DRAFT CLEANUP ACTION PLAN

B & L WOODWASTE SITE

JULY 2007

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ACRONYMS AND ABBREVIATIONS

AGI	Applied Geotechnology, Inc.
AOC	Area of Contamination
ARAR	applicable or relevant and appropriate requirement
BOF	basic oxygen furnace (material)
CAA	Cleanup Action Area
CAMU	Corrective Action Management Unit
CAP	Cleanup Action Plan
CB/NT Site	Commencement Bay Nearshore/Tideflats Superfund Site
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COCs	constituents of concern
COD	chemical oxygen demand
CSM	Conceptual Site Model
CUL	Cleanup Level
CWA	Clean Water Act
DOC	dissolved organic carbon
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EMNA	Enhanced Monitored Natural Attenuation
EEI	Ecology and Environment, Inc.
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FWS	free water surface
GAE	Groundwater Alternatives Evaluation
gpd	gallons per day
gpm	gallons per minute
HAZWOPER	Hazardous Waste Operations and Emergency Management
I-5	Interstate 5
K/J/C	Kennedy/Jenks/Chilton
LDR	land disposal restriction
LEL	lower explosive limit
LFG	landfill gas
MNA	Monitored Natural Attenuation
MSA	Magnuson-Stevens Act
MSL	mean sea level
MTCA	Model Toxics Control Act
Murray	Murray Pacific Corporation

NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	net present value
O&M	operations and maintenance
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Act
PLP	potentially liable person
POTW	Publicly Owned Treatment Works
PRB	Permeable Reactive Barrier
PSCAA	Puget Sound Clean Air Authority
QA/QC	quality assurance/quality control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
Redox	Reduction-oxidation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SEPA	State Environmental Policy Act
SMS	Sediment Management Standards
SR	State Route
SRB	sulfate-reducing bacteria
SSF	subsurface flow
SVOC	Semivolatile organic compound
TDS	total dissolved solids
TPCHD	Tacoma-Pierce County Health Department
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WISHA	Washington Industrial Safety and Health Act
WSDOT	Washington State Department of Transportation

CLEANUP ACTION PLAN
B&L LANDFILL FACILITY
PIERCE COUNTY, WASHINGTON

1.0 INTRODUCTION

This Cleanup Action Plan (CAP) has been prepared for the B&L Woodwaste Site (aka, B &L Landfill) located in unincorporated Pierce County, Washington (herein referred to as the Site) (Figure 1). The CAP has been prepared in accordance with the requirements of Enforcement Order No. DE 92TC-S214 (as amended) issued by the Washington State Department of Ecology (Ecology) pursuant to the authority of Chapter 70.105D.050(1) of the Revised Code of Washington (RCW 70.105D.050[1]), and entered into by the potentially liable persons (PLPs) Asarco Incorporated (Asarco), Murray Pacific Corporation (Murray), and Executive Bark Incorporated (Executive Bark), to meet the requirements of the Washington State Model Toxics Control Act (MTCA) cleanup regulation, as established in Chapter 173-340 of the Washington Administrative Code (WAC). The CAP describes the Site, the nature and extent of contamination, the cleanup action alternatives considered, and the proposed cleanup action for soil, groundwater, sediments and surface water with concentrations of arsenic above the applicable MTCA cleanup levels. The CAP will be implemented pursuant to the one of the following: the existing Enforcement Order, a new Consent Decree or an Agreed Order between the PLPs and Ecology. Other PLPs may be included as appropriate.

Previous work conducted at the Site included a Remedial Investigation (RI), prepared by Kennedy/Jenks/Chilton and Applied Geotechnology, Inc. (K/J/C & AGI 1990a), a Feasibility Study (FS) also prepared by K/J/C & AGI (1990b), and an Engineering Design report prepared by Hydrometrics, Inc. (1992). These documents were used as the basis for a 1991 CAP that was prepared by Ecology (1991) for the Site.

The 1991 CAP recommended a remedy consisting of landfill consolidation, the installation of a multi-media cap, the creation of stormwater retention basins, groundwater pumping and treatment (as needed), ditch remediation, landfill gas controls, surface water controls, and institutional controls (barrier fencing around the landfill), and groundwater and surface water monitoring. The 1991 CAP recommended remedy did not contain a bottom liner for the landfill. The recommended remedy was installed in 1993.

In 2001, Ecology determined that arsenic-contaminated groundwater was continuing to migrate from beneath the landfill toward the Wetlands area located to the north of the Landfill. In 2005, Asarco declared bankruptcy. Since 2005, a substantial effort has been made by Murray to investigate the nature and extent of this migration of arsenic-contaminated groundwater. This effort was recently summarized in the Groundwater Alternatives Evaluation Report (Floyd|Snider 2007a), referred to as the GAE Report. The GAE Report, Ecology's Comments on the Report, and three Technical Memoranda addressing key comments have been included in CD-ROM format as Appendix A to this CAP.

1.1 Purpose

The purpose of this CAP is to address the need to implement additional remedial actions to halt the continued migration of arsenic into shallow groundwater and to address the existing off-site contamination.

This CAP has been prepared in accordance with WAC 173-340-380 to present the proposed cleanup action and to specify cleanup standards and other requirements for the cleanup action. The cleanup action will meet the threshold requirements of WAC 173-340-360 to protect human health and the environment, comply with cleanup standards, comply with applicable state and federal laws, and provide for compliance monitoring.

For the purposes of this CAP, the B&L Site has been divided into three cleanup action areas (CAAs); the Landfill/Ditch area, the Wetlands area, and the End of Plume area.

The cleanup action proposed by Ecology in this CAP for each area includes:

- **Landfill/Ditch CAA**. Installation of a perimeter slurry wall around the landfill that is tied into both the existing landfill cap and a low-permeability soil unit located below the landfill, the diversion of clean surface water and groundwater before it reaches the slurry wall, and the extraction and treatment of leachate from within the slurry wall to maintain hydraulic control by creating an inward hydraulic flow gradient. Once the slurry wall is installed, contaminated sediments in the adjacent agricultural drainage ditches will be excavated and disposed of at a permitted landfill.

- **Wetlands CAA.** A groundwater pump and treat system will be used to remove arsenic from the groundwater plume in the Wetlands CAA. Performance-based criteria will be used to assure compliance with MTCA requirements. It is anticipated that up to 120 million gallons of water may require treatment.

- **End of Plume CAA.** *In situ* treatment will be used to precipitate out dissolved arsenic followed by monitored natural attenuation of groundwater that reaches 12th Street East. Performance-based criteria will be used to assure compliance with MTCA requirements. Only a thin layer of arsenic-contaminated groundwater remains above the cleanup level in the End-of-Plume CAA; without treatment this area would likely come into compliance as the effect of cleanups in the Landfill and Wetlands CAAs reached the End-of-Plume CAA. Treatment in the End-of-Plume CAA is, therefore, intended to reduce the restoration timeframe by bringing the area into compliance within 2 to 5 years; although treatment will be continued as long as needed based on the performance criteria.

2.0 SITE DESCRIPTION AND BACKGROUND

Much of the content of this section was initially summarized in the GAE Report (Floyd|Snider 2007a). These summaries have been adapted for use in this CAP.

2.1 Site Description

2.1.1 Physical Site Description

The B&L Landfill is located on a tax parcel of approximately 18.5 acres in unincorporated Pierce County, Washington, approximately 1/4 mile east of Interstate 5 (I-5) and 5 miles east of Tacoma. The Landfill, shown on Figure 2, is situated in a residential and agricultural area in northern Pierce County. Farmland borders the western and southwestern edges of the Landfill, and an apartment complex adjoins the southeastern corner. Fife Way defines the southeastern boundary, and Puget Power Access Road (also known as Barth Road) delineates the north side. The pentagonal landfill occupies approximately 13 acres and rises to an elevation of approximately 50 feet above mean sea level (MSL).

To the north of the Landfill is former farmland that has re-established itself as a grassy wetland that stretches north and west to I-5. The wetland ground surface is flat and lies at approximately 9 to 10 feet above MSL. During winter months, the ground is generally covered with shallow standing water. Several hundred feet north of Puget Power Access Road is another roadway, 12th Street East, a primitive, unused and now mostly overgrown road grade that cuts through the wetland, marking the boundary between land parcels.

2.1.2 Land Use

Historically, land surrounding the Landfill has been used for agriculture, but in recent years it has become increasingly developed, as has most of the land in northern Pierce and southern King Counties. The population of Pierce County increased nearly 20 percent between 1990 and 2000, and the growth rates in the Site vicinity (the Cities of Fife and Milton) were even greater. Future growth estimates project similar rates for the next two decades. The Landfill, wetlands, and 12th Street East parcels are zoned for moderate density single family development (Pierce County 2006). The Puget Power Access Road is owned by the City of Milton, and is zoned as an open space district as part of the Interurban Trail project (City of Milton 1999).

Land use in the general vicinity is changing from the once agricultural, semi-rural uses, to more suburban residential, commercial, recreational, and environmental restoration project uses. Figure 3 shows the existing and proposed future land use in the larger Hylebos Creek Watershed where the Landfill is located. These types of development increase stormwater flow through the creation of impervious (paved) surfaces. This increased flow is likely to affect groundwater and surface water hydrology in and around the Site.

The Landfill is currently bordered by vacant and/or agricultural lands immediately to the south (farmed land), west (vacant and farmed lands,) and north (wetlands). East of the Landfill is Fife Way East, a public road. To the south, is a multi-unit residential complex built in the late 1980s. To the northeast lies a parcel of land currently occupied by a single private residence, which, according to public record, has recently been the subject of permit applications for development of ten single-family homes. The Cities of Fife and Milton both have explored the potential for the commercial and/or recreational development of lands near and/or adjacent to the Landfill. The City of Fife recently purchased the agricultural fields to the south and west of the Site. Ownership of parcels adjacent the landfill is illustrated on Figure 4.

Hylebos Creek and Surprise Lake Drain Restoration

Several parcels to the north and west of the Landfill would likely to be directly impacted by a major proposed Washington State Department of Transportation (WSDOT) highway project, the completion of State Route (SR) 167 between SR 161 in North Puyallup and the SR 509 freeway in Tacoma. The final Environmental Impact Statement (EIS) for this project has recently been issued, and once the Record of Decision (ROD) is prepared, the project will move into the design phase. If the funding for the project becomes available, construction will be done in stages based on available money.

As part of its proposed SR 167 project, WSDOT has proposed major riparian restoration projects to manage stormwater, including relocating the channel of Hylebos Creek from its current path adjacent to I-5 northwest of the Landfill. The proposed relocation is designed to mitigate SR 167 construction impacts, to improve stormwater management, and to enhance and protect aquatic habitat in this stretch of the creek. While the exact location of the new creek channel is subject to change in the final design, the proposed general area of relocation, as shown on Figure 5, indicates that the creek channel will meander several hundred feet closer to the Landfill. The current Surprise Lake Drain ditch will also be restored to a more natural meandering channel. According to public records, in recent years, WSDOT has purchased a number of parcels in the area that will be impacted by the project.

Mitigation efforts planned for the SR 167 project include increasing the floodplain capacity of the area by deepening a section of the Hylebos Creek channel located between the Site and the mouth of the creek at the Hylebos Waterway. This channel deepening would decrease regional flooding by lowering the water surface elevation during recurring flood events, such as the 100-year flood. As shown on Figure 6, the mitigation projects are expected to prevent the 100-year flood waters from inundating the portion of the Site south of the Puget Power Access Road—including the perimeter of the Landfill, the drainage ditch system, and the adjacent agricultural fields.

Several other Hylebos Creek restoration projects have been completed in recent years or are currently underway. Such projects include those identified in the CB/NT site natural resource damage assessment process, and wetlands and instream habitat enhancement projects by groups such as Friends of the Hylebos and Citizens for a Healthy Bay.

2.1.3 Regional Topographic and Hydrologic Setting

The regional topographic and hydrologic settings exert significant influence on the surface water and the shallow groundwater regime at the Site. More detailed information on Site hydrogeology, groundwater occurrence, and local surface water drainage is presented in the GAE Report.

Regional topography, surface water, and drainage features are shown on Figure 7. The Site is located in the floodplain of the Hylebos Creek Watershed, close to where it merges with the larger Puyallup River valley. To the east of the Site, Fife Way marks the steep transition between the flat floodplain and the rolling hilly relief of the uplands glacial drift plain.

The Hylebos Creek Watershed is a tributary sub-basin that drains 19 square miles of urban and suburban area between Fife and Federal Way (Entranco 2004). The primary surface water body, Hylebos Creek, is primarily a man-made channel in the vicinity of the Landfill. Hylebos Creek generally flows in a southerly direction until turning west for the last 2 miles prior to its discharge into the Hylebos Waterway. The last 1.6 miles of stream are influenced by tidal backwater (MSG et al. 2004). A historical survey completed in 1870 indicates the floodplain was already cleared, drained, and at least partially diked for agriculture by the time of the survey (MSG et al. 2004).

The Hylebos Creek floodplain is situated on a series of alluvial deposits. The transition between the adjacent glacial drift hills and the floodplain alluvium is marked by a mixed gravel and sand colluvial deposit. Groundwater flowing from the glacial hills recharges the several hundred feet of water-bearing alluvial sand units that are punctuated by low-permeability strata (aquitards). The inputs of groundwater from this higher elevation drive groundwater flow beneath the Landfill in a northwesterly direction toward its eventual discharge into Hylebos Creek. Recent field studies indicated recurring flooding during major storm events is likely the result of a combination of flat topography, high groundwater table, and backwater conditions experienced at high tide during major storm events (Entranco 2004).

2.2 Site History

A detailed history of B&L Landfill is presented in Section 2 of the GAE Report; the discussion below is a brief summary.

The permitted Landfill was owned and operated by Mr. William Fjetland of Executive Bark and Eagle Trucking. The Landfill contains primarily deck debris from log sort yards operating in the Tacoma Tideflats area. The log sort yards operators had used Asarco slag as roadway and yard ballast believing it to be inert "rock." This slag was mixed with the bark and dirt that was cleaned periodically from the log sort yards and transported to the Landfill for disposal.

In the early 1980's Ecology discovered that the slag at the yards and at B&L Landfill was leaching arsenic and other heavy metals at concentrations far in exceedance of their surface water standards.

In September 1983, USEPA placed the Commencement Bay Nearshore/Tideflats Superfund Site (CB/NT Site) on the National Priorities List (NPL), pursuant to Section 105 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 U.S.C. Sec. 9605). The CB/NT Site included the Hylebos Waterway and sites that were believed to contribute contamination to the waterway. The 1989 ROD for the CB/NT Site lists the B&L Landfill as one of the sources of metals contamination.

