Calgary Municipal Land Corporation

West Village
Environmental Analysis Background Report

April 2016

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EXECUTIVE SUMMARY

Calgary Municipal Land Corporation (CMLC) has focused on understanding the complexities associated with West Village since 2012 when its Shareholder first provided direction to investigate the redevelopment potential of the area. Building off that work, CMLC has further focused on three areas specific to environmental analysis:

- Site assessment;
- Risk assessment; and
- Approaches to remediation.

CMLC has used its expertise to review these areas with an eye to capitalizing on future redevelopment opportunities. A team of specialists was assembled by CMLC to provide expertise and advice. Deliverables included a rigorous review of historical studies, investigative fieldwork, data gap analysis, and a human health risk assessment. A total of 54 boreholes and a subset of monitoring wells were completed during CMLC's Site Assessment phase. These results were analyzed from a technical and health risk assessment perspective to provide approaches for future remediation.

While much of the analysis confirmed past historical reports, CMLC did uncover key new insights:

- There are no immediate adverse health effects due to current conditions;
- Potential risks to future users can be managed and mitigated; and
- A plume of highly concentrated contaminants (dense non-aqueous phase liquid, or DNAPL) extends further to the west than previously identified;

Six remediation techniques were chosen by the team based on each technology's timeframe and ability to address the contaminants found. The technologies were then used to configure six potential remedial approaches to address the unique development scenarios in West Village, based on the Province of Alberta's commercial Tier II guidelines for select contaminants used as indicator compounds of the extent of contamination (naphthalene and PHC).

These configurations include:

- Excavation and disposal;
- Excavation and thermal treatment;
- Excavation and biostabilization;
- In-Situ Solidification;
- In-Situ Thermal; and
- Enhanced Containment.

Each approach was then evaluated with respect to its advantages and limitations, duration and cost specific to addressing the Canada Creosote site (44 acres), while the balance of West Village was evaluated based on its similarity to the environmental remediation and redevelopment efforts of East Village.

Estimated Costing of Remedial Approaches	Expedited Approach*	Measured Approach*
Canada Creosote Site	$110,000,000	$65,000,000
Balance of West Village	$30,000,000	$20,000,000
Estimated Total	$140,000,000	$85,000,000
Estimated Timeline for Canada Creosote Site Work		
Additional Investigation, Regulatory Approvals and Permitting (approximate time)	3-5 years	3-5 years
Remediation (approximate time)	3 years	5 years
TOTAL	**6-8 years**	**8-10 years**
*The expedited approach is represented by excavation and disposal of all impacted areas, where as the measured approach is represented by excavation and on-site biostabilization and reuse.		

CMLC has concluded that given the recent interaction and feedback from the regulator and additional information gathered during the most recent investigations, further studies should be continued in order to align and optimize the triple bottom line solution for West Village contamination and redevelopment efforts.

1.0 INTRODUCTION

1.1 Background

Calgary Municipal Land Corporation (CMLC) has been working on analyzing the future redevelopment potential for West Village over the past four years. CMLC was asked by City Council in April 2012 to explore strategic opportunities related to future redevelopment projects beyond the Rivers District. Through a series of strategic planning meetings with both the CMLC Board of Directors and City Council as Shareholder, West Village was confirmed as a key future redvelopment area for the City of Calgary that could benefit from CMLC's expertise. A summary of some of the key milestones associated with the strategic planning process from 2012 to 2015 are as follows:

- April 23, 2012 – CMLC's Shareholder, Calgary City Council, approved a Notice of Motion (NM2012-22) requesting CMLC to examine opportunities for next steps in the CMLC Business Plan including West Village.
- September 7, 2012 – CMLC's Board attended a Strategic Planning Retreat and discussed in addition to the future strategic focus of CMLC, options for various potential redevelopment projects that could benefits from the expertise brought to the table by CMLC.
- December 14, 2012 – A Special Shareholder meeting was held and a key component of this meeting was to identify specific redevelopment areas from Council's perspective that could benefit from CMLC's expertise. A short list was created and included West Village.
- February 22, 2013 – CMLC's Shareholder approved CMLC's 2013 Business Plan and budget which included specific direction to perform due diligence and develop preliminary plans for further shareholder consideration for West Village amongst other potential projects.
- March 24, 2014 – CMLC's Shareholder directs CMLC to undertake further due diligence for long term strategic opportunities for West Village.
- February 11, 2015 – CMLC's Shareholder provides specific direction for CMLC to continue analysis of redevelopment options for West Village "including but not limited to environmental and legal investigations related to the future redevelopment potential of the site".

As a result of the above direction CMLC has performed preliminary due diligence on the site that has covered land use, planning, land ownership, infrastructure requirements and of course preliminary environmental review based on existing reports to gain a good understanding of past site uses and impacts on future redevelopment efforts. In 2014 and 2015, CMLC began to collaborate with the City's Environmental & Safety Management division that was undertaking all environmental work related to West Village. Prior work undertaken by this business unit focused on risk management and continued operation of the containment system in place. CMLC's perspective further focusses on what is needed to facilitate redevelopment of the site.

