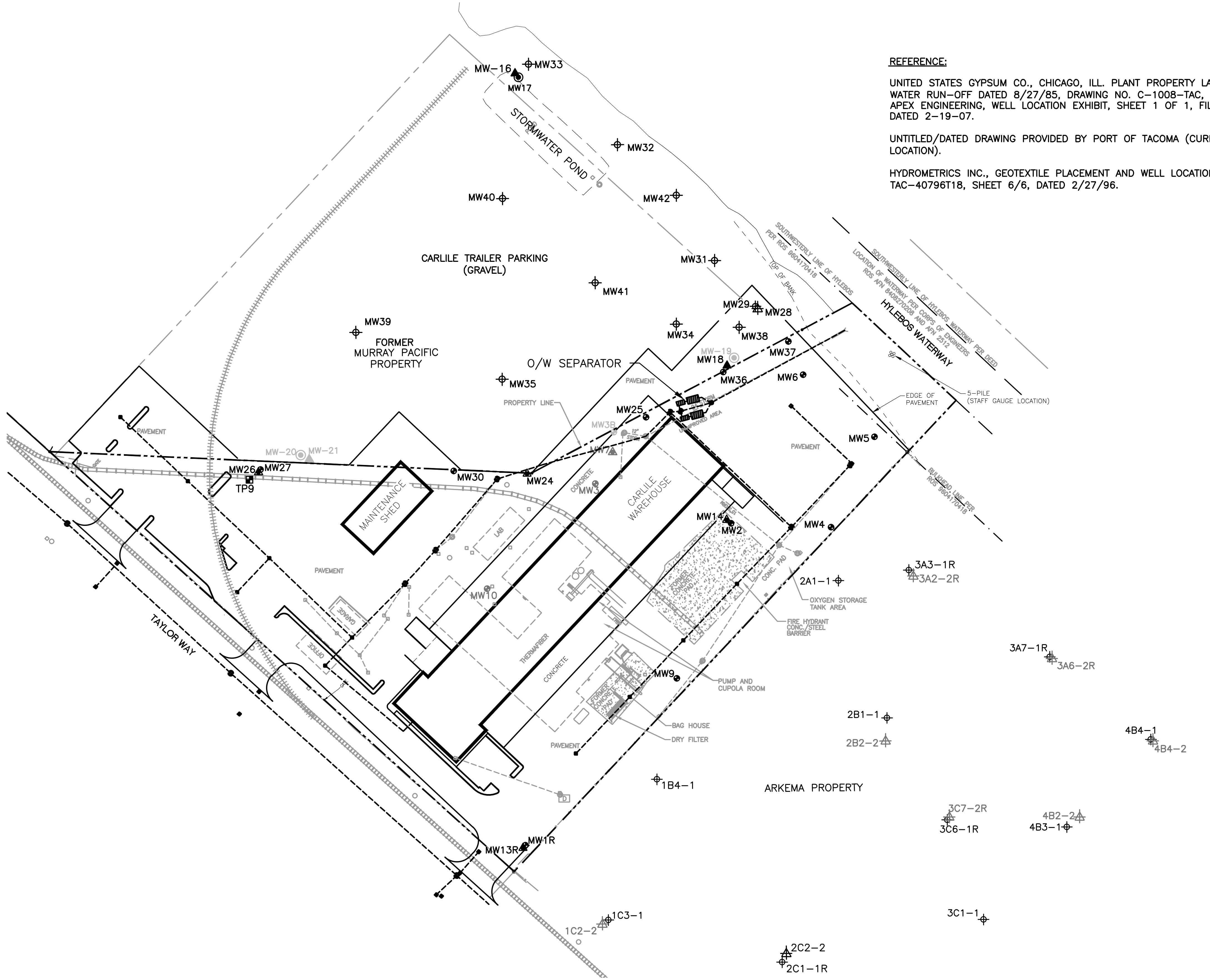
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 2
Taylor Way, Murray Pacific and Arkema Property Parcels

pw:\\pw.cdmsmith.com:PW_PL1\Documents\19921\96914\03 Reports and Studies\213642 - Tacoma FS\CADD\2019 Draft CADD\Figure-2 (2019 DRAFT REPORT).dwg



REFERENCE:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.
APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2-19-07.

UNTITLED/DATED DRAWING PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION).

HYDROMETRICS INC., GEOTEXTILE PLACEMENT AND WELL LOCATIONS, DWG.# TAC-40796T18, SHEET 6/6, DATED 2/27/96.

1" = 150'
75 0 150

N

LEGEND:

- MW6 — SURFACE AQUIFER WELL AND DESIGNATION (ABANDONED WELLS SHADED BACK)
- MW26 — SECOND AQUIFER WELL AND DESIGNATION (ABANDONED WELLS SHADED BACK)
- 1C3-1 — OFF-SITE SURFACE AQUIFER WELL AND DESIGNATION
- 2B2-2 — OFF-SITE SECOND AQUIFER WELL AND DESIGNATION
- MW-20 — ORIGINAL MURRAY PACIFIC PROPERTY SURFACE AQUIFER WELL LOCATION AND DESIGNATION (ABANDONED WELLS SHADED BACK)
- MW-21 — ORIGINAL MURRAY PACIFIC PROPERTY SECOND AQUIFER WELL LOCATION AND DESIGNATION (ABANDONED WELLS SHADED BACK)
- TAYLOR WAY PROPERTY BOUNDARY
- EXISTING BUILDING
- NEW ASPHALT PAVED AREA
- FORMER CONCRETE PAD
- FORMER BUILDING LOCATION
- STORM DRAIN SYSTEM (PREVIOUS LAYOUT)
- STORM DRAIN SYSTEM (CURRENT LAYOUT)

NOTE:

ORIGINAL (NOW ABANDONED) MONITORING WELL LOCATIONS ON THE MURRAY PACIFIC PROPERTY ARE SCANNED IN FROM A HARD COPY 1996 DRAWING. THE PRECISION OF THE FEATURES AS THEY RELATE TO THE USG SITE FEATURES CANNOT BE DETERMINED.

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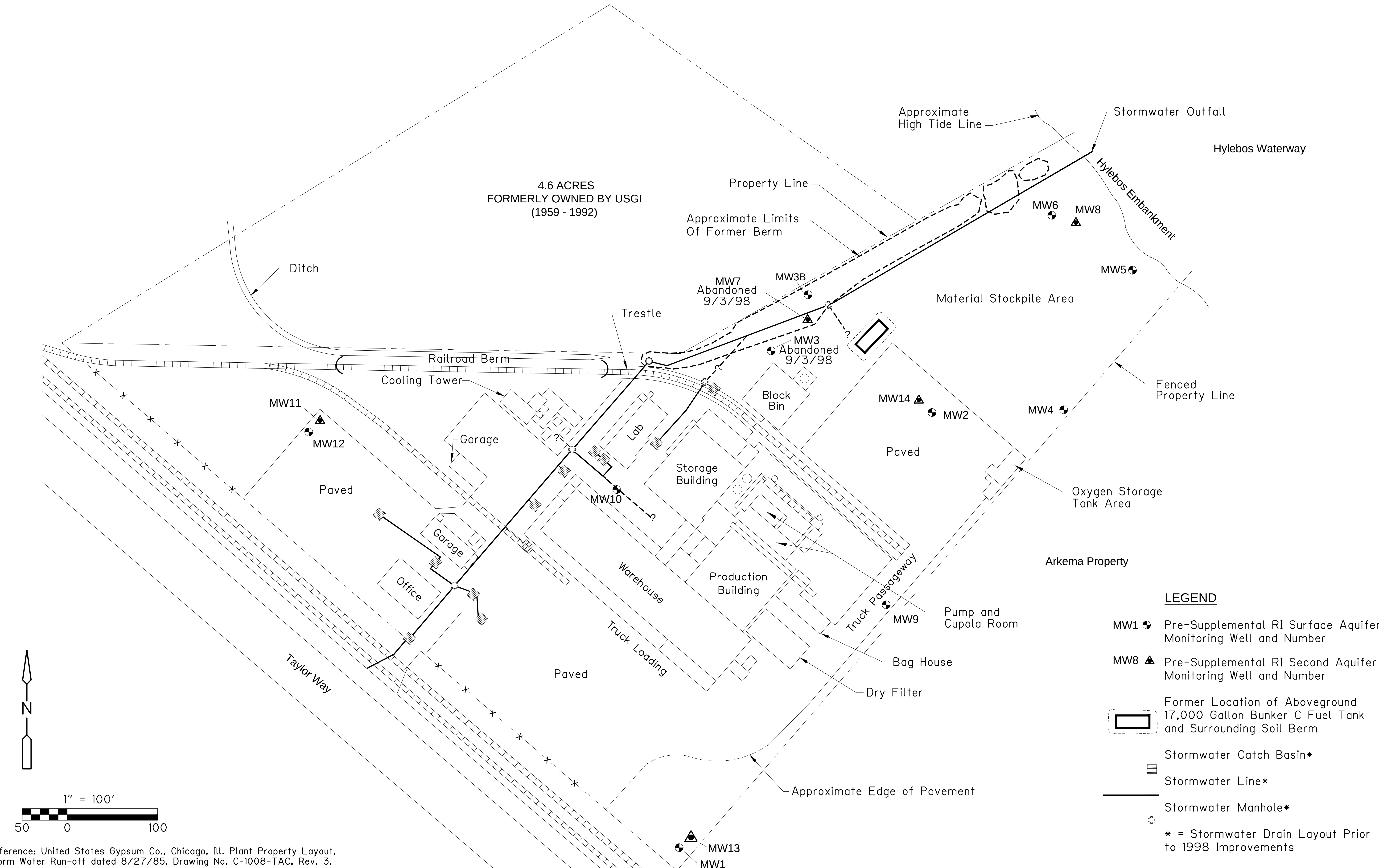
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 3
Current/Historical Site Plan



Reference: United States Gypsum Co., Chicago, Ill. Plant Property Layout, Storm Water Run-off dated 8/27/85, Drawing No. C-1008-TAC, Rev. 3.