2.2.1 The Early Regulatory Years—1988 to 1991

In January 1988, Ecology sent notices to a number of entities advising them of their status as PLPs under MTCA for contamination at the B&L Landfill, and requesting their participation in an investigation and the development of a remedial strategy for the Site. The original PLP letters were sent to Asarco, Mr. Fjetland, Murray, Louisiana-Pacific, Inc., the Weyerhaeuser Corporation, and L-Bar Products, Inc. Following discussions with the PLPs and additional research into historical landfill operations, Ecology sent additional letters to a revised list of parties. This revised PLP list was comprised of Asarco, Mr. Fjetland, L-Bar Products, Inc., Murray, Louisiana-Pacific, Inc., Portac, Inc., U.S. Gypsum, Inc., Executive Bark, Inc., General Metals, Inc., Wasser Winters, Inc., and

West Coast Orient, Inc. With the exception of Murray, the PLPs declined Ecology's request to address environmental problems at the Site. Murray and Ecology negotiated a Consent Decree in March 1989, pursuant to which Murray agreed to conduct a remedial investigation and feasibility study (RI/FS) and implement a cleanup remedy at the Site. Ecology agreed to join Murray, following completion of the remedy, in pursuing other PLPs for contribution to the cost of the studies and the cleanup (see Section III of the Consent Decree). Murray engaged Kennedy Jenks, Inc. and Applied Geotechnology, Inc. to prepare the RI/FS, which was completed in September 1990.

In 1988, the log sort yard owners and the Port of Tacoma sued Asarco for slag-related contamination at the yards and at B&L Landfill. The court found Asarco liable for 79 percent of the costs to cleanup the Site, the Landfill operator for 14 percent (assigned equally to Eagle Trucking, Inc. and William Fjetland), and Murray responsible for the remaining 7 percent. The verdict and decision were affirmed on appeal in 1994.

2.2.4 Asarco Project Lead Years—1991 to 2005

Following the judgment in the federal lawsuit, Ecology issued an Enforcement Order (No. DE 91TC-S267) to Asarco, Murray, and Executive Bark, Inc. (c/o Camille Fjetland, Mr. Fjetland's widow) to develop preliminary designs for the remedial actions identified in the CAP. In June 1992, Ecology issued another Enforcement Order (No. DE-92TC-S214) to Asarco, Murray, and Executive Bark, Inc. for construction, operation, and monitoring of the selected remedial action. Asarco and its consultant, Hydrometrics, Inc. (Hydrometrics), took the lead in implementation of the remedy, which was substantially completed in 1993.

The B&L Landfill remedial action primarily consisted of consolidating and capping landfill materials with a multi-layer, RCRA- equivalent capping system; installing landfill gas collection wells; installing a leachate monitoring system; a stormwater collection pond and infiltration trenches; ditch remediation; institutional controls (site fencing); and routine monitoring of surface water and groundwater. A groundwater remedy (pump and treat) was evaluated, but not implemented, as it was viewed only as a future contingency action. The 1993 capping of the B&L Landfill by Asarco was effective in reducing surface water infiltration into the Landfill and likely ceased the production of leachate generated by surface water infiltration; however, it did not adequately address groundwater under or adjacent to the B&L Landfill.

In a draft report to Ecology in May 2001, "Review of Remedial Activities at the B&L Landfill," Asarco presented monitoring data that indicated a migration of arsenic in groundwater into ditches adjacent to and downstream of the Landfill, and in the wetlands north of the Landfill (Hydrometrics 2001a). In June 2001, Asarco submitted a "Contingency Plan for the B&L Landfill" that proposed several remedies for controlling groundwater at the Landfill (Hydrometrics 2001b). Asarco did not complete the activities scoped in the Plan.

In February 2005, the Second Amendment to the Enforcement Order issued by Ecology required the resumption, completion, and implementation of the activities outlined in the 2001 Contingency Plan.

2.2.5 Recent Activity—2005 to Present

Asarco declared bankruptcy on August 10, 2005, with none of the activities outlined in the Second Amendment to the Enforcement Order completed. Executive Bark, Inc., has not participated in remedial activities at the Site. In the interim, Murray has taken on the investigation of groundwater contamination in the wetlands and the development of remedial alternatives to address groundwater.

The GAE Report summarized all information known about the landfill starting with the original RI and continuing through Asarco work through 2005 and ending with identification of a series of data gaps investigations performed by Floyd|Snider for Murray in 2006 and 2007. A copy of the GAE Report, Ecology's Comments to the GAE Report, and Tech Memos related to the comments are contained on a CD-ROM in Appendix A.

2.3 The 1993 Remedial Action

This section presents the basis for the remedial approach that was selected by Ecology in 1991 and implemented in 1993.

The 1993 Remedy as Implemented

In the 1991 CAP, Ecology identified a selected remedial alternative for the Site consisting of the following:

- Consolidation of the landfill to a less than 13 acre footprint.

- Installation of a multimedia (RCRA) cap or equivalent.
- Installation of a stormwater system including a detention basin.
- Excavation of ditch sediments.
- Passive landfill gas controls.
- Placement of institutional controls (including barrier fencing around the Landfill and groundwater and surface water monitoring).
- Surface and groundwater monitoring.
- Contingency for groundwater actions, if needed in the future.

The selected remedy did not include the bottom liner for the Landfill that was a component of the preferred remedy in the FS. In the CAP, Ecology determined that the selected remedy was equivalent to the construction of a raised landfill base or a bottom liner system, but that these latter alternatives were more expensive than the selected remedy, and required more earth moving and truck traffic, resulting in excessive short-term negative impacts on human health and the environment.

The consolidation and capping alternative that was implemented has been successful in eliminating or significantly reducing risks to human health and the environment in a number of critical ways. Capping and perimeter fencing of the Site have eliminated human exposure to landfill waste through accidental ingestion, inhalation, and dermal contact. Excavation of contaminated ditch sediment eliminated existing sediment impacts and associated surface water contamination by the sediments. Capping has eliminated the pathway of runoff to surface water and significantly reduced water transmission through Landfill materials by blocking infiltration, thereby greatly reducing the volume of leachate generated. This has decreased the transport of contaminants to surface water and groundwater, and to sediments in perimeter ditches. Since the implementation of the 1993 remedy, conditions in the perimeter ditches have improved to such an extent that metals contamination is no longer reaching Hylebos Creek via the ditches.

However, the 1993 remedy was not completely effective in preventing the formation of arsenic-containing leachate nor in preventing the leachate from leaving the landfill and entering the adjacent wetlands and slowly recontaminating the perimeter ditch sediments. The base of the landfill is continually wet due to groundwater intrusion and the groundwater beneath the landfill, and in the adjacent wetlands, in the Upper Sand

Aquifer is heavily contaminated with arsenic. Therefore Ecology has made the determination that additional remedial action is necessary.

3.0 REMEDIAL INVESTIGATION

The GAE Report presents a longer discussion of site conditions and is included in Appendix A. The following is a summary.

3.1 Surface Water and Hydrology

3.1.1 Surface Water

Surface water at the Site drains to Hylebos Creek via two small sub-basins, one north of the Puget Power Access Road in the wetlands within the floodplain of Hylebos Creek and the other south of the road, in the agricultural farmlands of the Puyallup River valley. Surface water features close to the Landfill are shown on Figure 7.

Land south of the Puget Power Access Road is drained by the agricultural ditches, including those that run along the perimeter of the Landfill. These ditches discharge into the larger Surprise Lake Drain, which, in turn, discharges into Hylebos Creek via the 70th Avenue culvert under I-5.

Within the fenced area of the Landfill footprint, precipitation infiltrates the multi-layer cap until reaching a drainage layer that directs stormwater into troughs around the Landfill that lead to one of two infiltration ponds. Within the main infiltration pond south of the Puget Power Access Road is an overflow pipe that leads into the adjacent agricultural ditch system, as shown on Figure 2. This ditch system also captures stormwater that overflows from the smaller secondary stormwater pond at the northeast corner of the Landfill, outside the footprint edge of refuse, and the fenced perimeter.

The wetlands located north of Puget Power Access Road are part of a larger system of wetlands along Hylebos Creek (see section 2). The wetlands receive significant surface water input via precipitation, runoff from Fife Way, seasonally expressions of the rising water table, and, during flood stages, overflow from Hylebos Creek.

3.1.2 Geology and Hydrostratigraphy

Cross Sections F-F' (Figure 8) and E-E' (Figure 9) illustrate the relevant geologic and groundwater-bearing (hydrostratigraphic) units underlying the Landfill and Wetlands. Underneath the Landfill material and forming the surface soils in the Wetlands is an organic silt and peat unit 4 to 7 feet thick that transitions into a plastic silt deposit approximately 6 inches thick at its base. These deposits correspond to the pre-Landfill ground surface. Boring logs indicate the silt unit beneath the Landfill has been compacted and partially reworked into the fill material by grading and filling activities.

Saturated alluvial deposits (primarily sands) underlie the surface soils and comprise the Upper and Lower Sand Aquifer. These alluvial sands were encountered to the depths of the deepest RI borings. At the southeastern edge of the Site, closest to the glacial drift plain, the alluvial deposits grade into the colluvium and Pleistocene glacial silty gravel deposits[1]. Previous subsurface investigations (K/J/C & AGI 1990b; Hydrometrics 2001a) identified the Upper Sand Aquifer and Lower Sand Aquifer as the primary water-bearing units underlying the Landfill. At the Landfill, the water level of Upper Sand Aquifer exists within the lower 4 to 6 feet of landfill materials.

The alluvial deposits are divided into the Upper and Lower Sand Aquifer by the Lower Aquitard, a 3-to 6-foot-thick layer of interbedded silt, peat, and silty sand. This low permeability silt unit was encountered in all borings except those drilled into colluvium at the toe of the bluff.

3.1.3 Groundwater Flow Direction and Gradients

Three potentiometric surfaces as measured in April 2002 (Hydrometrics 2002), August 2006, and October 2006 (Floyd/Snider 2007a) are displayed on Figure 10. These contours indicate a northerly to northwesterly groundwater flow direction in the Upper Sand Aquifer, which is consistent with topography and a flow path toward Hylebos Creek. The groundwater gradient is generally steepest from the bluff to beneath the Landfill, relatively flat through the wetlands, and begins to get steeper

[1] In general, the uplands areas surrounding Hylebos Creek consist of glacial deposits, while the lowlands consist of flood plain (alluvial) deposits of silts and sands. Colluvium deposits consist coarse materials that have eroded off the bluff and exist at the toe of the slope.

again north of MW-15. These gradients also reflect the topography of the area.

Upward vertical groundwater gradients are present beneath the wetlands but tend to flatten toward the bluff. Potentiometric surfaces are approximately one foot higher in the Lower Sand Aquifer than in the Upper Sand Aquifer in the Wetlands area. Such upward gradients indicate a strong component of upward flow of groundwater. The Lower Aquifer beneath the Wetlands exerts hydraulic pressure on the aquitard between the Lower and Upper Aquifers, and thus probably acts as a hydraulic barrier to the downward migration of arsenic-contaminated groundwater that is present in the Upper Aquifer in the Wetlands area. According to Hydrometrics (2001a), data collected during the RI indicate vertical hydraulic gradients between the Lower and Upper Sand Aquifers are flat or slightly upward in the Landfill and show an increasingly upward trend in the Wetlands area north of the Landfill. This finding was confirmed by 2006 and 2007 field measurements (Floyd/Snider 2006; Floyd/ Snider 2007b) that showed strong upward gradients beneath the wetlands, even with several feet of ponded surface water atop the Upper Sand Aquifer. This is characteristic of floodplains that function as regional groundwater discharge areas. Many of the residential wells in the area south (upgradient) of the Landfill are reported to be artesian flowing wells—confirming a general upward vertical gradient trend in the lowland area (Hydrometrics 2001a).

Vertical hydraulic gradients are lower beneath the landfill and can be as low as zero indicating no net upward or downward gradients. When combined with the aquitard, this acts to prevent downward migration of contamination.

3.1.4 Hydraulic Conductivity and Average Linear Velocity

Pumping tests of the Upper Sand Aquifer (Floyd/Snider 2007a) in the Wetlands area indicates a highly transmissive aquifer with a preferential direction of hydraulic conductivity in the north–south direction. Calculated hydraulic conductivities are in the range of 100 to 250 feet per day parallel to the direction of groundwater flow and 2.7 to 5.7 feet per day perpendicular to the direction of groundwater flow. These findings are generally consistent with Asarco's 1999 slug test results.

The observed anisotropy in hydraulic conductivities, with conductivity an order of magnitude greater in the approximate north-south direction than in the east-west direction, is consistent with the observed presence of coarser sand grain sizes (up to medium to coarse and thin deposits of coarse sand at the base of the Upper Sand Aquifer) along the eastern edge of the wetlands investigation area. This may reflect that the Upper Sand Aquifer is composed of highly elongated sand channels that were deposited by alluvial processes, predominantly in a north-south direction.

Average linear groundwater seepage velocities, calculated based on a wetlands gradient of 0.001 and an assumed effective porosity of 35 percent, indicate representative wetlands groundwater seepage velocities ranging from approximately 100 to 260 feet/year. At these velocities, it would take approximately 2 to 6 years for groundwater to travel the 600 feet from the edge of the refuse in the Landfill to 12th Street East.

3.1.5 Groundwater Interaction with Surface Water

Groundwater-surface water interactions are important processes in both the Landfill and the Wetlands because the Upper Sand Aquifer beneath the Site maintains a very high water table that is at, or within a few feet of, land surface throughout the year.

As a consequence, agricultural drainage ditches (illustrated on Figure 2) are deep enough to receive groundwater discharge from the Upper Sand Aquifer based on staff gage and monitoring well measurements (K/J/C & AGI 1990b). These ditches primarily collect groundwater discharge, but locally and seasonally can recharge the shallow groundwater system. The section of ditch along the northern perimeter of the Landfill is higher than the rest of the ditch system and is often dry, and not as prone to receiving groundwater discharge. The ditch system drains to the west where it joins the Surprise Lake Drain; however, drainage of ditch water is limited by the shallow depth of the ditch, its flat gradient, and the generally consistent base flow elevation of water in the Surprise Lake Drain. These factors limit the ability of the ditches to function as an active groundwater drain. They also limit the flow rate along the ditch giving any arsenic that reaches the ditch ample opportunity to precipitate out before it reaches the larger Surprise Lake Drain.

In the Wetlands, during winter months or other wet conditions, the potentiometric surface rises above the ground surface due to both flooding inputs and upward discharge from the aquifer. The majority of groundwater flux through the Upper Sand Aquifer, however, occurs in the sands below the upper 3 to 8 feet of silty surface soils and especially in the coarser sand deposits at the base of the aquifer.