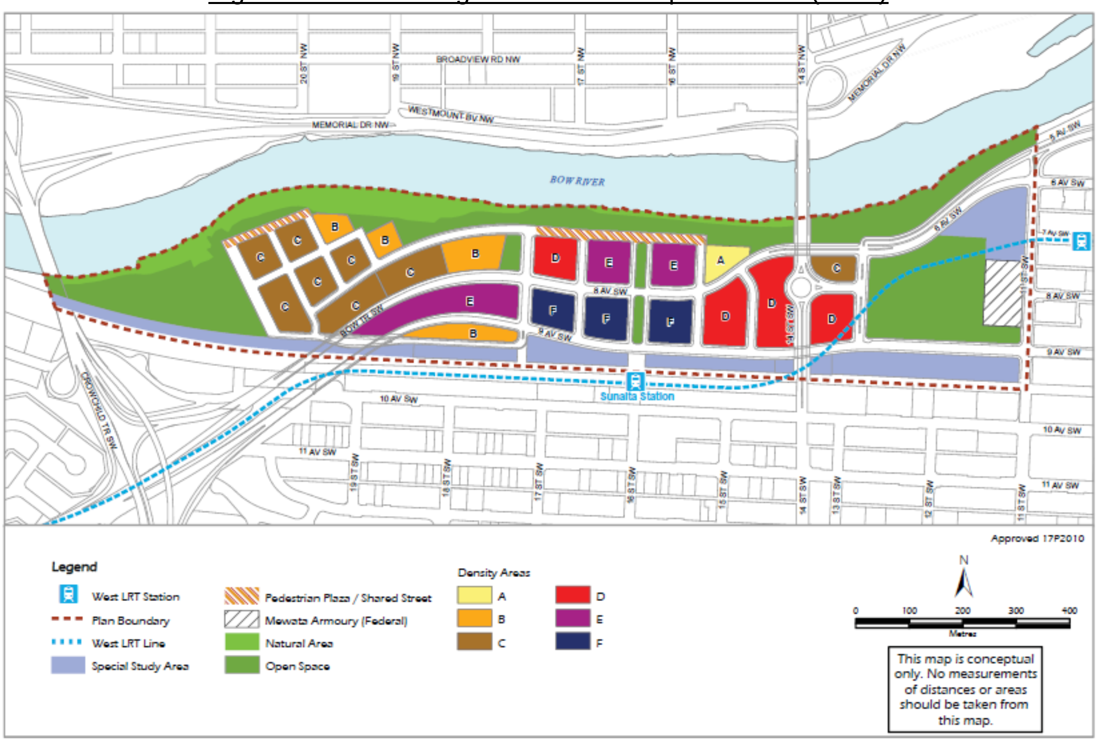
1.2 Purpose of the Report

The purpose of the West Village Environmental Analysis Report is to provide information on the existing environmental conditions, assess the human health risk and provide remedial solutions to redevelopment in West Village. In practice the specific remedation plans are tied directly to the detailed redevelopment plans for a site. As this project is still at the conceptual stage in order to guide the environmental analysis, CMLC identified three specific potential redevelopment scenarios within the West Village. These scenarios were based on the proposed location of the Council approved Area Redevelopment Plan, CalgaryNEXT located at the west end of West Village, and CalgaryNEXT project as identified by the Calgary Sports and Entertainment Corporation (CSEC). The following provides a brief summary of each redevelopment scenario.

1.2.1 West Village Area Redevelopment Plan (2010)

The West Village Area Redevelopment Plan (ARP) is a statutory document approved by Calgary City Council in 2010. It provides the vision and guiding policies for the long-term redevelopment of the area, specifically relating to scale, urban form, and land use. The 2010 ARP did not envision multi-sports complex facility.

Figure 1-1 West Village Area Redevelopment Plan (2010)



Source: City of Calgary, West Village Area Redevelopment Plan

1.2.2 CalgaryNEXT West

Figure 1-2 West Village, CalgaryNEXT West

Footprint of CalgaryNEXT, located at the western edge of West Village Source: CMLC

CMLC studied a second opportunity to locate a version of the CalgaryNEXT facility to the west edge of West Village. This scenario could allow for the redevelopment of a more cohesive West Village neighbourhood. With the Sunalta LRT station a 5 minute walk away, a strong desire line between CalgaryNEXT and the LRT station will be created. This allows for the opportunity to provide an enhaced streetscape between the two points so that the journey to and from CalgaryNEXT is created.

1.2.3 CalgaryNEXT Centre

In the final scenario sports complex is located adjacent to the the Sunalta LRT transit stop. This scenario replicates CSEC's proposal, as CMLC understands it.

Figure 1-3: CalgaryNEXT as Proposed by CSEC

Source: Calgary Sports and Entertainment Corporation

1.3 Environmental Analysis Process

1.3.1 CMLC

CMLC is a leader in brownfield redevelopment and has applied this knowledge to understand the redevelopment potential in West Village. CMLC's organizational capacity ensured this project was guided by best practices in other jurisdictions, existing planning documents, and environmental documents. CMLC's expertise focused in on the redevelopment potential of the neighbourhood while incorporating historical public input. CMLC built on the foundation of work completed by the City of Calgary, and followed by engaging local and international experts successful in similar remediation projects.

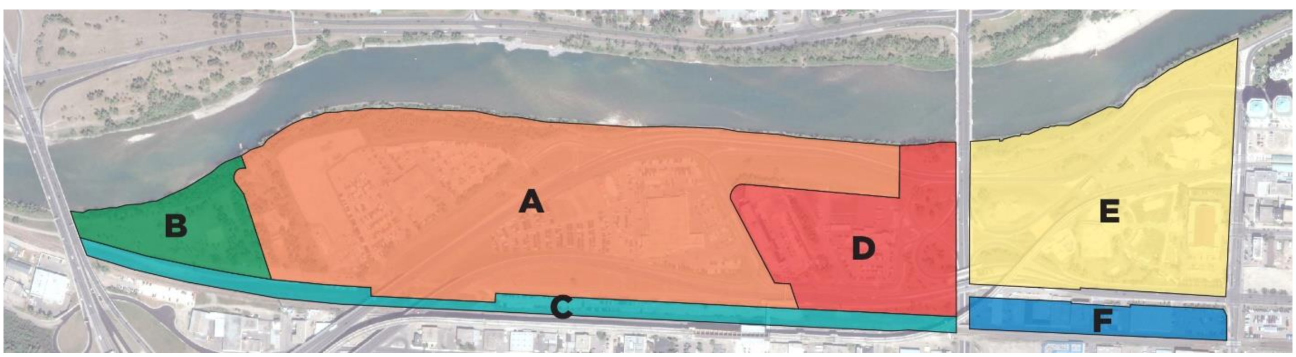
2.0 SITE ASSESSMENT KEY FINDINGS

2.1 West Village Site Characterization

One objective of this report was to evaluate available environmental information for the study area, identify data gaps, and develop a framework to direct future investigations in the context of future redevelopment scenarios. The framework developed involves six management areas, identified as Areas A through F.

Management Area A– the former Canada Creosote Site (CCS) – has a complex set of contaminants to deal with. Management Areas B through F have contamination that is consistent with what is expected for historical industrial land use. These areas have hosted a variety of industrial and commercial operations since the early 1900s including incinerators, gas/service stations, bus terminal, military armoury, former auto body repair operations, car dealerships, railway right-of-way/spur lines/loading docks, asphalt operations, metal machining and transportation corridors. The majority of these previous uses lead to an identification of areas of potential environmental concern (APECs) within these management areas.

Figure 2-1 West Village Environmental Management Areas



Source: CMLC, 2016

2.2 Area A – Canada Creosote Site (CCS)

Management Area A (44 acres), primarily used by Canada Creosote Co., was a wood treatment facility active from 1924 to 1963. The wood preservatives used—coal tar, creosote, pentachlorophenol (PCP), and zinc—dripped or spilled on the ground, leaked from waste ponds and contaminated the soil, groundwater, and the bedrock below. Due to the length of time the company operated, the extent of the site's contamination is significant. Alberta Environment, which manages issues beyond the CCS, has documented preservatives extending under the Bow River and across into the West Hillhurst area.

Existing land uses on site include the City of Calgary's snow dump, and two car dealerships, Renfrew Chrysler, and Chevy City. Contamination related to these operations, including fuel releases and high salinity, may also determine how soils from these areas can be remediated.

2.3 Area B – Pumphouse Theatre and Park

This is the western edge of West Village and houses the Pumphouse Theatre, a designated historic resource, and adjoining park. This site did not have any active industrial uses other than the pumphouse that was an integral component of Calgary's water system. However, many of the prior industrial uses were in close proximity, and it appears that a significant amount of fill was added to this area, including a large amount of debris and contaminated fill. Therefore, further assessment is needed to evaluate the extent of contaminated fill and possible effect to the underlying groundwater prior to redevelopment taking place.

