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DRAFT
FEASIBILITY STUDY

Chevron Site No. 30-2095
Former Chevron Bulk Terminal
149 and 167 Main Avenue
Morton, Washington

March 2006

Prepared for:

Chevron

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LIMITATIONS

In preparing this report, SAIC has relied on verbal and written information provided by secondary sources, including information provided by Chevron. Because the assessment consisted of evaluating a limited supply of information, SAIC may not have identified all potential items of concern and/or discrepancies and, therefore, SAIC warrants only that the project activities under this contract have been performed within the parameters and scope communicated by Chevron and reflected in the contract. SAIC has made no independent investigations concerning the accuracy or completeness of the information relied upon.

1.0 INTRODUCTION

This Feasibility Study (FS) evaluates possible remediation alternatives for the former Standard Oil Company of California petroleum bulk plant terminal in Morton, Washington. The FS fulfills the requirements of the Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) (WAC 173-340-350[8]) and is being submitted in accordance with Section IV (5) of Enforcement Order DE03TCPSR5715. The FS is submitted by Science Applications International Corporation (SAIC) on behalf of Chevron Environmental Management Company (Chevron).

Under MTCA, the purpose of a feasibility study is to develop and evaluate cleanup action alternatives to enable a cleanup action to be selected for the site. If concentrations of hazardous substances do not exceed the cleanup level at the standard point of compliance, then no further action is necessary [WAC 173-340-350(8)]. For media with contaminants exceeding cleanup levels, specifying the exposure route rather than just the acceptable contaminant levels is important because protectiveness can be achieved by preventing exposures (e.g., by containment or institutional controls) as well as by cleanup. Although MTCA strongly reflects a preference for permanent remedial actions to the maximum extent practicable, less permanent solutions may be accepted if controls are put into place to ensure that the solution is protective of human and ecological receptors.

1.1 Site History

Standard Oil constructed the former bulk terminal in 1924 near the intersection of Main Avenue and First Street on property leased from Chehalis Western Railroad (Figure 1-1). The terminal was fenced and included six vertical above-ground storage tanks (ASTs) (two 19,000-gallon, one 13,000-gallon, and three 6,000-gallon tanks) for gasoline, diesel, kerosene, and heating oil. The terminal also included tank truck and rail car unloading headers, tank truck loading racks, and a pump house. Other structures included a 2,500-square foot warehouse, part of which was used as a garage and part of which was used to handle drummed product, and a 300-square foot office building (Figure 1-2).

From 1924 until the mid-1950s the terminal was supplied by rail. Rail tank cars were positioned on a railroad spur located southwest of the warehouse. The facility was later modified to allow unloading of tank trucks via tank truck unloading headers located near the ASTs. In 1971 a tank truck loading area was constructed to the east of the warehouse. The terminal operated until the late 1970s. Around 1981 the ASTs, piping, pumps, and headers were removed from the site. The warehouse and office building were left intact and remain on the site.

In 1985 the property on which the terminal was located, which consisted of two separate parcels, was sold to Pacific Fire Trails. Pacific Fire Trails did not develop the property, and in 1993 sold it to Dana and Diana Wolfe. The Wolfes soon after sold the western parcel to Janet Parks. The Parks parcel contains a 5,000-square foot building, which currently houses a thrift store (Jan's Lost & Found). The thrift shop building was formerly occupied by "Fairhart's Feed Store." The building was heated with an oil heater located approximately in the middle of what is now the retail portion of the thrift shop. The heater was supplied from a large heating fuel AST located in the former shed-roofed area along the north side of the building to the east of the present-day door into the retail portion of the shop. (The shed-roof area is visible in historical aerial photos.) At that time, the ground beneath the AST and the heater were reportedly saturated with heating oil and smelled strongly of petroleum. (The floor in the store is wooden planks over dirt.) In addition, the former feed store dispensed gasoline and/or diesel fuel from drums and/or AST(s) located to the west of the present-day door into the retail part of the thrift shop apparently for use in vehicles and farm machinery (Richardson, 2006). The structure currently housing Jan's Lost & Found existed during the period the bulk terminal was in operation; however, it was located outside of the terminal fence and was not associated with terminal operations.

A portion of the warehouse and the office building from the former bulk terminal are still located on the eastern parcel. Adjacent properties to the north and south are owned by Chester Walker and the City of Tacoma respectively (Figure 1-2).

In 2003 a citizen reported to Ecology that a fuel odor had been noted during an excavation at the site in the early 1980s. Lewis County Health Department, in conjunction with Ecology, conducted an initial investigation and identified petroleum-contaminated soil at several locations. Based on these findings, Ecology issued Enforcement Order DE 03TCPSR-5715 to Chevron, Dana and Diana Wolfe, and Janet Parks on January 20, 2004, requiring the parties to investigate and clean up petroleum contamination at the site. Chevron initiated activities outlined in the Enforcement Order in May 2004.

In June 2005 the Cowlitz River Valley Historical Society (CRVHS) acquired the eastern parcel of the former terminal site from Dana and Diana Wolfe. The CRVHS plans to develop the site as an historic tourist facility. On October 15, 2005, a partially restored railway depot was moved onto the property. Future development plans include construction of a railway platform adjacent to the depot, a parking area, museum, and restrooms.

1.2 Hydrogeology

Subsurface conditions at the site were investigated by Chevron in 2004–2005 with the installation of 55 soil borings and 12 groundwater monitoring wells. Soil borings indicate the site is underlain by unconsolidated materials consisting of fill and alluvial deposits. The uppermost unit at the site is fill that typically ranges between 1 and 4 feet in thickness, but is absent in places. The fill consists of poorly sorted silt, sand, and gravel. Below the fill is a sequence of mottled silts and clays, organic-rich in places, which is split by a thin sand and/or sandy gravel layer. The coarse-grained unit occurs at a depth of between 8 and 12 feet and is continuous across a portion of the site. The lower units that have been investigated at the site consist mostly of thinly interstratified silts and sands.

During drilling, saturated conditions were usually first encountered at depths of 5 to 10 feet within the coarser-grained sediments. Often, saturated sands were sandwiched between unsaturated silty units. Once installed, water levels in the monitoring wells typically stabilized at between 1 and 6 feet below land surface, suggesting the presence of some local, semi-confined conditions.

A series of depth-to-water measurement rounds conducted over a 12-month period indicate that the water table at the site, as defined by the water levels in the monitoring wells, is irregular and variable. This situation is typical of sites dominated by local recharge and conditions where wells tap discontinuous and/or perched water-bearing zones. In general, flow beneath most of the site appears to be generally to the southeast but varies broadly between south and east. Given the discontinuous nature of the water-bearing zones at the site, the groundwater gradients constructed from depth-to-water measurements may not reflect actual groundwater flow paths.

1.3 Remedial Investigation

A Remedial Investigation (RI) was begun in May 2004. Results of the investigation are contained in the draft RI Report (SAIC, 2005). As part of the RI, a total of 55 soil borings were completed on the site. Borings were geologically logged and field screened to depths of 12 to 16 feet, well beyond the limits of detectable contamination in most locations. At least one sample from the most highly contaminated interval (based on field observations and measurements) was collected from each boring for laboratory analysis. Soil analytical results are summarized in Table 1-1.

GRO is the most widespread contaminant at the site occurring in concentrations exceeding 300 mg/kg (>10 times Method A cleanup level) throughout the AST area, between the AST area and the railroad tracks, beneath the northern portion of the warehouse, and to the south and southeast of the warehouse. High concentrations of GRO in soil were also found in two samples beneath the west portion of the thrift store and in one sample immediately adjacent to the south side of the thrift store. Historical records indicate that this structure was formerly a feed warehouse and do not indicate that it was ever part of the bulk terminal operations; the source of GRO in these samples does not appear to be connected to the contamination from the former AST area.

The extent of DRO and benzene contamination is much more restricted than GRO and is generally limited to the AST area between the former ASTs and the railroad tracks. As with GRO, a disconnected area of diesel contamination exists in the vicinity of Jan's Lost and Found. No benzene was detected in the vicinity of Jan's Lost and Found.

Based on analytical results and field observations, the main vertical zone of soil contamination occurs largely within the range of seasonal water-table fluctuation. The vertical constraints on the contamination zone place it within the interbedded silt, clayey silt, and sand. Soil contamination typically is first encountered at a depth of about 2 feet and is limited to a maximum depth of 6 to 8 feet in most places. Contaminants were detected to somewhat greater depths in SB-43 (10 feet) and SB-39 (12 feet).

A total of 12 monitoring wells were installed on the site as part of the RI. All monitoring wells were completed at a depth of 20 feet and were screened from 5 to 20 feet. Four complete groundwater monitoring rounds were conducted during 2004–2005, and no separate phase hydrocarbons were detected in any wells on site. Groundwater analytical results are summarized in Table 1-2. The groundwater contaminants exceeding MTCA Method A cleanup levels are benzene, GRO, and DRO. Monitoring results suggest that the areal extent of groundwater contamination is largely restricted to the area of soil contamination. The highest groundwater impacts have been encountered in wells located in the central portion of the property, adjacent to or downgradient from former bulk terminal facilities. As discussed in the RI, the low-permeability soils at the site and groundwater monitoring data indicate that contamination is not migrating off site; however, an additional groundwater monitoring point is planned.

1.4 Interim Action

In October 2005, an interim action was performed on the property in accordance with criteria set forth in (1), (2), and (3) of WAC 173-340-430. This action was deemed necessary as the current property owner had plans to develop the site by transporting an existing building (an historic rail depot) onto the south-central portion of the property. The footprint of the historic rail depot covered an area of known soil contamination, and remediation of this area would not be feasible once the depot had been placed.

The interim action was performed prior to the building move and involved excavating contaminated soil beneath the footprint of the depot and platform area, properly disposing of the excavated soil, collecting and analyzing performance monitoring samples, and backfilling the excavation with clean, compacted material. The interim action was completed in mid-October 2005, and the historic depot is currently resting on temporary cribbing where it will remain until the CRVHS constructs a foundation for the depot to rest on. Foundation construction is not expected to impact the development or implementation of remediation alternatives discussed below.

2.0 CURRENT AND FUTURE SITE USE

The site history indicates that the primary sources of soil contamination were from discharges of petroleum products to surface or subsurface soils via leaks or spills. Results of the investigation indicate that soil contamination is restricted to the former terminal property (portions of the Parks and CRVHS parcels).

Part of the former terminal property is currently occupied by a thrift store and associated parking lot. The rest of the property is not used at present and is awaiting development by the CRVHS as an historic tourist facility; this portion of the property is occupied by a railroad depot, railroad tracks, and two other unoccupied buildings. During the next 12 to 24 months, the former terminal property is expected to be developed by the CRVHS. Development plans call for the site to be almost completely covered by buildings (depot, museum, and restrooms) and paved areas (parking lot, driveways, and sidewalks). The proposed development plan is presented in Figure 2-1.

