FINAL DRAFT ENGINEERING EVALUATION/COST ANALYSIS

Bremerton Auto Wrecking Landfill - Gorst Creek Site
Port Orchard, Washington
TDD: 10-08-0011

REGION 10

START-3

SUPERFUND TECHNICAL ASSESSMENT & RESPONSE TEAM

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List of Abbreviations

Abbreviation	Definition
ARAR	applicable or relevant and appropriate requirement
BMP	best management practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
cfs	cubic feet per second
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
E & E	Ecology and Environment, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
HDPE	high-density polyethylene
J	estimated value
JH	estimated value – quantified using peak heights rather than peak areas
KCHD	Kitsap County Health Department
MCL	maximum contaminant level
mg/kg	milligrams/kilogram
mph	mile per hour
MTBE	methyl tert-butyl ether
MTCA	Washington Model Toxics Control Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PCB	polychlorinated biphenyl
PHS	priority habitats and species
PRG	Preliminary Remediation Goals
QA	quality assurance
QC	quality control

RCRA	Resource Conservation and Recovery Act
RSL	EPA's Regional Screening Levels for Chemical Contaminants at Superfund Sites
SQIRT	Screening Quick Reference Tables
START	Superfund Technical Assessment and Response Team
SVOC	semi-volatile organic compound
TCLP	toxicity characteristic leaching procedure
TPHD	total petroleum hydrocarbon – diesel range
TPHG	total petroleum hydrocarbon – gasoline range
µg/kg	micrograms/kilogram
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Service
VOC	volatile organic compound
U.S.C.	United States Code
WDFW	Washington Department of Fish and Wildlife
WSDNR	Washington State Department of Natural Resources
WSDOT	Washington State Department of Transportation

Executive Summary

The Bremerton Auto Wrecking Landfill - Gorst Creek Site (the Site) is a former landfill site near Port Orchard in Kitsap County, Washington. The Site operated as a landfill from the 1950s until 1989 and contains approximately 150,000 cubic yards of waste. The landfill primarily received auto wrecking wastes but also received other wastes such as medical waste from Puget Sound Naval Shipyard as well as demolition debris and municipal solid waste.

In 1968, a 24-inch corrugated steel culvert was installed along the base of the Gorst Creek ravine so that the ravine could be filled with waste and Gorst Creek could flow through the culvert beneath the landfill. Waste was placed on top of the culvert until the top of the waste became approximately even with the top of the ravine. In 1997 and 2002, after significant storm events, Gorst Creek backed up on the southeast side (upstream side) of the landfill and overtopped the surface of the landfill, causing a portion of the northwest slope of the landfill to fail and wash downstream into Gorst Creek. Review of a 2003 inspection video revealed a collapse of the culvert approximately 460 feet upstream of the outflow, severely diminishing the maximum flow capacity of the culvert. A partial collapse was also noted approximately 20 feet downstream of the culvert inflow. Landfill debris was found approximately 0.5 miles downstream in Gorst Creek.

Previous sediment and groundwater sampling results had indicated the presence of contaminants associated with landfill waste. The eroded waste in the stream sediments and groundwater is being transported downgradient into the Gorst Creek watershed. The contamination at the Site includes pesticides, polychlorinated biphenyls, semi-volatile organic compounds, metals, and volatile organic compounds. Substances found at the Site, including the substances identified above, constitute "hazardous substances" as defined by Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 United States Code (U.S.C.) § 9601(14).

The actual or threatened release of hazardous substances within and from the Site may present an imminent and substantial endangerment to the public health, welfare, or the environment within the meaning of Section 106(a) of CERCLA, 42 U.S.C. § 9606(a). This engineering evaluation/cost analysis (EE/CA) identifies and evaluates removal action alternatives to mitigate off-Site migration of the contaminants of concern and the potential for surface water to become impounded behind the collapsed culvert.

The United States Environmental Protection Agency (EPA), through its Superfund Technical Assessment and Response Team (START) contractor, conducted field sampling in July and August 2011 to collect additional data for this EE/CA, including samples of surface soil, sediment, and groundwater for laboratory analyses of chemical constituents and toxicity and subsurface soil samples for geotechnical analyses. Data from the 2011 field sampling were primarily used to prepare streamlined human health and ecological risk evaluations.

The objectives for the proposed removal actions evaluated in this EE/CA are to protect human health and the environment by preventing human and ecological receptor contact with landfill contents and associated hazardous substances and to comply with applicable or relevant and appropriate requirements to the extent practicable. Specific removal action objectives include either removing the contents of the landfill and transferring them to a secure off-Site facility or providing an engineered solution that affords sufficient hydraulic conveyance to prevent upstream surface water impoundment.

The alternatives developed to achieve the removal action objectives are described and evaluated in this report. The alternatives include contaminant excavation and off-Site disposal with restoration of Gorst Ravine or stabilization and covering of the landfill with alternative methods of bypassing surface water in Gorst Creek. Methods that were evaluated for bypassing Gorst Creek include constructing a natural bypass channel adjacent to the landfill or installing new conveyance piping beneath the landfill (microtunneling/pipe jacking). The removal action alternatives were analyzed individually and also compared against each other using the criteria of effectiveness, implementability, and cost. The estimated implementation costs for the removal action alternatives are $2,630,000 for a bypass installed using microtunneling/pipejacking techniques, $8,520,000 for a bypass channel constructed around the landfill, and $34,080,000 for removal and off-Site disposal of the landfill contents. Microtunneling/pipe jacking is the recommended removal action alternative. Installing a creek bypass pipe would reduce the potential for backup and overtopping of the landfill during significant storm events by providing a new primary pathway for Gorst Creek beneath landfill. It would prevent further landfill embankment erosion mitigating potential contamination and waste migration to protect human health and the environment.

1 Introduction

The United States Environmental Protection Agency (EPA) has tasked the Superfund Technical Assessment and Response Team (START) contractor to prepare this Engineering Evaluation/Cost Analysis (EE/CA) for the Bremerton Auto Wrecking Landfill - Gorst Creek Site (Site) in Gorst, Washington. This EE/CA provides a vehicle for public involvement and evaluates and recommends the preferred removal action alternativefor the Site. E & E performed the work under START-3 contract EP-S7-06-02, Technical Direction Document (TDD) 10-08-0011.

1.1 Site Description and History

The Bremerton Auto Wrecking Landfill - Gorst Creek Site (Comprehensive Environmental Response, Compensation, and Liability Information System [CERCLIS] ID No. WAN 001 002 414 and Site Identification Number 10GL) is located at 4275 State Highway 3 SW approximately 5 miles southwest of Port Orchard, 6 miles south-southwest of Bremerton, and 1.5 miles west of Gorst, Washington (see Figure 1-1, Site Location Map). The Site is identified by the Kitsap County Tax Assessor as parcel 012301-4-022-1005; it is located in the northwest quarter of the southwest quarter of Section 1, Township 23 North, Range 1 West (EPA 2003) (see Figure 1-2A, Site Conditions 2000, and Figure 1-2B, Site Conditions 2011). The latitude is 47°30' 36.40" North and the longitude is 122°44' 29.40" West. The Site is a closed landfill that has not accepted waste since 1989.

The Site encompasses an approximately 5.7 acre triangular parcel centered over approximately 880 feet of the Gorst Creek Ravine. The Site contains approximately 150,000 cubic yard of automotive wrecking debris, construction debris, medical wastes, and other waste from public dumping. Gorst Creek flows northwest under the property through an approximately 880 foot-long 24-inch corrugated steel culvert (E & E 2004). Immediately downstream of the landfill, Gorst Creek flows under State Highway 3 SW through a 48-inch box culvert. The Site is bordered by an auto wrecking and salvage facility (Airport Auto Wrecking), a privately owned property (Alpine Farms), McCormick Land Company, Washington State Department of Transportation (WSDOT) property, which includes State Highway 3 SW with an easement corridor on either side of the highway, and one private residential property.

Kitsap County Health Department (KCHD) records show that the Site began operating as a landfill in 1950 under the name Ames Auto Wrecking. At this time, the property was owned by Mel Marler of Bremerton, Washington, who operated the landfill until 1972. In 1972, the property was purchased by Earl King and Louis King. In 1973, K. R. Crawford and Clara D. Crawford and Northern, Inc. became partners with the Kings in ownership of the Site. Mr. and Mrs. King, Mr. and Mrs. Crawford, and Northern, Inc. operated the landfill under the name of Ames Refuse - Bremerton Auto Wrecking, Inc. until 1980. In 1980, the property was obtained by Sid Uhinck and Lucille Uhinck who operated the Site as Bremerton Auto Wrecking, Inc. until its closure in 1989. Ownership from the time of closure until 2001 is unknown, and at some point the property reverted to Kitsap County. In February 2001, the property was obtained from the Kitsap County Treasurer by Vern L. Padgett of Tacoma, Washington. In February 2002, Mr. Padgett deeded the property to the Carina Trust. In November 2002, the property was acquired from the Carina Trust by the current owner William Nilles.

In 1968, a 24-inch corrugated steel culvert was installed along the base of the Gorst Creek Ravine so that the ravine could be filled with waste, and the creek could pass through the landfill via the culvert (E & E 2004). Waste was placed on top of the culvert until the top of waste became level with the top of the ravine. There is some evidence that the landfill was extended beyond its original planned limits along the ravine, implying that the culvert may have been placed at two or more different times. The original planned limits of the landfill are depicted in Figure 1-3, Site Plan – 1968.

In March 1997, after a significant rainstorm (7.3 inches in a 24-hour period), Gorst Creek backed up on the upstream side (southeast side) of the landfill and overtopped the surface of the landfill, causing a portion of the northwest slope of the landfill (i.e., downgradient side) to fail and wash into Gorst Creek; landfill debris was found approximately 0.5 miles downstream (Hart Crowser 2000). Following this failure, two riprap catchment berms containing 24-inch corrugated metal pipes were installed in Gorst Creek in an attempt to prevent future possible failures from washing landfill debris downstream. In January 2002, after another significant storm, Gorst Creek again backed up and overtopped the landfill, resulting in another (smaller) slope failure. Landfill debris was released to Gorst Creek, and the upstream riprap catchment berm was destroyed. The lower riprap catchment berm was still in place as of May 2003 (E & E 2004).

In October 2003, a mobile camera was deployed into the culvert beneath the landfill to identify potential causes for the backup and flooding of the landfill. Review of the culvert inspection video revealed a collapse of the culvert approximately 460 feet upstream of the culvert outflow, severely diminishing the maximum flow capacity of the culvert. A partial collapse was also noted approximately 20 feet downstream of the culvert inflow. Approximately 400 feet of culvert was not inspected because the mobile camera was not able to pass the collapse points (E & E 2004; Bravo 2003).

The landfill is estimated to contain approximately 150,000 cubic yards of waste (Hart Crowser 2000). A sizable portion of the total waste disposed of in the Gorst Creek ravine originated from the Puget Sound Naval Shipyard under a contract to dispose of construction and other industrial debris between approximately 1969 and 1970 (Hart Crowser 2000). Subsequent to the end of the Puget Sound Naval Station contract, the landfill continued to accept residential waste and demolition debris until it was shut down by the Kitsap County Health Department in 1989. Chemicals of potential concern at the landfill include chlorinated pesticides, polychlorinated biphenyls (PCBs), metals, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). Information also indicates that medical waste from the Puget Sound Naval Station was received and disposed of in the landfill (E & E 2004).

A population of 1,027 people resides within a 1-mile radius of the Site and 8,425 people are within a 4-mile radius (see Section 1.5.1, Streamlined Human Health Risk Evaluation, for additional detail). Sunnyslope Elementary School is located within 1 mile of the Site, and Pleasant Valley School is located within 3 miles of the Site. No other schools or daycare facilities are located within 1 mile of the Site (USGS 2011).

The Site and immediate properties to the northeast are zoned "business center" and are not occupied by residents. Adjoining land is zoned as incorporated city and rural residential (Kitsap County 2010a). Kitsap County comprehensive land use planning indicates that the zoning would remain the same in the future for the Site property and surrounding area (Kitsap County 2010b).

Several aquifers are present in the region. While not all of the aquifers are used for drinking water purposes, all are available to be used as drinking water. Within a 4-mile radius of the Site are 587 domestic wells and 40 municipal wells serving a population of more than 8,400 people (see Appendix C, Streamlined Human Health Rick Evaluation). The residential population relying on domestic wells is approximately 1,500 persons.[1]

Because of the collapsed culvert beneath the landfill, impoundment of surface water from Gorst Creek behind the landfill is a concern. The culvert's reduced flow capacity may again result in water overtopping the landfill and eroding the landfill cover, carrying landfill debris into the creek and downstream. In addition, impounded water upstream of the landfill can potentially result in elevated water level within the landfill with saturation of landfill debris.

1.2 Physical Characteristics of the Site

1.2.1 Hydrology

The elevation of the Site ranges from approximately 350 to 420 feet above mean sea level, determined from a survey performed on the Site and surrounding vicinity on October 11, 2011, by START subcontractor White Shield, Inc. The top of the Site is mostly flat; however, the northwestern (downstream) and southeastern (upstream) ends of the landfill slope towards Gorst Creek ravine at an estimated grade of 30% to 45%. In the 2003 Preliminary Assessment, the EPA identified two probable points of entry (locations where the entry of contaminants of concern to surface water is most likely to occur) within the 15-mile target distance limit. The first probable point of entry was located in Gorst Creek upgradient of the property at the point where the creek enters the pipe under the landfill. The second probable point of entry was located in Gorst Creek on the downslope side of the landfill. At this second probable point of entry, a spring was observed flowing from the west face of the landfill into Gorst Creek. From this second probable point of entry, the creek flows for 3.72 miles to Puget Sound. The 15-mile target distance limit concludes as several radial arcs within Puget Sound.

The mean annual precipitation in Bremerton, Washington, which is located approximately 4 miles northeast of the Site, is 56.37 inches (WRCC 2012). The 2-year 24-hour rainfall event for the Site is 2.25 inches (NOAA 1973). A flood insurance rate map shows that the Site is located in Zone X, meaning it lies outside of both the 100- and 500-year flood plain. The drainage area for the Site was calculated at 300 acres. During large precipitation events, water from Gorst Creek backs up at the first probable point of entry and flows in a northwest direction over the landfill cover before dropping back into Gorst Creek upstream of State Highway 3 SW.

[1] This number was determined by multiplying the number of domestic wells within 4 miles by the average number of persons per Kitsap County household.

A hydrologic analysis for the Site determined the anticipated flow rates during peak storms that could potentially cause the overtopping of the landfill under existing conditions. These flows were used as the basis of design for several of the alternatives proposed under this assessment. Flow rates were calculated using the Santa Barbara Urban Hydrograph method, as specified by the Kitsap County Stormwater Design Manual (Kitsap County 2010) and Washington State Department of Ecology's 2005 revision of the Stormwater Management Manual for Western Washington for flow control designs (see Table 1-1). This method simplifies the runoff hydrograph computations using Site-specific land area type, drainage area, time of concentration, runoff curve numbers, and historical precipitation depths at selected storm frequencies.

Table 1-1 Peak Flow Rates at the Bremerton Auto Wrecking Landfill – Gorst Creek Site

Storm Event	Estimated Peak Flow through Site (cubic feet per second [cfs])
2-year	12.3
10-year	30.2
25-year	40.7
100-year	57.5
500-year	80.2

1.2.2 Geology

Kitsap County lies entirely within the Puget Trough. The Puget Trough is a large structural basin in consolidated rocks of Tertiary and earlier age that extends south from Canada to the central part of western Oregon (Raisz 1965), running along a north/south-trending lowland located between the Cascade Mountains to the east and the Olympic and Coast Range Mountains to the west. The trough has been partly filled by unconsolidated deposits of clay, silt, sand, gravel, and glacial till. These unconsolidated sedimentary materials were deposited by water and ice during the Pleistocene glacial epoch (Ice Age), but recent alluvial deposits underlie the surface in some low-lying areas. The upper materials of this fill, except the recent deposits, were deposited by ice and glacial melt water streams during the latest glaciation of the area (Vashon glaciation). During that glaciation, a large tongue of ice moved southward from British Columbia and Vancouver Island and partly filled the Puget Sound basin (Bretz 1913). The northern portion of the Gorst Creek watershed contains a large deposit of recessional outwash that consists of fine-grained sand (Sceva 1957).

The Gorst area basin is underlain by three geologic units: Vashon till, Vashon recessional outwash, and Tertiary bedrock (EPA 2003). Geotechnical borings advanced by EPA in August 2011 on the north and south sides of Gorst Creek revealed sand and gravel deposits to depths up to 90 feet below grade, characteristic of the Vashon recessional outwash. During the drilling groundwater was encountered only in boring SB04, located near the creek channel, at a depth of 5 feet below the ground surface.

1.2.3 Hydrogeology

In the Gorst area four aquifers have been described: the Twin Lakes aquifer, the Gorst Creek Valley aquifer, the upland aquifer, and the sea-level aquifer. In the Anderson Creek qatershed area east of the Gorst Creek watershed five aquifers have been described: an upland aquifer, sea-level aquifer, a shallow artesian aquifer, the deep artesian aquifer, and the lower deep artesian aquifer. One Bremerton City Water Resource Division monitoring well (BR-11) is located approximately 0.15 miles northeast of the Site. The well was installed in 1992 to a depth of 74 feet.

1.2.4 Meteorology

Records from 1981 through 2010 from the weather station closest to the Site, Bremerton Station, located in Bremerton, Washington, show that the Gorst Creek area has a mean maximum temperature of 60.4 degrees Fahrenheit (°F) and a mean minimum temperature of 43.6°F. The warmest months are July and August, when the monthly mean high temperatures are 75.9°F and 76.6°F, respectively, and the monthly mean low temperatures range from 54.1°F to 54.3°F, respectively. The coldest month has been observed to be December, with an average monthly high temperature of 45.0°F and an average monthly low temperature of 34.5°F (WRCC 2011a).

The mean annual precipitation from 1981 through 2010 was 56.37 inches. November and December receive the highest amount of precipitation, with averages of 9.39 and 10.07 inches, respectively. July and August are the driest months, with average precipitation amounts of 0.86 and 1.03 inches respectively. Gorst Creek receives 5.33 inches of snowfall each year, with most falling in December and January (1.73 and 3.55 inches as an annual average, respectively). Snowfall has been recorded from November through April (WRCC 2011).

Average annual wind speed in the region has been calculated as 0.7 miles per hour (mph), with a range of 0.53 mph in August to 1.0 mph in March (Western Regional Climate Center n.d.). The Quilcene, Washington, weather station was the nearest location that had available, verified wind records; measurements were available from 2001 through 2011.

1.2.5 Sensitive Ecosystems

Gorst Creek has many areas of unrestricted access downstream of the Site, as well as a recreational park (Otto Jarstad Park) located within 4 miles downstream of the Site. A tribal fishery is also located near the mouth of Gorst Creek, on Sinclair Inlet, approximately 3.7 miles downstream of the Site. The fishery is supported by a Suquamish Tribe Chinook salmon fish-rearing facility, located on Gorst Creek approximately 1 mile upstream of the confluence with Sinclair Inlet (Zischke 2003). Fishing reportedly does not occur on Gorst Creek downstream of the Site; rather, fish are harvested from Sinclair Inlet (Huff 2003). In addition, a golf course is located near the Site and Gorst Creek; however, it relies on City of Bremerton municipal water for irrigation and drinking water (Folk 2011).