2.4 Area C – Canadian Pacific Railway

The Canadian Pacific Railway (CPR) right-of-way has been located south of 9th Avenue SW since 1883 and forms the southern boundary of West Village. The portion that extends from 14th Street to Crowchild Trail SW comprises Area C. The rail lines in this right-of-way and the associated spur lines were used to service Area A to the north and transport bulk goods, including hazardous substances such as fuels and wood preservatives and therefore there is potential for a release to have occurred. In addition to railway ballast often contaminated with metals, creosote railway ties, debris, suspect fill, and stained areas have been observed along the length of Area C. Further assessment is warranted prior to redevelopment.

2.5 Area D – West of 14 Street SW

Area D is a combination of several parcels that have had a wide variety of historical uses, including lumber storage associated with CCS and CPR, asphalt operations, service stations, automobile repair, automobile salvage operations, metal machining, and car dealerships. Its eastern and north-central portion have been the locations of two City of Calgary municipal waste incinerators, and asphalt operations. These operations, and the placement of poor fill in Area D, indicate further assessment is appropriate.

The western portion is currently the location of the Greyhound Terminal, the Hyatt Auto Gallery, and the Mercedes Benz Service Center, while the eastern portion is the location of the Mewata (14 Street) Bridge and 14 Street/Bow Trail interchange.

2.6 Area E – East of 14 Street SW

Area E, east of 14th Street has been primarily used for large public or government uses such as the Mewata Armoury, a designated historic resource, and the former Mewata Football and Soccer Stadium. Significant fill of unknown quality has been placed in Area E, primarily for the construction of the Mewata Bridge and surface street connectors. The Mewata Armoury, in operation since 1917, is listed as a Contaminated Site on the Federal Land database, reporting minor amounts of contamination.

The remainder of Area E is currently occupied by the Millennium Skate Park, and the former Calgary Planetarium.

2.7 Area F – South of 9 Avenue SW & East of 14 Street SW

Area F hosts six commercial parcels that were developed in the late thirties. Historical uses include automotive repair and parts distribution shop, a seed processing plant, a laboratory, a metal machining shop, commercial printing operations, and a parts and hardware distributor. A CPR spur line and a loading platform were located at the eastern end of Area F. Staining was observed in historical photographs for several parcels in Area F. That, in combination with the nature of businesses in this Area, including the use of volatile organic compounds (VOCs) by past printing operations, indicates further evaluation is appropriate.

2.8 Summary

With the exception of Area A where environmental concerns will have a high impact on the redevelopment process and cost for West Village, the remaining Areas B through F each have potential environmental concerns that will have a moderate degree of impact on the process and cost.

Overall the environmental concerns identified outside of the CCS site are consistent with those found in the redevelopment of the East Village. The estimated cost of addressing remediation issues in areas B-F is approximately $20 million (measured approach) to $30 million (expedited approach). The majority of these concerns can be addressed efficiently throughout redevelopment as each piece of property is developed.

3.0 MANAGEMENT AREA A—CANADA CREOSOTE SITE

One of the biggest development challenges of West Village is the former Canada Creosote property. The property has been studied through environmental investigations initially conducted in the late 1980s and early 1990s. Much of the historical environmental information is now dated. New information was collected as part of the West Village environmental analysis that built on characterization updates commissioned by the City starting in 2010 as part of the ARP process.

Information collected to date is sufficient for site characterization and planning, but additional investigation and evaluation will still be needed to reliably and cost-effectively deal with the contamination in a manner that is protective of human health and the environment. Key to that is making use of a conceptual site model (CSM). A CSM is used to organize and communicate information about the environmental characteristics of a site. It provides a summary of how and where contaminants are expected to move and what impacts that may have. It supplies information to explain what you know, what you don't know, what you need to know, why there is a problem, and why remediation may be required. A CSM is iteratively developed and refined during the lifetime of a project. Developing a good CSM is necessary to understand the site and develop appropriate approaches for cleanup, as well as provide certainty around costs and risks. This was the process used to scope and implement this analysis.

3.1 Background

Former operations at the Canada Creosote Site (CCS) primarily consisted of treating wood to preserve it from decay. The operations lead to releases of wood treating chemicals from specific operational areas of the CCS (referred to as "source areas"), which include:

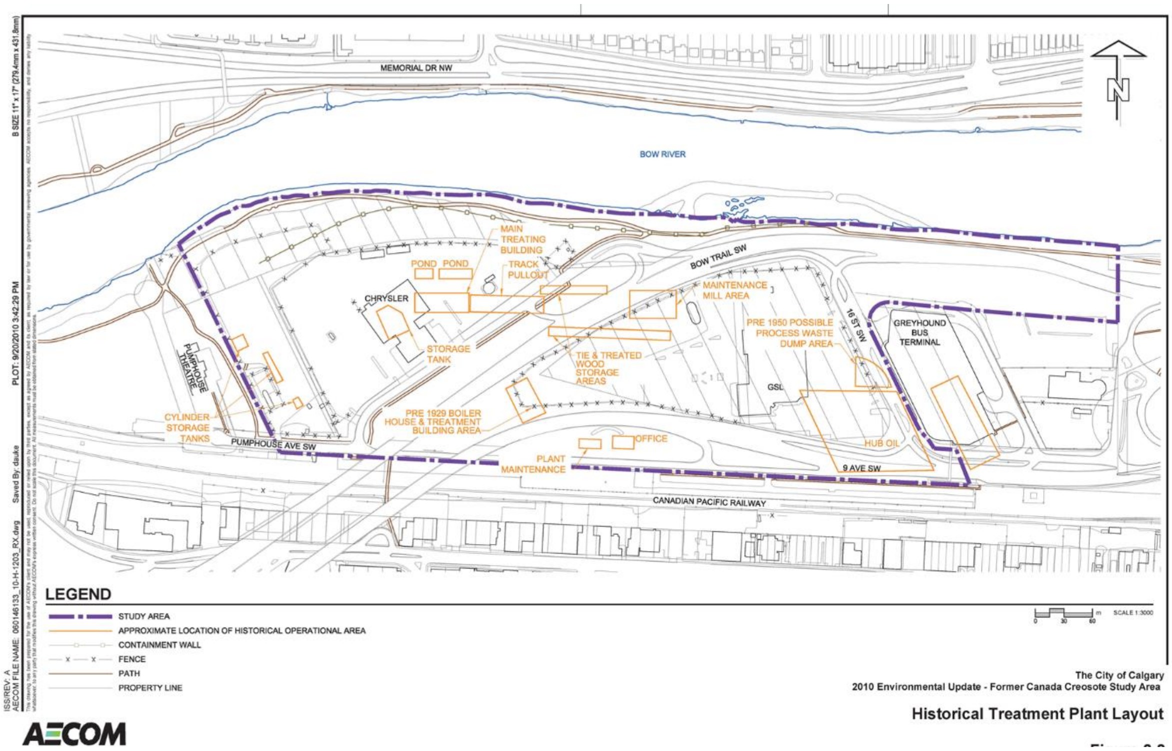
- product storage tanks;
- treatment buildings;
- process water storage ponds; and
- treated wood drying and storage areas.

Contamination migrated from the source areas into the underlying soils, through the unsaturated fill soils, into the saturated, native soils and groundwater, and the weathered and fractured bedrock.