3.2 Nature and Extent of Contamination

Multiple investigations and monitoring activities have been conducted to examine soil, surface water, ditch sediment, and groundwater conditions at the Landfill and in the surrounding vicinity. The results of these investigations and years of monitoring indicate that arsenic is the only COC that still exceeds cleanup levels. Arsenic exceeds cleanup levels in groundwater, surface water, and ditch sediments.

Other slag-related metals (copper, lead, and nickel) and the organic compound phenol (a natural component within wood waste) were occasionally detected in some samples during the RI at concentrations greater than screening levels and, therefore, were identified as Site-wide COCs. Subsequent monitoring indicates that these non-arsenic COCs are still only occasionally detected, and at low concentrations in association with arsenic.

Elevated arsenic concentrations in groundwater generally extend from beneath the Landfill and downgradient into the Upper Sand Aquifer beneath the Wetlands. Arsenic-contamination in surface water and sediments in the drainage ditch system extends to the west of the Landfill. The pattern of groundwater contamination at the Landfill perimeter consists of a broad area of elevated concentrations along the northern perimeter where the arsenic plume flows into the wetlands and a "halo" of slightly elevated concentrations immediately adjacent to the Landfill perimeter. Groundwater monitoring since the 1990s has indicated that the arsenic plume in the Wetlands is generally stable.

3.2.1 Arsenic Release to Groundwater from Landfill Materials

Arsenic speciation and the reduction-oxidation (redox) chemistry that controls it are central to the release, transport, and attenuation mechanisms at the Site. The plume of elevated arsenic concentrations in groundwater beneath the Landfill and Wetlands is primarily comprised of As(III), a form of inorganic arsenic known as trivalent arsenic or arsenite that generally occurs under mildly reducing conditions. Such reducing conditions within the Landfill are generally responsible for releases of arsenic trapped on mineral surfaces in soil or slag via dissolution and desorption. In addition to arsenic and iron, Landfill materials appear to be the source of elevated groundwater concentrations of dissolved organic carbon (DOC) and common groundwater ions present in landfill leachate—including chloride, calcium, magnesium, and sodium. The presence of elevated concentrations of DOC and these ions, and the resulting elevated total dissolved solids (TDS), salinity, and specific conductivity, define a general leachate plume in the Wetlands that overlaps with, but is broader than, the arsenic plume.

The pattern of arsenic concentrations in the Upper Sand Aquifer along the boundary of the Landfill with the Wetlands suggests that arsenic-contaminated groundwater discharges along the whole northern border of the landfill, and flows beneath the Puget Power Access Road.

3.2.2 Extent of Arsenic Groundwater Plume

The arsenic groundwater plume exists only within the Upper Sand Aquifer. In the wetlands, it forms a broad western lobe that terminates within approximately 300 feet of the Landfill boundary in the upper section of the aquifer, and an elongated deeper plume "finger" that extends approximately 400 feet further downgradient. The extent of the arsenic plume in shallow groundwater is shown on Figure 8, which shows arsenic concentrations along a section parallel to the axis of the entire plume and Figure 11, which is a plan view of arsenic concentrations at two different depths in the Upper Sand Aquifer.

Figure 11 also shows that a relatively small "halo" of arsenic surrounds the Landfill to the west and south near locations D-8 and D-9. Results from off-site monitoring wells (MW-18 through MW-22, now decommissioned, but shown on Figure 11) confirm that the halo does not extend a significant distance off the Site. A localized area of elevated concentrations exists upgradient to the east of the Landfill as well, around monitoring well D-10A. This well is completed in an isolated pocket of colluvium that is not hydraulically connected to the Upper Sand Aquifer (based on potentiometric surface data). Arsenic concentrations typically drop an order of magnitude to near background levels in a short distance (from 250 μg/L in D-10A to 25 μg/L in MW-23, lying 100 feet downgradient). The source of this contamination is unknown, but its footprint and concentrations have remains stable since the RI in the late 1980s.

The northern extent of the plume is characterized by a thin seam of elevated concentrations at the more permeable coarse sandy base of the aquifer. A cross section showing arsenic concentrations through the full reach of the northern extent of the plume is illustrated in Figure 9. Dissolved arsenic, at a maximum concentration of 0.056 mg/L, was detected across an area no greater than 200 feet wide by 5 feet thick between depths of 17 and 22 feet. The exact downgradient extent of this plume "finger," however, is not currently established because of difficult field conditions in 2006. Regardless, given the low concentrations at 12th Street East, it is likely that the plume "finger" extends a limited distance north of 12th Street East, before attenuating to background levels.

Groundwater monitoring in the Lower Sand Aquifer indicates that the landfill has had little or no impact on the aquifer. The only exceedance of arsenic in the Lower Sand Aquifer potentially related to the Landfill exists at D-8B. In this area the aquitard may be discontinuous, but hydraulic gradients are upwards. Arsenic concentrations at this well are generally around 15 to 20 µg/L – higher that the site cleanup standard of 5 µg/L, but still low; wells downgradient of D-8B are at or below background concentrations.

3.2.3 Non-Toxic Leachate Indicators in Groundwater

Leachate indicators other than arsenic, including DOC, TDS, dissolved iron, and oxidation-reduction potential (ORP) are present in Wetlands area groundwater in patterns similar to but broader than the arsenic plume. These visually apparent similarities are supported by quantitative correlations between these constituents and parameters (Floyd/Snider 2006).

Correlations between arsenic and negative ORP, DOC, TDS, and iron (total and dissolved) support the model of reductive dissolution of arsenic, iron, and other ions. The correlations also support the transport of arsenic in groundwater with DOC, iron, and elevated TDS under the mildly reducing conditions measured (ORP between 0 and –100 mV).

Monitoring of leachate indicators in the Lower Sand Aquifer have shown that they are not present in the aquifer, further supporting the absence of landfill impact on the Lower Sand Aquifer.

3.2.4 Plume Stability and Attenuation Processes

The stable boundaries of the arsenic plume indicate that the plume is largely controlled at its downgradient edges by natural attenuation processes, primarily sorption to the soil and diffusion, that slow the rate of arsenic migration relative to the flow of groundwater. Several lines of evidence support attenuation, including:

- The arsenic plume boundaries have remained stable since the beginning of post-remedy Wetlands groundwater monitoring in 1994.
- Leachate indicators (elevated iron, TDS and DOC) are more widespread than the distribution of the arsenic plume. Individual conservative tracers (i.e., ions that stay in solution) for leachate, such as chloride, are present in relatively uniform concentrations downgradient from the Landfill, while arsenic concentrations in groundwater decrease. This indicates that arsenic in wetlands groundwater is not as mobile as these other Landfill-related constituents.
- Arsenic concentrations in D-6A, at the heart of the Wetlands plume, have been between 1 and 4 mg/L consistently since the well was installed in 1994. Groundwater travel times indicate that groundwater from D-6A would have reached 12th Street East in approximately 2 to 5 years. Yet, today (13 years after the first measurements at D-6A), concentrations at 12th Street East are 50 times lower than the concentrations at D-6A, indicating that at least 95 percent of the arsenic is attenuating between the two locations.
- The shallow, more oxidized portion of the plume does not extend more than 400 feet from the edge of the Landfill.
- The highest percentages of As(V), a less mobile form of arsenic than As(III), were measured in monitoring wells at the downgradient edge of the plume, a finding that is consistent with a shift in geochemical conditions.

Additionally, as suggested by Cross Section F-F’ (see Figure 8), simple recharge of stormwater from the Landfill stormwater pond may be diluting/attenuating arsenic from the upper part of the aquifer.

3.2.5 Wetlands Soil Quality and Groundwater Attenuation

It is possible that the aquifer soils in the Wetlands accumulate arsenic over time due to a cyclical pattern of sequestration and dissolution associated with Wetlands flooding. As water levels drop and oxidizing conditions extend several feet into the aquifer, arsenic is likely to be adsorbed onto and/or co-precipitated with iron oxide mineral coatings. When water levels rise again, and reducing conditions return, arsenic would then be re-dissolved by reductive dissolution processes similar to those that originally released arsenic from the Landfill waste.

Although this sequestration/dissolution cycle appears to be occurring in the Wetlands, soil analytical results indicate that the mass of dissolved arsenic in groundwater is not significant enough to cause concentrations of arsenic in soil to become elevated. Soil core samples from throughout the Wetlands, including the area with the highest concentrations in groundwater, resulted in only five detections of arsenic at concentration greater than 10 mg/kg.

3.2.6 Extent of Contamination in Ditch Surface Water and Sediments

Discharge of leachate into the adjacent ditch system to the west of the Landfill has resulted in localized arsenic contamination in agricultural ditch surface water that when oxidized, precipitates out iron/arsenic solids that settle into ditch sediments. The lateral extent of surface water and sediment contamination, based on 2006 results, is presented on Figures 12 and 13, respectively.

The extent of the arsenic contamination of the ditch system is generally limited to the agricultural ditch along the western Landfill boundary. Significantly lower arsenic concentrations were detected in the ditch segment downgradient of the Landfill. The highest detections of arsenic in ditch sediments were co-located with the highest detections of arsenic in ditch surface water.

In addition to generally decreasing occurrences in ditches downgradient from the Landfill, arsenic concentrations in ditch sediments decrease by orders of magnitude within a few inches of the surface. This depth profile indicates that the likely mechanism for ditch recontamination (the ditches were cleaned out as part of the 1993 remedy) is interaction with oxygen and precipitation of arsenic that is deposited in the upper part of the ditch sediments.

No arsenic impact to the Surprise Lake Drain or surface water downgradient of this input has been observed. Arsenic concentrations

(0.011 mg/L) in surface water downgradient of the Surprise Lake Drain are reflective of background levels

3.2.8 Methane

Emission of landfill gas (LFG), including methane, was not identified during the 1990 RI as a pathway by which contamination leaves the Site, and was not included in the 1991 CAP as a risk associated with the Site. Passive gas controls were installed as part of the consolidation and capping remedy implemented in 1993 to control the potential release of LFG. Methane was monitored at the edge of the Landfill mound to ensure it did not exceed the lower explosive limit (LEL) as part of protection monitoring (Hydrometrics 1994). Based on November 2005 air quality measurements of the vents of the gas collection system, the Landfill has apparently ceased emission of measurable quantities of methane (the component of LFG that is associated with generating subsurface pressure and potentially explosive concentrations). The Landfill is also not emitting measurable quantities of hydrogen sulfide, a toxic air pollutant. Because VOCs are not detected in landfill leachate or Site groundwater, there is no reason to suspect emission of other toxic air pollutants from the Landfill gas collection system or from fugitive emissions.

3.3 Site Conceptual Model

3.3.1 Potential Exposure Pathways and Receptors

The 1993 remedy was effective in eliminating the potential for direct contact to the Landfill waste and ditch sediment, in preventing the formation of contaminated surface water discharge, in eliminated most of the discharge of contaminated leachate into the perimeter ditch system, and in reducing leachate by preventing the infiltration of rainwater. The 1993 Remedy was effective in reducing the major risks to human health and the environment from B&L Landfill. Despite this, a number of potential exposure routes remain, all of which stem from the continued discharge of leachate-contaminated groundwater from the base of the landfill.

While leaching associated with stormwater infiltration is controlled by the consolidation and capping of landfill materials, leachate is still produced when groundwater flowing beneath the Landfill saturates landfill waste. The bottom 4 to 6 feet of the Landfill are believed to remain saturated under current conditions. Specifically, the discharge from adjacent bluff into the landfill and surrounding lands acts to continually "recharge" the landfill wastes with water that forms arsenic-contaminated leachate. The leachate, in turn, migrates as contaminated groundwater from beneath the landfill into the adjacent wetlands, and seasonally into the perimeter ditch system.

Seasonal groundwater discharge to the perimeter ditches has slowly recontaminated ditch sediments. The groundwater discharge to the wetlands has resulted in a distinct plume of arsenic contaminated groundwater that seasonally discharges to land surface where it impacts "ponded" surface water quality in part of the wetlands.

Exposure to Contaminated Groundwater

Arsenic-contaminated groundwater beneath the Landfill and Wetlands areas is not in an aquifer that is currently used as a drinking water source. There is no completed hydrogeologic pathway for arsenic to reach nearby drinking water wells (i.e., City of Milton wells) based on a number of factors; including well locations upgradient of the Landfill, the depths of well completions below the Upper Sand Aquifer, and the protective aquitard and upward vertical gradients that separate the Upper Sand Aquifer from deeper aquifers. Additionally, Washington State Well Regulations require that no drinking water well be screened at depths less than 20 feet and wells are banned from being drilled within 1,000 feet of an existing landfill. As described in Section 3.2, elevated arsenic concentrations in groundwater are limited to the upper 20 feet of soil and arsenic apparently does not extend more than 700 feet away from the Landfill boundary.

The attenuation mechanisms at work in the Wetlands are limiting migration of arsenic by precipitating the arsenic onto subsurface soils. Although this reduces the concentrations in groundwater, it has not yet raised arsenic soil concentrations above background. Eventually groundwater from the landfill discharges into Hylebos Creek. The section of the current Hylebos Creek channel located closest to the arsenic plume, near the culvert channeling the creek under I-5, is located approximately 600 feet from the downgradient end of the Wetlands plume. As indicated earlier in this section, the downgradient extent of the arsenic plume is in a relatively thin seam of sand at the base of the aquifer. Although natural attenuation is likely to prevent further movement of the plume and the arsenic has not currently reached the creek, the potential remains for a completed pathway in the future due to the proposed relocation of Hylebos Creek by WSDOT. Preliminary designs by WSDOT (refer to Figure 5) place the relocated channel within 200 feet of the known extent of the plume and could alter the existing shallow groundwater flow regime and potentially the stability of the plume.

Exposure to Contaminated Surface Water

The discharge of arsenic-contaminated groundwater into perimeter ditches and the groundwater-surface water interaction in the Wetlands creates the potential for surface water exposure pathways.

Contaminated ditch surface water creates a potential pathway for direct human contact under a trespass scenario. The drainage of ditch surface water to Surprise Lake Drain, which drains to Hylebos Creek, creates a potential pathway to human exposure through fish consumption and for direct contact to aquatic receptors. Available data indicate that only background concentrations of arsenic have been measured downgradient of the ditch. Changes in land use within the basin, however, may result in a complete pathway in the future if the ditches are rerouted.

The seasonally high water table creates a condition for the arsenic in the Wetlands plume to discharge and commingle with the intermittently ponded surface water in the Wetlands. This creates a potential pathway for direct human contact under a recreational or trespass scenario and for terrestrial exposure by Wetlands biota.