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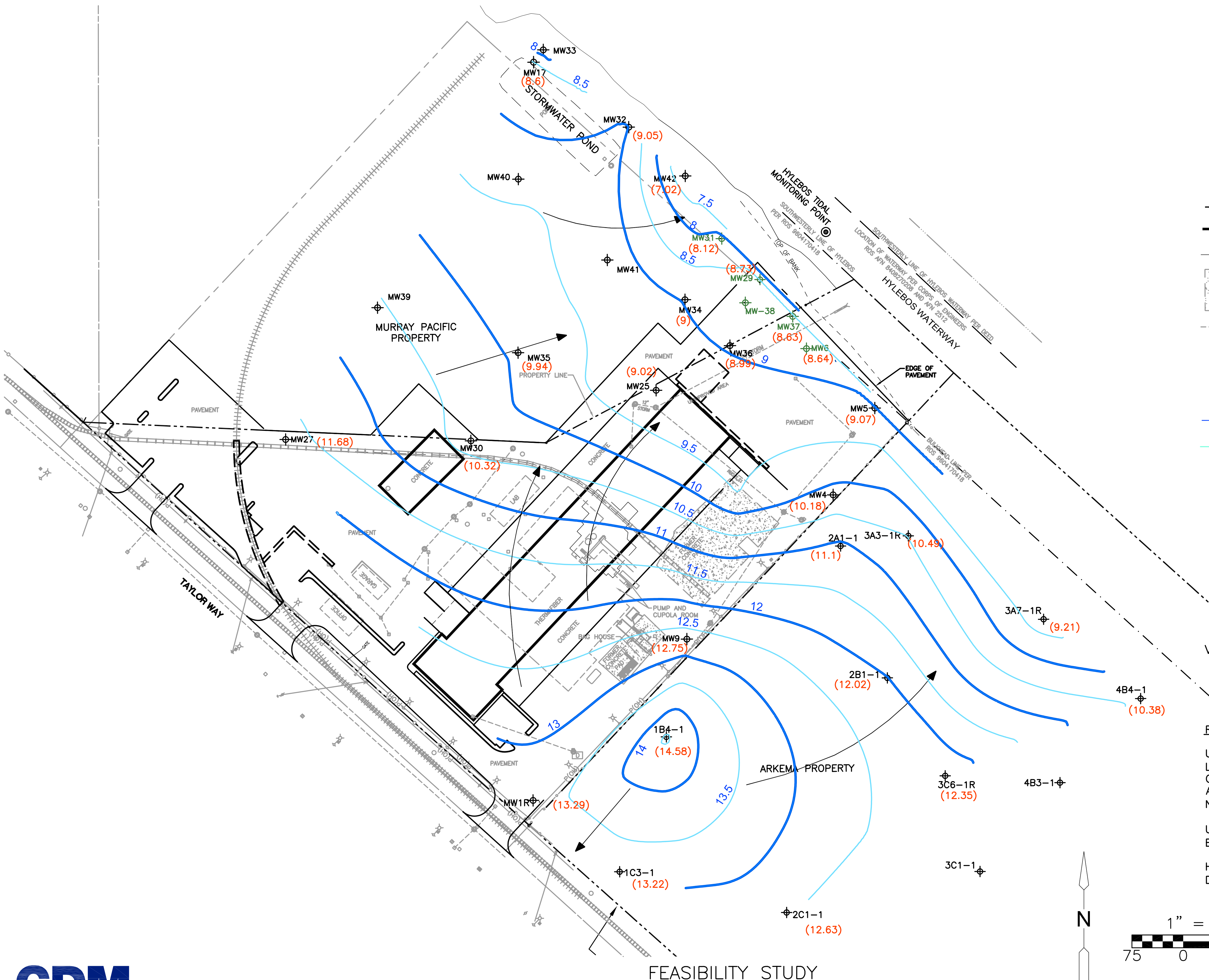
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 4
Taylor Way Property Historical Features
(Prior to 2002)



LEGEND:

- TIDAL MONITORING POINT
- 2B1-1 MONITORING WELL
- MW-37 SLUG TEST LOCATION MONITORING WELL
- TAYLOR WAY PROPERTY BOUNDARY
- EXISTING BUILDING
- NEW ASPHALT PAVED AREA
- FORMER CONCRETE PAD
- FORMER BUILDING LOCATION
- STORM DRAIN SYSTEM (FORMER)
- (7.75) MONITORING WELL WATER ELEVATION IN FEET (NAVD88)
- 14 1 FT GROUNDWATER CONTOURS
- 1/2 FT GROUNDWATER CONTOURS
- GROUNDWATER FLOW DIRECTION

VERTICAL DATUM: FEET–NORTH AMERICAN VERTICAL DATUM 1988

REFERENCE:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.
APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2/12/14.

UNTITLED/DATED DRAWING PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION).

HYDROMETRICS INC., GEOTEXTILE PLACEMENT AND WELL LOCATIONS, DWG.# TAC-40796T18, SHEET 6/6, DATED 2/27/96.

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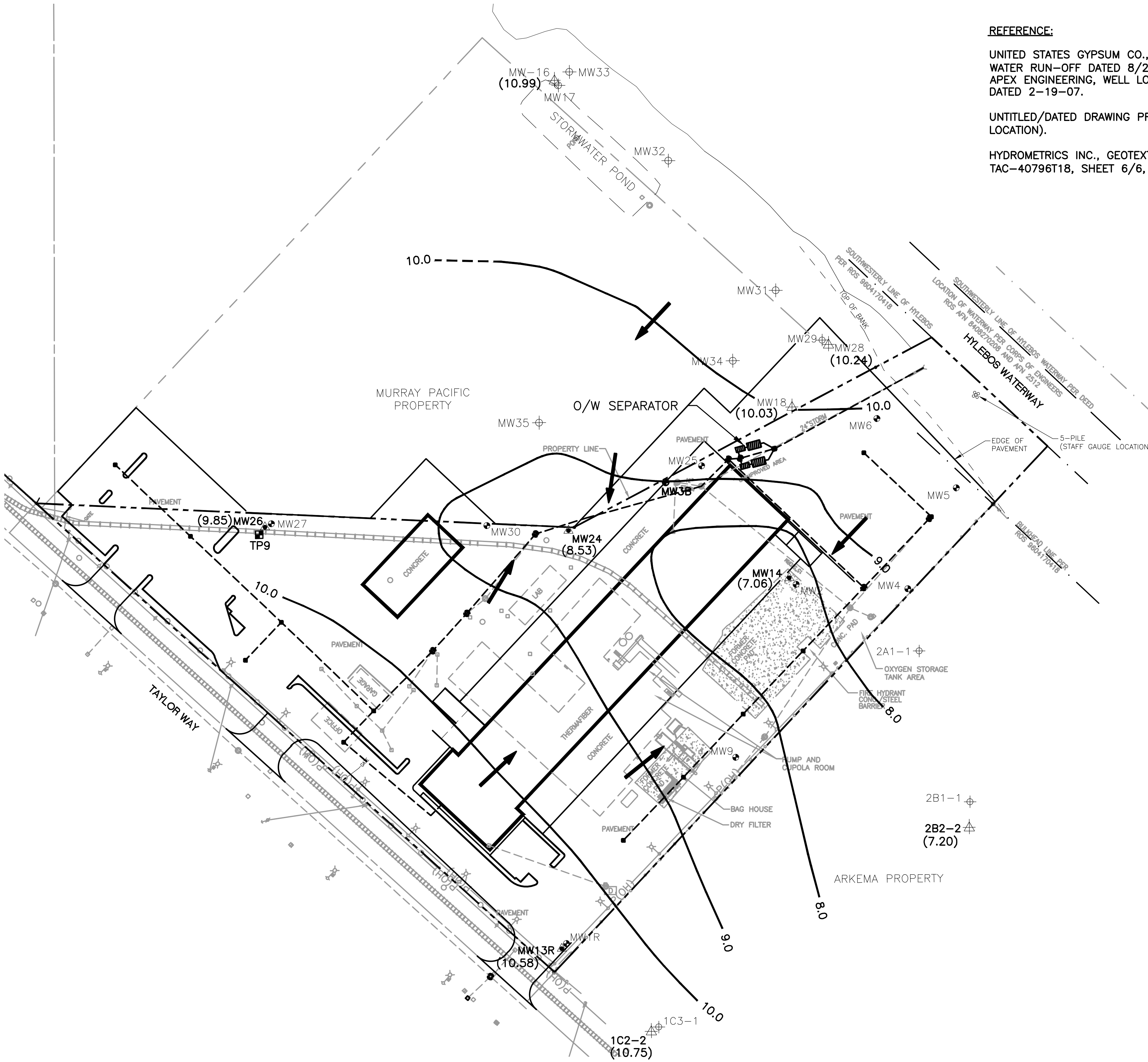
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 5
Potentiometric Surface Map,
Surface Aquifer
March 17, 2017



REFERENCE:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.
APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2-19-07.

UNTITLED/DATED DRAWING PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION).

HYDROMETRICS INC., GEOTEXTILE PLACEMENT AND WELL LOCATIONS, DWG.# TAC-40796T18, SHEET 6/6, DATED 2/27/96.

1" = 150'

75 0 150

N

LEGEND:

MW6 — SURFACE AQUIFER WELL AND DESIGNATION
MW26 (9.85) — SECOND AQUIFER WELL AND DESIGNATION WITH WATR LEVEL ELEVATION
1C3-1 — OFF-SITE SURFACE AQUIFER WELL AND DESIGNATION
2B2-2 (7.20) — OFF-SITE SECOND AQUIFER WELL AND DESIGNATION WITH WATR LEVEL ELEVTION
TAYLOR WAY PROPERTY BOUNDARY
EXISTING BUILDING
NEW ASPHALT PAVED AREA
FORMER CONCRETE PAD
FORMER BUILDING LOCATION
STORM DRAIN SYSTEM (PREVIOUS LAYOUT)
STORM DRAIN SYSTEM (CURRENT LAYOUT)
GROUNDWATER FLOW DIRECTION
8.0 — GROUNDWATER CONTOUR AND ELEVATION

NOTE:

VERTICAL DATUM: FEET—MEAN LOWER LOW WATER

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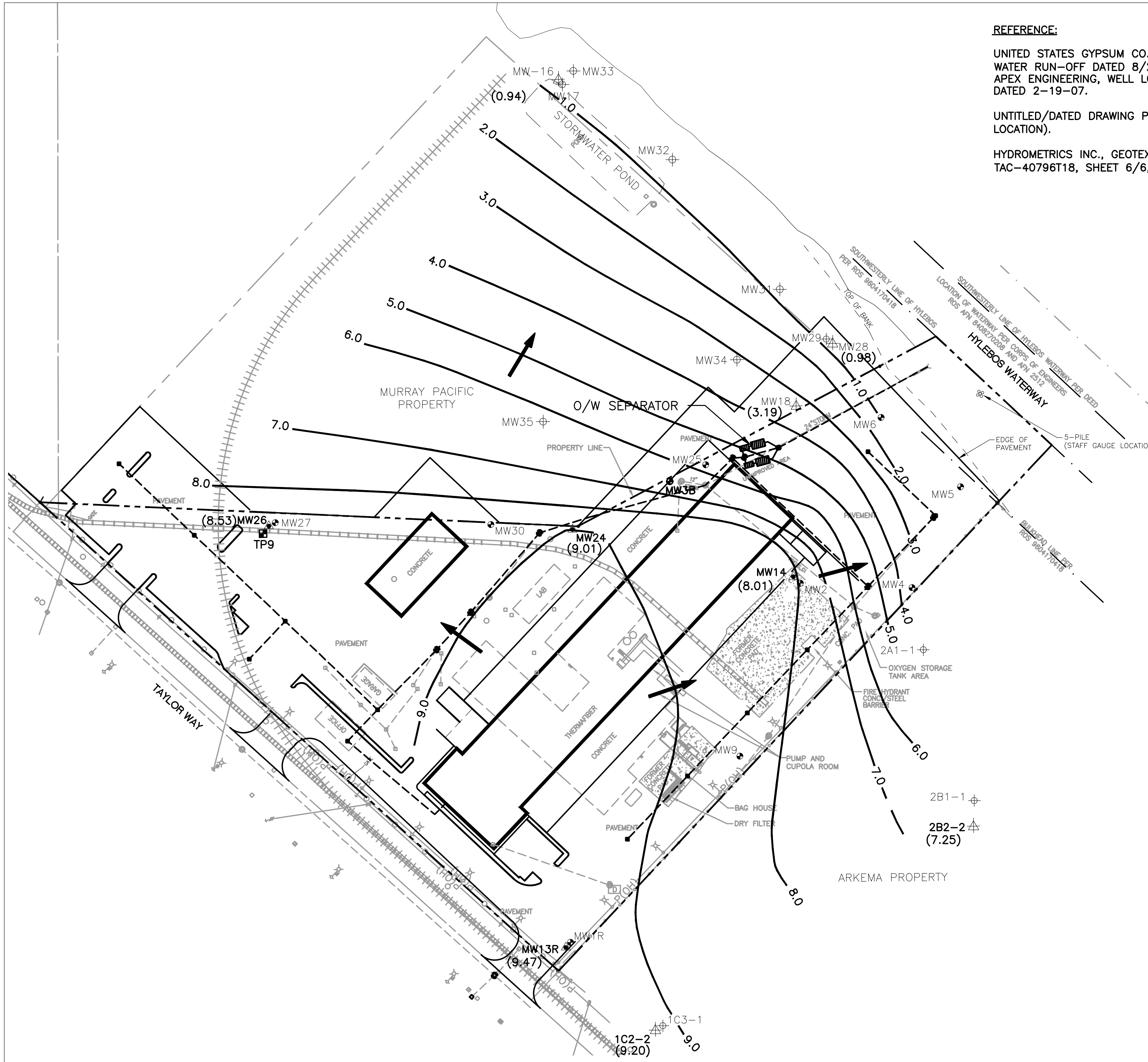
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 6
High Tide Potentiometric Surface Map
August 27, 2008
Second Aquifer



REFERENCE:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.
APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2-19-07.

UNTITLED/DATED DRAWING PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION).

HYDROMETRICS INC., GEOTEXTILE PLACEMENT AND WELL LOCATIONS, DWG.# TAC-40796T18, SHEET 6/6, DATED 2/27/96.

1" = 150'
75 0 150

N

LEGEND:

- MW6 — SURFACE AQUIFER WELL AND DESIGNATION
- MW26 (8.53) — SECOND AQUIFER WELL AND DESIGNATION WITH GROUNDWATER ELEVATION
- 1C3-1 — OFF-SITE SURFACE AQUIFER WELL AND DESIGNATION
- 2B2-2 (7.25) — OFF-SITE SECOND AQUIFER WELL AND DESIGNATION WITH WATER LEVEL ELEVATION
- TAYLOR WAY PROPERTY BOUNDARY
- EXISTING BUILDING
- NEW ASPHALT PAVED AREA
- FORMER CONCRETE PAD
- FORMER BUILDING LOCATION
- STORM DRAIN SYSTEM (PREVIOUS LAYOUT)
- STORM DRAIN SYSTEM (CURRENT LAYOUT)
- GROUNDWATER FLOW DIRECTION
- 7.0 — GROUNDWATER CONTOUR AND ELEVATION

NOTE:

VERTICAL DATUM: FEET-MEAN LOWER LOW WATER

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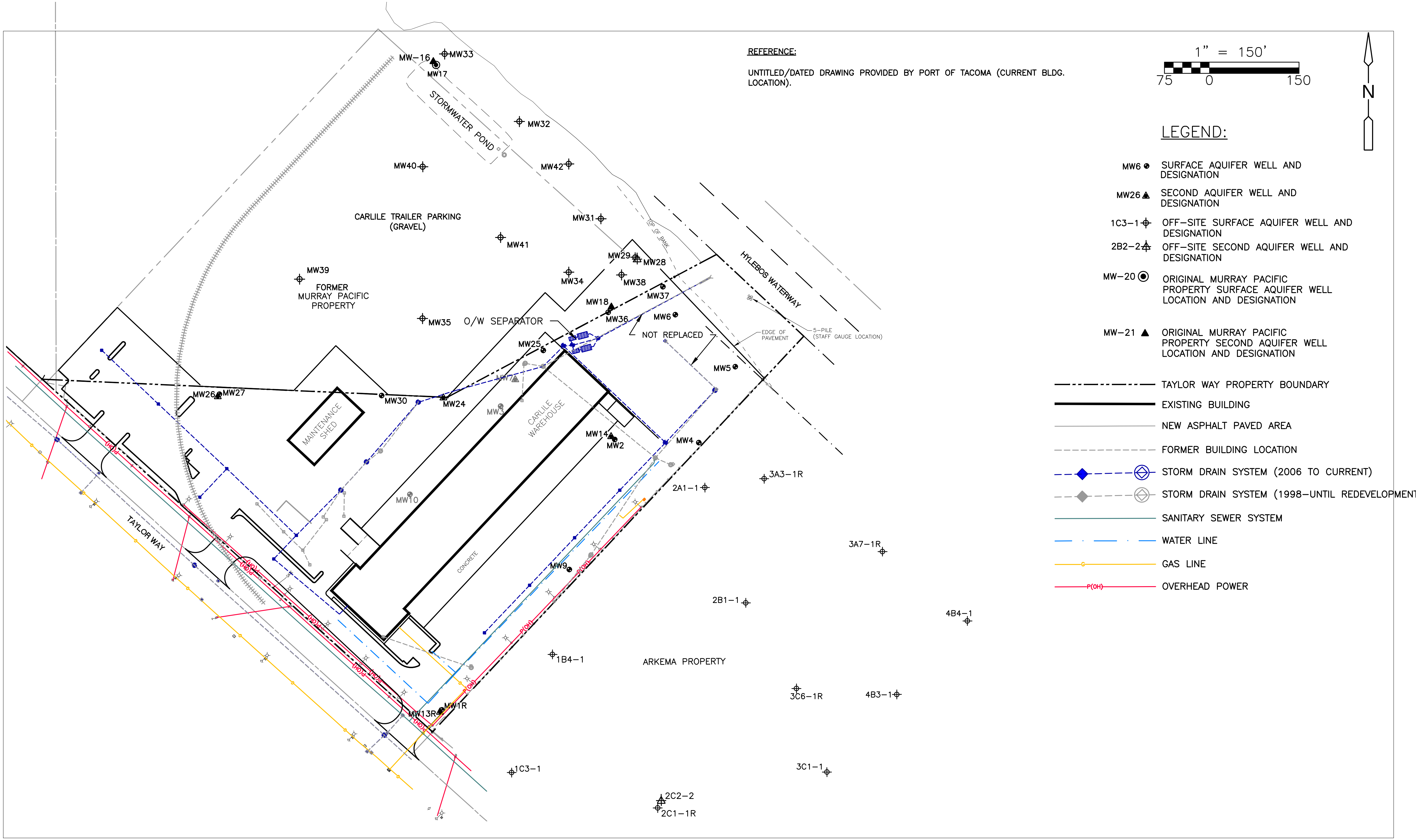
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 7
Low Tide Potentiometric Surface Map
August 29, 2008
Second Aquifer



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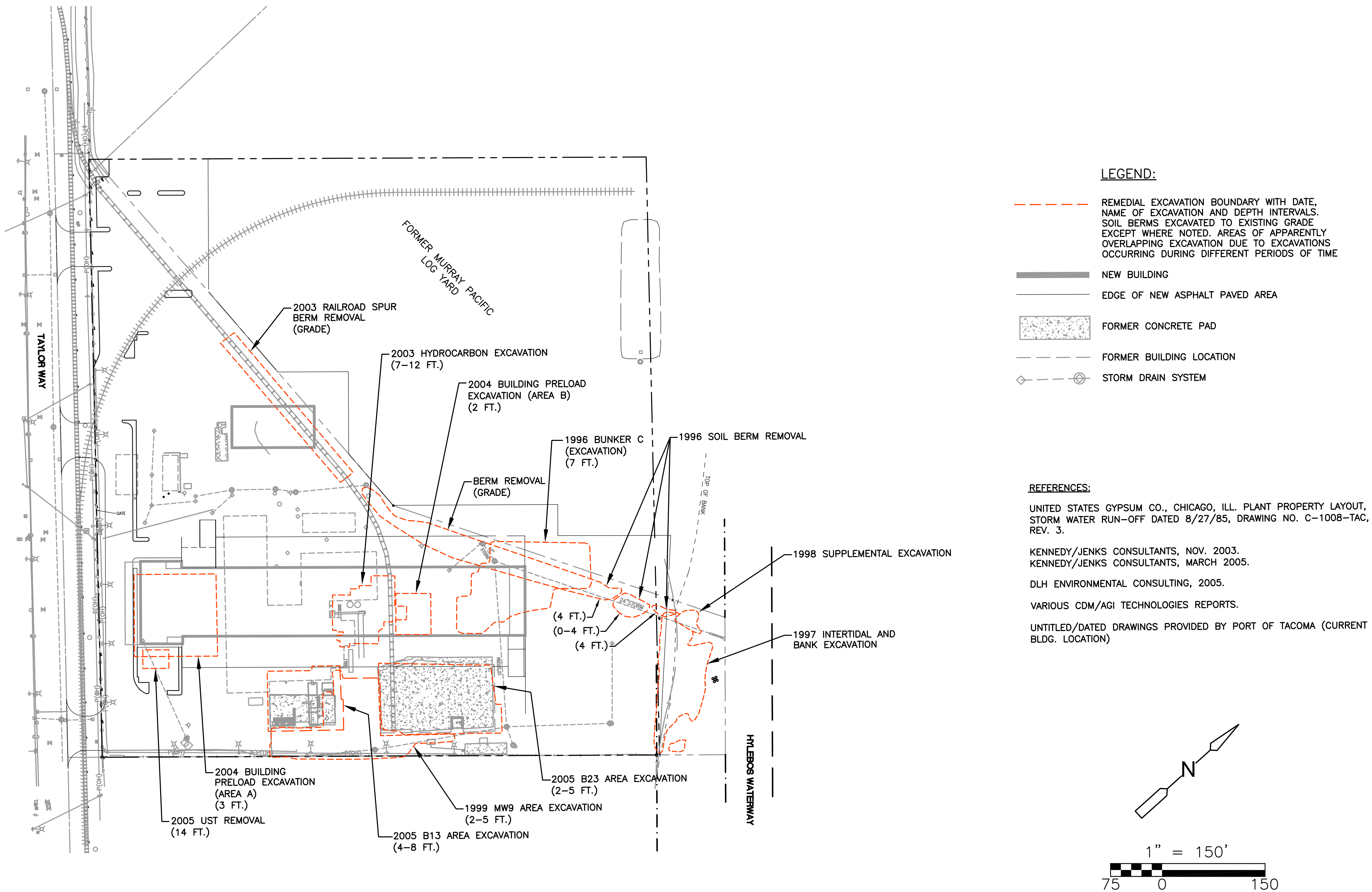
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 8
Locations of Existing Utility Lines and Pre-Redevelopment Storm Drain Lines