There are 2.6 miles of wetland frontage along the 15-mile target distance limit and 633.7 acres of designated wetlands within 4 miles of the Site (EPA 2003). The wetland nearest to the Site along the surface water target distance limit is located on Sinclair Inlet approximately 3.72 miles downstream of the Site. All wetland frontage occurs on the waters of the Puget Sound (USFWS 1997a, 1997b, 1997c, 1997d, 1997e, 1997f, 1997g, and 1997h).

Available information from the Washington Department of Fish and Wildlife (WDFW), Washington State Department of Natural Resources (WSDNR), United States Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration (NOAA) regarding the presence of sensitive plant and animal species in the Site vicinity were reviewed, and a summary of the information from these agencies is provided below.

The WDFW priority habitats and species (PHS) database (WDFW 2011) indicated that the Coho salmon (*Oncorhynchus kisutch* [federally listed as threatened]) and coast-resident cutthroat trout (*O. clarki* [PHS-listed]) occur or migrate in Gorst Creek. The information in the PHS database suggests that these species may occur throughout Gorst Creek, including the portion of the creek near the Site.

The WSDNR (2011) indicated that six rare plants species occur in Kitsap County: pink sand-verbena (*Abronia umbrellata* var. *brevifolia* [state-listed as endangered]); Vancouver ground-cone (*Boschniakia hookeri* [state-listed as of potential concern]); bog clubmoss (*Lycopodium inundata* [state-listed as sensitive]); western yellow oxalis (*Oxalis suksdorfii* [state-listed as threatened]); humped bladderwort (*Utricularia gibba* [state-listed as of potential concern]); and chain fern (*Woodwardia fimbriata* [state-listed as sensitive]). The Vancouver ground-cone, bog clubmoss, humped bladderwort, and chain fern were sighted in west Kitsap County within approximately 10 miles of the Site. However, none of these species would be expected to occur at the Site given their habitat requirements. Vancouver ground pine is a root parasite and typically is found growing in young forest stands near salt water. Associated tree species include western hemlock, western red cedar, Sitka spruce, and Douglas fir. Bog clubmoss, humped bladderwort, and chain fern prefer perennially wet habitats (bogs, lakeshores, etc.) that are not offered by the Site.

The USFWS (August 26, 2010) indicated that the bull trout (*Salvalinus confluentus*) – Coastal-Puget Sound distinct population segment and marbled murrelet (*Brachyramphus marmoratus*) are listed as threatened and endangered species, respectively, in Kitsap County. Also, the USFWS considers the yellow-billed cuckoo (*Coccyzus americanus*) as a candidate species in Kitsap County and 12 other animals as species of concern in Kipsap County, including the bald eagle (*Haliaeetus leucocephalus*), long-eared myotis *(Myotis evotis)*, long-legged myotis (*Myotis volans*), northern goshawk (*Accipiter gentilis*), northern sea otter (*Enhydra lutris kenyoni*), northwestern pond turtle (*Emys* (= *Clemmys*) *marmorata marmorata*), Pacific lamprey (*Lampetra tridentata*)*,* Pacific Townsend's big-eared bat (*Corynorhinus townsendii townsendii*), peregrine falcon (*Falco peregrinus*), river lamprey (*Lampetra ayresi*), tailed frog (*Ascaphus truei*), and western toad (*Bufo boreas*). Some of these species (e.g., marbled murrelet, northern sea otter, and peregrine falcon) would not be expected to occur in the Site vicinity given their habitat requirements. The marbled murrelet feeds in coastal marine water and nests in old growth forests. The northern sea otter is found in coastal marine habitats. The peregrine falcon requires high cliff environments or high-rise buildings for roosting and nesting. These habitat types are not provided by the Site. However, the possibility that the other above-mentioned species might occur in the Site vicinity cannot be definitely ruled out, although none were observed during field work at the Site in July 2011.

The National Marine Fisheries Service (NMFS), a branch of NOAA, identified the Puget Sound Chinook salmon (*O. tshawytscha*) as an evolutionarily significant unit and Puget Sound steelhead (*O. mykiss*) distinct population segment as federally listed as a threatened species in Puget Sound (National Marine Fisheries Service August 15, 2011). Because Gorst Creek is a tributary of Puget Sound, the occurrence of these species in Gorst Creek cannot be definitively ruled out.

1.3 Previous Investigations and Removal Actions

1.3.1 Site Hazard Assessment

In 1999 and 2000 Hart Crowser conducted a Site Hazard Assessment of the Site for the Puget Sound Naval Station to determine the nature and possible extent of contamination at the Site. Puget Sound Naval Station was working in accordance with the Kitsap County Department of Health to assist in the cleanup from previous disposal of medical wastes at the facility. During the study, Hart Crowser conducted a property boundary and elevation survey, a limited landfill soil and slope stability assessment, and a characterization of the area hydrogeology. As part of this study, Hart Crowser also sampled surface soils, sediments, groundwater, and surface water. Analytical results summary tables from this sampling event are included in Appendix A.

Four discrete surface soil samples were collected from the ravine walls surrounding the Site including a sample from a background location. Three 3-point composite surface soil samples were collected were collected from northern slope of the landfill. The surface soil samples were analyzed for total gasoline and diesel-range petroleum hydrocarbons, pesticides and PCBs, priority pollutant metals, VOCs, and SVOCs. Sixteen pesticides and PCBs, 22 SVOCs, and nine priority pollutant metals were detected above the instrument detection limit. No VOCs were detected above the instrument detection limit in these soil samples

Hart Crowser also collected four sediment samples, including one upstream sample and three composite samples from Gorst Creek downstream of the landfill. Sediment samples were analyzed for gasoline and diesel-range petroleum hydrocarbons, pesticides and PCBs, priority pollutant metals, SVOCs, VOCs, and total organic carbon. One pesticide, 14 SVOCs, and seven priority pollutant metals were detected above the instrument detection limit. No VOCs were detected above the instrument detection limit in the sediment samples.

One groundwater sample was collected from monitoring well BR-11, which is located near Gorst Creek approximately 0.15 miles downstream from the Site. No analytes were detected above the instrument detection limit. The well had been previously sampled on March 26, 1997, seven days after the first flood event at the Site. During that sampling cadmium was detected in the well at 42.7 micrograms per liter (µg/L), copper was detected at 3.0 µg/L, and zinc was detected at 75 µg/L (Cahall January 27, 2003). Finally, Hart Crowser collected two surface water samples, one upstream and one downstream of the landfill. Mercury was detected in the sample at the upstream sample location. No analytes were detected in the sample from the downstream location.

1.3.2 EPA Preliminary Assessment and Integrated Assessment

The EPA conducted a preliminary assessment in 2003. A preliminary assessment is an evaluation of available information about a site to determine whether the site poses a threat to human health and the environment and whether the threat requires further investigation. The preliminary assessment concluded that there was a threat posed by the Site, so EPA further investigated the Site through an integrated assessment. An integrated assessment is a combination of a site inspection, which involves the collection and analysis of site samples to provide data for Hazard Ranking System scoring and documentation, and a removal screening, in which EPA determines whether a further removal assessment is justified at a site.

EPA conducted the integrated assessment at the Site in 2003-2004. Samples were collected from the Site and surrounding area in order to determine the presence or absence of contaminants at the source and target receptors. During the integrated assessment, subsurface samples were collected from six boreholes drilled directly into the landfill. Six surface soil samples were also collected at the same locations. Sediment samples were collected from Gorst Creek including a location downstream of the landfill between the landfill and State Highway 3, downstream of State Highway 3, and just upstream of the landfill near the southeastern slope of the landfill. The results of the integrated assessment indicated that the Aroclor 1254, benzo(a)pyrene, benzo(a)anthracene, and lead in Site soil samples exceeded health-based screening levels. Dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), Aroclor 1254, and copper exceeded the NOAA Screening Quick Reference Tables (SQIRT) screening levels in sediment samples located between the landfill and State Highway 3 and downstream of State Highway 3. In addition to these contaminants of concern, the integrated assessment noted that medical waste may also be present in the landfill.

A summary of the sampling results from the integrated assessment are listed below.

Table 1-2A Integrated Assessment Surface Soil Analytical Results – June 2004

Compound	Concentration	Region 6 PRGs Residential/Industrial	Detection frequency
DDT	4.9 – 54 JH µg/kg	1,700/7,800 µg/kg	4 of 6
Aroclor 1254	50 J – 88 J µg/kg	220/2,900 µg/kg	2 of 6
Benzo(a)pyrene	**70 J µg/kg**	**15/230 µg/kg**	**1 of 6**
Benzo(a)anthracene	73 J µg/kg	150/2300 µg/kg	1 of 6
Lead	9.6 – 278 mg/kg	400/800 mg/kg	6 of 6
Mercury	0.19 – 0.62 mg/kg	23/610 mg/kg	2 of 6

Key:
DDT Dichlorodiphenyltrichloroethane
J Estimated value
JH Estimated value – quantified using peak heights rather than peak areas
mg/kg milligrams/kilogram (equivalent to parts per million)
PRG Preliminary Remediation Goal
µg/kg micrograms/kilogram (equivalent to parts per billion)

Bold: indicates that the compound exceeds the screening level.

Table 1-2B Integrated Assessment Subsurface Soil Analytical Results – June 2004

Compound	Concentration	Region 6 PRGs Residential/Industrial	Detection frequency
DDT	6.9 – 43 µg/kg (70 J)	1,700/7,800 µg/kg	5 of 6
DDE	7.5 – 40 µg/kg	1,700/7,800 µg/kg	5 of 6
Aroclor 1254	**65 – 280 µg/kg (370 J)**	**220/2,900 µg/kg**	**5 of 6**
Benzo(a)pyrene	**55 J – 490 J µg/kg**	**15/230 µg/kg**	**6 of 6**
Benzo(a)anthracene	**43 J – 2,000 J µg/kg**	**150/2,300 µg/kg**	**5 of 6**
Lead	**2.5 – 1,410 mg/kg**	**400/800 mg/kg**	**6 of 6**
Mercury	0.13 – 1.1 mg/kg	23/610 mg/kg	3 of 6

Key:
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
J Estimated value
JH Estimated value – quantified using peak heights rather than peak areas
mg/kg milligrams/kilogram (equivalent to parts per million)
PRG Preliminary Remediation Goal
µg/kg micrograms/kilogram (equivalent to parts per billion)

Bold: indicates that the compound exceeds the screening level.

Table 1-2C Integrated Assessment Sediment Analytical Results – June 2004

Compound	Concentration	NOAA SQIRTs	Detection frequency
DDT	**88 JH – 340 JH µg/kg**	**50 µg/kg (upper effects level)**	**2 of 3**
DDE	**33 JH – 110 JH µg/kg**	**8.51 µg/kg**	**2 of 3**
Aroclor 1254	**750 – 2,500 J µg/kg**	**277 µg/kg**	**2 of 3**
Copper	**201 JH mg/kg**	**197 mg/kg**	**1 of 3**
Lead	47 – 47.5 mg/kg	91.3 mg/kg	2 of 3
Zinc	153 – 159 mg/kg	315 mg/kg	2 of 3

Key:
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
J Estimated value
JH Estimated value – quantified using peak heights rather than peak areas
mg/kg milligrams/kilogram (equivalent to parts per million)
NOAA National Oceanic and Atmospheric Administration
SQIRT Screening Quick Reference Tables
µg/kg micrograms/kilogram (equivalent to parts per billion)

Bold: indicates that the compound exceeds the screening level.

1.4 Sources, Nature, and Extent of Contamination

1.4.1 Landfill Characteristics and Contents

The landfill is a triangular-shaped parcel of approximately 5.7 acres centered along the Gorst Creek ravine. The ravine was 60 to 80 feet deep at this location before being used as a landfill.

Gorst Creek is located in the ravine and is conveyed under the landfill through a culvert that was constructed when landfill operations began in 1968. The pipe under the landfill is a approximately 880 feet in length. Presently, the top of the landfill is flush with the surrounding topography over much of the landfill surface and is overgrown with vegetation and covered with debris.

The landfill contains approximately 150,000 cubic yards of waste. In addition to automotive debris, the landfill accepted waste from public dumping, occasional demolition debris contracts, and refuse from the Puget Sound Naval Shipyard, including a limited amount of medical waste from that facility. Hazardous substances detected in environmental media at the landfill include chlorinated pesticides, PCBs, SVOCs, and VOCs.

1.4.2 Topographic Survey and Landfill Extents

A topographic survey of the Site in the summer and fall of 2011 used topographic elevations on a 50-foot grid to establish 1-foot contours. The survey data were used to develop the engineering alternatives and cost estimates presented in this report.

1.4.3 Analytical Data

Site analytical data is available from previous investigations (Hart Crowser October 2000; E & E 2004) and the 2011 field sampling events that were performed to support this EE/CA. The data from previous investigations were reviewed to assist in the planning for the 2011 field sampling events and to help develop the conceptual site model of potential pathways and receptors (see Section 1.4.3.1 below).

Analytical data used in the streamlined risk evaluation (see Section 1.5) were obtained primarily from the 2011 field sampling, with one exception. Because there was no surface water in Gorst Creek at the time of the 2011 field sampling events, surface water results from the Integrated Assessment Report (E & E 2004) were used in the streamlined human health risk evaluation.

2011 Field Sampling Events

To collect additional data for this EE/CA, EPA collected surface soil samples and sediment samples on July 27, 2011. Because there was no water in Gorst Creek during the sampling event, no surface water samples were collected. Sample locations are shown on Figure 1-4, Sample Location Map – July-August 2011. A Site-specific sampling plan was developed and approved by EPA before initiating the field sampling (E & E 2011). The Site-specific sampling plan described the sampling strategy, sampling methodology, and analytical methods.

Surface soil samples were collected from seven locations in the landfill. All samples were collected from the surface to 6 inches depth. The samples were submitted to GEL Laboratories in Charleston, South Carolina, for analyses of VOCs, SVOCs, pesticides, PCBs, and metals (see Appendix A). Summarized results of the soil samples are included in Table 1-3, Surface Soil Sample Results – July 2011. Laboratory results indicated that chromium occurred at concentrations ranging from 19.6 mg/kg in sample LF05SS to 47.8 mg/kg in sample LF03SS, exceeding the EPA Regional Screening Level of 5.6 mg/kg for industrial soils, and the Washington Model Toxics Control Act (MTCA) Method A level of 19 mg/kg.

Two sediment samples (samples GC01SD and GS02SD, respectively) were collected in Gorst Creek at locations 150 feet and 50 feet upstream of the corrugated metal pipe inlet on the southeastern (upstream) end of the landfill. Sediment sample GC03SD was collected between the landfill and Highway 3. Sediment sample GC04SD was collected approximately 150 feet downstream of Highway 3. Locations are shown on Figure 1-4.

The sediment samples were submitted to GEL Laboratories for analyses of VOCs, SVOCs, pesticides, PCBs, and metals and to Northwestern Aquatic Sciences Laboratory in Newport, Oregon for toxicity testing using 10-day midge (*Chironomus dilutus*) and 28-day amphipod (*Hyalella azteca*) sediment bioassays (see Appendix A). Results of the sediment sample analyses are summarized in Table 1-4A, Sediment Sample Results – July 2011 samples and Table 1-4B, Sediment Bioassay Results – July 2011. No EPA or MTCA screening level exceedances of chemicals of potential concern were observed in the sediment samples. A discussion of the toxicity testing results is included in the Streamlined Ecological Risk Evaluation in Section 1.5.2 below.

EPA remobilized to the Site on August 17 to 19, 2011, to collect subsurface samples. Five soil borings were installed at the Site using a hollow stem auger drilling rig operated by Cascade Drilling of Woodinville, Washington. The soil borings were designated SB01 through SB05 (Figure 1-4). Boring logs are included in Appendix B. The general location, total boring depth and geotechnical soil sample collection depths are shown in Table 1-5, Hollow Stem Auger Boring Installation – August 2011.

The only boring in which groundwater was encountered was SB04, located northwest and downstream of the landfill near Gorst Creek. A groundwater sample was collected from boring SB04 and submitted to GEL Laboratories for analyses for VOC, SVOCS, pesticides, PCBs, and metals. Table 1-6 summarizes the results of the groundwater sample, and the laboratory report is included in Appendix A. The chemicals of potential concern that exceeded the MTCA's cleanup levels and EPA's Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs) included three metals (arsenic, chromium, and cobalt) and two VOCs (chloroform and methyl tert-butyl ether [MTBE]).

Geotechnical soil samples were submitted to GeoTesting Express in Acton, Massachusetts, for grain size analyses and/or direct shear testing. Results are summarized in Table 1-7, Grain Size and Direct Shear Results – August 2011. The geotechnical laboratory report is included in Appendix B.

1.5 Streamlined Risk Evaluation

This section presents a streamlined human health and ecological risk evaluation for the Site. EPA guidance on conducting non-time-critical removal actions (EPA 1993) requires that a streamlined risk evaluation be included as a component of an EE/CA in order to assist in determining whether a removal action is justified and to identify the potential current and future exposures that should be prevented. This evaluation is consistent with federal guidance for conducting streamlined risk evaluations for non-time critical removal actions (EPA 1993) and other applicable federal and regional human health and ecological risk assessment guidance (EPA 1989 and 2010a, Ecology 2007). Substances found at the Site, including the substances identified above in Section 1.4, constitute "hazardous substances" as defined by Section 101(14) of CERCLA, 42 U.S.C. § 9601(14).

The primary exposure pathway of concern for human populations, animals, and the food chain is the surface water pathway. A tribal fishery is located near the mouth of Gorst Creek, on Sinclair Inlet, approximately 3.72 miles downstream of the Site. The fishery is supported by a tribal Chinook salmon fish-rearing facility, located on Gorst Creek approximately 1 mile upstream of the confluence with Sinclair Inlet (Zischke August 25, 2003).

Federal-listed threatened species are documented to exist within the 15-mile target distance limit of the Site. The federal-listed threatened Chum salmon (*O. keta*) and Chinook salmon (*O. tshawtscha*) use Gorst Creek for spawning from the headwaters of the creek down to its mouth in Sinclair Inlet, including the portion of the creek that crosses underneath the Site (Huff 2003a, WDFW 2002).

There are 2.6 miles of wetland frontage along the 15-mile target distance limit and 633.7 acres of designated wetlands within 4 miles of the Site (EPA 2003b). The nearest wetland to the Site along the surface water target distance limit is located on Sinclair Inlet approximately 3.72 miles downstream of the Site (see Figure 1-5). All wetland frontage occurs on the waters of the Puget Sound (USFWS 1997a, 1997b, 1997c, 1997d, 1997e, 1997f, 1997g, and 1997h).

1.5.1 Streamlined Human Health Risk Evaluation Summary

Figure 1-6, the human health conceptual site model, shows the pathways and potential ecological receptors that could be affected by exposure to landfill waste. The streamlined human health risk evaluation (see Appendix C) is a streamlined evaluation in which chemicals of potential concern for the Site were identified by comparing Site concentrations with screening levels. Screening levels included EPA published and calculated risk-based concentrations, Washington State MTCA cleanup levels, and applicable standards.