Additionally, when wood treating operations ceased in 1964, the wood treating plant was demolished but contaminated soil and rubble was left at the ground surface as well as pushed to lower lying areas of the site and covered with fill.

Several years later, from 1988 through to the mid 1990s, extensive investigative work was completed to identify why wood treating residuals were surfacing in the bed and banks of the Bow River and how to stop surfacing of these residuals. This resulted in the Province of Alberta constructing a containment system, consisting of a containment wall, "dirty" extraction well system, a clean groundwater diversion system, and a groundwater treatment plant by 1996. The Province of Alberta then operated the system until transferring that responsibility, but not liability for the contamination, to the City of Calgary in 1997.

Figure 3-1 Historical Uses



Source: AECOM, 2010

3.1.1 Chemicals of Potential Concern

CCS operations used several wood preservatives, including coal tar and creosote, thinned with diesel-like oil, to treat raw railway and utility poles. Creosote is comprised of a wide range of chemicals and is created when coal is heated to produce coke. This process produces coal tar creosote, coal tar and coal tar pitch, which are all mixtures of similar compounds that are commonly referred to as creosote.

Because creosote is a general name for a mixture of different chemicals and limited research on health effects has been completed, it is difficult to quantify the risks. Creosote has been classified as a probable carcinogen by the International Agency for Research on Cancer (IARC 2A).

In addition to coal tar creosote, pentachlorophenol (PCP) dissolved in a diesel-like oil was added to the operation in the 1950s. PCP is a pesticide used to preserve wood and is considered a possible carcinogen (IARC 2B). Dioxins and furans are present at trace levels in commercial grade PCP as a by-product of its manufacture. Excessive exposure to these compounds can lead to a variety of serious health problems. Finally, for a short period during World War II, wood was also treated with zinc chloride.

Based on the predominant use of coal tar, creosote and PCP in carrier oil, contamination from CCS activities is primarily characterized by testing for polycyclic aromatic hydrocarbons (PAHs), other petroleum hydrocarbons (PHCs), and PCP. Although the physical and chemical nature of these compounds varies in terms of their relative hazard, they, and the additional suite of compounds that can occur in the environment due to site operations or poor-quality fill, are chemicals of potential concern (COPCs).

3.1.2 Other Sources of Chemicals of Potential Concern

During the lifetime of the CCS, other industrial operations were taking place on adjacent properties. To the west where the City of Calgary snow dump is today, and possibly to the southwest, bulk oil was stored and distributed. These areas have related contamination characterized by PHCs and related volatile organic compounds (VOC's) (e.g., benzene), and salinity.

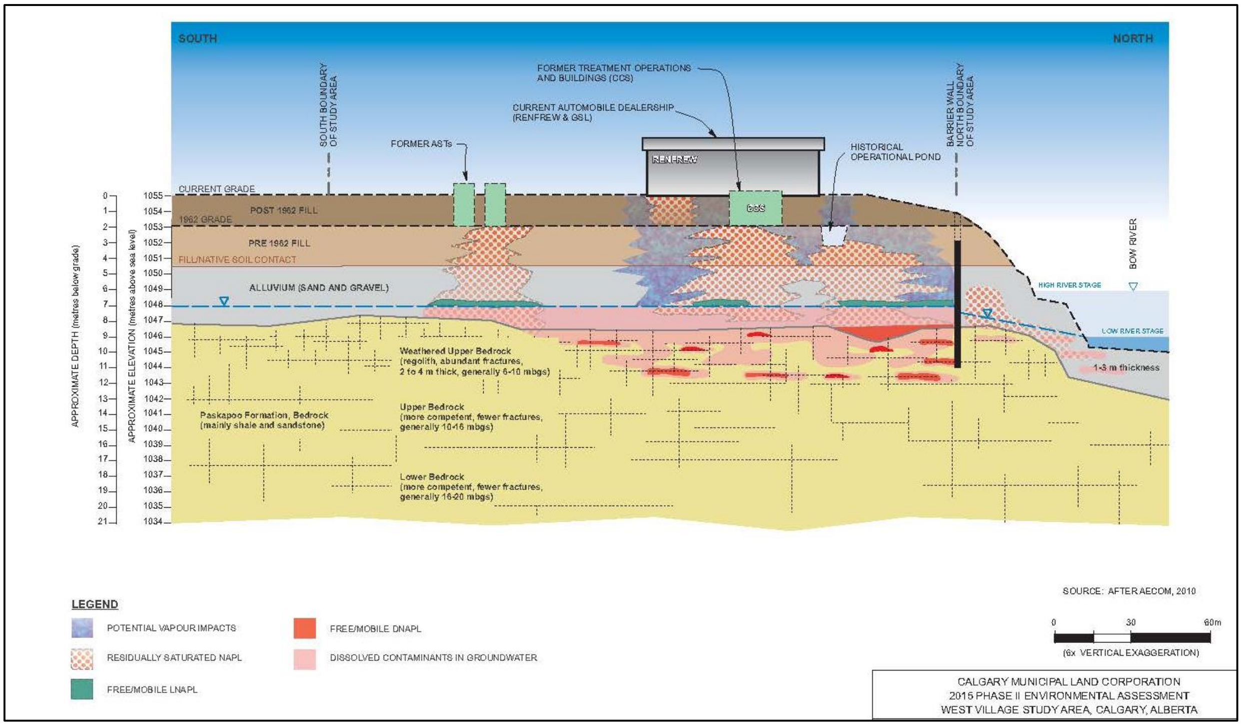
After the wood treatment facility was decommissioned and demolished, fill was imported to the area in the mid-1960s. The site was then redeveloped in the late 1960s to early 1970s for car dealerships and transportation corridors, which is what is seen today. Both car dealerships had leaky underground storage tanks (USTs) that were replaced by Above Ground Storage Tanks (AGSTs). These areas also have related contamination characterized by PHCs and VOHs.

Finally, because poor-quality fill (from an environmental perspective) has been used both during operations and in the 1960s, some areas have high metal concentrations (e.g., lead).

3.1.3 The Conceptual Site Model

In addition to chemicals of potential concern (COPCs) and their source areas, the site's conceptual site model involves several different layers of soil and bedrock: two types of fill (pre- and post-1962), alluvium (mostly wet or "saturated", but some is dry or "unsaturated"), and bedrock (a highly weathered surface or "regolith" and more competent bedrock underneath). The two types of fill are due to the phases of placing fill during the operation of Canada Creosote (pre-1962 fill) and after the plant was demolished (post-1962 fill). The fill at the site is typically above groundwater; however, when the river is high (e.g., spring), groundwater can extend into the base of the fill, particularly nearer to the river. Alluvium is the underlying native soil that was deposited by the historic reach of the river on top of the bedrock. This is where groundwater beneath the site is first encountered. The top of the bedrock is highly weathered, having been broken down into looser rock and soil called regolith. Beneath this regolith is more competent, or much less weathered and harder bedrock, which is still fractured in many places. The bedrock also carries groundwater.