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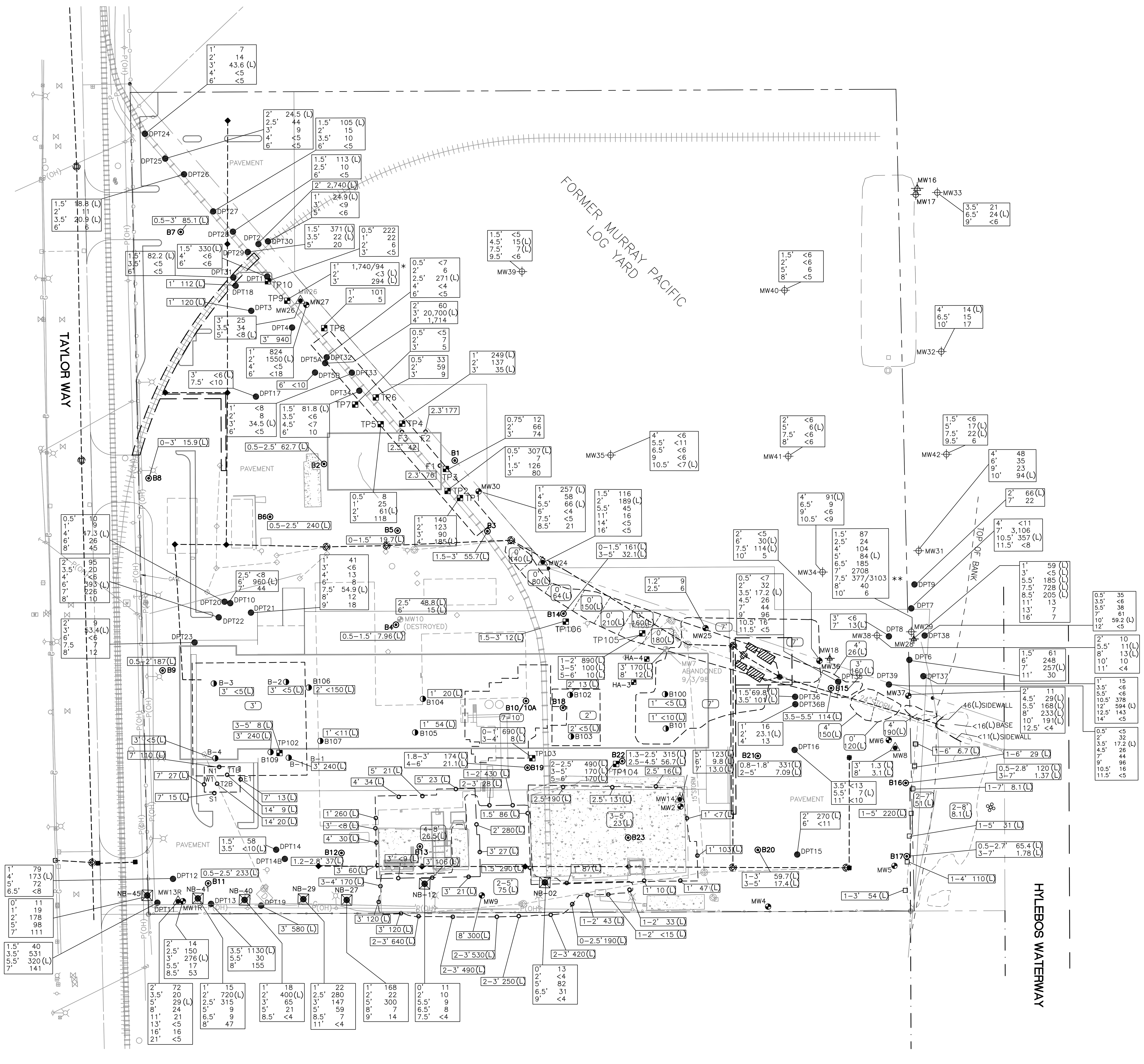
FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

Figure No. 9
Interim Action Excavations: 1996–2005



LEGEND

- EXCAVATION SIDEWALL SAMPLE
- B17 — DPT LOCATION (KJC, 2002)
- B102 — SOIL SAMPLE LOCATION UNDER NEW BUILDING FOOTPRINT (KJC, 2005)
- MW33 — OFF-SITE SURFACE AQUIFER WELL
- MW28 — OFF-SITE SECOND AQUIFER WELL
- DPT9 — DPT LOCATION (CDM SMITH)
- TP7 — TEST PIT LOCATION (CDM, 2005b; POT 2005)
- NB-12 — DPT LOCATION (DOF, 2012)
- MW24 — ON-SITE SECOND AQUIFER MONITORING WELL LOCATION
- MW5 — ON-SITE SURFACE AQUIFER MONITORING WELL LOCATION
- HISTORICAL EXCAVATION BOUNDARY
- NEW BUILDING
- EDGE OF NEW ASPHALT PAVED AREA
- FORMER CONCRETE PAD
- FORMER BUILDING LOCATION
- STORM DRAIN SYSTEM (PREVIOUS LAYOUT)
- STORM DRAIN SYSTEM (CURRENT LAYOUT)

X–X' XX — SAMPLE DEPTH AND ARSENIC CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) (LAB) OR PARTS PER MILLION (PPM) (XRF) (SEE NOTE)

2–8' 7.7 — EXCAVATION DEPTH AND ARSENIC CONCENTRATION IN mg/kg (AVERAGE CONCENTRATION WHEN MULTIPLE BOTTOM SAMPLES COLLECTED) SOME EXCAVATIONS NOT SAMPLED FOR ARSENIC

* HIGHER ARSENIC VALUE IS A LAYER OF SHOT OBSERVED ON ONE END OF THE TEST PIT (LAB) LOWER VALUE IS SOIL ON THE OPPOSITE END (XRF)

** LOWER ARSENIC VALUE IS AN AVERAGE OF THREE LAB SOIL ANALYSES AND HIGHER ARSENIC VALUE IS AN AVERAGE OF TWO XRF READINGS

(L) LETTER VALUE INDICATES LAB ANALYSIS

NOTE:
ARSENIC CONCENTRATIONS FROM BOTH ANALYTICAL LABORATORY AND XRF DATA. SEE TABLE B–1 IN APPENDIX B. WHEN BOTH XRF AND LABORATORY DATA WERE AVAILABLE THE LABORATORY DATA WERE USED.

REFERENCES:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN–OFF DATED 8/27/85, DRAWING NO. C–1008–TAC, REV. 3.

APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2–19–07.

KENNEDY/JENKS CONSULTANTS, NOV. 2003.

VARIOUS CDM/AGI TECHNOLOGIES REPORTS.

UNTITLED/DATED DRAWINGS PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION)

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: PJM
DRAWN BY: O.N
SHEET CHK'D BY: PJM
CROSS CHK'D BY:
APPROVED BY:
DATE: JUNE 2019

