FINAL
PRELIMINARY SCREENING OF CLEANUP ACTION COMPONENTS
CHELAN CHEVRON SITE
CLEANUP SITE ID: 6660
Chelan, Washington

December 22, 2023

Prepared for:
Washington State Department of Ecology – Central Region Office
1250 West Alder Street
Union Gap, Washington 98903

Prepared by:
Leidos, Inc.
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Bothell, Washington 98011

On Behalf of:
Resource Environmental, LLC
925 Salida Del Sol Drive
Paso Robles, California 93446

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TABLE OF CONTENTS

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TABLES

FIGURES

FINAL
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1 INTRODUCTION AND OBJECTIVES

Leidos, Inc. (Leidos), on behalf of Resource Environmental, LLC (RELLC), an environmental service provider to Chevron Environmental Management and Real Estate Company (Chevron), has prepared this document to summarize a preliminary screening of cleanup action components performed for the Supplemental Feasibility Study (SFS) for the Chelan Chevron Site (the Site). Preparation of the SFS is being performed pursuant to the requirements of Agreed Order No. DE 10629, which was entered into by Chevron and the Washington State Department of Ecology (Ecology) in June 2014.

As required and regulated by the Model Toxics Control Act (MTCA [Chapter 173-340 of the Washington Administrative Code]), the purpose of a feasibility study is to develop and evaluate cleanup action alternatives to enable selection of a cleanup action for a site. Cleanup action alternatives consist of one or more cleanup action components, which may include treatment technologies, containment or removal actions, engineered or institutional controls, or other types of remedial actions that are utilized individually or in combination to achieve cleanup of a site.

The objective of this preliminary screening document is to streamline preparation of the SFS by engaging Ecology early in the process, in order to ensure alignment on the cleanup action components that will be further evaluated by the SFS and to facilitate identification of additional work that may be necessary to complete that evaluation.

2 BACKGROUND

2.1 SITE DESCRIPTION

The Site is identified by Ecology as Cleanup Site ID (CSID) No. 6660. It encompasses an area of approximately 10 acres in the historical downtown and central retail area of Chelan, Washington (Figure 1). It is generally located along and adjacent to E. Woodin Avenue, between Sanders Street to the east and Columbia Street to the west. To the north, it is generally bound by E. Johnson Avenue, and to the south by E. Wapato Avenue.

Within this area, petroleum impacts to soil, groundwater, and soil vapor have been documented, including the routine presence of residual petroleum product, also referred to as light non-aqueous phase liquid (LNAPL) in approximately 12 monitoring wells at the Site.

Petroleum impacts at the Site were originally attributed to a release from the Chelan Chevron service station, located at 232 E. Woodin Avenue. However, more recent investigation activities have confirmed contributions of petroleum impacts to the Site from at least three other discrete sources, which are shown on Figure 1. These sources include:

- A gasoline service station that formerly operated on the property at 221 E. Woodin Avenue;
- A gasoline service station that formerly operated on the property at 141 E. Woodin Avenue; and

- One or more currently unknown sources of diesel fuel or heating oil that are located on or in the vicinity of the property at 136 E. Johnson Avenue.

Another former service station, which previously operated on the property located at 125 E. Woodin Avenue, is also suspected of being a contributing source to the Site. The existence of other contributing petroleum sources that have not been identified to date is also considered likely. For example, soil sampling conducted in the vicinity of the Site in 2022, which was performed in association with utility upgrades by the City of Chelan, identified releases from four orphaned underground storage tanks (USTs) that have resulted in petroleum impacts to soil near the Site at concentrations exceeding MTCA Method A cleanup levels (Leidos, 2022).

The Site is also located in the vicinity of the following other petroleum cleanup sites managed by Ecology's Toxics Cleanup Program:

- Chelan Sewer Pump Station No. 1 (Ecology CSID No. 5772) – 100 W. Woodin Avenue
- Chelan Self Service Texaco (Ecology CSID No. 6399) – 101 E. Woodin Avenue

2.2 SITE REGULATORY HISTORY

A release of petroleum product at the Site was first documented in 1987, when a leak was discovered from the gasoline UST system at the Chelan Chevron service station. The discovery of this release initiated a series of independent environmental investigation and cleanup activities that were performed by Chevron through the remainder of the 1980s and 1990s to address gasoline impacts to soil and groundwater on the Chelan Chevron service station property. In 2001, Chevron began to conduct additional independent investigations to evaluate the potential migration of released petroleum product beyond the Chelan Chevron service station property boundaries.

2.2.1 Agreed Order No. DE 02TCPCR-4905

In 2002, Chevron entered into a cleanup agreement (Agreed Order No. DE 02TCPCR-4905) with Ecology to complete a Remedial Investigation (RI) and Feasibility Study (FS) for the Site. Three RI field events were conducted in March 2003, June/July 2003 and May 2004. Findings of the RI confirmed the presence of petroleum impacts to soil and groundwater at locations approximately 600 feet from the Chelan Chevron service station property, including LNAPL in seven monitoring wells located on and to the west of Emerson Street. A final RI/FS Report was submitted to Ecology, on behalf of Chevron, by Science Applications International Corporation (SAIC, now Leidos) in December 2006. The 2006 RI/FS Report identified Alternative 2C (natural attenuation of soil, periodic LNAPL removal by bailing, and monitored natural attenuation (MNA) of groundwater in the shallow perched aquifer) as the preferred cleanup action alternative for the Site.

The 2006 RI/FS Report was approved by Ecology in January 2007. On September 6, 2007, Ecology issued a letter to Chevron providing notice of completion of Agreed Order No. DE 02TCPCR-4905.

2.2.2 Agreed Order No. DE 10629

Following satisfaction of Agreed Order No. DE 02TCPCR-4905, Chevron continued implementation of ongoing LNAPL removal activities and monitoring of groundwater natural attenuation while working with Ecology to complete a draft Cleanup Action Plan (CAP) for the Site. However, a CAP was never finalized.

In November 2012, after additional review, Ecology rescinded acceptance of the 2006 FS and requested that Chevron enter a new Agreed Order to govern production of an SFS and new CAP.

Agreed Order No. DE 10629 was executed on June 25, 2014. This Agreed Order requires Chevron to:

- Perform a Supplemental Remedial Investigation (SRI);
- Prepare an SFS;
- Prepare a Draft CAP; and
- Prepare and submit quarterly reports summarizing progress on meeting the requirements of the Agreed Order.

To date, five additional phases of investigation have been conducted in association with the SRI. The results of this work have been used to update and refine our current conceptual site model (CSM) for the Site.

3 SUMMARY OF CURRENT CONCEPTUAL SITE MODEL

A CSM is a conceptual understanding of the conditions at a site that is developed to assess potential risks to human health and the environment that may result from the presence of hazardous substances. The CSM incorporates known and suspected information about site conditions like:

- Current and anticipated future land use;
- Site geology and hydrogeology; and
- Contaminant sources, types, concentrations, and extents within the environmental media present at or near a site.

This information is used to evaluate potential exposure pathways that could result in risks to human or environmental receptors under current or anticipated future land use scenarios. The CSM is typically developed initially during the scoping of a remedial investigation and is further refined as additional information is collected. It is a tool used to assist in risk-based decision making for a site.

3.1 CURRENT AND FUTURE SITE USE

Land use on and in the vicinity of the Site area has been as a commercial/retail district for more than a century. Property use and businesses in this vicinity currently include three active service stations, restaurants and retail shops, a bank, museum, theater, hotel, fire station, post office, parking lots and streets, and other miscellaneous businesses. Within this area, several properties are known to have residential apartments on the upper floors. Beyond the boundaries of the Site, residential properties are located nearby to the south of E. Wapato Avenue and east of Saunders Street.

The Site is almost entirely paved or covered by buildings. The Site area consists of multiple privately owned properties, as well as public spaces and rights-of-way that are operated and maintained under the jurisdiction of the City of Chelan, Washington State Department of

Transportation, and Chelan County Public Utilities District (PUD). Chevron does not own or otherwise control any portion of the Site or surrounding vicinity.

Because the Site is located along the main downtown street in Chelan, which has maintained the same commercial usage for more than a century, it is considered unlikely that land use in this area will change.

3.2 SITE GEOLOGY AND HYDROGEOLOGY

This section provides a brief overview of local geologic and hydrogeologic conditions at the Site, which is based on the results of the environmental investigations conducted to date. A more detailed discussion of both local and regional geologic and hydrogeologic conditions can be found in Section 3 of the 2006 RI/FS Report (SAIC, 2006).

3.2.1 Geology

Within the depth limits that have been investigated for the Site, three major distinct lithologic units have been identified, which are referred to in the 2006 RI/FS Report, from top to bottom, as unit A, unit B, and unit C.

3.2.1.1 Lithologic Unit A

Lithologic unit A consists of probable alluvial deposits and fill material. It is laterally and vertically varied, but generally consists of silt and sand. Below depths of approximately 4 to 5 feet below ground surface (bgs), coarser materials consisting of sand with varying degrees of gravel and cobbles are often encountered, which is difficult to drill through and may cause refusal for some drilling and sampling methods. The contact between units A and B has been encountered across the Site at depths ranging from approximately 8 to 20 feet bgs.

3.2.1.2 Lithologic Unit B

Lithologic unit B underlies unit A and consists of finer grained lacustrine deposits, including laminated silt with varying amounts of clay and clay-rich material. Thin layers of very fine sands are rarely present in this unit. In the northern portion of the Site, this silt and clay lithology is present at thicknesses of more than 60 feet. This lithology thins southward and is present at thicknesses averaging 25 feet (minimum 11 feet) in borings advanced along the southern portion of the Site, near Wapato Avenue. The contact between units B and C has been encountered across the Site at depths ranging from approximately 20 to 75 feet bgs, increasing to the north and northeast.

3.2.1.3 Lithologic Unit C

Lithologic unit C consists of glacially deposited material, including till and outwash. In the 2006 RI/FS Report (SAIC, 2006), four glacial layers (subunits) were recognized within unit C. More recent drilling/sampling and compilation of data have resulted in recognition of five glacial layers within the depth of drilling of unit C. These include alternating layers of till-like material within a fine-grained matrix, and coarser-grained outwash-like material. These five subunits from top to bottom include:

- C1: Silty sand and silt with gravel (till)
- C2: Very fine to coarse sand with gravel (outwash)
- C3: Silty sand and silt with gravel (till)

- C4: Very fine to medium sand with gravel (outwash)
- C5: Silty sand with gravel (till)

3.2.2 Hydrogeology

Groundwater occurs primarily in two water-bearing zones at the Site: a shallow perched water-bearing zone (referred to as a shallow perched aquifer in the 2006 RI/FS Report), and a deeper water-table aquifer. Most wells at the Site are screened within or above the shallow perched water-bearing zone. Only three monitoring wells (MW-30, MW-31, and MW-37) are screened in the deeper water-table aquifer.

3.2.2.1 Shallow Perched Water-Bearing Zone

The shallow perched water-bearing zone is present largely within lithologic unit B, the silt and clay unit. During very wet years, the perched water-bearing zone may extend locally up into unit A. The lower part of this saturated zone may extend a short distance into the upper portion of unit C, but the top of the dense till generally forms the base of this water-bearing zone, acting as a confining and perching layer.

Groundwater in the shallow perched water-bearing zone is typically encountered at depths of approximately 20 to 30 feet bgs, except for in monitoring wells located along and near Emerson Street (MW-16, MW-25, and MW-36), and in monitoring wells located in the Wells Fargo Bank parking lot (MW-9 and RW-2), where groundwater is more typically encountered at depths of approximately 40 feet bgs (Leidos, 2021b).

The horizontal component of groundwater flow in the shallow perched water-bearing zone is generally toward the south. However, localized southwesterly and southeasterly gradients are present, which suggest that flow is generally converging toward the central portion of the Site (along Emerson Street). In the shallow perched water-bearing zone, groundwater elevation is consistently lowest at monitoring well MW-16, which is located in the Emerson Street right-of-way. Monitoring wells located south of MW-16 were found to be consistently dry. The area south of the perched water-bearing zone, extending to the lakeshore, appears to be unsaturated.

Groundwater horizontal flow rates in the perched zone are very low, calculated to be less than 10 centimeters per year (SAIC, 2006). Based on groundwater elevation measurements in monitoring well pairs with differing screen depths that are located in close proximity to each other (e.g., RW-1/MW-10, RW-2/MW-9, and RW-2/MW-7), a downward vertical gradient exists in the shallow water-bearing zone. For these well pairs, the RW wells are screened deeper into this water-bearing zone, and measurements from these wells generally indicate groundwater elevations that range from approximately 0.5 to over 5 feet deeper than the adjacent MW well. This downward vertical gradient is expected in a perched water-bearing zone that lies far above the water table.