3.0 CLEANUP STANDARDS AND REMEDIATION LEVELS

Cleanup standards are defined for the particular hazardous substances at a site and the specific areas or pathways, such as land or water, where humans and the environment can become exposed to these substances. Each cleanup standard addresses the following:

- The cleanup levels for hazardous substances
- The point of compliance

A cleanup level is the concentration of a hazardous substance in a particular media that is determined to be protective of human health and the environment under specified exposure conditions. Cleanup levels, in combination with points of compliance, typically define the area or volume of soil, water, air, or sediment at a site that must be addressed by a cleanup action.

On sites where the cleanup action is routine or may involve relatively few hazardous substances, MTCA allows the use of Method A cleanup levels. MTCA Method A cleanup levels are appropriate for this site because contaminants are limited to petroleum constituents. Media-specific cleanup levels are discussed below.

Under MTCA, a point of compliance is specified for each exposure pathway. The point of compliance is the point or points where the soil cleanup levels shall be attained. Potential exposure pathways and corresponding points of compliance for each impacted medium are discussed below.

In addition to cleanup levels, MTCA allows development of remediation levels (RELs) at sites where a combination of cleanup action components are used to achieve cleanup levels at the point of compliance or where the cleanup action involves containment of soil. Remediation levels are used to define the concentration of hazardous substances at which different cleanup action components will be used. Establishment of RELs at a site does not preclude the requirement to meet cleanup levels at the point of compliance. RELs associated with each of the exposure pathways have been defined for this site and are discussed below.

3.1 Soil

3.1.1 Cleanup Levels

MTCA states that cleanup levels shall be based on the reasonable maximum exposure expected to occur during both current and future land use. By default, MTCA further states that residential land use represents the reasonable maximum exposure. Therefore, cleanup levels must be protective of residential or unrestricted land use. The Method A cleanup levels for soil presented in Table 740-1 (Soil Cleanup levels for Unrestricted Land Use) are applicable to this site.

Additionally, MTCA Method A requires that exposure of terrestrial organisms to contaminated soils be evaluated by performing a Terrestrial Ecological Evaluation (TEE) as described in WAC 173-340-7491. A TEE was performed as part of the Remedial Investigation. The relevant values from this evaluation for the site are as follows:

- GRO – 200 mg/kg
- DRO – 460 mg/kg
- Lead – 220 mg/kg

To be protective of ecological receptors, the more stringent soil cleanup levels for DRO and lead derived from the TEE will be used at this site. For all other contaminants at the site, the cleanup levels protective of residential land use are the most stringent.

The MTCA Method A cleanup levels for soil combined with the point of compliance determines the cleanup standard for the site. Under MTCA, the point of compliance is pathway dependent. Potential pathways for exposure to contaminants in the soil and the relevant points of compliance are discussed below.

- **Protection of human exposure via direct contact/incidental ingestion.** The point of compliance is in the soils throughout the site to a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface during site development activities (i.e., ground surface to 15 feet below the ground surface [bgs]).
- **Protection of ecological receptors.** The standard point of compliance is in the soils throughout the site from ground surface to 15 feet bgs (the reasonable depth of soil that could be excavated during site development and could result in exposure by ecological organisms). For sites with institutional controls preventing excavation of deeper soil, MTCA allows the use of a conditional point of compliance set in the soils throughout the site at a depth of 6 feet bgs.
- **Protection of groundwater.** The point of compliance is throughout the site.
- **For protection from vapors.** The point of compliance is in soils throughout the site.

3.1.2 Remediation Levels

Due to the nature of the contaminants at this site and the planned future land use, it is anticipated that a combination of cleanup components will be used to attain soil cleanup levels at this site. For this reason, RELs associated with each of the exposure pathways have been defined.

- **Protection of human exposure via direct contact/incidental ingestion.** An REL that addresses the direct contact/incidental ingestion risk was developed for this site using the Washington Department of Ecology Workbook for Calculating Cleanup Levels for Petroleum Contaminated Sites (MTCATPH Version 10). Using analytical data from soil samples collected at the site, a direct contact REL of 2,225 mg/kg total TPH was calculated for this pathway (Appendix A). The MTCA Method A soil cleanup level for lead presented in Table 740-1 is based on preventing unacceptable blood lead levels via ingestion of contaminated soil. Therefore, the REL for lead is consistent with the MTCA Method A cleanup level of 250 mg/kg.
- **Protection of ecological receptors.** The RELs for this pathway are consistent with the cleanup levels determined by the TEE. The RELs for GRO, DRO, and lead are 200, 460, and 220 mg/kg, respectively.
- **Protection of groundwater.** The MTCA Method A cleanup levels presented in Table 740-1 for petroleum and BTEX compounds are based on protection of groundwater. Therefore, the RELs for this pathway are consistent with the values in Table 740-1. The RELs for GRO, DRO, and benzene are 30, 2,000, and 0.03 mg/kg, respectively.
- **For protection from vapors.** This pathway is defined as the potential for subsurface contamination in soil to adversely impact indoor air quality and lead to exceedances of acceptable levels of carcinogenic and noncarcinogenic risk. An REL for this pathway was determined by entering the results of analytical data from soil samples collected at the site into the Johnson and Ettinger Vapor Intrusion Model (J&E Model). Input parameters for the model included the following assumptions:

- A slab on grade building with dimensions similar to the museum shown on the proposed site plan.
- An air exchange rate for libraries as specified by WAC Chapter 51–13-304
- The highest exposure risk would be to full-time museum workers (8 hours/day, 5 days/week, 52 weeks/year).

Based on these input parameters, the only contaminant detected in onsite soils that could potentially result in adversely impacting indoor air quality is benzene (see Appendix B). The REL calculated by the model for benzene is 0.06 mg/kg. Since this value is close to the MTCA Method A cleanup level of 0.03 mg/kg, the REL for benzene in soil for the vapor pathway is considered to be the Method A cleanup level.

3.2 Groundwater

There are currently no drinking water wells at the site. The city of Morton, including the thrift shop, is served by the city's municipal water supply system. Future site development plans indicate that the CRVHS depot project will be also connected to the municipal supply. The results of the present investigation indicate that groundwater contamination does not extend more than 100 to 150 feet downgradient to the south and east from the likely sources of past leaks and spills. Although additional data will be collected to fully define the downgradient extent of contamination to the southeast of the site, it not likely that such contamination extends significantly farther in this direction than it does to the south and east. Given that the nearest domestic or industrial supply wells to the site are located more than one-quarter mile from the site, the potential exposure of humans to contaminated groundwater from the site is considered to be extremely low.

Despite the low potential exposure to contaminated groundwater at this site, MTCA requires that groundwater cleanup levels be based on the highest beneficial use and reasonable maximum exposure under both current and future land use at the site. For groundwater, MTCA specifies that drinking water is the highest beneficial use and that ingestion of drinking water represents the reasonable maximum exposure [WAC 173-340-720]. The Method A cleanup levels for groundwater presented in Table 720-1 (Method A Cleanup Levels for Groundwater) are applicable to this site.

MTCA states that groundwater cleanup levels shall be attained in all groundwater from the point of compliance to the outer boundary of the hazardous substance plume. The standard point of compliance as defined by MTCA is throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth that could potentially be affected by the site.

In cases where it is not practicable to meet the cleanup level throughout the site in a reasonable restoration time frame, MTCA allows establishment of a conditional point of compliance. The conditional point of compliance shall be as close as practicable to the source of hazardous substance and not exceed the property boundary. An appropriate conditional point of compliance for protection of drinking water at this site is at the property boundary.

The RELs for groundwater are consistent with the MTCA Method A cleanup levels presented in Table 720-1. The RELs for GRO, DRO, and benzene are 800, 500, and 5 µg/L, respectively

4.0 EXTENT OF ENVIRONMENTAL MEDIA REQUIRING CLEANUP ACTION

Contaminants of concern (COCs) for the site have been identified by comparing concentrations of analytes detected in the soil and groundwater during the remedial investigation with the respective MTCA Method A cleanup levels. The COCs for this site are limited to gasoline-range hydrocarbons, diesel-range hydrocarbons, and lead.

4.1 Extent of Soil Requiring Cleanup Action

The area or volume of soil and groundwater at the site that must be addressed by a cleanup action is defined by the appropriate cleanup level in combination with points of compliance. The approximate extent of benzene, GRO, DRO, and lead exceeding the MTCA Method A soil cleanup levels is presented in Figure 4-1. As stated in Section 1.3, soil contamination is generally within the range of seasonal water-table fluctuation at a depth of 2 to 8 feet bgs. Following the interim action, soil within the limits of the excavation now meets MTCA Method A cleanup levels and does not need to be further addressed in this feasibility study.

As shown in Figure 4-1, two separate areas of petroleum-impacted soil are present at the site; these are described below:

- The main (eastern) area of impact is centered over the portion of the property formerly occupied by the bulk terminal (i.e., the potion of the site previously occupied by the ASTs, tank unloading headers, loading racks, pump house, and warehouse). Contamination in this area is clearly attributed to former bulk terminal operations and is addressed in this feasibility study.
- The smaller (western) area of impact is centered around the western part of the former feed store building. Because the feed store was not associated with bulk terminal operations, soil contamination in this area is not attributed to former bulk terminal operations and is not addressed in this feasibility study. Recently obtained historical information (Richardson, 2006) indicates that a leaking heating oil AST was located adjacent to the north side of the west end of the former feed store and that a leaking oil heater and piping were formerly located inside the western portion of the feed store (the area currently occupied by the retail portion of Jan’s Lost & Found). Motor fuel was also reportedly dispensed from the north side of the western portion of the former feed store. The leaking oil tank, heater, piping, and motor fuel dispensing activities are all potential sources for the observed soil contamination in this area.

To facilitate development of cleanup components, the area impacted by operations at the former bulk terminal has been further refined to reflect the exposure pathways and respective RELs discussed in Section 3.1. Delineation of contaminant zones in this manner allows development of individual cleanup action components to close a specific exposure pathway. The cleanup action components can then be assembled into cleanup actions to ensure that all pathways are closed. Based on the potential exposure pathways for soil identified in Section 3.1, four contaminant zones have been identified. These zones are discussed briefly below and are depicted in Figure 4-2.

- Zone 1 reflects the extent of soil posing a direct contact/incidental ingestions risk to humans.
- Zone 2 reflects the extent of soil posing a potential risk via inhalation of indoor air.
- Zone 3 reflects the extent of soil posing a potential risk via direct contact/ingestion to terrestrial organisms.
- The Peripheral Zone reflects soil that does not fall within the boundaries of Zones 1, 2, or 3, but is above the MTCA Method A cleanup levels.