CDM Smith
50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000

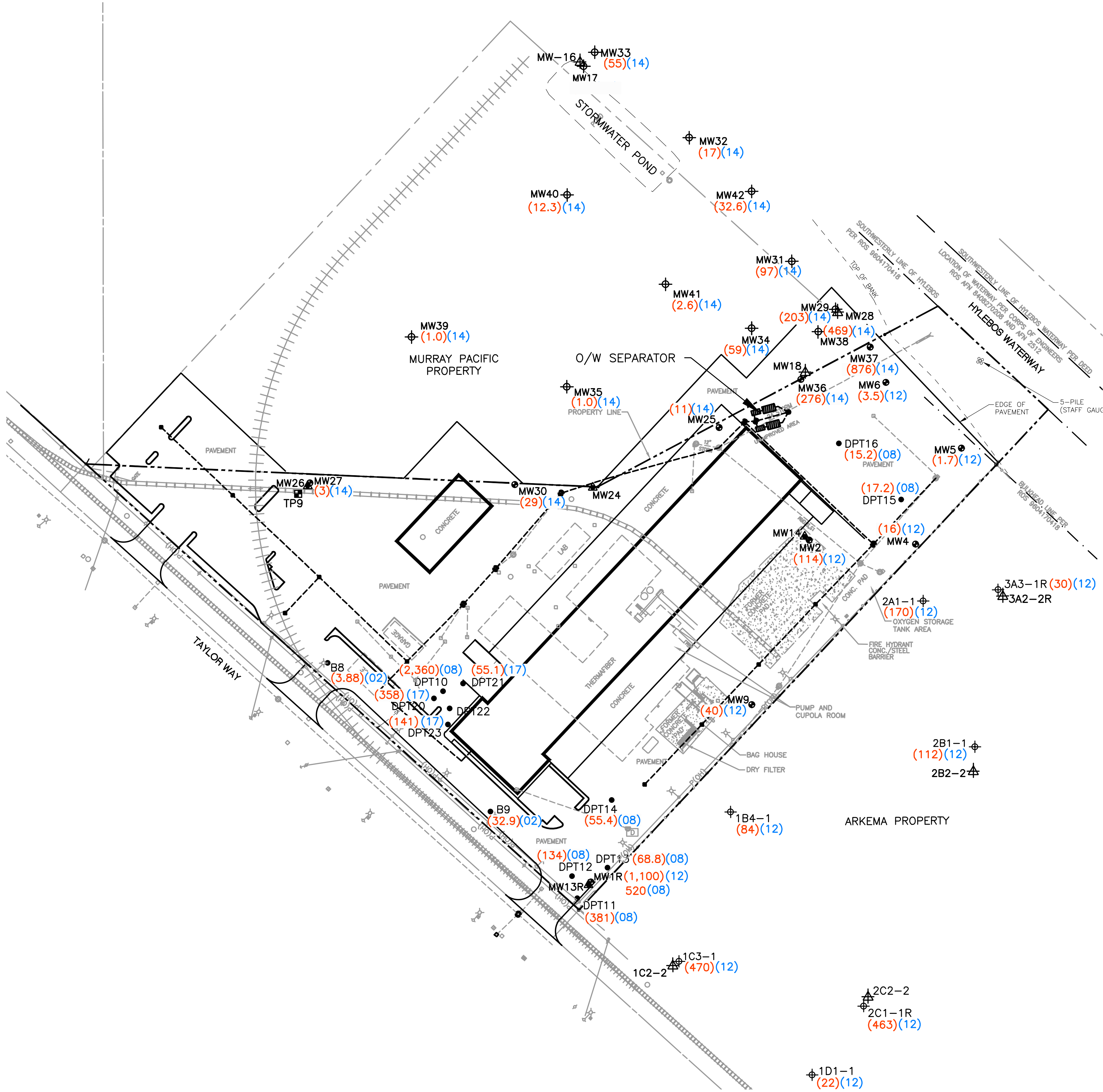
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

FEASIBILITY STUDY
2301 TAYLOR WAY
TACOMA, WASHINGTON

ARSENIC CONCENTRATIONS IN SOIL

PROJECT NO. 19921–96914
FILE NAME: Figure–10 (2019 DRAFT REPORT)

Figure 10



LEGEND:

- DPT16 ● DPT BORING WITH GRAB GROUNDWATER SAMPLE
- MW6 SURFACE AQUIFER WELL AND DESIGNATION
- MW26 SECOND AQUIFER WELL AND DESIGNATION
- 1C3-1 OFF-SITE SURFACE AQUIFER WELL AND DESIGNATION
- 2B2-2 OFF-SITE SECOND AQUIFER WELL AND DESIGNATION
- TAYLOR WAY PROPERTY BOUNDARY
- EXISTING BUILDING
- NEW ASPHALT PAVED AREA
- FORMER CONCRETE PAD
- FORMER BUILDING LOCATION
- STORM DRAIN SYSTEM (FORMER)
- STORM DRAIN SYSTEM (CURRENT)
- (2.6) (14) DISSOLVED ARSENIC CONCENTRATION IN MICROGRAMS PER LITER (RED) AND YEAR SAMPLED (BLUE)

REFERENCE:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.
APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED REV 2/12/14.

UNTITLED/DATED DRAWING PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION).

HYDROMETRICS INC., GEOTEXTILE PLACEMENT AND WELL LOCATIONS, DWG.# TAC-40796T18, SHEET 6/6, DATED 2/27/96.

N

1" = 150'

75 0 150

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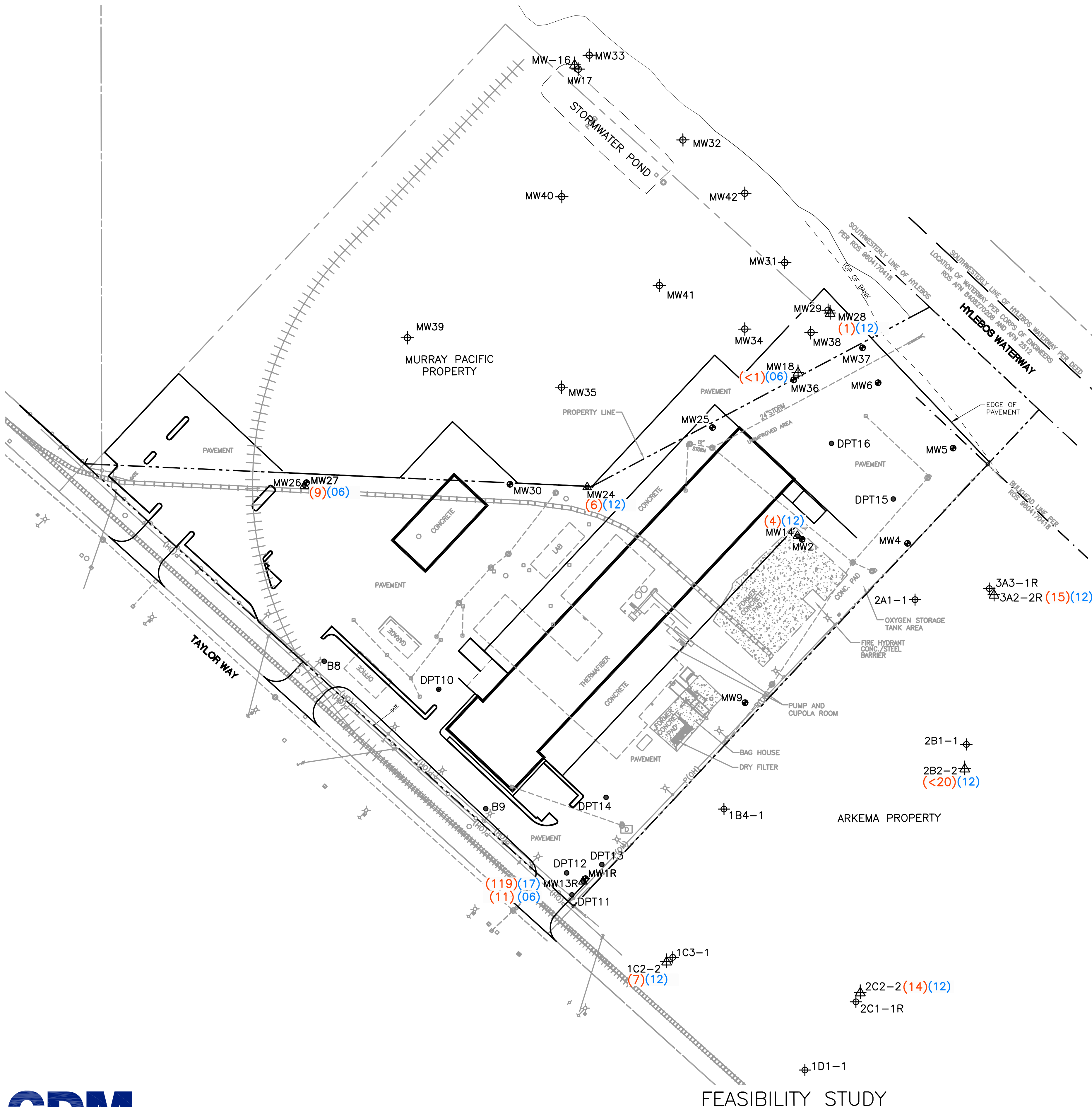
TACOMA, WASHINGTON

Figure No. 11
Surface Aquifer Dissolved Arsenic Concentrations



LEGEND:

- MW6 — SURFACE AQUIFER WELL AND DESIGNATION
- MW26 — SECOND AQUIFER WELL AND DESIGNATION
- 1C3-1 — OFF-SITE SURFACE AQUIFER WELL AND DESIGNATION
- 2B2-2 — OFF-SITE SECOND AQUIFER WELL AND DESIGNATION
- TAYLOR WAY PROPERTY BOUNDARY
- EXISTING BUILDING
- NEW ASPHALT PAVED AREA
- FORMER CONCRETE PAD
- FORMER BUILDING LOCATION
- STORM DRAIN SYSTEM (FORMER)
- (15) (12) DISSOLVED ARSENIC CONCENTRATION IN MICROGRAMS PER LITER (RED) AND YEAR SAMPLED (BLUE)

REFERENCE:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.
APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED REV 2/12/14.

UNTITLED/DATED DRAWING PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION).

HYDROMETRICS INC., GEOTEXTILE PLACEMENT AND WELL LOCATIONS, DWG.# TAC-40796T18, SHEET 6/6, DATED 2/27/96.

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Figure No. 12
Second Aquifer Dissolved Arsenic Concentrations