Figure 3-2 Conceptual Site Model



Source: CMLC, 2015

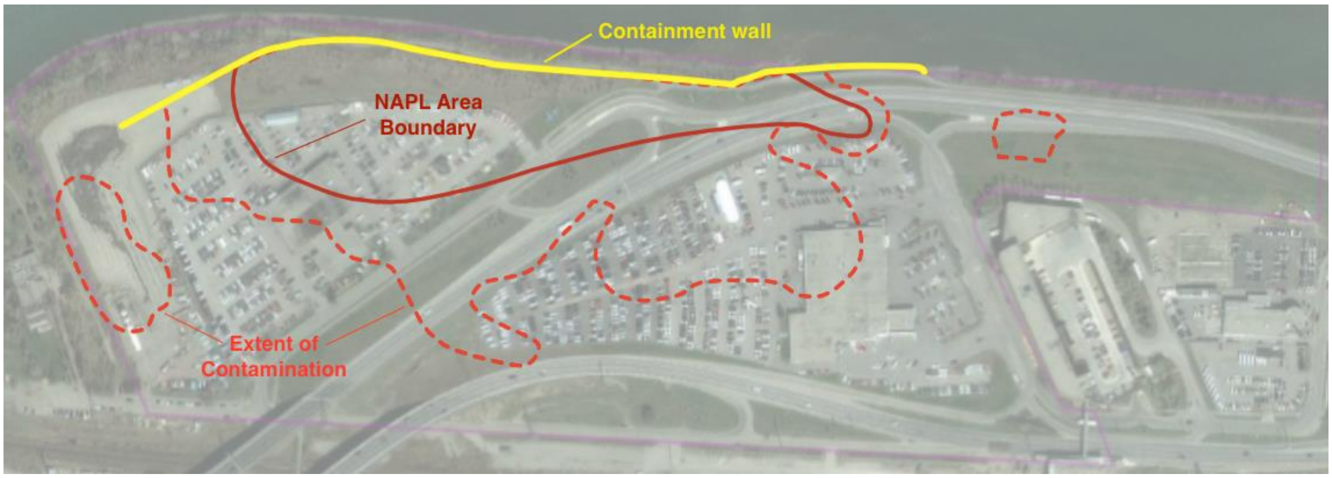
The main wood preservatives that were used are denser than water and immiscible. They are known as dense non-aqueous phase liquids or DNAPLs. If enough DNAPL is released, gravity will cause it to sink through the saturated soil to bedrock, where it will flow along the bedrock surface, and into the bedrock as well. The diesel-like oil is lighter than water and may separate and accumulate as a light non-aqueous liquid (LNAPL). LNAPL will float on and move with the top of groundwater, so as the groundwater level moves up and down seasonally, a contaminated smear zone fringe is created. These NAPLs are long-term sources of contamination due to the concentrated presence of COPCs within them

The high concentrations of COPCs in NAPL, and its ability to migrate in the alluvium along the bedrock surface to beneath the river is what led to the installation of the containment wall. The wall not only contains the NAPL that is south of the river, but in combination with clean and dirty pumping wells, contains much of the contaminated groundwater.

The volatile portion of wood treating compounds also generates a soil vapour plume in the subsurface that can migrate toward the ground surface. If it does not naturally degrade first, it can infiltrate underground structures like parkades, utility corridors, basements and buildings through cracks and present a possible human health risk. Because of this mobility, soil vapour can also be used during site investigations to detect surrounding or underlying soil or groundwater contamination.

The following figure shows the estimated extent of a plume of NAPL, and the footprint of contamination in soil and bedrock, projected over an aerial photograph of the current development.

Figure 3-3 Estimated Extent of Contamination



Source: CMLC, 2016

3.2 2015-2016 Environmental Site Assessment

CMLC's environmental site assessment built on and refined the site's existing CSM by focusing on collecting data from areas that were needed with respect to evaluating the three development scenarios. Past work has focused on developing and maintaining the existing containment system. By integrating past and current work into data visualization software, a more sophisticated and refined CSM was created. The software used allowed the site to be depicted by COPC concentration, location and volume, so that the three West Village development scenarios and potential remediation costs could be evaluated as well.

To provide a sense of the work involved to refine the CSM, the following summarizes work completed and key findings.

3.2.1 Conceptual Site Model-Background Work

The site assessment involved several components: ground surface and downhole geophysics, installing and sampling soil vapor monitoring wells, drilling several borings to sample soil and install monitoring wells to sample groundwater, and investigating bedrock.

Geophysical techniques were first used at the ground surface in accessible locations to map the surface of bedrock, and the interface between the alluvium and fill.

The soil vapour program was designed to provide insight for the CSM and support evaluating human health risks. Soil vapour probes were installed at 10 locations across the Site and sampled.

Fifty-four borings were drilled and numerous soil samples were collected and analyzed to better identify where NAPL and COPCs exist in the fills, alluvium, regolith and underlying bedrock. This included gathering information on COPCs, including VOCs, metals, and dioxins and furans, for evaluating potential risks to human health. Monitoring wells were installed in 21 of the borings, and groundwater samples were collected and analyzed. Geophysical techniques were used down some boreholes that extended into bedrock. Geotechnical information was also collected and used to help configure and cost potential remedial approaches, and provide baseline information for future redevelopment.

The key findings include:

- Dioxins and furans were confirmed to be present;
- The DNAPL plume extends further to the west than previously identified;
- The LNAPL plume is small and focused in the former processing area and immediate area near the containment system pumping wells;
- Minor hot spots of NAPL and COPCs were identified near a former outer-lying boiler house and treatment building;
- NAPL is present in the uppermost bedrock, but does not appear to penetrate into the underlying less fractured, more competent bedrock;
- Volatile PHCs are present beneath the snow dump where storage tanks were located;
- The distribution of COPCs in groundwater is similar to what has been seen in the past. This includes the presence of lighter PHCs fractions in groundwater from a well; and
- Groundwater contamination in the deeper bedrock is minimal.

4.0 CANADA CREOSOTE SITE, HEALTH RISK ASSESSMENT

A Human Health Risk Assessment (HHRA) was undertaken on the Canada Creosote Site (CCS) to estimate the potential risk of adverse health effects from exposure to the wood treating chemicals or chemicals of potential concern (COPCs). HHRAs take into account the inherent characteristics of the COPCs as well as the characteristics of target populations or “receptors”. Receptors are those people who could live and/or work in an area under study that may have an adverse health effect due to unwitting exposures to COPCs. Conservative assumptions were applied to ensure potential risks were not underestimated. The riverbank along the north perimeter of West Village, as well as the river itself, are important habitats, and these should be evaluated as well. Alberta Environment, who has responsibility for these areas, conducted an ecological risk assessment in the mid-1990s.

4.1 Human Health Risk Assessment (HHRA) Framework

In order to provide a framework for evaluating COPCs and potential health risks, Management Area A, or the Canada Creosote Site, was further divided into six areas or Areas of Potential Environmental Concern (APECs) based on historical land use, available monitoring data and a grouping of COPC types. Six major COPC groups were identified: polycyclic aromatic hydrocarbon (PAHs), petroleum hydrocarbons (PHCs), pentachlorophenol (PCP) and other phenols, halogenated aliphatics, other organic compounds, and metals.