Long-term groundwater elevation monitoring data for the Site, which has been collected since 1992, indicate that groundwater elevation changes in the shallow perched water-bearing zone are primarily driven by precipitation levels for the Chelan area. Within that timeframe, two periods of unusually high groundwater elevation have occurred – one from approximately August 1995 to February 2001, and the second beginning in March 2016 and lasting through December 2018 (see hydrographs presented in Appendix D of *2020 Groundwater Monitoring Summary Report* [Leidos 2021b]). Data from the first of these high periods exist only for the monitoring wells constructed on the Chelan Chevron service station property, which were installed in 1992. All other monitoring wells at the Site were constructed after May 2001.

In several monitoring wells screened in the shallow perched water-bearing zone, some seasonal variation has been observed, under certain hydrogeologic conditions, that appears to be related to seasonal changes in the surface elevation of Lake Chelan. Further discussion regarding the relationship between Lake Chelan and the shallow perched water-bearing zone is presented below in Section 3.2.2.3.

As part of the original RI for the Site, short-term pumping tests were conducted in 2003 at monitoring wells MW-17, MW-21, and MW-28 to evaluate sustainable yield in the shallow perched water-bearing zone. Based on the results of these tests, SAIC estimated an overall sustainable yield rate of approximately 0.1 gallons per minute (SAIC, 2006). Due to the very low sustainable yield expected for this water-bearing zone, it is considered unlikely to be utilized in the future as a potable water source.

3.2.2.2 Deep Water-Table Aquifer

The deep water-table aquifer is situated entirely within lithologic unit C, the glacial drift unit. This aquifer occurs both within the sandy outwash and silty till layers, although the base of the aquifer is poorly defined. The deep aquifer appears to be unconfined (in areas with deep borings) based on the presence of dry soils above the water table in Unit C, and because water levels in the deep wells did not soon rise beyond where first encountered during drilling (SAIC, 2006).

Currently three monitoring wells at the Site (MW-30, MW-31, and MW-37) are screened in the deep water-table aquifer. Long-term groundwater monitoring results for these wells indicate that the water table has typically been encountered at depths of approximately 65 to 90 feet bgs. Within this aquifer, the horizontal component of groundwater flow is generally to the southeast, toward the Chelan River. The annual seasonal groundwater elevation change in these monitoring wells is typically on the order of 10 feet (see Appendix D, Leidos, 2021b).

3.2.2.3 Groundwater Relationship to Lake Chelan

Lake Chelan is the reservoir for the Lake Chelan Hydro Project, which is managed by the Chelan County PUD. The lake level is managed on an annual cycle to generate hydroelectric power, provide recreation, protect fish, reduce erosion, and restore year-round flows to the Chelan River.

The Chelan County PUD expects to maintain the lake level within a range of 1,084 to 1,100 feet above sea level during most years. In extremely wet years, the lake level could be lowered to 1,083 feet above sea level, or lower (the license minimum is 1,079 feet above sea level) as more room is needed to capture increased runoff (chelanpud.org/parks-and-recreation/lake-chelan-levels). Lake Chelan surface elevation data dating back to January 1, 1992 are presented graphically in groundwater elevation hydrographs, which were most recently presented in Appendix D of the *2020 Groundwater Monitoring Summary Report* (Leidos, 2021b).

As previously discussed in Section 3.2.2.2, the annual seasonal groundwater elevation change in monitoring wells MW-30, MW-31, and MW-37, which are screened in the deep water-table aquifer, is typically on the order of 10 feet. These vertical changes closely mimic the seasonal pattern of surface level elevation changes for Lake Chelan, but with a time lag.

As discussed in Section 3.2.2.1, monitoring data indicate that groundwater elevation changes in the shallow perched water-bearing zone are primarily driven by precipitation levels for the Chelan area. However, some evidence has been observed of groundwater elevation changes in the perched water-bearing zone in response to the changing surface elevation of Lake Chelan, with a time lag, especially in monitoring well MW-23.

Throughout the year, the lake level maintains an elevation that is higher than the deeper water table, and also higher than the perched-zone water level on its downgradient southern edge. Consequently, although the lake appears to be affecting the water levels in these two water-bearing zones (with uncertain mechanisms), the groundwater in these zones do not affect or reach the lake water. The lake and the perched water-bearing zone at the Site are separated laterally by more than 200 feet of unsaturated soil.

A groundwater elevation survey using data-logging pressure transducers, which was conducted as part of SRI Phase 5, has yielded similar results confirming the trend in deep wells and in MW-23, with less response to the east. However, a report presenting the full analysis of these data is still forthcoming.

3.3 PETROLEUM RELEASE SOURCES

SRI results collected to date confirm that the Site has been significantly impacted by petroleum product releases from at least four discrete sources (Figure 1), which include:

- The still active Chevron service station located at 232 E. Woodin Avenue. A service station has continuously occupied this property since 1931. The first documented release of petroleum at the Site was discovered on this property in 1987.
- A gasoline service station that formerly operated on the property at 221 E. Woodin Avenue. Historical records indicate that a service station operated on this property beginning as early as 1910 and continuing until the 1970s.
- A gasoline service station that formerly operated on the property at 141 E. Woodin Avenue. Historical records indicate that service station operations began on this property as early as 1924 and continued until at least 1945.
- One or more currently unknown sources of diesel fuel or heating oil that are located on or in the vicinity of the property at 136 E. Johnson Avenue.

Soil sampling conducted in the vicinity of the Site in 2022 (along the alley between Wooden and Johnson Avenues) also identified releases from four orphaned underground storage tanks (USTs) that have resulted in petroleum impacts to soil exceeding Washington's MTCA Method A cleanup levels (Leidos, 2022). The extent of these releases, or their potential impact to the Site, have not been determined at this time.

An automotive repair shop and service station that was built on the property at 125 E. Woodin Avenue in 1920 and operated at least into the 1930s is also considered a suspected source of petroleum impacts present in the western portion of the Site. This property is alternatively identified as 127 E. Woodin Avenue by the Chelan County Assessor.

3.4 CONTAMINANTS OF CONCERN

MTCA defines a contaminant as "any hazardous substance that does not occur naturally or occurs at greater than natural background levels." Contaminants of concern (COCs) are those hazardous substances that are known to be present at a site and those which may be present based on information regarding the nature of a known release or past operations at a site. Based on the results of environmental investigation activities performed to date, the following hazardous substances are currently considered COCs for the Site:

- Gasoline-range organics (GRO)
- Diesel-range organics (DRO)
- Heavy-oil-range organics (HRO)
- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- 1,2-Dibromoethane (EDB)
- 1,2-Dichloroethane (EDC)
- Naphthalenes (naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene)
- Lead
- Carcinogenic polycyclic aromatic hydrocarbons (PAHs)

3.5 LNAPL CSM

For sites where a significant portion of the contaminant mass present exists as LNAPL, an LNAPL CSM (LCSM) is an important component of the overall CSM for the site. The LCSM incorporates additional information and considerations specific to the LNAPL body, or bodies, present at a site.

3.5.1 LNAPL Occurrence

Recent investigation and monitoring data indicate that LNAPL is currently present in twelve monitoring wells at the Site (Figure 2). Of these monitoring wells, seven (MW-9, MW-10, MW-12, MW-16, MW-21, MW-27, and RW-2) routinely contain LNAPL at thicknesses greater than 1 foot. Since 2016, monitoring wells MW-16, MW-21, and MW-27 have each contained LNAPL at thicknesses greater than 10 feet. Historically, LNAPL has also been found in monitoring wells MW-3, MW-6, MW-7, MW-15, and MW-18. All monitoring wells at the Site containing measurable LNAPL are screened in the shallow perched water-bearing zone within lithologic unit B.

3.5.2 LNAPL Mobility and Saturation

The presence of measurable LNAPL in monitoring wells indicates that some fraction of the LNAPL present at the Site is mobile. Mobile LNAPL represents the portion of LNAPL present at concentrations greater than residual saturation levels. This portion of an LNAPL body is sufficiently mobile to be redistributed in response to water table fluctuations (including a perched water table), which may result in its changing presence or absence in monitoring wells but does not typically result in changes in the lateral extent of an LNAPL body.

Although considered mobile, LNAPL at the Site is considered laterally stable and does not appear to be migrating. Migrating LNAPL refers to plume-scale behavior in which the overall or portion of an LNAPL body is expanding. LNAPL migration tends to occur over the relatively early stages of a release, when LNAPL head pressures and LNAPL saturations are greatest, except in the case of a change in hydraulic conditions. Based on the results of LNAPL forensics analysis (further discussed in Section 3.5.3), as well as service station operational history information, petroleum releases at the Site are generally expected to have occurred prior to about 1995, which is when Chevron discontinued selling leaded regular gasoline in Washington State.

In addition to the mobile fraction of the LNAPL present at the Site, the cleanup alternative selection process must also consider the portion of LNAPL mass present at concentrations that are less than residual saturation levels. Residual LNAPL represents the portion of the LNAPL mass that occupies a fraction of pore space that is discontinuous and too small for LNAPL flow to occur. Because it is immobile, residual LNAPL cannot be recovered by conventional hydraulic recovery systems. However, residual LNAPL can represent a significant portion of the LNAPL mass present at a site, and if left in place can serve as a source of dissolved-phase impacts to groundwater for many years. Residual LNAPL saturation is inversely related to grain size; therefore, more LNAPL mass will typically remain as residual LNAPL in finer-grained soils.

3.5.3 LNAPL Product Types and Spatial Distribution

One or more rounds of forensics analysis has been performed on LNAPL samples from each of the monitoring wells at the Site containing LNAPL. The results of these analyses are reported and discussed in the SRI Phase 5 summary report (Leidos, 2021) and the 2006 RI/FS report (SAIC, 2006).

Figure 3 presents a visual depiction of the distribution of LNAPL product types at the Site, which is based on interpretation of the LNAPL forensics results collected to date. The approximate historical extents of LNAPL shown on this figure are based on past and current observations of measurable in-well LNAPL in Site monitoring wells.

As shown on this figure, an area of gasoline LNAPL is present in the eastern portion of the Site, which is defined by monitoring wells MW-7, MW-9, MW-10, MW-12, MW-18, MW-44 and RW-2. Early LNAPL forensics results reported in the 2006 RI/FS Report indicated that LNAPL in monitoring wells MW-9, MW-10, and MW-12 was alkylate-rich lead gasoline. However, results of the more recent forensics analysis performed for SRI Phase 5 suggested that the LNAPL present in monitoring wells MW-9 and RW-2 may be from two discrete sources despite the close proximity of these monitoring wells, which are approximately 25 feet distant from each other.

Further to the west, near the intersection of E. Woodin Avenue and Emerson Street, another area of leaded gasoline LNAPL exists, which is defined by monitoring wells MW-15, MW-16, MW-21, MW-25 and MW-36. Previous LNAPL forensics analysis reported in the 2006 RI/FS Report indicated compositional similarities in LNAPL samples from monitoring wells MW-15, MW-16, MW-25, and MW-36, which were described as being alkylate poor. Although monitoring well MW-21 also contains leaded gasoline LNAPL, and is located in the vicinity of these wells, results from the SRI Phase 5 LNAPL forensics work indicated no similarities between LNAPL samples collected from monitoring wells MW-16 and MW-21. Qualitative field observations have also been noted regarding the color of LNAPL samples collected from monitoring wells MW-21 and MW-36, which are located approximately 70 feet distant from one another. LNAPL collected from monitoring well MW-36 has been noted to display a distinct red color, while LNAPL collected from monitoring well MW-21 displays a pale-yellow color that is not seen in

LNAPL samples from any other monitoring well at the Site. It is unclear whether these color differences may result from differences in weathering of LNAPL in these areas. However, it is also plausible that the red alkylate-poor LNAPL present in the vicinity of monitoring well MW-36 may be the result of another unidentified leaded gasoline source located in the vicinity or west of Emerson Street.