Ditch Sediments

Contaminated ditch sediments associated with leachate discharging to surface water in the perimeter ditches creates potential pathways for direct human and animal contact under a trespass scenario. These sediments were excavated in the 1993 Remedy removing this exposure pathway; however, seasonal discharge of leachate into the ditches continues and the sediments are slowly recontaminating; although at no where near their historical concentrations.

Wetland Soils

The concentrations of arsenic detected in shallow Wetlands soils (depths of 0 to 2 feet) are at or less than MTCA Method A CULs for arsenic of 20 mg/kg. In addition, shallow soil arsenic concentrations in Wetlands soils are within the moderate range for the Tacoma Smelter Plume area-wide contaminated site, and less than the Interim Action Trigger Level of 100 mg/kg (Landau 2006). Shallow Wetland soils, therefore, do not present a potential pathway for exposure. The concentrations of arsenic in deeper Wetlands soils are less than CULs, and there is no potential pathway for exposure from deeper Wetlands soils.

3.4 Cleanup Action Areas

The B&L Site was divided into three cleanup action areas (CAAs) to facilitate the selection of the cleanup action appropriate for the Site. The CAAs are discussed below, and illustrated on Figure 14.

3.4.1 Landfill/Ditch CAA

The Landfill/Ditch CAA consists of the B&L Landfill and the surrounding agricultural ditch system. This represents the original 18.5-acre footprint of Landfill operations. Although the Landfill was consolidated in 1993 to approximately 13 acres, the remaining acreage is used for access roads, maintenance of landfill closure systems, stormwater management, and fencing. No Landfill waste is believed to remain outside of the Landfill/Ditch CAA. The agricultural ditch system that surrounds the Landfill drains to the west, where it joins the Surprise Lake Drain.

3.4.2 Wetlands CAA

The Wetlands CAA consists of that section of wetlands immediately downgradient of B&L Landfill that contains arsenic-contaminated groundwater released from the B&L Landfill that remains above the cleanup level. This plume has been stable in size since its discovery in 2001. On the south, it is bounded by Puget Power Access Road and then the Landfill/Ditch CAA, on the east and west it is bounded by groundwater that meets the groundwater CUL established for the Site. Near the Landfill, contamination is present throughout the shallow aquifer and has a potential to seasonally discharge to the land surface. As the groundwater moves to the north, (the direction of groundwater flow) the upper reaches of the aquifer comply with the groundwater CUL and no exposure is present in the surface soils or near-surface groundwater; however, contaminated groundwater remains at the base of the shallow aquifer. The northern boundary of the Wetlands CAA is taken as E. 12th St. This unused right-of-way acts as a property line for ownership of the Wetlands CAA, and represents the location where only a narrow seam of contamination at the base of the shallow aquifer remains. Contaminated groundwater remains at the base of the aquifer but can not reach terrestrial receptors in the wetlands. This contamination at the base of the aquifer is included in the next cleanup area, the End of Plume CAA.

3.4.3 End of Plume CAA

The End of Plume CAA is defined as the extension of the Wetlands CAA's groundwater plume at E 12th St.. Within the End of Plume CAA, soils already comply with CULs, as does the upper section of the Upper Sand Aquifer. The area is defined by a narrow seam of groundwater contamination at the base of the aquifer that is less than or equal to 5 feet thick and less than 200 feet wide. There is no known current exposure to this contamination. However, depending on the rate of naturally occurring attenuation and future plans by WSDOT to relocate Hylebos Creek as part of the SR 167 project, it may reach Hylebos Creek in the future unless action is taken.

Remedial alternatives implemented in the upgradient Landfill/Ditch CAA and the Wetlands CAA are expected to control the source of contamination in this area. However, additional alternatives are proposed for the End of Plume CAA to speed its recovery and bring it into compliance in a faster time frame.

4.0 CLEANUP STANDARDS

4.1 Remedial Action Objectives (RAOs)

RAOs are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, including:

- Implement administrative principles for cleanup (WAC 173-340-130);

- Meet requirements, procedures, and expectations for conducting an FS and developing cleanup action alternatives (WAC 173-340-350 through 173-340-370); and
- Develop CULs (WAC 173-340-700 through 173-340-760).

In particular, RAOs must include the following threshold requirements from WAC 173-340-360:

- Protect human health and the environment;
- Comply with CULs;
- Comply with applicable state and federal laws; and
- Provide for compliance monitoring.

In addition to the threshold requirements, the following selection criteria, provided in WAC 173-340-360, allow for selecting among alternatives that meet the threshold requirements. The selection criteria require cleanup actions to:

- Use permanent solutions to the maximum extent practicable;
- Provide for a reasonable restoration time frame; and
- Consider public concerns.

MTCA [WAC 173-340-350(8)] allows for an initial screening of possible alternatives that eliminates those alternatives that do not meet the threshold requirements, are disproportionately costly compared to other alternatives that meet the threshold requirements, or are technically impossible at the site.

Once the initial screening has been performed and several alternatives remain that meet the threshold requirements, a more detailed analysis to select the alternative that "uses permanent solutions to the maximum extent practicable" is performed. This review makes use of a "disproportionate cost" analysis. If one alternative is clearly preferred by both Ecology and the PLP at this stage, this analysis is not required [WAC 173-340-360(3)(d)]. In the disproportionate cost analysis, the following criteria are evaluated [WAC 173-340- 360(3)(e and f)]:

- Overall protectiveness;
- Permanence;
- Cost;

- Effectiveness over the long term, which includes reductions in toxicity, mobility, and volume;
- Management of short-term risks;
- Technical and administrative implementability; and
- Consideration of public concerns.

In addition to these criteria, the restoration time frame must be considered when choosing between alternatives.

MTCA also sets forth requirements specifically for groundwater cleanups. Cleanup actions for groundwater must be permanent, or, if non-permanent, must contain and either treat or remove the source of any release that cannot be reliably contained.

MTCA also includes the following expectations, paraphrased from WAC 173-340-370, that are potentially appropriate for the Site.

- Treatment technologies will be emphasized at sites with areas contaminated with high concentrations of hazardous substances, highly mobile materials, and/or discrete areas of hazardous substances that lend themselves to treatment.
- Engineering controls, such as containment, are appropriate for sites or portions of sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable.
- Active measures will be taken to prevent/minimize releases to surface water via surface runoff and groundwater discharges in excess of CULs.
- Natural attenuation of hazardous substances may be appropriate at sites where source control has been conducted to the maximum extent practicable; leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health or the environment; there is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

The RAOs for the B&L Site are also guided by specific MTCA requirements defined in WAC 173-340-360 for groundwater cleanup actions, institutional controls, releases and migration, and remediation levels.

Soils that are contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) are met:

> *WAC 173-340-740 (6) (f)*
>
> *The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:*
>
> *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
>
> *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
>
> *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
>
> *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
>
> *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*
>
> *(vi) The types, levels, and amount of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances are specified in the draft.*

4.2 Applicable or Relevant and Appropriate Requirements (ARARs)

The selected groundwater alternative must comply with MTCA cleanup regulations (Chapter 173-340 WAC) and with applicable state and federal laws. Under WAC 173-340-350 and 173-340-710, the term "applicable requirements" refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a COC, remedial action, location, or other circumstance at the facility. The "relevant and appropriate" requirements are regulatory requirements or guidance that do not apply to the facility under law, but have been determined to be appropriate for use by Ecology. ARARs are discussed in more detail in the GAE Report.

Remedial actions conducted under a Consent Decree with Ecology must comply with the substantive requirements of the ARARs, but are exempt from their procedural requirements, such as permitting and approval requirements [WAC 173-340-710(9)]. This exemption applies to state and local permitting requirements, including; the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Hazardous Waste Management Act, the Clean Air Act, the State Fisheries Code, the Shoreline Management Act, and local laws requiring permitting.

4.2.1 State and Local ARARs

The following state and local ARARs have been considered in selecting the remedy:

- Model Toxics Control Act Cleanup (Chapter 173-340 WAC)
- Sediment Management Standards (Chapter 173-204 WAC)
- Water Quality Standards for Washington Surface Waters (Chapter 173-201A WAC)
- Washington State Shoreline Management Act (RCW 90.58, Chapter 173-18 WAC, Chapter 173-22 WAC, and Chapter 173-27 WAC)
- Pierce County Shoreline Management Use Regulation (Title 20)
- Pierce County Development Regulations—Critical Areas (Title 18E)
- The Clean Water Act (33 USC 1251 et seq.), Pierce County Ordinances (Title 13.06 for Publicly Owned Treatment Works), and National Pretreatment Requirements (40 CFR 403)
- Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC)

- State Environmental Policy Act (RCW 43.21C)
- Washington State Hydraulics Projects Approval (RCW 75.20.10 through 75.20.160, Chapter 220-110 WAC)
- Washington Dangerous Waste Regulations (Chapter 173-303 WAC)
- Water Quality Standards for Surface Waters of the State of Washington (RCW 90.48 and 90.54; Chapter 173-201A WAC)
- Federal, State, and Local Air Quality Protection Programs
- Federal and State of Washington Worker Safety Regulations

4.2.2 Federal ARARs

The following federal ARARs have also been considered in remedy selection:

- The Clean Water Act (33 USC 1251 et seq.)
- National Toxics Rule
- Magnuson-Stevens Act (16 USC § 1801 et seq.)
- Comprehensive Environmental Response Compensation, and Liability Act of 1980 (42 USC 9601 et seq. and 40 CFR 300)
- Endangered Species Act (16 USC § 1531 et seq.)
- Native American Graves Protection and Repatriation Act (25 USC 3001 through 3113; 43 CFR Part 10) and Washington's Indian Graves and Records Law (RCW 27.44)
- Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR Part 7)
- National Historic Preservation Act (16 USC 470 et seq.; 36 CFR Parts 60, 63, and 800)

4.3 Cleanup Standards Established for the B&L Site

4.3.1 Cleanup Levels

The Table below presents the CULs established by Ecology for the B&L Site. The B&L Site has been in compliance for all COCs except arsenic since the implementation of the 1993 remedy. Therefore, Ecology is shortening the COC list for future compliance to include only arsenic. For completeness, arsenic cleanup levels for soil, sediment, groundwater, and surface water are included in this CAP.

B&L Wood Waste Site Cleanup Levels

Parameter	Soil/Fill[(a)] in mg/kg	Groundwater[(b)] in ug/L	Surface Water in ug/L	Sediments[(d)] in mg/kg
1991 CAP COCs				
Arsenic	20 (e)	5.0 (e,j) 10.0 (f)	5.0 (h) 10.0 (f)	20 (e)
Copper	--	--	12.0	390 (g)
Lead	250 (e)	5.0 (e,j) 10.0 (f)	3.0 (h) 1.0 (f)	250 (e)
Nickel	--	320 (i)	--	--
Phenol	--	9,600 (i)	2,560 (c)	--
Current CAP COC				
Arsenic	**20 (e)**	**5.0 (e,j)**	**5.0 (h)**	**20 (e)**

Notes:

a More restrictive soil cleanup levels may be required to maintain compliance with groundwater and surface water cleanup levels.

b Points of compliance are the Upper Aquifer and Lower Aquifer at the Slurry Wall boundary.

c USEPA ambient freshwater quality chronic criterion.

d Cleanup levels have been chosen as the more stringent level between MTCA residential soil cleanup level, Commencement Bay ROD sediment cleanup objectives, and Ecology salt water sediment cleanup level.

e MTCA Method A residential cleanup levels.

f Practical Quantitation Level (PQL). These values serve as the cleanup level where listed. If lower PQLs become achievable during the cleanup an evaluation will be made to determine whether cleanup levels should be lowered by Order/Agreed Order/Consent Decree amendment.

g Sediment Management Standards Minimum Cleanup Levels WAC 173-204-520.

h National Toxics Rule; defaulting to the State of WA background level of 5.0 ug/L used in MTCA Method A Groundwater Standard.

i MTCA Method B Cleanup Levels.

j Natural background may be demonstrated by Ecology to be higher than the cleanup level per WAC 173-340-708(11). In that case, natural background concentration may be substituted by Ecology as cleanup level.

4.3.2 Point of Compliance

Per WAC 173-340-720(8)(c) a Conditional Point of Compliance (CPOC) for soil, sediment, groundwater and surface water is established at the landfill/cap perimeter areally, extending downward through the first aquitard vertically.

4.4 Remedial Action Objectives for Each Cleanup Area

The following section discusses narrative performance standards for each of the cleanup areas.

4.4.1 Landfill/Ditch CAA

Remedial Action Objectives

Since the installation of the 1993 Remedy, the exposure pathways from the Landfill are limited to the migration of arsenic-contaminated groundwater beyond the perimeter of the Landfill and into the surrounding ditches and adjacent Wetlands area.

The drainage ditch system along the perimeter of the Landfill presents potential exposure pathways to terrestrial receptors (animals and birds) and occasional recreational human users. Both groups would come into incidental direct contact with the surface water and sediments. Since water from the ditches eventually drains into Hylebos Creek, there is also the potential for contamination from the perimeter ditches to reach Hylebos Creek, although current data indicate that this has not happened since the 1993 remedy was implemented.

The following RAOs apply to this action area:

- Meet MTCA Threshold Requirements, as defined by WAC 173-340-760(6)(f) for containment remedies;
- Implement closure requirements from Minimum Functional Standards for Solid Waste Landfills (Chapter 173-304 WAC);
- Prevent arsenic-containing groundwater from migrating beyond the Landfill into adjacent wetlands and agricultural drainage ditches;
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent possible; and
- Protect the sediment and surface water quality of Hylebos Creek (and associated restoration projects) from arsenic releases from the B&L Landfill.

Cleanup Levels

The CUL for arsenic in **soil** is 20 mg/kg. The point of compliance for soil, as defined in WAC 173-304-462(2)(e)(i) and WAC 173-304-100, is limited to those soils that are outside the footprint of the Landfill containment area. Since this CAA only includes the Landfill footprint and surrounding ditches, this effectively means that the clean soil layer of the Landfill cap must meet the soil CUL.

The CUL for arsenic in **groundwater** is 5 ug/L or the background level, whichever is higher. The conditional groundwater point of compliance for the landfill is the edge of waste. A series of groundwater wells (most of which already exist) will be installed (by the remedy selected for the Site) around the perimeter of the Landfill and will act to measure groundwater quality at the edge of waste. Monitoring at this point will be used to assess the successful implementation of source control at the landfill. As discussed in the next section on the Wetlands CAA, 12th Street East is considered to be the best location to quickly stop the migration of the arsenic plume, as required by WAC 173-340-360(2)(f), because of this former road bed's access to the far end of the plume prior to its potential future discharge to Hylebos Creek.

The CUL for arsenic in **sediment** is 20 mg/kg and includes consideration for the protection of Hylebos Creek. The point of compliance for this area is throughout the ditch system.