Exposure scenarios evaluated in the streamlined human health risk evaluation include current and future residents, current and future workers, current and future trespasser, and current and future recreational users. Human receptors at the Site could be exposed to chemicals through contact with surface soil, groundwater, sediment, and surface water. Routes of exposure include ingestion, dermal absorption, and inhalation. Screening levels were selected to be consistent with these exposure scenarios.

Screening levels were compared with maximum detected concentrations reported for surface soil, groundwater, and sediment samples collected in July and August 2011. Surface water samples were not collected at this time due to lack of water flow, so historical data from 2003 were used in the streamlined human health risk evaluation. If the maximum concentration of a chemical was above a screening value, the chemical was considered a chemical of potential concern for the Site. Generally, at sites where contaminant concentrations fall below screening and/or natural background levels, no further action or study is warranted to ensure the protection of human health for that compound. Results of the screening level comparison are as follows:

- As discussed in the streamlined human health risk evaluation in Appendix C, a conservative assumption was made that all of the chromium detected in surface soil samples was in the hexavalent form due to lack of Site-specific speciation data that would provide the proportions of the various forms of chromium in Site soil. The hexavalent form of chromiuim is considered carcinogenic and has lower screening levels, while trivalent chromium is not considered carcinogenic and typically has higher screening levels. The total chromium concentrations in all seven surface soil samples exceeded the EPA industrial worker RSL and MTCA Method A cleanup level for hexavalent chromium. The EPA RSL is conservatively based on a cancer target risk level of 1 in 1,000,000 which is typically used for screening chemicals to be carried forward in a risk assessment or in a streamlined screening level evaluation such was done here. However, if a higher target risk level of 1 in 100,000 in the EPA RSL calculations, the RSL increases tenfold and no exceedences for hexavalent chromium occur. Assuming a 1 in 100,000 target risk level may be appropriate for industrial sites. Comparison of the total chromium concentrations to the EPA RSL for trivalent chromium results in no RSL exceedences. While the total chromium contentrations found at the Site are comparable to typical background leves (42 mg/kg state-wide, and 48 mg/kg in the Puget Sound area) and trivalent chromium is the form predominantly found in natural background soils, chromium cannot be completely ruled out as a chemical of potential concern given the prior landfill disposal useage of the Site. Without chromium speciation data the screening level comparison in this streamlined human health risk evaluation does not provide a definitive picture of chromium as a chemical of potential concern at this Site. However, based on the various comparisons made above, chromium is considered only nominally a chemical of potential concern at this Site.

- Arsenic, chromium, cobalt, chloroform, and MTBE concentrations exceeded respective EPA RSLs for residential tap water in the one sample collected in 2011. Arsenic also exceeded the MTCA Method B drinking water cleanup level. However, with the exception of cobalt and MTBE, which have no promulgated national standards, the other chemicals had concentrations that were well below the respective maximum contaminant levels (MCLs). The MTBE concentration is only slightly above EPA's drinking water advisory concentration range. This range is only for guidance and not mandatory regulation. Cobalt has no such advisory.

- All chemicals detected in sediment and historical surface water samples showed concentrations below applicable screening levels.

There are inherent uncertainties in the streamlined human health risk evaluation process. Significant sources of uncertainty in the human health risk evaluation include the use of fixed input parameters in risk estimates, cleanup levels, and screening level calculations; the use of published screening level and standards, which tend to rely on conservative default assumptions to represent conservative and protective estimate of exposure; and the use of maximum Site concentrations for comparison to screening levels due to the streamlined nature of the evaluation and the limited number of available data points.

1.5.2 Streamlined Ecological Risk Evaluation Summary

The streamlined ecological risk evaluation is presented in Appendix D. The ecological conceptual site model (Figure 1-7) shows the pathways and potential ecological receptors that could be affected by exposure to landfill waste. The assessment endpoints for the ecological risk evaluation included terrestrial vegetation, soil invertebrates, wildlife, benthic invertebrates, and fish and other aquatic organisms exposed to surface water. Potential ecological risks to one or more assessment endpoints using the landfill surface or Gorst Creek near the landfill were identified. On the landfill surface, terrestrial plants, soil invertebrates, and wildlife (songbird and small mammals) may be at risk from high levels of metals in soil: cadmium, lead, nickel, and zinc pose the greatest potential risks. In Gorst Creek downstream from the landfill, sediment PCB levels are great enough to reduce growth of benthic macroinvertebrates. Birds and mammals using the creek are unlikely to be adversely affected by current levels of chemicals in sediment. The following points are noteworthy.

- **Terrestrial Vegetation –** Potential risks to terrestrial plants on the landfill surface were evaluated by comparing soil chemical concentrations with screening benchmarks for effects on plant survival, growth, or reproduction. These comparisons indicate that copper, lead, manganese, mercury, nickel, and zinc in soil may pose a potential risk to terrestrial plants in some areas of the landfill surface.

- **Soil Invertebrates –** Potential risks to soil invertebrates on the landfill surface were evaluated by comparing soil chemical concentrations with screening benchmarks for effects on survival, growth, or reproduction or earthworms. These comparisons indicate that copper, manganese and zinc in soil may pose a potential risk to soil invertebrates in some areas of the landfill surface. Potential risks from copper and manganese are restricted to a single location, whereas the risks from zinc appear to be more widespread.

- **Birds and Mammals –** Food-chain modeling shows that cadmium, lead, nickel, and zinc in soil are likely to pose a risk to song birds and small mammals such as the American robin and masked shrew, which feed extensively on soil invertebrates. Risks to aquatic-dependent wildlife that may forage in Gorst Creek near the Site appear to be minimal.

- **Benthic Invertebrates –** Potential risks to benthic macroinvertebrates were evaluated by comparing sediment chemical concentrations with sediment screening levels and by toxicity tests of Gorst Creek sediment. The sediment screening results suggest that levels of PCBs in sediment downstream from the landfill are great enough to adversely affect benthic macroinvertebrates. The sediment toxicity tests found no effects on survival of laboratory-reared organisms (midges and amphipods) in Gorst Creek sediment. However, three sediment samples showed reduced midge growth and two samples showed reduced amphipod growth compared with clean control sediment. The sample with the lowest midge and amphipod growth (GC03SD) contained the greatest concentrations of Aroclor 1248 and 1254. This sample was collected downstream from the landfill and upstream from Highway 3.

- **Fish, Amphibian, and Other Aquatic Organisms Exposed to Surface Water –** No surface water samples were collected in July 2011 because Gorst Creek near the landfill was dry. Hence, potential risks to this assessment endpoint from Site-related chemicals in surface water were not directly evaluated. However, while surface water was not directly sampled, sediment samples collected in Gorst Creek are an indicator of the creek contaminant levels, as contaminants tend to become deposited in sediments. The sediment screening results suggest that growth of benthic organisms may be impaired in Gorst Creek, and this could result in less prey for fish, amphibians, and other organisms that feed on benthic organisms. Consequently, sediment contamination may be having an impact on this assessment endpoint.

Significant sources of uncertainty in the streamlined ecological risk assessment include several factors. The bioavailability of chemicals in environmental media at the site is poorly understood; therefore, it was conservatively assumed that 100% of the chemicals in soil and sediment were bioavailable to all ecological receptors. Many soil screening benchmarks for plants and soil invertebrates were developed from laboratory studies in which the added chemicals are highly bioavailable. Comparing total chemical concentrations in field samples to solution-based soil benchmarks (developed from laboratory studies in which the added chemicals are highly bioavailable) is conservative and likely results in an overestimation of risk. Screening benchmarks are not available for all chemicals in all media; for example, soil screening benchmarks for plants and soil fauna are not available for many volatile and semivolatile organic compounds and pesticides. Food-chain transfer of chemicals at the site is poorly understood. The potential risks to wildlife at the site are largely driven by estimated concentrations of chemicals in wildlife prey. Prey concentrations were estimated from measured soil and sediment concentrations using uptake factors from the literature, if available, or it was assumed that the prey concentration was the same as the soil or sediment concentration which is likely to result in an overestimation of risk.

1.5.4 Contaminants of Potential Concern

If the maximum concentration of a chemical is above a screening value, the chemical is considered a chemical of potential concern for the Site. Generally, at sites where contaminant concentrations fall below screening and/or natural background levels, no further action or study is warranted to ensure the protection of human health or ecological function. While chromium is considered only nominally a chemical of potential concern related to human health on the Site, there are contaminants of ecological concern at the site include six metals (cadmium, copper, lead, manganese, mercury, nickel, and zinc) and two PCBs (Aroclor 1248 and Aroclor 1254).

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Table 1-3. Surface Soil Sample Results - July 2011

Analyte	Sample Number, Concentration, and Data Qualifier						
	LF01SS	LF02SS	LF03SS	LF06SS	LF04SS	LF05SS	LF07SS
	11070005	11070006	11070007	11070008	11070009	11070010	11070011
Metals (mg/kg)							
Aluminum	11700	19300	11600	14200	10400	9160	13100
Arsenic	10.1	6.0	8.9	2.1	3.2	3.5	1.3
Barium	194	97.5	181	48.9	58	84.5	47.4
Beryllium	0.184	0.269	0.244	0.177	0.132	0.161	0.176
Cadmium	1.1	0.37	3.2	0.33	1.00	0.69	0.09
Calcium	14100 JK	4880 JK	7390 JK	4440 JK	4940 JK	4610 JK	3150 JK
Chromium	28.2 JK	34 JK	47.8 JK	29.1 JK	28.6 JK	19.6 JK	19.7 JK
Cobalt	7.12 JK	9.93 JK	7.65 JK	7.78 JK	6.64 JK	5.08 JK	6.48 JK
Copper	37.9 JK	20.4 JK	83.1 JK	30.2 JK	19.1 JK	15.2 JK	10.7 JK
Iron	16100	23500	16400	17200	16500	9940	14200
Lead	691	21.8	446	54.8	33.3	99.4	3.21
Mercury	1.28	0.0595	0.647	0.103	0.123	0.185	0.00943
Magnesium	4400	5320	5080	5520	4560	3170	4210
Manganese	305 JK	654 JK	385 JK	289 JK	240 JK	168 JK	316 JK
Nickel	40.9 JK	36.2 JK	40 JK	44.8 JK	28.6 JK	21.8 JK	28.8 JK
Potassium	480	681	483	382	648	868	724
Selenium	0.386 U	0.394 U	0.405	0.354 U	0.424 U	0.374 U	0.334 U
Sodium	250	358	196	184	213	358	74.2
Thallium	0.0701 U	0.088 U	0.0927 U	0.0643 U	0.0771 U	0.0681 U	0.0607 U
Zinc	364	59	565	112	836	173	31.1
Volatile Organic Compounds (µg/kg)							
Acetone	6.71 UJL	30.3 JL	5.12 JQ	5.08 UJL	10.7 JL	5.53 UJL	4.62 UJL
2-Butanone (MEK)	6.71 UJL	2.13 JQ	8.33 UJL	5.08 UJL	6.21 UJL	5.53 UJL	4.62 UJL
Ethylbenzene	1.34 U	0.51 JQ	1.67 U	1.02 U	1.24 U	1.11 U	0.923 U
4-Isopropyltoluene	1.34 U	0.956 JQ	1.67 U	0.315 JQ	1.24 U	1.11 U	0.923 U
m,p-Xylene	0.416 JQ	2.55 U	0.5 JQ	2.6 U	2.6 U	2.21 U	2.6 U
Methylene chloride	6.71 U	4.18 JQ	8.33 U	5.08 U	6.21 U	5.53 U	4.62 U
Styrene	0.483 JQ	0.51 JQ	1.3 JQ	0.468 JQ	0.423 JQ	0.885 JQ	0.305 JQ
Toluene	0.429 JQ	0.688 JQ	1.12 JQ	1.02 U	1.24 U	1.11 U	0.923 U
Xylenes (total)	0.416 JQ	1.27 U	0.5 JQ	1.02 U	1.24 U	1.11 U	0.923 U
Polychlorinated Biphenyls (µg/kg)							
Aroclor-1248	243	3.92 U	20.4 U	37.8 U	44.5 U	40.5 U	3.53 U
Aroclor-1254	345	3.92 U	20.4 U	37.8 U	44.5 U	40.5 U	3.53 U
Aroclor-1260	171	3.92 U	136	37.8 U	44.5 U	40.5 U	3.53 U
Pesticides (µg/kg)							
alpha-BHC	7.85 U	7.96 U	8.2 U	7.56 U	8.93 U	25.2	7.13 U
4,4'-DDD	15.7 U	15.9 U	16.4 U	6.37 JQ	17.9 U	16.2 U	14.3 U
4,4'-DDT	89.9 JL	15.9 U	16.4 U	9.1 JQ	17.9 UJL	15.8 JQ	14.3 UJL
endosulfan sulfate	15.7 U	15.9 U	16.4 U	15.1 U	17.9 U	42.1	14.3 U
Polycyclic Aromatic Hydrocarbons (µg/kg)							
2-Methylnaphthalene	78.6 U	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Acenaphthylene	78.6 U	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Acenaphthene	78.6 U	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Anthracene	78.6 U	39.8 U	56.7 JQ	75.7 U	44.7 U	4040 U	35.6 U
Benzo(a)anthracene	164	39.8 U	151	75.7 U	44.7 U	4040 U	35.6 U
Benzo(a)pyrene	145	39.8 U	155	75.7 U	44.7 U	4040 U	35.6 U
Benzo(b)fluoranthene	291	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Benzo(k)fluoranthene	78.6 U	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Benzo(ghi)perylene	117	39.8 U	89.5	75.7 U	44.7 U	4040 U	35.6 U
Chrysene	210	39.8 U	204	75.7 U	44.7 U	4040 U	35.6 U
Dibenzo(a,h)anthracene	78.6 U	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Fluoranthene	250	39.8 U	254	75.7 U	44.7 U	4040 U	35.6 U
Fluorene	78.6 U	39.8 U	42.7 JQ	75.7 U	44.7 U	4040 U	35.6 U
Indeno(1,2,3-cd)pyrene	117	39.8 U	78.8 JQ	75.7 U	44.7 U	4040 U	35.6 U
Naphthalene	78.6 U	39.8 U	82.1 U	75.7 U	44.7 U	4040 U	35.6 U
Phenanthrene	91.1	39.8 U	409	75.7 U	44.7 U	4040 U	35.6 U
Pyrene	351	39.8 U	425	75.7 U	17 JQ	4040 U	35.6 U
HPAH sum	1723.6	39.8 U	1480.45	75.7 U	218.15	4040 U	35.6 U
LPAH sum	326.9	39.8 U	672.6	75.7 U	44.7 U	4040 U	35.6 U
Other Semivolatile Organic Compounds (µg/kg)							
bis(2-Ethylhexyl)phthalate	335 JQ	398 U	568 JQ	757 U	447 U	40400 U	356 U
Butylbenzylphthalate	786 U	398 U	1230	757 U	447 U	40400 U	356 U

Key:
HPAH = high molecular weight PAH
JK = estimated value; direction of bias unknown
JL = estimated value; low bias
JQ = estimated value; direction of bias unknown; value lies between MDL and MQL
LPAH = low molecular weight PAH
MDL = method detection limit
mg/kg = milligrams per kilogram
MQL = method quantitation limit
PAHs = polycyclic aromatic hydrocarbons
U = undetected (value listed is quantitation limit)
µg/kg = micrograms per kilogram
UJL = undetected (value listed is quantitation limit); quantitation limit is estimated and biased low

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Table 1-4A. Sediment Sample Results - July 2011

Analyte	Sediment Screening Levels			E & E and Laboratory Sample Number				Remarks
				GC01SD	GC02SD	GC03SD	GC04SD	
				283018002	283018001	283018004	283018003	
	TEL	PEL	Other[a]	150' Upstream from Landfill (background)	50' Upstream from Landfill	Between Landfill and Hwy 3	Downstream from Hwy 3	
Metals (mg/kg)								
Aluminum	--	--	58,000	11900	13400	12300	11200	No exceedances
Arsenic	9.8	33	--	2.03	2.42	1.73	1.11	No exceedances
Barium	--	--	--	43.6	68.4	54.7	44.8	--
Beryllium	--	--	--	0.119	0.197	0.168	0.181	--
Cadmium	1	4.98	--	0.111	0.133	0.522	0.605	No exceedances
Calcium	--	--	--	3100	3130	3090	2860	--
Chromium	43.4	111	--	22.5	23.5	18.1	19.6	No exceedances
Cobalt	--	--	50	7.32	16.9	5.53	6.13	No exceedances
Copper	31.6	149	--	9.94	8.94	38.5	30.5	One sample exceeds TEL
Iron	--	--	21,200	16600	17500	14600	14400	No exceedances
Lead	35.8	128	--	2.57	4.57	35.3	25.5	No exceedances
Magnesium	--	--	--	4360	3540	4050	4600	--
Manganese	--	--	460	505	1160	239	237	Two exceedances of Ontario LEL benchmark.
Mercury	0.18	1.06	--	0.0251	0.00713	0.0593	0.0442	No exceedances
Nickel	22.7	48.6	--	29.6	35.7	33.4	32.3	Three samples exceed TEL
Potassium	--	--	--	334	281	426	419	--
Selenium	--	--	5	0.0129	0.185	0.0467	-0.00455	No exceedances
Sodium	--	--	--	123	88.5	94.4	113	--
Thallium	--	--	--	0.0488	0.101	0.0449	0.0362	--
Zinc	121	459	--	35.4	41	130	115	One sample exceeds TEL
SVOCs (ug/kg)								
All compounds	--	--	--	ND	ND	ND	ND	--
PCBs (ug/kg)[b]								
Aroclor 1248	60	676	--	ND	ND	**746**	437	Two samples exceed TEL, one exceeds PEL.
Aroclor 1256	60	676	--	ND	ND	**908**	84	Two samples exceed TEL, one exceeds PEL.
Aroclor 1260	60	676	--	ND	7.2	516	248	Two samples exceed TEL.
Pesticides (ug/kg)								
All compounds	--	--	--	ND	ND	ND	ND	--
VOCs (ug/kg)[b,c]								
4-Isopropyltoluene	--	--	--	ND	ND	ND	3.19	--
Acetone	--	--	--	2.7	ND	ND	3.85	--
Styrene	--	--	--	ND	ND	0.426	ND	--

Key:

- -- = Not available or not applicable
- E & E = Ecology and Environment, Inc.
- LEL = low effect level
- ND = Non-detect
- PCBs = Polychlorinated biphenyls
- PEL = Probable effect level
- SVOCs = Semivolatile organic compounds
- TEL = Threshold effect level
- Value = Exceeds TEL or other benchmark. Adverse effect possible.
- **Value** = Exceeds PEL. Adverse effect likely.
- VOCs = Volatile organic compounds

Notes:

a = From table of eco-risk screening levels provided to EPA in July 2011.
b = Detected chemicals only are listed.
c = VOCs do not accumulate in sediment; hence, sediment benchmarks typically are not available for VOCs.