4.2 Extent of Groundwater Requiring Cleanup Action

The approximate extent of benzene, GRO, and DRO exceeding the relevant groundwater cleanup levels is depicted in Figure 4-3. The areal extent of groundwater contamination is largely restricted to the area of soil contamination. As discussed in the RI, the low-permeability soils at the site and groundwater monitoring data indicate that contamination is not migrating off site.

5.0 ALTERNATIVE COMPONENTS

A cleanup action alternative is defined as one or more treatment technology, containment action, removal action, engineered control, institutional control, or other type of remedial action ("cleanup action components") that individually, or in combination, achieves a cleanup action at a site [WAC 173-340-200]. For purposes of this feasibility study, it is convenient to think of a "cleanup action component" as dealing with a specific media/exposure pathway. The media/exposure pathway cleanup action components are then assembled into cleanup action alternatives, which address the site-wide cleanup requirements.

In accordance with MTCA, potential cleanup action components have been screened prior to assembling the components into cleanup action alternatives to reduce the number of alternatives for the final detailed evaluation in this FS. According to WAC 173-340-350(8), an alternative component may be screened from further consideration if either of the following conditions applies:

- The component does not meet the minimum requirements in WAC 173-340-360, including components in which costs are clearly disproportionate. More specifically:
  1. The component is not protective of human health and the environment, or
  2. The component does not comply with the cleanup standards, or
  3. The component does not comply with applicable state or federal laws, or
  4. The component does not provide for compliance monitoring.

- The component is not technically feasible.

The initial screenings for soil and groundwater cleanup alternative components are presented in Tables 5-1 and 5-2, respectively. Based on this screening step, the retained alternative components are summarized in Section 5-3.

6.0 DEVELOPMENT OF ALTERNATIVES

The following sections discuss each alternative with a focus on the rationale for the actions and components that have been selected. The proposed alternatives are analyzed in detail in Section 7.0 in accordance with evaluation criteria mandated under MTCA.

Each alternative includes components that are expected to be capable of accomplishing the cleanup levels established for a particular exposure pathway and contaminants as identified in Section 3.0. The alternatives have been developed by assembling various cleanup alternative components in appropriate combinations from among those selected in Section 5.0. Selection of a specific cleanup action component for detailed evaluation in the FS does not preclude later consideration of similar components that are represented by the selected component. Similar cleanup action components that can achieve the same cleanup levels could be re-evaluated for cost effectiveness during the final design phase.

The alternatives developed for the site provide a range of cleanup action components within the confines of protecting the environment and human health as required by MTCA. MTCA [WAC 173-340-360] specifies that each alternative meet the following threshold requirements:

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

A range of cleanup action alternatives was developed by assembling appropriate cleanup action components from those identified and selected in Section 5.0 (Alternative Components). For media with contaminants exceeding cleanup levels, identifying the exposure route rather than just the acceptable contaminant levels is important because protectiveness can be achieved by preventing exposures (e.g., by containment or institutional controls) as well as by cleanup. Although MTCA strongly reflects a preference for permanent remedial actions to the maximum extent practicable, less permanent solutions may be accepted if controls are put into place to ensure that the solution is protective of human and ecological receptors.

MTCA requires that a feasibility study include at least one “permanent cleanup action alternative” to serve as the baseline against which all other alternatives are evaluated for the purpose of determining whether the cleanup action selected is permanent to the maximum extent practicable (WAC 173-340-350). MTCA defines a permanent cleanup action to be one in which the cleanup standards of WAC 173-340-700 through 173-340-760 can be met without any further action, with the exception of the disposal of any treatment residue.

The alternatives are summarized in Table 6-1 and described below.

6.1 Alternative 1 – Containment and Natural Attenuation

This alternative would reduce and control exposures to subsurface contaminants using the following cleanup alternative components.

- Meet MTCA Method A soil (i.e., Zones 1, 2, 3, and Peripheral) and groundwater cleanup levels through natural attenuation
- Use of vapor barriers on new construction in Zone 2, if required to mitigate vapor risk
- Surface paving and covers
- Deed restrictions / Soil management plan
- Implement environmental monitoring

6.1.1 Natural Attenuation

Relying on natural processes to achieve the MTCA Method A cleanup levels for soil and groundwater exceedances is appropriate because the contamination is posing a low level of risk to human health, no NAPL has been encountered at the site, and the contaminants are primarily limited to the site. In addition, hydrocarbon compounds are readily biodegradable into less harmful constituents (typically carbon dioxide and water).

6.1.2 Vapor Barriers

The possibility of vapor intrusion into onsite occupied spaces was investigated individually for the Historic Train Depot and the future Museum building. Prior to the relocation of the Historic Train Depot building, an interim action was completed that removed approximately 1,230 tons of petroleum contaminated soils from beneath the future footprint of the Depot. Confirmation samples collected from the excavation base indicated that all existing contamination from beneath the depot has been removed. Vapor intrusion into the Depot building is not a concern, as all contamination from beneath the building was removed by the interim action.

The site layout plan provided by the Cowlitz River Valley Historical Society (CRVHS) (Figure 2-1) indicates that the future museum will be located in the southeastern portion of the property. Soil analytical data collected during the RI confirm that the REL for this pathway is currently met at this location.

Although current site plans do not include placement of a building within Zone 2, soil in this area does not currently meet the REL. To ensure that future site development is not limited by the presence of subsurface contaminants, Alternative 1 includes the use of vapor barriers on potential construction within Zone 2. This will eliminate the possibility of vapor intrusion into occupied areas, with no restrictions on building placement. In the future, when new construction plans are finalized, it may be possible to determine that a vapor barrier is not necessary, based on detailed data related to building specifications.

6.1.3 Surface Paving and Covers

The use of surface paving and covers over areas of contamination would eliminate the potential for exposure to ecological receptors through the direct contact pathway and is consistent with future development plans. Alternative 1 includes the paving or covering of any area not covered by the buildings within any Zone (i.e., soil exceeding MTCA Method A cleanup levels). Covers may be constructed of a rock layer overlain by landscaping material, or a similar permanent cover. Under Alternative 1, approximate 10,200 square feet of surface would require some form of cover to eliminate the exposure pathway to ecological and terrestrial organisms.

6.1.4 Deed Restrictions / Soil Management Plan

Development of deed restrictions and a Soil Management Plan would place requirements on future site development and intrusive subsurface work conducted in areas of soil contamination left on the property above the MTCA Method A cleanup levels. These areas are presented in Figure 6-1, and include soils beneath the rail lines and the public right of way bordering the southern property line. Requiring notification to Chevron Environmental Management Company (Chevron) prior to any subsurface activities would ensure controls to reduce potential exposures to workers are in place and contaminated soil is properly disposed of. Deed restrictions would have no effect on property value or limit development.

Restrictions will be placed on the installation of groundwater wells on the property for drinking water purposes, until site groundwater has attenuated to meet MTCA cleanup levels. Since groundwater contamination has not significantly migrated off the property, restrictions on adjacent properties will not be necessary.

6.1.5 Long-Term Monitoring

Under MTCA, compliance monitoring is required for all cleanup actions (WAC 173-340-410). Three categories of compliance monitoring are defined under MTCA:

- Protection monitoring to confirm that human health and the environment are protected during construction and operation of the cleanup action.
- Performance monitoring to confirm that the cleanup action has attained cleanup standards or remedial action objectives. Performance monitoring will be conducted from site groundwater monitoring wells regularly to ensure that natural attenuation of groundwater is occurring. Soil samples will be collected from within the known area of soil contamination to ensure MTCA Method A cleanup standards have been met, following a sufficient timeframe for natural attenuation in soil to occur.
- Confirmation Monitoring to confirm the long-term effectiveness of the cleanup action after remedial action objectives have been attained. Offsite monitoring wells will be installed and monitored to ensure that transport of contaminants off site does not occur.

6.2 Alternative 2 – Hot-Spot Excavation, Containment, ORC, and Natural Attenuation

This alternative would reduce and control exposures to contaminants by the following cleanup alternative components:

- Meet MTCA Method A soil cleanup levels through excavation of Zones 1 and 2, and monitored natural attenuation of soil in Zones 3 and Peripheral
- Addition of Oxygen Release Compound to groundwater during excavation activities
- Manage/treat excavated material
- Deed restrictions / Soil management plan
- Implement environmental monitoring

These actions would meet the cleanup levels established for soil and groundwater. Each action is described below.

6.2.1 Hot Spot Excavation and Natural Attenuation

Alternative 2 would reduce the cleanup timeframe, eliminate exposure risk via inhalation of indoor air, and reduce the potential for direct contact by human and ecological receptors by excavation soil with the highest contamination concentrations. Alternative 2 includes excavation soil within the boundaries of Zones 1 and 2, through the use of backhoes and excavation equipment, to an estimated depth of 8 feet below the current grade (Figure 6-2). The estimated volume of soil to be removed and disposed of off site with this alternative is approximately 800 cubic yards. Use of an onsite laboratory will confirm concentrations above MTCA Method A cleanup standards have been met prior to backfilling the excavated area with imported clean material. The excavation will be extended vertically and horizontally until confirmation samples indicate that soils exceeding the RELs for Zones 1 and 2 have been removed. Following the excavation of Zones 1 and 2, Alternative 2 will meet MTCA cleanup levels for soil by natural attenuation of soil as discussed above in Section 6.1.1.

The proposed extents of soil excavation encompass a majority of the diesel contamination exceeding the MTCA Method A cleanup level for unrestricted land use, and the associated direct dermal contact to human receptor pathway. Removing the diesel contamination will decrease the overall site cleanup timeframe by removing the heavier range hydrocarbons, which degrade at a slower rate. Diesel contamination exceeding cleanup levels for protection of ecological receptors would remain following the limited excavation activities, and the associated risk will be dealt with through covers and paving discussed below.

Because this alternative will remove all of the soil with benzene concentrations above the REL, the potential for adverse risks due to soil vapors in indoor air will be eliminated.

6.2.2 Surface Paving and Covers

Soils left on site posing a risk to ecological receptors (Figure 6-2) will be paved or covered as discussed above in Section 6.1.3. The planned site development will pave a fraction of this area, and Alternative 2 will require paving or covering approximately 8,200 square feet to close the risk pathway associated with ecological receptors.

6.2.3 Deed Restrictions / Soil Management Plan

This alternative will require a Soil Management Plan and Deed restrictions as discussed in Section 6.1.4 to deal with soil contamination remaining on site above the site cleanup levels.