The CUL for arsenic in **surface water** is 5 ug/L or the background level, whichever is higher. Because much of the surface water comes from groundwater recharge (these are drainage ditches for flooded agricultural lands), the regional groundwater background concentration has been considered in establishing the surface water standard. The point of compliance for surface water is everywhere within the perimeter ditch system.

4.4.2 Wetlands CAA

Remedial Action Objectives

Because of the discharge of arsenic-contaminated groundwater into the Wetlands CAA, there is a risk of arsenic exposure to human and ecological receptors. This risk of exposure does not necessarily correspond to risks of toxic effects, degradation, bioaccumulation, or other harms to ecological receptors. There is no evidence that such harm has or is currently taking place.

The RAOs for this CAA include the following objectives to prevent or minimize exposure to the Upper Sand Aquifer and surface water, as well as exposure to surface water and sediments in the Wetlands CAA.

The following RAOs apply to this CAA:

- Meet MTCA threshold requirements, including protection of recreational, human and ecological receptors from arsenic contamination that is seasonally present in ponded surface water, soil porewater, and groundwater;
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable;
- Remove or control the potential for the groundwater plume in the Wetlands CAA to continue to migrate downgradient into the End of Plume CAA, within a reasonable restoration timeframe; and
- Ensure remediation activities in Wetlands CAA will be consistent with the potential restoration activities in the area associated with the WSDOT SR 167 Project and potential Hylebos Creek relocation. Coordination with the WSDOT planning process is anticipated to ensure the selected alternative will not negatively impact the planned riparian restoration along Hylebos Creek.

Cleanup Levels

The CUL for Wetlands soils is 20 mg/kg. The point of compliance is the upper 15 feet of the Wetlands soils throughout the cleanup area.

The CUL for groundwater in the Wetlands CAA is 5 ug/L.. This CUL protects potential future drinking water uses (minimum 1,000 feet from the Landfill) and protects surface water quality at Hylebos Creek. The existing groundwater plume extends to the vicinity of 12th Street East; whereas both of these potential future receptors are well downgradient of 12th Street East. Between the Landfill and 12th Street East, the property is owned by a private party who has granted access for investigation tasks only. Beyond 12th Street East the wetlands are owned by the municipal parties. The WSDOT SR 167 project would relocate Hylebos Creek much closer to 12th Street East and, therefore, potentially alter the current groundwater flow regime. 12th Street East is considered to be the best location to quickly stop the migration of the arsenic plume, as required by WAC 173-340-360(2)(f), because of this former road bed's access to the far end of the plume prior to its potential future discharge to Hylebos Creek.

As discussed in Section 5, no feasible alternative was identified that would comply with CULs throughout the Wetlands CAA in a reasonable restoration time frame. Alternatives were identified, however, that would be able to meet CULs relatively quickly at 12th Street East. For this reason, alternatives in the Wetlands CAA were evaluated in their ability to (1) protect human health and the environment throughout the Wetlands, (2) treat Wetlands arsenic to the maximum extent practicable, and (3) support the rapid cleanup action at the End of Plume CAA.

4.4.3 End of Plume CAA

Remedial Action Objectives

The following RAOs apply to this CAA:

- Meet MTCA threshold requirements, including considerations for the long-term potential for the plume to reach Hylebos Creek;
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent possible; and
- Ensure that remediation activities in the End of Plume CAA will be consistent with the potential restoration activities in the area associated with the WSDOT SR 167 project and potential Hylebos Creek relocation. Coordination with the WSDOT planning process is anticipated to ensure the selected alternative will not negatively impact the planned riparian restoration along Hylebos Creek.

Cleanup Levels

Soils in the End of Plume CAA already comply with MTCA. The CUL for arsenic in groundwater is 5 ug/L. Within the End of Plume CAA, there appears to be no current exposure to the thin seam of arsenic-contaminated groundwater at the base of the aquifer. Potential future exposures in this area could be controlled with institutional controls if the owner of the property agrees. Beyond 12th Street East, the PLPs do not have reasonable controls on the use of groundwater, and exposure at Hylebos Creek could conceivably occur at some time in the future, especially if the creek is rerouted by WSDOT. Therefore, groundwater at the far side of 12th Street East must comply with the CUL throughout the Upper Sand Aquifer.

5.0 DESCRIPTION AND EVALUATION OF CLEANUP ALTERNATIVES

The GAE Report contains a detailed screening and evaluation of technologies for the Landfill, Wetlands, and End-of-Plume CAA. Ecology determined that the screening of technologies was adequate to for Ecology to build specific alternatives to be considered at the Site. The alternatives have a series of "common elements" that appear in all alternatives.

5.1 Identification of Cleanup Alternatives

Ecology identified the following 5 cleanup alternatives for further evaluation:

- Alternative 1:Slurry Wall Containment
- Alternative 1a: Slurry Wall with Hydraulic Control
- Alternative 2: Slurry Wall Containment with Waste Dewatering
- Alternative 3a: Excavation and Disposal of Landfill Waste ("Dig and Haul")
- Alternative 3b: Excavation and Disposal of Landfill Waste and Contaminated Soils Below the Landfill Waste ("Deep Dig and Haul")

A number of remedy elements are common to all of the above alternatives, as listed below:

- Excavation of contaminated sediment in perimeter ditches.
- Installation of an upgradient interceptor trench
- Pumping and treatment of groundwater along the landfill perimeter outside of the slurry wall
- Pumping and treatment of groundwater in the Wetlands CAA
- In-situ sequestration and monitored natural attenuation in the End-of-Plume CAA.

- Long Term Monitoring and Maintenance

5.2 Common Elements to All Cleanup Alternatives

The common elements are briefly described below. Further information on each element is described in the GAE report.

Excavation of Sediment in Ditches

Excavation of ditch sediments was performed during the Landfill consolidation and capping in 1993. Localized recontamination has occurred due to the continued discharge of arsenic-contaminated groundwater and precipitation of arsenic into ditch sediments. The depth of ditch sediment contamination in the perimeter ditches is generally limited to approximately the upper 12 inches and therefore, is easily mucked out by a backhoe. Additional sampling would need to be performed to identify specific sections of the ditch where contaminant concentrations exceed CULs before remediation would begin and also after remediation to confirm compliance. For the purposes of this document, it is assumed that the affected ditch segment starts at the adjoining apartment complex and continues until approximately 400 feet downgradient of the Landfill (sediment Station SW-4). Assuming a 3-foot wide ditch bottom dug 12 inches, on average, this represents approximately 250 tons of sediment. The sediments would be stabilized, as necessary, to reduce their water content and then disposed of at a permitted landfill. The ditches would remain, following excavation, and continue to function to drain the agricultural fields and apartment complex.

Upgradient Interceptor Trench

The natural groundwater flow through the Landfill will be blocked by the installation of a slurry wall, and will instead migrate around the sides of the slurry wall. If the natural rate of migration is thus limited, this may cause groundwater along the upgradient section of the slurry wall to build up, causing uneven hydrostatic pressure on the slurry wall and/or groundwater ponding. This pressure could be alleviated by interceptor drains or other means (e.g., French drains) that would funnel away upgradient groundwater. Upgradient clean water in the upper section of the Shallow Sand Aquifer will be intercepted by the trench system before it reaches the landfill and will be redirected within the watershed. This will lower the hydraulic gradient in the aquifer between the bluff and the landfill. This alone is expected to greatly decrease the amount of water entering the landfill area and forming leachate. Therefore, the interceptor trench is a major component of the proposed slurry wall remedy.

Treatment of Groundwater Outside the Landfill Perimeter

Groundwater containing arsenic at concentrations above CULs was detected in wells D-8, D-9, and MW-23 at locations (refer to Figure 11) adjacent to but outside of the perimeter of the existing Landfill cover. This area of contamination, at points of the landfill perimeter, has been referred to as the "halo". Pumping wells will be used to remove the contaminated groundwater and it will be treated to remove the arsenic along with groundwater treatment occurring in other parts of the site. The quantity of water, and the length of time that groundwater would have to be removed and treated at these locations is not known at this time but will be evaluated during the design stage.

Pumping and Treatment of Groundwater in the Wetlands CAA

The proposed remedy for the Wetlands CAA is pumping of groundwater from the Upper Sand Aquifer beneath the wetlands, treatment of the groundwater to remove arsenic and iron, and re-infiltration of the treated groundwater into existing stormwater ponds or back into the wetlands. The intent is to install a number of pumping wells in order to quickly remove dissolved arsenic mass from the system as quickly as possible. The work can only be performed in the dry season due to the surface water ponding and flooding that occurs in the wet season, which would greatly limit the effectiveness of mass removal by pumping. Some rebound of arsenic concentrations from the soil is expected following shutdown of pumping; therefore, it is not known how many years it will take to permanently achieve cleanup levels. However, the intent is to use groundwater pump and treat as a rapid method for mass reduction, to better protect downgradient and surface water receptors.

In-situ Sequestration and Monitored Natural Attenuation in the End-of-Plume CAA

This remedy consists of enhancing the natural attenuation that is already occurring by adding specific sequestration agents that will act to quickly and, to the extent possible, irreversibly to precipitate the dissolved arsenic. This will be accomplished along the 12th Street East right of way. This location was selected for the following reasons:

- The 12th Street East right of way is an unused roadway that cuts through the wetlands and allows for easy access to the wetlands without further disruption to the wetlands.
- The land between the Landfill and 12th Street East is owned by a single party, which will simplify getting access agreements and institutional controls, although it may still be difficult to do so.
- The residual contamination at 12th Street East exists as a thin seam of moderately elevated arsenic at the base of the aquifer in a well defined and accessible sand zone.
- Land beyond 12th Street East is planned for habitat restoration, including the potential relocation of Hylebos Creek, making the control of arsenic at 12th Street East critical.

A series of injection wells or a single trench will be used to inject the sequestering solution into the base of the aquifer where natural conditions are already reducing and favorable. On the downgradient side of 12th Street East, compliance monitoring wells will be installed to monitor the success of the remedy and confirm compliance with site arsenic cleanup standards.

Long Term Monitoring and Maintenance

This common element consists on continuing the maintenance obligations for the 1993 remedy including inspection and repairs of the cap, fence, stormwater controls, and passive gas system. Additionally, the selected remedy will include new systems for each of the CAA that each involve operation, long term monitoring and maintenance to be successful. A financial mechanism is needed to ensure the availability of funding for operation, maintenance and monitoring of this long term project. A combined operations, maintenance and monitoring plan for the entire site will be developed during the design and implementation phase.

5.2 Landfill/Ditch CAA Alternatives

The RAOs for the Landfill CAA will be met by preventing arsenic-contaminated leachate from migrating beyond the edge of the waste. Technologies that involve simply pumping or dewatering of the leachate to achieve this were excluded as impractical or ineffective. The retained remedial technologies were those that will contain groundwater within the Landfill/Ditch CAA or alternatively, removal of the landfill waste itself as well as contaminated soils below the landfill waste that would continue to contribute to groundwater contamination following removal of only the landfill waste.

Additionally, sediment in the nearby agricultural drainage ditches has become recontaminated since the 1993 remedy was installed. While the landfill area alternatives would eliminate future recontamination of the ditches, contaminated sediment that is presently in the ditches will need to be remedied.

Alternative 1 - Slurry Wall without Hydraulic Control and Alternative 1a - Slurry Wall with Hydraulic Control

Alternative 1 is a passive (no leachate pumping) slurry wall with an upgradient interceptor trench. Alternative 1a incorporates technical enhancements that augment the effectiveness of the passive slurry wall by including:

- Pumping of groundwater/leachate within the slurry wall to maintain hydraulic control.
- Extraction and treatment of the water removed from within the slurry wall.
- Construction of a permanent facility to treat groundwater.
- Pump and treat of groundwater from contaminated well locations D-8, D-9 and MW-23; located outside the slurry wall.

The reduction in the water level inside the slurry wall will create a hydraulic head that will develop an inward gradient for water outside the wall, and increase the ability of the wall to prevent the horizontal flow of contaminated groundwater. The additional upward flow of 'clean' groundwater from the Lower Aquifer to the Upper Aquifer within the slurry wall may also increase the ability of the wall to contain contaminants in the Upper Aquifer. The rate of upward flow from the Lower Aquifer will be monitored.

The drawdown of leachate within the slurry wall will proceed in an incremental manner to first identify the groundwater level that ensures a small upward gradient from the Lower Aquifer to the Upper Aquifer.

Alternative 2 – Slurry Wall and Landfill Waste Dewatering

Alternative 2 adds one additional treatment element to the remedy proposed by Alternative 1a—the pumping of additional leachate from within the slurry wall to lower the water level to a level below the landfill waste that increases the upflow of groundwater from the Lower Aquifer to the Upper Aquifer.

Alternative 2 would initially remove leachate to lower the water level within the slurry wall (approximately 11 feet MSL when the slurry wall is initially installed) to a level that increases the upflow of groundwater from the Lower Aquifer to the Upper Aquifer with the goal of lowering the groundwater to a level that is lower than the base of the wood waste, slag, and other debris (approximately 6 feet MSL). Continued extraction of leachate would be required permanently to prevent the leachate levels from rising up into the waste materials following cessation of pumping.

This approach provides a level of protection beyond that provided by Baseline Alternatives 1 and by Alternative 1a. Alternative 2 removes and treats additional arsenic by extracting more groundwater that may accumulate within the slurry wall than Baseline Alternative 1 or Alternative 1a. By keeping the waste de-watered, Alternative 2 should result in cleanup over time of the aquifer within the slurry wall, such that the degree of treatment needed may eventually be reduced or eliminated. An added benefit of reducing the arsenic concentration inside the slurry wall would be to reduce any damage which might be done by future short term leaks through the containment wall.

As in Alternative 1 and Alternative 1a, Alternative 2 includes an interceptor drain upgradient of the slurry wall. This drain would redirect water coming off the bluff from the upgradient edge of the slurry wall and prevent it from flowing under the landfill. The location of the trench is shown in Figure 16. This water will be diverted to the agricultural drainage ditch system at the southern boundary of the Landfill.

It may not be possible to reduce the level of groundwater within the slurry wall to a level that is below the level of the waste in the landfill without potentially damaging the containment system (i.e., slurry wall and aquitard). Monitoring of groundwater, both inside and outside of the slurry wall, will be used to ensure that this will not occur. Similar to Alternative 1a, this alternative also removes arsenic as the water pumped is extracted and treated each day.

