APPENDIX D. DESIGN CRITERIA

Provided separately for Parksville Community Park Stormwater Management Master Plan.

Project Name | Parksville Community Park Stormwater Management Master Plan **Date |** April 2021
To / Contact info | Michael Lonsdale (MLonsdale@parksville.ca)
Cc / Contact info | Ayla Defoor (ADefoor@parksville.ca)
From / Contact info | Kerri Robinson, P.Eng. (krobinson@eorinc.com)
Regarding | Characterization & Design Criteria

1 Introduction

The City of Parksville (City) has retained EOR to develop the Stormwater Management Master Plan (SWMMP) for the Parksville Community Park (the Park). As part of this work, EOR is developing design criteria for upgrades to the stormwater management system in the Park. This memorandum outlines the draft design criteria for performance objectives (i.e. level of service) of the system and criteria for screening/assessing feasibility of individual stormwater management practices.

The Park is located in the centre of Parksville, BC on the east side of Vancouver Island and is within the traditional territories of the Coast Salish Nations. The Park is within the core asserted traditional territory of the Snaw-Naw-As, Qualicum and K'omoks First Nations. The Park is bordered by Island Highway East to the south, Corfield Street North to the east, the Park Sands Beach Resort to the west, and Parksville Bay to the north, as shown in Figure 1.

Figure 1. Location Map

2 Baseline Characterization

This section summarizes the existing environment in and around the Park relevant to stormwater management planning. The existing environment includes the physical, social, cultural, and natural environments of the Park. The physical environment includes climate, topography, geology, soils and surface/groundwater. The social environment includes existing and proposed land uses and the built components of the environment that alter or manage the quantity and quality of stormwater. The cultural environment includes archaeological heritage features that retain the evidence of human activity. The natural environment includes terrestrial and aquatic habitats and species as well as environmentally significant or sensitive areas. Some components of the natural environment, such as trees and wetlands, also provide stormwater management related functions such as evapotranspiration. The baseline characterization of the Park is based on review of relevant plans and studies, as well as new analysis conducted by EOR and the consulting team as part of the SWMMP project. Gaps in information and data have been identified and the SWMMP implementation plan will include recommended next steps to address the gaps.

2.1 Physical Environment

2.1.1 Climate and Precipitation

2.1.1.1 Baseline Climate

The City is located within the Coastal Douglas-Fir (CDF) bio-geoclimatic zone which is characterized by warm, sunny summers and mild, wet winters. Average climate conditions (1981-2010) can be characterized using Environment Canada's weather station in Coombs, BC located approximately 6 km from the Park. The average temperature is about 9.2°C while daily extreme temperatures range from 24.2°C in August to -0.9°C in February (Table 1). Total annual precipitation averages 1,138.5 mm with less than 60 mm of rain each month from May to September (Table 2).

Table 1. Climate Normals for Temperature at Coombs Station (1981 to 2010)

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Daily Max. (°C)	6	7.6	10.3	13.8	17.6	20.6	24	24.2	20.6	13.8	8.2	5.5	14.4
Daily Mean (°C)	2.8	3.4	5.4	8.2	11.6	14.6	17.2	17.1	13.8	8.9	4.7	2.6	9.2
Daily Min. (°C)	-0.4	-0.9	0.5	2.5	5.5	8.4	10.4	10	7	3.9	1.1	-0.4	1.4

Source: (Environment Canada, 2019)

Table 2. Climate Normals for Precipitation at Coombs A Station (1981 to 2010)

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	162.8	100.1	103.1	75.1	56.3	46.6	24.4	34.5	39.3	113.2	180.7	157.3	1093.2
Snowfall (cm)	13.5	10.1	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.7	7.5	7.6	45.2
Total Precipitation (mm)	176.3	110.1	109	75.1	56.3	46.6	24.4	34.5	39.3	113.9	188.2	164.9	1138.5

Source: (Environment Canada, 2019)

2.1.1.2 Historic Rainfall Events

Multiple weather and precipitation stations in and near Parksville provide insights into local and regional climate and precipitation trends, as summarized in Table 3. The City has operated two weather stations within Parksville at the Public Works Yard (30 minute intervals) and in the Park (5 minute intervals). Park Operations staff operate a second rain gauge in the Park to guide real-time operation of the irrigation system, but data was not available for this study and not necessary since sufficient information was available through the other stations.

Table 3. Summary of Climate Station Data

Station Name	Location	Recording Interval	Period of Record
060B-ParksvilleMuni	Community Park N 49.3223°, W 124.3082°	5 minute	2009-present
Public Works (Ops)	1116 Herring Gull Way N 49.3036°, W 124.2694°	30 minute	2004-present
Nanaimo A	N 49.0544°, W 124.8700°		
Station ID: 1025370		hourly	1954-2013
Station ID: 1025369		hourly	2013-2020
Coombs **Station ID: 1021850**	N 49.305833°, W 124.429167°	daily	1960-2010
Park Operations	Public Works (Ops)	n/a	n/a

Extreme historic events recorded at the Park station are summarized in Table 4. No winter storms with return periods greater than 5 years have been recorded at the Park station. Additional regional historic events are reviewed and discussed in Appendix B. Overall, many historical events extend over multiple days and have resulted in flooding with combined effects of other contributing factors, such as pre-existing snow pack and high tides. One short-duration, high-intensity rainfall event was observed in September 2013.

Table 4. Historic Rainfall Events at Park Weather Station

Date	Total Rainfall Depth (mm)	Maximum Intensity (mm/hr)	Duration	Estimated Return Period	
Oct 1-2, 2009	14.6	14	2 hours	2 year	5 minute to 2 hour
Nov 18-19, 2009	80	9.6	2 days	2 to 5 year	6 to 24 hour
Sept 2, 2013	33.2	96	30 minute	> 100 year	5 minute to 2 hour
Oct 21-22, 2014	42	4.8	2 days	2 year	6 to 12 hour
Jan 10-11, 2014	45.2	12	2 days	< 5 year	5 minute to 24 hour
Feb 15-16, 2014	44	12	2 days	< 5 year	5 minute to 24 hour
Dec 8-11, 2014	98.8 mm	12	4 days	2 year	4 day
Jan 31-Feb1, 2020	47.4 mm (80.2 mm in preceding week)	7.2	2 days	< 2 year	48 hour

2.1.1.3 *Historic Intensity-Duration-Frequency Curves*

The City's current Engineering Standards and Specifications (City of Parksville, 2018) include the Intensity-Duration-Frequency (IDF) curves that were developed as part of the City-wide Storm Drainage Master Plan. The IDF curves were developed by factoring the Environment Canada Nanaimo City Yard climate station (ID: 10253G0) IDF to the Environment Canada City of Parksville South climate station (ID: 1025977) based on the correlation between the rainfall data recorded at each station over the same time period (1983 to 1992). The Nanaimo City Yard station included a 25 year period of record from 1980 to 2005 (Koers & Associates Engineering Ltd., 2016). As part of the SWMMP for the Park, Dillon Consulting reviewed available climate data and developed updated IDF curves using the Nanaimo Airport data (1985-2017), including extending the curves to multi-day durations. More information, including a comparison with the current IDF curves included in the City of Parksville Engineering Standards, is provided in Appendix B. Depth duration frequency (DDF) relationships are summarized in Table 5.

Table 5. Rainfall Depth-Duration-Frequency Curves (mm) based on Nanaimo Airport Station (1985-2017)

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5-min	2.8	3.7	4.3	5	5.6	6.1
10-min	4.1	5.6	6.6	7.8	8.8	9.7
15-min	5	7.1	8.5	10.3	11.6	13
30-min	7.1	10.1	12.1	14.7	16.6	18.4
1-h	10	13.4	15.7	18.5	20.7	22.8
2-h	14.9	18.2	20.3	23.1	25.1	27.1
6-h	29.8	35.3	38.9	43.5	46.9	50.2
12-h	42	50.4	56	63	68.2	73.4
24-h	55.6	69.7	79	90.9	99.6	108.3
2-day	69.8	85.6	96.0	109.2	119.0	128.7
3-day	81.8	99.0	110.4	124.8	135.5	146.1
4-day	96.1	117.0	130.9	148.4	161.4	174.3
5-day	108.6	133.2	149.5	170.1	185.4	200.6
6-day	118.1	142.9	159.4	180.1	195.5	210.8
7-day	124.9	151.3	168.9	191.0	207.4	223.7
8-day	133.5	162.1	181.0	204.9	222.6	240.3
9-day	142.5	172.9	193.1	218.5	237.4	256.2
10-day	150.6	183.5	205.3	232.9	253.4	273.6

Source: Rainfall Design & Climate Change Guidance – Final Technical Report (See Appendix B)

2.1.1.4 First Flush Event

The stormwater runoff during the early stages of a storm can deliver a potentially high concentrations of pollutants due to the washing effect of runoff from impervious areas directly connected to the storm drainage system. Managing this "first flush" of runoff is a common approach to mitigating non-point source pollution from stormwater. While some jurisdictions target the 90th percentile storm event for water quality treatment, this event is often based on the common expectation that rainfall events equal to or less than the 90th percentile event generate approximately 80% of the annual runoff volume, and as such corresponds to controlling approximately 80% of total suspended solids.

EOR conducted a precipitation frequency analysis of daily precipitation recorded at Environment Canada's Nanaimo Airport station to estimate the first flush event applicable to Parksville. The datasets were combined and sorted by daily rainfall depth. The cumulative runoff depth was calculated assuming a 5 mm runoff threshold (i.e. daily rainfall depths below 5 mm were excluded from the analysis). As shown in Figure 2, 24-hour rainfall events smaller than 30.7 mm produce approximately 80% of annual runoff volume and include approximately 93% of annual rainfall events. As such, water quality treatment in stormwater management facilities in Parksville is recommended to manage at least the 31 mm, 24-hour rainfall event to provide 80% control of total suspended solids (TSS) on an average annual basis. The method used to establish this target could be improved upon by a more detailed analysis that separates individual events without truncating them every 24 hours.

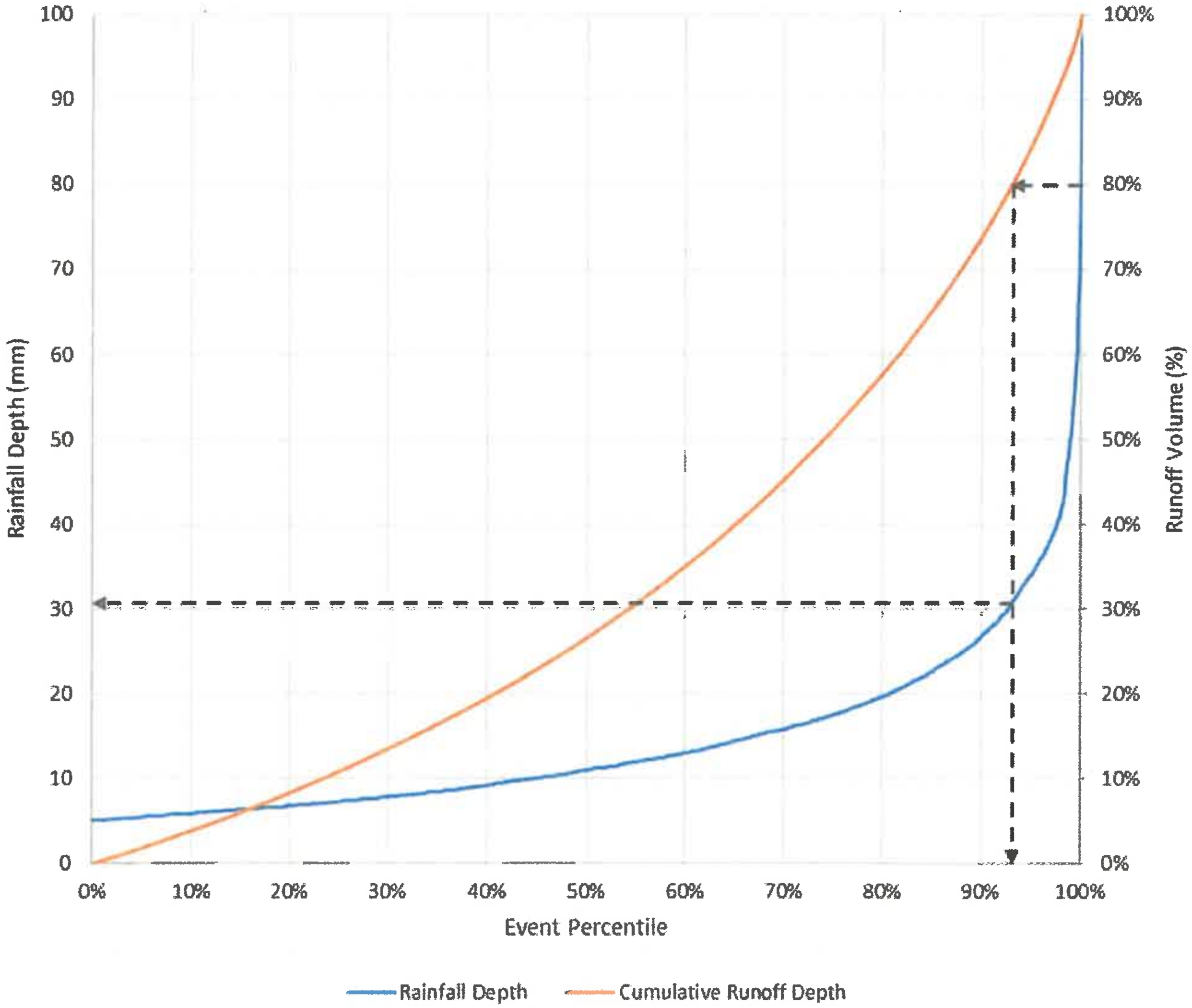

Figure 2. Rainfall Frequency Analysis, Nanaimo Airport (1947-2020)

2.1.1.5 Future Climate

Climate change in Parksville and across Canada has multiple implications for how we design, build and live in our cities. The first step for considering climate change in community plans is to estimate the climate change projections within each community. Key changes to anticipate in Parksville include wetter falls and winters as well as drier and much warmer summers, as illustrated by the projections in Figure 3 and Table 6. These anticipated climate changes in Parksville and other changes across Canada will introduce or exacerbate multiple risks to communities, built infrastructure and the natural environment. Five of the top six areas of climate change risk in Canada, which are relevant to Parksville, are outlined in Table 7.

Table 6. High Carbon Climate Change Projections for Parksville, BC

Variable	Base Period 1976-2005	Future Projections 2051-2080		
	Mean	Low	Mean	High
Highest temperature of year	30 °C	31 °C	34 °C	38 °C
Typical coldest winter day	-7.8 °C	-7.2 °C	-2.2 °C	1.9 °C
Number of +25°C days per year	21	38	66	92
Number of freeze-thaw cycles per year	24	0	4	11
Date of first fall frost	Nov 17	Nov 18	Dec 16	Dec 30
Frost-free season (number of days)	235	278	325	361
Annual precipitation	1151 mm	955 mm	1247 mm	1553 mm
Summer precipitation	106 mm	37 mm	93 mm	166 mm
Winter precipitation	490 mm	366 mm	555 mm	771 mm
Number of below-zero days per year	42	0	7	18

Source: The Climate Atlas of Canada includes climate change indices derived from 24 downscaled climate models obtained from the Pacific Climate Impacts Consortium (PCIC; pacificclimate.org). The results shown are based on the 'High Carbon' scenario (RCP8.5) of each model and the 2051-2080 time period. The high and low model projections indicate the 90th and 10th percentiles values for the 24 model ensemble (Prairie Climate Centre, 2019).

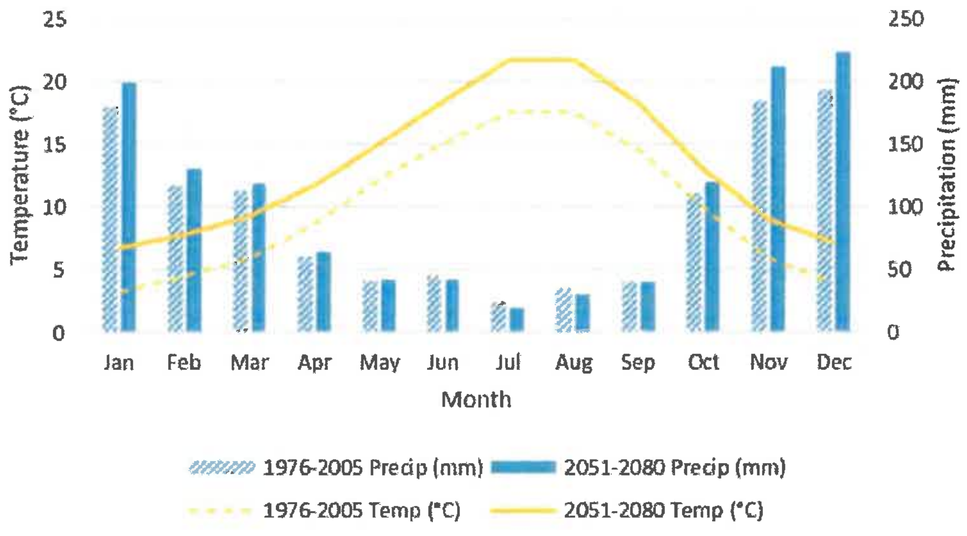

Figure 3. High Carbon Climate Change Projections for Parksville, BC (Prairie Climate Centre, 2019)

Table 7. Top Areas of Climate Change Risk Facing Canada (Council of Canadian Academies, 2019)

Area of Risk	Description
Physical Infrastructure	Risks to physical infrastructure in Canada from extreme weather events, such as damage to homes, buildings, and critical infrastructure from heavy precipitation events, high winds, and flooding; increased probability of power outages and grid failures; and an increasing risk of cascading infrastructure failures.
Coastal Communities	Risks to coastal communities in Canada, including damage to coastal infrastructure, property, and people from inundation, saltwater intrusion, and coastal erosion due to sea-level rise and storm surges.
Human Health and Wellness	Risks to human health and wellness in Canada, including adverse impacts on physical and mental health due to hazards accompanying extreme weather events, heatwaves, lower ambient air quality, and increasing ranges of vector-borne pathogens.
Ecosystems	Risks to Canadian ecosystems and species, including threats to biodiversity, ecosystem resilience, and the ability of ecosystems to provide a range of benefits to people such as environmental regulation, provision of natural resources, habitat, and access to culturally important activities and resources.
Fisheries	Risks to Canadian fisheries and fish stocks, including declining fish stocks and less productive/resilient fisheries due to changing marine and freshwater conditions, ocean acidification, invasive species, and pests.

*A sixth area of risk to Northern Communities is not listed because it's irrelevant to Parksville.

Communities are planning for climate change through both mitigation and adaptation strategies. Mitigation strategies include those that will reduce greenhouse gas emissions by replacing fossil fuels with renewable energy (e.g. power lights with solar panels), reducing energy use (e.g. offer free bus shuttles to reduce single occupant vehicle trips, install electric vehicle charging stations) and reducing the carbon footprint of infrastructure projects. The City's Official Community Plan (2013) committed to reduce per capita greenhouse gas emissions by 33% of 2007 levels by 2020, which was aligned with the Community Energy and Emissions Plan for the Regional District of Nanaimo towards 80% reductions by 2050 (Regional District of Nanaimo, 2013). The City's Official Community Plan highlights the carbon sequestration services provided by street trees, the urban tree canopy and riparian areas which should be protected. The Community Park Master Plan (2018) recommended establishing a free bus shuttle from downtown, which would contribute to emissions reductions related to the Park. Although progress towards these local targets have not yet been evaluated, globally the need for greenhouse gas emissions is increasing as little progress has been made in the last decade. The United Nations recently defined a new target of 7.6% reduction in greenhouse gas emissions every year from now until 2030. This updated target will compensate for the gap between pledged and accomplished cuts, as well as offsetting the additional damage that will be caused by emissions that have increased over the past decade (United Nations Environmental Program, 2019).