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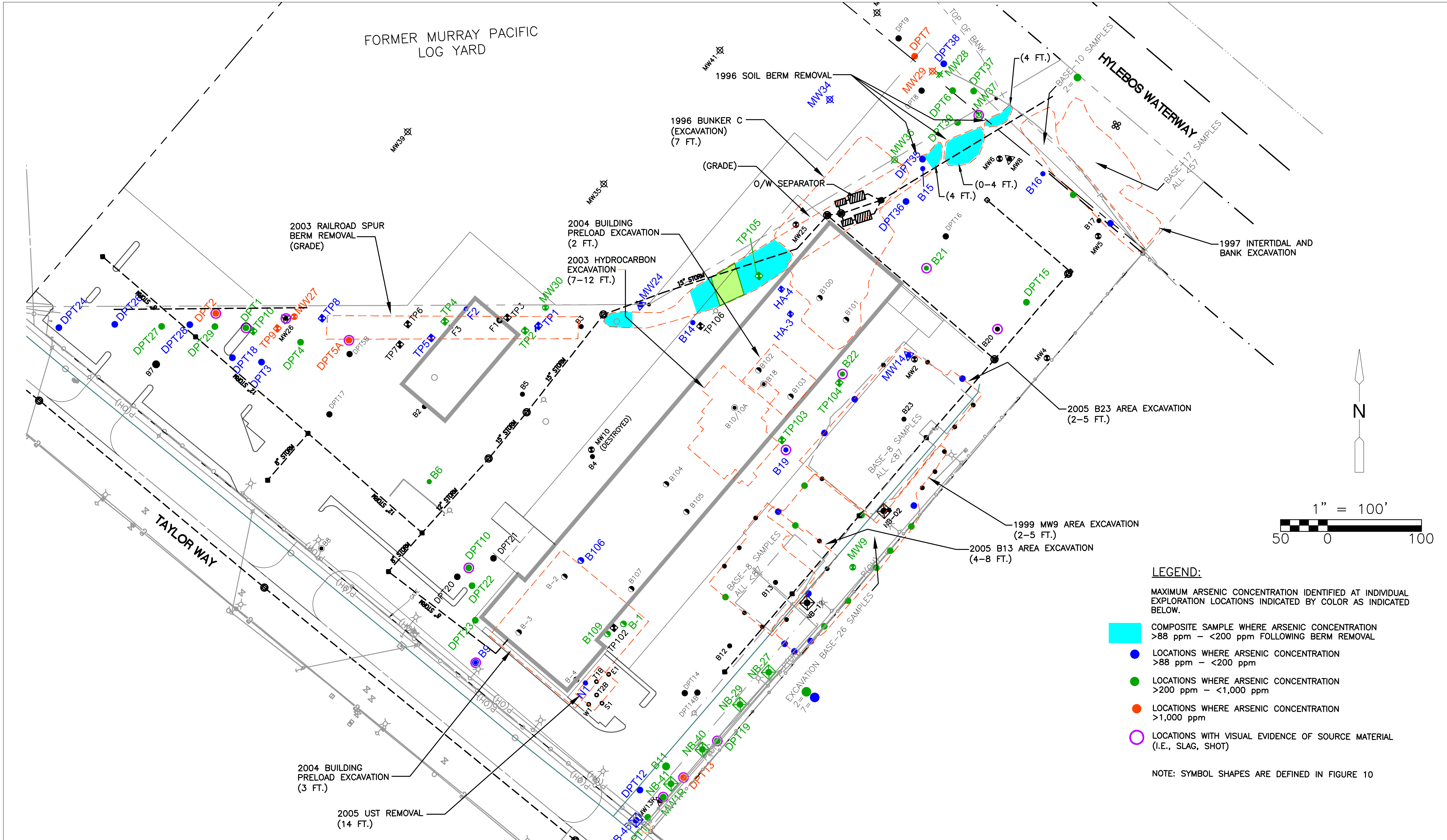

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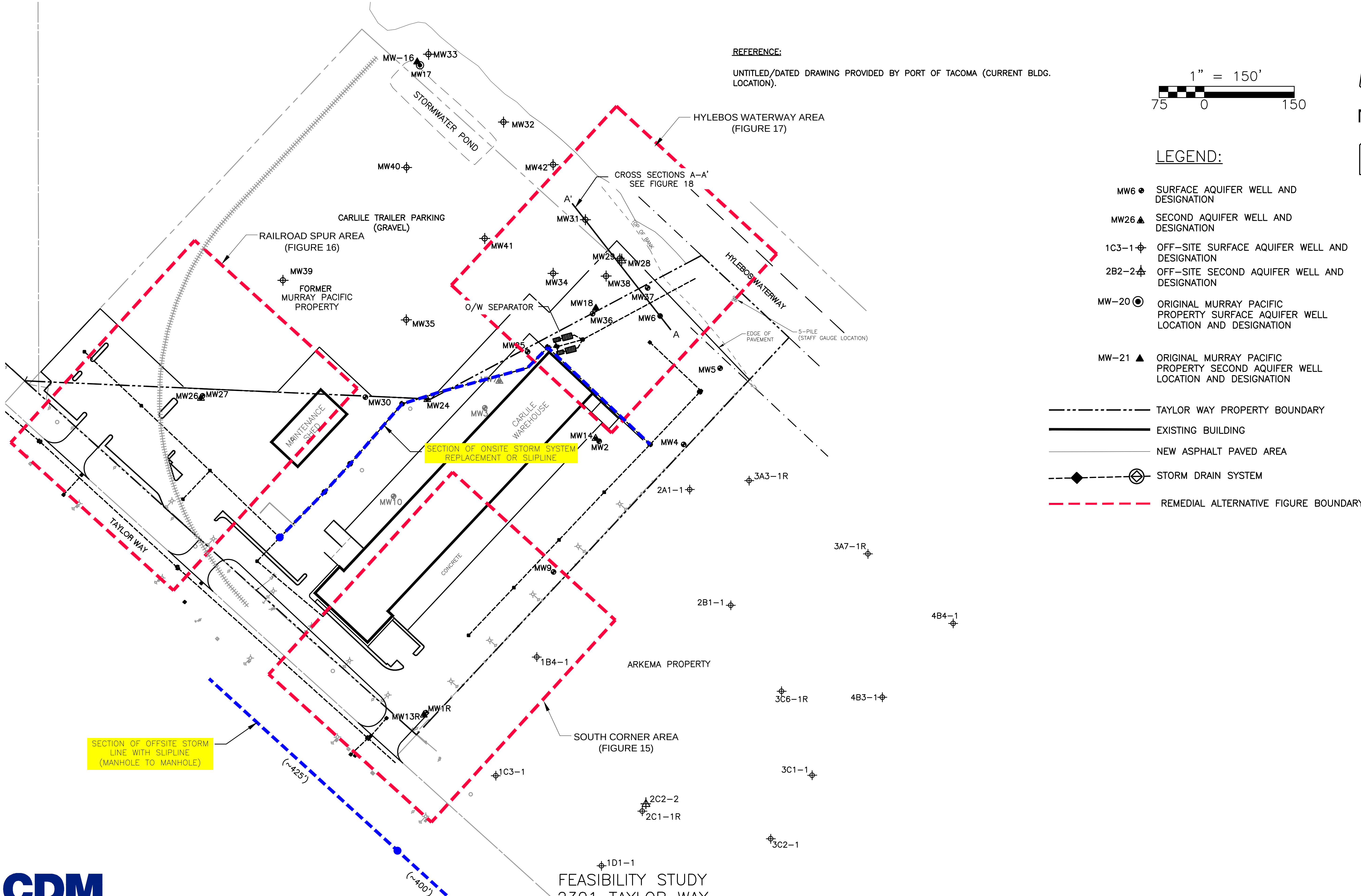
TACOMA, WASHINGTON

Figure No. 13
Soils Exceeding 88 ppm Arsenic and/or Containing Source Materials



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TACOMA, WASHINGTON

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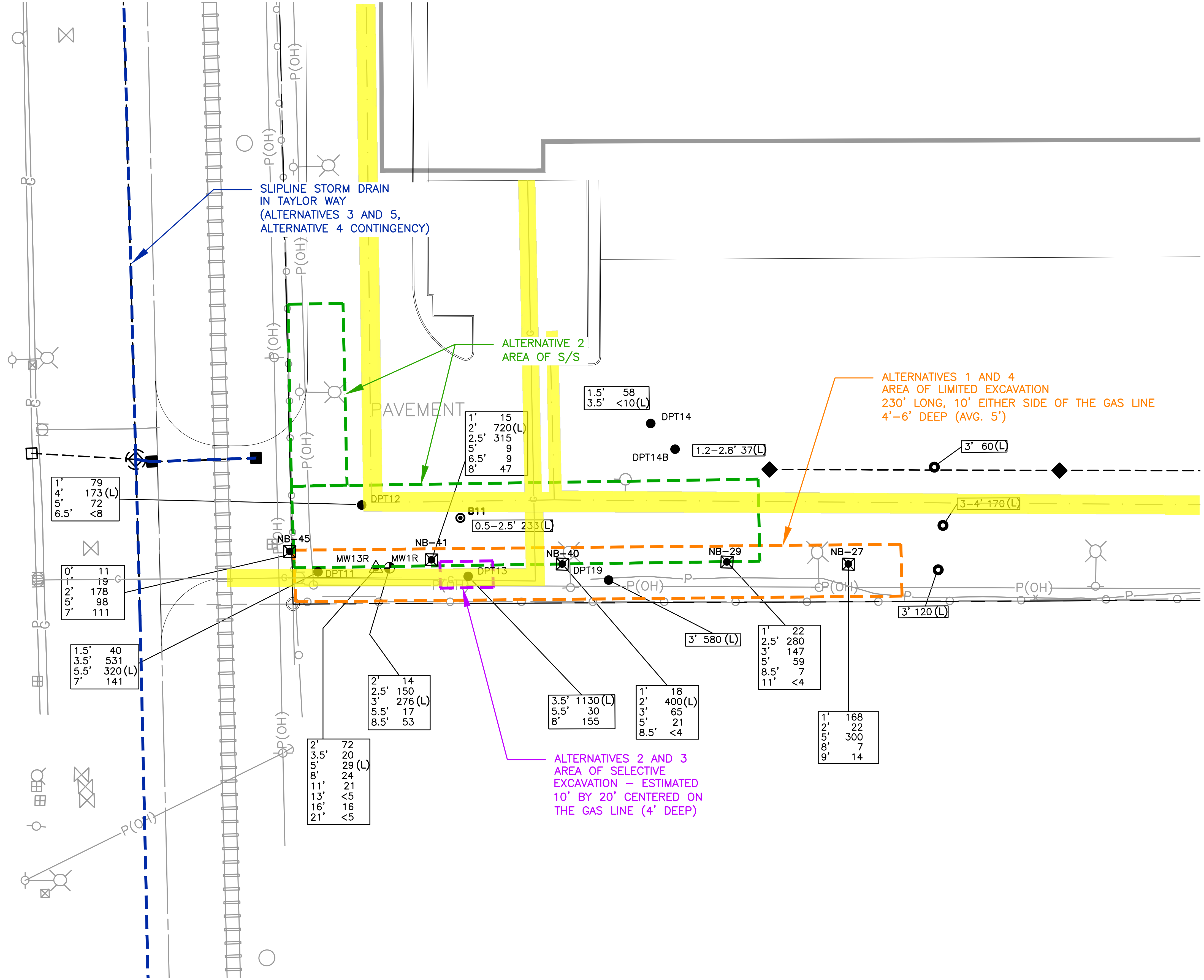
Figure No. 14
Locations of Remedial Alternatives 1 Through 4
Focus Areas and Storm Drain Line Repair



LEGEND

- EXCAVATION SIDEWALL LOCATION (CDM SMITH, 2005)
- B1 — DPT LOCATION (KJC, 2002)
- DPT9 — DPT LOCATION (CDM SMITH)
- NB40 — DPT LOCATION (DOF, 2012)
- MW24 — ON-SITE SECOND AQUIFER MONITORING WELL LOCATION
- MW5 — ON-SITE SURFACE AQUIFER MONITORING WELL LOCATION
- NEW BUILDING
- EDGE OF NEW ASPHALT PAVED AREA
- STORM DRAIN SYSTEM
- X–X' XX — SAMPLE DEPTH AND ARSENIC CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) (LAB) PARTS PER MILLION (PPM) (XRF) (SEE NOTE)
- (L) — LETTER VALUE INDICATES LAB ANALYSIS
- LOCATIONS OF UNDERGROUND UTILITIES (WATER/GAS)

NOTE:
ARSENIC CONCENTRATIONS FROM BOTH ANALYTICAL LABORATORY AND XRF DATA. WHEN BOTH XRF AND LABORATORY DATA WERE AVAILABLE THE LABORATORY DATA WERE USED.