Alternative 3 – Alternative 3(a and b) — Excavation and Disposal of Contaminated Soils within the Landfill

Alternative 3a installs a sheet pile wall to a depth of approximately 15 feet below grade or until a connection to the aquitard is achieved, and installs an upgradient interceptor trench. The sheet pile wall will connect with the aquitard layer, and the existing Landfill cover will be removed. Wood waste and other materials in the Landfill will be removed from the top downward. It is expected that the Landfill mass will not require dewatering until the excavation reaches an elevation of about 13 feet MSL, a level that is 2 feet above the expected level of leachate in the Landfill area (11 feet MSL when the sheet pile wall is initially installed). Wood waste and other materials removed from below an elevation of about 13 feet MSL will require dewatering prior to disposal.

The volume of original Landfill waste is estimated to total approximately 350,000 cubic yards (Floyd/Snider 2007a). This estimate assumes that the bottom of the Landfill lies at an elevation of 8 feet MSL. As discussed in Section 2.3, the top 2 to 3 feet of soil that were originally on site were mixed into the Landfill waste as it was emplaced. Alternative 3a excavates soil within the slurry wall to a depth of 6 feet MSL. The total volume of soil that would be excavated by Alternative 3a is estimated to be approximately 400,000 cubic yards or a mass of approximately 480,000 tons (assuming a bulk density of 1.2 tons/cy).

Alternative 3b removes both the capped waste as well as contaminated sub-soils existing beneath the waste and down to the aquitard layer. This Alternative will excavate soil to a depth of 4 feet MSL (approximate top of the aquitard). This will require that the sheet pile wall be driven down to about 30 feet below grade. Alternative 3b, also includes the upgradient interceptor trench. Approximately 620,000 cubic yards of waste and soil (or approximately 745,000 tons assuming a bulk density of 1.2 tons/cy) would be excavated as part of Alternative 3b. The sheet pile wall will be removed (optional) once the excavation for Alternative 3b has been backfilled.

Water removed from the Landfill mass is likely to contain arsenic at concentrations that exceed CULs. This water will be treated by the groundwater treatment system proposed in Alternative 1a and 2. For Alternative 3a, it is expected that approximately 5 million gallons of water will result from the dewatering process. This water will be treated at a rate of 15 gpm for a period of approximately 230 days.

For Alternative 3b, it is expected that approximately 18 million gallons of water will be produced during the dewatering process. This water will be treated at a rate of 40 gpm for a period of approximately 320 days over two construction seasons. The sheet pile wall can be removed once the excavation for Alternative 3b has been backfilled. Therefore, groundwater extraction and treatment from within the sheet pile wall under Alternative 3b will be focused on dewatering the landfill mass, rather than on creating an inward hydraulic gradient across the sheet pile wall.

Wood waste and other materials removed from the Landfill will be stockpiled on Site, prior to transport and disposal at the appropriate Landfill. The soils excavated will likely consist of some soils that will require disposal in a RCRA Subtitle C (hazardous) landfill and other soils that can be disposed of at a RCRA Subtitle D disposal facility. For the purposes of this evaluation, it was assumed that 75 percent of the excavated soils could be disposed of at a Subtitle D facility, while 25 percent would require disposal at a RCRA Subtitle C facility.

The segregation of Subtitle C from Subtitle D soils will be difficult; and may not be practicable. Pilot-scale tests will be needed to address this issue. These tests will be conducted during the engineering design phase of the project.

The existing Landfill cover is made up of five layers and consists of a Geosynthetic Clay Liner, a 40 mil polyvinyl chloride (PVC) liner, a Geocomposite drainage net, 19 inches of sandy pit run, and 6 inches of topsoil (Hydrometrics 1994).

Since soils below the existing grade at the Site will be excavated, it will be necessary to import fill material. This fill material will be needed to create a surface contour that will effectively drain rainwater from the new cap for Alternative 3a. Approximately 300,000 cubic yards of imported fill will be required to bring the grade within the sheet pile wall from 6 feet MSL to 11 feet MSL for Alternative 3a and approximately 845,000 cubic yards of imported fill will be required to bring the grade within the sheet pile wall from –4 feet MSL to 11 feet MSL for Alternative 3b.

5.3 Comparative Analysis of Landfill Remedial Alternatives

Containment vs. Excavation and Disposal Alternatives

The 1993 Remedy was effective in eliminating the potential for direct contact to the Landfill waste and ditch sediment, and in eliminating leachate production via stormwater, and thus reducing certain risks to human health and the environment. Despite this, a number of potential exposure routes remain, all of which stem from contaminated groundwater. While leaching associated with stormwater infiltration is controlled by the consolidation and capping, leachate is still produced when groundwater flowing beneath the Landfill saturates landfill waste, which has no liner beneath it. Arsenic in this leachate travels away from the Landfill via groundwater. Contaminated groundwater has the potential to contaminate other media that may provide additional transport or exposure pathways. Groundwater discharge to the perimeter ditches or in the wetlands area has re-contaminated ditch sediments and seasonally may impact wetlands surface water quality.

The focus of remedial activities at the B&L Site is protecting potential human and ecological receptors from exposure to arsenic. The primary exposure routes are as follows:

- Wetlands biota and human trespasser exposure to contaminated surface water and/or shallow groundwater in the Wetlands CAA.
- Biota and human trespasser exposure to contaminated surface water and/or ditch sediments in the perimeter ditches.
- Potential exposure at Hylebos Creek due to discharge of contaminated groundwater into the Creek.

The decision of whether to use containment or "dig and haul" must be based on an assessment of the reduction in risk that the alternative provides to these receptors. Since each of the alternatives (1, 1a, 2, 3a, and 3b) evaluated remediate the ditch sediments in the same way, only the environmental benefits provided to the potential receptors in the

Wetlands CAA by each alternative was assessed as part of this disproportional cost analysis.

Leaching of arsenic from the landfill waste by groundwater flowing below the Landfill toward the Wetlands is the source of the arsenic that is present in Wetlands surface water, groundwater, and soils. Thus cleanup of this groundwater is the driver for this evaluation. The ability of containment alternatives (1, 1a, and 2), and excavation and disposal alternatives (3a and 3b) to effect the cleanup of groundwater in the Wetlands CAA is a key factor in the disproportional cost analysis used to select a remediation approach at the B&L Site.

Alternatives 3a and 3b treat the groundwater in the Wetlands and End of Plume CAAs in the same way and for the same duration as the groundwater treated by Alternatives 1a and 2. This occurs since it is expected that 'arsenic rebound' will occur once an initial volume (about 20 million gallons) of groundwater and surface water in the Wetlands is treated (refer to Section 3.2). Ecology expects that up to approximately 120 millions gallons of groundwater and surface water in the Wetlands CAA may require treatment, and that the End of Plume treatment system may have to operate for up to 30 years to achieve CULs, regardless of whether an excavation and disposal or an effective containment alternative is selected for the Site.

Alternative 3a also excavates and disposes of approximately 400,000 cubic yards of landfill waste. Alternative 3b excavates and disposes of all of the landfill waste, plus contaminated sub-soils that are present above the aquitard (approximately 620,000 cubic yards). Both of these alternatives provide a higher degree of protection to the environment as a whole than do any of the containment alternatives that were evaluated.

However, the cleanup of groundwater in the Wetlands does not benefit by Alternatives 3a or 3b if 1) it is possible to construct a competent slurry wall or sheet pile containment around the Landfill waste to stop horizontal groundwater flow, 2) there is a competent aquitard below the Upper Aquifer at the Site, and 3) the successful operation and maintenance of the barrier and water treatment systems can be maintained over the long term. Ecology's analysis of existing data suggests that these three items are more likely than not to be valid (refer to Section 3). Thus each alternative was presumed capable of stopping the flow of contaminated groundwater from below the Landfill to the Wetlands CAA.

Alternatives 3a and 3b provide more protection to the "environment as a whole" than the containment alternatives since these excavation alternatives directly remove arsenic and other COCs from the landfill.

Alternatives 3a and 3b would provide much higher short-term risks to human health and the environment than would the containment remedies. Developing detailed work plans and health and safety plans could mitigate these risks.

Both the containment remedies and Alternatives 3a and 3b could potentially comply with cleanup standards and likely exhibit equivalent technical and administrative implementability. Both the containment remedies and Alternatives 3a and 3b are expected to take up to 30 years to bring the Wetlands and End of Plume CAAs into compliance with CULs. The containment alternatives and Alternative 3a are expected to operate for 50 years or longer since these alternatives remove groundwater from within the barrier. This groundwater must be treated for as long as it is produced. Groundwater treatment for Alternative 3b is expected to operate for a shorter time period (up to 30 years) since pumping within a barrier is not required under this excavation option.

This conceptual-level (±25 percent) cost estimate prepared for each alternative uses an interest rate of 2 percent and a duration of 50 years to compute the net present value of most recurring annual costs. The present worth factor associated with this interest rate and duration is 31.424. If the duration was increased to 100 years, the present worth factor would become 43.098.

The estimated cost (±25 percent) of each alternative was developed in Sections 5.1 through 5.4 and is summarized below:

Alternative	Costs for Years 1 & 2	Costs for Years 3 to 5	Total
1	$3.6 million	$3.7 million	$7.3 million
1a	$6 million	$12 million	$18 million
2	$7 million	$13 million	$20 million
3a	$73 million	$13 million	$86 million
3b	$114 million	$8 million	$122 million

Since each alternative is considered to be equally capable of stopping the flow of contaminated groundwater from below the Landfill to the

Wetlands CAA and able to treat groundwater in the Wetlands and End of Plume CAAs, each alternative should provide a generally equivalent degree of protection to the receptors of interest in the Wetlands CAA. Because the cost of Alternatives 3a and 3b ($86 to $122 million) are substantially greater than equally protective containment Alternatives 1, 1a, and 2 ($7 to $20 million), the cost of excavation is judged to be disproportional to the benefits provided to the treatment of Site groundwater alone. **Thus the excavation and treatment alternatives were not selected for implementation at the B&L Site.**

Selecting Among the Containment Alternatives

The three containment alternatives were described above and include:

- Baseline Alternative 1—Containment with Groundwater Controls (Sections 5.1 through 5.3);
- Alternative 1a— Alternative 1 with Additional Protections Added (Section 5.4.1); and
- Alternative 2— Reduce Water Level within Containment Wall to Below Level of Waste (Section 5.4.2).

Alternative 1a was developed to address technical uncertainties that were inherent in Alternative 1, and includes additional protections to safeguard human health and the environment by increasing the likelihood that a containment remedy would protect receptors in the Wetlands and End of Plume CAAs. These additional enhancements would only be implemented if needed to meet the performance criteria as discussed in Section 6; they include:

- Installation of an internal drain within the slurry wall to create an inward groundwater flow gradient across the barrier;
- Extraction and treatment of up to 1,000 gallons/day of water removed from within the slurry wall;
- Ten additional treatment passes (about 100 million gallons) for the water within the Wetlands (assumed needed to meet a “process” performance specification);
- 25 additional years of operation of the End of Plume *in situ* treatment system (assumed needed to meet a “performance” specification);
- Extraction and treatment of groundwater from locations D-8, D-9 and MW-23; and

- Establishment of a trust fund or similar financial mechanism to support the long-term operation and monitoring of the facilities at the Site.

Alternative 2 adds one additional treatment element to the remedy proposed by Alternative 1a; the collection and treatment of additional leachate within the barrier that results from the drawdown of the level of groundwater within the barrier to a level that ensures a controlled upflow of groundwater from the Lower Aquifer to the Upper Aquifer, and potentially to a level (approximately 6 feet MSL) expected to be below the level of the waste in the landfill. The flow of groundwater from the Lower Aquifer to the Upper Aquifer has the potential to increase the protectiveness of this remedy to human health and the environment compared to Alternative 1a.

Alternatives 1a and 2 may have to operate for a long period of time. The development of a trust fund or other financial assurance would be required that can fund annual expenses such as long-term monitoring, groundwater pumping and treatment of water removed from inside the containment wall (Alternatives 1a, 2, and 3a), the potential long-term operation of the Wetlands and End of Plume treatment systems, and the long-term maintenance or replacement of the Landfill cap and slurry wall (except for Alternative 3b in which case the cap will not be necessary).

Aquitard Continuity, Vertical Gradients, and Lower Sand Aquifer Quality

As described in Appendix A, the preponderance of boring log evidence suggests that an aquitard is present beneath the Landfill footprint and below the Upper Aquifer in the Wetlands CAA. In addition, the absence of elevated arsenic or other leachate indicators in Lower Sand Aquifer groundwater, summarized in Section 3, provides additional evidence for the continuity of the aquitard and/or a lack of downward plume migration in areas where the aquitard may not be continuous.

As indicated in Section 3, upward groundwater gradients from the Lower Aquifer to the Upper Aquifer were present in the Wetlands CAA, while flatter gradients were measured in the Landfill CAA. Thus the weight of the available evidence indicates that it is more probable than not that: 1) an aquitard separates the Upper Aquifer from the Lower Aquifer in the Landfill and Wetlands CAAs, and 2) a properly installed slurry wall would prevent the horizontal flow of groundwater in the Upper Aquifer from transporting arsenic downgradient to the Wetlands CAA.

Permanence

Alternative 1a and 2 remove more arsenic from groundwater (in the Wetlands and End of Plume CAAs and from within the slurry wall or sheet pile wall), and provide additional safeguards that will assure that CULs will be met in the Wetlands CAA and at the conditional point of compliance along 12th Avenue East, than Alternative 1. Thus Alternatives 1a and 2 are considered to be more permanent remedies than Alternative 1.

Alternative 2 has the potential to be more protective than Alternative 1a since the additional drawdown of groundwater within the slurry wall is expected to increase upflow of "clean" water from the Lower Aquifer to the Upper Aquifer within the Landfill footprint. This upflow would produce another driving force to contain contaminated groundwater within the footprint of the Landfill.

Thus Alternative 2 provides more protection to the environment as a whole than Alternative 1a.

Effectiveness over the Long Term

Alternatives 1a and 2 are expected to be more effective over the long term than Alternative 1 since these alternatives use process specifications to guide the treatment of groundwater in the Wetlands and End of Plume CAAs and propose to treat this groundwater for a much longer time period than Alternative 1.

Alternatives 1a and 2 extract groundwater from within the slurry wall or sheet pile wall to maintain an inward hydraulic flow gradient across the barrier wall and, in the case of Alternative 2, reduce the groundwater elevation to a level that induces an upflow of groundwater from the Lower Aquifer to the Upper Aquifer, and potentially to a level that is below the base of the most contaminated waste in the Landfill. The extracted groundwater will have to be treated for the life of the remedy (50 years or more). Thus Alternatives 1a and 2 are more likely to encounter long-term operational problems than Alternative 1.

The slurry wall technology used by each containment remedy is well developed and has been successfully demonstrated at other locations.

The most significant technology risk at the Site is the ability of the groundwater treatment systems proposed for the Wetlands and End of Plume CAAs to achieve CULs for arsenic in a reasonable restoration time frame. Bench- and pilot-scale tests would reduce the uncertainty associated with this concern. This risk is associated with each containment alternative.