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Table 1-4B. Sediment Bioassay Results - July 2011

E & E Sample ID	Laboratory Sample ID	Sample Location	10-day *Chironomus dilutus* (Midge) Test Results				28-day *Hyalella azteca* (Amphipod) Test Results			
			% Mortality (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?	Average ash free dry weight per midge (mg) (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?	% Mortality (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?	Average ash free dry weight per amphipod (mg) (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?
Control	--	Clean control sediment.	15.0 ± 5.3	--	0.85 ± 0.13	--	5.0 ± 10.7	--	0.50 ± 0.08	--
CG01SD[a]	11070002	150 ft upstream from landfill.	16.3 ± 5.2	No	0.73 ± 0.11	Yes	11.3 ± 9.9	No	0.40 ± 0.06	Yes
GC02SD	11070001	50 ft upstream from landfill.	28.8 ± 19.6	No	0.81 ± 0.18	No	3.8 ± 5.2	No	0.52 ± 0.07	No
GC03SD	11070004	Between landfill and Highway 3.	11.4 ± 6.4	No	0.59 ± 0.10	Yes	3.8 ± 5.2	No	0.33 ± 0.04	Yes
GC04SD	11070003	Downstream from Highway 3.	13.8 ± 11.9	No	0.71 ± 0.09	Yes	6.3 ± 7.4	No	0.50 ± 0.12	No

Key:

ft = feet

p = probability

s.d. = standard deviation

Note: a = Site-specific background sample.

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Table 1-5. Hollow Stem Auger Boring Installation – August 2011.

Boring Number	Location	Total Depth	Geotechnical Soil Sample Depths	Depth to Groundwater
SB01	>100 feet North/East of Landfill	90 feet	20.5 feet 25 feet 50 feet	>90 feet
SB02	>100 feet North of Landfill	60 feet	22 feet 30.5 feet 50.5 feet 55 feet	>60 feet
SB03	200 feet North of Landfill	80 feet	20.5 feet 21 feet 25 feet 50 feet 57.5 feet	>80 feet
SB04	500 feet Northwest of Landfill	13 feet	10 feet 10.5 feet 11 feet	5 feet
SB05	200 feet Southwest of Landfill	61.5 feet	20 feet 25.5 feet 55 feet	>61.5 feet

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Table 1-6. Groundwater Sample Results - August 2011

Analyte[a]	USEPA RSL Resident Tap	Res RSL FoE	USEPA MCL	MCL FoE	MTCA Method B CUL	MTCA FoE	Sample Results SB04 11080101 Northwest of Landfill Site	COPC?	Rationale
	Health-Based Screening Level Comparison								
Metals (μg/L)									
Aluminum	37000	0/1	NA	--	16000	0/1	8170	N	< SLs
Arsenic	**0.045**	**1/1**	10	0/1	**0.058**	**1/1**	**2**	**Y**	**>RSL & MTCA**
Barium	7300	0/1	2000	0/1	3200	0/1	112	N	< SLs
Beryllium	73	0/1	4	0/1	32	0/1	0.21	N	< SLs
Calcium	NA	--	NA	--	NA	--	4930	N	NUT
Chromium[b]	**0.031**	**1/1**	100	0/1	48	0/1	**14.5**	**Y**	**>RSL**
Cobalt	**4.7**	**1/1**	NA	--	NA	--	**5.1**	**Y**	**>RSL**
Copper	1500	0/1	1300	0/1	640	0/1	10	N	< SLs
Iron	26000	0/1	NA	--	11000	0/1	6850	N	< SLs
Lead	NA	--	15	0/1	NA	--	3.6	N	< SLs
Magnesium	NA	--	NA	--	NA	--	2590	N	NUT
Manganese	880	0/1	NA	--	2200	0/1	275	N	< SLs
Nickel	730	0/1	NA	--	320	0/1	16.4	N	< SLs
Potassium	NA	--	NA	--	NA	--	907	N	NUT
Sodium	NA	--	NA	--	NA	--	3590	N	NUT
Zinc	11000	0/1	NA	--	4800	0/1	14.9	N	< SLs
Semivolatile Organic Compounds (μg/L)									
bis(2-Ethylhexyl)phthalate	4.8	0/1	6	1/1	6.3	1/1	4.6	N	< SLs
Volatile Organic Compounds (μg/L)									
1,3,5-Trimethylbenzene	370	0/1	NA	--	80	0/1	2.9	N	< SLs
2-Butanone (MEK)	7100	0/1	NA	--	4800	0/1	12.1	N	< SLs
4-Methyl-2-pentanone (MIBK)	2000	0/1	NA	--	640	0/1	7.8	N	< SLs
Acetone	22000	0/1	NA	--	7200	0/1	959	N	< SLs
Chloroform	**0.19**	**1/1**	80	0/1	80	0/1	**0.43**	Y	**>RSL**
Methyl tert-butyl Ether (MTBE)	**12**	**1/1**	NA	--	NA	--	**55**	Y	**>RSL**

[a]Includes only analytes detected at least once in groundwater sample

[b]In the absence of speciated chromium data, RSL and MTCA CUL are for hexavalent chromium (Cr VI) (see text); MCL is for total chromium. Chromium III screening levels are 55,000 ug/L (RSL resident tap) and 24,000 ug/L (MTCA Method B).

-- = Not applicable
COPC = chemical of potential concern
CUL = cleanup level
FoE = frequency of exceedence (number of samples that exceed screening level over total number of samples)
MCL = maximum contaminant level
MTCA = Model Toxics Control Act
NA = Not available
NUT = essential nutrient for humans
μg/L = micrograms per liter
RSL = Regional Screening Level
USEPA = United States Environmental Protection Agency

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Table 1-7. Grain Size (ASTM D 422) and Direct Sheer (ASTM D 3080) Results - August 2011

Boring ID	Depth, ft	Grain Size			Percent Finer than Designated Sieve Size, %													Direct Shear	
		Gravel, %	Sand, %	Fines, %	2.0-inch Sieve	1.5-inch Sieve	1-inch Sieve	3/4-inch Sieve	1/2-inch Sieve	3/8-inch Sieve	No. 4 Sieve	No. 10 Sieve	No. 20 Sieve	No. 40 Sieve	No. 60 Sieve	No. 100 Sieve	No. 200 Sieve	Normal Stress, psf	Maximum Shear Stress, psf
SB-01	20.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2400	2044
SB-01	25	38.3	53.4	8.3	100	94	89	83	76	71	62	50	37	23	15	11	8	---	---
SB-01	50-52	34.9	56.3	8.8	---	---	100	90	84	79	65	48	33	23	16	11	9	---	---
SB-02	22	2.0	87.3	10.7	---	---	---	---	100	99	98	96	92	74	34	16	11	---	---
SB-02	30.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3600	3755
SB-02	50.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6000	7794
SB-02	55	46.1	48.4	5.5	---	100	89	86	76	68	54	38	22	15	11	7	6	---	---
SB-03	20.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2401	2522
SB-03	21	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2400	2210
SB-03	25	36.5	53.1	10.4	---	100	86	80	780	67	64	59	52	34	18	12	10	---	---
SB-03	50	37.4	52.7	9.9	---	100	85	85	81	77	63	47	34	24	17	13	10	---	---
SB-03	57.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6800	8687
SB-04	10	12.4	83.4	4.2	---	---	100	96	95	91	88	77	59	34	14	6	4	---	---
SB-04	10.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1201	1452
SB-04	11	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1300	1756
SB-05	20	45.8	45.4	8.8	---	100	94	87	71	63	54	41	32	25	16	11	9	---	---
SB-05	25.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3000	2833
SB-05	55	1.2	87.3	11.5	---	---	---	---	---	100	99	97	93	74	36	16	11	---	---

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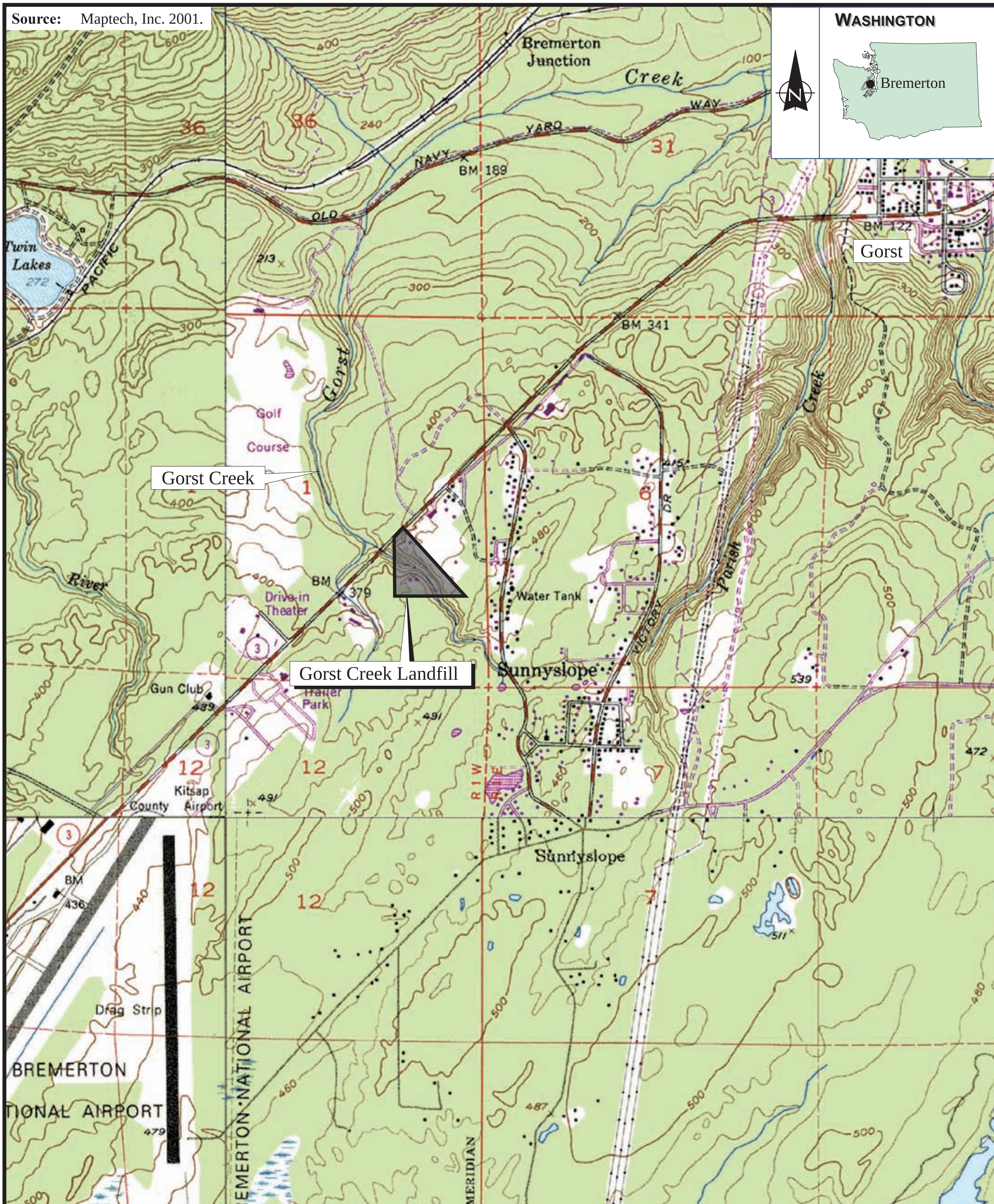
Source: Maptech, Inc. 2001.



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Seattle, Washington

GORST CREEK LANDFILL
Gorst, Washington

Figure 1-1

SITE LOCATION MAP

0 1000 2000
Approximate Scale in Feet

Date: 1-20-12

Drawn by: AES

10:START-3\10080011\fig 1-1

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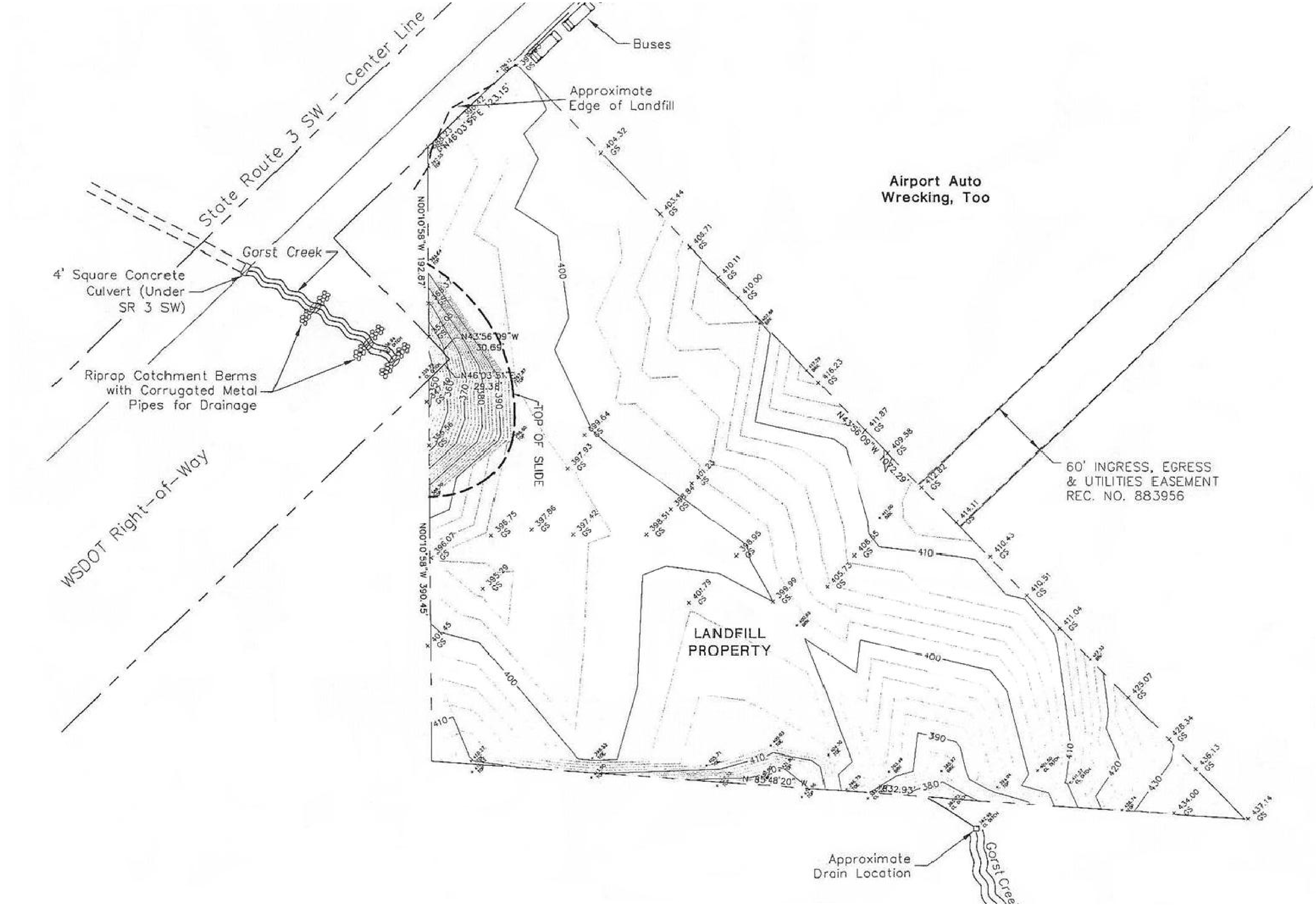

Gorst Creek Landfill

Port Orchard, Washington

Map Projection: NAD 1983 Washington State Plan North Feet

Figure 1-2A
Site Conditions 2000
(Gorst Creek EE/CA)
January 2012

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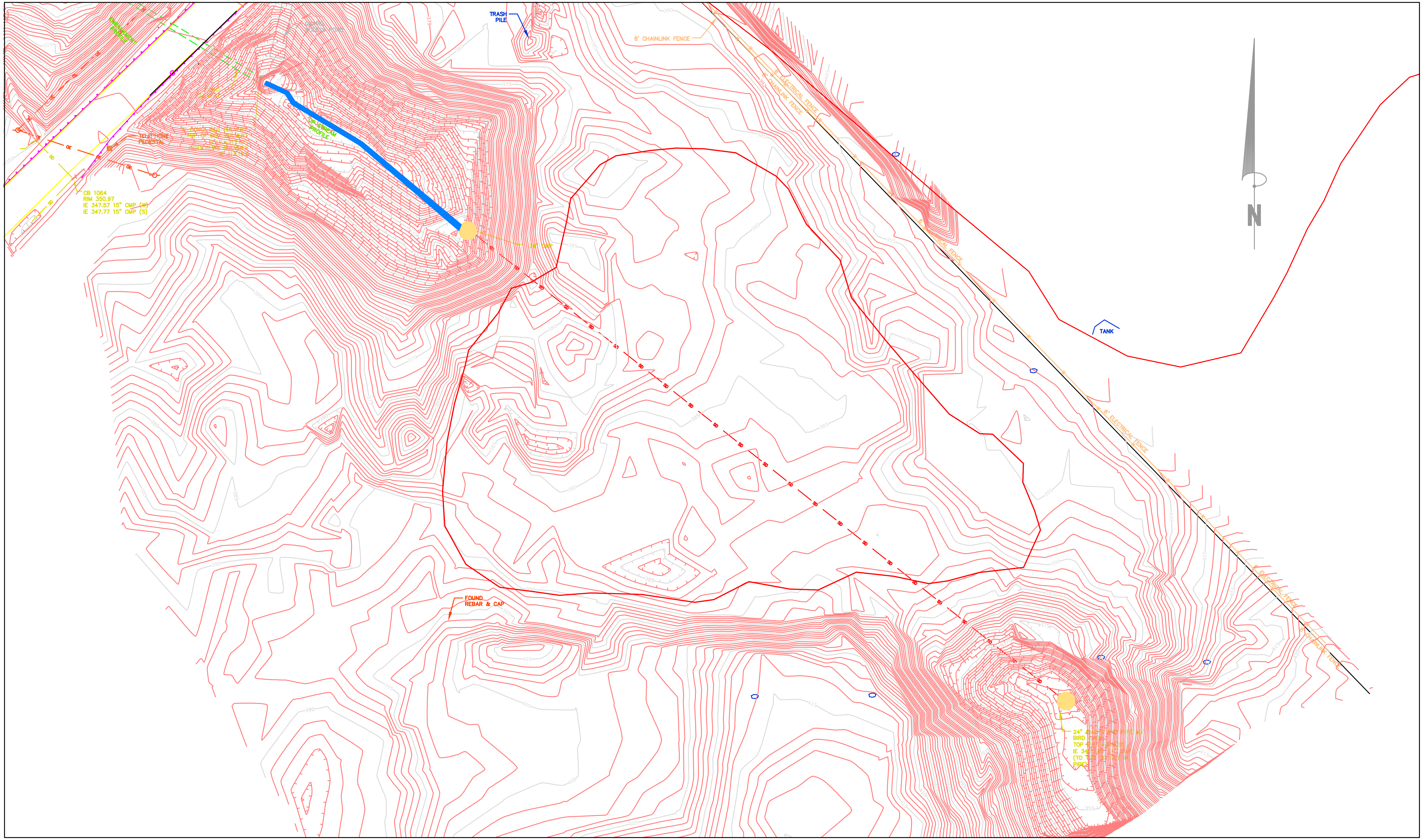