Adaptation strategies include actions that will most effectively reduce the local impacts of climate change on communities. These impacts are anticipated even with emission reductions because of the pollution that has already been released into our atmosphere. As such, communities need to plan for these impacts while also reducing emissions to prevent even worse impacts. The City's Official Community Plan (2013) established development requirements to mitigate the potential impacts of climate change hazards, including rising sea levels in coastal areas. A goal of the Community Park Master Plan (2018) is to protect the shoreline of the Park and mitigate erosion, which may increase due to the hazards of sea level rise and severe weather, through monitoring the efficacy of past improvements and stabilizing the shoreline with native vegetation. The Community Park Master Plan also called for developing and implementing the SWMMP, which will reduce potential inland flooding risks.

Multiple climate-related hazards and impacts are especially relevant to the Park. High temperatures in urban centres can be hazardous, especially for the elderly and chronically ill, and extended warm periods can inhibit outdoor activities and cause stress. Extended dry periods will also increase demands for irrigation. Wetter falls and winters will need to be managed by stormwater management systems, which are already facing challenges due to deterioration, other deficiencies and sea level rise. The hazards and potential impacts related to stormwater management in the Park are discussed and assessed throughout this memorandum to guide development of the SWMMP.

Stormwater management adaptation strategies will provide additional capacity so that the system is more resilient under more intense or multi-day precipitation events and exacerbated boundary conditions (e.g. high sea level, high groundwater). Stormwater management adaptation strategies also offer additional benefits, such as capturing pollutants from runoff, sequestering carbon, providing shade, greening the community, promoting livability, and increasing biodiversity. Preparing for the consequences of climate change and reducing the City's energy consumption are key components of the City's Official Community Plan (2013).

2.1.1.6 Future Intensity-Duration-Frequency Curves

As part of the SWMMP for the Park, Dillon Consulting developed projected IDF curves for mid- and late-century timeframes, representing the 2050s and 2080s, under the "worst case" representative concentration pathway (RCP) 8.5 (Intergovernmental Panel on Climate Change, 2013). Although referred to as a "worst case" scenario, RCP 8.5 represents a "business as usual" carbon-intensive future emissions pathway with little greenhouse gas mitigation, which is an appropriate scenario to plan for based on the current progress in global greenhouse gas mitigation. The projected IDF curves were used to develop Depth-Duration-Frequency (DDF) relationships provided in Table 8 and Table 9, and include multi-day rainfall events (2-10 days) in addition to sub-daily duration events for standard return periods (2-100 year events). The extended curves will enable the City to consider the multi-day rainfall events that have historically caused riverine and pluvial flooding in the region. Overall, the combination of the updated baseline IDF curves and the climate change projections result in significant increases in rainfall volumes. Additional details are provided in Appendix B and in the separate MS Excel Spreadsheets prepared by Dillon Consulting (e.g. 25th and 75th percentile IDF Curves).

Table 8. Mean Future (2050s) Rainfall Depth-Duration-Frequency Curves for Parksville, BC (mm)

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5-min	3.3	4.4	5.1	5.9	6.7	7.3
10-min	4.9	6.7	7.8	9.3	10.5	11.5
15-min	5.9	8.4	10.1	12.2	13.8	15.5
30-min	8.4	12.0	14.4	17.5	19.7	21.9
1-h	11.9	15.9	18.7	22.0	24.6	27.1
2-h	17.6	21.5	24.0	27.3	29.6	32.0
6-h	34.1	40.4	44.5	49.8	53.7	57.4
12-h	48.0	57.7	64.1	72.1	78.0	84.0
24-h	63.6	79.7	90.4	104.0	113.9	123.9
2-day	79.9	97.9	109.9	125.0	136.1	147.3
3-day	93.6	113.3	126.3	142.8	155.0	167.1
4-day	109.9	133.9	149.7	169.8	184.7	199.4
5-day	124.2	152.4	171.0	194.6	212.1	229.5
6-day	135.2	163.5	182.3	206.0	223.7	241.1
7-day	142.8	173.1	193.2	218.5	237.3	256.0
8-day	152.7	185.4	207.1	234.4	254.7	274.9
9-day	163.0	197.8	220.9	250.0	271.6	293.0
10-day	172.3	210.0	234.9	266.4	289.8	313.1

Source: Rainfall Design & Climate Change Guidance – Final Technical Report (See Appendix B)

Table 9. Mean Future (2080s) Rainfall Depth-Duration-Frequency Curves for Parksville, BC (mm)

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5-min	3.7	4.9	5.7	6.6	7.4	8.1
10-min	5.4	7.4	8.8	10.4	11.7	12.9
15-min	6.6	9.4	11.3	13.7	15.4	17.3
30-min	9.4	13.4	16.1	19.5	22.1	24.5
1-h	13.3	17.8	20.9	24.6	27.5	30.3
2-h	19.5	23.9	26.6	30.3	32.9	35.5
6-h	37.0	43.8	48.2	53.9	58.2	62.2
12-h	52.1	62.5	69.4	78.1	84.6	91.0
24-h	68.9	86.4	98.0	112.7	123.5	134.3
2-day	86.6	106.1	119.1	135.4	147.6	159.6
3-day	101.4	122.8	136.9	154.7	168.0	181.1
4-day	119.1	145.1	162.3	184.0	200.1	216.2
5-day	134.6	165.2	185.4	210.9	229.9	248.7
6-day	146.5	177.2	197.6	223.3	242.4	261.4
7-day	154.8	187.6	209.4	236.8	257.2	277.4
8-day	165.5	201.0	224.4	254.1	276.1	297.9
9-day	176.7	214.4	239.4	271.0	294.4	317.6
10-day	186.7	227.6	254.6	288.8	314.2	339.3

Source: Rainfall Design & Climate Change Guidance – Final Technical Report (See Appendix B)

2.1.1.7 *Baseline & Future Water Balance*

As part of the SWMMP for the Park, Dillon Consulting developed projected monthly water balances based on the Environment Canada weather station in Coombs, BC for mid- and late-century timeframes, representing the 2050s and 2080s, under the "worst case" RCP 8.5 (Intergovernmental Panel on Climate Change, 2013). Overall, the projections indicate that the wettest winter months will become wetter (up to 18% by 2080s in the winter) and driest months will become even drier (up to a 22% decrease in the summer), as shown in Figure 4. Potential evaporation is estimated based on average temperature and is anticipated to increase in every month, as shown in Figure 5. The difference between precipitation and potential evaporation is an indicator of the local water balance conditions. As shown in Figure 6, the water surpluses in the cooler months (October to April) and deficits in warmer months (May to September) are expected to increase. Cooler months may have surpluses up to approximately 175 mm, while warmer months can have a deficit of approximately 75 mm historically. Historic precipitation records indicate an increasing trend in summer dry periods from 20 days in 1984 to 24 days by 2009, which may continue into future summer periods since smaller rainfall events are expected to occur less frequently. Additional details are provided in Appendix B and in the separate MS Excel Spreadsheets.

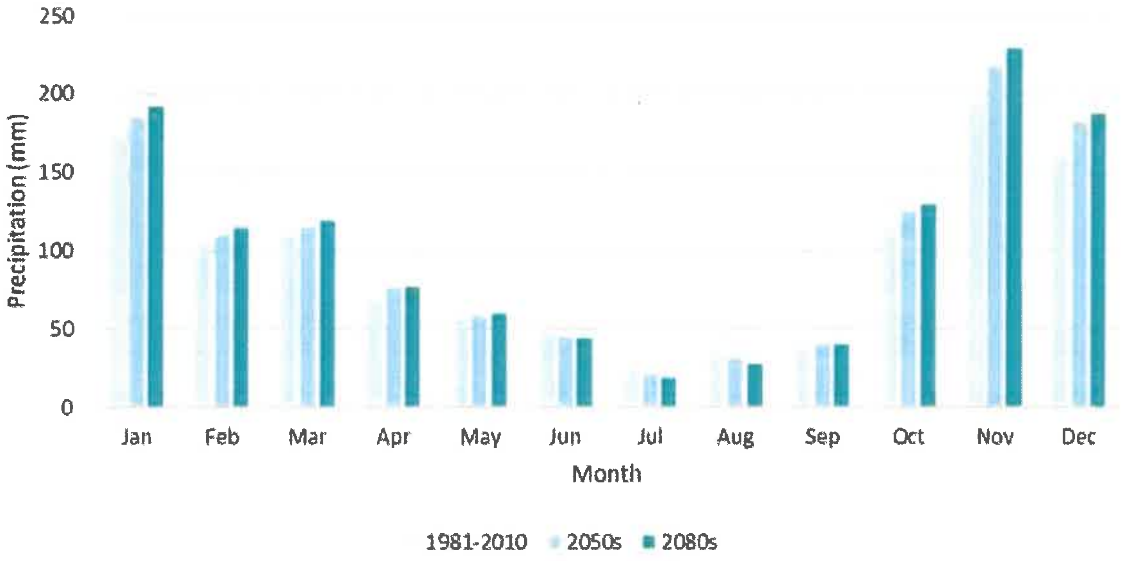

Figure 4. Monthly Precipitation in Coombs, BC (Adapted from Dillon Consulting, 2020)

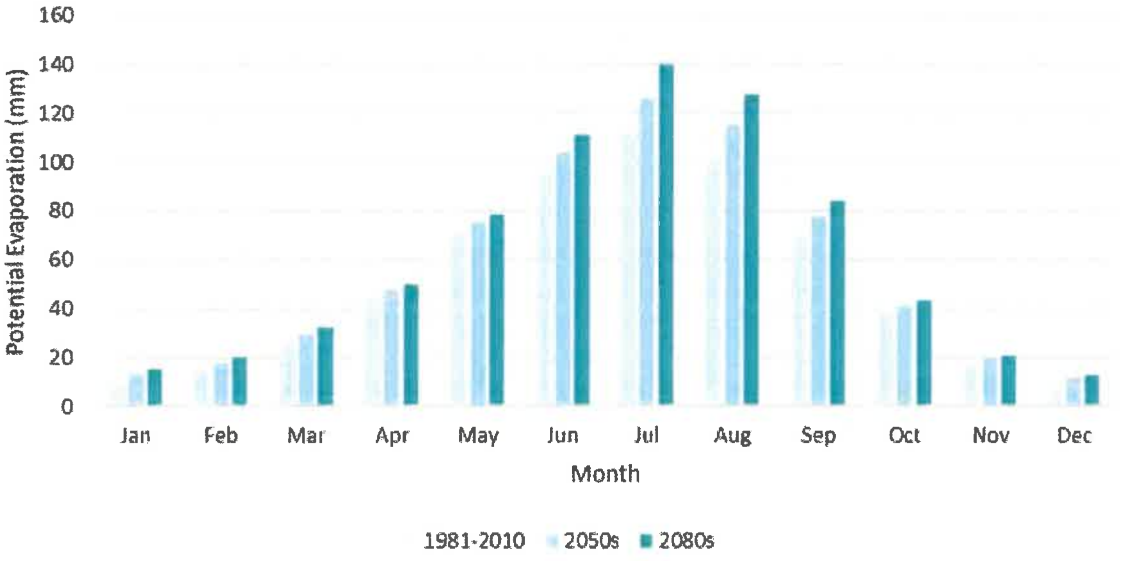

Figure 5. Monthly Potential Evaporation in Coombs, BC (Adapted from Dillon Consulting, 2020)

Figure 6. Water Balance (Precipitation - Potential Evaporation) in Coombs, BC (Adapted from Dillon Consulting, 2020)

2.1.1.8 Hyetographs

The City-wide Storm Drainage Master Plan (SDMP) considered the applicability of multiple synthetic hyetographs to represent the distribution (i.e. amount and intensity) of rainfall events over time in Parksville. The SDMP considered the Atmospheric Environment Services (AES) Canada, Soil Conservation Services (SCS), and Huff distributions. The Chicago distribution was not considered because it does not represent rainfall patterns for the BC coast. Multiple durations of the AES distribution were simulated in the City-wide XPSWMM model, which indicated that the 1-hour AES hyetograph governed all systems except for the Romney Creek catchment, which was governed by the 6-hour duration storm (Koers & Associates Engineering Ltd., 2016).

The SWMMP will use a 1-hour AES BC Coast and the 24-hour SCS Type IA (Pacific Coast) distributions for assessing conveyance and retention capacity, respectively, which are both relevant to the stormwater management system in the Park. Multi-day events may be represented by the distributions of historic events observed in the region.

2.1.2 Sea Level and Coastal Inundation

Extreme sea levels are often a result of high tides coinciding with storm surges. Storm surges are the temporary increases in sea levels caused by storms and their associated severe winds and decrease in atmospheric pressure. The 'storm tide level' is the combination of the astronomical tide level and storm surge, as shown in Figure 7, and is the effective 'still water level' during an extreme event. Wave effects are in addition to the storm tide level. Each of these contributing factors will be elevated in the future due to sea level rise (SLR). Coastal inundation from storm surges can be exacerbated when heavy rain associated with the storms also cause riverine flooding in estuaries and inland flooding in low-lying areas (Department of Sustainability and Environment, 2012).

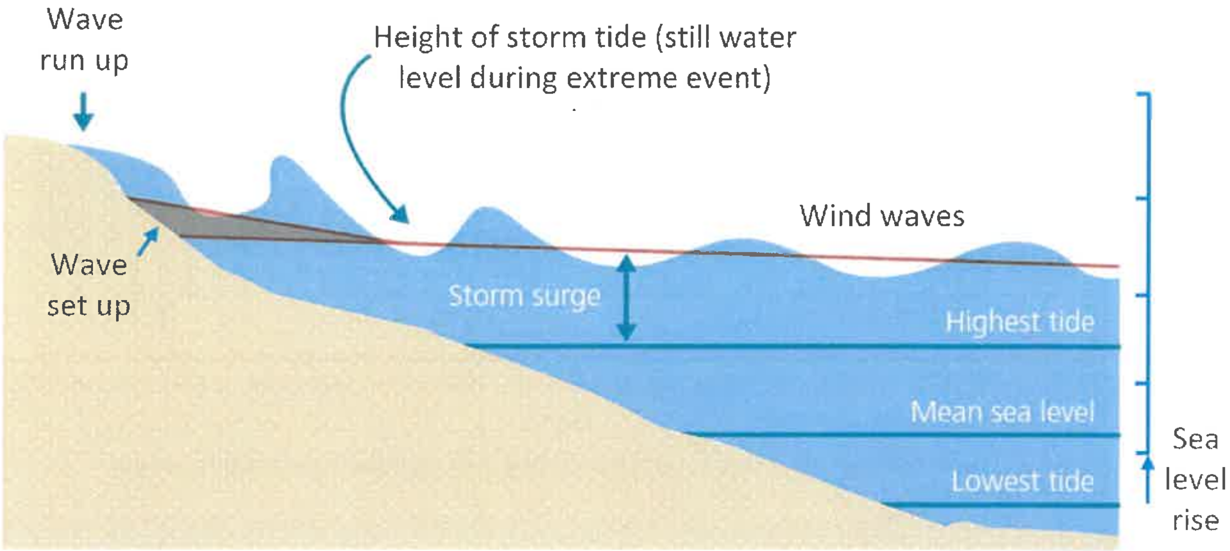

Figure 7. Impacts of Tides, Storm Surge and Wave Processes on Sea Level (Department of Sustainability and Environment, 2012)

As part of the SWMMP, Northwest Hydraulics Consultants (NHC) conducted a study to assess sea level under existing and future climate conditions, considering the effects of global SLR on tides and storm surge, as well as wave effects. Future, late-century projections were estimated based on applicable guidelines from the BC Ministry of Environment (BC MOE, 2018) and include considerable uncertainty. The study summarized tide levels at the Park as outlined in Table 10. NHC also developed a time series of sea water levels from September 2019 to April 2020 based on measured levels at Point Atkinson transformed to the project site. The time series includes the measured astronomical tide as well as residuals from storm surge and wind/wave set-up (Northwest Hydraulics Consultants, 2020b). An excerpt of the time series is shown in Figure 8. Figure 9 illustrates the time series shifted to account for regional SLR by year 2100 (+0.79 m) relative to the Park's existing storm sewer outfall and a new outfall which was recently installed, but not connected, as part of shoreline improvements. Sea levels will back up into the Park's stormwater management system through the outfall and will submerge parts of the contributing system under extreme sea levels. This effect will occur with increasing frequency and duration under future climate conditions due to SLR, even when the system is connected to the new outfall.

Table 10. Summary of Tides based on Northwest Bay (Northwest Hydraulics Consultants, 2020a)

Sea State	Year 2020 Tide Elevation (m, CGVD2013)	Year 2100 Tide Elevation (m, CGVD2013)
Higher High Water Large Tide (HHWLT)	2.18	2.97
Higher High Water Mean Tide (HHWMT)	1.68	2.47
Mean Water Level (MWL)	0.18	0.97
Lower Low Water Mean Tide (LLWMT)	-1.73	-0.94
Lower Low Water Large Tide (LLWLT)	-2.83	-2.04

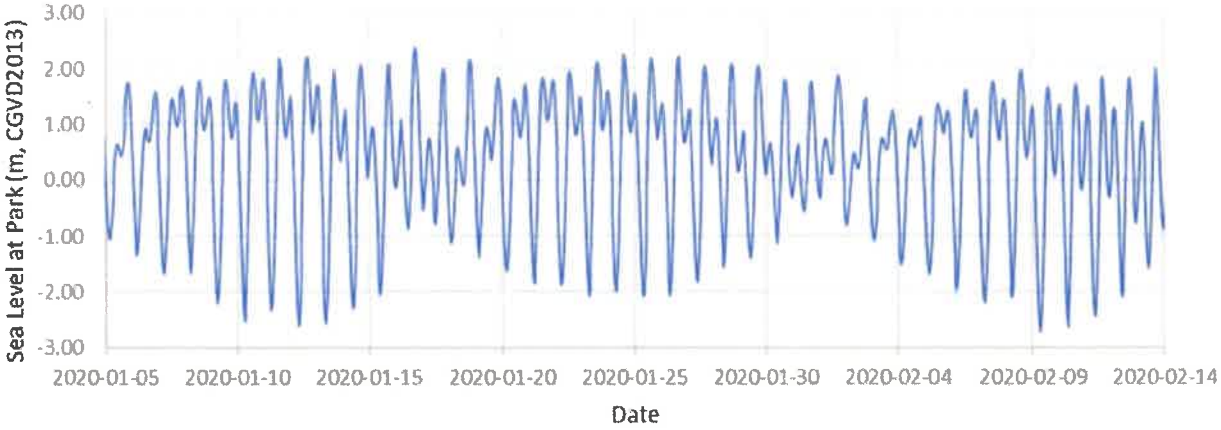

Figure 8. Example of Existing Variability in Sea Level at Park (Northwest Hydraulics Consultants, 2020b)

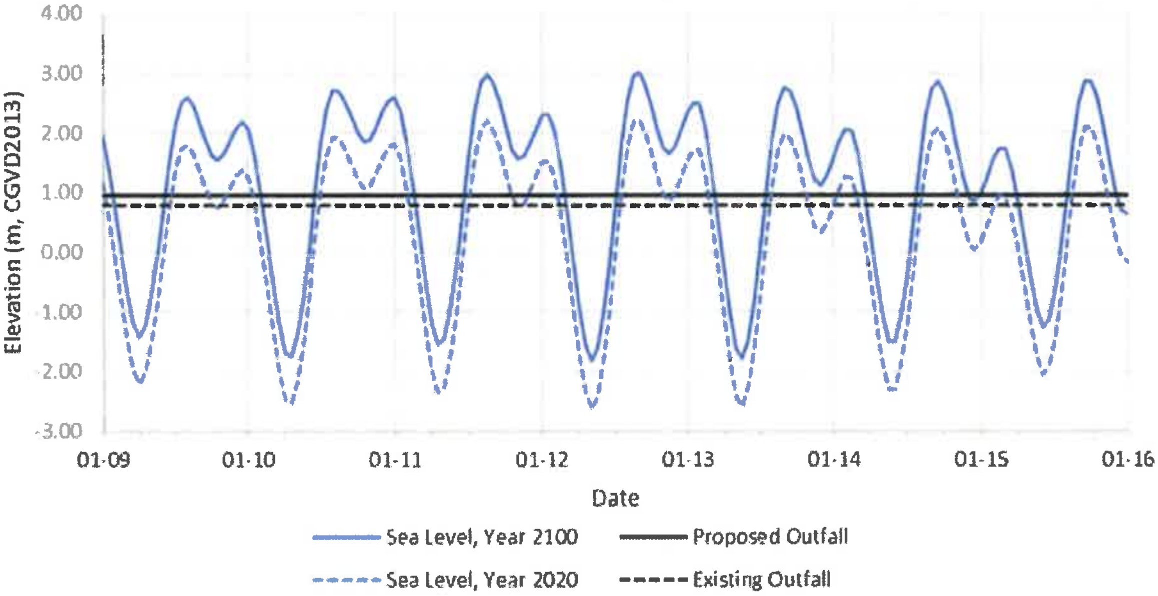

Figure 9. Existing and Future Sea Level Relative to Storm Sewer Outfall (Adapted from Northwest Hydraulics Consultants, 2020b)

NHC identified the design water levels (Table 11) with 10, 100 and 200 year annual exceedance probabilities based on joint probabilities of tides and storm surge. Late century levels also included global SLR (+1 m by 2100) and local uplift (-0.21 m by 2100). These design water levels represent 'still water level' during extreme events and do not include wave effects. Significant coastal inundation of the Park is likely to occur in Year 2100 based on the existing park topography relative to the design water levels, as shown in Figure 10, whereas present-day inundation will be limited to the beach. The duration of coastal flooding will typically be two to three hours due to the astronomical tides, however the ability of the coastal flood water to recede within the Park depends on drainage infrastructure (Northwest Hydraulics Consultants, 2020a). NHC assumed neighbouring properties will be raised to prevent coastal inundation via overland flow from those properties (G. Lamont, personal communication, July 23, 2020).