6.2.4 Oxygen Release Compound

Alternative 2 treats groundwater through the addition of an Oxygen Release Compound (ORC) to water encountered during excavation activities. The addition of ORC to contaminated groundwater accelerates the natural biodegradation process by increasing the oxygen levels in the groundwater. The stratigraphy of the site is discontinuous, and tight, ORC injection into onsite wells would most likely have minimal effect on the groundwater, as the distribution would be very limited. Introducing ORC during excavation activities would increase the volume of groundwater affected, and ensure a more even distribution of compound across the area of exposed contamination.

Although the introduction of ORC is expected to significantly enhance the degradation of petroleum constituents in the groundwater within the excavation limits, contaminated soil left within Zones 3 and Peripheral will continue to act as a source of groundwater contamination. Monitored natural attenuation will be used to address the remaining groundwater impacts.

6.2.5 Manage/Treat Excavated Material

All contaminated material excavated from the site will be transported to a disposal facility for treatment or permanent disposal. For purposes of this FS, it is assumed that all soil will be transported to the Rinker Materials Facility in Everett, Washington, by truck for thermal desorption.

6.2.6 Long-Term Monitoring

Following excavation and ORC activities, environmental monitoring will be implemented as discussed in Section 6.1.5.

6.3 Alternative 3 –Excavation, ORC, and Natural Attenuation

Alternative 3 reduces and controls exposures to contaminants by the following cleanup alternative components:

- Excavation of soil within Zones 1, 2, 3, and Peripheral
- Addition of Oxygen Release Compound during excavation activities
- Implement environmental monitoring

These actions would remove the risks associated with soil contamination, and reduces risk associated with groundwater contamination through the response actions discussed below.

6.3.1 Excavation

Similar to Alternative 2, Alternative 3 would remove the source for site risks associated with soil contamination; however, Alternative 3 would include excavation of all subsurface contamination above the selected site cleanup levels (i.e., Zones 1, 2, 3, and Peripheral).

Figure 6-3 presents the proposed extents of excavation for Alternative 3, which would include all accessible soil contamination. The estimated volume of this excavation is approximately 4,000 cubic yards, and assumes the entire excavation would extend to a total depth of 8 feet below the current ground surface. With this alternative, the only soils contaminated above the selected site cleanup levels to be left on site would include inaccessible soils located within 5 feet of the rail road tracks along the south property line, which cannot be removed without risking destabilizing the rail lines.

This alternative also assumes that the former warehouse building located near the center of the property will be removed as part of the remedial action.

6.3.2 Oxygen Release Compound

This alternative includes the addition of ORC to groundwater encountered during excavation activities, as discussed in Section 6.2.2.

The volume of ORC used, and the amount of groundwater to contact the ORC, is expected to be significantly larger due to the increased volume of excavation compared to Alternative 2. By accessing and treating a higher volume of the contaminated groundwater plume, and removing the source contamination, it is assumed that the remediation timeframe for groundwater with Alternative 3 will be significantly reduced.

6.3.4 Performance Monitoring

This alternative includes environmental monitoring as discussed in Section 6.1.4. with the following adjustment:

- Performance monitoring samples for soil will be collected from the excavation extents immediately following the excavation action to confirm that the site cleanup standards have been met.

7.0 ANALYSIS AND COMPARISON OF ALTERNATIVES

MTCA requires the use of permanent solutions in which cleanup levels will be attained at the site without additional remedial actions; however, MTCA also recognizes that costs of the permanent solution may be disproportionate to the benefits it provides. Disproportionate costs are defined in MTCA as cases where the incremental costs of an alternative over that of a lower cost alternative exceed the incremental degree of benefits provided by the higher cost alternative. In the case of disproportionate costs, MTCA allows selection of a lower cost alternative that "uses permanent solutions to the maximum extent practicable" (WAC 173-340-360). This lower cost alternative is selected by conducting a disproportionate cost analysis comparing the costs and benefits of all of the remedial alternatives in the feasibility study.

The disproportionate cost analysis requires that the alternatives be ranked from most to least permanent and that the permanent solution alternative serve as the baseline against which all other alternatives are evaluated. When the benefits of two or more alternatives are equal, the lower cost alternative shall be selected as the preferred alternative.

7.1 Permanence Ranking of Alternatives

Alternative 3 is the most permanent of the remedial alternatives included in the feasibility study because it eliminates risks by excavation, offsite disposal of all contaminated soil within the points of compliance, and enhances degradation of petroleum constituents in groundwater through the use of ORC. The remaining two alternatives rely on a combination of containment, institutional controls, natural attenuation, and limited excavation to prevent exposures above risk levels. Because Alternative 2 incorporates excavation and disposal of a portion of the contaminated soil, it is considered to be the next most permanent solution. Alternative 1 is ranked as the least most permanent solution. All of the alternatives will result in permanent solutions at the site. Other than cost, the primary distinguishing feature of the alternatives is the time required to reach cleanup levels.

7.2 Evaluation of Alternatives Against Disproportionate Cost Criteria

MTCA specifies the various criteria for evaluation and comparison of alternatives when conducting a disproportionate cost analysis to determine whether a remedial action is "permanent to the maximum extent practicable" [WAC 173-340-360(e)]. The alternative analysis presented in Table 7-1 involves an evaluation of each alternative relative to the specified criteria listed below. Capital costs and Operation and Maintenance (O&M) costs for each alternative are presented in Appendix B.

Protectiveness. Overall protectiveness of human health and the environment, including the following considerations:

- Degree to which existing risks are reduced
- Time required to reduce risks and attain cleanup standards
- Onsite and offsite risks resulting from implementation of the alternative
- Improvement in the overall environmental quality

Permanence. The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the following considerations:

- Adequacy of the alternative in destroying hazardous substances
- Reduction or elimination of hazardous substance releases or sources of releases
- Degree of irreversibility of the waste treatment process
- Characteristics and quantity of treatment residuals generated

Cost. The cost to implement the alternative, including the followings costs:

- Cost of construction (cost estimates for treatment technologies include pretreatment, analytical, labor, and waste management costs; the cost of replacement and repair of major elements for the estimated design life of the project is included.)
- Net present value of any long-term costs (includes O&M costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls)
- Agency oversight costs that are cost-recoverable

Long-term effectiveness. Long-term effectiveness includes the following considerations:

- Degree of certainty that the alternative will be successful
- Reliability of the alternative during the period of time that hazardous substances are expected to remain on site at concentrations exceeding cleanup levels
- Magnitude of the residual risk with the alternative in place
- Effectiveness of controls required to manage the treatment residues or remaining wastes

Management of short-term risks. Short-term risk includes the risk to human health and the environment associated with the alternative during construction and the implementation and effectiveness of mitigation measures.

Ability to implement technically and administratively. The ability of the alternative to be implemented includes the following considerations:

- Technical possibility of alternative
- Availability of necessary offsite facilities, services, and materials
- Administrative and regulatory requirements
- Scheduling, size, and complexity
- Monitoring requirements
- Access for construction operations and monitoring
- Integration with existing facility operations and other current or potential remedial actions.

Consideration of public concerns. Consideration of public concerns includes whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This criterion includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

An evaluation of the alternative versus the cost criterion was accomplished by preparation of estimates of probable capital cost and O&M expenses, and by estimating the life-cycle cost for each alternative using present worth analysis. The time period used in the present worth for each alternative was selected to match the estimate of the life of the remedial action; in cases where the life of the action would be indeterminate or long-term, a 30-year period was used. The present worth was calculated using net discount rates of 3, 5, and 7 percent before taxes and after inflation.

Unit costs were obtained from standard engineering cost indices for construction items (such as RS Means Co., 1997, 2000). Costs for treatment were obtained from local solid waste disposal facilities. Capital costs were developed using the factored-estimate method, in which the overall costs are derived from knowledge of the costs of major equipment or process items.

Factored estimates are generally believed to provide an accuracy of about 30 percent for specified process parameters (Peters and Timmerhaus, 1968). When process conditions are not well known or when a remedial action requires a detailed design or pilot test prior to implementation, uncertainties in the specified parameters (e.g., treatment volume or rate, concentrations of contaminants, or size of equipment) will result in additional cost uncertainty.

7.3 Comparative Evaluation of Alternatives

The remedial action alternatives are evaluated relative to the most permanent solution to illustrate the relative pros and cons between the alternatives and to assist in identification of the most permanent alternative to the extent practicable. Because it represents the most permanent solution, Alternative 3 will serve as the basis for comparison. A comparison of the alternatives is presented in Table 7-2. The last criterion in this table, public concern, is typically addressed in the final Cleanup Action Plan (CAP) after public comments on the FS and CAP have been received.

MTCA allows identification of a preferred alternative in the feasibility study [WAC 173-340-350(8)(c)]. Alternative 1 is has been identified by Chevron as the preferred alternative based on the following considerations:

- Alternative 1 is protective of human health and the environment.
- Alternative 1 is expected to have the lowest short-term risks during construction.
- Alternative 1 is highly implementable.
- Alternative 1 is the least likely alternative to impact the property owner's site development schedule.
- Alternative 1 is cost-effective having the lowest projected life-cycle cost.

8.0 REFERENCES

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TABLES

Table 1-1. Soil Analytical Results Summary

Soil Boring	Sample Depth (ft)	Sample Date	Gasoline-Range Hydrocarbons (mg/kg)	Diesel-Range Hydrocarbons (mg/kg)	Benzene (mg/kg)
SB-1	7	5/17/2004	20	10	<0.0005
SB-2	6.5	5/17/2004	**880**	**2500**	**0.265**
	9	5/17/2004	**--**	**--**	0.068
SB-3	2.5	5/18/2004	<1.0	<3.0	<0.0005
	4.5	5/18/2004	<1.0	<3.0	<0.0005
	6	5/18/2004	<1.0	<3.0	<0.0005
SB-4	2.5	5/18/2004	<1.0	<3.0	<0.0005
	6	5/19/2004	**370**	190	<0.062
	10	5/19/2004	8	7.5	<0.0020
SB-5	2.5	5/18/2004	<1.0	<3.0	<0.0005
	4.75	5/18/2004	<1.0	<3.0	<0.0005
	6.5	5/18/2004	18	7.2	<0.0005
SB-6	6	5/18/2004	**1300**	**1400**	<0.063
	7	5/18/2004	**690**	**750**	**0.42**
SB-7	6	5/18/2004	**1000**	**2100**	<0.062
	6 (Dup)	5/18/2004	**280**	**1600**	0.022
SB-8	1.5	5/18/2004	<1.0	4.1	<0.0005
	5.5	5/18/2004	**170**	6.9	<0.0010
SB-9	2.5	5/18/2004	8.2	4.3	<0.0005
	5	5/18/2004	**53**	**570**	<0.0020
	8.5	5/19/2004	9.6	9.8	<0.0005
SB-10	3.5	5/18/2004	<1.0	<3.0	<0.0005
	5.5	5/18/2004	23	6.1	<0.0005
	8.5	5/19/2004	11	<3.0	<0.0005
SB-11	1.5	5/18/2004	**75**	13	**0.15**
	3.5	5/18/2004	**1600**	**1400**	**0.16**
	11	6/8/2004	<1.0	<3.0	0.006
SB-12	2.5	5/18/2004	**240**	460	<0.0010
	5.5	5/18/2004	**210**	**500**	<0.0005
	5.5 (Dup)	5/18/2004	**210**	180	<0.0030
SB-13	5.5	5/19/2004	<1.0	43	<0.0005
	6.5	5/19/2004	**1400**	**1100**	**0.18**
SB-14	4.5	5/19/2004	<10	**680**	<0.0005
	5.5	5/19/2004	**1000**	**1000**	**0.25**
	11	6/8/2004	<1.0	<3.0	0.002
SB-15	2	5/19/2004	<10	150	<0.0005
	6.5	5/19/2004	**1300**	**1100**	**0.1**