REFERENCES:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.

APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2-19-07.

KENNEDY/JENKS CONSULTANTS, NOV. 2003.

VARIOUS CDM/AGI TECHNOLOGIES REPORTS.

UNTITLED/DATED DRAWINGS PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION)

C:\pw_pl1\thomastj\d1587094\Figure-15 (2019 DRAFT REPORT).dwg

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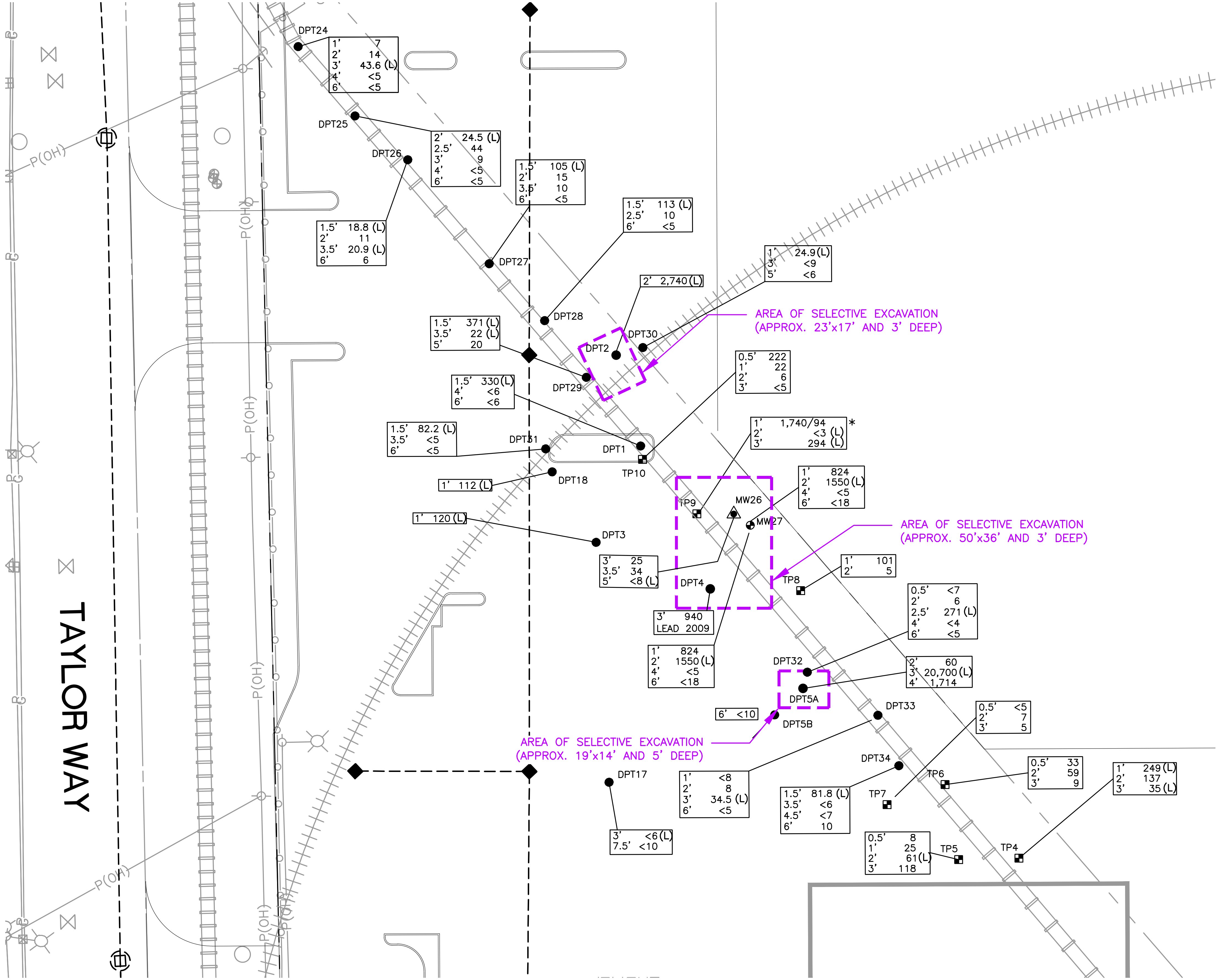
Figure No. 15
South Corner Area—
Remedial Alternatives 1 Through 4



LEGEND

- DPT9 — DPT LOCATION (CDM SMITH)
- MW24 — ON-SITE SECOND AQUIFER MONITORING WELL LOCATION
- MW5 — ON-SITE SURFACE AQUIFER MONITORING WELL LOCATION
- TP7 — TEST PIT LOCATION
- NEW BUILDING
- EDGE OF NEW ASPHALT PAVED AREA
- STORM DRAIN SYSTEM
- X–X' XX — SAMPLE DEPTH AND ARSENIC CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) (LAB) PARTS PER MILLION (PPM) (XRF) (SEE NOTE)
- (L) — LETTER VALUE INDICATES LAB ANALYSIS

NOTE:
ARSENIC CONCENTRATIONS FROM BOTH ANALYTICAL LABORATORY AND XRF DATA. SEE TABLE 3 OF THE RI REPORT. WHEN BOTH XRF AND LABORATORY DATA WERE AVAILABLE THE LABORATORY DATA WERE USED.

REFERENCES:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.

APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2-19-07.

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UNTITLED/DATED DRAWINGS PROVIDED BY PORT OF TACOMA (CURRENT BLDG. LOCATION)

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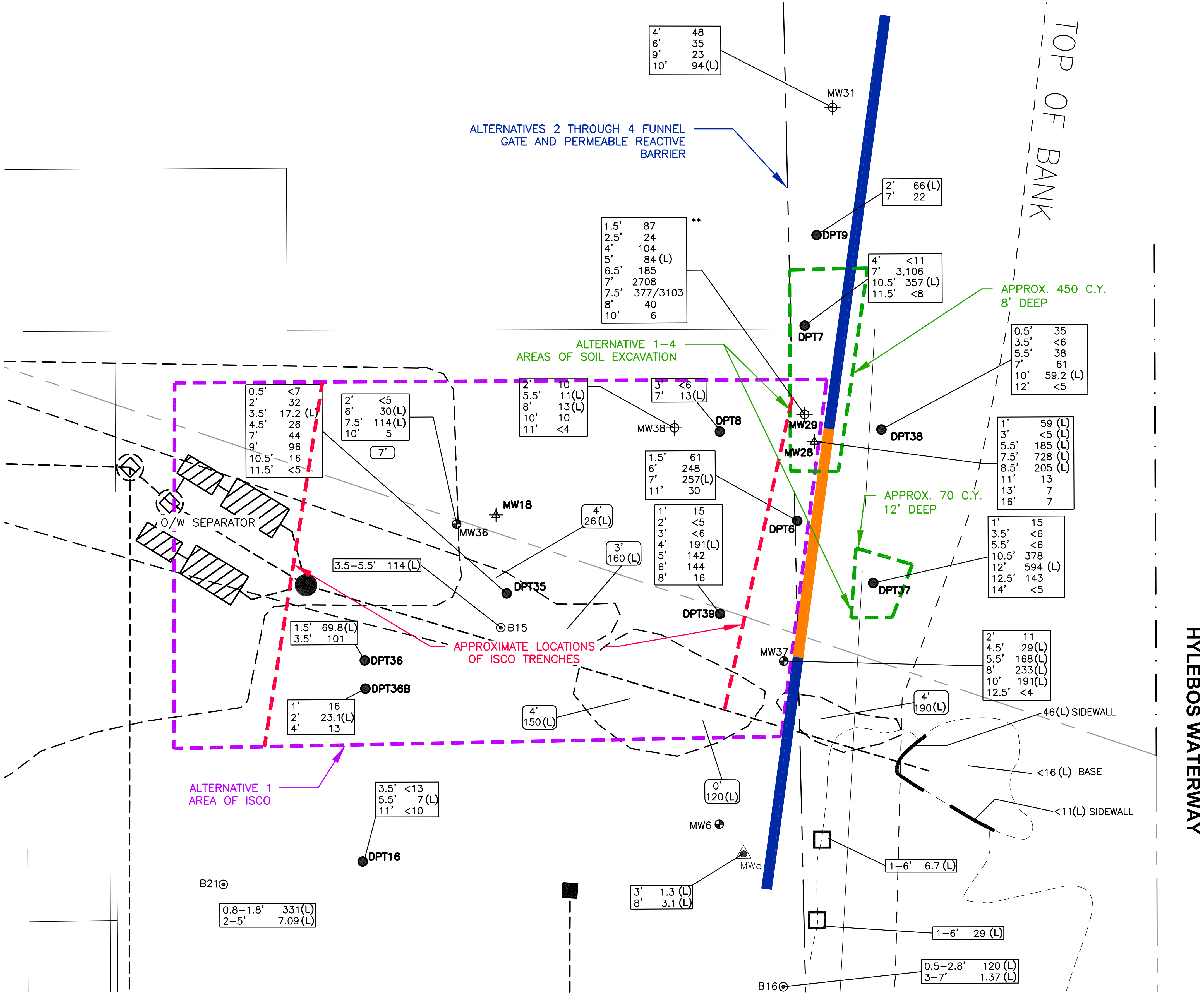
Figure No. 16
Railroad Spur Area–
Remedial Alternatives 1 Through 4



LEGEND

- B17 — DPT LOCATION (KJC, 2002)
- DPT9 — DPT LOCATION (CDM SMITH)
- MW33 — OFF-SITE SURFACE AQUIFER WELL
- MW28 — OFF-SITE SECOND AQUIFER WELL
- MW24 — ON-SITE SECOND AQUIFER MONITORING WELL LOCATION
- MW5 — ON-SITE SURFACE AQUIFER MONITORING WELL LOCATION
- NEW BUILDING
- EDGE OF NEW ASPHALT PAVED AREA
- STORM DRAIN SYSTEM
- X-X' XX — SAMPLE DEPTH AND ARSENIC CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) (LAB) PARTS PER MILLION (PPM) (XRF) (SEE NOTE)
- 2-8' 7.7 — EXCAVATION DEPTH AND ARSENIC CONCENTRATION IN mg/kg (AVERAGE CONCENTRATION WHEN MULTIPLE BOTTOM SAMPLES COLLECTED) SOME EXCAVATIONS NOT SAMPLED FOR ARSENIC
- (L) — LETTER VALUE INDICATES LAB ANALYSIS

NOTE:
ARSENIC CONCENTRATIONS FROM BOTH ANALYTICAL LABORATORY AND XRF DATA. SEE TABLE 3 OF THE RI REPORT. WHEN BOTH XRF AND LABORATORY DATA WERE AVAILABLE THE LABORATORY DATA WERE USED.