Figure 4-1 Areas of Potential Environmental Concern for the Human Health Risk Assessment

Area 1, 2, 4, and 5 have the highest chemicals of potential concern that exceed human health guidelines Source: CMLC, 2016

The highest COPC concentrations are located in APEC 2, which contains the large NAPL plume and also has the largest amount of monitoring data available. APECs 1, 2, 4, and 5 had multiple COPCs that exceeded human health guidelines. Lesser impacts were seen in APECs 3 and 6, which is consistent with the minimal historical infrastructure in these areas; these areas were also the least studied and therefore had the least amount of available monitoring data.

The target human population considered for the HHRA was based on the following three development scenarios:

1) West Village Area Redevelopment Plan (2010), which involves development of West Village as residential high rise buildings with commercial use at grade;

2) CalgaryNEXT West, which has the multi-purpose facility located on the west side of CCS and residential high rise buildings with commercial at grade; and

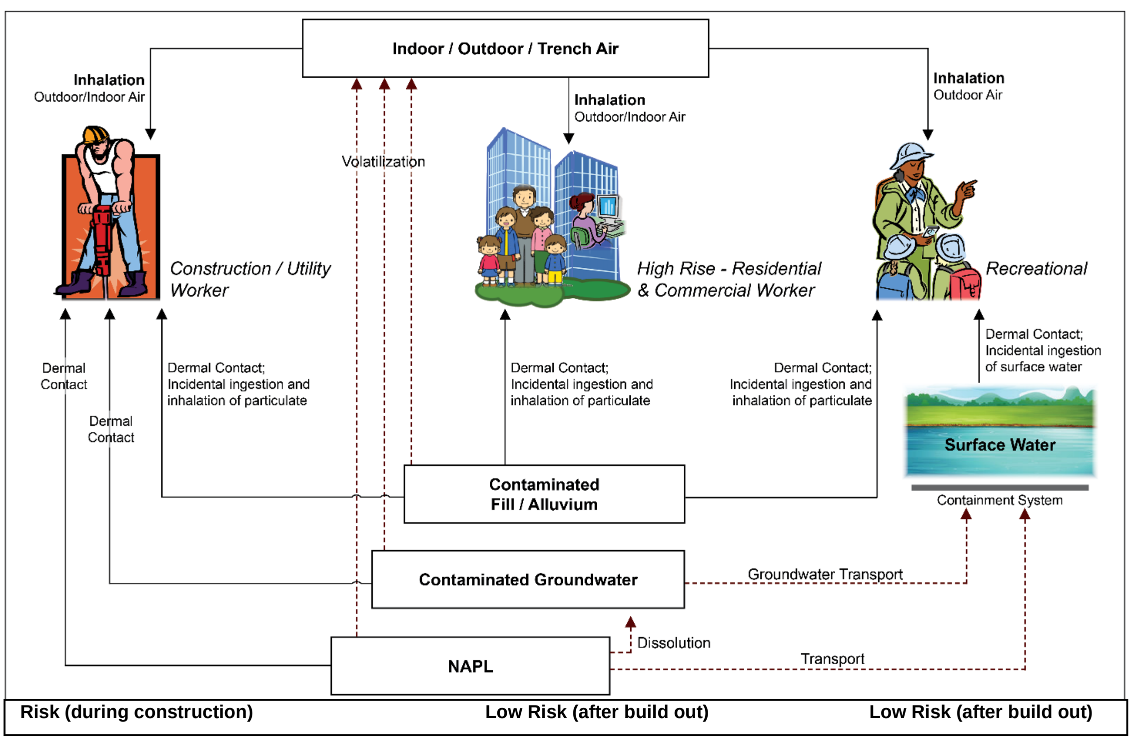
3) CalgaryNEXT Center, which has a multi-purpose recreational facility in the centre of West Village and residential high rise buildings with commercial use at grade and to the east and west of the facility.

Therefore, the HHRA included the assessment of those persons living or working in high-rise buildings (and spending time outdoors), using a multi-purpose facility, and those persons involved in construction or utilities installation and maintenance. The following assumptions were applied to the methodology:

i. All buildings will have underground parking facilities with commercial at grade;
ii. All residential units are assumed to be located above the first floor;
iii. No single detached residential or at grade residential is proposed;
iv. The City will supply water;
v. Groundwater would not be used for domestic purposes; and
vi. Construction or utility workers would have potential contact with contaminated soil, NAPL, and inhalation of vapours in trenches.

The CSM for the assessment can be summarised by the following figure:

Figure 4-2 Human Health Risk Assessment, During & Post Remediation and Construction, CSM



Source: CMLC, 2016

For each type of receptor, exposure to surface soil, inhalation of indoor air potentially impacted by soil vapour, and inhalation of outdoor air potentially impacted by soil vapour were assessed. The CSM assumes that NAPL and groundwater transport from contaminated areas south of the containment wall can be controlled by the containment system.

4.2 Preliminary Human Health Risk Assessment (HHRA) Findings

The preliminary results indicate the following:

- There are no immediate adverse health effects due to current conditions.
- Potential risks to future users can be managed and mitigated.
- Specific findings with regard to redevelopment includes:
    - There is low potential risk of adverse health effects due to direct contact with surface soil for all receptors (residential, recreational, and commercial), assuming that green spaces will be created with clean soil within 1 metre of the ground surface.
    - There is low potential risk of adverse health effects due to outdoor vapour inhalation for all receptors (residential, recreational, and commercial),
    - There is low potential risk of adverse health effects due to inhalation of soil vapour concentrations measured within the CCS for residential and commercial receptors in both slab-on-grade or parkade building structures.
    - If remediation does not occur, there is elevated risk of adverse health effects due to inhalation of naphthalene (APECs 2 and 4) and Petroleum hydrocarbons (APECs 1, 2, 4, and 6) in soil vapour using conservatively estimated (modelled) concentrations for the residential and commercial worker receptors.
    - There is potential risk of adverse health effects due to direct contact with petroleum hydrocarbons, and dioxins and furans, for construction and utility workers for five of the six APECs.
    - There is potential risk of adverse health effects due to inhalation of petroleum hydrocarbons and naphthalene for construction and utility workers in trenches, the magnitude of which varies with trench depth and width assumptions.

5.0 REMEDIATION, SCHEDULE AND COSTING

5.1 Remediation Overview

Former wood-treating sites such as the CCS site are a type of brownfield site found across North America. The wood-treating processes and the types of chemicals that were used are very similar and generally well understood. Thus, the contamination problems, technologies and remedies that work at these sites are also similar. Best practices applied to clean up these sites show that, in general, six technologies or strategies can be used, usually in combination. Other technologies are also available, but have less available performance data. These may be considered during subsequent stages as useful or appropriate for cleanup. Consequently, there is a range of means for addressing cleanup problems at CCS and the balance of West Village.