Table 1-1. Soil Analytical Results Summary

Soil Boring	Sample Depth (ft)	Sample Date	Gasoline-Range Hydrocarbons (mg/kg)	Diesel-Range Hydrocarbons (mg/kg)	Benzene (mg/kg)
SB-16	5.5	5/19/2004	**970**	**830**	**0.1**
	8	5/19/2004	**160**	**540**	**0.341**
SB-17	3.5	5/19/2004	<1.0	24	<0.0005
	5.5	5/19/2004	**1300**	**2400**	**0.44**
SB-18	4	5/19/2004	**1200**	**2500**	**1.3**
	8	5/19/2004	**1300**	**880**	**2.46**
	9	5/19/2004	23	11	0.002
	15	5/19/2004	<1.0	4.6	0.006
SB-19	4	5/19/2004	<1.0	5.5	<0.0005
	5	5/19/2004	**160**	**480**	0.002
SB-20	2	5/19/2004	**490**	370	<0.063
	2 (Dup)	5/19/2004	**730**	**670**	<0.062
	4.5	5/19/2004	**1200**	**1000**	<0.050
SB-21	4.5	5/19/2004	**280**	39	<0.0005
	8	5/19/2004	4.2	<3.0	<0.0005
SB-22	1	5/20/2004	**770**	**730**	0.003
	3	5/20/2004	**66**	70	0.0006
SB-23	2.5	5/20/2004	1.7	27	<0.0005
	4.5	5/20/2004	**380**	**620**	<0.0030
SB-24	2.5	5/20/2004	2.4	<3.0	<0.0005
	4	5/20/2004	**59**	72	<0.0005
SB-25	3.5	5/20/2004	2.6	82	<0.0005
	5.5	5/20/2004	**110**	200	<0.0030
SB-26	2.5	5/20/2004	<1.0	<3.0	<0.0005
	4	5/20/2004	2.4	12	<0.0005
SB-27	3	5/20/2004	14	<3.0	**0.041**
	4.5	5/20/2004	6.3	5.4	0.01
SB-28	4.5	5/20/2004	**330**	110	<0.0005
	8	6/8/2004	1.1	<3.0	<0.0005
SB-29	3.5	5/20/2004	1.7	5.4	<0.0005
	5	5/20/2004	<1.0	<3.0	<0.0005
SB-30	3	5/20/2004	1.2	15	<0.0005
SB-31	3	5/20/2004	**290**	**1400**	<0.0030
SB-32	3	5/20/2004	<1.0	<3.0	<0.0005
	6	5/20/2004	23	230	<0.0005
SB-33	2.5	5/20/2004	15	<3.0	<0.0005
	3.5	5/20/2004	<1.0	<3.0	<0.0005
	3.5 (Dup)	5/20/2004	1.2	<3.0	<0.0005

Table 1-1. Soil Analytical Results Summary

Soil Boring	Sample Depth (ft)	Sample Date	Gasoline-Range Hydrocarbons (mg/kg)	Diesel-Range Hydrocarbons (mg/kg)	Benzene (mg/kg)
SB-34	3	5/20/2004	<1.0	<3.0	<0.0005
SB-35	2.5	5/20/2004	<1.0	<3.0	<0.0005
SB-36	5.5	5/20/2004	<1.0	<3.0	<0.0005
SB-37	4	5/20/2004	**43**	180	<0.0005
	5.5	5/20/2004	1.6	8.2	<0.0005
SB-38	2.5	5/20/2004	**220**	**2100**	<0.0030
	5.5	5/20/2004	**190**	92	<0.0020
SB-39	2	6/7/2004	1.4	3.7	<0.0005
	5	6/7/2004	**950**	**2100**	**0.071**
	12	6/8/2004	**360**	38	0.006
SB-40	7.5	6/28/2004	**310**	250	**0.29**
SB-41	2.5	6/28/2004	**250**	**1500**	0.003
	5	6/28/2004	**1400**	**510**	**0.12**
SB-42	5	6/28/2004	**110**	180	<0.0030
SB-43	4	9/14/2004	**91**	240	<0.0010
	8	9/14/2004	**550**	**920**	<0.063
SB-44	4	9/14/2004	**180**	**5700**	<0.062
SB-45	4	9/14/2004	<1.0	<3.0	<0.0005
SB-46	5	9/14/2004	<1.0	4.6	<0.0005
SB-47	4	9/14/2004	<1.0	<3.0	<0.0005
	7	9/14/2004	22	21	<0.0005
SB-48	4	9/14/2004	<1.0	5.5	<0.0005
	7.5	9/14/2004	<1.0	4.2	0.002
SB-49	5	9/30/2004	<1.0	<3.0	<0.0005
	15	9/30/2004	<1.0	<3.0	<0.0005
SB-50	5	9/30/2004	<1.0	<3.0	<0.0005
	12.5	9/30/2004	<1.0	<3.0	<0.0005
SB-51	5.75	10/1/2004	<1.0	<3.0	<0.0005
SB-52	4.5	10/1/2004	**660**	**1600**	<0.063
	7	10/1/2004	**98**	220	<0.0005
SB-53	6.5	10/1/2004	**460**	**1200**	<0.0030
SB-54	6.5	10/1/2004	**74**	**690**	<0.0005
SB-55	5.5	10/1/2004	<1.0	<3.0	<0.0005

Table 1-1. Soil Analytical Results Summary

Soil Boring	Sample Depth (ft)	Sample Date	Gasoline-Range Hydrocarbons (mg/kg)	Diesel-Range Hydrocarbons (mg/kg)	Benzene (mg/kg)
Cleanup Levels			***30[1]***	***460[2]***	***0.03[1]***

Notes:

-- = Not analyzed

< = Analyte not detected at or above the laboratory reporting limit

Gasoline-Range Hydrocarbons by method NWTPG-Gx

Diesel- and Oil-Range Hydrocarbons by method NWTPH-Dx ext with silica gel cleanup

BTEX by method 8260

Some samples analyzed by WA-VPH. Benzene value is highest detection or lowest DL.

[1] MTCA Method A Cleanup level (Table 740-1)

[2] Terrestrial Ecological Evaluation (Table 749-2)

Table 1-2. Groundwater Analytical Results Summary

Monitoring Well	Date	Depth to Water (ft BTOC)	Water-table Elevation (ft)	Gasoline-Range Hydrocarbons (µg/L)	Diesel-Range Hydrocarbons (µg/L)	Benzene (µg/L)
MW-1	7/9/2004	3.92	93.70	<50	**630**	<0.5
	10/11/2004	1.79	95.83	<50	120	<0.5
	1/25/2005	2.01	95.61	<48	<79	<0.5
	4/13/2005	1.19	96.43	<48	450	<0.5
	7/11/2005	2.38	95.24	<48	380	<0.5
MW-2	7/9/2004	5.06	94.12	**2500**	**1800**	**1100**
	10/11/2004	2.68	96.50	**2500**	**560**	**1100**
	1/25/2005	2.82	96.36	**2200**	**1700**	**880**
	4/13/2005	2.31	96.87	**2800**	**960**	**1100**
Duplicate	4/13/2005	2.31	96.87	**2700**	**960**	**1100**
	7/11/2005	3.16	96.02	**2300**	**1400**	**760**
Duplicate	7/11/2005	3.16	96.02	**2100**	**1500**	**810**
MW-3	7/9/2004	6.03	93.97	80	290	**22**
Duplicate	7/9/2004	6.03	93.97	100	300	**23**
	10/11/2004	4.27	95.73	<50	<79	2
	1/25/2005	4.13	95.87	<48	**670**	2
	4/13/2005	3.78	96.22	<48	89	1.7
	7/11/2005	4.69	95.31	<48	<87	1.7
MW-4	7/9/2004	5.30	92.58	**1600**	**1700**	**160**
	10/11/2004	1.66	96.22	**1800**	**520**	**140**
	1/25/2005	1.79	96.09	**2000**	410	**140**
	4/13/2005	1.40	96.48	**2100**	**1300**	**120**
	7/11/2005	2.18	95.70	**1800**	**1200**	**54**
MW-5	10/11/2004	2.79	95.52	90	130	<0.5
	1/25/2005	2.79	95.52	100	**860**	<0.5
	4/13/2005	2.23	96.08	110	**530**	<0.5
	7/11/2005	3.38	94.93	64	**560**	<0.5
MW-6	10/11/2004	2.26	96.04	1000	**600**	1
	1/25/2005	2.46	95.84	**1100**	**1600**	1
Duplicate	1/25/2005	2.46	95.84	**1100**	**1700**	1
	4/13/2005	1.78	96.52	**860**	**900**	<2.0
	7/11/2005	3.16	95.14	1000	**1200**	2.3
MW-7	10/11/2004	3.79	96.10	200	**570**	<0.5
	1/25/2005	3.27	96.62	190	**1500**	<0.5
	4/13/2005	4.28	95.61	73	**880**	<0.5
	7/11/2005	4.02	95.87	140	**1100**	<0.5

Table 5-1. Initial Screening of Cleanup Alternative Components – Soil

Category	Cleanup Alternative Component	Description of Action	Technical Feasibility Screening Comment
Institutional Controls	Deed Restrictions	Covenants to limit conveyance of property and the type of future land uses and construction	**Retained.** Allows for natural attenuation of soil and groundwater contamination by controlling human contact.
Containment	Surface Paving	Paving all exposed surfaces over soil contamination extents, not covered by other structures.	**Retained.** This component would control all contact with subsurface contamination, limiting health risks, and allowing for natural attenuation to occur.
	Vapor Barriers	Installation of vapor barriers beneath slabs of all new construction on the property	**Retained.** The addition of vapor barriers on all new site buildings may be useful in eliminating vapor intrusion into buildings constructed over areas of soil contamination. May be instrumental in closing the indoor air/inhalation pathway.
Removal	Excavation	Use of mechanical equipment to unearth soil for on-site treatment, off-site treatment or disposal in order to achieve significant reduction in risk.	**Retained.** Accessible site contaminated soils could be removed by remedial excavation.
Onsite Treatment	Natural Attenuation	Reduction in mass, mobility, and concentration of contaminants in the subsurface by intrinsic processes.	**Retained.** The historic nature of the releases and tight soil types suggest that contaminant migration is not an issue. By nature, petroleum components are readily biodegradable and will attenuate in time.
	Soil Vapor Extraction (SVE)	Reduce the toxicity, volume, or mobility of contaminants by the use of processes that remove, destroy, or stabilize the contaminants of concern.	**Rejected.** The discontinuous stratigraphy of the soils, presence of silt and clay layers, and shallow groundwater indicate that SVE would not be effective at reducing the concentration of contaminants in the vadose zone. In addition, a significant volume of soil contamination is located below the seasonal low groundwater table elevation. And would not be treated by this technology.