REFERENCES:

UNITED STATES GYPSUM CO., CHICAGO, ILL. PLANT PROPERTY LAYOUT, STORM WATER RUN-OFF DATED 8/27/85, DRAWING NO. C-1008-TAC, REV. 3.

APEX ENGINEERING, WELL LOCATION EXHIBIT, SHEET 1 OF 1, FILE NO. 30528, DATED 2-19-07.

KENNEDY/JENKS CONSULTANTS, NOV. 2003.

VARIOUS CDM/AGI TECHNOLOGIES REPORTS.

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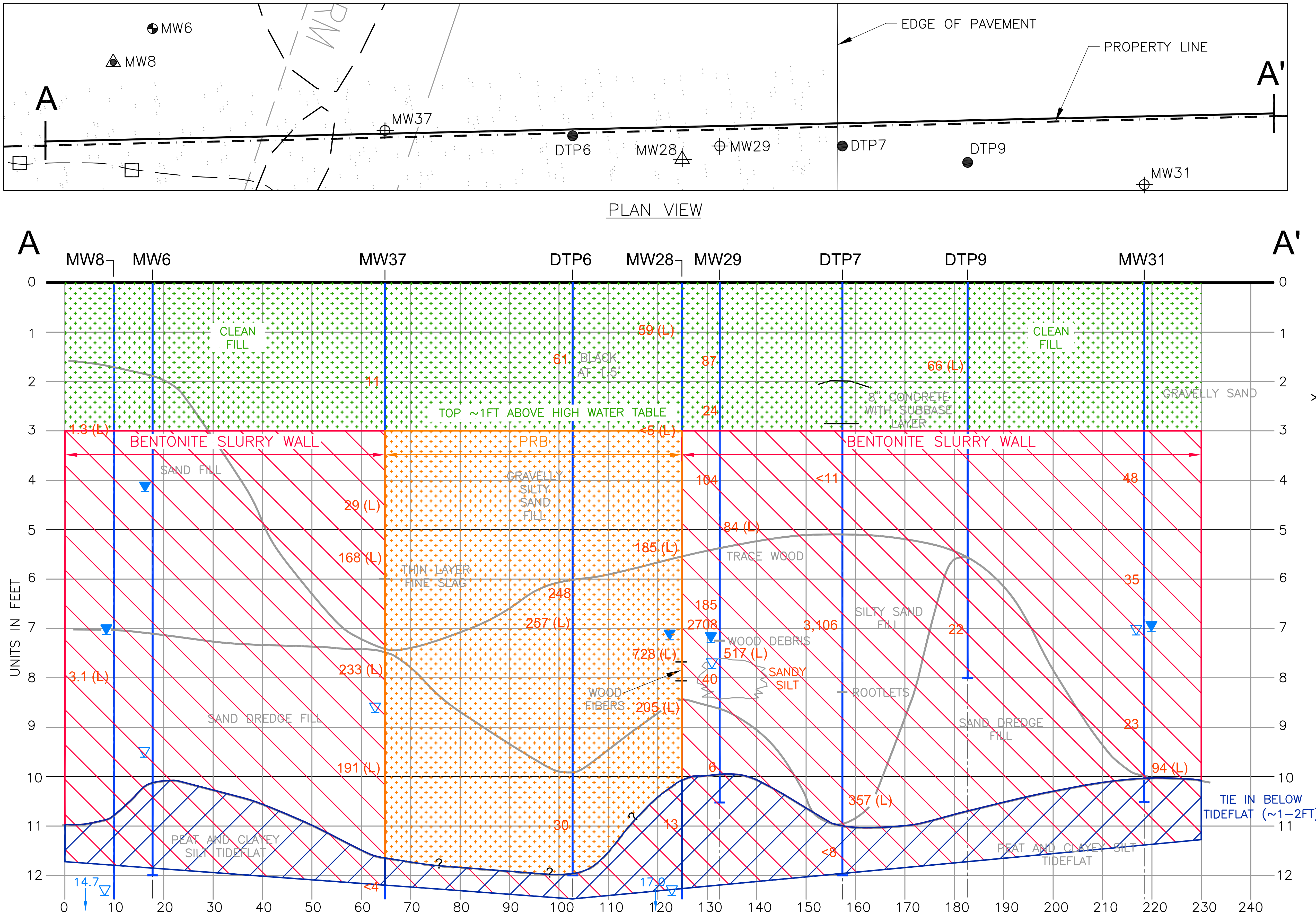
Figure No. 17
Hylebos Waterway Area–
Remedial Alternatives 1 Through 4



LEGEND:

22 ARSENIC CONCENTRATION IN PARTS PER MILLION (XRF) OR MILLIGRAMS PER KILOGRAM (LAB) (MOST DATA OBTAINED USING AN XRF)

(L) DENOTES LABORATORY ANALYZED SAMPLE

MONITORING WELLS

HIGHEST RECORDED WATER TABLE

LOWEST RECORDED WATER TABLE

* FOR SURFACE AQUIFER WELLS LITTLE OR NO FLUCTUATION IS MOSTLY DUE TO A LACK OF LONG–TERM DATA

** THE EXACT LENGTH OF THE PRB SECTION WILL DEPEND ON THE GW FLOW THROUGH THE WALL AND THE REQUIRED RESIDENCE TIME, WHICH WILL BE DETERMINED DURING THE PRE–DESIGN PHASE AFTER BENCH–SCALE TESTS HAVE BEEN CONDUCTED. THE PRB LENGTH PROVIDED IN THE SCHEMATIC IS APPROXIMATE AND SHOULD BE SUFFICIENT FOR FS/COSTING PURPOSES.

1" = 20' HORIZONTAL

1" = 2' VERTICAL

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Figure No. 18
Conceptual Cross Section of Funnel and Gate Permeable Reactive Barrier

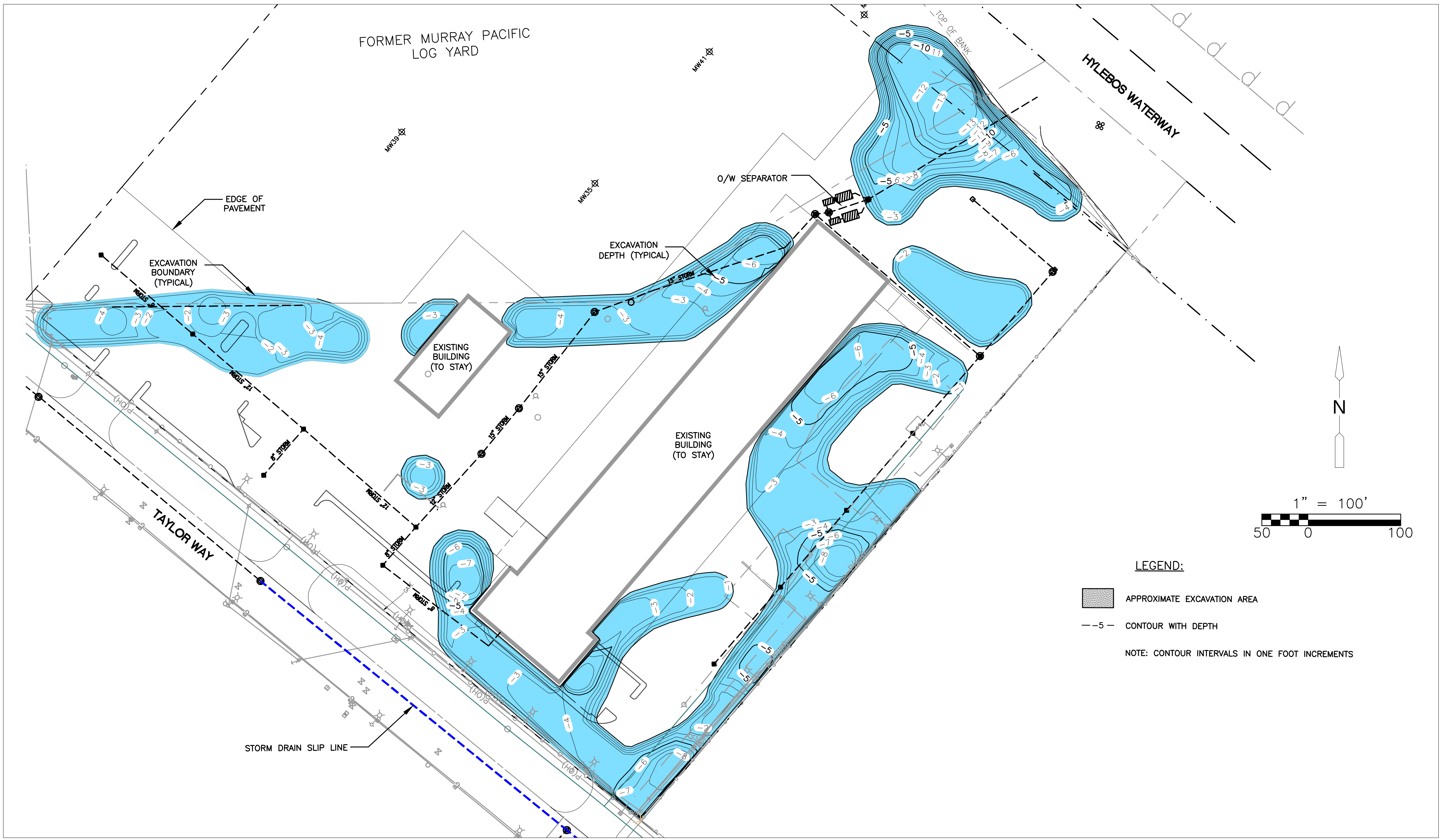

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Figure No. 19
Remedial Alternative 5
Excavation of Soils Exceeding 88 ppm.