Table 11. Design Water Levels for the Years 2020 and 2100 (Northwest Hydraulics Consultants, 2020a)

Annual Exceedance Probability	Year 2020 Water Level (m, CGVD2013)	Year 2100 Water Level (m, CGVD2013)*
10-Year	2.78	3.57
100-Year	3.02	3.81
200-Year**	3.14	3.93

*Year 2020 Level + Regional Sea Level Rise (+0.79 m)

**Coastal Designated Flood Level

NHC found that present day wave effects will be limited to the beach except for some overtopping and isolated ponding that will occur at the peak of a storm event, lasting two to three hours, at locations where the Park pathway has minimal freeboard (i.e. the western half of the Park shoreline, primarily to the southwest of the rock groyne where the beach crest elevation drops to approximately 3.1 m CGVD2013). Wave overtopping rates are dependent on the elevation of the beach crest, which may change based on the City's SLR adaptation strategy, and so the study developed this relationship for consideration in future planning. In Year 2100, wave heights within the inundated park area will likely be approximately 0.3 m, however additional analysis is required to assess the potential effects of wave breaking. The study considered potential wave runup under existing and future climate, with the latter assessment considering a scenario with future raised shoreline elevations. If the shoreline is not raised, then waves will break on the shoreline and impacts will be dependent on other factors needing further consideration (Northwest Hydraulics Consultants, 2020a).

Overall, the study utilized the 200-year design event levels and regional SLR to estimate the future Natural Boundary at an elevation of 4.2 m. NHC recommended adding 0.6 m of freeboard to the Natural Boundary to define the future Flood Construction Level at an elevation of 4.8 m (CGVD 2013), as shown in Figure 11 and in accordance with the probabilistic method illustrated in Figure 12 (Northwest Hydraulics Consultants, 2020a). The Flood Construction Level cited in the City's Official Community Plan is 4.1 m (City of Parksville, 2013). The Flood Construction Level indicates the elevations above which habitable spaces in buildings should be constructed and also can be used to establish the target elevation for shoreline berms. Details of the study method and findings are provided in Appendix C.

Typical risks related to sea levels in coastal areas include damage to coastal infrastructure, property and people from inundation, saltwater intrusion and coastal erosion due to SLR and storm surges. Although the projected extent of late-century coastal inundation is substantial in the Park, the establishment and management of the Park has protected this area from other developments which could have become more vulnerable to climate change than parklands. Implications of SLR on the Park's stormwater management system are assessed in Section 3, however implications on park layout and programming are beyond the scope of the SWMMP. The SWMMP will need to be updated and aligned with other City plans as they evolve with a growing understanding of climate change impacts and adaptation strategies. For example, the SWMMP and Park Master Plan would need to be aligned with a SLR adaptation plan for Parksville Bay and the Englishman River Estuary.

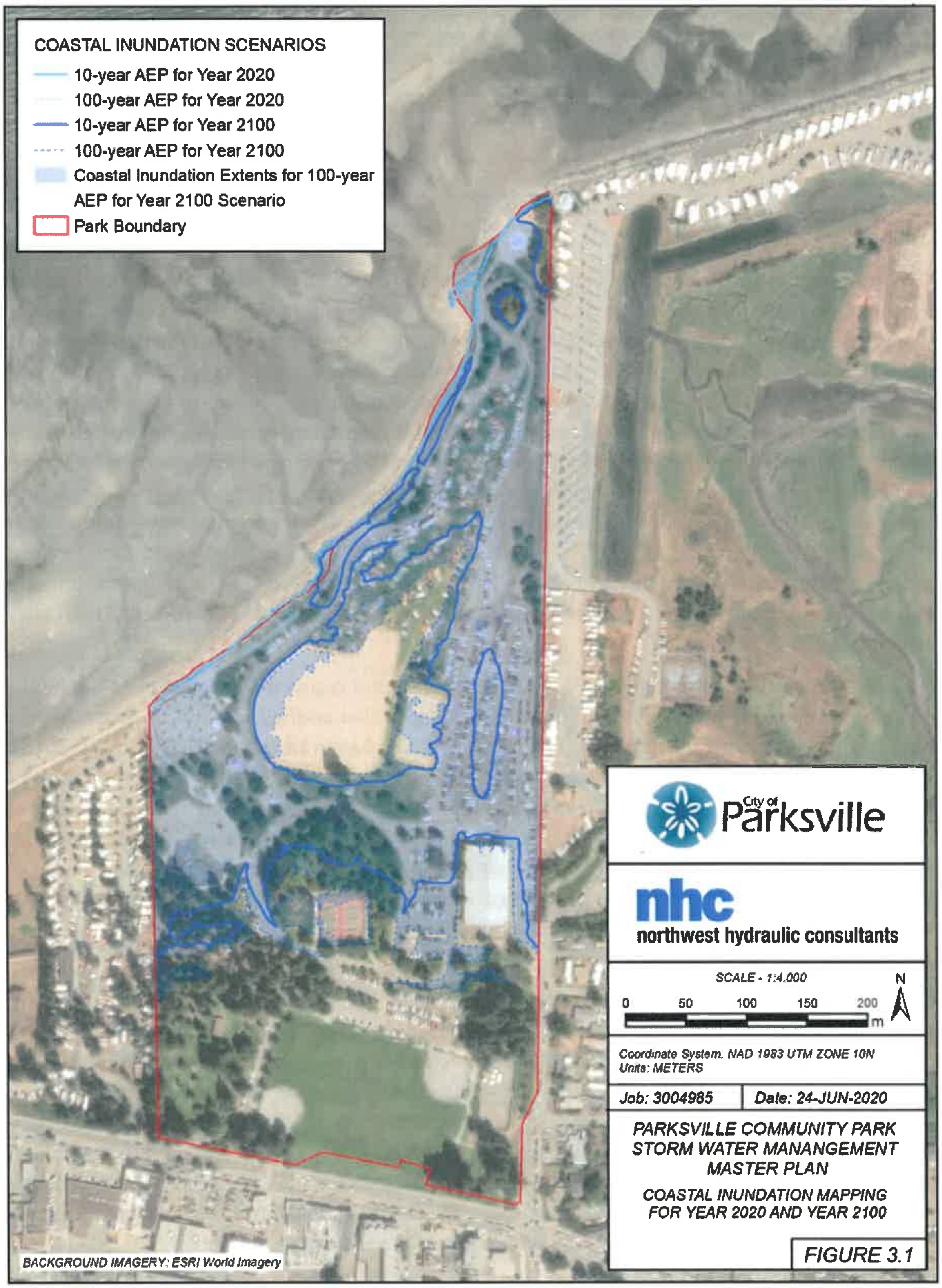

Figure 10. Coastal Inundation Mapping for Year 2020 and Year 2100 (Northwest Hydraulics Consultants, 2020a)

Figure 11. Depth of 100-Year Coastal Inundation, Year 2100 (Northwest Hydraulics Consultants, 2020a)

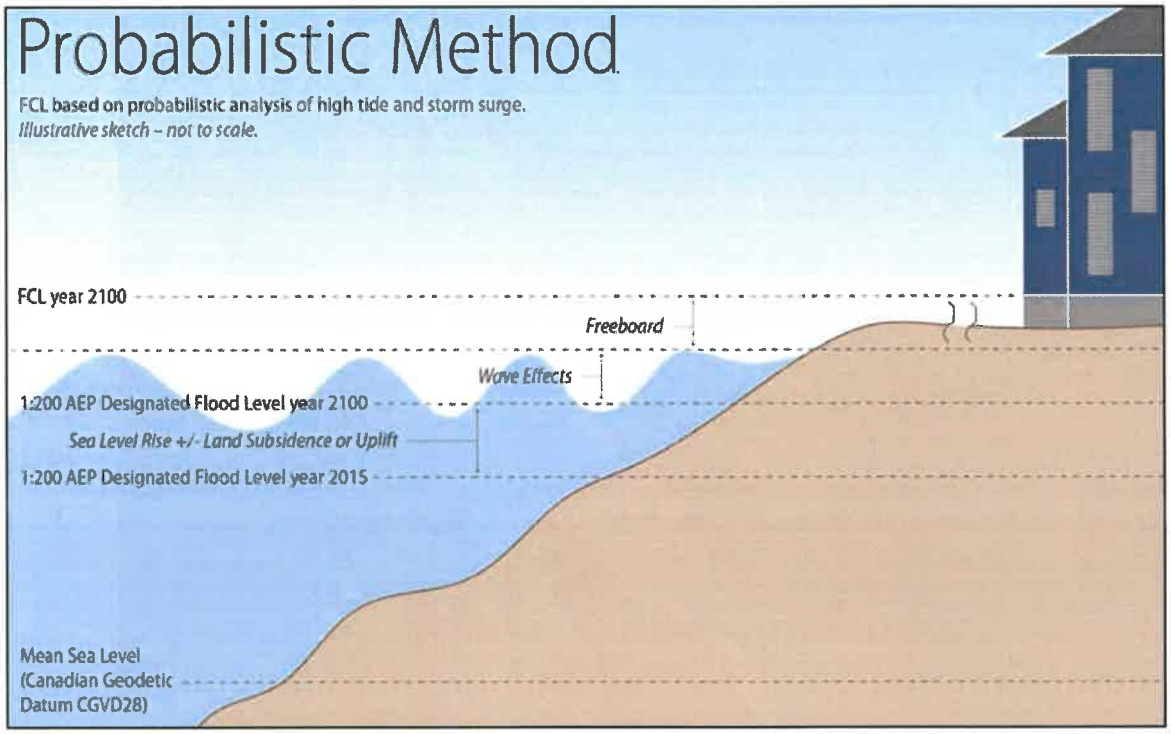

Figure 12. Illustration of Probabilistic Method for Estimating Flood Control Level (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2018)

2.1.3 Coastal Erosion

Shoreline erosion conditions at the Park are described as follows:

> "The Park is directly exposed to Northwesterly storms and is sheltered from Southeasterly waves by the Englishman River Estuary. However, Southeasterly storms are the source of significant longshore sediment transport, moving sediment from the Englishman River Estuary into Parksville Bay. A secondary source of sediment may be transported from the bluffs to the northwest of Parksville Bay during Northwesterly wave events. This results in the large beach and long shallow foreshore fronting the Park.
>
> Previously, NHC (2015) was retained by the City of Parksville to develop preliminary erosion protection options for Arbutus Point and Sutherland Stairs [Figure 13]. The scope of work for the previous study included the following:
>
> - Significant erosion has occurred at Arbutus Point near the old hovercraft pad. The City required a plan to identify the erosion processes and to determine what steps should be taken to control the current erosion problem. A combination of riprap, anchored large woody debris (LWD) on the backshore and gravel fill on the seaward side of the riprap was recommended. Construction of the preferred option was completed in August 2017.
> - Erosion was occurring at the Sutherland Stairs located at Sutherland Place approximately 250 m south of McMillan Street. Conceptual designs and sketches of

erosion mitigation measures were prepared by NHC. This solution was not implemented by the City of Parksville.

- There was a public perception that the existing sandy beach and tidal flats were being covered over by coarse gravel and cobbles. An assessment of the dynamic nature of the beach and factors governing sediment transport along the shoreline was required, including an analysis of wave climate and tidal current conditions and the influence of the Englishman River." (Northwest Hydraulics Consultants Ltd., 2015)

City staff have noted that sediment frequently accumulates in the existing storm sewer outfall from the Park at Arbutus Point.

Figure 13. Parksville Community Park and Parksville Bay Shoreline (Northwest Hydraulics Consultants, 2020a)

2.1.4 Topography

Elevations throughout most of the Park range from sea level to approximately 5 m above sea level, with a steep slope on the southern boundary rising to 11 m above sea level. The topography of the Park is mapped in Figure 14 using light detection and ranging (LiDAR) provided by Regional District of Nanaimo. Additional topographic survey was conducted of the Park by JE Anderson in January and February 2020. Sims Associates Land Surveying Ltd. surveyed the right-of-way adjacent to the Park on Corfield Drive and Highway 19A in May 2020.

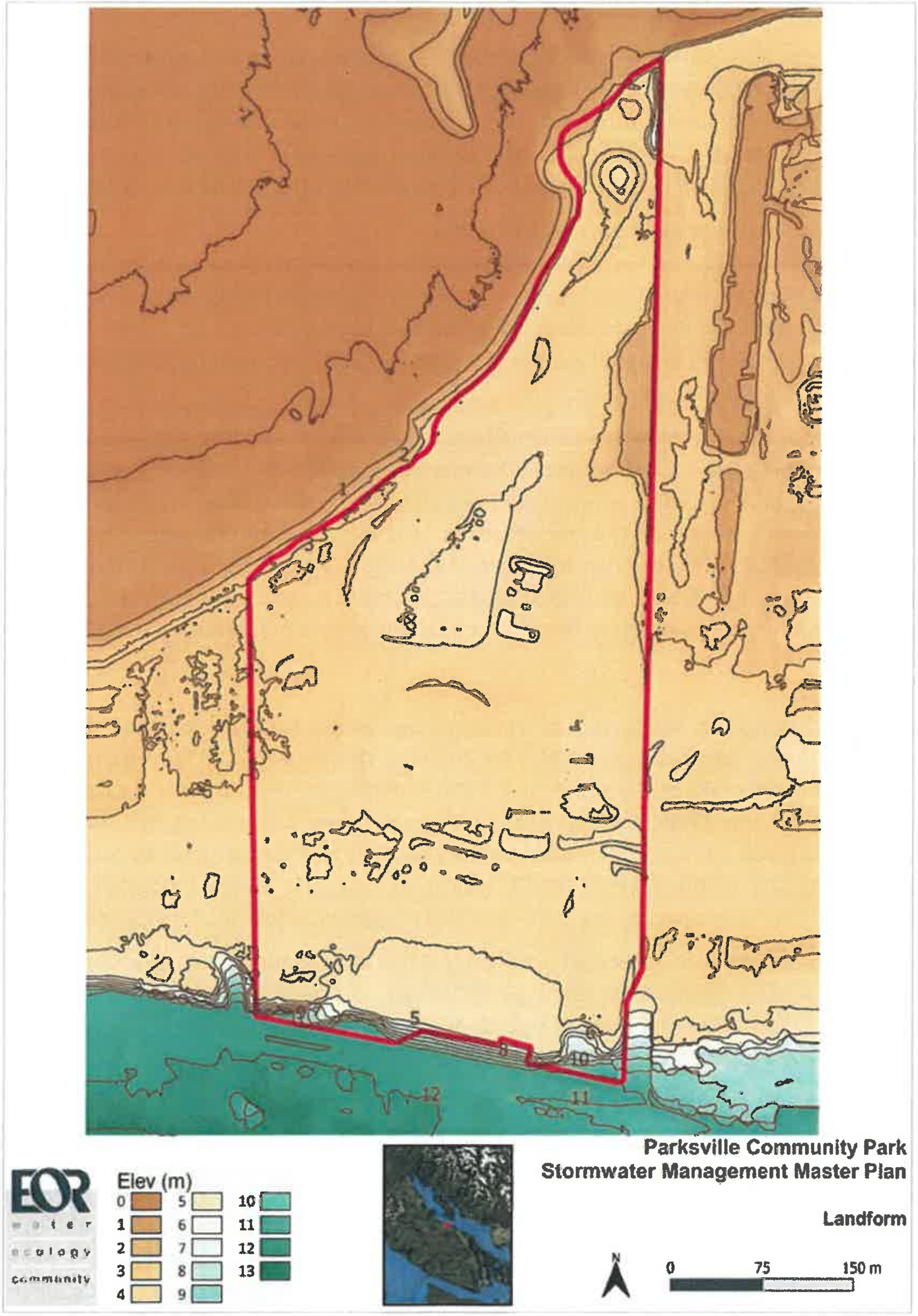

Figure 14. Topography

2.1.5 Surficial Soils

Surficial geology in the Park primarily consists of Salish Sediments (i.e. shore, deltaic and fluvial deposits composed of gravel, sand, silt, clay and peat) with a small area of terraced fluvial deposits at the southeast corner (i.e. deltaic deposits composed of gravel and sand underlain by silt and clay) (Fyles, 1963). As part of the SWMMP, Thurber Engineering Ltd. conducted a geotechnical investigation of the Park based on five test pits, which found the following typical soil conditions:

- Topsoil consisted of organic silt up to 0.45 m thick.
- Fill soils (immediately below topsoil) consisted of sand, gravelly sand and sandy gravel up to 2.4 m deep, except for TP20-3 (east of lacrosse court at southeast corner of park) where fill consisted of organic silt with some sand and gravel to a depth of 2.3 m.
- Native granular soils below the fill consisted of gravelly sand, or sand and gravel containing variable amounts of cobbles and silt.

Grain size analysis of selected samples were used to refine soil classifications. The grain size analysis confirmed that the confining layer at most test pit locations is poorly graded sand (SP), which has a design infiltration rate of 20.3 mm/hr (Appendix E) and should be confirmed by in-situ infiltration testing during detailed design of stormwater practices. The exception to this finding is the the organic silt encountered at TP20-3 to a depth of 2.3 m, indicating low potential for infiltration at this location. Infiltration capacity will also be affected by groundwater elevations, which are discussed in the next section. Additional information on the geotechnical investigation is provided in Appendix D.

2.1.6 Groundwater

The geotechnical investigation conducted by Thurber Engineering Ltd. characterized depth to groundwater at the time of the investigation (May 14, 2020). As shown in Figure 15, no groundwater was encountered at three of the test pits (TP20-4, TP20-5, TP20-6). Depth to groundwater in the three southernmost test pits (TP20-1, TP20-2, TP20-3) ranged from 2.3 to 2.7 m. The shallowest groundwater was observed 1.3 m below ground in the dry basin located northeast of the curling rink on the eastern boundary of the Park (TP20-7), which was also the lowest topographic point investigated. Additional information on the geotechnical investigation is provided in Appendix D.

An Archaeological Impact Assessment of the Park in early March also identified shallow groundwater in the dry basin at a depth of approximately 0.85 m. The assessment also identified indicators of groundwater (i.e. mottled soils) in a shallow test pit dug at the northeast corner of the volleyball courts approximately 0.34 m below the ground (Parsley & Thompson, 2020).

Groundwater elevations below the Park are expected to fluctuate seasonally due to relationship to sea level and precipitation, and may potentially be influenced by irrigation of the Park as well. TP20-1 is located west of the baseball fields, which are drained by a draintile system although their influence on groundwater is unknown. In addition, sea level rise associated with climate change may cause increased groundwater elevations. The extent of these influences at the Park is uncertain due to a lack of monitoring data, however the relatively shallow groundwater elevations observed at some locations in May 2020, especially in the dry pond, indicate vulnerability to groundwater flooding or shallow groundwater impeding infiltration capacity.