Table 5-1. Initial Screening of Cleanup Alternative Components – Soil

Category	Cleanup Alternative Component	Description of Action	Technical Feasibility Screening Comment
Onsite Treatment	Bioremediation	In-situ injection and mixing of specific acclimated microorganisms into the contaminated soil to enhance biodegradation breaking the contaminants down into carbon dioxide and water.	**Rejected.** Because the contaminated soil is located in the vadose zone, and beneath the seasonal low groundwater elevation. Due to the discontinuous stratigraphy, and tight soil types, injection into monitoring points would have significantly restricted radii of influence; therefore distribution of the microorganisms would require extensive mixing of the soil by augers or heavy equipment. Mixing would cause contaminated soils to be brought to the surface, increasing the possibility of human and ecological contact. This technology is not protective of human and ecological receptors.
	Thermal Desorption	In-situ heating of subsurface to increase the rate of volatilization of contaminants by passing electrical current through the subsurface	**Rejected.** This technology is limited by the high groundwater elevation. Although highly effective, this technology is most commonly used in conjunction with SVE to remove the volatilized contaminants from the subsurface. Safety concerns were also considered during the screening of this alternative.
Offsite Treatment	Excavation	N/A	**Retained.** The soil may be transported to a thermal treatment facility and subsequently recycled.
Disposal	Excavation	N/A	**Retained.** The excavated soil may be removed to a landfill.

Table 5-2. Initial Screening of Cleanup Alternative Components – Groundwater

Category	Cleanup Alternative Component	Description of Action	Technical Feasibility Screening Comment
Institutional Controls	Deed Restrictions on Construction of New Wells	Covenants to limit conveyance of property and the type of future land uses and construction.	**Retained.** Component does not treat groundwater contamination or prevent mobilization of contamination offsite, however it will control exposure to groundwater during the remediation timeframe, and will most likely be limited to on-site groundwater wells.
Containment	Vertical Barrier	Subsurface impermeable vertical wall constructed of various materials designed to minimize movement of contaminants.	**Rejected.** Groundwater flow at the site is limited, and highly variable. Since groundwater is not expected to move off-site, and the movement if any is highly variable, this would require installation of a vertical barrier surrounding a majority of the site.
Treatment	Groundwater Extraction and treatment	Groundwater extracted from the subsurface, treated by activated carbon filtration, or aeration, and disposed of through city systems	**Rejected.** Recharge information collected during well sampling and excavation activities indicate that the flow of groundwater across the site is slow, and would not be ideal for groundwater extraction. Discharge costs would also be disproportionately expensive, as treatment would be required for an extended timeframe, given the existing groundwater concentrations.
	Monitored Natural Attenuation	Groundwater sampling to confirm stable and shrinking dissolved –phase plume	**Retained.** Potentially useful and logical approach to a low-concentration, non-mobile plume, as petroleum readily biodegrades
	Oxidation	Injection of a chemical oxidant (Oxygen Release Compound)	**Retained.** Potentially useful in expediting the natural breakdown process.
	Air Sparge	Injection of air through sparge points, to volatilize contaminants.	**Rejected.** Due to the stratigraphy of the site, and the density of the soils encountered onsite, Air Sparge wells would have a very low radii of influence, distribution would be unreliable, and discontinuous, making this technology infeasible.

Table 5-3. Applicability of Retained Cleanup Alternative Components

Applicability	Cleanup Alternative Component
Soil	Deed Restrictions
	Surface Paving
	Vapor Barriers
	Excavation
	Natural Attenuation
Groundwater	Monitored Natural Attenuation
	Oxidation

Table 6-1. Remedial Alternatives

Media/Zone/Exposure Pathway	Action Level/Basis	Remedial Alternatives 1	Remedial Alternatives 2	Remedial Alternatives 3
SOIL				
Zone 1: Soil areas posing potential risk via direct contact/ingestion.	**TPH >2,223 mg/kg** (MTCATPH Ver. 10, unrestricted residential land-use scenario)	Institutional controls (e.g., soil management plan) to address future site activities. Natural attenuation.	Excavate soil in this zone.	Excavate soil in this zone.
Zone 2: Soil area posing potential risk via inhalation of indoor air.	**Benzene >0.03 mg/kg** (Johnson & Ettinger model/MTCA Method A – Table 740-1)	Provide vapor barrier beneath any future building(s) that may be constructed in this zone. (None are currently planned.) Natural attenuation.	Excavate soil in this zone.	Excavate soil in this zone.
Zone 3: Soil areas posing potential risk to terrestrial organisms.	**GRO > 200 mg/kg** **DRO >460 mg/kg** (Terrestrial Ecological Evaluation/MTCA Table 749-2)	Install hardscape (e.g., paved parking lot, driveways, sidewalks) to limit contact with soil. Natural attenuation.	Install hardscape to limit contact with soil. Natural attenuation.	Excavate soil in this zone.
Peripheral Zone: Soils beyond Zones 1, 2, & 3.	**GRO >30 mg/kg** **DRO >2,000 mg/kg** **Benzene >0.03 mg/kg** (Method A levels – Table 720-2)	Install hardscape (e.g., paved parking lot, driveways, sidewalks) to limit infiltration. Institutional controls (e.g., soil management plan) to address future site activities. Natural attenuation.	Implement soil management plan to address future site activities. Natural attenuation.	Excavate soil in this zone.

Table 6-1. Remedial Alternatives

Media/Zone/Exposure Pathway	Action Level/Basis	Remedial Alternatives		
		1	2	3
GROUNDWATER				
Groundwater posing potential risk via ingestion/inhalation	**GRO >800 µg/L** **DRO >500 µg/L** **Benzene >5 µg/L** (Method A levels – Table 720-1)	Decrease infiltration via increased hardscape area (Zones 1, 2 & 3). Monitored natural attenuation with sentinel well(s). Restrict future drinking-water wells. Long term monitoring	Source removal (excavate Zones 1 & 2). Decrease infiltration via increased hardscape area (Zone 3). Apply ORC Monitored natural attenuation. Restrict future drinking-water wells Long term monitoring	Source removal (excavate all Zones) Apply ORC Compliance monitoring

Table 7-1. Cleanup Action Alternative Analysis

Evaluation Criteria	Alternative 1 Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Degree of existing risk reduction	This alternative will reduce the risk associated with soil and groundwater contamination via natural attenuation. This alternative also limits the risk associated with terrestrial contact in the through surface paving and covers. Additionally, inhalation risks are reduced through the installation of vapor barriers when necessary. Deed restrictions will limit direct contact exposures through use of soil management plan and contact with the contaminated groundwater plume by restricting the construction of groundwater wells onsite.	This alternative will reduce the risk associated with soil contamination via limited soil excavation, paving and covers, and natural attenuation. Risk associated with groundwater will be reduced by ORC in-situ treatment and deed restrictions limiting construction of groundwater wells on-site. This alternative also limits the risk associated with terrestrial contact through surface paving and covers. Additionally, inhalation risks are reduced through the installation of vapor barriers when necessary. Deed restrictions will limit direct contact exposures through use of soil management plan and contact with the contaminated groundwater plume by restricting the construction of groundwater wells onsite.	This alternative will reduce the risk associated with soil contamination through complete source removal. Groundwater risk will be reduced by in-situ ORC treatment.

Table 7-1. Cleanup Action Alternative Analysis

Evaluation Criteria	Alternative 1 Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Time required to reduce risk and attain cleanup levels	This alternative relies on natural attenuation for soil, making prediction of the cleanup time frame difficult. Because the site is partially paved and expected to be completely paved as part of this alternative in conjunction with site development, the only risk identified for the soil contamination is during potential demolition or excavation activities, which might expose workers to the contaminated soil. This will be controlled through a soil management plan. Groundwater cleanup is also reliant on natural attenuation processes, so as with soil, timeframe is difficult to predict. For the purposes of this FS, monitoring is carried out the full 30 years.	With the limited soil excavation for Alternative 2, the risk associated with soil will be reduced immediately by the removal of the highest levels of contamination, and removal of all benzene above cleanup levels from the site. Soils not removed in the limited excavation will attain cleanup levels through natural attenuation, so the timeframe is difficult to predict. However, the cleanup timeframe is expected to be significantly reduced from the timeframe of Alternative 1, as the limited excavation will also remove the majority of diesel and heavy range hydrocarbon contamination onsite. These heavier range hydrocarbons take longer to breakdown than the lighter range gasoline range hydrocarbons, so by removing them, it is expected that the cleanup timeframe will be significantly reduced. Attenuation of groundwater will be assisted by the addition of ORC during excavation activities. It is expected that this in-situ treatment will reduce the restoration timeframe for this alternative, however not all impacted groundwater will be treated by ORC due to the limited extents of the excavation, so for the purposes of this FS, the restoration timeframe is assumed to be 20 years.	Alternative 3 would attain soil cleanup levels immediately by complete removal of impacted media. Groundwater cleanup levels are expected to be reached following ORC treatment of a majority of the contaminated groundwater plume during excavation activities, and attenuation. The restoration timeframe is assumed to be 3 years.