Further west along E. Woodin Avenue and to the north toward E. Johnson Avenue, LNAPL present in monitoring wells MW-19, MW-22, and MW-27 has been determined to consist of a mix of weathered gasoline and diesel-range petroleum products (diesel-range petroleum products include heating oil, which is also referred to as #2 fuel oil). Analysis of an LNAPL sample from MW-22 conducted in 2003 found the sample to be predominantly weathered diesel, with 60% of the sample consisting of diesel-range hydrocarbons, C15 and greater. Samples collected in 2020 from monitoring wells MW-19 and MW-27 were also found to contain mixtures of leaded gasoline and diesel-range products. The sample collected from monitoring well MW-27 was found to be predominantly diesel or #2 fuel oil with only a trace of gasoline. The hydrocarbon composition of the diesel/#2 fuel oil in the samples from MW-19 and MW-27 were found to be very similar, indicating that the two samples contain the same diesel-range petroleum product.

Results of the LNAPL forensics work conducted to date have been instrumental in confirming that the overall Site has been impacted by petroleum releases from multiple sources and by multiple petroleum product types. The understanding gained of the spatial distribution and physical properties (e.g., volatility and solubility of gasoline-range versus diesel-range petroleum products) of the LNAPL types present at the Site will be important information to consider during the cleanup action alternative evaluation process.

3.5.4 LNAPL Vertical Distribution

At this time, a thorough understanding of the vertical distribution of the mobile LNAPL intervals is not known. Two phases of investigation using laser induced fluorescence (LIF) were performed as part of SRI Phase 2 (Leidos, 2017) and SRI Phase 5 (Leidos, 2021) in order to further characterize the lateral and vertical distribution of LNAPL at the Site. The SRI Phase 5 work also included use of hydraulic profiling (HP) tooling to assess variations in hydraulic conductivity within the subsurface in an attempt to identify transport pathways for mobile LNAPL. These efforts were generally unsuccessful in identifying the presence of LNAPL, even in LIF borings advanced several feet away from existing monitoring wells containing measurable LNAPL.

One exception is the boring completed as part of SRI Phase 2 near monitoring well MW-16 (LIFB-2), which displayed strong fluorescence response characteristic of gasoline LNAPL within a thin interval from approximately 49 to 52 feet bgs (in lower part of unit B). The electrical conductivity and penetration rate logs for this boring suggest that LNAPL may be present at this depth due to a change in soil conditions to a higher permeability stringer or lens within this interval (Leidos, 2017).

Minor fluorescence response was also noted at a depth of approximately 38 feet bgs in boring UHP-2, which was completed near monitoring well MW-38 as part of SRI Phase 5 in December 2020.

The SRI Phase 2 work also included collection of soil cores that were frozen in the field and later examined by Core Lab under ultraviolet (UV) light conditions and subjected to additional laboratory analyses to assess LNAPL mobility. Results of the digital imaging analyses performed by Core Lab indicated that no to very faint UV response was detected in the soil cores submitted for analysis (Leidos, 2017).

Soil sampling data from SRI Phase 5, which was collected by conventional drilling methods in the immediate vicinity of three source areas, indicate petroleum impacts to soil that are on the order of concentrations that may exceed residual saturation. These impacts are primarily present in vadose zone soils at and below the interface of lithologic units A and B, often with decreasing concentrations at depth below this contact. Below these depths, intervals of significant petroleum impacts were often found to exist in thin layers of very fine sand and/or coarse silt present in the clay-rich silt lithology of unit B. These thin contaminated zones could easily be missed during routine drilling and soil sampling activities, which is now evident when reviewing results of much of the soil sampling work conducted for the original RI.

Collectively, the results of this work indicate that significant intervals of LNAPL saturated soil are generally not present in the areas in close proximity to monitoring wells containing measurable LNAPL. Instead, LNAPL accumulation in many of these monitoring wells may be related to connections to thin layers of higher permeability very fine sand and/or coarse silt present in unit B that allow LNAPL to drain to and collect in the low-pressure voids that are provided by these monitoring wells.

3.5.5 LNAPL Hydrogeologic Conditions

An understanding of the local hydrogeologic setting (i.e., unconfined, confined, perched, or fractured/preferential pathways) in which the mobile fraction of LNAPL is present at a site is useful for interpreting in-well LNAPL thickness data, and for understanding how it may change in response to groundwater elevation changes.

Under unconfined conditions, LNAPL thickness in a monitoring well may increase as the water table falls and LNAPL flows into the well. As the water table rises, LNAPL becomes trapped in the saturated soil and the apparent LNAPL thickness in the well decreases.

Under confined conditions, LNAPL thickness in a monitoring well typically increases as the potentiometric surface rises and decreases as the potentiometric surface falls. For confined conditions, the observed in-well LNAPL thickness is often exaggerated compared to the thickness of the mobile LNAPL interval within the formation.

Perched LNAPL is mobile LNAPL that accumulates in the vadose zone above less permeable layers, which exhibit a pore entry pressure greater than the available LNAPL head, and thus impedes the downward migration of LNAPL. Under perched conditions, LNAPL thickness in a monitoring well may be exaggerated compared to the adjacent mobile LNAPL interval. If the well extends into the underlying confining layer, LNAPL may flow into the “sump” created by installing the well into the underlying confining layer.

Fractured and preferential pathway conditions represent LNAPL confined in a large pore network that may consist of fractures in bedrock or desiccated soils, coarser-grained intervals within finer material, and macropores. Similar to LNAPL in confined conditions, the LNAPL thickness observed in a well is typically exaggerated compared to that within the formation. The LNAPL within the formation is limited to the secondary porosity features, rather than being distributed within the primary porosity of the matrix, or it is present within the coarser-grained material. Indicators of LNAPL within a preferential pathway include:

- Exaggerated LNAPL thickness in wells at equilibrium conditions;
- LNAPL observed at a considerable distance below the water table and laterally from the release location; and
- Areas where the geology is known to have preferential pathways, such as fractured clay and bedrock, coarser-grained intervals, or may have macropores or other secondary porosity features.

At sites with complex geology, LNAPL may exist in more than one of these hydrogeologic settings. It is also possible for the hydrogeologic setting of an LNAPL body to change in response to changes in site conditions. For example, an area initially under unconfined conditions may become confined due to a rise in groundwater elevation (ITRC, 2018).

Based on our current understanding of the vertical distribution of LNAPL, as well as evaluation of long-term groundwater elevation and LNAPL gauging results, Leidos believes that mobile LNAPL may be present under several hydrogeologic settings at the Site. Currently, a thorough evaluation of long-term groundwater elevation and LNAPL gauging results using diagnostic gauge plots would be expected to result in unclear or possibly erroneous results because of the effects of long-term bailing for LNAPL recovery and LNAPL bailing that has been performed for transmissivity testing.

3.5.5.1 Unconfined

Long-term groundwater elevation and LNAPL gauging data for the Site suggest that the mobile LNAPL interval in some areas may be present in an unconfined setting, where in-well LNAPL thickness would be expected to increase as the water table falls and decrease as the water table rises. These monitoring wells consist of those which have historically not contained exaggerated LNAPL thickness measurements of multiple feet. Examples of monitoring wells in which recent LNAPL occurrence trends have been consistent with expectations for unconfined conditions are MW-19, MW-22, and MW-36.

3.5.5.2 Confined

Mobile LNAPL was first detected in monitoring well MW-21 in March 2016, 13 years after this well was installed in 2003. The first LNAPL occurrence at MW-21 also coincided with the detection of LNAPL in monitoring well MW-27 at a thickness of 11.73 feet. Previously LNAPL was not present in monitoring well MW-27, or it had been detected at levels typically less than 0.5 foot. Long-term groundwater elevation data for the Site suggest that the occurrence of LNAPL in these two wells, often at thicknesses in excess of 10 feet, coincided with a rising groundwater trend that began in early 2016. Similar increases in LNAPL thickness were also observed in monitoring well MW-16 during this timeframe. These observations suggest that the mobile LNAPL interval at these locations may be present in a confined setting, which would result in exaggerated in-well LNAPL thickness during high groundwater elevation conditions.

3.5.5.3 Perched

As previously discussed in Section 3.5.4, soil sampling results from SRI Phase 5 indicate that the most heavily impacted soil at the Site is generally present in the vadose zone soils at the interface of lithologic unit A and the finer grained and less permeable soils of lithologic unit B. As discussed above, installation of monitoring wells into this underlying confining layer may create a "sump" to collect mobile LNAPL that exists in a perched setting above the confining layer and which would tend to result in exaggerated values for in-well LNAPL thickness. The early accumulation of LNAPL in monitoring well MW-36 to thicknesses approaching 12 feet in 2003 may be attributable to perched LNAPL conditions. This monitoring well may have intersected and largely drained a body of perched mobile LNAPL present in that vicinity. Although mobile LNAPL has continued to be observed in that monitoring well to date, in-well thickness measurements have never approached those observed in the initial weeks after that monitoring well was first installed (SAIC, 2006). LNAPL present in monitoring well MW-10 (near RW-1) and likely MW-44 also appear to derive perched LNAPL from the vadose zone near the upper contact of unit B.

3.5.5.4 Preferential Pathways

LNAPL in fine-grained media often occurs in macropores or secondary porosity, or in coarser-grained intervals, which can serve as preferential pathways for LNAPL transport. The small pore spaces of the primary pore matrix, combined with sufficient moisture content, result in a large barrier to LNAPL migration. However, these preferential pathways can transport LNAPL vertically and horizontally more easily.

Results of previous investigations also suggest that some portion(s) of the mobile LNAPL fraction at the Site may exist within preferential pathway settings. Evidence of this theory is suggested by the following SRI results:

- Identification of LNAPL fluorescence response in boring LIFB-2 (advanced near monitoring well MW-16 as part of SRI Phase 2), which showed strong fluorescence response typical of gasoline-range LNAPL between approximately 49 to 52 feet bgs. As previously stated, electrical conductivity and the penetration rate logs for this boring suggest that LNAPL in this boring was present in a thin higher permeability stringer or lens encountered between these depths.
- Identification of LNAPL fluorescence response in boring UHP-2 (advanced near monitoring well MW-38 as part of SRI Phase 5), which showed minor fluorescence response typical of gasoline-range LNAPL at a depth of approximately 38.5 feet bgs. This interval also appeared to coincide with an area of increased hydraulic conductivity that was encountered beginning at a depth of approximately 37 feet bgs at this boring location. The possible detection of LNAPL at this location, which is laterally distant from any currently known petroleum sources, would be consistent with behavior of mobile LNAPL in a preferential pathway setting.
- Observations of recently collected continuous soil cores reveal that intervals of LNAPL or residual saturation occur within discrete layers of slightly coarser-grained material in unit B. Based on field investigations and soil sample analytical results, thin layers of very fine sand and/or coarse silt within the finer silt/clay of unit B are often accompanied by significant petroleum contamination. These layers are as thin as an inch and commonly have a noticeably greenish coloration, possibly resulting from the presence of ferrous iron. These relatively coarser-grained intervals appear to form LNAPL preferential pathways within unit B.

Similar to mobile LNAPL existing in confined and perched settings, mobile LNAPL existing in a preferential pathway setting is known to result in exaggerated in-well LNAPL thickness at equilibrium conditions (ITRC, 2018).

3.5.5.5 Interpretation of In-Well LNAPL Thickness Measurements

As discussed in the preceding subsections, SRI results collected to date suggest that mobile LNAPL may be present, at one time or another, at each of the four hydrogeologic conditions (unconfined, confined, perched, and preferential pathways). Of these conditions, three of four (confined, perched, and preferential pathways) would be expected to be associated with complex geologic and hydrogeologic conditions, and each of these three conditions are known to be associated with exaggerated in-well LNAPL thickness measurements.

Based on the weight of evidence provided by the LNAPL delineation data provided by the SRI, Leidos believes that excessive in-well LNAPL thickness measurements (approaching or exceeding 10 feet), which have historically been observed in monitoring wells MW-9, MW-10, MW-12, MW-16, MW-21, and MW-27, are not representative of the mobile LNAPL interval in adjacent soil at those locations. Instead, we believe that these measurements represent exaggerated in-well thickness that is attributable to these monitoring wells intersecting thin intervals of mobile LNAPL within a complex hydrogeologic setting that allows the wells to act as sumps for exaggerated LNAPL accumulation.

3.5.6 LNAPL Transmissivity and Recoverability

LNAPL transmissivity is a measure of lateral mobility of LNAPL within the groundwater environment (API, 2016). Within more recent LNAPL science, transmissivity has emerged as a better metric than in-well LNAPL thickness for assessing LNAPL recoverability, and is now generally considered the standard metric for assessing LNAPL mobility and recoverability using hydraulic recovery systems. As a recoverability metric, it is comparable between different sites regardless of site-specific differences in geology or LNAPL product type. As such, LNAPL transmissivity is considered an essential component of the CSM at LNAPL sites, as it facilitates selection of LNAPL mass removal strategies and may be used as an endpoint criterion to discontinue use of LNAPL recovery systems.