- Outfall location
- SD — Existing 24-inch corrugated metal pipe
- Gorst Creek - Bremerton Auto Wrecking landfill boundary
- Stream Profile
- Culvert

Gorst Creek Landfill

Port Orchard, Washington

SCALE IN FEET: 0, 40, 80, 120

Map Projection: NAD 1983 Washington State Plan North Feet

Figure 1-2B
Site Conditions 2011
(Gorst Creek EE/CA)
January 2012

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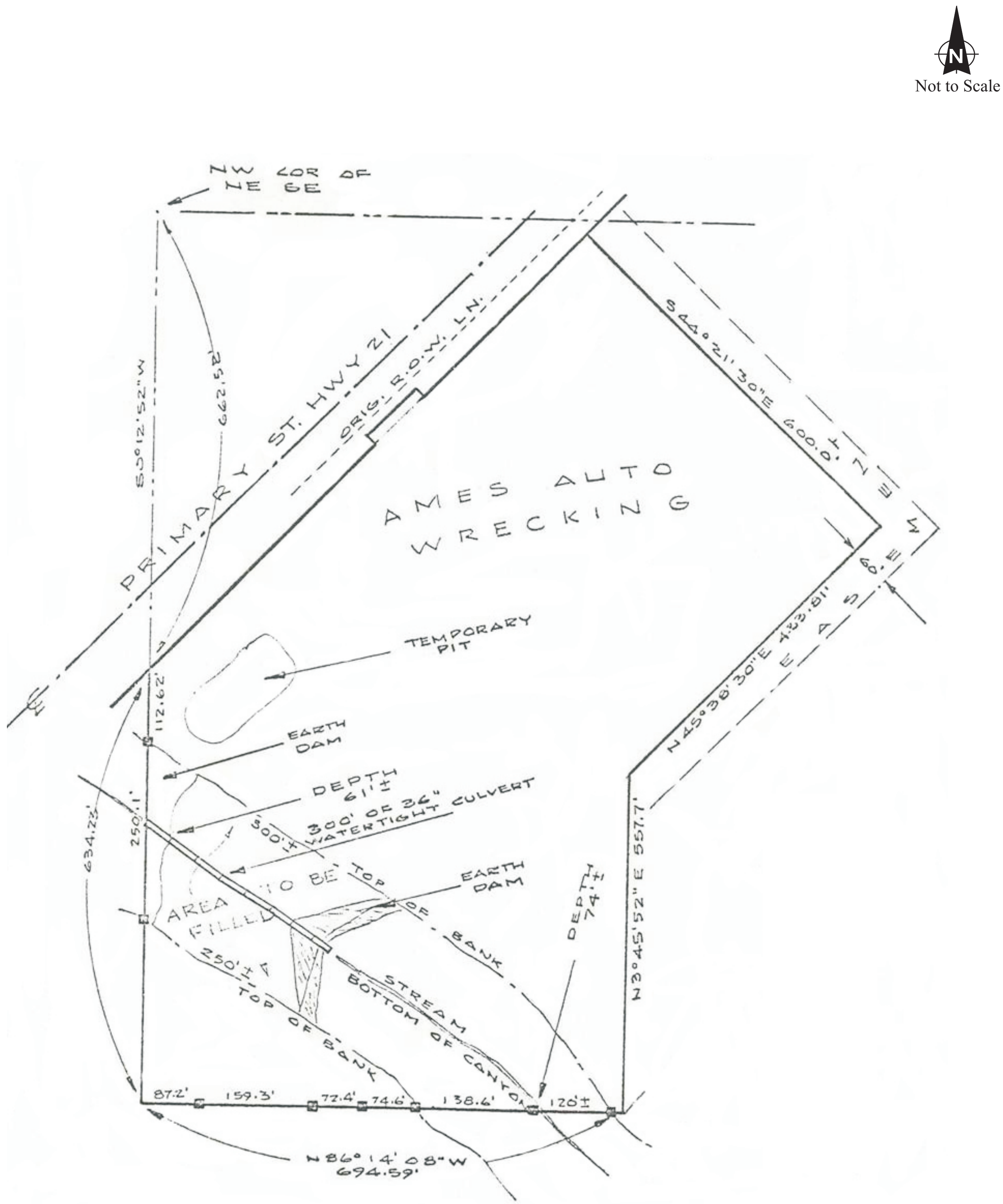

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	GORST CREEK LANDFILL Gorst, Washington	Figure 1-3 SITE PLAN (1968)		
	Source: EPA, 2002.	Date: 1-20-12	Drawn by: AES	10:START-3\10080011\fig 1-3

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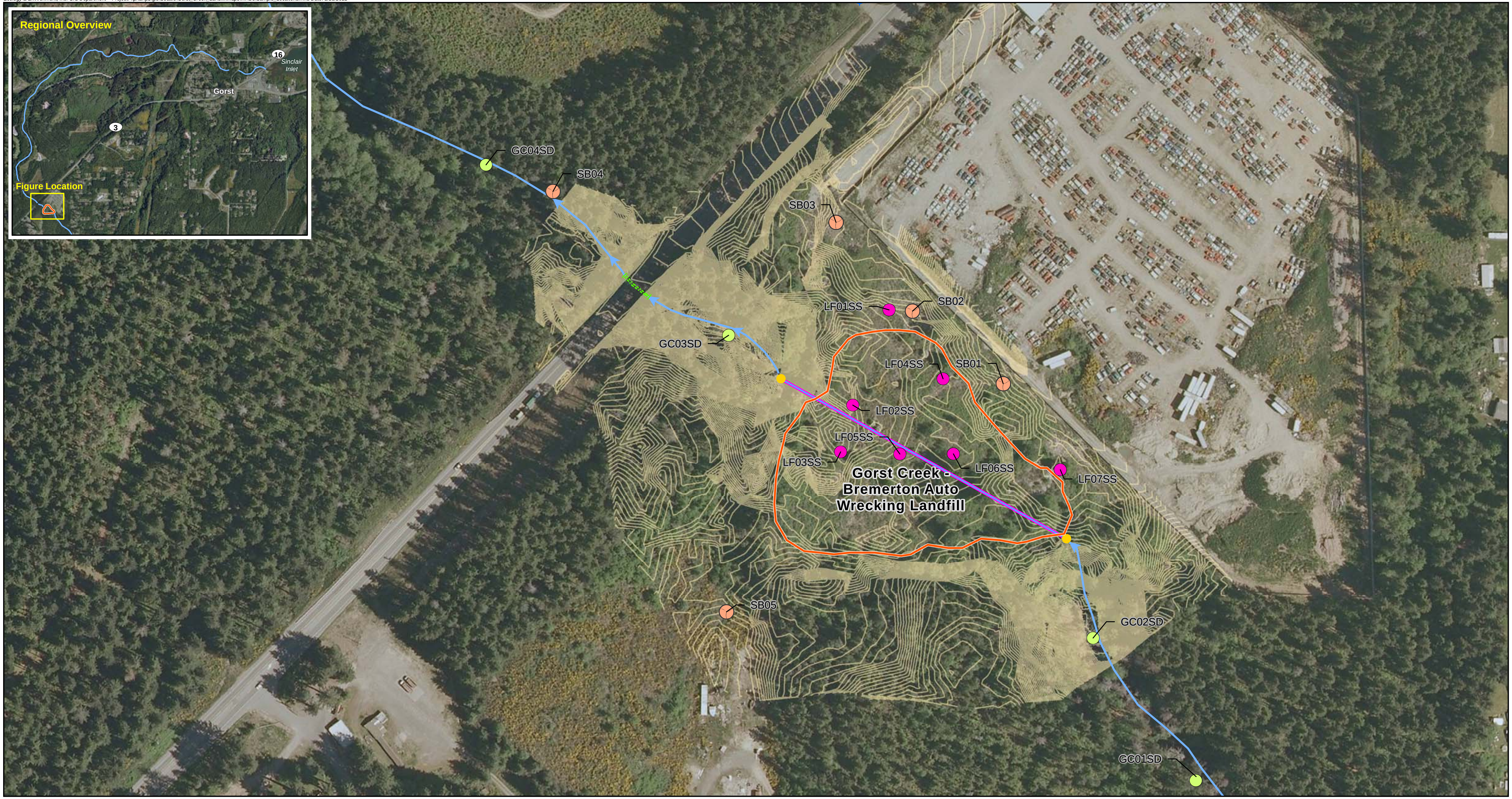
Ecology & Environment, Inc. GIS Department Project: \\prtbhp1\gis\Seattle\Gorst_Creek_Landfill\Maps\MXDs\Sample_Locaitons.mxd Date: 1/23/2012



Soil Boring Locaitons

Outfall location

G Series Samples; GC01S

24-inch corrugated metal pipe under the landfill

L Series Samples

Gorst Creek - Bremerton Auto Wrecking landfill boundary

Existing well

Gorst Creek Landfill

Port Orchard, Washington

N W E S

Map Projection: NAD 1983 UTM Zone 10N Meter
Map Scale: 1: 2,000
0 25 50 100 150 200 250
Feet
1 in = 167 ft

Figure 1-4
Sample Location Map
July - August 2011

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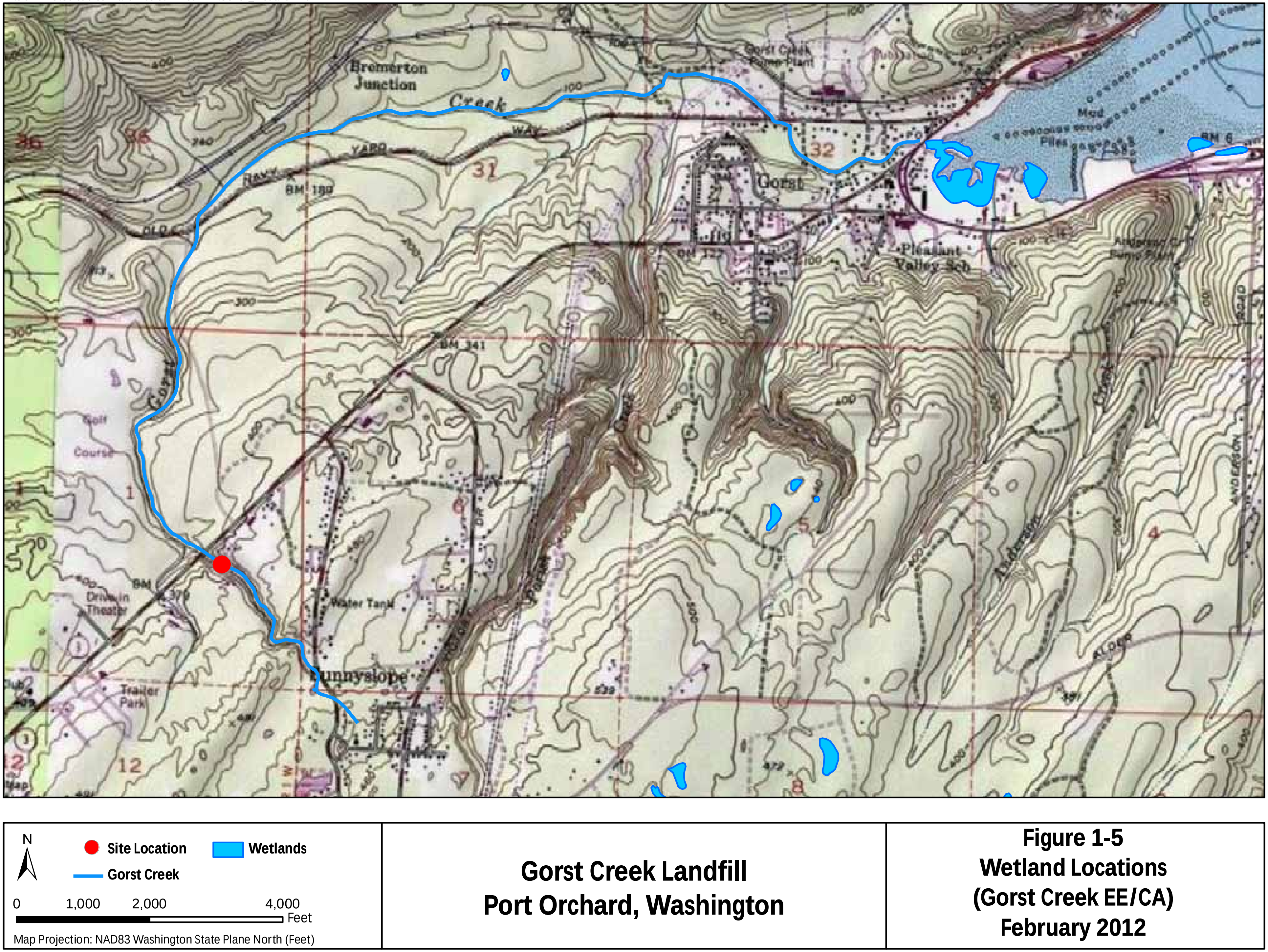

Gorst Creek Landfill
Port Orchard, Washington

Figure 1-5
Wetland Locations
(Gorst Creek EE/CA)
February 2012

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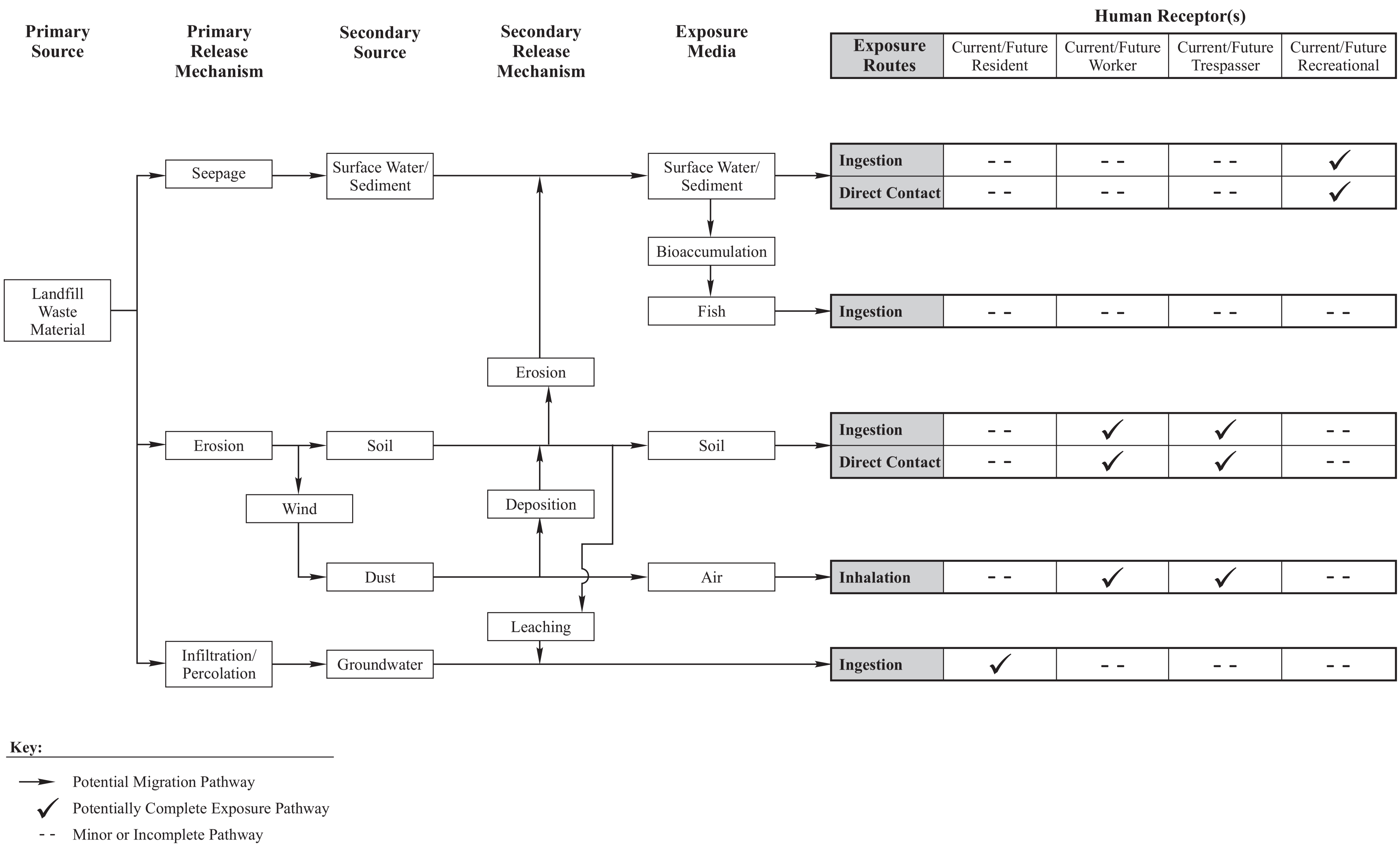

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Gorst, Washington

Figure 1-6
HUMAN HEALTH CONCEPTUAL SITE MODEL

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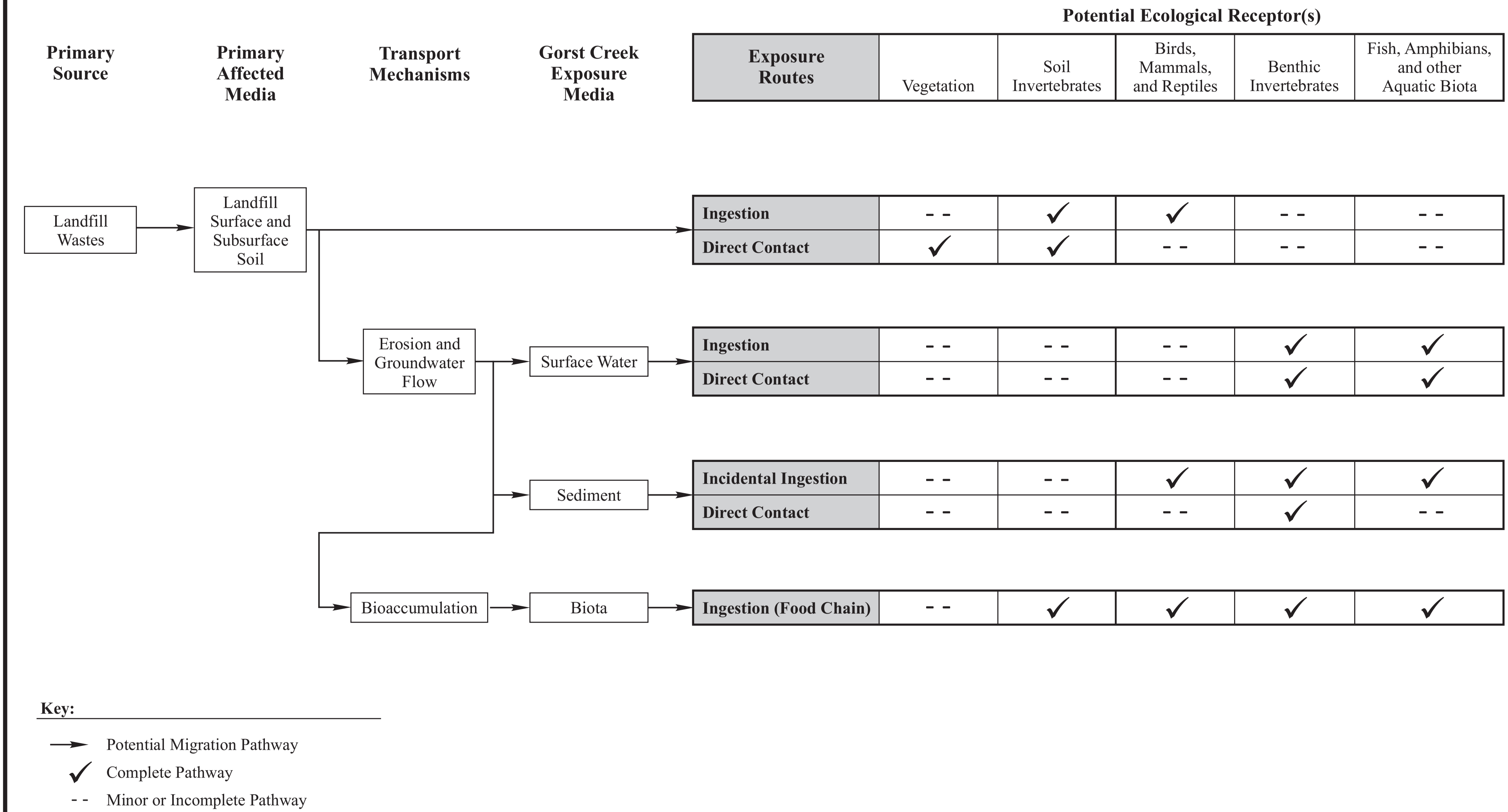

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GORST CREEK LANDFILL
Gorst, Washington

Figure 1-7
ECOLOGICAL CONCEPTUAL SITE MODEL

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2/29/12	AES	10:START-3\10080011\fig 1-7

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2 Removal Action Objectives

According to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), EPA must decide whether the Site poses a threat to public health or welfare or to the environment in order for a removal action to be conducted. If EPA determines that a threat exists, a removal action can be implemented in order to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release of hazardous substances.