Table 7-1. Cleanup Action Alternative Analysis

Evaluation Criteria	Alternative 1 Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
On-site and off-site risks resulting from implementation	This alternative has little on-site risk, due to the complete containment of the contaminants. There is a possibility of direct contact to shallow contaminants during future land development and site work. Since no contaminants will be removed, or transported from the site, there is no off-site risk associated with this alternative.	This alternative would result in an increase in on-site risk during excavation activities, and a reduction in on-site risks once excavation activities are complete. During excavation, contaminated soil and groundwater will be exposed, increasing the possibility for direct contact and inhalation exposure to site workers, and the public. Off-site risk associated with this alternative would increase during excavation activities due to the transport of contaminated media from the site over public roadways. There is a potential for exposure to the public, should vehicles transporting contaminated media be involved in any type of traffic accident. There is a potential vehicular accident risk to workers and the public during transport of excavated soil to the disposal facility over public roadways.	On and off-site risk associated with implementation of this alternative is similar to Alternative 2, with an increased risk associated with soil contamination due to the increased volume of the excavation. With an increase in excavation volume, contaminated media will be exposed for a longer period of time, increasing possible exposure to site workers and the public. The potential for off-site risk is also increased from those in Alternative 2, by increasing the volume, number of trips, and time associated with removal of the contaminated media. With a greater volume of contaminated soil being transported from the site, the risk associated with public contact increases.
Improvement in overall environmental quality	This alternative will result in an improvement to the environmental quality of the site over an extended period of time.	This alternative would result in a more timely improvement to the environmental quality of the site by removing hotspot soil contamination, and increasing the rate of groundwater attenuation.	This alternative would result in the most immediate improvement to the environmental quality of the site by removing all accessible soil contamination, and significantly increasing the rate of groundwater attenuation.
Adequacy of hazardous substances destruction	Soil and groundwater contamination will biodegrade.	Soil contamination will be removed from the site, and destroyed through thermal desorption, contaminated soils left onsite will biodegrade. Groundwater will be treated with ORC, and attenuate naturally.	Soil contamination will be removed from the site and destroyed through thermal desorption. Groundwater will be treated with ORC, and biodegrade.
Reduction or elimination of releases or sources of releases	The primary release sources were eliminated prior to initiating this FS.	Identical to Alternative 1.	Identical to Alternative 1.
Degree of irreversibility of waste treatment process	Natural attenuation of soil and groundwater are irreversible.	Off-site thermal treatment of soils, and natural attenuation of soil and groundwater are irreversible.	Identical to Alternative 2.

Table 7-1. Cleanup Action Alternative Analysis

Evaluation Criteria	Alternative 1 Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Treatment residual characteristics and quantity	N/A. There is no treatment residual associated with this alternative.	N/A. There is no treatment residual associated with this alternative.	N/A. There is no treatment residual associated with this alternative.
Cost of construction	$42,800	$217,100	$890,900
Net present value @ 5% discount rate	$163,800	$403,100	$966,900
Degree of certainty of alternative success	This alternative uses commonly employed remedial actions. Natural attenuation is commonly used to remediate petroleum contaminants in soil and groundwater.	This alternative uses commonly employed remedial actions. Natural attenuation, excavation, and ORC treatment are commonly used to remediate petroleum contaminants in soil and groundwater.	This alternative uses commonly employed remedial actions. Natural attenuation, excavation, and ORC treatment are commonly used to remediate petroleum contaminants in soil and groundwater.
Reliability while hazardous substances remain on-site at concentrations above cleanup levels	The reliability for this alternative is dependent on the rate of natural attenuation of soil and groundwater, and mobility of groundwater contaminants.	Identical to Alternative 1.	The reliability for this alternative is dependant on the rate of attenuation and mobility of groundwater contaminants.
Magnitude of residual risk with the alternative in place	Removal of contaminants in soil and groundwater will take years. It is not possible to predict the time required to attain cleanup levels.	Removal of the area of highest soil contamination will immediately reduce the residual risk, however, as with Alternative 1, removal of residual contaminants through attenuation will take years, and is impossible to predict.	Removal of soil contamination will immediately remove all associated risk. Residual risk associated with groundwater contamination will be significantly reduced by the addition of ORC, but will be dependant on the rate of attenuation following ORC addition.
Effectiveness of controls required to manage treatment residues or remaining wastes	No treatment residues will be generated.	Excavated materials will be transported to a licensed disposal facility for thermal treatment, or disposal. No other residues will be generated	Identical to Alternative 2.

Table 7-1. Cleanup Action Alternative Analysis

Evaluation Criteria	Alternative 1 Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Management of short-term risks	The largest potential risk to human health and the environment is the potential of exposure to site workers during site development. Disturbances to the subsurface will be kept to a minimum, and any materials that may be incidentally excavated during site work will be disposed of off-site at a licensed disposal facility.	The largest potential risk to human health and the environment is the potential for vehicular accidents occurring during off-site transport of excavated soil over public roadways. Additional risk includes exposure to site workers during remedial excavation, and site development. To minimize possible exposure, access to the site during remedial activities will be controlled, and site workers will be required to wear appropriate Personal Protective Equipment. All contaminated media excavated will be transported from the site as soon as possible, and treated at a licensed disposal facility. The excavation area will not remain open any longer than necessary to limit the possible exposure to vapors from the residual contaminants.	Similar to Alternative 2; however larger excavation would proportionally increase the risks.
Technical possibility of alternative	This alternative relies on standard techniques and is not expected to be technically difficult to implement.	Identical to Alternative 1.	Identical to Alternative 1.
Availability of necessary off-site facilities, services, and materials	All necessary services are expected to be available locally or within the state.	Identical to Alternative 1.	Identical to Alternative 1.
Administrative and regulatory requirements	This alternative is expected to comply with all regulatory requirements.	Identical to Alternative 1.	Identical to Alternative 1.
Scheduling, size, and complexity	All remedial activities will be completed in conjunction with site development. Construction requirements for this alternative are minimal, and common activities.	Scheduling for remedial components must be scheduled in conjunction with, and completed prior to, site development activities. Excavation could impact the planned development schedule for the site.	Similar to Alternative 2, however, the size and time required for remedial actions is slightly increased, but of equal complexity. Excavation of this size is likely to impact the planned development schedule for the site.

Table 7-1. Cleanup Action Alternative Analysis

Evaluation Criteria	Alternative 1 Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Monitoring requirements	Performance monitoring will be conducted from site groundwater monitoring wells regularly to ensure that natural attenuation of groundwater is occurring. Soil samples will be collected from within the known area of soil contamination to ensure cleanup standards have been met, following a sufficient timeframe for natural attenuation in soil to occur.	Performance monitoring will be conducted from site groundwater monitoring wells regularly to ensure that natural attenuation of groundwater is occurring. Soil confirmation sampling will occur during remedial actions to ensure cleanup standards are met within the excavation extents, and following a sufficient timeframe for natural attenuation to occur, confirmation soil samples will be collected from areas of residual soil contamination to ensure compliance with site cleanup standards.	Similar to Alternative 2, without the requirement for confirmation sampling of soils, as no residual soil contamination is expected.
Access for construction operations and monitoring	Construction operations are limited in scope, and will occur in conjunction with site development activities. Site access for future monitoring is not expected to be limited by site operations.	Assuming remedial activities are completed prior to site development, access for excavation activities and monitoring operations are not expected to be limited in any manner. Site access for future monitoring is not expected to be limited by site operations.	Identical to Alternative 2.
Integration with existing facility operations and other potential remedial actions	This alternative will work in conjunction with facility operations, and have no effect on the business at the site.	This alternative will limit site access, and potentially impact facility operations during excavation activities only.	Similar to Alternative 2, however impacts to facility operations may exist for a longer time period due to the increased scope of excavation activities.
Consideration of public concerns	Public concerns will be addressed following the public comment period.	Identical to Alternative 1.	Identical to Alternative 1.

Table 7-2. Comparison of Alternatives

Evaluation Factor	Alternative 1 (Preferred Alternative) Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Protectiveness	Direct contact/ingestion by humans pathway mitigated with institutional controls. Indoor air inhalation by humans pathway closed by vapor barrier if needed. Direct contact/ingestion to ecological organisms pathway closed through cover. Ingestion of groundwater pathway mitigated with institutional controls.	Direct contact/ingestion by humans pathway closed by source removal. Indoor air inhalation by humans pathway closed by source removal. Direct contact/ingestion to ecological organisms pathway closed through cover. Ingestion of groundwater pathway mitigated with source removal, treatment and institutional controls.	Direct contact/ingestion by humans pathway closed by source removal. Indoor air inhalation by humans pathway closed by source removal. Direct contact/ingestion to ecological organisms pathway closed through source removal. Ingestion of groundwater pathway closed through source removal, and treatment.
Permanence	Maintenance of cover and monitoring to ensure contaminants do not migrate beyond present extent will be required. Degradation of petroleum in soil and groundwater through natural attenuation is permanent. No irreversibility associated with off-site disposal of NAPL or soil remediation. Does not include waste treatment process, so no treatment residual.	Maintenance of cover and monitoring to ensure contaminants do not migrate beyond present extent will be required. Degradation of petroleum in soil and groundwater through natural attenuation is permanent. Degradation of petroleum in groundwater through oxygen enhancement is permanent. Thermal desorption of petroleum from contaminated soil is permanent. Treatment process will not result in residual.	Degradation of petroleum groundwater through oxygen enhancement and natural attenuation is permanent. Thermal desorption of petroleum from contaminated soil is permanent. Treatment process will not result in residual.
Cost	• $ 42,800 Capital Cost • $ 163,800 Present Value @ 5%	• $ 217,100 Capital Cost • $ 403,100 Present Value @ 5%	• $ 890,900 Capital Cost • $ 966,900 Present Value @ 5%
Long-Term Effectiveness	Long term effectiveness will rely on maintenance of cover and compliance monitoring.	Long term effectiveness will rely on maintenance of cover and compliance monitoring.	Excavation and thermal desorption have proven record of effectiveness. Does not rely on long term maintenance for effectiveness.
Management of Short-Term Risks	Low potential for short-term risks, worker soil exposures. Short term risks would be limited to potential for accidents related to paving/landscaping.	High potential for short-term risks, including vapor exposure, worker soil and groundwater exposures, public exposure to soil transported off-site, and vehicular accidents during off-site transport.	Similar to Alternative 2; however, larger excavation would require greater volume of soil for transport off-site.

Table 7-2. Comparison of Alternatives

Evaluation Factor	Alternative 1 (Preferred Alternative) Natural Attenuation of Soil and Groundwater, Vapor Barriers, Surface Paving	Alternative 2 Soil Limited Excavation, Oxidation, Natural Attenuation of Soil and Groundwater	Alternative 3 Soil Excavation, Oxidation, Natural Attenuation of Groundwater
Technical and Administrative Implementability	High technical implementability, uses standard construction techniques. Paving and landscaping are consistent with planned development at the site. Would not adversely impact development schedule for the site.	High technical implementability, uses standard construction techniques. Paving and landscaping are consistent with planned development at the site. Excavation could adversely impact development schedule for the site.	High technical implementability, uses standard construction techniques. Excavation expected adversely impact development schedule for the site.
Consideration of Public Concerns	To be addressed after public comment period.	To be addressed after public comment period.	To be addressed after public comment period.