Figure 15. Summary of Geotechnical Results

2.1.7 Drinking Water

There are no municipal drinking water intake points or wellhead protection areas located within the Park.

2.2 Cultural Environment

Cultural environmental features include any building, structure, site or object, including an underground or underwater site, of significance in the history, archaeology or culture of a study area and its communities.

The Community Park Master Plan describes the rich history of the Community Park, including First Nations' heritage and the history of the Park after European settlement. The City is located within the traditional territories of the Coast Salish Peoples who have lived in the region for thousands of years. The Park is within the asserted traditional territory of the Snaw-Naw-As, Qualicum and K'omoks First Nations. The Community Park Master Plan includes the goal, "to collaborate with local First Nations to provide meaningful recognition of traditional territory, First Nations' values, and culture in the Community Park."

A critical step towards honouring First Nations' heritage in the Park is understanding the extent and type of archaeological features in the Park to guide culturally sustainable development in the Park in the future. To take this first step, the City recently retained Aquilla Archaeology to conduct an Archaeological Impact Assessment and Inventory study. The purpose of the study was to confirm the boundary of archaeological site(s) at the Park, and also to facilitate a shift towards inclusion and connectivity with the Snaw-Naw-As and Qualicum First Nation communities. The study identified three key findings:

1. the presence of archaeological site[1] DhSb-2 is substantially larger and extends through the southern third of the Park in a discontinuous fashion, and
2. DhSb-2 is at a minimum nearly 1000 years old, and
3. the northern two-thirds of the Park are infilled former marine-riverine-deltaic intertidal areas.

The interim boundary of the archaeological site based on the study is illustrated in **Appendix H**. The findings will be used to guide planning for drainage improvements and associated site investigations/operations as part of the SWMMP. The areas with archaeological features are protected by legislation and may not be altered, damaged, moved, excavated in, or disturbed in any way without a permit issued under either Section 12 or Section 14 of the Heritage Conservation Act. The assessment recommended a 50 m buffer around the archaeological deposits as a best practice to help ensure archaeological conservation.

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[1] Archaeological sites are locations on public or private land containing evidence of human activity pre-dating 1846.

A contingency plan should be established if ground disturbance is required within the 50 m buffer to minimize any testing and include a monitoring/chance finds procedure. If archaeological material is unexpectedly encountered, work should stop and the Archaeology Branch and respective First Nation communities should be contacted immediately (Parsley & Thompson, 2020).

The Archaeological Impact Assessment report also discussed the implications of these findings more broadly for the Park and future management. Preliminary review of historic aerial imagery of the Park (see thumbnail, right, from Parsley & Thompson, 2020) indicates that the archaeological site is situated along the historic 1930s shoreline, prior to park establishment. While development of the Park has destroyed and degraded substantial amounts of the archaeological site, establishment of the Park has also protected the area from other types of development which may have had more extensive impacts to the archaeological site. Development of the Park involved infilling almost two thirds of the parkland north of the archaeological site to raise the topography, which has situated that area such that further development will not have any archaeological impacts and will reduce the potential depth of coastal inundation of the Park. The significance of this archaeological site is enhanced by its location in the popular Community Park, which provides more opportunity to educate the public of Indigenous presence in the past, present and future of the Park (Parsley & Thompson, 2020).

Additional cultural environmental features that have been installed since the Park's establishment include the memorial plaque program at benches and trees (recommended to be discontinued in the Community Park Master Plan) and the labyrinth at the old helicopter pad at Arbutus Point (Vancouver Island University & City of Parksville, 2017).

2.3 Natural Environment

The City is located in the Coastal Douglas Fir biogeoclimatic zone, one of the smallest of BC's ecological zones, which primarily contains Douglas Fir (*Pseudotsuga menziesii*) forest, estuarine, and some endangered Garry Oak (*Quercus garryana*) ecosystems (Natural Resources Canada, 2015). The shores of the Park are within the Parksville-Qualicum Wildlife Management Area (PQWMA). The PQWMA was designated to conserve the internationally significant intertidal, estuarine and riparian habitat used by a range of species, most notably the Pacific Brant Sea Goose and over 60 other water fowl species, along 1,024 hectares of eastern Vancouver Island shoreline (Regional District of Nanaimo, 2019). The Englishman River Estuary, located immediately east of the Park (Figure 16), includes 145 ha that was designated to protect the environmentally sensitive ecosystem, support the productivity of the estuary lands by restricting development and promote ongoing environmental study and monitoring (City of Parksville, 2013). The Englishman River Watershed Recovery Plan noted that the estuary supported many species of salmon although the ecosystem was degraded by low riverine flows in the late summer and non-point source pollution from storm sewer outfalls (LGL Limited, 2001), which includes runoff from the southeast corner of the Park.

The terrestrial environment in the Park includes turf grass, gardens and over 500 trees, some of which are located within the Arboretum encircled by Salish Sea Drive. In total, there are 170 tree species within the Park, including native and ornamental species. The majority of trees in the Park were recently identified as being in good or excellent health (Figure 17) and intercepting approximately 3.4 million litres of rainfall annually (City of Parksville, 2019), which is equivalent to 19 mm of rainfall over the Park every year. The City currently irrigates approximately 11 ha (61%) of the Park year-round to support tree and turf health. A recent Archaeological Impact Assessment and Inventory of the Park noted that there are few old growth trees in the Park and the old growth Douglas-fir are located in the east-west band of trees bisecting the Park. The assessment also noted the following regarding Culturally Modified Trees (CMTs)[2] in the Park:

> "The CMTs are slightly smaller in diameter in comparison to other culturally modified Douglas-firs in the vicinity (i.e. Milner Gardens and Woodland), however this smaller size is unlikely to be due to a younger age, but rather indicator of slow growth due to poor growing conditions. These Douglas-firs are situated within a nutrient poor, well-draining sand and are being strongly influenced by water availability during the late spring and summer. Spittlehouse (1996) suggested that a reduction in moisture availability in the summer could substantially reduce growth in Douglas-firs (Spittlehouse, 2003)." (Parsley & Thompson, 2020).

This SWMMP did not include an assessment of the terrestrial and aquatic ecosystems in the Park, or the risks associated with managing these natural resources over time. However, there are multiple potential climate change impacts to these ecosystems related to drought, coastal inundation, groundwater flooding, saltwater intrusion, soil salinization, biodiversity, and invasive species.

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[2] Culturally modified trees (CMTs) are "living trees that have been visibly altered or modified by Indigenous Peoples for usage in their cultural traditions" (Indigenous Corporate Training, 2019).

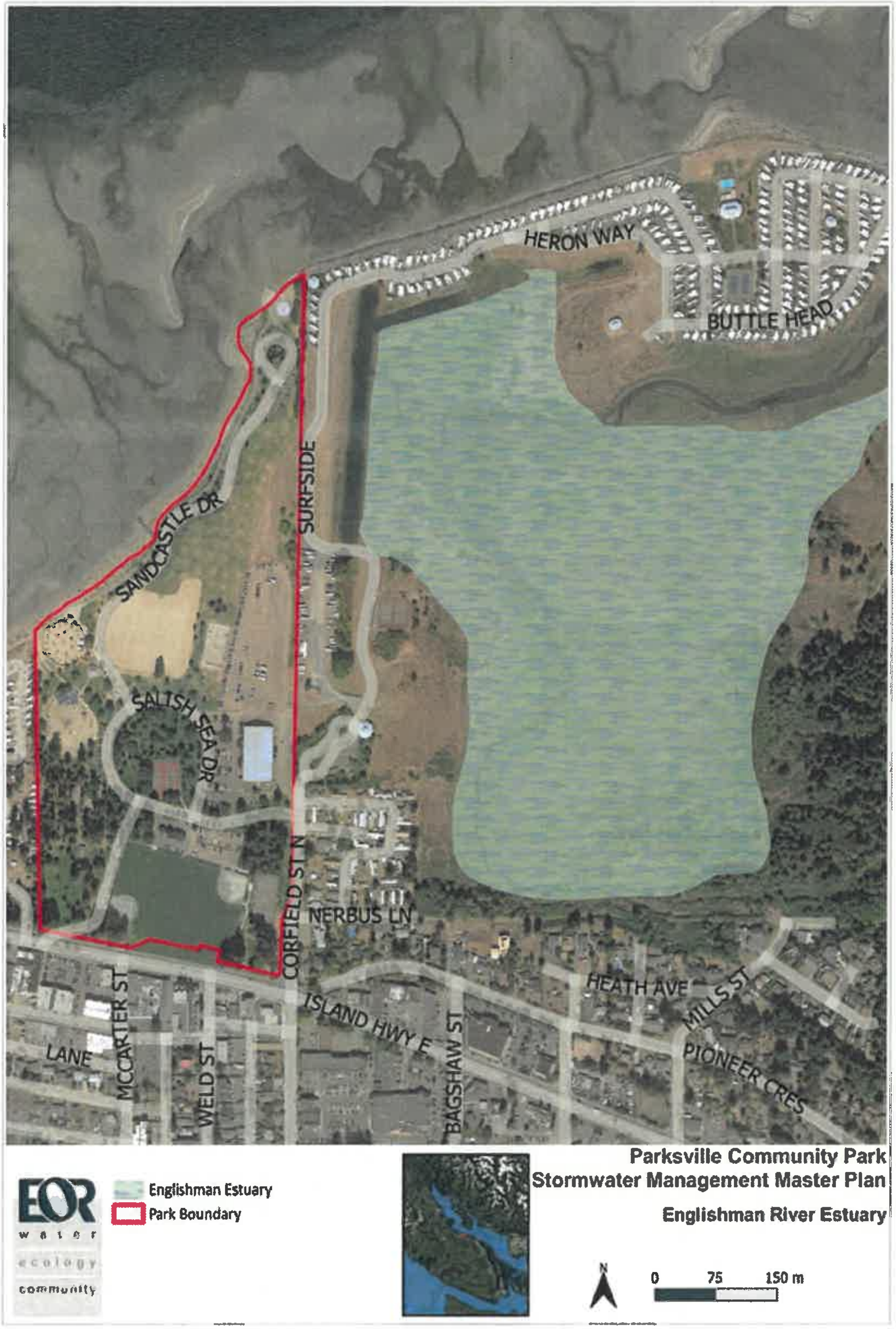

Figure 16. Englishman River Estuary

Figure 17. Trees in Community Park (Adapted from City of Parksville, 2019)

2.4 Built and Social Environment

The social environment includes infrastructure and amenities built within the Park. As the built environment in the Park expands, there will be more demands on the stormwater management system. A functioning stormwater management system is required to protect the Park and its users from pluvial (i.e. overland) flood risk and drain down future coastal inundation. Flooding generally occurs when the volume of stormwater cannot be contained or conveyed by the stormwater management system, in addition to sea levels backing up the storm sewer system. Typical risks from flooding include impassable roads, delayed emergency response, utility damage, property damage, delayed re-occupancy, damage to trees, degradation of wetlands, and injury or loss of life. There are no essential community services within the Park that require emergency access.

While this plan considers how sea levels affect the performance of the Park's stormwater management infrastructure, managing other hazards related to coastal inundation of the Park and developing a sea level rise adaptation strategy are beyond the scope of this SWMMP.

2.4.1 Land Cover and Land Use

Land cover in the Park includes buildings, parking lots (paved and gravel), roads, trails, a skate park, beach volleyball courts, playgrounds, baseball diamonds, tennis courts, a basketball/lacrosse court, a sand castle exhibition space, a splash pad, a tree arboretum, and other open spaces, as shown in Figure 14. Anticipated improvements in the Park that will increase impervious cover were compiled from City staff, the Community Park Master Plan and the ongoing Pedestrian Connections and Circulation Plan, and include an amphitheatre and trail improvements, as shown in Figure 19. The proposed layout of various improvements is subject to change, but overall, the future improvements are expected to increase the impervious cover of the Park from approximately 5.6 to 6.1 ha (31 to 34%).

Figure 18. Existing Land Cover

Figure 19. Future Land Cover

2.4.2 Road, Parking and Trail Infrastructure

The existing road, parking and trail infrastructure in the Park is illustrated in Figure 20. The three roads in the Park are Sandcastle Drive, Salish Sea Drive and Ravenhill Road. The three main parking lots in the Park are the paved and gravel lot by the sports field, the paved lot west of the curling rink, and the large gravel overflow lot north of the curling rink. Additional parking is provided in smaller, roadside parking along Sandcastle Drive. City staff noted some historic issues with accelerated asphalt deterioration in areas with frequent nuisance flooding issues, as well as east of the curling club. The City installed a section of permeable pavers in one of the roadside parking areas in 2015, which is functioning well so far. There are several limitations for pedestrians in the Park based on gaps between sidewalk and trail networks. The City sweeps the streets in the Park every two weeks.

The City is planning multiple road, parking and trail infrastructure improvements in the Park that are conceptually illustrated in Figure 21. These improvements are proposed through the Official Community Plan, Community Park Master Plan, Parks Trails and Open Spaces Master Plan, and Community Park Pedestrian Connections & Circulation Plan, including the following:

- Additional accessible parking at the southern section of Ravenhill Road near the picnic shelter and path to the picnic shelter.
- Reduce the total number of parking spaces as park access via other transportation options increases, which will provide more space for other activities in the Park.
- Construct sidewalks along the outside edge of Salish Sea Drive in front of the Parking spaces near the playground.
- Construct a multi-use path from the gravel parking lot along the south border of the beach volleyball area to the gathering space.
- Construct a permanent one-way road connecting the northeast corner, through the gravel parking lot, to the eastern exit. Include a sidewalk, designated bike path and street parking.
- Pave parking lot extension at sports field.
- Pave a portion of the large gravel lot nearest to the curling rink. Re-evaluate the need for overflow lot in 2037.
- Work towards extending the waterfront walkway through the downtown waterfront policies and parkland acquisitions as outlined in the Official Community Plan.
- Develop a pedestrian oriented, accessible connection from Rathtrevor Beach Provincial Park to the Parksville Community Park.

Figure 20. Existing Road and Trail Infrastructure in Park

Figure 21. Future Road and Trail Infrastructure in Park

2.4.3 Stormwater Management Infrastructure

The existing stormwater management system in the Park uses retention and conveyance strategies to manage stormwater runoff. Runoff from approximately half of the Park is retained by subsurface infiltration facilities (e.g. rock pits), a dry pond and landlocked topography. Runoff from another third of the Park drains to the storm sewer networks and ultimately to downstream outfalls. One of these areas is at the southeast corner of the Park, where the storm sewer network drains to an outfall to the Englishman River Estuary located northeast of the residential area east of Corfield Street North and north of Nerbus Lane. The second outfall is to Parksville Bay and is located at the northeast corner of the Park at Arbutus Point. Most of the remaining area of the Park also drains to the Parksville Bay storm sewer network, however a sag in the storm sewer network northwest of Salish Sea Drive prevents most drainage from reaching the Parksville Bay outfall, leaving the area partially isolated where runoff is retained at an infiltration manhole. Throughout the Park, the existing roads and parking lots direct runoff to the storm sewer network via curb and gutter systems. An inventory of the stormwater management infrastructure in the Park is summarized in Table 12 and illustrated in Figure 23. The major catchments throughout the Park are illustrated in Figure 22. As shown in Figure 23, an outfall stub with larger capacity than the existing storm sewer was installed at Arbutus Point during shoreline stabilization improvements designed by NHC and built in 2017(Northwest Hydraulics Consultants Ltd., 2017). The basic design parameters of the pipe (e.g. location and diameter) were selected by the City and the outfall invert elevation was set to the level of the beach at the base of the slope, approximately 0.15 m above the existing outfall. The City has noted that the existing outfall periodically clogs with sediment and debris, however it is unknown to what extent the new outfall will mitigate this issue.

Table 12. Inventory of Built Stormwater Infrastructure in the Park

Type	Quantity	Intended Purpose
Storm Sewer	2.1 km	Convey runoff away from roads and structures
Manholes	14	
Inlets (e.g. Catchbasins)	37	
Outfalls	2	
Ditches	108 m	
Infiltration Manhole	1	Infiltrate runoff where system has insufficient outlet capacity
Soakaway Pits (e.g. Rock Pits)	9	Infiltrate runoff in isolated areas of the Park
Dry Pond	1	Infiltration
Draintile	Unknown	Drain baseball fields

There is no operation and maintenance program for stormwater infrastructure in the Park. This could be contributing to some nuisance flooding issues in addition to other factors. For example, flooding on Ravenhill Road may be due to debris clogging the catchbasin inlet or the existing rock pit. Inspection of the rock pits was not possible because there is no cleanout port or other means for access/inspection. The City has well-established good housekeeping programs, including sweeping the streets in the Park every two weeks.

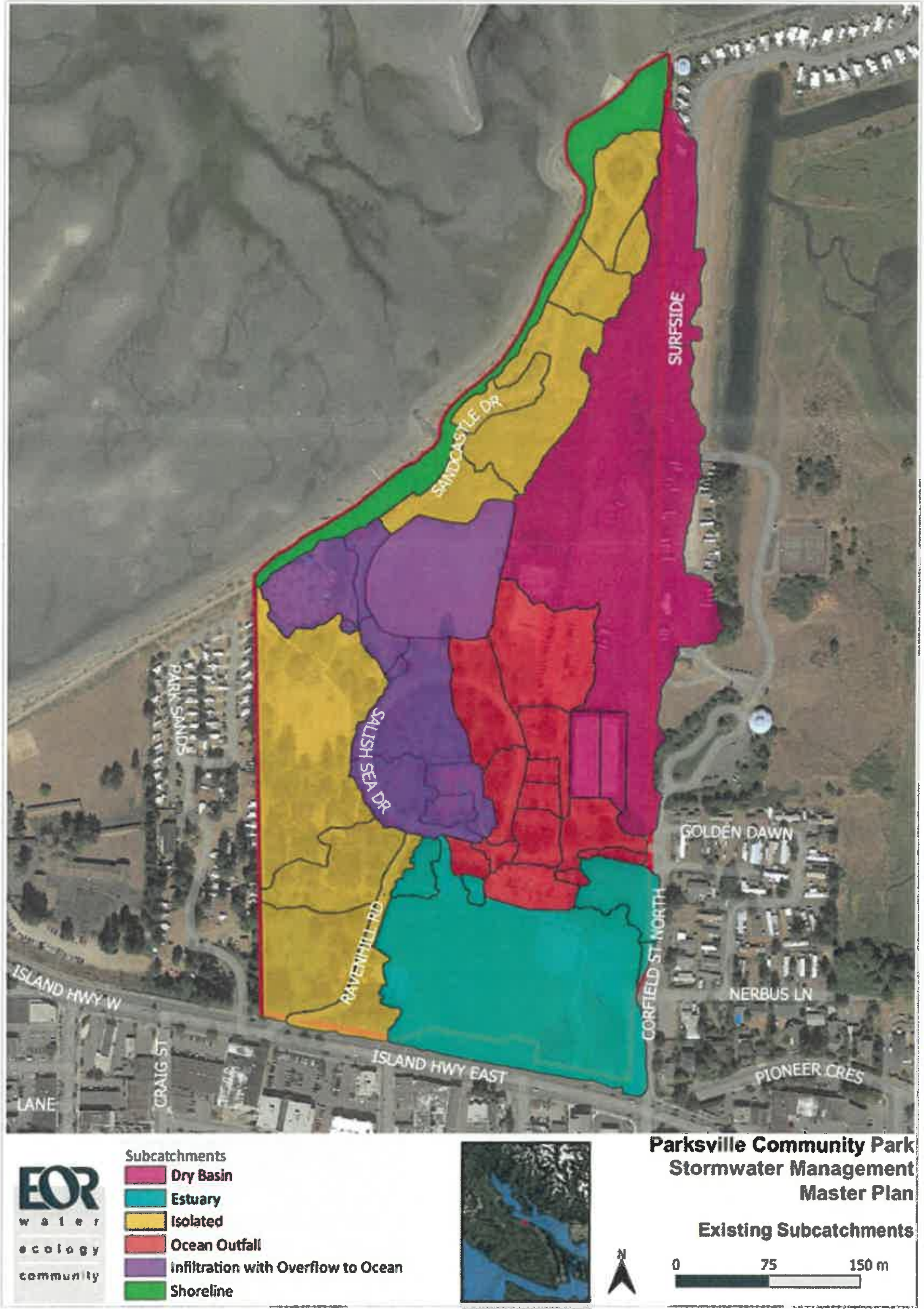

Figure 22. Park Catchments (Existing)

Figure 23. Existing Stormwater Management System

The age of the stormwater management infrastructure is uncertain; however sewer conditions were considered based on CCTV inspections by Pipe-Eye Video Inspections. Sewer condition codes were assigned by Pipe-Eye Video Inspections based on findings observed on the CCTV videos. Sewer condition codes are from the North American Association of Pipeline Inspectors Sewer Condition Codes Index (NAAPI, 2003) which uses the Water Research Centre (WRc) sewer conditions classifications (WRc, 1993). The codes assigned from the CCTV inspection, combined with the video records, were used to estimate a condition ranking for each pipe length using the ranking defined in (WRc, 1993). This ranking is not weighted by risk of failure, nor are any financial implications associated with it. Approximately 1084 m (51 %) of the storm sewer network is asbestos cement. The estimated condition ranking is shown in Figure 24. Hardcopy reports and video files were provided to the City of Parksville Engineering Department.