An approach to treating creosote and pentachlorophenol (PCP) contaminated soil, sludge, and sediments is generally developed from the following strategies:

- Excavation and disposal in authorized landfills;
- Excavation and thermal treatment (incineration);
- Excavation and biostabilization;
- In-place treatment using solidification and stabilization;
- In-place treatment using thermal desorption; and
- Containment (this was the chosen remedy at the CCS site implemented by the Province in 1995).

Each of these strategies has individual implementation and engineering challenges, which would need to be addressed prior to selecting a remedy.

Generally, remediation focuses on contaminated soils, sediments and sludges, while impacted groundwater is controlled via a combination of institutional controls and construction of containment systems.

Incineration is considered the most technically developed and proven technology, however it often has difficulty getting public support and is usually the most expensive remedy. The other technologies, including biostabilization, have track records indicating they may be appropriate; however, the selection of technologies that are less proven or less capable than incineration will always bring a greater risk of inability to achieve cleanup or redevelopment goals.

5.2 Alignment with Redevelopment

As West Village is still in the conceptual redevelopment stage and the three redevelopment scenarios are currently being assessed for viability, assumptions were made regarding the placement of future buildings, roadways, and the configuration of the CalgaryNEXT complex at the two different locations. These assumptions allowed conceptual layouts to be superimposed over the existing contamination at CCS, and allowed the timing and physical aspects of remediation to be evaluated and identify potential timeframe drivers or conflicts.

Practically speaking, the analysis determined whether the timing of any the development scenarios drove the selection of remedial technologies that could or should be used. At this level of analysis, it did not.

5.3 Identification and Screening of Remediation Strategies

The first step in evaluating remedies was to develop a list of proven remediation strategies that have been successfully applied at wood treating sites similar to CCS. The following technology options were identified: excavation and disposal in authorized landfills, incineration, bioremediation, solidification and stabilization, in-place treatment using thermal desorption, and enhanced containment. Enhanced containment involves updating the existing containment system (the chosen remedy for CCS implemented in 1995). Each of these is described briefly below.

Excavation of contaminated soil from a site involves digging it up for “ex situ” (above ground) for either treatment or for disposal in a landfill. Excavation also may involve removing buried debris that might be contaminated and screening oversized coarse granular materials for re-use. Contaminated soil is excavated using standard construction equipment, like backhoes and excavator track hoes. Excavation is a common and frequently implemented component for the management of contaminated soils. It is often coupled with off-site disposal for smaller sites. Off-site disposal for a project of this magnitude would be expensive.

Incineration is the process of burning creosote and PCP materials at temperatures high enough to destroy contaminants. Incineration is conducted in an “incinerator,” which is a type of furnace designed for burning hazardous materials in a combustion chamber. Incineration is a well-developed and proven technology but also subject to wide spread opposition. It is typically expensive, but less than off-site disposal.

Bioremediation is the use of microbes to clean up contaminated soil and groundwater. Microbes are very small organisms, such as bacteria, that live naturally in the environment. Bioremediation stimulates the growth of certain microbes that use contaminants as a source of food and energy. Contaminants treated using bioremediation include oil and other petroleum products, solvents, and creosote. For bioremediation to be effective, the right temperature, nutrients, and food also must be present. Proper conditions allow the right microbes to grow and multiply—and eat more contaminants. Wood treatment chemicals can be difficult to biodegrade, but bioremediation can transform the contaminants into more stable, non-leachable compounds. This process is called biostabilization. It is typically less expensive than other strategies.

Solidification and stabilization refer to a group of cleanup methods that prevent or slow the release of harmful chemicals from contaminated soil, sediment, and creosote. These methods usually do not destroy the contaminants. Instead, they keep them from “leaching” above safe levels into the surrounding environment. Solidification binds the waste in a solid block of material and traps it in place. This block is also less permeable to water than the waste. Stabilization causes a chemical reaction that makes contaminants less likely to be leached into the environment. It is typically expensive, but less than off-site disposal or incineration.

In-situ thermal treatment methods move or "mobilize" creosote in soil and groundwater using heat. The chemicals move through soil and groundwater toward wells where they are collected and piped to the ground surface to be treated using other cleanup methods. Some chemicals are destroyed underground during the heating process. Thermal treatment is described as "in situ" because the heat is applied underground directly to the contaminated area. It can be particularly useful for NAPLs, which do not dissolve readily in groundwater and can be a source of groundwater contamination for a long time if not treated. Similar to stabilization, it is expensive, but less than off-site disposal or incineration.

The containment system constructed in 1995 at CCS that remains operational has several components, including a downgradient barrier to intercept the flow of contaminated groundwater and creosote liquids towards the Bow River and an up-gradient system of groundwater wells to intercept clean groundwater moving in towards CCS. The downgradient barrier (a slurry wall) was made of impermeable materials, which means they prevent or minimize the flow of water and contaminants through the wall. The slurry wall was constructed by digging a narrow trench, 1.2 m wide and 8 m deep with a long-reach excavator. The trench was filled with slurry, which consisted of soil mixed with water and clay. A type of clay called "bentonite" was used because it expands when wet to fill gaps or holes in the barrier wall. Groundwater wells near the wall are used to extract contaminated groundwater for treatment. Containment is a common strategy that is less expensive, and often used in combination with other remedial technologies.

5.4 Assembly of Preliminary Remedy Combinations

Five technology combinations were configured based on above strategies, including three involving excavation and two involving treatment in place. A sixth approach that involves an upgrade or enhancement of the existing containment system was also configured to be used in combination with the others or by itself. The sixth approach would be used to maintain the conditions of the Release Agreement between the Province and the City. The Release Agreement releases the City from liability for the contamination but requires the City to maintain operation of the containment system. Operation and maintenance of the containment system forms part of each of the remedy combinations. The six approaches were then evaluated based on their relative benefits and limitations, effectiveness in reducing risk, duration, and cost.

Table 5-1 presents the assembled approaches that provide a representative range of actions to allow for subsequent detailed comparison and evaluation, and a reasonable range of planning-level cost.

Table 5-1 Assembly of Preliminary Remedy Combinations

Technology Grouping	Technology Type	Process Option	Description
Ex-situ	Excavation	Off-site Disposal	Remove all contaminated soils and dispose of as-is. A portion will require management and disposal as hazardous wastes. Dewatering for excavation may limit excavation cell size.
	Excavation	Thermal treatment and reuse	Remove all contaminated soils and treat in a thermal de-sorber or incinerator prior to reuse. Dewatering will be similar to excavation described above.
	Excavation	Biostabilization and reuse	Remove all contaminated soils and treat via bioremediation above grade prior to reuse. Dewatering will be similar to excavation described above.
In-Situ	Solidify Soils	Inject and mix bentonite	Auger or similar injection and mixing equipment will allow in-situ solidification of contaminants. No dewatering is necessary.
	Thermal	ERH	Electro-Resistive Heating applies heat to a well point and relies on thermal conductivity of the soil matrix to heat and remove contaminants. No dewatering is necessary. Vapour recovery and treatment is necessary. Disposal of waste concentrates is necessary.
	Enhanced Containment	Slurry wall, groundwater recovery and treatment	Maintains operation of the existing containment system. Provides maintenance updates to recovery wells and automation to the existing treatment plant components.