This section describes the statutory considerations on removal actions, the objectives of the proposed removal action, the scope of the removal action, and compliance with potential applicable or relevant and appropriate requirements (ARARs), and the general schedule for removal activities.

2.1 Statutory Considerations on Removal Actions

Section 300.415(b)(5) of the NCP stipulates that cost and duration of a removal action be limited to $2 million and 12 months for EPA-financed removal actions. Cost and implementation time exemptions may be granted if the EPA determines that the removal action is necessary to mitigate an immediate risk to human health, welfare, or the environment or that the removal action is otherwise appropriate and consistent with an anticipated long-term remedial action. EPA funds expended to conduct an EE/CA are CERCLA §104(b)(1) monies and are not counted toward the $2 million statutory limit for removal actions.

2.2 Determination of Removal Scope and Objectives

2.2.1 Removal Action Scope

Multiple collapses in the culvert beneath the landfill has severely diminished the maximum flow capacity of the culvert. The diminished capacity of the culvert causes the creek to become impounded upstream of the landfill following significant storm events. The elevated water level within the landfill can result in saturation of landfill debris. Large storm events have resulted in the level of the impounded water reaching the upper elevation of the landfill and overtopping the landfill, saturating and eroding the soil cover. Overtopping has caused two documented slope failures on the northwest end of the landfill (approximately 300 feet southwest of State Highway 3 SW). A sudden erosion of the landfill could send a surge of landfill material downstream, potentially impacting human health and the environment or overtopping and eroding the State Highway 3 SW embankment. Furthermore, potential migration of chemicals of potential concern from the landfill could be exacerbated by the collapsed culvert and overtopping of the landfill.

The scope of the potential removal action ranges from removing the entire landfill contents to re-directing or conveying surface water flows laterally around, through, or beneath the landfill contents. The proposed removal action would protect human health and the environment from exposure to landfill refuse and associated hazardous substances by preventing the release of chemicals of potential concern, eliminating exposure pathways, and preventing contaminant migration. By completing the removal action, Gorst Creek surface water would flow unimpeded through, beneath, or adjacent to the Gorst Creek Landfill to Sinclair Inlet, thus mitigating the continued release of hazardous substances from the landfill.

The landfill contains approximately 150,000 cubic yards of waste. Removing the landfill contents would require finding a suitable landfill repository to accept the waste. The waste contents are reported to contain automobile wrecking yard waste, construction debris, medical waste, and municipal waste. If removed for off-Site disposal, these waste materials may need to be separated for disposal at separate repositories. Landfill waste would need to be examined during the removal to identify any hazardous waste components because this type of waste stream would require appropriate licensed waste transportation and landfill facilities. Examples of regulated or hazardous waste that may be present in the landfill include asbestos, medical waste, and oily residual waste.

Installing a bypass channel, siphon, or microtunneled/jacked bypass pipe would require engineering considerations (see Section 4 below).

2.2.1 Removal Action Objectives

The goal of the proposed removal action are to protect human health and the environment by preventing human and ecological receptor contact with landfill contents and associated hazardous substances, and to comply with ARARs to the extent practicable.

To achieve these goals, the following removal action objectives have been developed:

1. If the selected removal alternative is to remove the contents of the landfill and transfer them to a secure off-Site facility, then the goals of the removal action would be obtained, and no other removal action objective apply.

2. If the selected alternative involves an engineered solution that does not require the removal of the landfill contents (i.e., the landfill contents would remain in place), the following removal action objective would apply:

    - Provide sufficient hydraulic conveyance to prevent upstream surface water impoundment, thus preventing saturation of the landfill and potential for overtopping;
    - Provide measures to appropriately cover waste at the landfill; and
    - Provide measures to stabilize slopes and prevent further erosion.

2.3 Applicable or Relevant and Appropriate Requirements

Potential ARARs have been screened to aid in technology and alternative evaluation. For the removal action, on-Site actions are to comply with the substantive requirements of any identified ARARs, to the extent practicable considering the exigencies of the situation. On-Site actions do not have to comply with the corresponding procedural requirements such as permit applications, reporting, and recordkeeping. Off-Site actions are to comply with ARARs to the extent practicable considering the exigencies of the situation.

ARARs are divided into the following categories:

- **Chemical-specific requirements** are health- or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants.

- **Action-specific requirements** are controls or restrictions on particular types of activities, such as hazardous waste management or wastewater treatment. Examples of action-specific requirements would be state and federal air emissions standards as applied to an in situ soil vapor extraction treatment unit.

- **Location-specific requirements** are restrictions on activities that are based on the characteristics of a site or its immediate environment. An example would be restrictions on work performed in wetlands or wetland buffers.

Additionally, to-be-considered materials are advisories, criteria, guidance or policy documents, or proposed standards that are not legally binding but that may provide useful information or recommended procedures relevant to a cleanup action. The potential chemical-, location-, and action-specific ARARs and to-be-considered materials for the EE/CA are summarized in Appendix E.

2.4 Determination of Removal Schedule

The removal action may be initiated after approximately four to six months of design and planning and, depending on the chosen alternative, is estimated to require from three to nine months to complete. The removal alternatives described in Section 3 include estimates on the time required for implementation. The removal schedule considers "fish windows"[2] for any critical species that inhabit Gorst Creek. The schedule is also dependent upon appropriate construction weather conditions, available funding, and commitment by partners to post-removal Site maintenance requirements. The general schedule for removal activities, including both the start and completion time for the non-time-critical removal action, will be subject to determinations to be made by the EPA.

[2] A fish window is a seasonal in-water work period that coincides with construction permit restrictions intended to minimize negative impacts to critical fish species.

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3 Identification and Development of Removal Action Alternatives

3.1 Identification of Removal Action Alternatives

This EE/CA is intended to help define the scope of the removal action. Based on the analysis of the nature and extent of contamination and on the removal action objectives developed as part of the EE/CA, a limited number of removal action alternatives have been identified and evaluated against the scope of the removal action and against each specific objective. The technology alternatives that are analyzed in detail include no action; contaminant excavation and off-Site disposal with restoration of the Gorst ravine; and stabilization and covering of the landfill with alternative methods of bypassing surface water in Gorst Creek. The methods evaluated for bypassing Gorst Creek include construction of a natural bypass channel parallel to the landfill or installation of new conveyance piping beneath the landfill (microtunneling/pipe jacking). The evaluation of alternatives also takes into consideration engineering principles that would affect the passage of the creek.

Some options were considered impracticable because of various engineering and technical reasons and thus were not included with the alternatives evaluated herein. These options include rehabilitating the existing pipe or creating a bypass that impounds the water behind the landfill. The options for pipe rehabilitation include slip lining, pipe lining using various methods (close-fit lining, cured-in-place lining, cement-mortar lining, epoxy-resin lining), or excavation and targeted section repair. Options for a bypass include using siphon tubes and elevated discharge pipes.

Pipe Rehabilitation

Slip lining involves placing a new, structurally supportive, but smaller pipe into the existing pipe to restore creek flow. Since slip lining reduces the inside diameter and flow rate through the pipe, this may result in water continuing to impound behind the landfill, increasing infiltration from landfill waste and potentially leading to additional overtopping.

Pipe lining involves lining the pipe with new material but relies on the existing pipe for structural support. Since the condition of the existing pipe is known to be compromised in several areas and the remaining sections are likely deteriorated and would continue to deteriorate externally even after a lining was applied, pipe lining is not a viable option.

Excavation and targeted repair of the pipe sections is not considered viable because it results in most of the landfill being excavated, based on the known location of the identified blockage. The integrity of the remaining pipe is unknown, but it is likely that the entire pipe should be replaced.

Pipe bursting is the only method of pipeline rehabilitation and replacement that can increase the size of an existing utility without trenching. However, replacement of the pipe using pipe bursting technology is not being further evaluated because of engineering limitations. Although pipe bursting is a well-established method for trenchless replacement of most pipes, it is not a successful method for steel corrugated pipes, the type of pipe that is currently under the Gorst Creek landfill. Corrugated steel pipe does not split when the expander head is pulled through the pipe; rather it tends to accordion in on itself. This tendency causes the expander head to jam inside the pipe.

There are several options that would carry water at a higher elevation over the landfill, including siphon tubes and elevated discharge pipes. These options result in water being impounded behind the landfill which would increase infiltration through the waste material and would trigger ARARs for dam construction. Since the landfill was not constructed as a dam, structural changes, permitting, and continued inspection and reporting would be required. Therefore, any option that results in impounded water behind the dam is not included.

3.2 Development of Alternatives

To address the objectives identified in Section 2.2.1, the following potentially viable removal action alternatives have been identified:

1. No action
2. Gorst ravine restoration
3. Gorst Creek re-alignment
4. Microtunneling/pipe-jacking

Brief descriptions and analyses of the removal action alternatives are provided in the following sections. The alternatives are discussed with regard to the identified removal action objectives.

3.2.1 Alternative 1. No Action

Under this alternative, no action would be taken to alter the hydraulic conveyance to prevent upstream surface water impoundment and preclude overtopping. Additionally, exposed waste at the landfill would not be covered and slopes would not be stabilized to prevent further erosion. Because all landfill material would remain in place, the potential for continued migration (erosion and landslide) of landfill material would not be mitigated. The No Action alternative provides a baseline for comparison with the remaining alternatives evaluated in this report.

This alternative does not improve on the protection already provided by the existing cover soils, nor is it considered a permanent removal alternative because it does not reduce the toxicity, volume, or mobility of the waste through treatment. The resultant risks associated with the No Action alternative would be the same as those identified in the streamlined human health risk evaluation and the streamlined ecological risk evaluation.

3.2.2 Alternative 2. Gorst Ravine Restoration: Landfill Material Excavation, Off-Site Disposal, and Restoration of Gorst Creek

Gorst Ravine restoration includes removing all landfill contents, off-Site disposal, and restoration of the original creek channel. The landfill is 5.7 acres and contains an estimated 150,000 cubic yards of waste. Creek flow would be temporarily diverted around the landfill and away from construction activities. Figure 3-1 shows the expected configuration of the Site following implementation of Alternative 2.

Excavation of the landfill waste would likely trigger Resource Conservation and Recovery Act (RCRA) requirements if it is found that the waste exhibits characteristics of hazardous waste. Removing the landfill contents would require identifying suitable landfill repositories to accept the differing wastes. The waste contents are reported to contain automobile wrecking yard waste, construction debris, medical waste, and municipal wastes. If removed for off-Site disposal, these waste materials may need to be separated for disposal at separate repositories. Landfill waste would need to be examined during the removal to identify any hazardous waste components, which would be segregated into the appropriate waste stream and disposed of at an appropriately licensed facility. Examples of hazardous waste could be asbestos-containing material, PCBs, medical waste, and oily residual waste.

This alternative improves on the protection provided by the existing cover soils and is considered a permanent on-Site removal alternative because it reduces the toxicity, volume, and mobility of the waste on the Site. It does not eliminate the toxicity, volume, and mobility of the waste through treatment, and therefore the off-Site facility where it is accepted takes on this liability. The resultant risks associated with the Gorst Creek and ravine restoration alternative would be less than those identified in the streamlined human health risk evaluation and the streamlined ecological risk evaluation.

3.2.3 Alternative 3. Gorst Creek Re-alignment: Install a Lateral Bypass Channel

In this alternative, Gorst Creek would be re-aligned to flow around the southern and western boundary of the landfill by constructing a new channel. The landfill contents would not be removed. Figure 3-2 shows the location of Gorst Creek in relation to the landfill following re-alignment. AutoCAD Civil 3D was used to determine the optimum channel location, channel slope, and side slopes. Due to the existing terrain and anticipated soil type, it was assumed for cost estimating purposes that the average depth of required excavation would be 60 feet and the required channel profile would have 3 to 1 (horizontal to vertical) side slopes. The approximate length of the channel is estimated to be 1,300 feet, which would require excavating approximately 500,000 cubic yards of soil. A portion of the excavated soil would be redistributed and used to restore the landfill surface (see Section 3.3.1). The remaining excavated soil would be taken to an off-Site borrow source facility. Creek flow would be temporarily diverted around the landfill and away from construction activities. Following completion of the creek re-alignment the existing pipe would be plugged with a cement grout.

To minimize erosion, a layer of cobblestone would be installed on the bottom of the channel, below the anticipated high water flow line. A portion of the trees that would be removed as part of excavation activities would be placed around the creek bends and serve as erosion control. Bendway weirs and other flow-altering features would be constructed to minimize erosion. Other long-term erosion protection measures may include plantings, erosion control fabric, seeding, and mulch. Excess trees would be chipped on-Site and used to restore the landfill surface. It is anticipated that the bypass channel would have more than enough capacity to convey and contain the 100-year peak storm event within the channel banks, given the proposed channel geometry; flooding of adjacent properties is highly unlikely under this design.

This alternative improves on the protection already provided by the existing cover soils, but is not considered a permanent removal alternative because it does not reduce the toxicity, volume, or mobility of the waste through treatment. The short-term mobility of waste material would be lessened because the landfill slopes would be stabilized and potential overtopping would be prevented. The resultant risks associated with Alternative 3 would be less than those identified in the streamlined human health risk evaluation and the streamlined ecological risk evaluation.

3.2.4 Alternative 4. Microtunneling/Pipe Jacking: Install Conveyance Pipe

In this alternative, a new culvert would be installed under the landfill via microtunneling/pipe-jacking to allow Gorst Creek to pass beneath the landfill. Figure 3-3 shows the potential location of the new pipe in relation to the landfill following construction. Microtunneling is a trenchless construction method that consists of digging the launch shaft, installing the jacking frame and tunneling machine, lowering pipes to the jacking frame, and advancing them (see Figure 3-4). Excavated tunnel spoils are removed from the tunnel via a closed loop slurry and slurry cleaning system.

The launch shaft would be located at the downstream end of the landfill, between the landfill and State Route 3. It would be excavated and reinforced with sheet piling to support the jacking frame and the generated forces. Once microtunneling operations began, sections of pipe would be lowered to the jacking frame with a crane, seamed to the previous pipe, and pushed behind the tunneling machine. This would be repeated until the pipeline reached the inlet location approximately 880 feet upstream from the outlet. The exact location of the new pipe would be determined in the final engineering design for the alternative.

Kitsap County requires conveyance systems to be designed to have the capacity to contain and transport the 100-year peak storm event (Kitsap County 2010). Based on this requirement, the pipe size recommended to be placed under the Site would meet the requirement. The proposed pipe size, 32 inches at minimum, is larger than the existing, failed 24-inch pipe and would provide a significantly greater conveyance capacity than the original design and would reduce the potential for surface water backing up and eroding the landfill embankment.

Appendix F contains the hydrologic and hydraulic calculations that determine the size of pipe required. A 32-inch diameter pipe was chosen as the required size for passing flow if contained gravity flow of Gorst Creek flow is part of the alternative. A 32-inch pipe can convey the 500-year flood at 100% capacity. The 1997 event that caused significant damage appears to have been a 500-year flood (based on precipitation depths frequency), so this pipe size should handle extreme events to reduce impoundment and potential overtopping with erosion on the upstream end of the landfill. Final design of this alternative would include a thourough hydraulic study and modeling to ensure adequate flow capacity for the design minimum storm event to prevent water impoundment behind the landfill and the triggering of Washington dam ARARs.

All necessary equipment and materials related to microtunneling/pipe-jacking operations would be transported to the launch shaft location via an access road leading from State Route 3 to a staging pad that would be constructed next to the launch shaft location. An access road leading to the exit location of the tunneling machine would also be constructed. Earthwork and armoring at the inlet and outlet of the drainage pipe would ensure proper entry and exit of flow. The pipe is anticipated to require an offset from the original pipe to avoid potentially large, dense debris that could have been placed near or against it. The offset would also prevent drilling through landfill waste, which might then require off-Site disposal.

Material from excavation of the jacking and receiving bore pits and channel restoration would be redistributed and used to restore the landfill surface (see Section 3.3.1 below). Creek flow would be temporarily diverted around the landfill and away from construction activities. Following completion of the new conveyance pipe installation the existing pipe would be plugged with a cement grout.

This alternative improves on the protection already provided by the existing cover soils but is not considered a permanent removal alternative because it does not reduce the toxicity, volume, or mobility of the waste through treatment. The short-term mobility of waste material would be lessened because the landfill slopes would be stabilized and potential overtopping would be prevented under most precipitation events. The resultant risks associated with Alternative 4 would be less than those identified in the streamlined human health risk evaluation and the streamlined ecological risk evaluation.

ARARs would necessitate continued monitoring of the cover. The Site would also require periodic inspections to ensure that the channel remains free of debris that could potentially clog the pipe. If the flow through the pipe became impaired, maintenance would be required to return it to a free-flowing condition.

3.3 Common Components of Alternatives

With the exception of Alternative 1 (No Action) and, in some instances, Alternative 2 (Gorst ravine restoration), each of the removal action alternatives would use similar construction methods and/or require similar actions. These common components are identified and described below.