Table 13. Physical Condition and Recommended Action (WRc, 1993)

Condition Rank	Implication	Definition	Rehabilitation Priority
0-1	Excellent Condition	No defects were detected	None
2	Good Condition	Deficiencies have insignificant influence to tightness, hydraulic/static pressure of pipe (wide joints, badly torched intakes, minor deformation of plastic pipe, minor erosions, etc.)	Long Term
3	Fair Condition	Constructional deficiencies diminishing static/hydraulic/tightness (open joints, untorched intakes, minor drainage obstructions, cracks, protruding laterals, minor wall damage, individual root penetrations, corroded pipe walls, etc.)	Medium Term
4	Poor Condition	Constructional damages with nonsufficient static safety, hydraulic or tightness (pipe bursts, pipe deformations, noticeable in/exfiltration, cavities in pipe wall, severe protruding laterals, severe root penetrations, severe corrosion of pipe wall, etc.)	Short Term
5	Failed or Failure Imminent	Pipe is already or soon will be impermeable (collapsed, deeply rooted/obstructed, pipe loses water or poses danger of backwater in basements, etc.)	Urgent

Emergency overland flow capacity to the Parksville Bay is limited because the shoreline and trail system along the north boundary of the Park are elevated above inland areas of the Park. The City and park users have identified nuisance flooding issues along roads, in parking lots and along the walking trails. The nuisance flooding typically recedes within a day or so, however in the wet winter season it is common for some nuisance flooding areas to remain flooded for multiple days. Prolonged flooding may be causing premature deterioration of pavement. One maintenance building south of the playground has flooded, however no other structures have been flooded in the past based on the City's anecdotal records.

Figure 24. Estimated Sewer Condition

2.4.4 Utilities

Other utilities in the Park include sanitary, water (including irrigation), gas and electrical utilities. Key utility alignments are illustrated in Figure 25. The City currently irrigates approximately 11 ha (61%) of the Park year-round, with coverage as indicated in Figure 26. The Park's underground irrigation system draws from the City's drinking water system, which was recently expanded to support on-going development in the region. The City irrigates the Park year-round and is operated by staff based on precipitation recorded at the Park (City of Parksville, n.d.). City staff estimate that the irrigation system applies over 38,000 m^3 of water annually at an equivalent cost of about $73,000 (2020 dollars) using By-law 1320 charge rate of $1.9096/$m^3$.

2.4.5 Potential Hot Spots

The City is not aware of any contaminated soils in the Park, however soils would need to be assessed prior to offsite disposal or onsite reuse.

Figure 25. Park Utilities

Figure 26. Irrigation Areas

3 Assessment of Existing Stormwater Management System

An integrated 1D-2D hydrologic and hydraulic model of the Park was developed and calibrated by EOR using PCSWMM to assess performance of the existing stormwater management system, identify deficiencies and consider the impact of external constraints, such as sea level. The model will continue to be used in the development of the SWMMP to conceptually size improvements to the stormwater system and test their resiliency to future climate and land use conditions. The existing conditions model development, calibration and results are detailed in a separate memorandum. This section summarizes key findings and discusses implications for design criteria.

3.1 Summary of Model Findings

Key findings from the existing conditions PCSWMM model results are summarized as follows:

- Critical design events (Figure 27 and Figure 28):
    - Minor System (10-year return period): 24-hour SCS Type 1A Pacific Coast
    - Major System (100-year return period): 24-hour SCS Type 1A Pacific Coast
- Existing conditions deficiencies:

Table 14. Deficiencies in Existing Stormwater Management System

Rainfall Event	% of CBs & MHs Flooded	% of Pipe Length with Limited Capacity	Total Area of Road Flooding
10-year 24-hour SCS Type 1A Pacific Coast	37.5	13.5	1843 m^2 > 0.06 m deep
100-year 24-hour SCS Type 1A Pacific Coast	45.8	28.2	1384 m^2 > 0.15 m deep

- Late summer short duration, high intensity events exceed the inlet and pipe capacity of the system.
- Observed surface flooding and water levels in storm sewer system on January 29, 2020 were used to validate the model. Infiltration facilities areas within the Park, shown in Figure 29, have many uncertainties associated with them including volume, depth, inlet capacity and infiltration rate. Estimates for these parameters were made for the infiltration sites in the model to best represent observed conditions on January 29, 2020.
- The infiltration capacity of some of the existing rock pits is insufficient to mitigate nuisance flooding of some roads and parking areas (e.g. Ravenhill Road). This may be due to poor construction, clogging with fines (lack of maintenance) or bioclogging, insufficient footprint area/storage, limited infiltration capacity of in-situ soils, and/or shallow groundwater. Additional construction information from the city would be needed to understand how these facilities function and whether they could be made to work better.
- The storm sewer system at the southwest end of Sandcastle Drive does not have positive drainage to the sea outfall due to a sag in the sewer system. An infiltration manhole located at the west corner of Sandcastle Drive and Salish Sea Drive retains all rainfall that cannot overtop the perched point in the system.

- Sediment clogging of the sea outfall appears to contribute to flood risk in the Park, however the frequency and mechanics of clearing the clogging is unknown. Due to insufficient information, the periods of flooding related to the sea outfall clogging were not included in the calibration.
- Calibration of the model to observed surface flooding and water levels in the storm sewer network indicate that flood risk is primarily caused by design, installation and operational deficiencies in underground infrastructure as well as grading for overland flow routing. In addition, the system draining to Parksville Bay has limited free outfall capacity due to astronomical tides (i.e. when sea level rises above the invert for a portion of each day).
- The above deficiencies are exacerbated by multi-day rainfall events since parts of the system cannot drain within 24 hours of an initial rainfall event.

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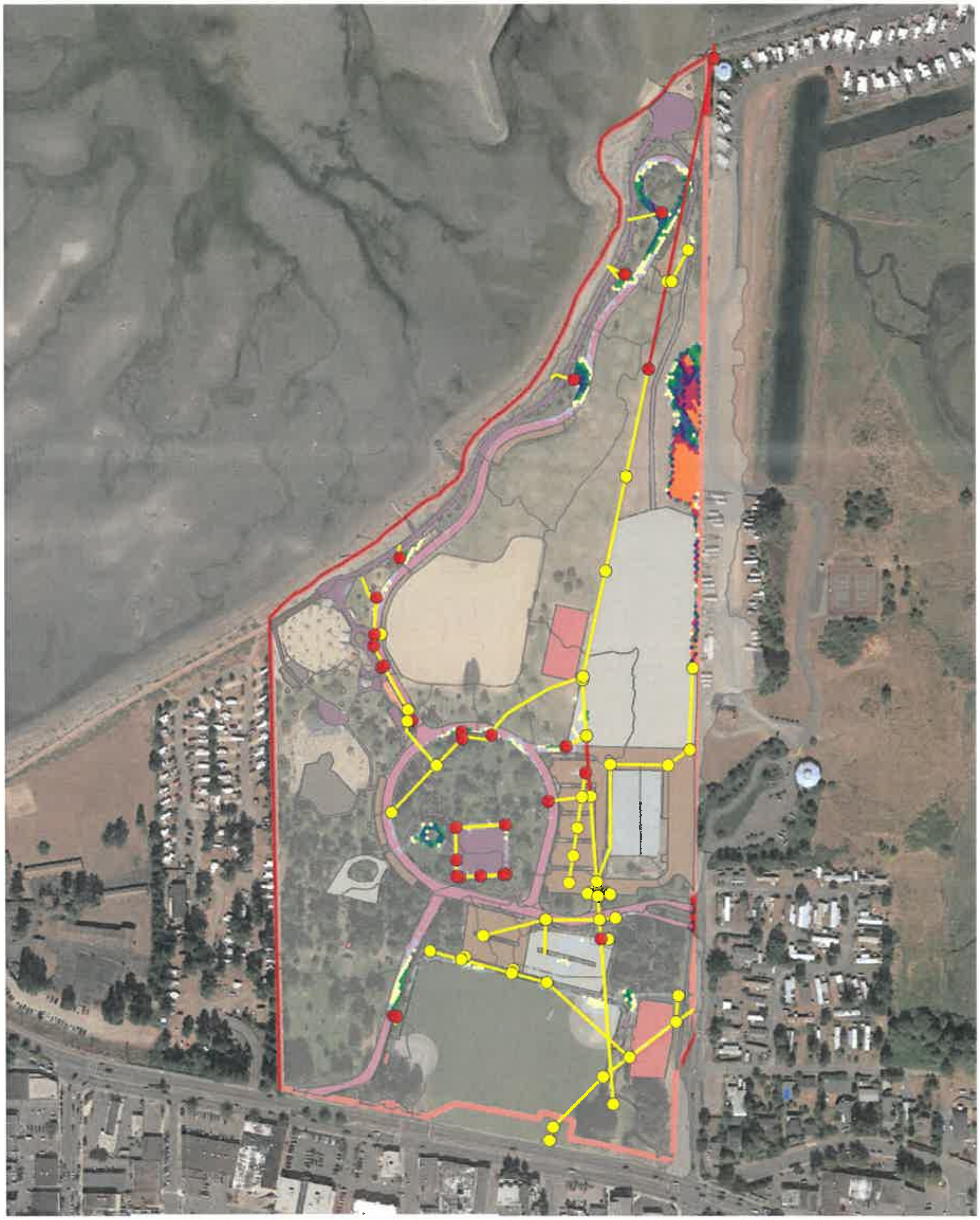

EOR
water
ecology
community

Parksville Community Park
Stormwater Mgmt Master Plan

Figure 27: Existing Conditions Model Results 10-yr 24 Hour SCS Type 1A Rainfall Event

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Surface Ponding Depth
- 1-15cm
- 15-20cm
- 20-25cm
- 25-30cm
- 30-40cm
- >40cm

Storm Sewer Pipes
- — Capacity Limited
- — Capacity Not Limited

Catchbasins/Manholes
- ● Flooded
- ● Not Flooded

Parksville Community Park
Stormwater Mgmt Master Plan

Figure 28: Existing Conditions Model Results 100-yr 24 Hour SCS Type 1A Rainfall Event

Figure 29. Infiltration Facilities and Areas in Park

3.2 Discussion

The existing conditions model results demonstrate multiple stormwater management deficiencies in the Park observed by EOR, City staff and park users. These deficiencies are in part due to the design and installation/retrofit of some components (e.g. the storm sewer sag northwest of the Arboretum, lack of emergency overflow routes for flood waters), which seem to be exacerbated by other factors such as groundwater levels limiting infiltration in some areas, sea level and debris limiting outlet capacity to Parksville Bay, and lack of pretreatment/maintenance increasing risk of infrastructure clogging with debris. The modeling process has also highlighted some unique opportunities at the Park, such as the existing dry basin northeast of the curling rink, which seems to be an underutilized component of the stormwater management system since it serves only a quarter of the Park's drainage area while being located near the system outlet. This section discusses some of these issues, uncertainties and opportunities for infrastructure improvements at a high level. Potential improvements are outlined in more detail in Section 5.

The capacity needed to store and convey flooding in the Park is primarily driven by rainfall and outlet capacity. Figure 30 illustrates an example of present-day astronomical tides at the Park based on a time series developed by NHC and late-century tides shifted to account for regional sea level rise by year 2100 (+0.79 m). The figure shows tides relative to the Park's existing storm sewer outfall and the proposed outfall which was recently installed, but not connected, as part of shoreline improvements. This data was used to assess the vulnerability of the system to changes in drain time (i.e. the time with free outfall, where the tides recede below the outfall elevation). The available average drain time in a given day decreases from approximately 12 to 9 hours from existing to future conditions. This average drain time was used in comparison to rainfall depths over 1-day and multi-day events based on existing and future IDF curves in Sections 2.1.1.3 and 2.1.1.6, respectively. Figure 31 illustrates that for every return period, the 1-day duration event is most critical in terms of both rainfall volume and the effective drain time[3]. Looking at only the 24-hour results in Figure 31 indicates that designing flood mitigation infrastructure for the present-day 100-year 24-hour event would not be able to manage the late-century 10-year 24-hour event. As such, it is recommended that the late-century 10-year 24-hour event and astronomical tides be used to size improvements to the Park that will mitigate pluvial flooding, in addition to providing conveyance capacity for short and high intensity events. Vulnerability of the system to more extreme conditions should be tested for the City to be aware of and identify the level of risk associated with extreme events through the following scenarios:

- Late-century 10-year rainfall during 10-year coastal inundation (which has a combined 100-year annual exceedance probability assuming the two are independent)

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[3] Effective drain time in Figure 31. System Drain time Relative to Rainfall Depth for 1-Day and Multi-Day Events includes the time with a free outfall during the rainfall event and the first 24 hours after the rainfall event. Drain time may be further constrained by sediment accumulation at the storm sewer outfall, but this is not considered in the drain time assessment.

- Drainage of late century 10-year and 100-year coastal inundation

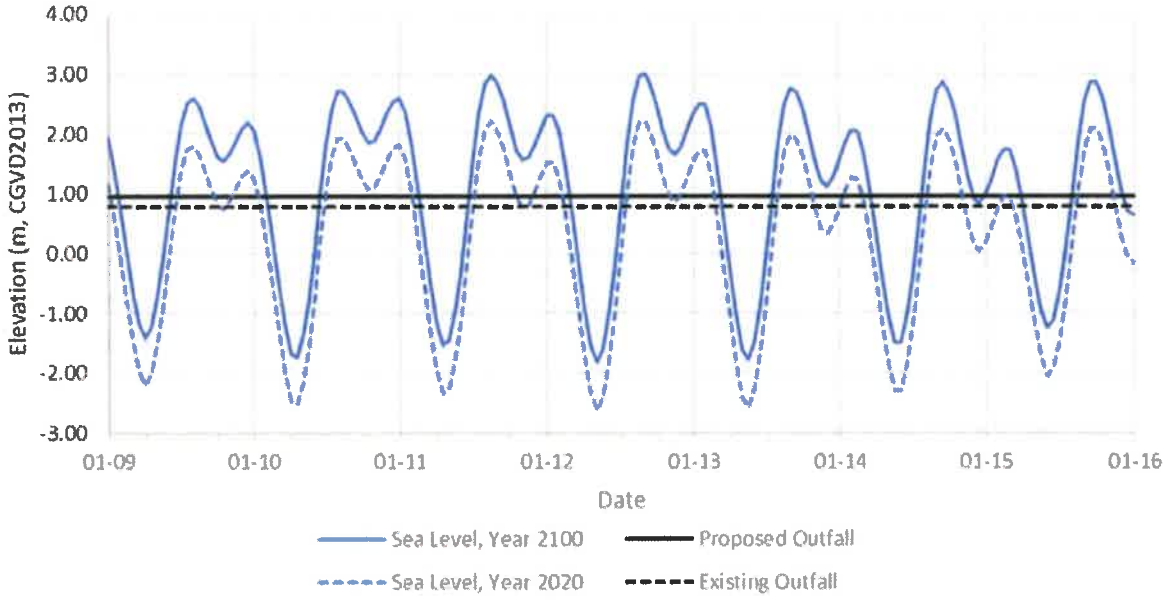


Figure 30. Existing and Future Sea Level Relative to Storm Sewer Outfall (Adapted from Northwest Hydraulics Consultants, 2020b)

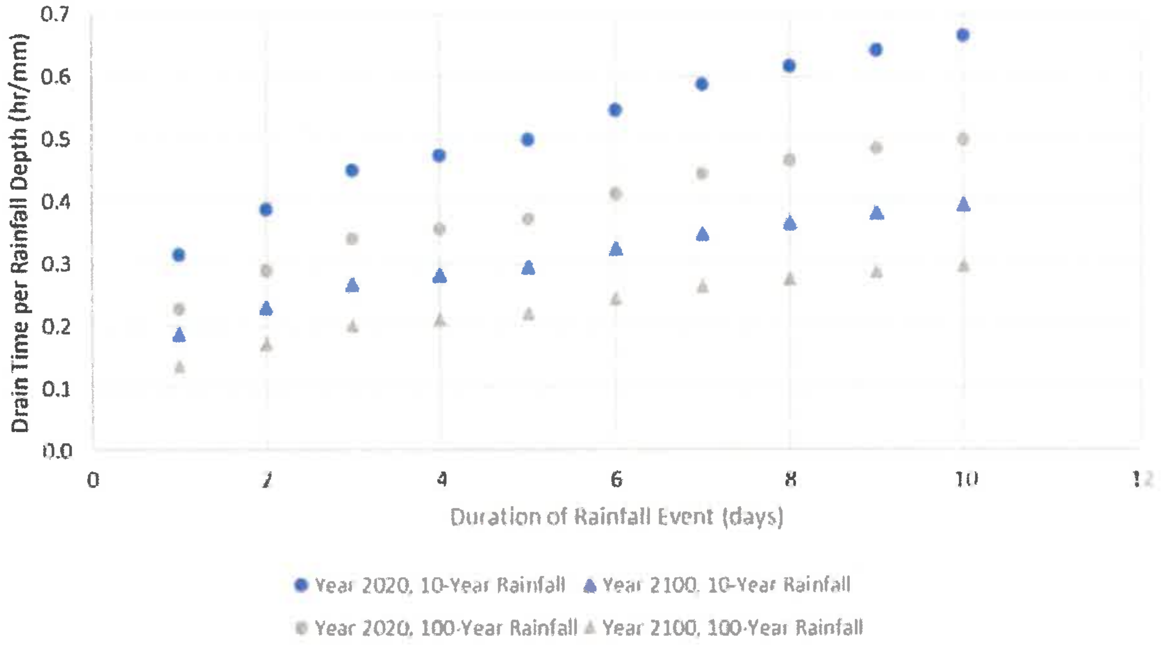


Figure 31. System Drain time Relative to Rainfall Depth for 1-Day and Multi-Day Events

Several uncertainties will also need to be considered in the SWMMP implementation recommendations. Operational uncertainties include the frequency and extent that the Parksville Bay outfall will be clogged. This can be accounted for in the proposed conditions modeling by limiting the outlet pipe diameter and can be mitigated in the design by improvements such as a self-clearing duck bill valve at the outfall. Another operational uncertainty is the potential for groundwater levels to rise with sea levels. This needs to be considered through a safety factor applied to design infiltration rates for facilities, as well as identifying areas that will be particularly vulnerable to groundwater flooding (e.g. dry basin). There are also planning uncertainties with respect to how stormwater upgrades may need to align with the City's sea level rise adaptation strategies around Parksville Bay and in the Englishman River Estuary. Potential infrastructure upgrades will be considered based on their resiliency to coastal inundation, such as resiliency to erosion and inundation with debris-laden saltwater.