APPENDIX B:

ESTIMATION OF SOIL VAPOR PATHWAY REL

The Johnson and Ettinger vapor model (SL-ADV, Version 3.0) was completed to determine the risk-based soil concentration expected to result in an acceptable level of human inhalation risk from soil vapor intrusion impacts on new site development. The following presents the input data used, assumptions made, and the resulting risk calculations.

Model risk calculations were performed assuming the contaminated layer underlies the entire building footprint.

Soil physical parameters have not been analytically tested, so the pertinent default model values for observed soil types were used. Soils beneath the site have been described in previous investigations as sands and silty sands. Sand was used as the soil type based on these previous investigations and on anticipated backfill material, as a conservative scenario.

The average soil temperature input value was obtained from the J&E user manual (p. 48 = assume 53 degrees F = 12 degrees C).

The depths to the top and bottom of the contaminated zone were based on previous field investigation observations and analytical data. Modeling was completed assuming the contaminated zone extends from 1.0 to 7.0 feet bgs.

Since final design drawings for the future museum have been provided, building dimension information was assumed from the site plan provided by the Historical Society, and is for estimation purposes only. From the drawing provided, the following model input values were used:

Enclosed space floor width = 72 ft = 2195 cm
Enclosed space floor length = 25 ft = 762 cm
Assume lowest possible ceiling height of 10 feet = 30.48 cm

The depth below grade of the enclosed floor space and enclosed space floor thickness values were assumed to be 0.5 feet, standard for a slab on grade construction.

MTCA standard exposure assumptions were used as model input for exposure duration and averaging times for carcinogens and noncarcinogens (WAC 173-340-750).

Johnson and Ettinger default values for floor wall crack seam width of 0.1 cm and the model default value for differential pressure were used.

A reasonable maximum exposure frequency was calculated assuming an individual who worked in the museum spent 8 hours per day, 5 days per week, and 52 weeks per year inside the museum building. This calculates to 87 (24-hour) days per year.

The final model input affecting the risk to human health is the indoor air exchange rate. Without details from the final building construction design, the air exchange rate inside the museum was calculated using WAC Chapter 51-13-304 ventilation requirements for library spaces. Based on the assumed building size, this results in an indoor air exchange rate of 1.8 exchanges / hour.

The Model was used to back-calculate a soil concentration resulting in an acceptable incremental risk level of $1.0E^{-06}$. This concentration is 0.065 mg/kg.

SL-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. belo

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemica
71432	6.50E+01	Benzene

MORE ↓

ENTER Average soil temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
12	15	30.48	213.36	30.48	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type Lookup Soil Parameters	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type Lookup Soil Parameters	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type Lookup Soil Parameters	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002										

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	762	2195	30.48	0.1	1.8	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
75	6	30	87	1.0E-06	1

Used to calculate risk-based soil concentration.

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
NA	NA	NA	3.13E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.0E-06	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

APPENDIX C:

ALTERNATIVE COST ANALYSIS

Table C-1
Capital Cost Estimate for Alternative 1
(Surface Capping, Vapor Barriers, Natural Attenuation of Soil and Groundwater

Cost Item	Quantity	Unit	Unit Cost	Total Direct Cost (rounded)	
Surface Covering					
Asphalting	8190	SF	2.5	$	20,475
Landscaping					
-- Rock	75	CY	21.5	$	1,613
-- Plantings	75	CY	7	$	525
Subtotal				*$*	*22,700*
TOTAL DIRECT CAPITAL COSTS (TDCC)				**$**	**22,700**
INDIRECT CAPITAL COSTS					
Engineering, legal, administration (20% of TDCC)				**$**	**4,500**
Contractor overhead and profit (25% of TDCC)				**$**	**5,700**
TOTAL INDIRECT CAPITAL COST				**$**	**10,200**
TOTAL CAPITAL COST REQUIREMENT					
Total direct and indirect capital costs				**$**	**32,900**
Contingency (30%)				**$**	**9,900**
TOTAL PROJECT CAPITAL COST				**$**	**42,800**

* Note: Due to rounding, numbers may not appear to add exactly.

Table C-2
O&M Cost Estimate for Alternative 1
(Surface Capping, Vapor Barriers, Natural Attenuation of Soil and Groundwater)

Cost Component	**Quantity**	**Unit**	**Unit Cost $**		**Annualized Cost $/Year**
Groundwater Monitored Natural Attenuation					
Laboratory Analysis	1	event	2592	$	2,600
Labor	1	event	1980	$	2,000
Report Preparation	1	event	2400	$	2,400
subtotal				*$*	*7,000*
Maintenance (3% Capital Cost)				$	700
Environmental Monitoring					
Soil Cleanup Level Compliance Monitoring (anticipated year 30)				$	10,000
Total Annual Cost (Year 1-29)				**$**	**7,700**
Total Annual Cost (Year 30)				**$**	**17,700**

* Note: Due to rounding, numbers may not appear to add exactly.

Table C-3
Capital Cost Estimate for Alternative 2
(Limited Soil Excavation, Oxidation, Natural Attenuation of Soil and Groundwater)

Cost Item	Quantity	Unit	Unit Cost	Total Direct Cost (rounded)	
Excavation					
Labor	1200	TON	25.8	$	31,000
Waste Disposal	1200	TON	21.4	$	25,700
Trucking	1200	TON	18	$	21,600
Backfill	1200	TON	1.29	$	1,600
Oversight	10	DAY	660	$	6,600
Onsite Analytical Laboratory	5	DAY	2000	$	10,000
Subtotal				***$***	***96,500***
Surface Covering					
Asphalting	6141	SF	2.5	$	15,353
Landscaping					
-- Rock	75	CY	21.5	$	1,613
-- Plantings	75	CY	7	$	525
Subtotal				***$***	***17,500***
Oxidation					
ORC (NaOH flakes)	1000	LBS	0.57	$	600
Feed Pump	1000	LBS	0.02	$	100
Labor	8	HOUR	55	$	500
Subtotal				***$***	***1,200***
TOTAL DIRECT CAPITAL COSTS (TDCC)				**$**	**115,200**
INDIRECT CAPITAL COSTS					
Engineering, legal, administration (20% of TDCC)				**$**	**23,000**
Contractor overhead and profit (25% of TDCC)				**$**	**28,800**
TOTAL INDIRECT CAPITAL COST				**$**	**51,800**
TOTAL CAPITAL COST REQUIREMENT					
Total direct and indirect capital costs				**$**	**167,000**
Contingency (30%)				**$**	**50,100**
TOTAL PROJECT CAPITAL COST				**$**	**217,100**

* Note: Due to rounding, numbers may not appear to add exactly.

Table C-4
O&M Cost Estimate for Alternative 2
(Limited Soil Excavation, Oxidation, Natural Attenuation of Soil and Groundwater)

Cost Component	**Quantity**	**Unit**	**Unit Cost $**		**Annualized Cost $/Year**
Monitored Natural Attenuation (Years 1-2, 19-20)					
Laboratory Analysis	4	event	2592	$	10,400
Labor	4	event	1980	$	7,900
Report Preparation	4	event	2400	$	9,600
Monitored Natural Attenuation (Years 3-18)					
Laboratory Analysis	1	event	2592	$	2,600
Labor	1	event	1980	$	2,000
Report Preparation	1	event	2400	$	2,400
Maintenance (3% Capital Cost)				$	3,500
Environmental Monitoring					
Soil Cleanup Level Compliance Monitoring (anticipated year 20)				$	10,000
Total Annual Cost (Years 1-2, 19)				**$**	**31,400**
Total Annual Cost (Years 3-18)				**$**	**10,500**
Total Annual Cost (Year 20)				**$**	**37,900**

* Note: Due to rounding, numbers may not appear to add exactly.

Table C-5
Capital Cost Estimate for Alternative 3
(Soil Excavation, Oxidation, Natural Attenuation of Soil and Groundwater)

Cost Item	Quantity	Unit	Unit Cost		Total Direct Cost (rounded)
Excavation					
Labor	6000	TON	25.8	$	154,800
Building Removal	1	Each	5000	$	5,000
Waste Disposal	6000	TON	21.4	$	128,400
Trucking	6000	TON	18	$	108,000
Backfill	6000	TON	1.29	$	7,800
Oversight	38	DAY	660	$	25,100
Onsite Analytical Laboratory	20	DAY	2000	$	40,000
Subtotal				***$***	***469,100***
Oxidation					
ORC (NaOH flakes)	5000	LBS	0.57	$	2,900
Feed Pump	5000	LBS	0.02	$	100
Labor	8	HOUR	55	$	500
Subtotal				***$***	***3,500***
TOTAL DIRECT CAPITAL COSTS (TDCC)				**$**	**472,600**
INDIRECT CAPITAL COSTS					
Engineering, legal, administration (20% of TDCC)				**$**	**94,500**
Contractor overhead and profit (25% of TDCC)				**$**	**118,200**
TOTAL INDIRECT CAPITAL COST				**$**	**212,700**
TOTAL CAPITAL COST REQUIREMENT					
Total direct and indirect capital costs				**$**	**685,300**
Contingency (30%)				**$**	**205,600**
TOTAL PROJECT CAPITAL COST				**$**	**890,900**

* Note: Due to rounding, numbers may not appear to add exactly.

Table C-6
O&M Cost Estimate for Alternative 3
(Soil Excavation, Oxidation, Natural Attenuation of Groundwater)

Cost Component	Quantity	Unit	Unit Cost $	Annualized Cost $/Year	
Monitored Natural Attenuation (Years 1-3)					
Laboratory Analysis	4	event	2592	$	10,400
Labor	4	event	1980	$	7,900
Report Preparation	4	event	2400	$	9,600
Total Annual Cost (Years 1-3)				**$**	**27,900**

* Note: Due to rounding, numbers may not appear to add exactly.

Table C-7
Present Worth Cost

Alternative	Initial Capital Investment $	Present Value of O&M Costs $	Total Present Worth $
ALTERNATIVE 1			
For 3% net discount rate	42,800	155,000	197,800
For 5% net discount rate	42,800	121,000	163,800
For 10% net discount rate	42,800	73,000	115,800
ALTERNATIVE 2			
For 3% net discount rate	217,100	220,000	437,100
For 5% net discount rate	217,100	186,000	403,100
For 10% net discount rate	217,100	132,000	349,100
ALTERNATIVE 3			
For 3% net discount rate	890,900	79,000	969,900
For 5% net discount rate	890,900	76,000	966,900
For 10% net discount rate	890,900	69,000	959,900