3.3.1 Landfill Surface Restoration

Alternatives 3 and 4 would restore the downstream landfill slope. As part of the landfill slope restoration activities, the downstream slope would be laid back at a 3 to 1 (horiontal to vertical) slope in the previously eroded area and slope drains would be installed to remove stormwater from the top of the slope. The cost is anticipated to be the same under both alternatives.

Alternatives 3 and 4 include the restoration of the landfill cover. The cost for landfill surface restoration activities is anticipated to be the same under both alternatives.

As part of the landfill surface restoration activities, the entire landfill surface would be inspected for visible waste and eroded areas. A crew of laborers and an operator with a crawler loader could accomplish the task. Restoration activities would include knocking down vegetation to allow for visual inspection of the landfill surface and removal of exposed waste on landfill surface. The recovered waste would be transported to an off-Site disposal facility. Eroded areas would be backfilled with soil, graded, and seeded. For cost estimating purposes, it was assumed that 20 tons of waste would be removed and require disposal, 10% of the landfill surface would require one foot of imported soil to repair the erosion damage, and 25% of the landfill surface would require seeding. Seeding would be accomplished through hydroseeding.

Restoration activities would also include laying back the downstream slope of the landfill surface at a 3 to 1 (horizontal to vertical) slope in the previously eroded areas, and installing slope drains to direct stormwater from the top of the slope.

3.3.2 Access Road

As part of all removal alternatives, except for the No Action alternative, an access road would be constructed to allow heavy equipment to access the Site. For cost estimating purposes, it was assumed that the length of the access road would be 1,500 feet. Access road construction activities would include clearing, grading, compaction, and placement of a gravel course suitable for heavy equipment. The amount of traffic this road would carry under each alternative varies, so costs for access road maintenance also vary.

3.3.3 Best Management Practices

Best management practices (BMPs) will be implemented to control for potential short-term cleanup-related impacts such as air emissions, erosion and sediment control, and noise levels, along with BMPs for achieving EPA's Region 10 Clean and Green Policy. Specific BMPs would be determined during design.

3.4 Analysis of Removal Action Alternatives

The individual analysis of alternatives is intended to provide the relevant information required to select a removal alternative. The evaluation of alternatives was conducted using EPA's evaluation criteria, which are listed in the guidance for conducting an EE/CA (EPA 1993). These criteria are:

Effectiveness - This criterion refers to the ability of each alternative to meet the removal action objectives as well as fulfill the following:

- Overall protectiveness of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term impacts and effectiveness.

Implementability - Each alternative is evaluated to determine the degree of difficulty in construction, scheduling considerations, compliance with applicable regulations, coordination with regulatory agencies, and off-Site treatment, storage and disposal requirements. The following criteria are used to evaluate implementability of the alternatives:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials
- State acceptance

- Community acceptance.

Cost- An estimate of direct and indirect capital costs and future costs are also considered in the evaluation. Cost is a factor in comparing alternatives that provide similar levels of protection.

It should be noted that the final two implementability criteria (state and community acceptance) are used to modify the selection of an alternative. Therefore, these two criteria are not used in the current evaluations with the exception of Alternative 1. Only the No Action alternative uses these two criteria, which are based upon anticipated acceptance given the current conditions at the Site. A public comment period will be used to gauge actual State and community acceptance and the evaluations will be modified based upon actual responses.

The remaining implementability criteria are used as the basis of the individual analysis, which will provide in-depth information that can be used in selecting an interim removal action alternative for implementation. The individual evaluation makes use of the following five-point scaling system:

Table 3-1 Five-Point Scaling System

Score	Rating
1	Unacceptable
2	Poor
3	Acceptable
4	Superior
5	Excellent

Thus, if an alternative scores a “1” on this scale with regard to a particular criterion, it is assumed that it does not meet the requirements or is unacceptably poor; if it scores a “2” than its performance against the criterion is considered inferior, etc.

Removal action alternatives in this section have been evaluated using the best available information. Technical information was gathered from vendors, available EPA guidance documents, and cost estimating publications such as RS Means Heavy Construction Cost Data.

3.4.1 Alternative 1. No Action

The no action alternative was evaluated in order to provide a baseline against which the other alternatives can be compared. Under this alternative no action would be taken to alter the hydraulic conveyance to prevent upstream surface water impoundment and prevent overtopping; exposed waste would not be covered; and slopes would not be stabilized. The landfill material would remain at the Site without mitigating the potential for continued erosion of the landfill and migration of landfill debris downstream along Gorst Creek.

No Action Effectiveness: The protection of human health and the environment is not provided by this alternative, as levels of contaminants and existing and future risks to human health and the environment would remain unchanged. The potential would still exist for landfill debris to be carried downstream during heavy precipitation events.

ARARs would not be met. Requirements for solid waste and dangerous waste would not be met under this alternative and no post-closure care requirements would be implemented. Since construction would not occur, the action specific ARARs would not apply. No location specific ARARs are applicable.

Alternative 1 offers no long-term effectiveness or permanence. Additionally, this alternative provides no reduction in the toxicity, mobility, or volume of contaminants through treatment. There would be no short-term impacts and effectiveness since no work would occur at the Site.

Effectiveness Rating 1: Unacceptable. Contamination would remain on-Site and no additional measures would be taken to reduce the potential for landfill debris migrating downstream. Because the current hydraulic conveyance, erosion potential, and current slopes have proven unacceptable, this alternative would not achieve the removal action objectives.

No Action Implementability: This alternative is readily implementable based on technical feasibility, administrative feasibility, and the availability of services because there are no technologies that have to be implemented, administrative coordination is not required, and there are no labor, equipment, material or laboratory services to be obtained.

The potential to adversely affect downstream receptors when a large precipitation event occurs is highly likely and considered inevitable. State and community acceptance of this alternative are not expected to rate it above unacceptable.

Implementability Rating 1: Unacceptable. Although this alternative does not require any construction or coordination and appears highly implementable, continued deterioration of the landfill will follow and will require future action to mitigate environmental damage; therefore, the implementability of this alternative is rated unacceptable.

No Action Cost: $0. The current cost is non-existent because no work would occur under the alternative. Although no future cost was calculated, the ineffectiveness of the removal alternative likely results in future overtopping of the landfill. This would lead to erosion of the landfill cover and eventual failure of the downstream slope, sending landfill contents throughout the Gorst Creek channel. The cleanup efforts would be extensive and would come at a higher cost than if the removal action objectives were achieved while the landfill waste remained accessible.

Cost Rating 1: Unacceptable. Although there are no present costs associated with this alternative, the anticipated future costs that would result from inaction make this an unacceptable rating.

3.4.2 Alternative 2. Gorst Ravine Restoration

This alternative involves removal of all landfill material (approximately 150,000 cubic yards) and restoration of the ravine/creek to its natural condition. If the selected removal alternative is to remove the contents of the landfill and transfer them to a secure off-Site facility, then the removal action objectives would be achieved.

Gorst Ravine Restoration Effectiveness: Removal of all landfill waste and restoring Gorst Creek to its original configuration would mitigate possible exposure pathways and prevent future landfill debris migration that could result from overtopping of the landfill. This alternative is effective in protecting human health and the environment.

Meeting most ARARs is achievable under this alternative. Since the removal of the landfill debris is unlikely to remove all contaminants that may be present, this alternative would likely meet ARARs for the Site only if additional post-removal cleanup alternatives and monitoring are implemented. While the landfill material would be removed, certain ARARs related to landfill closure (i.e., long-term groundwater monitoring) may be required.

The long-term effectiveness and permanence of the removal alternative effectively meet the removal action objectives. Furthermore, by removing landfill contents from the Site, a significant reduction in on-Site toxicity, mobility, and volume would be achieved; however, it should be noted that toxicity, mobility, and volume concerns would be transferred to the off-Site disposal facility.

Short-term potential risks should be considered as workers and adjacent properties may be exposed to contaminated media during excavation and transportation of landfill material. Truck traffic along the highway next to the Site would increase significantly and noise, dust, and odor may prove problematic to control. Additionally, BMPs would need to be put in place to ensure excavation and creek restoration activities do not cause significant increases in contaminated sediment downstream of the landfill. All construction-related ARARs would have to be met during the removal, including ARARs associated with hazardous waste shipping and disposal, which would be met through appropriate facility selection and transportation methods.

Effectiveness Rating 4: Superior. Because all contamination would be removed from the Site under this alternative all removal action objectives would be met. Some short-term potential hazards from construction and transportation activities are expected, and the overall long-term risks associated with the hazardous material at the Site would be displaced to an off-Site disposal facility.

Gorst Ravine Restoration Implementability: Implementation of this alternative is technically and administratively feasible. It is anticipated that labor and equipment is readily available for excavation and restoration activities. Trucking would be a major component of this alternative and staging trucks before loading would likely present the largest of the operational challenges.

Implementability Rating 3: Acceptable. Excavation and restoration activities are easily implemented; however, a large quantity of landfill waste would need to be transported and disposed off-Site. The time frame for the completing the removal is anticipated to be six months.

Gorst Ravine Restoration Cost: $34,080,000. It would be necessary to find a nearby disposal facility that has the capacity to accept the type and volume of waste material that may be excavated to keep this alternative cost-effective. Other methods of hauling the waste may also be available if trucking all the way to a disposal facility is not feasible. Future costs were not calculated but would involve continued monitoring as required by ARARs. Details of this cost are presented in Appendix G.

Cost Rating 1: Unacceptable. The cost for this alternative is high.

3.4.3 Alternative 3. Gorst Creek Re-alignment

This alternative involves excavating a lateral bypass channel around the landfill at stream grade and leaving the existing culvert in place but abandoned. To implement this removal alternative, the channel would have to be approximately 60 feet deep in order to provide a consistent channel slope transition between the existing stream elevation just upstream of Gorst landfill and the inlet elevation at State Highway 3. With 3 to 1 (horizontal to vertical) side slopes and a 10-foot wide channel bottom, the top of the cut would have to be approximately 210 feet wide. The existing culvert would be abandoned in place (e.g., filled with a cement grout) to prevent infiltration into the pipe with a direct channel to Gorst Creek. This alternative would achieve the Site removal action objectives.

Gorst Creek Re-alignment Effectiveness: Alternative 3 would reduce the potential for backup and overtopping of the landfill during significant storm events by providing a new primary pathway for streamflow. The diversion of Gorst Creek to the bypass channel would reduce surface water contact with contaminated material and prevent further erosion of the landfill embankments, which in turn mitigates the potential for migration of landfill waste. By preventing further erosion and slope failure this alternative is effective in protecting human health and the environment.

ARARs related to landfill closure would not be met. Requirements for solid waste and dangerous waste would not be met under this alternative and no post-closure care requirements would be implemented. Construction-related ARARs would apply and would be met. No location-specific ARARs are applicable.

The bypass channel would be a permanent feature and would offer long-term effectiveness. The on-Site mobility of landfill debris due to erosion would be drastically reduced, but treatment options to reduce mobility, toxicity, or volume of contamination would not be implemented. Additionally, the landfill cover would be repaired to a 12-inch depth of soil with vegetative cover and would not be otherwise improved upon except to prevent erosion and landslide potential.

Short-term impacts include a potential influx of sedimentation to Gorst Creek downstream of the bypass channel during installation. BMPs would be put in place during the implementation of this alternative to ensure excavation and creek restoration activities do not cause significant increases in contaminated sediment in the surface waters of Gorst Creek downstream of the landfill. No landfill material should be disturbed or removed from the Site during construction of the bypass channel, so there are no additional short-term risks associated with on-Site contamination. Excess soil would be removed from the Site. This soil is anticipated to be uncontaminated and can be beneficially used but would lead to a significant increase in truck traffic along the highway.

Effectiveness Rating 3: Acceptable. This alternative would reduce the potential for landfill waste to migrate downstream and reduce impacts on the integrity of the landfill embankments; however, landfill material would remain on-Site. Not all ARARs would be met.

Gorst Creek Re-alignment Implementability: Implementation of this alternative is feasible as labor and equipment is readily available for excavation and channel construction activities; however, given the Site topography, construction of the channel may be difficult and would produce a significant amount of excavated material. Some of the excavated material can be used to restore the landfill embankments; however, it would be necessary to find a nearby beneficial use for the remainder of the soil.

Administrative feasibility is uncertain because the channel cannot be placed on the parcel of land containing the landfill. Additional property south and west of the landfill would have to be acquired. The ability to acquire the land would affect project scheduling.

Implementability Rating 2: Poor. Although constructing the bypass channel is feasible and would use common construction practices, the Site terrain and hydraulic requirements of Gorst Creek mean that a substantial quantity of material would be excavated and transported off-Site. The new channel also would be positioned off-Site, which requires that property be acquired.

Gorst Creek Re-alignment Cost: $8,520,000. Costs for land acquisition are not included in this cost. In order to keep this alternative cost-effective, given the quantity of soil required for removal, a nearby beneficial use needs to be identified. Future costs were not calculated, but would involve continued monitoring as required by ARARs. Details of this cost are presented in Appendix G.

Rating 3: Acceptable. This cost can fluctuate based on options for beneficial use soil and on land acquisition.

3.4.4 Alternative 4. Microtunneling/Pipe Jacking

This alternative involves installing approximately 880 feet of new conveyance piping (i.e., culvert) beneath or through the landfill at approximately the existing stream grade. A 32-inch diameter or larger pipe would be installed using horizontal jacking and auger-boring. The jacking and receiving bore pits would need to be continuously dewatered during the installation and be of sufficient size to accommodate the pipe segments and jacking/augering machinery. The pipe would need to be of sufficient size to convey the Gorst Creek flow during significant storm events and be of sufficient strength to prevent collapse from the landfill overburden. The existing culvert would be abandoned in place (e.g., filled with a cement grout) to prevent infiltration into the pipe with a direct channel to Gorst Creek. This alternative would achieve the Site removal action objectives.

Microtunneling/Pipe Jacking Effectiveness: Pipe installation through horizontal jacking would reduce the potential for backup and overtopping of the landfill during significant storm events by providing a new primary pathway for streamflow under Gorst Landfill. This alternative would prevent further erosion of the landfill embankments and in turn mitigate the potential for migration of contaminated waste, making it effective in protecting human health and the environment.

ARARs related to landfill closure would not be met. Requirements for solid waste and dangerous waste would not be met under this alternative and no post-closure care requirements would be implemented. Construction-related ARARs would apply and would be met. No location-specific ARARs are applicable.

The conveyance pipe would be a permanent feature and would offer long-term effectiveness up to the expected life of the pipe material (pipe material would be chosen during design, but high-density polyethylene (HDPE) pipe has a life expectancy of at least 100 years). The on-Site mobility of landfill debris due to erosion would be drastically reduced but treatment options to reduce mobility, toxicity, or volume of contamination would not be implemented. Additionally, the landfill cover would be repaired to a 12-inch depth of soil with vegetative cover and would not be otherwise improved upon except to prevent erosion and landslide potential.

Short-term impacts on workers and adjacent properties should be minimal under this alternative because pipe-jacking utilizes subgrade pipe placement technologies. No landfill material would be removed from the Site under this alternative and protocols associated with minimizing dust generation during excavation and transportation activities would be incorporated in the removal design to ensure that all appropriate mitigation measures are satisfied. Additionally, BMPs would need to be put in to place during the implementation of this alternative to ensure excavation activities associated with the temporary trenches required for the pipe-jacking equipment do not cause significant increases in sediment in the surface waters of Gorst Creek downstream of the Site.

Rating 3: Acceptable. This alternative would reduce the potential for landfill contents to migrate downstream and reduce impacts on the integrity of the landfill embankments; however, landfill waste would remain on-Site. Not all ARARs would be met.

Microtunneling/Pipe Jacking Implementability: This alternative is both technically and administrative feasible. Labor and equipment is readily available for microtunneling/pipe-jacking because this is an industry-accepted procedure for pipe placement. Some of the excavated material from the equipment trenches can be used to restore the landfill embankments; however, it may be necessary to find an additional source of fill material to stabilize the slope of the landfill. Additional geotechnical information would be needed to determine if the Site soils in the intended location of placement are suitable for this pipe installation method.

Rating 4: Superior. This alternative can be implemented at the Site without removal and disposal of large quantities of material or disturbance of landfill material. Additionally, it is anticipated that no property acquisition would be required for pipe placement.

Microtunneling/Pipe Jacking Cost: $2,630,000. Details of this cost are presented in Appendix G. Future costs were not calculated, but would involve continued monitoring as required by ARARs. The Site would also require periodic inspections to ensure that the channel remained free of debris that could potentially clog the pipe. If flow through the pipe was found to be impaired, maintenance would be required to return it to a free-flowing condition.

Rating 5: Excellent. The cost of this alternative is low. The alternative does not rely on excavating, hauling, and disposal of significant amounts of material, which should reduce escalating costs.