City staff and EOR have identified potential stormwater infrastructure upgrades for further consideration in Section 5, including the following:

- divert southeast catchments towards sea outfall rather than continuing to discharge to the Estuary
- provide positive drainage from Sandcastle Drive to sea outfall
- divert existing storm sewer into dry basin to provide retention/detention and outlet the basin to the sea outfall stub
- establish an emergency overflow from dry basin to Estuary by overtopping the Surfside Resort access road
- harvest and reuse stormwater for irrigation, which would require consideration for isolating from saline water/intrusion to protect infrastructure and plants
- harvest and reuse rainwater from curling club roof
- connect Ravenhill Road depression to storm sewer network or enhance retention to mitigate road flooding

The potential stormwater management upgrades may also provide additional, ancillary benefits in addition to flood mitigation, such as the following:

- Reduce non-point source pollution of ecosystem in Estuary and shoreline of Parksville Bay
- Conserve drinking water resources
- Replenish groundwater with rain/stormwater, which may help offset saltwater intrusion
- Support healthy terrestrial ecosystems which will be threatened by future increased drought
- Reduce demand for irrigation using vegetation resilient to future climate conditions
- Protect and enhance shade for park users in hotter summers
- Extend the lifespan and reduce maintenance cost of park infrastructure, such as roads

4 Problem Statement and Goals

Parksville Community Park is a popular recreational hub located on the eastern shore of Parksville Bay and on the western border of the Englishman River Estuary. The Park is within the core asserted traditional territory of the Snaw-Naw-As, Qualicum and K'omoks First Nations. The Park was developed in the 1900's using fill to raise the elevations of the north and central areas of the Park that were originally part of Parksville Bay, a wider beach area, and potentially formed the natural western edge of the Englishman River Estuary. Today, the Park's stormwater system is intended to convey drainage away from frequently used park amenities. Continued development of the Park will increase impervious cover, runoff volumes and associated pollutants. Currently, runoff from approximately 35% of the Park is not treated to capture pollution before discharging into the Bay and Estuary while other areas are managed by isolated systems that retain the majority of rainfall events each year. Existing inland flooding issues will be exacerbated by climate change, including higher sea levels, more rainfall and potential additional impacts that have not yet been assessed, such as groundwater flooding. In addition, extreme sea levels are anticipated to inundate a substantial extent of the Park based on late-century climate change projections while higher "normal" tides will reduce discharge capacity. A significant archaeological site extends through the southern third of the Park, along the pre-developed shoreline, and provides an opportunity to educate the public of Indigenous presence in the past, present and future of the Park.

A SWMMP is required to increase resiliency of the stormwater system to extreme climate conditions, support continued use and development of the Park, and leverage opportunities for environmental and cultural sustainability. The plan will introduce stormwater management improvements to protect key park features from frequent/nuisance flooding while also providing room for flood water under extreme conditions. These improvements will demonstrate new local climate change adaptation approaches to the industry and public, while also mitigating the carbon footprint of public infrastructure. The City and First Nations will collaborate to preserve and improve the spiritual and archaeological significance of the Park while also stewarding park ecosystems for future generations.

Overall, the SWMMP outlines the strategies, capital improvements, and maintenance programs needed to improve the capacity of the current stormwater management system, support future development and protect the natural and cultural heritage features unique to the Park. The SWMMP will address the following goals to establish a sustainable and integrated stormwater management program:

Flood Mitigation & Resiliency: The Park's stormwater system effectively manages the quantity and delivery of runoff in a manner that protects the environment, infrastructure, and the health and safety of park users under existing and future climate conditions. The City sets clear expectations for park users for climate conditions that will exceed system capacity and require temporary closures.

Collaborate with First Nations: The City and First Nations are working collaboratively to maintain and improve the spiritual and archeological significance of the Park.

Ecosystem Health & Water Quality: The City and First Nations are working collaboratively as stewards of park ecosystems for future generations. The surface water, groundwater and natural resources in and downstream of the Park maintain their ecological integrity and provide their original level of function and value.

⚙ **Operations & Maintenance:** The Park's stormwater systems are maintained, managed and operated in a sustainable and cost-effective manner.

🔍 **Monitoring & Data Management:** The City monitors precipitation at the Park and aligns irrigation activities with actual precipitation events. The City expands monitoring programs to inform climate change adaptation measures.

$ **Funding & Organization:** The City has the resources and capacity needed to adequately implement an effective Stormwater Management Program in the Park.

& **Education & Outreach:** The City's residents and businesses have a good understanding of stormwater management, climate change adaptation and First Nation's heritage in the Park and are committed stewards of Parksville Bay and the Englishman River Estuary.

Developing objectives and action items that support attainment of each goal in the SWMMP Implementation Plan will chart a course of action for the City's stormwater management efforts in the Park over the next 20 years, aligned with the Community Park Master Plan 2017-2037, and help the City secure funding support, such as climate change adaptation grants. Longer term implementation will be refined through updates to the SWMMP that align with other planning exercises, such as a sea level rise adaptation plan for Bay and Estuary.

5 Stormwater Management Approach

5.1 Performance Objectives

The key objectives for performance of the Park's stormwater management system include the following:

1. Mitigate flood risk during extreme rainfall and coastal inundation events to acceptable levels of risk with measures such as allowing up to 0.15 m of flooding on roads and parking lots or temporarily closing areas where flood mitigation is cost prohibitive.
2. Mitigate non-point source pollution impacts to receiving waters and their ecosystems by capturing and treating the first flush event (31 mm 24-hour event).
3. Offset potable water demand to the extent feasible.
4. Be resilient to coastal inundation within the Park, such as excessive erosion from wave action, debris, and saltwater.
5. Prevent nuisance flooding during the late-century 10-year 24-hour rainfall event, considering the late-century astronomical tide as a potential constraint to sea outfall capacity.
6. Support future use and development of the Park and associated increases in imperviousness.
7. Support PCPSWMMP goals with public awareness and education initiatives, cost effective operation and maintenance plans, strengthened environmental stewardship and awareness by park users of the cultural importance of the First Nation archaeological site.

5.2 Sizing Criteria

- Water quality treatment provided for the first flush event (31 mm, 24-hour event) through infiltration facilities, raingardens, the dry basin or a water quality unit. Vegetated facilities must drain within 48 hours of the event to support vegetation and provide capacity for future events.
- Storage, infiltration and conveyance capacity in the system provided to prevent surface flooding greater than 6cm deep during the 10-year 24-hour late century rainfall event. Existing infiltration facilities must be rehabilitated to meet this design criteria. Discharge to the sea outfall must consider limited outlet capacity due to late-century astronomical tides and potential clogging from sediment.
- Assess vulnerability of the system and provide temporary ponding / emergency procedures for extreme rainfall and coastal inundation conditions, including:
  - *Drainage of late century 100-year 24-hour rainfall event*
  - *Drainage of late century 10-year and 100-year coastal inundation across the Park*

5.3 Treatment Train Approach

The treatment train approach to stormwater management is recommended for future upgrades. The approach uses multiple practices to manage the quantity and quality of stormwater runoff as it travels across the landscape from its point of origin to the downstream waterbody. A simple schematic of a treatment train is provided in Figure 32. Treatment trains often include pollution prevention, which are described in the next section. Practices are selected to minimize the amount of stormwater runoff generated on site and maximize control of pollutants while complying with constraints such as limited space, physical conditions and regulatory requirements. Source, conveyance, and site controls include Better Site Design (BSD) techniques, Low Impact Development (LID) and Green Infrastructure (GI) strategies that work with nature to manage stormwater as close to its source as possible (see Figure 38). In general, these practices are favoured over end-of-pipe facilities because they reduce stormwater volumes and pollutant loading, which often results in lower stormwater management costs (less hard infrastructure, smaller end of pipe practices, less expensive operation and maintenance). They mimic natural processes to infiltrate, filter, evaporate, and transpire stormwater. Where source, conveyance, and site controls are insufficient or infeasible, traditional conveyance (e.g. storm sewers, ditches, culverts) and end-of-pipe facilities (e.g. ponds) can be used as part of the treatment train approach. End-of pipe facilities focus on centralized detention of stormwater, which involves storing and then slowly releasing stormwater while settling suspended sediment and associated pollutants to the bottom of facilities. Detention is one approach to mitigating flood risk and improving resiliency to large rain events. Examples of conventional stormwater management facilities include wet ponds, dry ponds, constructed wetlands, detention chambers, and hydrodynamic separators (e.g. oil-grit separators). Additional processes can be included in end-of-pipe facilities to enhance their benefits, such as percolation trenches or rock pits to cool discharge from the ponds.

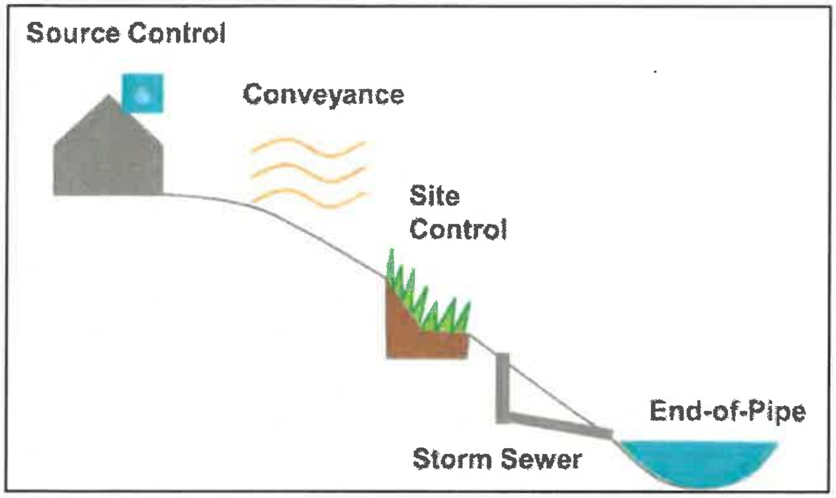


Figure 32. Treatment Train Components

The treatment train approach is consistent with current best practices in stormwater management to deliver cost-effective improvements that offer multiple benefits to the community. The increased use of Green Infrastructure to address issues related to water quality and flooding can also serve to increase community resilience to climate change and improve quality of life by providing other benefits such as increased tree canopy, reducing urban heat island effect, improving air quality and increasing wildlife habitat.

5.4 Feasibility Screening of Treatment Train Components

The stormwater management plan for Parksville incorporates numerous end-of-pipe practices such as wet and dry detention ponds, below ground chambers, rooftop storage, oil/water separators and a catchbasin flow restrictor. To supplement this existing network of practices, the city should consider using Green Infrastructure to provide the source control, conveyance and site control prior to relying on the end-of-pipe facilities. These best management practices (BMPs) should be used to retrofit the system and cost-effectively manage runoff volumes, as illustrated in Figure 33. The benefits, suitability and constraints of these practices are outlined in Table 15 to Table 17. Within the Community Park, the main constraint to consider in terms of runoff volume control is the potential risk of shallow groundwater limiting infiltration capacity at several locations. In addition, there is one location east of the lacrosse court where infiltration will be limited by organic silt soils. Table 18 summarizes feasibility-level screening of runoff volume control practices based on typical considerations within the Park.

Figure 33. Runoff Volume Control Practices

Table 15. Benefits of Runoff Volume Control Practices

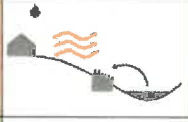
	Runoff Volume Reduction BMP	Location in the Landscape	Hydrologic Benefits			Surface Water Pollutant Removal					Ancillary Benefits				
			Infiltration	Evapo-transpiration	Runoff Volume Reduction	TP*	TN*	TSS	Metals*	Thermal**	Improve Air Quality	Reduce Urban Heat Island	Reduce Energy	Reduce CO2	Create Habitat
SOURCE CONTROL	Impervious Cover Reduction		⬤	⬤	40%	30-55%	64%			•	✓	✓			
	Soil Amendments/ Decompaction		⬤	⬤	75-90%	50-75%	50-75%		25-90%	⬤					
	Native Ground Cover		⬤	⬤	40%				25-90%	•	✓	✓		✓	✓
	Impervious Disconnection		⬤	⬤	25-50%	25-50%	25-50%			•					
	Urban Tree Canopy		⬤	⬤						⬤	✓	✓	✓	✓	✓
	Permeable Pavement		⬤		45-85%	40-55%	50-55%	60-80%	<0-90%	●					
	Green Roof			⬤	45-90%	highly variable	20-90%	70-90%	80%	●	✓	✓	✓	✓	✓
	Blue Roof			⬤	45-90%	highly variable	20-90%	70-90%	80%	●			✓		
ROUTING	Level Spreaders		•	•	50-75%	50-75%	50-75%			●					
	Filter Strips		•	•	25-75%	<0-45%	<0-15%	80-85%	<0-80%	●				✓	✓
	Dry Swales & Enhanced Grass Swales		•	•	10-60%	<0-10%	<0-10%	0-30%	<0-70%	•	✓	✓		✓	✓
SURFACE TREATMENT	Bioretention (without underdrain)		⬤	⬤	65-85%	<0-30%	<0-30%	70-90%	<0-90%	⬤	✓	✓		✓	✓
	Biofiltration (with underdrain)			⬤	40-45%	<0-30%	<0-30%	70-85%	<0-90%	•	✓	✓		✓	✓
	Tree Trenches / Soil Cells		⬤	⬤	50-90%	44%	50%	85%	35%	⬤	✓	✓	✓	✓	✓
	Infiltration Basins		⬤	⬤	50-90%	15-90%	60-90%			⬤				✓	✓
SUBSURFACE TREATMENT	Infiltration Trenches		⬤	⬤	50-90%	15-90%	60-90%			⬤					
	Below-ground Recharge Systems		⬤		85%	50-80%	40-70%	70-90%	70-90%	⬤					
REUSE	Rainwater Harvesting			•	40%	40%	40%			•			✓		
	Stormwater Harvesting		•	⬤	20-75%	45-95%		65-80%		●			✓		
	NOTES	LEGEND ⬤ High ● Med • Low	Reduction ranges represent variations in design and site conditions across multiple studies. As a result, comparisons between BMPs across different studies may not reflect true performance. Please refer to the individual references reported for more information on how the volume and pollutant reductions were calculated. Utilizing good design practices will generally achieve removals toward the top end of the range. *Effluent concentrations can be greater than influent, depending on facility soils and design. **Relative effectiveness estimated based on average runoff volume reduction as a surrogate for thermal load reduction. Reductions are also dependent on thermal load from catchment.								Extent of benefits depend on a variety of factors including size of BMP, pre-development condition, construction and maintenance methods, etc.				
	SOURCE:		WERF 2016; WERF 2014; Dane County; USEPA 2017; EOR; UNH 2012												

Table 16. Development Suitability and Simplicity of Runoff Volume Control Practices

		New/ReDevelopment			Land Use Setting												Simplicity of Implementation				
	Runoff Volume Reduction BMP	New Development	Retrofit	Redevelopment	Ultra Urban	Wide Urban Road ROW	Narrow Urban Road ROW	Rural Road ROW	Urban Park/Plaza	Open Space/Park	Commercial	Institutional	Industrial	Residential - Single Family	Residential - Multi-Family	Rural	Design	Construction	Inspection	City Process	Maintenance
SOURCE CONTROL	Impervious Cover Reduction	⬤	⬤	⬤	⬤	•	•	●	●	•	⬤	⬤	●	⬤	●	⬤	⬤	⬤	⬤	⬤	⬤
	Soil Amendments/ Decompaction	⬤	⬤	⬤	•	•	•	•	●	⬤	⬤	⬤	●	⬤	⬤	⬤	⬤	●	•	⬤	⬤
	Native Ground Cover	⬤	⬤	⬤	●	•	•	•	●	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	●
	Impervious Disconnection	⬤	⬤	⬤	•	•	•	⬤	⬤	•	•	•	•	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤
	Urban Tree Canopy	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	⬤	●	●	●
	Permeable Pavement	⬤	⬤	⬤	⬤	•	⬤	•	⬤	•	⬤	⬤	⬤	⬤	⬤	⬤	•	•	●	•	•
	Green Roof	⬤	●	⬤	⬤	N/A	N/A	N/A	●	•	⬤	⬤	⬤	⬤	⬤	⬤	•	•	•	•	●
	Blue Roof	⬤	●	⬤	⬤	N/A	N/A	N/A	●	•	⬤	⬤	⬤	⬤	⬤	⬤	•	•	•	•	●
ROUTING	Level Spreaders	⬤	⬤	⬤	•	•	•	•	●	⬤	⬤	⬤	⬤	⬤	⬤	•	●	•	●	●	●
	Filter Strips	⬤	⬤	⬤	⬤	•	•	⬤	●	⬤	⬤	⬤	●	⬤	⬤	⬤	•	⬤	●	●	⬤
	Dry Swales & Enhanced Grass Swales	⬤	●	⬤	●	•	•	⬤	●	⬤	⬤	⬤	⬤	⬤	⬤	⬤	●	•	•	•	●
SURFACE TREATMENT	Bioretention (without underdrain)	⬤	⬤	⬤	⬤	●	●	⬤	●	⬤	⬤	⬤	⬤	⬤	⬤	⬤	•	•	•	●	●
	Biofiltration (with underdrain)	⬤	⬤	⬤	⬤	⬤	⬤	⬤	●	⬤	⬤	⬤	⬤	⬤	⬤	⬤	•	•	•	●	●
	Tree Trenches / Soil Cells	⬤	⬤	⬤	⬤	⬤	⬤	●	⬤	•	⬤	⬤	⬤	•	⬤	•	•	●	●	•	●
	Infiltration Basins	⬤	●	⬤	●	•	•	⬤	•	⬤	⬤	⬤	⬤	⬤	⬤	⬤	•	●	•	●	●
SUBSURFACE TREATMENT	Infiltration Trenches	⬤	●	⬤	●	⬤	⬤	⬤	⬤	●	⬤	⬤	⬤	•	⬤	⬤	•	•	•	•	●
	Below-ground Recharge Systems	⬤	⬤	⬤	●	⬤	⬤	⬤	⬤	●	⬤	⬤	⬤	•	⬤	•	•	•	●	•	●
REUSE	Rainwater Harvesting	⬤	⬤	⬤	⬤	•	•	•	●	•	⬤	⬤	⬤	⬤	⬤	⬤	•	●	●	●	●
	Stormwater Harvesting	⬤	⬤	⬤	⬤	⬤	⬤	⬤	●	⬤	⬤	⬤	⬤	⬤	⬤	⬤	•	●	●	●	●
	NOTES		LEGEND ⬤ High ● Med • Low																		
	SOURCE:	DEQ 2016			DEQ 2016												COE 2016, TRCA 2016				