LNAPL transmissivity incorporates LNAPL physical properties, saturation, and relative permeability, as well as aquifer parameters. Due to the dependence of LNAPL transmissivity on multiple variables, it is expected that LNAPL transmissivity values may vary throughout a site, due to geologic variability and/or differences in LNAPL physical properties. LNAPL transmissivity values are also expected to change over the lifetime of a cleanup as LNAPL saturation levels are reduced or in response to changes in aquifer conditions due to groundwater elevation changes.

Based on empirical data, current LNAPL science suggests that LNAPL transmissivity values below 0.1 to 0.8 ft^2/day indicate low recoverability. Hydraulic recovery is considered practical if transmissivity is greater than 0.1 to 0.8 ft^2/day (ITRC, 2018).

To date, three rounds of baildown testing have been performed for the SRI to assess LNAPL transmissivity at the Site.

The first event was conducted in July 2015 and included baildown testing at monitoring wells MW-10, MW-12, and MW-16. A summary of the test methods and results is provided in the Supplemental Remedial Investigation Report – Phase 1 (Leidos, 2015).

Two additional rounds of baildown testing were performed in November 2017 and March 2019, which were conducted in association with Phase 3 of the SRI. The SRI Phase 3 transmissivity testing also included redevelopment of the test wells in April 2018, which was performed to assess whether transmissivity values could be improved by redevelopment to remove accumulated sediment and/or biogrowth in the test wells (Leidos, 2020).

LNAPL transmissivity values for these events ranged from 0.00 to 1.73 square feet per day (ft^2/day), with mean values ranging from 0.005 to 1.20 ft^2/day. No increase in LNAPL transmissivity values was observed following redevelopment of the test wells. Mean values of 0.8 ft^2/day or more were found only for monitoring well MW-27. Mean LNAPL transmissivity values for monitoring well MW-21, which contained 15.09 feet and 10.54 feet of LNAPL, respectively, on the November 2017 and March 2019 baildown event test dates, were 0.73 ft^2/day and 0.11 ft^2/day, respectively. These results suggest that mobile LNAPL at the Site is currently at or near the point of impracticability for recovery by hydraulic recovery systems.

3.6 EXTENT OF IMPACTS TO ENVIRONMENTAL MEDIA

3.6.1 Impacts to Soil

3.6.1.1 Lateral Extents

Figure 4 presents a visual depiction of the approximate lateral extents of petroleum impacts to soil at the Site, which is indicated by the shaded area shown in the figure. This area represents the outer-most lateral extents of petroleum impacted soil, resulting from multiple petroleum release sources, that is currently considered attributable to the Site. For the purpose of this figure, this area was defined by soil sampling results indicating the detection of one or more petroleum constituents at or above MTCA Method A cleanup levels and/or by the historical presence of measurable LNAPL in a monitoring well at the Site. No further delineation of the lateral extents has been interpolated beyond the sampling results confirmed at these locations, and no delineation is provided within the shaded area in an attempt to define the area of petroleum impacts resulting from each of the four confirmed source areas.

To the east, relatively low levels of GRO have been detected along Sanders Street in the borings for monitoring wells MW-42 and MW-43. However, the relatively shallow depths at which these impacts were detected (9 and 10.5 feet bgs, respectively) suggests that they resulted from releases at one or both of the service stations located to the east of the intersection of E. Woodin Avenue and Sanders Street, instead of from one or more of the four source areas currently associated with the Site.

To the west of Emerson Street, along E. Woodin Avenue, petroleum impacted soil was previously encountered in the borings for monitoring wells MW-19 and MW-22. However, the possibility that petroleum impacts at these locations may have originated from a source further to the west, like the former service station at 125 E. Woodin Avenue, has not been confirmed to date. Both of these wells have also contained LNAPL (containing a mix of gasoline and diesel or heating oil) recently, and in the past.

To the north, petroleum impacted soils are known to be present on the property at 136 E. Johnson Avenue (vicinity of monitoring well MW-27). However, along the 200 block of E. Woodin Avenue (between Emerson Street and Sanders Street), petroleum impacts associated with the Site have not been encountered north of the alley between E. Woodin and E. Johnson avenues.

To the south, beyond the alley south of E. Woodin Avenue, LNAPL is present in monitoring wells MW-9 and RW-2, and high levels of GRO and BTEX were previously detected in the boring for former monitoring well MW-11. Further to the west, relatively low levels of GRO were detected in the borings for monitoring wells MW-34 and MW-35 (SAIC, 2006). An indication of gasoline LNAPL presence was also detected at the bottom of the LIF boring UHP-2, near monitoring well MW-38. However, this area was not included in the shaded portion shown on Figure 4 because it was not confirmed by laboratory analytical results, and the detection of LNAPL in this area is not consistent with the soil sampling results for monitoring well MW-38, which showed no indications of petroleum impact.

With regard to the lateral extents of petroleum impacted soil at the Site, data gaps still existing regarding:

- The extent of petroleum impacts from each of the currently identified source areas, and the extent of contaminant comingling that may exist; and
- Whether all petroleum sources impacting the Site have been identified.

As previously discussed, it is also considered likely that additional sources such as the former service station at 125 E. Woodin Avenue, or abandoned USTs that were discovered near the Site during the City's alley utility project in 2022, have also contributed petroleum impacts to the Site.

3.6.1.2 Vertical Extents

Due to the geology of the Site area, petroleum impacted soils are generally first encountered at depths of approximately 15 feet bgs, which corresponds with the upper contact of the unit B layer. As previously discussed in Section 3.2.1, above this depth a coarse-grained interval consisting of sand with gravel and cobbles has typically been encountered. Results of soil sampling conducted in this coarse interval near the base of the abandoned USTs near 141 E. Woodin Avenue and at 221 E. Woodin Avenue suggest that this coarse material is unlikely to retain petroleum impacts.

Within unit B, which includes the shallow perched water-bearing zone, petroleum contaminated soil has been encountered to depths of nearly 75 feet (boring SCB-1, SRI Phase 2). In this, and several other soil borings completed for the SRI, the bottom-most extents of petroleum impacts were not delineated due to concerns about potentially compromising the confining layer between unit B and the water-table aquifer.

3.6.2 Impacts to Groundwater

Figure 2 includes groundwater sampling results from the July and December 2020 monitoring events, which are generally representative of current and historical dissolved-phase petroleum concentrations at the Site. Petroleum impacted groundwater is generally confined to monitoring wells screened in the shallow perched water-bearing zone. However, petroleum-range organics have occasionally been detected in the monitoring wells screened in the deeper water-bearing aquifer, typically at concentrations less than MTCA Method A cleanup levels.

Groundwater monitoring at the Site previously included laboratory analysis of samples for natural attenuation indicator parameters, including nitrate, alkalinity, methane, and ferrous iron. Results of these analyses indicated that anaerobic geochemical processes are likely contributing to natural biodegradation of dissolved-phase petroleum constituents in groundwater at the Site (Leidos, 2018).

3.6.3 Impacts to Soil Vapor

To date, several phases of vapor intrusion assessment have been performed that provide data regarding petroleum impacts to soil vapor at the Site.

In June/July 2003, soil vapor samples were collected from seven paired sets of soil vapor sampling wells. These wells were constructed in adjacent pairs, with the screened interval of one well set near the approximate basement floor depth of the adjacent building (top of screen depths ranged from 8.5 to 12.5 feet bgs) and the screened interval of the second well set at or just above the first field indication of significant petroleum contamination (top of screen depths ranges from 16.5 to 25 feet bgs) Sampling results from these locations, which are presented in Table 4-4 of the 2006 RI/FS Report, indicated significant attenuation of petroleum constituents between the deep and shallow well pairs. Sampling results from the shallow vapor wells were also used to model potential vapor intrusion to indoor air, the results of which suggested that exposure to petroleum chemicals originated from the subsurface are not adversely impacting occupational workers breathing indoor air within the buildings assessed (SAIC, 2006).

Between 2014 and 2016, Leidos planned and conducted two rounds of Tier 2 vapor intrusion assessment to further evaluate petroleum vapor intrusion potential to buildings with basements that were located in close proximity to areas of known petroleum impacts. Sampling events were conducted in June 2015 and February 2016, which included collection of sub-slab and indoor air vapor samples from nine building locations, as well as collection of outdoor air samples from five locations around the Site area. Sampling results indicated that petroleum constituents, primarily BTEX and naphthalene, were detected in indoor air at concentrations exceeding MTCA Method B cleanup levels for indoor air. However, based on the results of the sub-slab and outdoor air samples, Leidos concluded that detections of BTEX and naphthalene in indoor air samples were due to indoor and outdoor air sources that are not attributable to historical petroleum releases at the Site (Leidos, 2015 & 2016).

More recent assessment of potential petroleum impacts to soil vapor was performed as part of SRI Phase 5, which included installation and sampling of two shallow soil vapor sampling wells installed along the north side of E. Woodin Avenue. This work was conducted to assess for potential petroleum vapor intrusion to buildings located in the vicinity of the former service station source areas identified on the properties at 141 and 221 E. Woodin Avenue. Shallow soil vapor sampling wells were installed in November 2020 and sampled on April 16, 2021. Results from the SRI Phase 5 soil vapor sampling event indicated no exceedances of the MTCA Method B screening levels for sub-slab soil gas (Leidos, 2021c). These results were also similar to previous soil vapor sampling results in the following ways:

- BTEX concentrations in the outdoor air samples were higher than those detected in the shallow soil vapor samples.
- Oxygen concentrations in the shallow soil vapor samples ranged from 19 to 20 percent, which indicate that the shallow soils near these sampling locations are well oxygenated. In the presence of sufficient oxygen, aerobic biodegradation will usually degrade vapor-phase petroleum hydrocarbons before they can intrude into buildings. These results are also consistent with the results of soil vapor sampling performed in 2003 for the RI, which showed significant attenuation of hydrocarbon concentrations between the deep and shallow sampling wells at each location.

3.7 POTENTIAL RECEPTOR AND EXPOSURE PATHWAY ANALYSIS

Potential receptors are individuals or populations that are at risk of being exposed to hazardous substances at, or originating from, a contaminated site. Based on the location and setting of the Site, the following are currently considered potential receptors:

- Humans;
- Terrestrial ecological organisms (e.g., vascular plants, ground-feeding birds, herbivorous small mammals, and ground-feeding small mammal predators).

An exposure pathway is the path that a hazardous substance takes from a source to a receptor. Exposure pathways include transport pathways (how a hazardous substance moves through and across different environmental media) and an exposure route (the path by which hazardous substances may enter a receptor). Examples of exposure routes include:

- Direct contact – Ingestion and/or dermal contact with hazardous substances
- Inhalation – Breathing in hazardous substances in air (dust, vapor, or gases)

3.7.1 Potential Soil Transport and Exposure Pathways

The following tables provide an evaluation of potential transport pathways and exposure routes that may be associated with the presence of petroleum impacted soil at the Site.

Evaluation of Potential Transport Pathways - Soil	
Potential Transport Pathways	**Applicability**
Migration from soil where LNAPL is present at levels exceeding residual saturation conditions	**Transport pathway of concern –** Widespread LNAPL occurrence in monitoring wells at the Site indicates that LNAPL is mobile. Although LNAPL at the Site is considered laterally stable, and not expanding, some localized migration may occur in response to changes in groundwater elevation or other subsurface conditions.
Leaching to groundwater	**Transport pathway of concern –** Long-term groundwater sampling data have confirmed petroleum-range hydrocarbon impacts to groundwater. Residual LNAPL remaining in soil will continue to serve as a long-term source for petroleum impacted groundwater.
Volatilization to soil vapor	**Transport pathway of minor concern –** Petroleum-range hydrocarbon impacts to soil vapor have been confirmed by soil vapor sampling. However, the results of this work indicate that petroleum constituents in soil vapor are readily attenuated due to the presence of oxygen in shallow soils.