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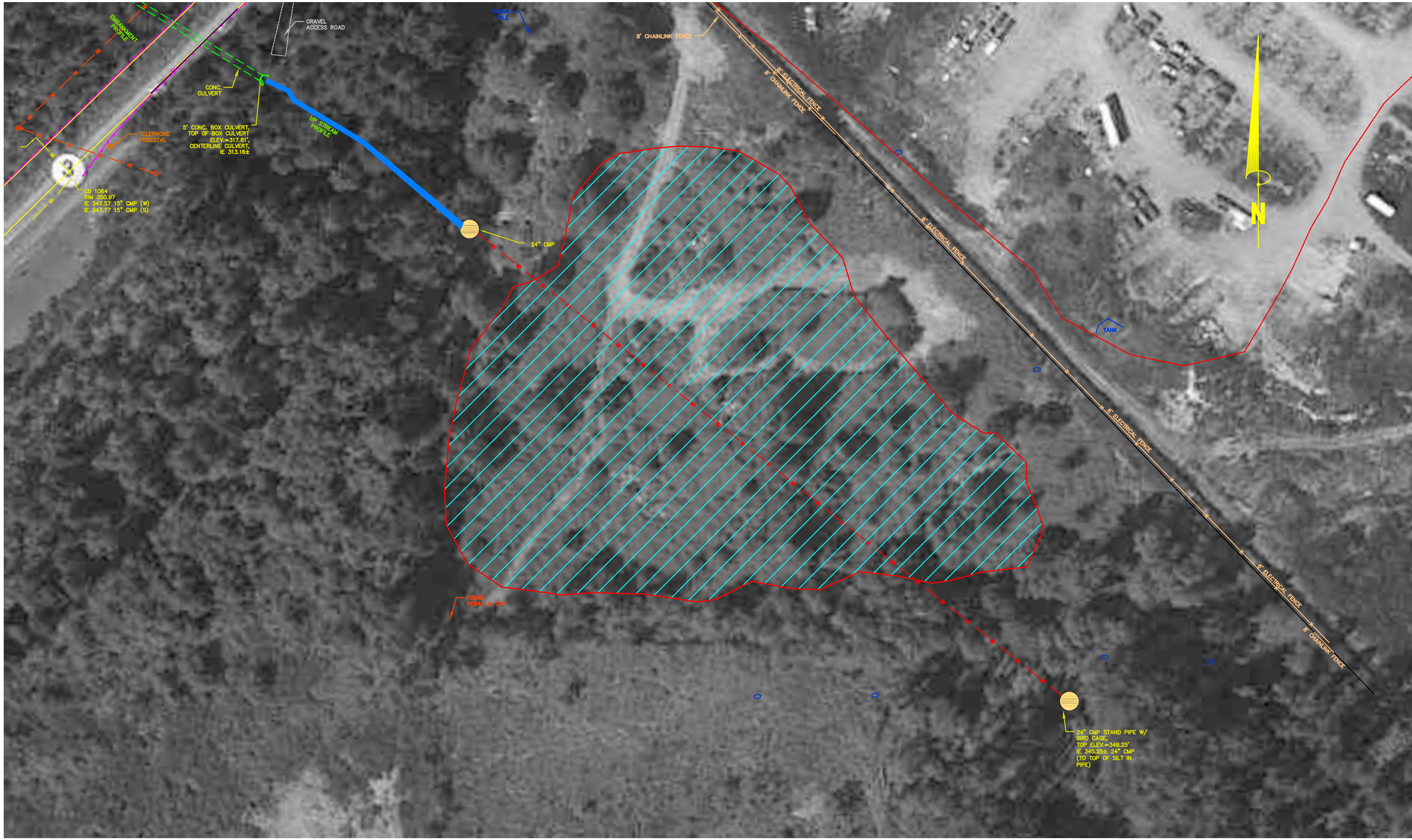

Outfall location
Existing 24-inch corrugated metal pipe
Gorst Creek - Bremerton Auto Wrecking landfill boundary
Landfill Removal Area
Stream Profile
Culvert

Gorst Creek Landfill

Port Orchard, Washington

SCALE IN FEET: 0 40 80 120

Map Projection: NAD 1983 Washington State Plan North Feet

Figure 3-1
Alternative 2 - Landfill Removal
(Gorst Creek EE/CA)
January 2012

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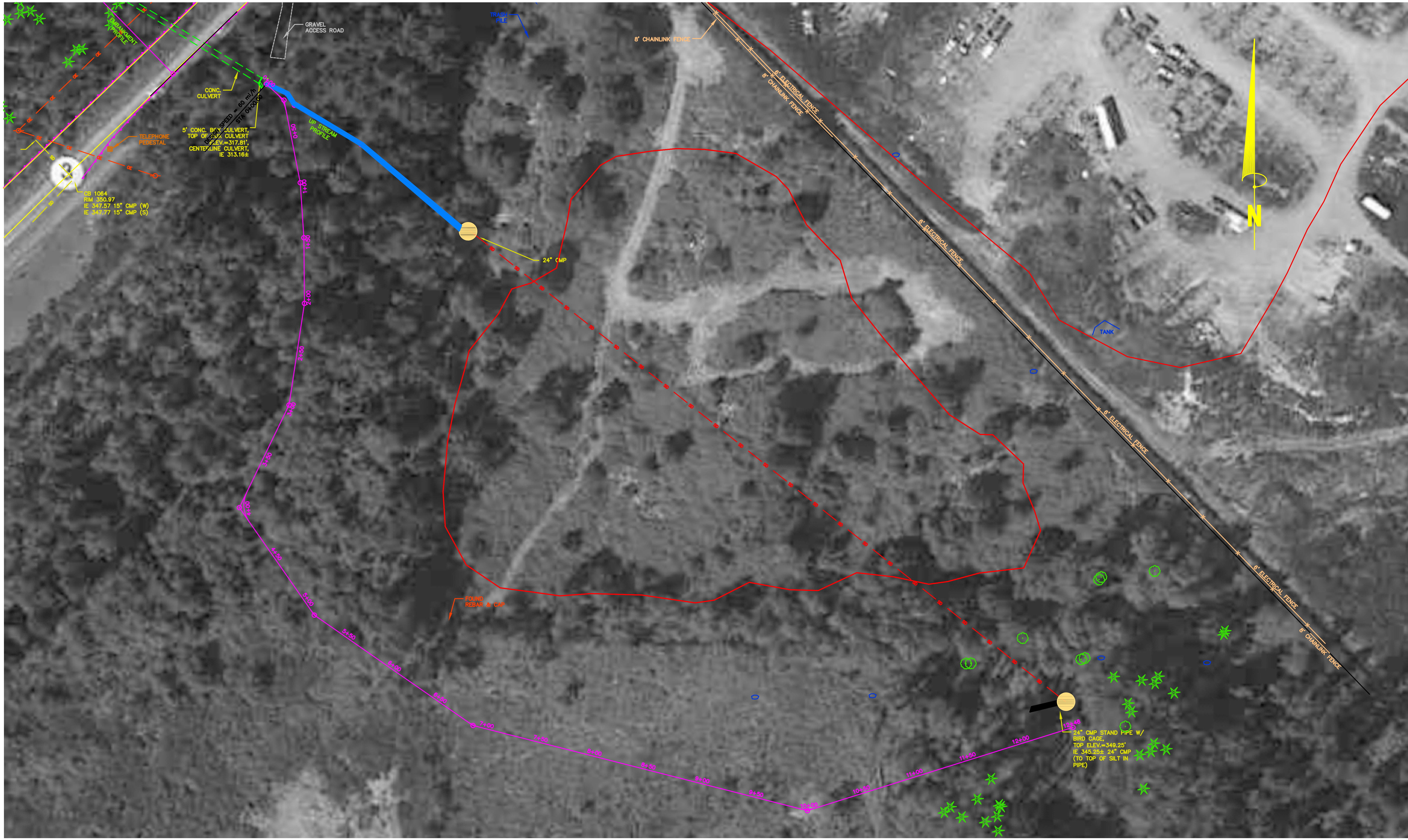

(orange dot)	Outfall location
— SD — SD —	Existing 24-inch corrugated metal pipe
60+00 50+00	Creek Realignment
(blue line)	Stream Profile
(green symbol)	Culvert

Gorst Creek Landfill

Port Orchard, Washington

N W E S

SCALE IN FEET 0 40 80 120

Map Projection: NAD 1983 Washington State Plan North Feet

Figure 3-2
Alternative 3 - Creek Re-alignment
(Gorst Creek EE/CA)
January 2012

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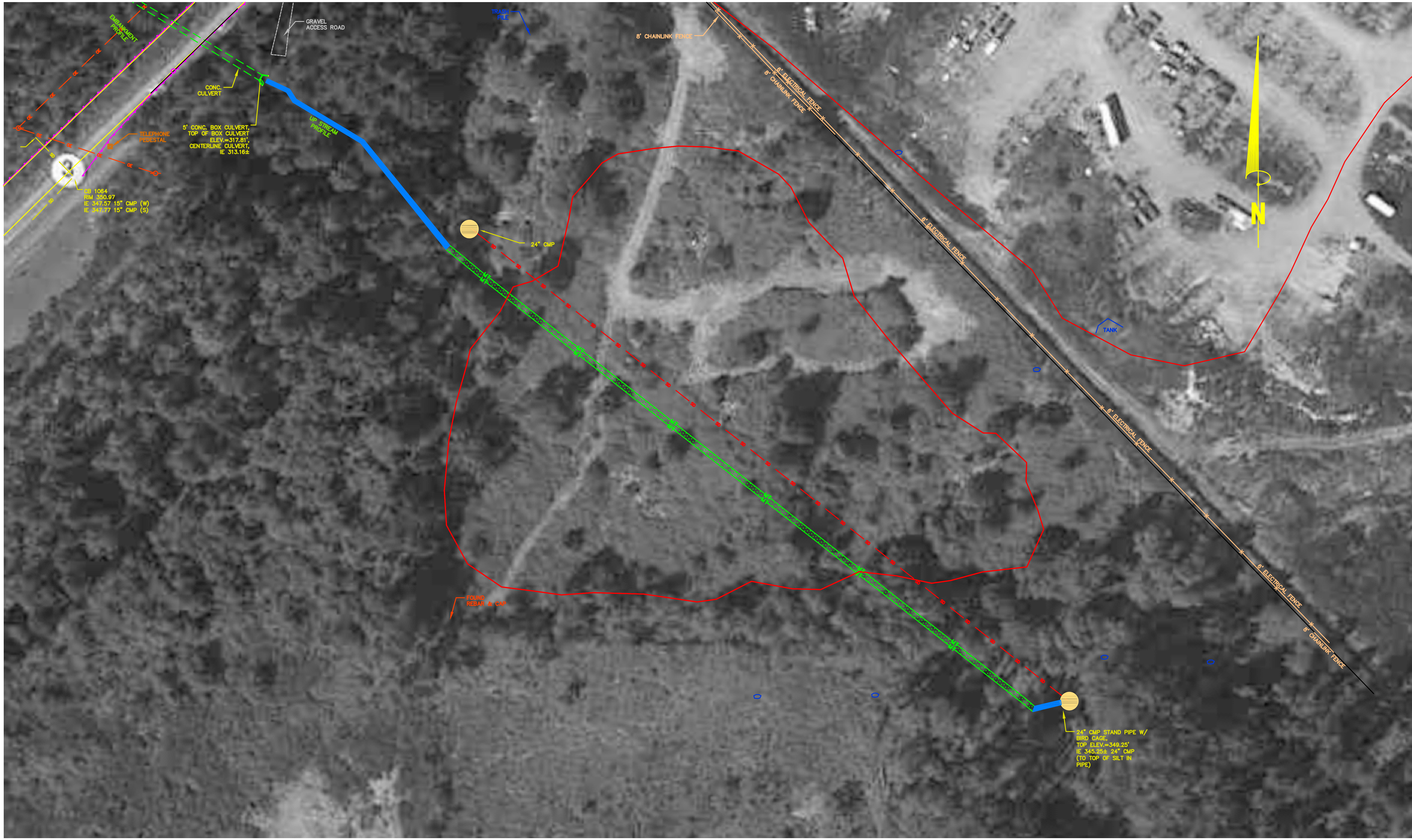

Outfall location	Stream Profile	**Gorst Creek Landfill**	
Existing 24-inch corrugated metal pipe	Culvert	**Port Orchard, Washington**	
Pipe Jacking			

SCALE IN FEET: 0, 40, 80, 120

Map Projection: NAD 1983 Washington State Plan North Feet

Figure 3-3
Alternative 4 - Pipe Jacking
(Gorst Creek EE/CA)
January 2012

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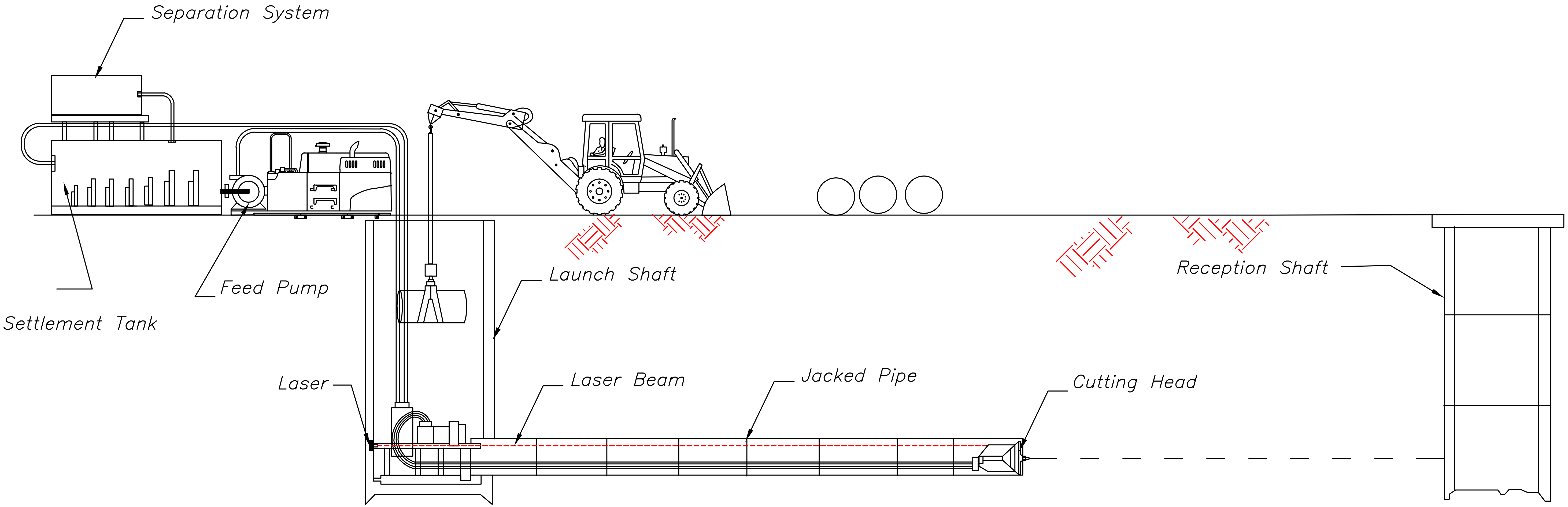

Gorst Creek Landfill

Port Orchard, Washington

Map Projection: NAD 1983 Washington State Plan North Feet

Figure 3-4
Conceptual Pipe Jacking Detail
(Gorst Creek EE/CA)
January 2012

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4 Comparative Analysis of Alternatives

The removal action alternatives developed and individually analyzed using EPA's three broad criteria of effectiveness, implementability, and cost are compared here using the same broad criteria. The comparative analysis is intended to provide the relevant information required to select a removal alternative.

As part of the individual removal action alternative analysis, a numeric value was assigned to each alternative representing its ability to meet the specific criteria. Table 4-1 provides a summary of this analysis.

Table 4-1 Summary of Criteria Comparison

Criterion	Alternative 1 No Action	Alternative 2 Landfill Removal	Alternative 3 Bypass Channel	Alternative 4 Microtunneling/ Pipe Jacking
Effectiveness	1	4	3	3
Implementability	1	3	2	4
Cost	1	1	3	5
Total	3	8	8	12
Average	1	2.7	2.7	4

4.1 Effectiveness

With the exception of Alternative 1 (No Action), the remaining three removal alternatives provide at least an acceptable level of effectiveness.

Of the three action alternatives, Alternative 2 (landfill removal) provides the most protection of human health and the environment because the waste would be removed from the Site. Both Alternatives 3 and 4 provide a similar level of protection in that the eroded areas of the landfill cover would be repaired and Gorst Creek would be rerouted to prevent further contact with waste materials.

The landfill cover would be restored to provide a vegetated soil cover as required in Washington Administrative Code 173-304-461; however, no alternative would fully meet the ARARs associated with landfills. Alternative 4 can more easily meet its associated ARARs than Alternatives 2 and 3. Alternative 4 does not involve obtaining land or disposal of more than 150,000 cubic yards of mixed waste. In comparing Alternative 2 to Alternative 3, Alternative 2 would meet the ARARs better than Alternative 3 given that more of the ARARs associated with landfills would be met since waste materials would be removed from Site.

For long-term effectiveness and permanence, Alternative 2 is the most effective and permanent action because the landfill contents would be removed and transported off-Site. Alternative 3 is considered to be slightly more effective and permanent than Alternative 4. While both alternatives would grout the existing culvert closed and repair the eroded section of the existing landfill cover, under Alternative 3 a new channel would be constructed and under Alternative 4 a new culvert would be installed. The new culvert, like the current culvert, could fail over a long-period of time. Additionally, Alternative 3 has a greater capacity for handling flood events.

None of the waste under any of the proposed removal alternatives would be treated, so none of the alternatives provide a reduction in toxicity. Alternative 2 provides the greatest reduction in on-Site mobility because the landfill contents would be removed and disposed of at other disposal facilities. Alternatives 3 and 4 provide the same amount of mobility reduction in that Gorst Creek would be redirected and the existing culvert would be grouted closed. Under Alternative 2, there is the potential for metal to be reclaimed. Therefore, Alternative 2 provides for a better reduction in volume of contaminants than Alternatives 3 and 4, which do not address the landfill contents.

In the short-term, Alternative 4 would be the most effective because construction activities would be limited compared with the other action alternatives. Under Alternatives 2 and 3 a minimum of 100,000 cubic yards of materials would have to be excavated, hauled, and disposed. Because Alternative 3 only involves handling native, undisturbed earth, it has better short-term effectiveness compared to Alternative 2, which requires handling over 150,000 cubic yards of waste material.

4.2 Implementability

While all of the removal alternatives are technically implementable, Alternative 4 (micro-tunneling/pipe jacking) is considered to be the most implementable. Unlike Alternative 2 (landfill removal) and Alternative 3 (bypass channel), the amount of earthwork, material handling, and disposal needed is much less. Given that land acquisition is a major component of Alternative 3 and Alternative 4 does not require it, Alternative 4 is more implementable than Alternative 3.

Alternative 3 is considered to be more implementable than Alternative 2. A considerable amount of material handling is involved with both Alternatives 2 and 3. However, under Alternative 2, multiple types of waste streams would be excavated that would require sorting, characterization, and potentially multiple disposal sites. Alternative 3, on the other hand, involves excavating and handling native, undisturbed materials. Implementation of Alternative 3 requires the acquisition of property. Alternative 2 requires manifesting, characterizing, and transporting multiple waste streams.

While technically implementable, from an administrative, state, and community acceptance standpoint, Alternative 1 (no action) is not considered to be implementable because inaction will result in continued deterioration of the landfill, necessitating future mitigation action; therefore, the implementability of this alternative is rated unacceptable

4.3 Cost

While there is no initial cost associated with Alternative 1 (no action), as previously stated, there are unknown costs associated with on-going landfill debris washing into Gorst Creek and traversing the adjacent highway. Therefore, this alternative has unacceptable costs associated with it when compared with the costs associated with the remaining action alternatives. Of the three remaining removal alternatives, Alternative 4 (microtunneling/pipe jacking) has the least cost ($2,630,000). Alternative 3 (bypass channel) costs more ($8,520,000) than Alternative 4 but significantly less than Alternative 2 (landfill removal), which has an estimated cost of $34,080,000.

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5 Recommended Removal Action Alternative

The actual or threatened release of hazardous substances within and from the Site may present an imminent and substantial endangerment to the public health, welfare, or the environment within the meaning of Section 106(a) of CERCLA, 42 U.S.C. § 9606(a). This EE/CA was prepared to identify alternatives, effectiveness, implementability, and cost associated with mitigating off-Site migration of the landfill contaminants of concern and the potential impounding of surface water.

EPA criteria were used as the basis of a comparative analysis, which provided in-depth information that was used in selecting an interim removal action alternative for implementation. The comparative evaluation makes use of the following five-point scaling system:

1-Unacceptable
2-Poor
3-Acceptable
4-Superior
5-Excellent

Alternative 1 (no action) was evaluated as a requirement of the NCP and scored 3 out of a possible 15 points for a 1 point average. Alternative 2 (Gorst ravine restoration) and Alternative 3 (Gorst Creek re-alignment) both scored 8 out of a possible 15 points for a 2.7 point average. Alternative 4 (microtunneling/pipe jacking) scored 12 out of a possible 15 points for a 4 point average.

Based upon the scoring and the comparative analysis Alternative 4 (microtunneling/pipe jacking) is recommended as the preferred alternative. The reader should note, however, that funding a removal action is not guaranteed by completion of the EE/CA report.

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6 References

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