Table 17. Design Criteria and Considerations for Runoff Volume Control Practices

		Design Criteria					Design Considerations				Maintenance		Cost	
	Runoff Volume Reduction BMP	Suitability by Soil Type	Slope	Suitability for Contaminated Site	Drainage Area to Footprint Ratio	Seasonal High Groundwater Separation	Pre-Treatment	Setback	Cold Climate	Potential for Urban Aesthetic	Lifespan (yrs)	Level of Effort	Capital Cost ($/ha catchment)	Lifecycle Cost ($/ha catchment)
SOURCE CONTROL	Impervious Cover Reduction	⬤	<15%	●						N/A	30+	•	$$	$
	Soil Amendments/ Decompaction	⬤	<15%	●						N/A	30+	•	$	$
	Native Ground Cover	⬤	1-5%	●						N/A	30+	•	$	$
	Impervious Disconnection	⬤	1-5%	●		0.6 m				▮	30+	•	$$	$
	Urban Tree Canopy	⬤		⬤				Foundation		🏢	30+	●	$$	$$
	Permeable Pavement	⬤	1-5%	●	Area 1.2:1	1 m		Foundation		🏢	15-25	⬤	$$$	$$
	Green Roof	⬤	0-10% (>5% req. design mod.)	⬤	Area 1:1 (Direct Rainfall Only)					🏢	asphalt life + 20	●	$$$	$$
	Blue Roof	⬤	0-10% (>5% req. design mod.)	⬤	Area 1:1 (Direct Rainfall Only)					🏢	asphalt life + 20	●	$$$	$$
ROUTING	Level Spreaders	⬤	<15%	●						N/A	10-20	•	$$	$$$
	Filter Strips	⬤	1-5%	⬤	<25 m Length <3% slope	0.6 m				N/A	30+	•	$$	$$$
	Dry Swales & Enhanced Grass Swales	●	0.5-3%*	●	Length 5-15:1 (<0.8 ha)	1 m	⬤	Foundation		N/A	30+	⬤	$$	$$$
SURFACE TREATMENT	Bioretention (without underdrain)	●	1-5%	•	Area 5-15:1 (0.2-0.8 ha)	1.5 m	⬤	Foundation	❄	▮	25	●	$	$$
	Biofiltration (with underdrain)	⬤	0.5-2%	⬤	Area 5-15:1 (0.2-0.8 ha)	1 m	⬤	Foundation	❄	▮	25	⬤	$	$$
	Tree Trenches / Soil Cells	⬤	0.5-2%	⬤	Area 5-15:1 (0.2-0.8 ha)	1 m *	⬤	Utilities, Foundation	❄	🏢	30+	⬤	$$	$$$
	Infiltration Basins	●	<15%	•	Area 5-30:1 (10 for Roads)	1.5 m	⬤	Foundation	❄	N/A	20-30	●	$	$$
SUBSURFACE TREATMENT	Infiltration Trenches	●	<15%	•	Area 5-30:1 (10 for Roads)	1.5 m	⬤	Foundation	❄	🏢	20-30	⬤	$	$$
	Below-ground Recharge Systems	●	<15%	•	Area 5-30:1 (10 for Roads) Width > Depth	1.5 m	⬤	Foundation	❄	🏢	20-30	⬤	$$	$$$
REUSE	Rainwater Harvesting	⬤	<15%	⬤			⬤		❅	🏢	30+	⬤	$	$$
	Stormwater Harvesting	⬤	<15%	⬤			⬤		❅	🏢	30+	⬤	$	$$
	NOTES	All: ⬤ A or B Only: ●	*slopes greater than 1% require check dams or grade control			* design mod. required when <1 m	Required: ⬤		design mod. required ❄ reduced performance ❅	high potential: 🏢 low potential: ▮			LEGEND $$$ $$ $	 High Med Low
	SOURCE:	DEQ 2016	CVC/TRCA 2010	DEQ 2016	CVC/TRCA 2010		CVC/TRCA 2010; DEQ 2016				CRWA, EOR COE 2016		EOR, CHI & Autocase, 2017	

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Table 18. Runoff Volume Control Practice Feasibility at Community Park

Shallow Groundwater

	Runoff Volume Reduction BMP	Land Use Compatibility	Design Criteria soils	slope	contaminated sites	Drainage Area to Footprint Ratio	Groundwater Table Separation	Constraints from Design Considerations	Preferred Feasible BMPs
	SITE CONDITIONS	Open Space/Park	A/B	2%	None	Varies	<1.5m	Setback minimal from adjacent buildings	
SOURCE CONTROL	Impervious Cover Reduction	•							•
	Soil Amendments/ Decompaction	⬤							⬤
	Native Ground Cover	⬤							⬤
	Impervious Disconnection	•							⬤
	Urban Tree Canopy	⬤							⬤
	Permeable Pavement	•					*		*
	Green Roof	•							•
	Blue Roof	•							•
ROUTING	Level Spreaders	⬤							⬤
	Filter Strips	⬤					*		*
	Dry Swales & Enhanced Grass Swales	⬤					*		*
SURFACE TREATMENT	Bioretention (without underdrain)	⬤					*		*
	Biofiltration (with underdrain)	⬤					N/A		N/A
	Tree Trenches / Soil Cells	•					*		*
	Infiltration Basins	⬤					*		*
SUBSURFACE TREATMENT	Infiltration Trenches	●					*		*
	Below-ground Recharge Systems	●					*		*
REUSE	Rainwater Harvesting	•							•
	Stormwater Harvesting	⬤							⬤

Deep Groundwater

	Runoff Volume Reduction BMP	Land Use Compatibility	Design Criteria soils	slope	contaminated sites	Drainage Area to Footprint Ratio	Groundwater Table Separation	Constraints from Design Considerations	Preferred Feasible BMPs
	SITE CONDITIONS	Open Space/Park	A/B	2%	None	Varies	>=1.5m	Setback minimal from adjacent buildings	
SOURCE CONTROL	Impervious Cover Reduction	•							•
	Soil Amendments/ Decompaction	⬤							⬤
	Native Ground Cover	⬤							⬤
	Impervious Disconnection	•							•
	Urban Tree Canopy	⬤							⬤
	Permeable Pavement	•							•
	Green Roof	•							•
	Blue Roof	•							•
ROUTING	Level Spreaders	⬤							⬤
	Filter Strips	⬤							⬤
	Dry Swales & Enhanced Grass Swales	⬤							⬤
SURFACE TREATMENT	Bioretention (without underdrain)	⬤							⬤
	Biofiltration (with underdrain)	⬤							⬤
	Tree Trenches / Soil Cells	•							•
	Infiltration Basins	⬤							⬤
SUBSURFACE TREATMENT	Infiltration Trenches	●							●
	Below-ground Recharge Systems	●							●
REUSE	Rainwater Harvesting	•							•
	Stormwater Harvesting	⬤							⬤

Organic Silt Soils

	Runoff Volume Reduction BMP	Land Use Compatibility	Design Criteria soils	slope	contaminated sites	Drainage Area to Footprint Ratio	Groundwater Table Separation	Constraints from Design Considerations	Preferred Feasible BMPs
	SITE CONDITIONS	Open Space/Park	D	2%	None	Varies	>=1.5m	Setback minimal from adjacent buildings	
SOURCE CONTROL	Impervious Cover Reduction	•							•
	Soil Amendments/ Decompaction	⬤							⬤
	Native Ground Cover	⬤							⬤
	Impervious Disconnection	•							•
	Urban Tree Canopy	⬤							⬤
	Permeable Pavement	•							•
	Green Roof	•							•
	Blue Roof	•							•
ROUTING	Level Spreaders	⬤							⬤
	Filter Strips	⬤							⬤
	Dry Swales & Enhanced Grass Swales	⬤	N/A						
SURFACE TREATMENT	Bioretention (without underdrain)	⬤	N/A						
	Biofiltration (with underdrain)	⬤							⬤
	Tree Trenches / Soil Cells	•							•
	Infiltration Basins	⬤	N/A						
SUBSURFACE TREATMENT	Infiltration Trenches	●	N/A						
	Below-ground Recharge Systems	●	N/A						
REUSE	Rainwater Harvesting	•							•
	Stormwater Harvesting	⬤							⬤

N/A = BMP not compatible with site

* = BMP requires design modifications

COMPATIBILITY	
⬤	High
●	Med
•	Low

5.5 Alternatives for Key Areas

There are multiple alternatives for addressing objectives within key areas of the Park, as outlined below. Within each alternative are possible design options, which are referenced in the notes.

5.5.1 Southwest Ravenhill Road Catchment

Summary of existing conditions and future considerations:

- Sag in Ravenhill Road frequently floods
- Drains to an underground rock pit that may be undersized, clogged or within 1 m of seasonal high groundwater table
- Limited emergency overflow pathway based on topography
- An amphitheatre is planned in the southwest corner of the Park

Objectives:

- No surface flooding in road during future 10-year, 24-hour rainfall event
- Mitigate flooding during extreme events to acceptable levels of risk
- Minimize risk of stormwater practice failure due to clogging and high groundwater

Alternatives:

A. Do nothing

B. Abandon Ravenhill Road – *Note: This is not feasible because the City plans to maintain this road.*

C. Connect to trunk storm sewer – *Note: This conflicts with archaeological site.*

D. Connect to draintile system under baseball diamonds – *Note: Unclear if this would meet design objectives based on uncertain capacity and configuration of draintile system. The City may not be comfortable directing drainage into draintile system due to possible impacts to turf grass.*

E. Increase capacity of underground storage with infiltration – *Note: The design alternatives include but are not limited to a larger rock pit and under-the-road storage. The extent of the archaeological site under the road is not understood and so there is a risk of encountering archaeological material. There is also a risk of groundwater elevations limiting infiltration potential from a subsurface storage facility.*

F. Increase capacity of underground storage with reuse for irrigation – *Note: This could include under-the-road storage, however the extent of the archaeological site under the road is not understood. Connecting to existing irrigation system may conflict with archaeological site. In order to avoid provincial reclaimed water treatment requirements, underground trickle irrigation is required (See Appendix G).*

G. Install curb cut on west side of road sag to divert surface flooding in road to forested area west of the road – *Note: Uncertain if this would conflict with archaeological site, however this seems the least intrusive of the alternatives in terms of ground disturbance. Possible impacts to surface flooding in forested area would need to be mitigated, potentially with a level spreader or other design elements. This option provides an added benefit of reducing irrigation demand in wooded area west of Ravenhill Road.*

Additional considerations:

- Timing and design of flood mitigation measures could be coordinated with the amphitheatre to provide cost-efficiencies of any of the above alternatives.

5.5.2 Southeast Catchment to Estuary Outfall

Summary of existing conditions and future considerations:

- The catchment ultimately drains to an outfall to the Englishman River Estuary
- Water quality in the Estuary is degraded from non-point source pollution and runoff from the catchment does not receive water quality treatment
- The storm sewer between the Park and outfall crosses private property, raising concerns related to the City's liability and inability to access the pipe for maintenance
- Shallow flooding occurs in northeast baseball diamond
- Poor infiltration potential east of lacrosse court based on organic silt identified in geotechnical analysis
- Existing conditions model calibration indicates that there may be moderate infiltration potential in the wooded area north of the lacrosse courts
- The baseball diamonds are drained by a draintile system

Objectives:

- Mitigate non-point source pollution to the Estuary
- No surface flooding during future 10-year, 24-hour rainfall event
- Mitigate flooding during extreme events to acceptable levels of risk
- Minimize risk of stormwater practice failure due to clogging or high groundwater

Alternatives:

A. Do nothing
B. Divert to trunk storm sewer – *Note: This conflicts with archaeological site. It would not be feasible to provide positive slope towards the trunk sewer based on existing elevations of the two systems because the existing trunk is elevated above the estuary system.*
C. Divert to dry pond via new storm sewer and retrofit to ditch northeast of curling rink – *Note: This would require a significant length of new storm sewer and possible modifications to the existing system, but could be coordinated with the extension of Sandcastle Drive.*
D. Capture and treat runoff and draintile in local BMPs & maintain estuary outfall – *Note: Opportunities for BMPs will be limited by archaeological site and park amenities (e.g. baseball diamond and lacrosse court). A closed-loop harvest & reuse system sized for the majority of rainfall events (e.g. first flush event) may be an effective design alternative (see Appendix G). City input is needed regarding maintaining estuary outfall for events exceeding the first flush event.*
E. Capture and treat runoff and draintile in local BMPs & provide emergency overflow to dry basin – *Note: emergency overflow cannot be an overland flow pathway without significant*

reconstruction to provide positive grade along Corfield Drive to the dry basin. Another design option would be to temporarily store runoff and pump it to the dry basin via a forcemain installed with the future extension of Sandcastle Road. See notes in Alternative D regarding local BMPs.

F. Capture and treat runoff and draintile in local BMPs & establish an isolated system (i.e. no outfall) to manage future extreme events – *Note: This would require more storage capacity than other alternatives in order to achieve the same level of service regarding flood risk. A design alternative to provide additional storage but avoid conflicts within the Park would be under-the-road storage below Corfield Drive. Infiltration potential and risk of encountering archaeological material along the road is unknown and would require further consideration. City input is required regarding potential to combine an improvement like this with upgrades to Corfield Drive.*

Additional considerations:

- Timing and design of flood mitigation measures could be coordinated with planned paving of east gravel parking lot, north of ball diamonds, or removal of Kin Hut and site reclamation.

5.5.3 Southwest Sandcastle Drive Catchment

Summary of existing conditions and future considerations:

- The catchment ultimately drains to the sea outfall but a sag in the storm sewer prevents small rainfall events from draining to the trunk sewer and outfall
- Isolated events are retained by an infiltration manhole
- This area is vulnerable to minor ponding from waves breaking along the shoreline and very vulnerable to late-century coastal inundation / associated impacts as it is located at the low point in the Park's shoreline pathway
- The design and storage capacity of the infiltration manhole is unknown, but the system was not intended to drain inland flooding from coastal inundation
- A small area of roadside parking consists of permeable pavers installed in 2015
- A small increase in impervious cover is anticipated in this catchment based on future trail and amenity improvements

Objectives:

- Mitigate non-point source pollution to Parksville Bay
- No surface flooding during future 10-year, 24-hour rainfall event
- Mitigate flooding during extreme events to acceptable levels of risk
- Avoid maintenance issues at infiltration manhole due to clogging

Alternatives:

A. Do nothing
B. Retrofit storm sewer connection from Sandcastle Drive to trunk sewer – *Note: Design alternatives include providing positive drainage for all events or retrofitting connection such that some rainfall events are still retained. The latter would be best configured as a bypass pipe so that large events bypass the infiltration manhole, reducing risk of clogging.*
C. Retrofit the infiltration manhole to mitigate risk of clogging
D. Increase capacity of underground storage with infiltration – *Note: This could include under-the-road storage or adjacent BMPs such as tree trenches. There is a risk of groundwater elevations limiting infiltration potential from a subsurface storage facility.*
E. Increase capacity of underground storage with reuse for irrigation – *Note: Draining the storage for reuse may mitigate risk of shallow groundwater impacting the effectiveness of the facility. In order to avoid provincial reclaimed water treatment requirements, underground trickle irrigation is required (See Appendix G).*
F. Divert impervious runoff to permeable surfaces – *Note: This is a viable option with existing topography for non-road impervious surfaces (e.g. trails, rooftops, plazas). However, there is limited technical feasibility to divert road runoff to permeable surfaces with existing topography because the road is lower than the adjacent permeable surfaces. City input is needed regarding the potential plans to raise Sandcastle Drive as part of planned improvements and considering future risk of inundation due to sea level rise. Design alternatives would also need to consider potential changes to adjacent permeable surfaces, such as establishing grassed swales or underground tree trenches between the road and volleyball area.*

Additional considerations:

- Timing and design of flood mitigation measures could be coordinated with development and construction of the Central Gather Place.

5.5.4 Central and Northeast Sandcastle Drive Catchments

Summary of existing conditions and future considerations:

- The catchments drain to underground rock pits
- One of the existing rock pits is undersized or clogged, causing runoff to frequently pond above the catchbasin inlet located in parking bay southwest of the Arbutus Point cul-de-sac.
- This area will be vulnerable to late-century coastal inundation and associated impacts

Objectives:

- Mitigate non-point source pollution to Parksville Bay
- No surface flooding during future 10-year, 24-hour rainfall event
- Mitigate flooding during extreme events to acceptable levels of risk

Alternatives:

A. Do nothing
B. Retrofit deficient rock pits
C. Retrofit all rock pits to mitigate risk of clogging
D. Increase capacity of underground **storage with infiltration** – *Note: This could include under-the-road storage or adjacent BMPs such as tree trenches. There is a risk of groundwater elevations limiting infiltration potential from a subsurface storage facility, however the model calibration indicates that some of the rock pits servicing this catchment are functioning well.*
E. Increase capacity of underground **storage with reuse for irrigation** – *Note: Draining the storage for reuse may mitigate risk of shallow groundwater impacting the effectiveness of the facility. In order to avoid provincial reclaimed water treatment requirements, underground trickle irrigation is required (See Appendix G).*
F. **Divert impervious runoff to permeable surfaces** – *Note: This is a viable option with existing topography for non-road impervious surfaces (e.g. trails). However, there is limited technical feasibility to divert road and parking bay runoff to permeable surfaces with existing topography because the road is lower than the adjacent permeable surfaces. City input is needed regarding the potential plans to raise Sandcastle Drive as part of planned improvements and considering future risk of inundation due to sea level rise. Design alternatives would also need to consider potential changes to adjacent permeable surfaces, such as establishing grassed swales or underground tree trenches between the road and volleyball area.*

5.5.5 Tennis Court Catchment

Summary of existing conditions & future considerations:

- The tennis courts drain to an underground rock pit that may be undersized or clogged
- Runoff frequently ponds above drain inlets located around the tennis courts
- This area will be vulnerable to late-century coastal inundation / associated impacts

Objectives:

- No surface flooding during future 10-year, 24-hour rainfall event
- Mitigate flooding during extreme events to acceptable levels of risk

Alternatives:

A. Do nothing
B. Increase capacity of underground **storage with infiltration** – *Note: This could include re-building the rock pits according to engineering specifications. There is a risk of groundwater elevations limiting infiltration potential from a subsurface storage facility in the future, however the geotechnical investigation did not encounter groundwater in this area or indications of a seasonal high groundwater table.*
C. Increase capacity of underground **storage with reuse for irrigation of Arboretum** – *Note: Draining the storage for reuse may mitigate risk of shallow groundwater impacting the*

effectiveness of the facility. In order to avoid provincial reclaimed water treatment requirements, underground trickle irrigation required (Appendix G).

D. Divert impervious runoff to **permeable surfaces** – *Note: use positive drainage to provide flood irrigation to Arboretum during rain events. This may require additional education and management of park user expectations regarding temporary ponding in grass areas of Arboretum during and shortly following rain events.*

5.5.6 Volleyball Court Catchment

Summary of existing conditions and future considerations:

- Ponding within volleyball courts occurs during large rain events
- Drain pipes direct water west, through the berm, to catchbasins along Sandcastle Drive
- This area will be vulnerable to late-century coastal inundation / associated impacts

Objectives:

- Mitigate non-point source pollution to Parksville Bay
- No surface flooding during future 10-year, 24-hour rainfall event
- Mitigate flooding during extreme events to acceptable levels of risk

Alternatives:

A. Do nothing

B. Regrade volleyball courts to provide positive drainage toward dry pond

C. Increase capacity of **underground storage with infiltration** – *Note: This could include underground storage installed beneath the volleyball courts or directed to adjacent BMPs such as tree trenches along Sandcastle Drive. There is a risk of groundwater elevations limiting infiltration potential from a subsurface storage facility based on indications of shallow groundwater identified in the Archaeological Assessment study.*

D. **Increase capacity of underground storage with reuse for irrigation** – *Note: Draining storage beneath the volleyball courts for reuse may mitigate risk of shallow groundwater impacting the effectiveness of the facility. In order to avoid provincial reclaimed water treatment requirements, underground trickle is irrigation required (see Appendix G).*

5.5.7 Dry Basin Catchment & Overall System

Summary of existing conditions and future considerations:

- Surface ponding occurs in parking lot southwest of Arbutus Point, and the gravel pedestrian pathway at the north end of this key area. The City has recently installed an area drain connection to the main storm sewer trunk to mitigate this issue.
- Curling Club rooftop runoff directs water through a ditch to dry basin
- Available volume underutilized due to site grading
- Dry pond currently empties through infiltration and evapotranspiration
- Adjacent RV Park drains to dry pond
- Adjacent gravel path is planned to be converted to formal roadway connecting Sandcastle Drive to Corfield Street North
- This area will be vulnerable to late-century coastal inundation / associated impacts

Objectives:

- Mitigate non-point source pollution to Parksville Bay
- Fully utilize existing volume in dry pond
- Provide end of pipe treatment and control through dry pond
- Mitigate flooding during extreme events to acceptable levels of risk

Alternatives:

A. Do nothing
B. Regrade kite field to maintain positive drainage to dry pond and design future Sandcastle Drive extension to provide positive drainage across to the dry pond
C. Increase storage and infiltrate – *Note: Long-term groundwater monitoring at this site is recommended to confirm natural function. There is a risk of groundwater elevations limiting infiltration potential from the dry pond based on indications of shallow groundwater identified in the Geotechnical Investigation.* Increase storage and reuse for irrigation – *Note: Pumping from the dry pond to irrigate adjacent park areas may provide the Park with a public relations water conservation initiative. In order to avoid provincial reclaimed water treatment requirements, underground trickle irrigation required (see Appendix G). Due to the observed natural infiltration capacity of the dry pond, the City may need to install an impermeable liner through part or all of pond to ensure sufficient water is available for irrigation. A robust water balance of the pond would be required to balance the irrigation demands with the critical stormwater management function of the pond. Future coastal inundation events would alter water quality for irrigation use and therefore water quality should be assessed following these events, prior to resuming irrigation from the pond.*
D. Increase storage and pump to ocean – *Note: Pumping would only be required following larger storm or coastal inundation events to restore storage capacity for site stormwater management. There may be additional regulatory implications of pumping directly to the ocean that need to be considered.*

E. Increase storage and connect overflow to storm trunk – *Note: The dry pond would fill during storm events and infiltrate as per current conditions for the majority of storm events. An overflow pipe connected to the existing storm trunk would be installed to prevent overtopping in large stormevents. This system would facilitate site drainage following future coastal inundation events. The overflow capacity would be limited by the tides and pipe clogging that impact the existing or future outfall.*

Additional considerations:

- Timing and design of flood mitigation measures could be coordinated with the Sandcastle Drive extension, paving of the gravel parking lot and skatepark upgrades.