Evaluation of Potential Exposure Routes – Soil	
Potential Exposure Routes	**Applicability**
Ingestion of, or dermal contact with, contaminated soil	**Exposure route of concern for future subsurface work –** The areas of soil impacted by petroleum-range hydrocarbons at the Site are covered by buildings and pavement and are generally present at depths that would not be encountered by routine construction activities. Therefore, the potential for ingestion or dermal contact by human or ecological receptors is considered limited. However, potential ingestion or dermal contact exposures may be possible for workers, the public, and ecological receptors if impacted soils are exposed during future subsurface construction activities.
Inhalation of hazardous vapors and/or airborne particulates (i.e., dust) in outdoor air	**Exposure route of concern for future subsurface work –** Similar to above, under typical conditions the potential for exposure by inhalation of hazard vapors or dust in outdoor air from contaminated soil is limited. However, potential for exposure by inhalation may exist for workers, the public, and ecological receptors if impacted soils are exposed during future subsurface construction activities.

3.7.2 Potential Groundwater Transport and Exposure Pathways

The following tables provide an evaluation of potential transport pathways and exposure routes that may be associated with the presence of petroleum impacted groundwater at the Site.

Evaluation of Potential Transport Pathways - Groundwater	
Potential Transport Pathways	**Applicability**
Groundwater migration to a downgradient water-bearing zone	**Transport pathway of minor concern –** Dissolved-phase petroleum impacts appear to be limited to the shallow perched water-bearing zone. Groundwater within this shallow zone likely slowly recharges the deep water-table aquifer. However, based on contaminant modeling during the RI/FS (SAIC, 2006) and groundwater sampling results for the deep aquifer, significant attenuation is occurring and the deep aquifer is not impacted by shallow contamination at the Site.
Groundwater discharge to surface water	**Transport pathway of minor concern –** The perched water-bearing zone does not extend to and does not appear to be in hydraulic connection with Lake Chelan.
Volatilization of dissolved-phase petroleum constituents to soil vapor	**Transport pathway of minor concern –** Petroleum-range hydrocarbon impacts to soil vapor have been confirmed by soil vapor sampling. However, the results of this work indicate that petroleum constituents in soil vapor are readily attenuated due to the presence of oxygen in shallow soils.

Evaluation of Potential Exposure Routes – Groundwater	
Potential Exposure Routes	**Applicability**
Ingestion of, or dermal contact with, contaminated groundwater	**Exposure route of minor concern –** The perched water-bearing zone and deep aquifer in the vicinity of the Site are not currently used as a source of water for any purpose by any known individuals. The perched water-bearing zone has very low yield (approximately 0.1 gpm) and is unlikely to ever be used as a source of water because the lake is an abundant and economical source. Due to the proximity to the lake, construction of a drinking water well into the deep aquifer would not be necessary or economical. Because groundwater is not encountered above depths of 20 to 25 feet bgs, groundwater would not be encountered during routine site development or utility construction activities.

3.7.3 Potential Soil Vapor Transport Pathways and Exposure Pathways

The following tables provide an evaluation of potential transport pathways and exposure routes that may be associated with the presence of petroleum impacted soil vapor at the Site.

Evaluation of Potential Transport Pathways – Soil Vapor	
Potential Transport Pathways	**Applicability**
Migration to indoor air	**Transport pathway of minor concern –** VI assessment results for work performed to date indicate that petroleum constituent concentrations in shallow soil vapor are typically less than those found in outdoor air in the vicinity of the Site. However, the potential for migration of impacted soil vapor to indoor air should be considered for new construction or modifications to existing buildings that will include regular human occupancy of subgrade spaces.

Evaluation of Potential Exposure Routes – Soil Vapor	
Potential Exposure Routes	**Applicability**
Inhalation	**Exposure route of minor concern –** VI assessment results for work performed to date indicate that petroleum constituent concentrations in shallow soil vapor are typically less than those found in outdoor air in the vicinity of the Site. However, the potential for migration of impacted soil vapor to indoor air should be considered for new construction or modifications to existing buildings that will include regular human occupancy of subgrade spaces.

4 CLEANUP ACTION OBJECTIVES

This section presents a discussion regarding the objectives for a future cleanup action at the Site. For the purpose of this document, the cleanup action objectives will be utilized as the basis to assess the appropriateness of the cleanup action components screened in Section 5.

The cleanup action objectives for a site include the cleanup standards, which are developed as required under MTCA to define the requirements that must be met to achieve closure of a site. However, cleanup action objectives may also include remediation levels, which define interim endpoints for one or more cleanup action components at complex sites, where multiple cleanup action components may be utilized.

4.1 CLEANUP STANDARDS

Cleanup standards define the requirements that must be achieved by a cleanup. As defined in WAC 173-340-700, cleanup standards consist of the following three components:

- Cleanup levels for the hazardous substances present at a site;
- The location(s) where these cleanup levels must be met (point(s) of compliance); and
- Other regulatory requirements that apply to the site because of the type of action and/or location of the site. These requirements are specified in applicable state and federal laws

and are generally established in conjunction with the selection of a specific cleanup action.

4.1.1 Cleanup Levels

A cleanup level defines the concentration of a hazardous substance above which a contaminated medium (e.g., soil, groundwater, or soil vapor) must be remediated in some manner (Ecology, 2013). The MTCA Cleanup Regulation provides the following three options for establishing cleanup levels:

- **Method A** - Method A cleanup levels are intended to provide conservative cleanup levels for relatively simple sites undergoing routine cleanup actions or for site with relatively few hazardous substances. Most petroleum-contaminated sites can use this method. Method A provides tables of cleanup levels that are protective of human health for a number of the most common hazardous substances found in soil and groundwater at contaminated sites. For soil, the Method A cleanup level must also be at least as stringent as a concentration that will not result in significant adverse effects on the protection and propagation of terrestrial ecological receptors, unless it can be demonstrated that such impacts are not a concern at the site.
- **Method B** - Method B is the universal method to establish cleanup levels under MTCA. It can be used at any site to develop site-specific cleanup levels for all of the hazardous substances present.
- **Method C** - Method C can only be used under limited circumstances for cleanup at industrial facilities.

The 2006 RI/FS Report proposed use of Method A cleanup levels for the Site because the COCs are limited to petroleum product constituents. Although site-specific cleanup levels could be developed under Method B, these cleanup levels would be expected to be similar to, or more stringent than, Method A cleanup levels due to the Site COCs, which include benzene, and the presence of petroleum impacts to groundwater, which has not been classified by Ecology as nonpotable.

For some site situations, Method B cleanup levels can be developed for nonpotable groundwater per the requirements of WAC 173-340-720(6). Ecology previously indicated that the shallow perched water-bearing zone would not be classified as nonpotable, despite the fact that this water-bearing zone is not used as a current source of drinking water and groundwater is present in insufficient quantity to yield greater than 0.5 gallons per minute on a sustainable basis. However, further discussion on this topic is warranted, as drinking water cleanup standards are considered unlikely to be achievable in the shallow perched water-bearing zone within a reasonable restoration timeframe.

Use of Method C cleanup levels would not be appropriate for the Site due to current and expected land use, which is not industrial.

4.1.2 Points of Compliance

Points of Compliance (POCs) are the locations on a site where cleanup levels must be met. MTCA defines the standard POC for each environmental media (soil, groundwater, air, and surface water). The POC is generally defined as throughout the Site.

For certain environmental media (such as groundwater), MTCA allows for establishment of less stringent conditional points of compliance (CPOCs) if certain specified conditions are met.

4.1.2.1 POCs for Soil

The standard POCs for the exposure pathways of concern for petroleum impacted soil at the Site are:

- Direct-contact – Soils from the ground surface to a depth of 15 feet bgs.
- Soil leaching to groundwater – All soils throughout the Site.
- Terrestrial ecological receptors – The standard POC is all soils throughout the Site from the ground surface to a depth of 15 feet bgs (the reasonable depth of soil that could be excavated during site redevelopment and could result in exposure to ecological organisms). MTCA also allows use of a CPOC for soil from the ground surface to 6 feet bgs for sites with institutional controls preventing excavation of deeper soil.

4.1.2.2 POCs for Groundwater

The standard POC for groundwater under MTCA is defined as "…throughout the site from the uppermost level of the saturated zone to the lowest depth potentially affected by the site."

However, under MTCA Ecology may also approve use of CPOCs in cases when it is not practicable to meet groundwater cleanup levels at the standard POC within a reasonable restoration time frame.

Further discussion with Ecology will be necessary to determine whether Ecology will accept CPOCs for groundwater at the Site. Without the use of CPOCs, it is unlikely that Method A cleanup levels for groundwater can be achieved throughout the Site within a reasonable restoration timeframe.

4.1.3 Other Regulatory Requirements

WAC 173-340-710 requires that all cleanup actions conducted under MTCA comply with applicable state and federal laws. Applicable state and federal laws include those that are legally applicable requirements, as well as those requirements that Ecology determines are relevant and appropriate. Applicable, relevant, and appropriate requirements are collectively referred to as ARARs.

For the purpose of this document, a detailed analysis and discussion of potential ARARs is not intended. However, when identified, potential ARARs that may be associated with a specific cleanup action component evaluated for this screening will be considered. For example, remediation technologies resulting in the discharge of hazardous substances to the atmosphere may require discharge permitting by a state or regional agency.

4.2 REMEDIATION LEVELS

Remediation level means the concentration (or other method of identification) of a hazardous substance in soil, water, air, or sediment above which a particular cleanup action component will be required as part of a cleanup action at a site. Remediation levels are useful at more complex cleanup sites where cleanup actions often involve a combination of cleanup action components to meet the cleanup standards.

For most sites, it will not be cost-effective to select a single remediation technology to address the full extent of cleanup necessary to achieve the cleanup standards for the site. Instead, it is usually beneficial to focus one or more cleanup action components on the early stages of the cleanup, when contaminant levels are highest, and one or more other cleanup action components on later stages of the cleanup when contaminants concentrations have decreased, but still remain above the site cleanup levels. For these situations, remediation levels may be established to define the start or end points for use of a particular cleanup action component.

Examples of potential remediation levels that may be considered for the Site include:

- Utilizing LNAPL transmissivity testing results to define the end point of hydraulic recovery of LNAPL.
- Using site-specific Method B cleanup levels for direct-contact to the standard point of compliance for soil to define the end point for certain institutional controls on property use.
- Using asymptotic hydrocarbon mass removal rates to define the end point for operation of a remediation system.

4.3 SUMMARY OF CLEANUP ACTION OBJECTIVES FOR REMEDY SELECTION

Based on regulatory requirements discussed in the preceding subsections, the following cleanup action objectives have been identified to conduct a preliminary screening of cleanup action components for the Site:

- Address mobile interval of gasoline-range LNAPL and diesel/heating oil-range LNAPL to satisfy Ecology nonaqueous phase liquid limitation [WAC 173-340-720(7)(d)].
- Achieve Method A, or site-specific Method B cleanup levels in soil and groundwater if Ecology determines that groundwater in the shallow perched water-bearing zone is nonpotable. Further discussion with Ecology will also be required to determine the POCs to be used for groundwater cleanup at the Site.

5 PRELIMINARY SCREENING OF CLEANUP ACTION COMPONENTS

This section presents the preliminary screening of remedial technologies that was conducted to identify potential cleanup action components to be included in the future SFS. The following subsections present a discussion of site-specific conditions that were considered in the screening process, and a discussion of the results.

5.1 SITE FACTORS AFFECTING SCREENING

The following Site factors, which are likely to impact the design and implementation of a cleanup action at the Site, were considered during the preliminary screening of cleanup action components:

- **Accessibility** – The Site is almost entirely paved or covered by buildings and includes multiple subgrade utilities. Therefore, much of the Site area will be inaccessible for large-scale implementation of many potential cleanup action components.
- **Complex geologic and hydrogeologic conditions** – The presence of contamination primarily within fine-grained heterogeneous soils and within a complex hydrogeologic setting will make successful cleanup of the Site more challenging. Contamination is also present in both unsaturated and saturated zone soils.
- **Lateral and vertical extents of contamination** – The significant lateral and vertical extents of petroleum impacts at the Site, due to area-wide contributions from multiple petroleum sources, will make successful cleanup of the Site more challenging.
- **Site setting** – The Site setting, within the primary corridor of Chelan's commercial/retail district, will complicate implementation of nearly all potential cleanup action alternatives. The Site area consists of multiple privately owned properties, as well as public spaces, and rights-of-way that must be maintained and accessible for their primary use. Chevron does not own or otherwise control any portion of the Site or the surrounding vicinity. Therefore, additional risks and public safety must be considered when evaluating cleanup action components. Long-term access to these areas, especially during Chelan's summer tourist season, is likely to be considered a disruption to local business owners and the public.
- **Site location** – The Site location is relatively remote from major population centers. Therefore, typical operation and maintenance schedules for active remediation systems may be difficult to maintain. This could result in an extended restoration timeframe or failure to meet cleanup objectives for an active remediation cleanup component due to low remediation system run time.