The volumes of contaminated soil requiring remediation are shown in Table 5-2. Table 5-2 presents the estimated schedule for implementing the remedial strategies, and Table 5-4 presents the estimated time to when construction of each of the redevelopment scenarios could proceed.

Table 5-2 CCS Soil Volumes

Site Area	Estimated Soil Volume (cubic metres)
NAPL impacted soils[1]	171,000
The unsaturated fringe zone (contamination in soil above groundwater outside of the NAPL zone)	47,000
The saturated fringe zone (contamination in soil below groundwater outside of the NAPL zone)	39,000
Hot spot excavations	12,000
Total	269,000

Notes: Volume of soils between bedrock and highest measured NAPL elevation[1]

Table 5-3 CCS Remediation Schedule

Strategy	Investigation, Design, and Permitting (Approximate years)	Remediation Phase (Approximate years)	Total Duration (Approximate years)
Excavate and Dispose	2	3	5
Excavate, Treat Thermally and Reuse	3	4	7
Excavate, Biostabilize and Reuse	2.5	5.5	8
In-Situ Solidification	2.5	5	7.5
In-Situ Thermal	3	7	10
Enhanced Containment*	1	0.5	1.5

* Enhanced Containment timeline is assumed to be used in combination with one of the other remedial options.

5.5 Cost Estimate

Cost estimates were generated for the six remedy combinations presented above using peer-reviewed base cost data accumulated by the remediation team over the years from prior projects and from site-specific cost corrections applicable for Calgary. These costs are limited to primary treatment technologies with some technology-specific polishing activities for groundwater. Costs do not include any redevelopment specific needs nor coordination costs or schedule impacts. Costs are presented in present value dollars using a 0% discount rate for construction and monitoring cash flow. Specific cost details for each Remedial Alternative grouping are summarized in Table 5-4 below.

Table 5-4 Estimated Cost Summary ($CAD) for Each Remedy Combination

Remedy Combination	**1**	**2**	**3**	**4**	**5**	**6**
Criteria \ Value	**Excavate and Dispose**	**Excavate Treat Thermally and Reuse**	**Excavate Biostabilize and Reuse**	**In-Situ Solidification**	**In-Situ Thermal**	**Enhanced Containment**
Construction Cost Estimate	$69,000,000	$57,000,000	$42,000,000	$51,000,000	$48,000,000	$1,800,000
Loaded Project Estimate	$41,000,000	$31,000,000	$23,000,000	$28,000,000	$26,000,000	$1,100,000
Total	$110,000,000	$88,000,000	$65,000,000	$79,000,000	$74,000,000	$2,900,000

The above-referenced construction cost estimate comprises contractor costs. The loaded total project estimate includes costs such as pre-design investigations, consulting, design, and permitting. In addition, weather is not expected to impact in-situ technologies except during initial set-up. All other technologies have weather and climate related scheduling of site activity.

5.4 Class of Cost Estimate and Risk

CMLC considers the cost estimates provided to be of an order of plus or minus 50%. While the cost estimates provide a reasonable level of cost understanding for site remediation, they are not based around a known end land use. The desired scenario for redevelopment needs to be determined prior to the final remediation remedy being defined and costs determined.

5.5 Summary

Estimated costing for the range of remedial approaches for an expedited schedule and more measured approach are summarized in Table 5-5 below. The summary costing associated with the various remediation options range from $85,000,000 to $140,000,000. The schedule allows for the time to investigate, design and permit the chosen remedy plus the construction effort. In the case of the expedited schedule, construction would occur continuously until completion, while in the measured approach, construction would occur seasonally and then intermittently until completion.

Table 5-5 Estimated Costing and Timeline of Remedial Approaches

Estimated Costing of Remedial Approaches	**Expedited Approach***	**Measured Approach***
Canada Creosote Site	$110,000,000	$65,000,000
Balance of West Village	$30,000,000	$20,000,000
Estimated Total	$140,000,000	$85,000,000
Estimated Timeline for Canada Creosote Site Work		
Additional Investigation, Regulatory Approvals and Permitting (approximate time)	3-5 years	3-5 years
Remediation (approximate time)	3 years	5 years
TOTAL	**6-8 years**	**8-10 years**
*The expedited approach is represented by excavation and disposal of all impacted areas, where as the measured approach is represented by excavation and on-site biostabilization and reuse.		

CMLC has concluded that given the recent interaction and feedback from the regulator and additional information gathered during the most recent investigations, further studies should be continued in order to align and optimize the triple bottom line solution for West Village contamination and redevelopment efforts.

9.0 LIST OF FIGURES

10.0 LIST OF TABLES

11.0 APPENDICES

11.1 References

AECOM, Canada Creosote Study Area 2011 Evaluation of Groundwater Containment System Calgary, Alberta, Canada, May 2012

The City of Calgary, Corporate Project Management Framework Estimation & Contingency Guidance Document, February 2012

International Agency for Research on Cancer (IARC), 2010. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 92, Some Non-heterocyclic Polycyclic Aromatic Hydrocarbons and Some Related Exposures*, pg 772, 2010.

International Agency for Research on Cancer (IARC), 2010. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 53, Occupational Exposures in Insecticide Application, and Some Pesticides*, pg 394, 1991.

11.2 List of Acronyms

APEC	Area of potential environmental concern
ARP	Area redevelopment plan
AST	Above ground storage tank
CSEC	Calgary Sports and Entertainment Corporation
CCS	Canada Creosote site
CMLC	Calgary Municipal Land Corporation
COPC	Chemical of potential concern
CSM	Conceptual site model
DNAPL	Dense non-aqueous phase liquid
ESA	Environmental site assessment
HHRAs	Human health risk assessment
LNAPL	Light non-aqueous phase liquid
mbgs	metres below ground surface
NAPL	Non-aqueous phase liquid
PCP	Pentachlorophenol
PAH	Polycyclic aromatic hydrocarbon
PHC	Petroleum hydrocarbons
SVOC	Semi-volatile organic compounds
UST	Underground storage tank
VOC	Volatile organic compounds

11.3 Reports Informing 2016 WV Environmental Analysis Report

The following is a list of reports produce in 2015 and 2016 specifically to inform the contents of this report:

- Site Characterization Gap Analysis - Proposed West Village Area, Calgary, Alberta
- 2015 Geophysical Investigation at the Former Canada Creosote Site - Seismic Refraction, ERT & GPR
- Site Characterization Gap Analysis - Remaining West Village Lands - Proposed West Village Area, Calgary, Alberta
- Geotechnical Investigation at the West Village Study Area – Former Canada Creosote Site
- Chlorodibenzo-P-Dioxins and Chlorodibenzofurans Strategy-Former Canada Creosote Site, West Village Study Area
- 2015 Phase II Environmental Site Assessment-West Village Study Area, Calgary, Alberta-Volume 1, 2 and 3
- 2015 Data Review and Gap Analysis
- 2016 Problem Formulation
- 2016 Preliminary Soil Vapor Intrusion Modelling
- 2016 Preliminary Results, Human Health Risk Assessment
- 2016 Remediation Options Assessment Model