Management of Short-Term Risks

Short-term risks to human health and the environment would occur if any of the containment alternatives were implemented. These short-term risks will be present during installation and operation of the Wetlands and End of Plume CAAs groundwater treatment systems and the installation of a slurry wall.

Detailed work plans would be developed to identify potential implementation issues and identify procedures that would be used to resolve these installation and operational concerns. Health and Safety Plans would be prepared to address risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a worker monitoring program will provide additional protection to site workers and the public who may visit the Site.

Alternative 1 provides the least short-term risk since it employs the fewest number of technologies during its implementation. Alternatives 1a and 2 add the additional long-term risk associated with extracting and treating groundwater from within the slurry wall.

Technical and Administrative Implementability

Slurry wall and sheet pile technologies are well developed and have been successfully demonstrated at other locations to stop the horizontal flow of groundwater. Routine monitoring is expected to identify whether leaks occur or are likely to occur. These leaks can be stopped by conventional sealing techniques.

The most significant technology risk at the Site is the ability of the groundwater treatment systems proposed for the Wetlands and End of Plume CAAs to achieve arsenic CULs in a reasonable restoration time frame. Bench- and pilot-scale tests will be required to reduce the uncertainty associated with this risk.

Another significant technical risk is the ability of the aquitard below the landfill to isolate contamination in the Upper Aquifer from the Lower Aquifer. The weight of the available data (refer to Appendix A) indicates that this aquitard is present below the Landfill. The slurry wall or sheet piles installed will be driven down until they reach this aquitard. The inward hydraulic gradients across the slurry wall established by Alternatives 1a and 2 will be monitored.

Alternative 2 reduces the level of groundwater within the slurry wall to a level that will encourage the upflow of "clean" groundwater from the Lower Aquifer to the Upper Aquifer. This upflow would increase the ability of the aquitard to prevent contaminated groundwater in the Upper Aquifer from migrating into the Lower Aquifer. However, current information does not allow the calculation of the maximum upflow rate that could be achieved without creating a 'hole' in the aquitard between the Lower Aquifer and the Upper Aquifer.

The additional capability to remove and treat groundwater from within the slurry wall provides Alternative 2 with additional operational flexibility (compared to Alternative 1a) as the alternative is implemented and operated over time.

Restoration Time Frame

The containment remedy is expected to be effective in halting releases of arsenic from the landfill immediately upon installation. This is true for Alternatives 1, 1a, and 2. The End-of-Plume remedy, a common element in all three alternatives, is designed to bring groundwater concentrations at 12th Street East into compliance as soon as possible, likely within a few treatment cycles. Compliance in the Wetlands CAA is expected to take longer than in the other two areas, but the remedy is expected to result in concentrations that are protective of human health and the environment is a reasonable time frame. Bench-scale studies and actual operations and monitoring data will allow for a better estimate of when the Wetlands CAA will come into compliance. This data will be available for future MTCA reviews.

Current and future land use in the three Cleanup Action Areas are compatible with the proposed remedy. Institutional controls within the Wetland CAA are expected to be implemented throughout the restoration time frame, effectively reducing risks posed by contaminants in this area.

Alternatives 1a and 2 pump and treat an additional 100 million gallons of water in the Wetlands CAA (by pumping for more years) as compared to Alternative 1. This additional removal is expected to result in compliance in the Wetlands CAA is a shorter timeframe.

Conceptual-Level Cost

Conceptual-level (±25 percent) cost estimates and supporting assumptions for Alternatives 1, 1a, and 2 are summarized above.

The estimate of the cost of Alternative 1 (approximately $7 million) is summarized in Table 8. The cost of the compliance monitoring program included in Baseline Alternative 1 is also a part of Alternatives 1a and 2. The cost of additional performance monitoring recommended for each alternative was also included in these cost estimates.

Alternatives 1a and 2 treat an additional 100 million gallons of water in the Wetlands CAA, and operate the End of Plume treatment process for 25 years more than Alternative 1 and extract groundwater from within the slurry wall. The cost (±25 percent) of this additional capability has a net present value (I = 2 percent, n= 50 years) of about $11 to $13 million. The actual length of time that treatment would be needed and the cost of that treatment cannot be known with certainty until appropriate site-specific bench- and pilot-scale tests have been conducted at the Site.

Alternative 2 appears to be more protective than Alternative 1a since Alternative 2 provides additional capability to drawdown groundwater within the slurry wall to a level that is expected to increase the upflow of “clean” water from the Lower Aquifer to the Upper Aquifer within the Landfill footprint. This upflow produces another driving force to contain contaminated groundwater within the footprint of the Landfill. However, current information does not allow the calculation of a maximum upflow rate that could be achieved without creating a ’hole’ in the aquitard between the Lower Aquifer and the Upper Aquifer. Alternative 2 also provides additional groundwater extraction and treatment capacity than Alternative 1a.

The additional protectiveness provided by Alternative 2 compared to Alternative 1a comes at the cost of about $3 million. This additional cost results from the need to remove and treat a greater volume of groundwater drained from inside the slurry wall, since the upflow from the Lower Aquifer to the Upper Aquifer is expected to be higher for

Alternative 2 (refer to Appendix A). This greater volume of groundwater would have to be treated for an extended period of time.

Ecology cannot assume at this time that the redirection of clean groundwater alone will result in sufficient decrease in hydraulic head to maintain upward gradients to protect deeper groundwater; therefore, Ecology has added to the slurry wall alternative in the GAE Report the requirement of active pumping to maintain inward hydraulic gradients within the slurry wall. Two options have been considered as follows:

Hydraulic control (Alternatives 1a and 2). The first option assumes that a groundwater extraction system is installed within the landfill area that will decrease the water levels inside the slurry wall to levels that are lower than levels outside the wall. This will cause groundwater outside the slurry wall and below the aquitards to flow inward preventing contaminated leachate from leaking out. This situation is more protective than a slurry wall without leachate/groundwater pumping.

Ecology expects that the landfill waste (slag, bark, and soil) could be dewatered and remain dewatered. This would require approximately 6 feet of drawdown within the slurry wall. Since a high volume of water will need to be removed initially to achieve this drawdown, and also due to the fact that the waste sits on the organic-rich silts of the original land surface, this level of drawdown will take time to be established and result in relatively high volumes of water to be pumped and treated, compared with Alternative 1a. Nevertheless, Ecology assumes that if waste can be dewatered, this would better protect the underlying groundwater as it would over time become cleaner as more clean groundwater from outside the slurry wall is works it way into the system. If this system functions as planned, eventually the water pumped from within the slurry wall would be clean enough to discharge with little or no treatment.

Based on the above analysis Ecology has selected Alternative 2 as the proposed Remedial Alternative for the site.

Consideration of Public Concerns

Ecology has worked extensively with the community, and continues to do so, with the objective of identifying and addressing public concerns. The communities of Milton, Fife and Tacoma, along with Pierce County and local Tribes of Indians and several environmental groups are concerned about delaying the cleanup process, and would like the cleanup to proceed as soon as possible. In addition, they are concerned about disruption caused by cleanup, and would like Ecology to minimize the short-term disruption remediation construction will cause. Ecology will continue to consider public concerns during the cleanup process. The Draft Cleanup Action Plan will be available to the public for review and comment for 30 days. In addition, a public meeting will be held to discuss with stakeholders and citizens the selection of the cleanup remedy.

6.0 PROPOSED CLEANUP ACTION – ALTERNATIVE 2

The cleanup action selected by Ecology is summarized in the following sections and is based heavily on Alternative 2 from Section 5:

- Landfill/Ditch CAA – Section 6.1;
- Wetlands CAA – Section 6.2;
- End of Plume CAA – Section 6.3;
- Satisfying the MTCA Criteria- Section 6.4
- Funding and Planning for Future Contingencies - Section 6.5; and
- Long Term Operations, Maintenance and Monitoring- Section 6.6
- Additional Requirements- Section 6.7

6.1 Landfill/Ditch CAA

The proposed cleanup action for the Landfill/Ditch CAA includes the following elements:

- A **slurry wall** around the entire perimeter of the landfill, tied into the existing landfill cap above and the Silt Aquitard below. The Landfill cap, slurry wall, and silt aquitard will work together to form a robust containment system for landfill materials, leachate, and contaminated groundwater beneath the Landfill. The containment system is supported by the upward gradients between the Upper and Lower Sand Aquifers.
- An **interceptor trench** between the landfill and the bluff along Fife Way to redirect clean groundwater and surface water that historically would have entered the Landfill. The goal will be to lower the water

level in the Upper Sand Aquifer immediately upgradient of the landfill by several feet to prevent build-up of groundwater pressure and to help prevent seasonal flooding of the area by surface water runoff.

- **Hydraulic control** will be maintained within the slurry wall containment system to ensure that any groundwater leakage is clean groundwater leaking inward and not contaminated groundwater leaking outward. Hydraulic control will be maintained using groundwater extraction, treatment of the extracted groundwater, and discharge.

- The groundwater extraction system within the slurry wall will be designed to **dewater the saturated landfill waste** if this is practicable. The specific amount of groundwater that will be removed will be determined once the slurry wall is constructed. At a minimum, enough groundwater must be removed to create an inward hydraulic gradient; sufficient groundwater to dewater the refuse will be withdrawn if proven practicable If effective in dewatering the landfill waste and in "flushing" contamination from beneath the site, this component has the potential to allow for eventual downscaling or decommissioning of the treatment system.

- The groundwater extraction system will be designed to include the installation of a system of additional wells outside of the slurry wall to **remove the groundwater "halo."** This halo exists as an area of localized contamination near wells MW-23/D-10, D-8, and D-9.

- Following installation of the slurry wall, **excavation of contaminated sediments in the agricultural ditches adjacent to the Landfill** will be performed. Eventually, the ditches may be buried and/or rerouted when the agricultural fields are redeveloped by the owner (currently the City of Fife). The removal of contaminated sediments will be performed as part of the B&L Landfill remedy; the eventual modification/removal of agricultural ditches will be performed by the developer as part of the redevelopment of the surrounding lands and is not part of the proposed landfill remedy.

- Installation of additional **compliance monitoring** wells and probes (As needed to bolster the existing well systems), inside and outside of the landfill, in the Wetlands and in End of Plume areas, to monitor the effectiveness of the remedy, and the progress of the cleanup.

With the addition of the slurry wall and associated elements to the existing 1993 landfill remedy, the Landfill/Ditch CAA will meet the following RAOs identified in Section 4.3:

- Meet MTCA threshold requirements, and WAC 173-340-740(6)(f) requirements for containment remedies and implement the closure requirements under Minimum Functional Standards for Solid Waste Landfills (Chapter 173-304 WAC).
- Prevent arsenic-contaminated groundwater from migrating beyond the Landfill perimeter into adjacent wetlands and agricultural drainage ditches.
- Meet MTCA minimum requirements.
- Protect the sediment and surface water quality of Hylebos Creek and associated restoration projects from future arsenic releases from B&L Landfill.

Landfill CAA Performance Based Criteria

Hydraulic control within the slurry wall must be maintained as a performance standard for the slurry wall. Pumping rates may have to be adjusted throughout the year as the natural gradients undergo seasonal change. Waste dewatering, assuming it proves it to be practicable, is Ecology's preferred alternative as it halts the production of new leachate, and should over time reduce the concentration in the groundwater within the slurry wall to levels that would require little or no treatment. This in turn could allow for the treatment system to be downscaled or turned off. The extraction system (removing clean groundwater) would continue to operate to maintain the water level below the waste.

In order to assess the practicability of waste dewatering it will be necessary to perform a series of extraction and treatment tests (to be established during the Remedial Design phase) after the slurry wall and interceptor trench have been installed; as well as during long term monitoring of system operation. In order for the technology to be considered practicable, each of the following will need to be evaluated as part of the design process, and again during system operation, when the system is built:

- Depth of Drawdown – it must be physically possible to obtain sufficient drawdown of the water level to fully dewater the waste.

That is, if the waste can not be dewatered with practicable pumping rates, then the remedy will not be considered to be practicable.

- Ability to Downscale or Shut Down the Treatment System – the two key goals of the waste dewatering are (1) to stop the production of leachate and (2) to flush out the contaminated groundwater beneath the Landfill. The first goal would be accomplished by drawing the water level to beneath the landfill waste and maintaining it at that level over time. This would stop the production of new leachate. The second goal would be to "flush" the existing contamination in the aquifer beneath the landfill (and contained within the slurry wall) out by removing contaminated groundwater and causing new clean groundwater to leak into the containment. Since arsenic would continue for some time to dissolve from the aquifer soils, and since this "flushing" would likely be a slow process, the likelihood of achieving this goal is unknown at this time. If successful, this system would result in the extracted groundwater being clean enough for direct discharge with little or no treatment allowing for the treatment facility to be either modified into a less rigorous and less costly type of treatment, or to allow the treatment system to be shut down completely. If studies, based on system performance over time, indicate that either or both of these goals are unlikely to be achieved, then Ecology may determine that the waste dewatering component of the remedy is not practicable.

- Overall Remedy Protectiveness – the pumping rate that is sufficient to dewater the waste must not cause adverse effects on the integrity of the slurry wall or the aquitard. For example, if continued pumping to maintain the water level results in a decrease of the containment integrity, the dewatering system would be modified or stopped to protect the overall containment integrity.

- Protection of Wetlands – the drawdown sufficient to dewater the waste must not cause a loss of water to the watershed that would adversely affect the adjacent wetlands and restoration projects.

6.2 Wetlands CAA

Once the slurry wall containment has been implemented surrounding the Landfill, no further releases from the Landfill are expected to enter the Wetlands CAA. However, the Wetlands CAA already contains groundwater that has arsenic concentrations up to 1,000 times background. This groundwater contamination will need to be remediated in order to bring the Site into compliance with MTCA and landfill closure requirements.

The proposed cleanup action for the Wetlands CAA contains the following elements:

- Pumping of groundwater from the Upper Sand Aquifer beneath the wetlands in the core of the plume.
- Treatment of the pumped groundwater to remove arsenic and iron.
- Re-infiltration of treated groundwater into existing stormwater ponds or back into the wetlands.

The intent of the cleanup alternative in he Wetlands CAA is to install a number of pumping wells to intensely manage the residual mass of dissolved arsenic and remove it from the system as quickly as possible. The extracted groundwater will be piped to the treatment system used to treat groundwater extracted from within the slurry wall.