5.2 PRELIMINARY SCREENING RESULTS

This section provides a listing of the remedial technologies included in the preliminary screening process and a summary of the results. Additional details regarding the factors considered for each technology are presented in Table 1.

- **Excavation** – Excavation is considered unlikely to be implementable on a Site-wide basis because of the limited extent of contamination that could be accessed for removal due to existing buildings and infrastructure, as well as the depth of contamination at the Site. However, this remedial technology has been retained for further evaluation as a cleanup action component for source mass "hot-spot" removal, when circumstances may allow such work to be implemented in a cost-effective manner.

- **Containment (physical or hydraulic)** – This remedial technology was not retained for further evaluation as a cleanup action component because it is considered to provide limited to no benefit toward achieving the Site cleanup objectives.
- **In-situ soil mixing and stabilization** – This remedial technology was not retained for further evaluation as a cleanup action component because of concerns regarding implementability at the Site.
- **Hydraulic LNAPL recovery** – Passive hydraulic recovery methods were retained for further evaluation as a cleanup action component. Active hydraulic recovery methods were not retained because they are unlikely to be practicable and cost-effective due to low LNAPL transmissivity in most monitoring wells at the Site.
- **Enhanced LNAPL recovery** – Enhanced LNAPL recovery (most likely using surfactants) has been retained for further evaluation as a cleanup action component.
- **Air sparge/soil vapor extraction (AS/SVE)** – AS/SVE has been retained for further evaluation as a cleanup action component.
- **Biosparging/bioventing** – Biosparging/bioventing has been retained for further evaluation as a cleanup action component.
- **Multiphase extraction (MPE)** – MPE was not retained for further evaluation as a cleanup action component because of site access issues, concerns about effectiveness, technical complexity, and remediation system run-time concerns for a remote system that would be required to treat and discharge groundwater.
- **In-situ chemical oxidation (ISCO)** – ISCO was not retained for further consideration as a cleanup action component because it is not well suited for geologic conditions at the Site, concerns about cost-effectiveness, and because of worker and public safety concerns.
- **Enhanced anaerobic biodegradation** – Enhanced anaerobic biodegradation has been retained for further evaluation as a cleanup action component.
- **Activated carbon** – Activated carbon was not retained for further consideration as a cleanup action component due to lack of benefit and concerns regarding implementability at the Site due to access limitations.
- **Phytotechnology** – Phytotechnology was not retained for further consideration as a cleanup action component due to lack of benefit and implementability at the Site.
- **Thermal-based remediation technologies** – Thermal-based technologies were not retained for further consideration as a cleanup action component due to implementation and safety concerns and Site access difficulties.
- **Natural source zone depletion (NSZD)** – NSZD was retained for further consideration as a cleanup action component. This remedial technology is expected to be a component of all cleanup action alternatives evaluated in the SFS.
- **Monitored natural attenuation (MNA)** – MNA was retained for further consideration as a cleanup action component. This remedial technology is expected to be a component of all cleanup action alternatives evaluated in the SFS.
- **Institutional controls** – Institutional controls were retained for further consideration as a cleanup action component. This remedial technology is expected to be a component of all cleanup action alternatives evaluated in the SFS.

6 CONCLUSIONS AND RECOMMENDATIONS

This preliminary screening document serves to summarize current information regarding contamination at the Site and to begin the initial process of selecting an appropriate cleanup action or actions. As previously stated, the specific objective of this document is to streamline preparation of the SFS by engaging Ecology early in the process to ensure alignment on the cleanup action components that will be included in the SFS, and to facilitate identification of data gaps and/or additional work that may be necessary to complete the SFS evaluation.

Based on our current understanding of conditions at the Site, the following remedial technologies were identified as potential cleanup action components to be considered for inclusion in the future SFS:

1. Excavation
2. Hydraulic LNAPL recovery
3. Enhanced LNAPL recovery
4. AS/SVE
5. Biosparging/bioventing
6. Enhanced anaerobic biodegradation
7. NSZD
8. MNA
9. Institutional controls

The above technologies comprise an initial list of potential cleanup action components that will be used to develop cleanup action alternatives in the SFS. This list is not considered final, and it is compiled for the sake of future discussion purposes. As previously discussed in Section 4.1, questions remain regarding the MTCA cleanup standards that will be established for the Site, due to current uncertainties regarding Ecology's previous determination regarding the potability of the shallow perched water-bearing zone and the point(s) of compliance to be used for groundwater at the Site. These uncertainties will need to be addressed before a more detailed evaluation of cleanup alternatives can be performed.

Ecology rescinded approval of the 2006 FS by letter dated November 1, 2012 and requested that Chevron explore cleanup options that would achieve cleanup of the Site in approximately 10 years or less. Based on the results of five subsequent phases of SRI activities that have been performed to date, Leidos believes that it is technically impossible to achieve cleanup of the shallow perched water-bearing zone to drinking water standards in a 10-year timeframe, given the Site conditions and constraints of the Site setting. Furthermore, such an aggressive cleanup action is not warranted given the minimal risk posed by the Site to human and ecological receptors. Instead, implementation of an overly aggressive cleanup action at this Site is likely to result in increased risk to workers, the public, and the environment.

On behalf of RELLC, Leidos looks forward to continuing to work collaboratively with Ecology and the City of Chelan to develop a cleanup action for the Site that satisfies MTCA and is acceptable to local stakeholders.

7 REFERENCES

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LIMITATIONS

This technical document was prepared on behalf of RELLC and is intended for their sole use and for use by the local, state, or federal regulatory agency that the technical document was sent to by Leidos. Any other person or entity obtaining, using, or relying on this technical document hereby acknowledges that they do so at their own risk, and Leidos shall have no responsibility or liability for the consequences thereof.

Site history and background information provided in this technical document are based on sources that may include interviews with environmental regulatory agencies and property management personnel and a review of acquired environmental regulatory agency documents and property information obtained from RELLC and others. Leidos has not made, nor has it been asked to make, any independent investigation concerning the accuracy, reliability, or completeness of such information beyond that described in this technical document.

Recognizing reasonable limits of time and cost, this technical document cannot wholly eliminate uncertainty regarding the vertical and lateral extent of impacted environmental media.

Opinions and recommendations presented in this technical document apply only to site conditions and features as they existed at the time of Leidos site visits or site work and cannot be applied to conditions and features of which Leidos is unaware and has not had the opportunity to evaluate.

All sources of information on which Leidos has relied in making its conclusions (including direct field observations) are identified by reference in this technical document or in appendices attached to this technical document. Any information not listed by reference or in appendices has not been evaluated or relied on by Leidos in the context of this technical document. The conclusions, therefore, represent our professional opinion based on the identified sources of information.

Tables

Table 1. Preliminary Screening of Cleanup Action Components

Remedial Technology	Description/Objective	Advantages	Disadvantages/Limitations	Implementability	Applicability for the Site
Excavation	• Physical removal and replacement of impacted media by conventional excavation equipment or other means (e.g., bucket-auger drilling equipment)	• Complete contaminant removal in accessible areas • Accomplishes removal and/or reduction of all contaminant phases including LNAPL, absorbed, dissolved, and vapor • Short restoration timeframe (when implemented under ideal conditions)	• Accessibility limitations – limited opportunities to utilize at this Site due to existing buildings and infrastructure, utilities, and depth of contamination • High cost • Waste generation • High carbon footprint • Worker and public safety concerns • Disruption to community and local businesses	• Unlikely to be implementable on a site-wide basis because of the limited extent of contamination that could be accessed for removal due to the presence of existing buildings and infrastructure, utilities, and depth of contamination • Could be utilized for excavation of smaller "hot-spots", especially in conjunction with planned utility upgrades or other municipal projects that may facilitate access to impacted area	• Retained for further evaluation for source mass "hot-spot" removal when conditions may allow such work to be cost effective
Containment (Physical or Hydraulic)	• Use of engineered physical or hydraulic barriers (e.g., barrier wall, slurry wall, French drain, groundwater pumping system) to prevent further migration of contaminant mass	• None identified for the conditions at this Site	• Limited or no benefit provided at this Site because contamination appears to be stable and not migrating • Costly, intrusive, and technically challenging remedy to implement that would provide little, if any, benefit	• Would be costly and technically challenging to implement on a site-wide basis due to the size of the Site	• Not retained for further evaluation due to minimal benefit provided
In-Situ Soil Mixing and Stabilization	• Mechanical mixing of soil or aquifer materials with low-permeability materials such as clay and/or reactive media such as chemical oxidants or electron acceptors, and/or stabilizing media such as Portland cement	• Manages hydrocarbon mass in place by creating a homogenous zone of soil with lower mass flux	• Unlikely to be effective because of limited accessibility due to existing buildings and infrastructure, utilities, and depth of contamination • Moderate to high cost • Moderate to high carbon footprint • Disruptive technology with significant physical space and logistical demands	• Unlikely to be implementable on a site-wide basis because of the limited extent of contamination that could be accessed for mixing due to the presence of existing buildings, utilities, and other infrastructure	• Not retained for further evaluation due to concerns regarding implementability
Hydraulic LNAPL Recovery	• Recovery of mobile LNAPL that accumulates in monitoring wells by passive (e.g., absorbent socks, passive skimmers) or active (e.g., pumps, vacuum truck events)	• Passive recovery could be implemented on a relatively low-cost basis in conjunction with on-going monitoring at the Site • Would contribute to LNAPL mass removal and elimination of mobile LNAPL	• Effectiveness is limited to the mobile fraction of LNAPL present at the Site • Active hydraulic recovery methods are unlikely to be cost-effective at the Site due to low LNAPL transmissivity in most monitoring wells	• Passive recovery could be implemented on a relatively low-cost basis in conjunction with on-going monitoring at the Site • Implementation of some active hydraulic recovery methods may be logistically and technically challenging due to regulations and risks associated with storage of LNAPL waste	• Passive hydraulic recovery methods retained for further consideration as a cleanup action component
Enhanced LNAPL Recovery	• Fluids (e.g., hot water, cosolvents, or surfactants) are injected into the subsurface to enhance LNAPL recovery by hydraulic means	• Facilitates removal of residual LNAPL that cannot be addressed by standard hydraulic recovery methods	• Hydraulic control required • Generation of additional liquid waste stream requiring treatment or disposal • Unlikely to be effective for vadose zone soils far above the water table • Better suited to very small areas	• Surfactant enhanced recovery could be readily implemented on a well-by-well basis utilizing a vacuum truck for liquid recovery	• Retained for further evaluation as a cleanup action component

Table 1. Preliminary Screening of Cleanup Action Components

Remedial Technology	Description/Objective	Advantages	Disadvantages/Limitations	Implementability	Applicability for the Site
Air Sparge/Soil Vapor Extraction (AS/SVE)	• Air is injected into the subsurface to volatize petroleum constituents, which are then extracted from the subsurface in the vapor phase through SVE	• If effective, would address both vadose zone and saturated zone petroleum impacts • If effective, would address residual LNAPL • In addition to removal of the volatile fraction of petroleum constituents present, AS/SVE induced air flow through the subsurface would enhance naturally occurring aerobic degradation of contaminants	• Limited space to implement • Air sparge may not be effective in the fine-grained soils of lithologic unit B, where most contamination is present • Potential for increased VI risk to nearby buildings if SVE system fails to adequately capture injected sparge air. • Remediation system operation along E. Woodin Avenue is likely to be viewed negatively by the public and local business owners • Not as effective for less volatile petroleum products such as diesel or heating oil	• Would be difficult to implement due to lack of space for siting and power needs of AS/SVE equipment	• Retained for further evaluation as a cleanup action component
Biosparging/Bioventing	• Similar to AS/SVE except that air (or alternatively oxygen) is injected more slowly with the main goal being stimulation of aerobic biological degradation of petroleum constituents in the saturated and unsaturated zones	• Reduced potential for increased VI risk to nearby buildings, in comparison to AS/SVE • Would address petroleum impacts to soil at concentrations less than residual saturation • Would address dissolved-phase impacts by enhancing biological degradation of petroleum constituents in groundwater • Applicable to any biodegradable petroleum hydrocarbon • No waste generation • Generally more cost-effective than other active LNAPL technologies	• Fine-grained soil may not allow sufficient air flow, field testing may be necessary to make this determination • Heterogeneity is an important consideration, air will selectively flow in more permeable channels • Potential vapor generation and migration dangers if done too aggressively near receptors	• Some challenges due to lack of space for siting and power needs of equipment, but likely easier to implement than AS/SVE or MPE due to smaller scale of equipment needed	• Retained for further evaluation as a cleanup action component
Multiphase Extraction (MPE)	• LNAPL and groundwater are extracted from the subsurface using pumps in order to dewater contaminated soils in the saturated zone while SVE is used to volatilize and extract petroleum constituents from vadose zone and dewatered saturated zone soils	• If effective, would address both vadose zone and saturated zone petroleum impacts • If effective, would address residual LNAPL • In addition to removal of the volatile fraction of petroleum constituents present, SVE induced air flow through the subsurface would enhance naturally occurring aerobic degradation of contaminants	• System complexity and maintenance needs are increased by the need to extract, treat, and discharge groundwater • Effectiveness is questionable due to fine-grained geologic conditions in the shallow water-bearing zone • System effectiveness would be based on maintaining a high degree of "run time" for the system, which could be challenging given the Site's relatively remote location	• Would be more difficult to implement than AS/SVE due to added technical challenges of processing extracted groundwater • Site conditions (size and distance between source areas) would likely not allow construction of a centralized treatment system. Implementation would likely require use of a mobile treatment system that would be moved between source areas • Coordination of space, power, and utility connections for a mobile treatment system to be used at multiple locations throughout the Site would be challenging •	• Not retained for further consideration as a cleanup action component

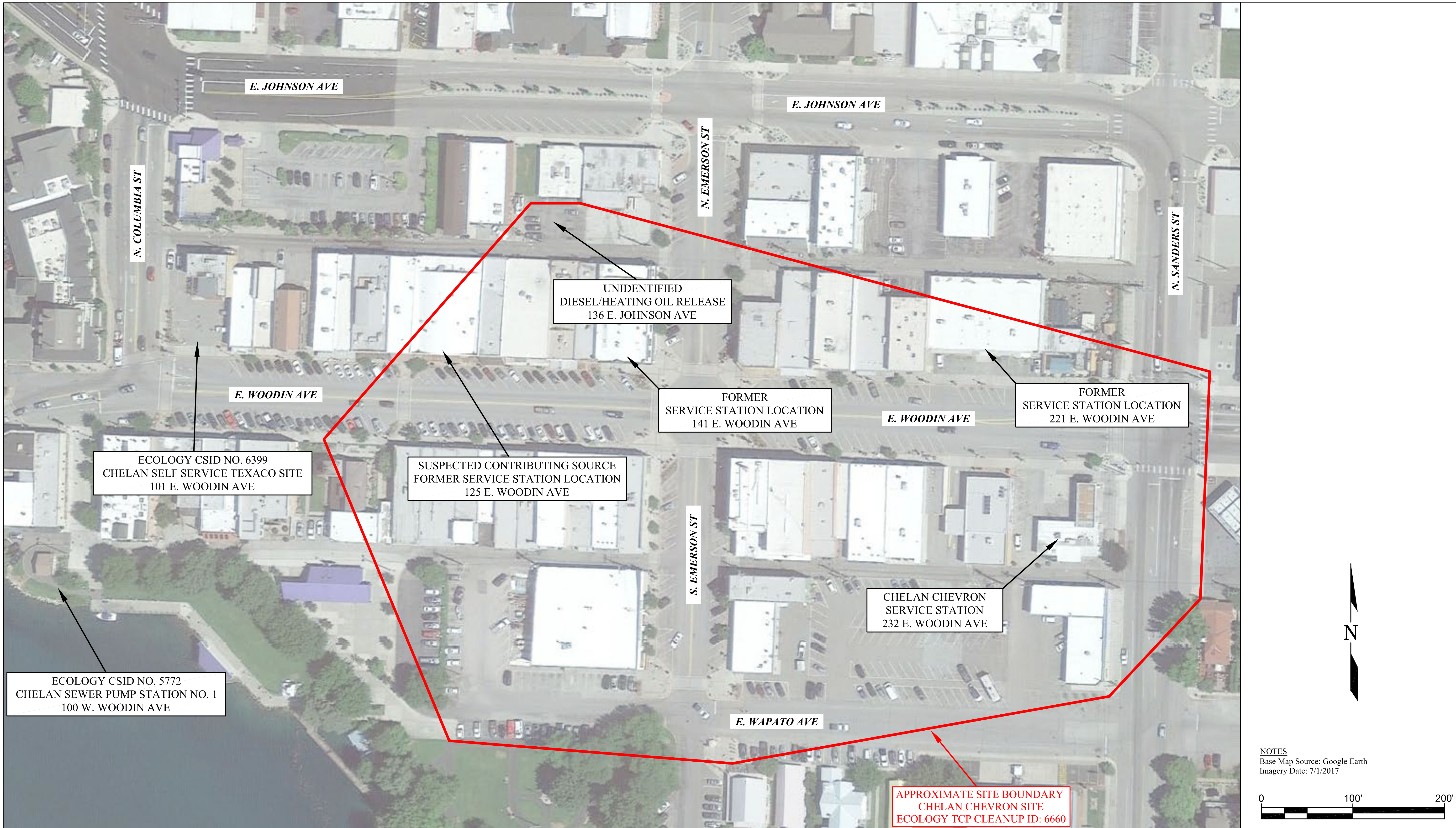
Table 1. Preliminary Screening of Cleanup Action Components

Remedial Technology	Description/Objective	Advantages	Disadvantages/Limitations	Implementability	Applicability for the Site
In-Situ Chemical Oxidation (ISCO)	• Application of chemical oxidants (typically by injection) to react with and destroy organic compounds by breaking down molecular bonds, producing CO_2 and water as by-products	• Low carbon footprint • Short restoration timeframe (when implemented under ideal conditions)	• Limited effectiveness in vadose zone • Low permeability and heterogeneity are challenging for amendment delivery and reduce efficiency and effectiveness • Better suited to small areas with minor LNAPL in-well thickness • Moderate to high cost • By-products • Safety concerns for workers and the public – oxidant reactions can be very rapid and exothermic	• Application of chemical oxidants could be readily implemented at the Site through the use of existing monitoring wells and/or new injection points • Implementation may require restriction of public access during and immediately after injection events to ensure public safety	• Not well suited for Site geologic conditions • Not retained for further consideration as a cleanup action component
Enhanced Anaerobic Biodegradation	• Supply of electron acceptor other than oxygen (e.g., nitrate and sulfate) to enhance anaerobic biodegradation of petroleum constituents	• No waste generation • Low safety concerns • Low carbon footprint • Low to moderate cost	• Restoration timeframe is expected to be high to very high due to time associated with anaerobic biodegradation • Heterogeneity challenges delivery of enhancements and will reduce effectiveness • Because enhancements must typically be injected, this technology is more effective in medium to high permeability zones	• Implementable; however, some concerns regarding effectiveness at this Site due to complex geology	• Retained for further evaluation as a cleanup action component
Activated Carbon	• Application of activated carbon by excavation or injection to sorb dissolved-phase contaminants	• None identified for the conditions at this Site	• Use of activated carbon to sorb/destroy LNAPL has been tested in the field, but the results are not conclusive • Potential for sorbed contaminants to be re-released to the aqueous phase • Not well suited to address vadose zone impacts	• Not well suited for site-wide cleanup at this Site due to access limitations for application by excavation and/or injection	• Not retained for further consideration as a cleanup action component
Phytotechnology	• Use of plants to remediate or contain contaminants in soil, groundwater, surface water, or sediments via phytohydraulics or rhizodegradation	• None identified for the conditions at this Site	• Unlikely to be effective at this Site due to depth of contamination and existing infrastructure and improvements	• Not considered implementable at this Site due to land use and existing infrastructure and improvements	• Not retained for further consideration as a cleanup action component
Thermal-Based Remediation Technologies	• Mobilize and volatilize LNAPL using electrical resistance or thermal conduction heating techniques • Mobilized LNAPL is recovered from extraction wells and volatilized LNAPL is collected via vapor extraction wells	• Low restoration timeframe • Carbon footprint is high, but may be offset somewhat by short remediation timeframe	• Significant safety concerns for workers and the public • Cost • Similar, yet increased, concerns as for MPE for siting, powering, and operating system equipment	• Would be more difficult to implement than MPE due to added technical challenges associated with soil heating	• Not retained for further consideration as a cleanup action component
Natural Source Zone Depletion (NSZD)	• LNAPL mass reduction via naturally occurring volatilization (in the unsaturated zone), aqueous dissolution (in the saturated zone), and biodegradation (in both zones)	• Low cost • Low carbon footprint • Low public safety concerns	• Long restoration timeframe	• Easily implemented	• Retained for further consideration as a cleanup action component
Monitored Natural Attenuation (MNA)	• Aqueous-phase contaminant attenuation in groundwater by a range of naturally occurring in-situ physical, chemical, and biological processes	• Relatively low cost and low carbon footprint; however, the cumulative cost and carbon footprint of long-term MNA can become significant	• Long restoration timeframe • Overall project life-cycle costs are still expected to be high due to the need for long-term monitoring during implementation of an MNA remedy	• Implementable – previous investigation work has confirmed that anaerobic degradation of petroleum contaminants in groundwater is already occurring at the Site	• Considered a component of all cleanup action alternatives to be evaluated in the SFS

Table 1. Preliminary Screening of Cleanup Action Components

Remedial Technology	Description/Objective	Advantages	Disadvantages/Limitations	Implementability	Applicability for the Site
Institutional Controls	• Use of administrative controls such as deed restrictions, legal agreements, or soil management plans to control or minimize receptor exposure to contaminants remaining in place during implementation of a cleanup action	• Provide a cost-effective means to eliminate or minimize potential exposure to hazardous substances	• Provide no active remediation to reduce the restoration timeframe	• Implementability of some institutional controls may be based on approval from property owners	• Considered a component of all cleanup action alternatives to be evaluated in the SFS

Figures



leidos

Chelan Chevron Site
Chelan, Washington

FIGURE 1
Site Area Map

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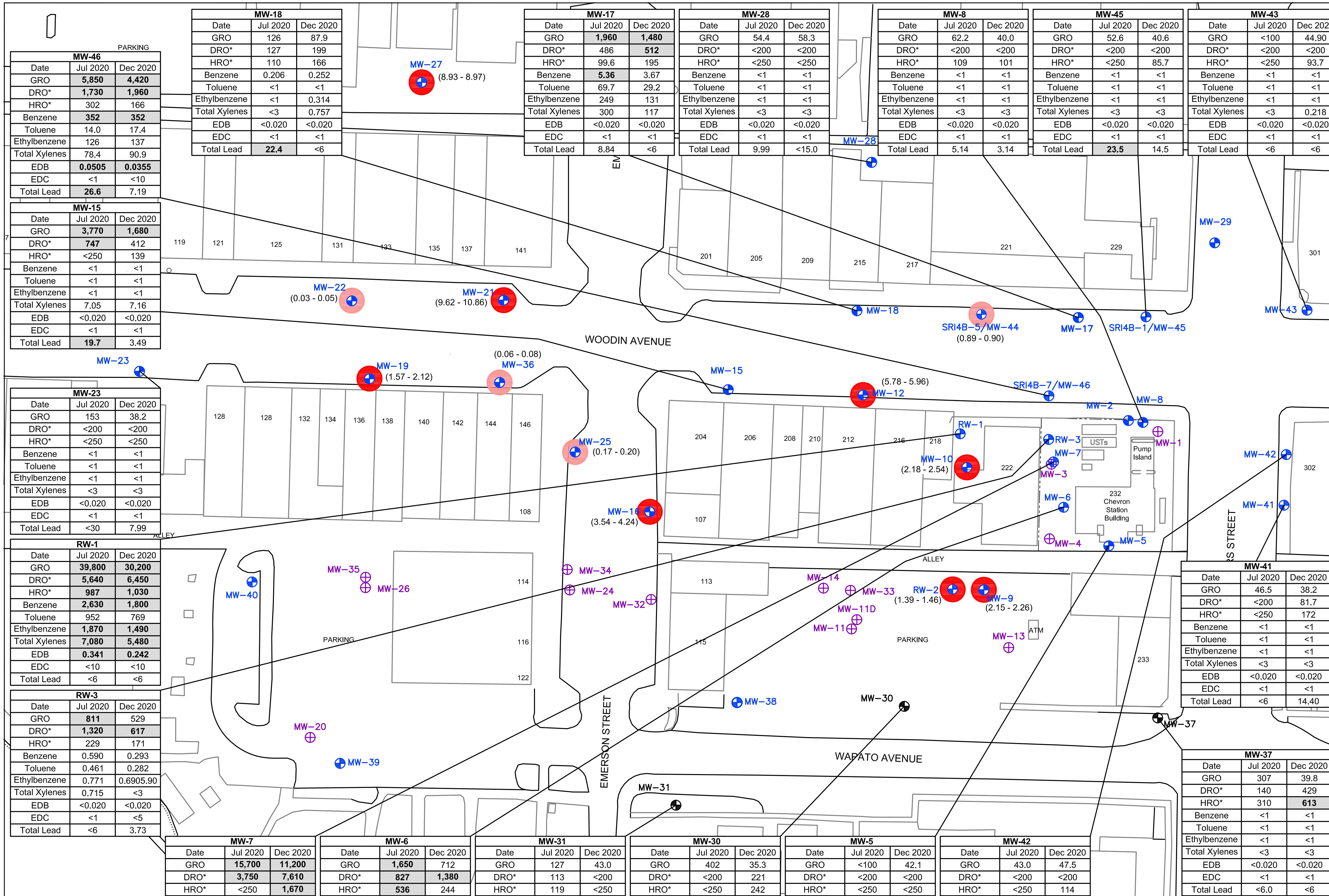
DATE: 9/6/2022