The preferred remedy for the Wetlands CAA relies on the following observations based on existing data:

- Soil concentrations in the Wetlands CAA are already in compliance with the soil cleanup level, that is, groundwater and ponded surface water are the only media of concern in this area.
- Groundwater in the Wetlands CAA exists in a relatively homogeneous and transmissive aquifer with a demonstrated capacity for sustained groundwater pumping.
- Arsenic is present in groundwater as a dissolved phase that will migrate readily to nearby pumping wells.
- Historical data shows that 95 percent of the arsenic is already attenuating in the wetlands as groundwater migrates from the landfill to 12th Street East; therefore, the area that needs remedial action is limited and well defined

The preferred remedy for the Wetlands CAA also relies on the following assumptions:

- .Future releases from the Landfill will be eliminated by the slurry wall remedy for the Landfill CAA, and the Wetlands CAA remedy will not be installed until after the slurry wall is completed.
- Restoration areas along Hylebos Creek are being developed and will potentially move Hylebos Creek closer to the Landfill. For this reason, risk of migration of arsenic from Landfill releases beyond 12th Street East is unacceptable.

The pump and treat remedy would meet the RAOs for the Wetlands CAA by:

- Lowering groundwater arsenic concentrations to levels that comply with site cleanup standards, and are protective of human health and the environment within the wetlands;
- Decreasing the mobility and volume of arsenic in the wetlands plume through treatment; and
- Increasing the overall permanence and effectiveness and decreasing the restoration time frame of the overall remedy by removing as much residual mass of dissolved arsenic from the wetlands as is practical.

It is considered likely that the Wetlands CAA remedy would meet the groundwater CUL within the Wetlands CAA only after many years, but the remedy would support the End of Plume remedy in meeting the CUL at the 12th Street East End of Plume CAA by removing arsenic and limiting further migration to toward Hylebos Creek.

The land between the Landfill and the 12th Street East End of Plume CAA is currently owned by a single party, whose permission will be needed to proceed with this element of the cleanup.

Wetland CAA Performance-based Criteria

The goal for cleanup of the Wetlands CAA is to meet the groundwater CUL of 5 μg/L. Pump and treat, however, may result in long term rebound concentrations in the Upper Sand Aquifer that are greater than CULs. If the pump and treat Wetlands CAA remedy is proven to be unable to achieve CULs in that area, then Ecology and the PLPs may consider development of an alternative treatment technology for the Wetland CAA. Additional details on performance-based monitoring will be provided in the Long Term Operations, Maintenance and Monitoring Plan.

6.3 End of Plume CAA

The proposed cleanup action for the Wetlands CAA contains the following element:

- Enhancement of the natural attenuation that is already occurring by adding specific sequestration agents that will act more quickly and irreversibly to precipitate the dissolved arsenic. This will be accomplished along the 12th Street East right of way.

The 12^{th} Street right-of-way was selected as the location for implementation of the End of Plume CAA for the following reasons:

- The 12th Street East right of way is an unused roadway that cuts through the wetlands and allows for easy access to the wetlands without further disruption to the wetlands.
- The land between the Landfill and 12th Street East is owned by a single party, which will simplify getting access agreements and institutional controls, although it may still be difficult to do so.
- The residual contamination at 12th Street East exists as a thin seam of moderately elevated arsenic at the base of the aquifer in a well-defined and accessible sand zone.
- Land beyond 12th Street East is planned for habitat restoration, including the potential relocation of Hylebos Creek, making the control of arsenic at 12th Street East critical.

A series of injection wells or a single trench will be used to inject the sequestering solution into the base of the aquifer where natural conditions are already reducing and favorable. On the downgradient (North) side of 12th Street East, compliance monitoring wells will be installed to monitor the success of the remedy and confirm compliance with site arsenic cleanup standards.

Bench- and pilot-scale treatability tests will be needed to determine the means of treatment and length of time that this remedy will have to operate to achieve the CULs for arsenic at the point of compliance.

This remedy meets the RAOs for this area by:

- Reducing the mobility and volume of arsenic in groundwater by sequestering it onto the soil matrix at the base of the aquifer;
- Protecting human health and the environment, including potential future receptors at Hylebos Creek; and
- Attaining CULs and meeting ARARs at 12th Street East.

End of Plume Performance-based Criteria

Performance-based criteria will be used to assess compliance and determine the frequency and duration of the in situ treatment applications that will accompany monitoring. Performance-based criteria will be attainment of the groundwater arsenic cleanup level of 5 μg/L in monitoring wells downgradient of 12^{th} Street E.

Additional details on performance-based monitoring will be provided in the Long Term Operations, Maintenance and Monitoring Plan.

6.4 Satisfying the MTCA Selection Criteria

6.4.1 Compliance with Threshold Criteria

The selected cleanup action alternative must be able to meet the threshold criteria established by MTCA. These threshold criteria are:

- Protect Human Health and the Environment;
- Comply with Cleanup Standards (WAC 173-340-700 through 173-340-760);
- Comply with Applicable State and Federal Laws (WAC 173-340-710); and
- Provide for Compliance Monitoring (WAC 173-340-410 and 173-340-720 through 173-340-760).Provide for a Reasonable Restoration Timeframe (WAC 173-340-360(4)
- Provide for a Reasonable Restoration Timeframe (WAC 173-340-360(4)

Overall Protection of Human Health and the Environment

The cleanup of groundwater at the B&L Site by implementation of a containment remedy with off-site groundwater extraction and in-situ treatment of historical releases will be protective of human health and the environment by stopping the release of arsenic from the landfill and by bringing the adjacent wetlands into compliance with cleanup standards in a reasonable restoration timeframe.

Comply with Cleanup Standards

Ecology has established cleanup standards have been established consistent with the MTCA regulations, including consideration of ARARs. These cleanup standards are expected to be meet by this remedial action is a reasonable restoration timeframe.

Comply with Applicable State and Federal Laws

The ARARs applicable to remedial action at this Site were identified in Section 4. Chemical-specific ARARs were considered in the development of cleanup levels. Action- and location-specific ARARs were used during the screening and selection of alternatives in Section 5. ARARs will also be considered during the design, permitting, and implementation of the remedy.

Compliance Monitoring

Long term compliance monitoring is as a component of existing 1993 Remedy, landfill closure requirements, and as part of the currently selected groundwater remedial action. Monitoring requirements are discussed further in the next section.

Reasonable Restoration Timeframe

The individual components of the proposed remedy are expected to provide for a reasonable restoration time frame, considering the potential risks posed by the Site, the practicability of achieving a shorter timeframe, the current and proposed future uses of the Site and surrounding areas, the likely effectiveness of institutional controls, the ability to control and monitor migration of contaminants from the Site, the toxicity of the hazardous substance (arsenic) and the natural attenuation processes that have been observed at the site.

The containment remedy component is expected to be effective in halting releases of arsenic from the landfill immediately upon installation. The End-of-Plume remedy is designed to bring groundwater concentrations atthe 12^{th} Street East End of Plume CAA into compliance as soon as possible, likely within a few treatment cycles. Compliance in the Wetlands CAA is expected to take longer than in the other two areas, but the remedy is expected to result in concentrations that are protective of human health and the environment is a reasonable time frame. Current and future land uses in the three Cleanup Action Areas are compatible with the proposed remedy. Institutional controls within the Wetland CAA are expected to be implemented throughout the restoration time frame, effectively reducing risks posed by contaminants in this area.

6.5 Long Term Operations, Maintenance and Monitoring

6.5.1 Long Term Operations and Compliance Monitoring

Monitoring of the cleanup action will be performed in accordance with the requirements of WAC 173-340-410, and will include protection, performance, and confirmation monitoring. The monitoring requirements for the cleanup action are presented in the following sections. Specific requirements for monitoring the cleanup action will be provided in an Operations, Maintenance, and Monitoring Plan (OM&MP) as part of the Engineering Design Report package.

6.5.2 Protection Monitoring

Protection monitoring, which will include monitoring wetlands soil, groundwater, and surface water quality, will be conducted during the cleanup action to confirm that receptors in the Wetlands CAA and at the End of Plume CAA, and workers at the site are protected during the cleanup action.

6.5.3 Performance Monitoring

Groundwater and surface water monitoring and sampling and analysis will be conducted to assure that the proposed pump and treatment system, which will remove arsenic from groundwater and leachate extracted from within the slurry wall, and from water removed from the Wetlands CAA, will meet appropriate discharge requirements. Performance groundwater and surface water monitoring and sampling and analysis will also be conducted to ensure that the End of Plume treatment system achieves MTCA CULs for arsenic. The frequency, scope, and duration of the monitoring and sampling and analysis will be detailed in the OM&MP.

6.5.4 Confirmation Monitoring

Following completion of the remedial action, confirmation soil, groundwater, ditch sediment and surface water monitoring and sampling and analysis will be performed to evaluate the effectiveness of the cleanup action and to assess when the cleanup levels have been met at the defined points of compliance. The frequency, scope, and duration of the monitoring and sampling and analysis will be detailed in the OM&MP.

6.6 Special Requirements for Containment Remedies

6.6.1 Type, Level, and Amount of Hazardous Substances Remaining on Site

The remedy for the B&L Site contains, rather than removes, the arsenic and other contamination contained in the Landfill. MTCA [WAC 193-340-380 (a)(ix)] requires that "the type, level, and amount of hazardous substances remaining on site and the measures that will be taken to prevent the migration of those substances" be specified.

Information about the concentration of contaminants in the Landfill refuse is summarized in the focused Remedial Investigation prepared by K/J/C and AGI (1990b). This information suggests that the landfill refuse may contain up to approximately 250,000 pounds of arsenic. This arsenic will be contained by the slurry wall, which connects to the aquitard and the existing multi-layer cap. Some amount of arsenic in the refuse will be eliminated over time as groundwater and leachate are extracted from within the slurry wall, and treated, but this amount is not expected to significantly reduce the mass of arsenic currently contained in the landfill.

6.6.2 Institutional Controls

The selected remedial action is a containment remedy and includes institutional controls. The Wetlands and Landfill CAA includes land owned by third parties. Implementation of the remedy will require access to the Landfill as well, the adjacent Wetlands to 12th Street East, the adjacent agricultural drainage ditches, the 12th Street East and Puget Power right of ways, and the small section of the Wetlands beyond 12th Street East (for monitoring well installation and access). The remedy for the Site includes the continued payment for the rights to access this land.

Additionally, the interceptor drain associated with the slurry wall will likely require interactions with the adjoining apartment complex and with the City of Fife.

The parties likely to implement this remedy do not own any of these properties. Therefore, implementation of the remedy may require significant negotiations of both short-term and long-term access agreements. Figure 4 shows current property ownership in the vicinity of the B&L Site.

Institutional controls will include on-site features such as signs and fences to protect the integrity of the landfill cap and remedy, and legal mechanisms, such as lease restrictions, deed restrictions, land use and zoning designations, and building permit requirements. Institutional controls for the wetlands and Landfill may be different. Specific institutional controls will be presented in the Engineering Design Report.

6.6.3 Financial Assurance

The arsenic in the landfill will not “decompose” over time, but will require containment in perpetuity, and the containment remedy will require operations, maintenance, and monitoring in perpetuity. Accordingly, Ecology has decided that a critical component of the remedy is the establishment of a trust fund or equivalent financial mechanism to support the long-term operations, maintenance, and monitoring at the Site associated with both the 1993 remedy and the current groundwater remedy. The financial mechanism must include sufficient funds to cover the following:

- Operations and maintenance of all components of the 1993 remedial action and the current groundwater remedial action.
- Long term compliance monitoring, including reporting and the MTCA 5-year Review Process.
- Replacement costs for all landfill components that have the potential to fail within the first 100 years of the life of the landfill.
- Payment of Ecology project oversight cost billings.

Ecology has estimated that the trust fund or equivalent financial mechanism would likely need to contain between $12 and $15 million dollars.

6.7 Permitting, Design, and planning Requirements

This section discusses additional requirements that apply to the permitting, design, and planning for the remedial action.

6.7.1 Permits/Other Requirements

The Cleanup Action will be conducted under an Ecology Agreed Order, Enforcement Order, or Consent Decree; therefore, the Cleanup Action is exempt from the procedural requirements of certain laws and all local permits [WAC 173-340-710(9)(a)] but must comply with the substantive requirements of these laws and permits. The exemption from procedural requirements applies to the:

- Washington Clean Air Act (RCW 70.94);
- Solid Waste Management Act (RCW 70.95);
- Hazardous Waste Management Act (RCW 70.105);
- Construction Projects in State Waters (RCW 75.20);
- Water Pollution Control Act (RCW 90.48); the Shoreline Management Act (RCW 90.58); and
- Any laws requiring or authorizing local government permits or approvals.

The exemption is not applicable if Ecology determines that the exemption would result in the loss of approval from a federal agency that may be necessary for the state to administer any federal law.

The Cleanup Action for the B&L Site is expected to fully comply with all action-, chemical- and location-specific ARARs as described in Section 4.2. The Cleanup Action also includes all of the elements of landfill closure as specified in Minimum Functional Standards for Solid Waste Landfills (Chapter 173-304 WAC), including the use of a slurry wall to halt migration of leachate and contaminated groundwater from beneath the Landfill.

6.7.2 Engineering Design Report

An Engineering Design Report will include sufficient information for the development and review of construction plans and specifications to document engineering concepts and design criteria used for the design of the cleanup action. The information required under WAC 173-340-400(4)(a)(i) through 173-340-400(4)(a)(xx) will be included in the Engineering Design Report including the specific criteria that govern the design of each of the components listed in Section 6.1.

The Engineering Design Report will also include an OM&MP describing long-term operations, maintenance, and monitoring for the remedy.

The Enforcement Order, Agreed Order or Consent Decree which requires the current remedial action to be implemented, and/or the Engineering Design Report will also include the proposed Deed Restriction for the Landfill property and the Wetlands Properties.

6.7.3 Construction Plans and Specifications

The Construction Plans and Specifications will detail the construction of the cleanup action to be performed. As required by WAC 173-340-400(4)(b), the documents will include the following information, as applicable:

- A description of the work to be performed, and a summary of the engineering design criteria from the Engineering Design Report;
- A site location map and a map of existing conditions;
- A copy of applicable permit applications and approvals;
- Detailed plans, procedures, and specifications necessary for the cleanup action;
- Specific quality control tests to be performed to document the construction, including specifications for testing or reference to specific testing methods, frequency of testing, acceptable results, and other documentation methods; and
- Provisions to ensure that the health and safety requirements of WAC 173-340-810 are met.

All aspects of construction will be performed and documented in accordance with WAC 173-340-400(6). These aspects include approval of all of the plans listed above prior to commencement of work, oversight of construction by a Professional Engineer licensed in the State of Washington, and submittal of a Construction Completion Report that documents all aspects of the cleanup and includes an opinion of the engineer as to whether the cleanup was conducted in substantial compliance with the CAP, the Engineering Design Report, and the Construction Plans and Specifications.

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