MW-46		
Date	Jul 2020	Dec 2020
GRO	**5,850**	**4,420**
DRO*	**1,730**	**1,960**
HRO*	302	166
Benzene	**352**	**352**
Toluene	14.0	17.4
Ethylbenzene	126	137
Total Xylenes	78.4	90.9
EDB	**0.0505**	**0.0355**
EDC	<1	<10
Total Lead	**26.6**	7.19

MW-15		
Date	Jul 2020	Dec 2020
GRO	**3,770**	**1,680**
DRO*	**747**	412
HRO*	<250	139
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	7.05	7.16
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	**19.7**	3.49

MW-23		
Date	Jul 2020	Dec 2020
GRO	153	38.2
DRO*	<200	<200
HRO*	<250	<250
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<30	7.99

RW-1		
Date	Jul 2020	Dec 2020
GRO	**39,800**	**30,200**
DRO*	**5,640**	**6,450**
HRO*	**987**	**1,030**
Benzene	**2,630**	**1,800**
Toluene	952	769
Ethylbenzene	**1,870**	**1,490**
Total Xylenes	**7,080**	**5,480**
EDB	**0.341**	**0.242**
EDC	<10	<10
Total Lead	<6	<6

RW-3		
Date	Jul 2020	Dec 2020
GRO	**811**	529
DRO*	**1,320**	**617**
HRO*	229	171
Benzene	0.590	0.293
Toluene	0.461	0.282
Ethylbenzene	0.771	0.6905.90
Total Xylenes	0.715	<3
EDB	<0.020	<0.020
EDC	<1	<5
Total Lead	<6	3.73

MW-18		
Date	Jul 2020	Dec 2020
GRO	126	87.9
DRO*	127	199
HRO*	110	166
Benzene	0.206	0.252
Toluene	<1	<1
Ethylbenzene	<1	0.314
Total Xylenes	<3	0.757
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	**22.4**	<6

MW-17		
Date	Jul 2020	Dec 2020
GRO	**1,960**	**1,480**
DRO*	486	**512**
HRO*	99.6	195
Benzene	**5.36**	3.67
Toluene	69.7	29.2
Ethylbenzene	249	131
Total Xylenes	300	117
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	8.84	<6

MW-28		
Date	Jul 2020	Dec 2020
GRO	54.4	58.3
DRO*	<200	<200
HRO*	<250	<250
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	9.99	<15.0

MW-8		
Date	Jul 2020	Dec 2020
GRO	62.2	40.0
DRO*	<200	<200
HRO*	109	101
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	5.14	3.14

MW-45		
Date	Jul 2020	Dec 2020
GRO	52.6	40.6
DRO*	<200	<200
HRO*	<250	85.7
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	**23.5**	14.5

MW-43		
Date	Jul 2020	Dec 2020
GRO	<100	44.90
DRO*	<200	<200
HRO*	<250	93.7
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	0.218
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<6	<6

MW-41		
Date	Jul 2020	Dec 2020
GRO	46.5	38.2
DRO*	<200	81.7
HRO*	<250	172
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<6	14.40

MW-37		
Date	Jul 2020	Dec 2020
GRO	307	39.8
DRO*	140	429
HRO*	310	**613**
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<6.0	<6

MW-7		
Date	Jul 2020	Dec 2020
GRO	**15,700**	**11,200**
DRO*	**3,750**	**7,610**
HRO*	<250	**1,670**
Benzene	0.429	1.09
Toluene	0.758	1.95
Ethylbenzene	6.54	5.90
Total Xylenes	15.6	19.6
EDB	<0.020	<0.020
EDC	<1	<5
Total Lead	**76.1**	**146**

MW-6		
Date	Jul 2020	Dec 2020
GRO	**1,650**	712
DRO*	**827**	**1,380**
HRO*	**536**	244
Benzene	2.77	1.91
Toluene	0.405	<5
Ethylbenzene	4.66	4.93
Total Xylenes	1.07	<15
EDB	<0.020	<0.020
EDC	<1	<5
Total Lead	**22.0**	**17.1**

MW-31		
Date	Jul 2020	Dec 2020
GRO	127	43.0
DRO*	113	<200
HRO*	119	<250
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<6.0	<6.0

MW-30		
Date	Jul 2020	Dec 2020
GRO	402	35.3
DRO*	<200	221
HRO*	<250	242
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	0.488	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<6.0	<6.0

MW-5		
Date	Jul 2020	Dec 2020
GRO	<100	42.1
DRO*	<200	<200
HRO*	<250	<250
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	<6	<6

MW-42		
Date	Jul 2020	Dec 2020
GRO	43.0	47.5
DRO*	<200	<200
HRO*	<250	114
Benzene	<1	<1
Toluene	<1	<1
Ethylbenzene	<1	<1
Total Xylenes	<3	<3
EDB	<0.020	<0.020
EDC	<1	<1
Total Lead	9.49	**15.3**

LEGEND

- MW-2 — PERCHED GROUNDWATER MONITORING WELL
- MW-30 — DEEP GROUNDWATER MONITORING WELL
- MW-1 — ABANDONED DRY MONITORING WELL
- MONITORING WELLS WITH LNAPL THICKNESS FREQUENTLY > 1 FOOT
- MONITORING WELLS WITH LNAPL THICKNESS CONSISTENTLY < 1 FOOT
- (2.15 - 2.26) — RANGE OF LNAPL THICKESS MEASURED DURING THE CURRENT REPORTING PERIOD (FEET)
- 46.5 — LABORATORY ANALYTICAL RESULT (MICROGRAMS PER LITER)
- **1,960** — LABORATORY ANALYTICAL RESULT EXCEEDING THE MTCA METHOD A CLEANUP LEVEL (MICROGRAMS PER LITER)
- * — LABORATORY RESULTS FOR DRO AND HRO SHOWN IN THE TABLES ARE FOR ANALYSES PERFORMED WITHOUT SILICA GEL CLEANUP

N

0 80' 160'

NOTES

Base Map from City of Chelan, 1994

Additional Reference Material:
Aerial Photograph from September 1991
(Washington State Department of Natural Resources)

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Chelan Chevron Site
Chelan, Washington

FIGURE 2
2020 LNAPL Monitoring and Groundwater Analytical Results

FILE NAME: PASD_FIGURES.dwg
DATE: 9/6/2022

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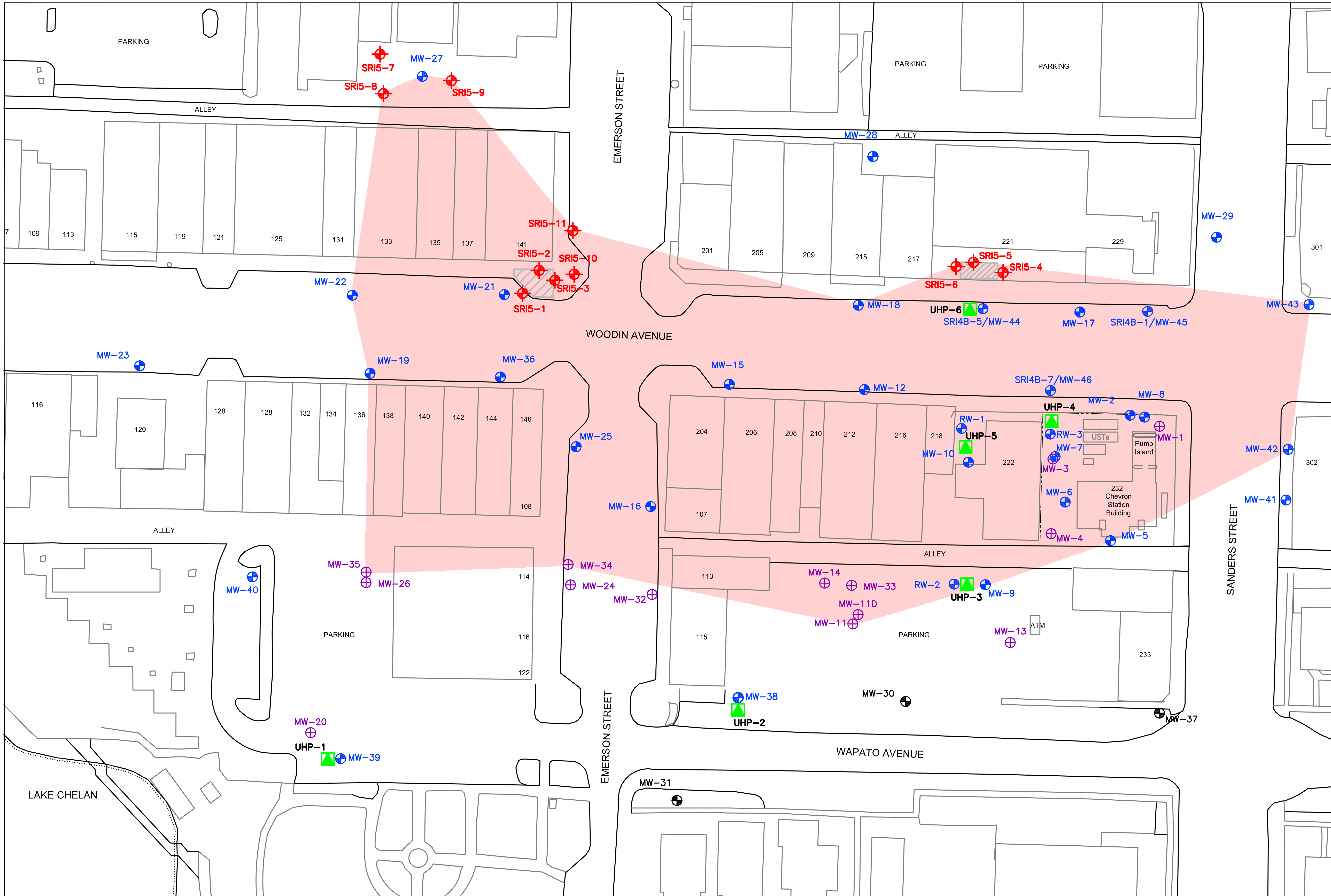
Chelan, Washington

FIGURE 3
Inferred Extents of Petroleum LNAPL Product Types

FILE NAME: PASD_FIGURES.dwg
DATE: 9/6/2022



LEGEND

MW-2	EXISTING PERCHED GROUNDWATER MONITORING OR RECOVERY WELL
MW-30	EXISTING DEEP GROUNDWATER MONITORING WELL
MW-1	EXISTING ABANDONED DRY MONITORING WELL
SRI5-1	SRI PHASE 5 SHALLOW SOIL BORING LOCATION
UHP-1	SRI PHASE 5 UVOST-HP BORING LOCATION
	APPROXIMATE AREA OF ABANDONED UST BASIN
	APPROXIMATE AREA OF PETROLEUM IMPACTED SOIL EXCEEDING MTCA METHOD A CLEANUP LEVELS

NOT ALL RI AND SRI SOIL BORING LOCATIONS SHOWN. PLEASE CONSULT THE 2006 RI/FS REPORT AND SRI SUMMARY REPORTS FOR THE LOCATIONS OF ADDITIONAL SOIL BORINGS NOT SHOWN.

N

NOTES

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0 80' 160'

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Chelan, Washington

FIGURE 4

Approximate Lateral Extents of Petroleum Impacted Soil

FILE NAME: PASD_FIGURES.dwg

DATE: 9/15/2022