5.6 Non-Structural Practices

Non-structural practices are policies and programs that aide in improving or preventing the need for stormwater management. Examples of policies include reducing impervious coverage through land use planning (e.g. reducing parking stall requirements, impervious surface coverage limitations). Examples of programs include maintenance programs for stormwater management infrastructure, pollution prevention programs (e.g. street sweeping), temporary/emergency procedures, and public outreach/education.

In Parksville Community Park, potential non-structural practices may include, but are not limited to:

- Education promoting stormwater as a resource with a place in the landscape.
- Expectation management regarding:
    - the level of service of the stormwater management system, and
    - the role of pervious surfaces in the Park for naturally managing stormwater.
- Maintenance program to prevent clogging of rock pits, underground storage and infiltration facilities.
- Temporary emergency procedures to block access to flooded roadways during future coastal inundation events.
- Continuing the frequent street sweeping program within the Park.

6 Next Steps

As the City reviews this draft memorandum, EOR is seeking feedback on the following key aspects that will inform next steps in development of the SWMMP:

1. Identify any information missing from the baseline characterization (Section 2) based on City staff's in-depth knowledge of the Park.
2. Seek approval from Aquilla Archaeology regarding content in Sections 2.2 and 2.3 which rely on their confidential Archaeological Impact Assessment and Inventory report.
3. Provide comments on the draft Problem Statement and Goals (Section 4). Some aspects of these goals will not be addressed immediately by the SWMMP developed by EOR, but instead will be addressed over time by through the recommended implementation plan. This is an important clarification as some key uncertainties will need further study and the plan will

need to adapt as understanding of climate change impacts and adaptation strategies across the Bay and Estuary continue to evolve.

4. Provide compiled comments on preferred alternatives for each of the key areas outlined in Section 5.5.
5. Confirm that the City is planning on developing a sea level rise adaptation plan to coordinate strategies around Parksville Bay and Englishman River Estuary. The following implementation considerations will be key to developing recommended stormwater upgrades, but is beyond the scope of our analysis because decisions would require public consultation, partnership with First Nations and consideration of other alternatives:
    a. Future changes to park topography to mitigate coastal inundation may be considered in the future, but the SWMMP will assess vulnerability of the stormwater system based on existing topography within the Park. The SWMMP will assume that neighbouring properties will be raised to prevent coastal inundation via overland flow from those properties, consistent with assumptions made by NHC in their coastal inundation analysis (G. Lamont, personal communication, July 23, 2020).
    b. Future regional plans may integrate park planning with plans for managed retreat from adjacent lands, but the SWMMP will assume adjacent land uses will remain in place.

Following our meeting to discuss this draft, EOR will consider the key areas of the Park and alternatives in more detail, select a recommended alternative and provide conceptual sizing/cost for the implementation plan.

Respectfully submitted,

Emmons & Olivier Resources Canada Inc.

Kerri Robinson, M.Sc., P.Eng.
Project Manager
Emmons & Olivier Resources Canada Inc.

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Appendix A: Summary of Background Information

Previous studies, plans and standards are summarized below as they relate to the CPSWMMP.

EOR reviewed the following background information to compile applicable stormwater management design criteria:

City of Parksville

1. Plan Parksville: A Vision for Our Future – Official Community Plan (City of Parksville, 2013)
2. Parksville Community Park Shoreline Erosion Protection (Northwest Hydraulics Consultants Ltd., 2015)
3. City Storm Drainage Master Plan (Koers & Associates Engineering Ltd., 2016)
4. Community Park Master Plan 2017-2037 (Vancouver Island University & City of Parksville, 2017)
5. City of Parksville Engineering Standards and Specifications (City of Parksville, 2018)
6. Parks, Trails and Open Spaces Master Plan (City of Parksville et al., 2019)

Regional District of Nanaimo

7. Regional District of Nanaimo Liquid Waste Management Plan Amendment (Regional District of Nanaimo, 2014)
8. Drinking Water and Watershed Protection (DWWP) Action Plan 2.0 2020-2030+ (Regional District of Nanaimo, 2020)

Province of British Columbia

9. Stormwater Planning – A Guidebook for British Columbia (Province of British Columbia, 2002)
10. Develop with Care 2014: Environmental Guidelines for Urban & Rural Land Development in BC (Province of British Columbia, 2014)
11. Environmental Best Management Practices for Urban & Rural Land Development in BC, DRAFT, 2014 (Province of British Columbia, 2004)
12. Riparian Areas Protection Act (SBC 1997 Chapter 21) (Riparian Areas Protection Act, 1997)
13. Reclaimed Water Guideline (Province of British Columbia, 2013)
14. Municipal Wastewater Regulation (Municipal Wastewater Regulation, 2018)

Government of Canada

15. Fisheries Act (RSC 1985, c F-14) (Fisheries Act., 2016)
16. Land Development Guidelines for the Protection of Aquatic Life (Department of Fisheries and Oceans, 1993)
17. Canadian Environmental Protection Act (SC 1999, c 33)(Canadian Environmental Protection Act., 2000)

City of Parksville Regulation and Plans

The following plans and bylaws contain guidance and requirements for stormwater management in the City of Parksville. Criteria for design and operation of stormwater management facilities that apply to Parksville Community Park are outlined below.

Plan Parksville: A Vision for Our Future – Official Community Plan (City of Parksville, 2013) (OCP) includes guidelines for incorporating on-site stormwater management techniques and providing stormwater treatment for groundwater protection.

The OCP contains goals for managing the quantity and quality of stormwater generated within the City before it is discharged from the storm drainage system back into the natural environment. These include:

- Improving storm water drainage quality prior to discharging into the environment (Chapter 6, Storm Drainage),
- Providing scientific information on climate change and the potential implications for municipal infrastructure (Objective 9),
- Mimicking pre-development runoff flows through rainwater capture, stormwater infiltration, and detention (Section 6.1, Goal 3)
- Minimizing non-essential impervious surfaces, and
- Specific guidelines for Development Permit Area 11 - Coastal Protection that may apply to Parksville Community Park include:
    - Where no practical alternative exists, development within 30 metres of the present natural boundary, or within 15 metres of the top of a bank with a slope of 30% or greater, shall be located and designed in a manner that considers and minimizes impacts to the marine foreshore and the adjacent upland;
    - All collected stormwater within this area shall be diverted away from the marine foreshore or estuary and, where feasible, should be directed towards the City's stormwater drainage system;
    - Development should minimize impervious surfaces and should incorporate on-site storm water management techniques that retain pre-development infiltration rates;

The ***Parksville Community Park Shoreline Erosion Protection*** (Northwest Hydraulics Consultants Ltd., 2015) developed a plan to identify and mitigate erosion processes near Arbutus Point in Parksville Community Park. The report identifies the erosion and deposition processes at work in Parksville Bay as the result of movement of river sediment (gravel, cobble) into the bay, raising the land in the western portion of the Englishman Estuary and hardening of the shoreline east of Arbutus Point and west of the Englishman River. A combination of riprap, anchored logs and beach fill was designed and installed to meet the required level of protection while meeting Green Shore objectives. A stormwater outfall stub was placed along with reconstruction of the shoreline at Arbutus Point.

The ***Storm Drainage Master Plan*** (Koers & Associates Engineering Ltd., 2016) (SWMP) developed a calibrated hydrologic/hydraulic model of the City's existing storm sewer system based on the City's GIS databased and identified infrastructure upgrades required to accommodate future development in the City's Official Community Plan. The program XP-SWMM was used to develop the City-wide model, which was calibrated to flow monitored at five sites from December 2013 to February 2014.

The SWMP found that extreme precipitation in the Parksville area is expected to increase by 15% to 50% for the hourly events by the 2050s, which is the governing time of concentration for the City's storm drainage network, excluding Romney and Shelly Creeks with their approximate 6 hour time of concentration.

Given the uncertainty in future extreme rainfall intensities, the SWMP recommended that drainage system resilience be improved through the use of a percentage full limit for pipe design which requires increasing to the next available pipe size if design flow results in pipe flowing more than a set limit, for example 80% full. The SWMP also recommended updated IDF curves

Based on global sea level rise forecasts, the Provincial Government has recommended that average sea level rise of 1 m by year 2100 and 2 m by 2200 be used for coastal flood planning. For the Parksville region, a minimum Flood Construction Level (FCL) of 5.4 m (geodetic datum) has been calculated based on the recommended 1 m increase (to year 2100) plus allowances for wave effects and freeboard as per the provincial sea level rise guideline. According to the Regional District of Nanaimo Floodplain Management Bylaw, 2006, the FCL is defined as the water elevation of a flood with a 200 year recurrence interval, plus the allowance for freeboard, and is used to establish the first floor elevation of a habitable area (Bylaw No. 1469). However, detailed site specific analysis is recommended to establish FCL for specific coastal developments as wave effects and storm surge can be affected by local coastal processes.

The SWMP recommended that the City require first flush treatment of runoff prior to discharge to the environment.

The SWMP did not include mapping or analysis of the storm sewer system in the community park.

The ***Community Park Master Plan 2017-2037*** (Vancouver Island University & City of Parksville, 2017) outlines the existing infrastructure and programming for Parksville Community Park (PCP) and, following extensive engagement, identifies the staged upgrades to infrastructure and programming desired by 2037. Site stormwater management must evolve with the park, to accommodate changes and increased imperiousness. Of the changes planned for the park, the following will have an impact on how, what and where stormwater management facilities can be and should be implemented in the park:

- Amphitheatre in the southwest corner
- Accessible parking and access to the picnic shelter west of Ravenhill Drive
- Removing the Kin Hut washrooms and replacing them with washrooms near the sports field, off Ravenhill Drive.
- Adding sidewalks and pathways to provide continuous pedestrian connection through the park.
- Development of the Gathering Space, northwest of the playground, with plaza type surfacing, permanent food vendors, expansion of the gazebo to accommodate live events, seating for the improved gazebo.
- Connection of Sandcastle Drive at Arbutus Point to the gravel parking lot by the curling rink.

- Paving the gravel parking lots at the sports field and curling rink.
- Potentially adding a small washroom facility at Arbutus Point.
- Relocating the curling club away from the park, and repurposing or removing the existing facility.

City of Parksville Engineering Standards and Specifications (City of Parksville, 2018) include the following items specific to stormwater runoff control, quality, and quantity:

D-1 DRAINAGE DESIGN CRITERIA

> 1.0 Introduction - Design and construction of storm drainage facilities are subject to the requirements of the Fish and Wildlife Branch of the Ministry of the Environment, Department of Fisheries and Oceans, and any other agencies having jurisdiction.
>
> 3.0 Drainage Design Methods and Flows b) Storm Water Management Systems shall incorporate such techniques as lot grading, surface infiltration, and sub-surface disposal, storage, or other acceptable methods, to limit the peak runoff from development.
>
> 7.0 Site and Lot Grading e) Individual lot(s) will not be permitted to direct storm water discharge or drainage into any natural watercourse, park, or green belt area. Sheet flow may be permitted.
>
> 10.0 Detention Facilities - Large developments, generally independent of existing drainage facilities, or where the existing drainage system is known or proven to be inadequate, will be required to provide detention of storm water to the pre-development runoff flows. Detention facilities will be designed with bottom drainage to ensure the facility is dry when not in use.
>
> 24.0 Rockpits - The use of rockpits in the Municipality is discouraged and will only be permitted at the discretion of the Municipal Engineer. Rockpits will only be considered in certain areas of the Municipality where it can be demonstrated that the subsoil conditions will provide a percolation rate equal to, or in excess of, twice the minor runoff flows.

Specific provisions:

- Downstream storm sewer design shall assume that all infiltration facilities have failed, i.e., downstream design must accommodate the 1:100 year storm.
- Storm water management shall incorporate such techniques as lot grading, surface infiltration, sub-surface disposal, storage or other acceptable methods to limit the peak runoff from the development during frequent storm events. Such allowances will not be considered applicable for long storm events (e.g. 10 years and 100 years) unless approved by the City Engineer.
- Use City's standard IDF curves in the Engineering Standards and Specifications (2018)
- Ultimate land use for the purpose of storm drainage calculations shall be determined by referring to the current "Official Community Plan", and for areas outside the City by the current Official Regional District Settlement Plans.

- The Minor System shall consist of pipes and ditches which convey flow of a 10 year return frequency.
- The Major System shall consist of surface flood paths, roadways, and watercourses which convey flow of a 100 year return frequency. Major flood path routing may allow for minor inconveniences but no major damage shall result from the 100 year return period storm. Any allowances for inconveniences shall be outlined in the servicing report and approved by the City Engineer.
- Unlined open channels designed to carry minor or major flows shall be restricted to a maximum velocity of 1.5 m/s, maximum depth of 0.3 m, minimum freeboard of 0.15m, and maximum slope of 3:1 (horizontal:vertical).
- Pipes shall be designed to flow at a maximum of 80% of full capacity.
- The minimum velocity for pipes shall be 0.91 m/s.
- The storm used for computer modelling of sites larger than 10 ha or detention facilities shall be the Canadian AES 1 hour storm with rainfall = 100 mm using a K = 5 (BC coast), dt = 3 minutes, and TP (time to peak) = 28 (BC coast).
- Manning's n values:
    - 0.050 Natural channels
    - 0.030 Excavated ditches
    - 0.013 Concrete pipe
    - 0.011 smooth PVC
- The storm drainage system shall be designed to accommodate the anticipated flows from roof and perimeter drains and from overland lot drainage.
- Storage facilities shall be designed to ensure the facility is dry when not in use. Wet storage facilities should be avoided. The design of permanent storage facilities shall consider safety, appearance and economical maintenance of operations as it relates to the storage of stormwater.
    - The storage facility shall be designed using the 100 year storm event as the design storm with a freeboard of 300 millimetres.
- All storm drain mains shall be installed at a minimum clear horizontal distance of 3.0 m and a vertical distance of 0.5 m from any water main, with the water main on top. If the minimum horizontal clearance cannot be obtained, then the water main shall be protected to the satisfaction of the Regional Public Health Engineer.
- The minimum storm main line pipe diameter shall be 300 mm, except that in residential areas 250 mm diameter is acceptable in the final section of a storm drain where not more than one catch basin connects to it and extension in the future will not take place.
- Catch basin leads shall be a minimum 200 mm in diameter.
- The elevation of storm drains at the upstream tributary points must be of sufficient depth to service all of the tributary lands.
- Storm drain manhole rim elevations in off road areas shall be designed to be above the surrounding ground so that infiltration from ponding will not occur.
- Swales required for lot grading shall be a maximum 300 millimetres deep, have a minimum 1 percent grade and a maximum wall slope of 3:1. A swale is to be lined with clean rock or sod with a minimum of 150 millimetres of topsoil. Swales must be directed to lawn basins

on each lot. Swales for major flood path routing shall be designed to accommodate the anticipated 100 year storm event flow.

- French drains shall be installed only where the topography, soil and groundwater conditions prove the need for such drains. The use of these drains is to be approved by the City Engineer. A soils report prepared by a geotechnical engineer is required to confirm the suitability of the soil. These drains shall be connected to a manhole, and provided with a cleanout structure at the upstream end.
- The use of rock pits will only be permitted at the discretion of the City Engineer, and if engineered. Rock pits will only be considered in certain areas of the City where it can be demonstrated that the soil allows storage and percolation of the 10 year storm. A soils report prepared by a geotechnical engineer will be required to confirm the suitability of the soil. Rock pit design shall incorporate an overflow to a major flood path route for rainfall in excess of the 10 year storm. If major flood path routing is not possible, the rock pit shall be designed to store and infiltrate the 100 year storm.

Parks, Trails and Open Spaces Master Plan (City of Parksville et al., 2019) provides direction to ensure that these recreational resources continue to support the needs of the community into the future. Within the PTOSMP, Parksville Community Park is considered a principal park and was planned separately from other pocket, neighbourhood and linear parks. Following extensive public engagement, recommended improvements to principal parks included wayfinding signage, pollinator gardens and enhanced maintenance. Trail recommendations included additional trail lighting and safe surfaces for walking and jogging, circular trail routes, as well as wayfinding signage. Specific recommendations for Parksville Community Park were to:

- 18. Make a looped trail by improving connectivity from Parksville Community Park to the Englishman River Estuary.
- 21. Include sidewalk connections between trails as part of trail network.
- 22. Improve public access to the waterfront and linkages from neighbourhoods to the downtown core.
- 23. Before installing signage, facilitate neighbourhood engagement to establish names for new parks or for spaces with more than one (or no) names.
- 28. Install trail maps at trail heads and wayfinding signage throughout the City trail network.
- 32. Use native species when rehabilitating disturbed areas, riparian or waterfront areas (eg. beach strips).
- 33. Prioritize sustainable and ecological integrity in landscaping and vegetation management. Integrate native species into landscapes wherever feasible.
- 55. Increase the capacity of principal parks to host community events by developing additional covered areas that are appropriate in size and scale to each of the parks spaces.
- 61. Direct people towards PCTC with the addition of wayfinding elements, such as signage and maps.
- 62. Add park amenities such as water fountains and seating to make PCTC a more accessible community park space.

Regional District Regulation and Plans

The Regional District of Nanaimo's (RDN) ***Liquid Waste Management Plan Amendment*** (Regional District of Nanaimo, 2014) (LWMP) references stormwater as rainwater, solidifying its value as a shared and interconnected resource. Parksville is also home to the French Creek Pollution Control Centre, which treats wastewater from the City of Parksville and surrounding towns and service areas. As part of the RDNs approach to valuing all water as an interconnected resource, reclaimed water from the FCPCC is used for irrigation at Morningstar Golf Course (May to Sept) as well as within the FCPCC for non-potable uses. In order to further the rainwater management and watershed protection initiatives in the region, RDN has committed to the following:

OBJECTIVES

1. *Use of rain as a resource*
2. *Promote the maintenance of hydrologic function*
3. *Protect the quality of water*

TARGETS

The RDN will:

1. *Develop a regional strategy on rainwater management in coordination with member municipalities*
2. *Implement rainwater management initiatives as detailed in the Drinking Water & Watershed Protection Action Plan*

As one of four municipalities within the RDN, Parksville has complied with requirements of the LWMP to have and follow their own stormwater management plan. The LWMP has specifically highlighted that the City of Parksville actively pursues:

- Participation in regional Wastewater and Water Collaborative (W3C) meetings to advance rainwater management
- Restoring and/or realigning creeks and streams to improve drainage
- Providing a checklist with building permits highlighting sustainable rainwater management practices
- Developing ditches into bioswales and installs flush curb mounts
- Capital projects to upgrade underground infrastructure
- Proactively implementing innovative strategies to manage rainwater
- Maintaining flow and rainfall gauges throughout the City

Commitments under the LWMP require development of a regional rainwater management strategy with member municipalities and implementation of a rainwater management initiatives as outlined in the ***Drinking Water and Watershed Protection (DWWP) Action Plan 2.0 2020-2030+*** (Regional District of Nanaimo, 2020). The DWWP was developed to achieve regional priorities related to climate change, land-use planning, asset management and protection of the natural environment by fostering the relationships required to facilitate collective and collaborative action within the region. It has been enacted through the "Drinking Water and Watershed Protection Service Establishing Bylaw No. 1556, 2008, with the following amendments 1556-01; 1556-02, 1556-03 and 1556-04.

Partnerships are key to implementing the DWWP, specifically as meaningful partnership with First Nations, and with all levels of government, municipalities, academia, industry, not-for-profit sector and other agencies. The program goals are to support regional initiatives that:

- *Protect, manage and restore ecosystems and the overall health and functioning of our watersheds and aquifers.*
- *Safeguard and manage source waters to secure a sustainable drinking water supply.*
- *Increase water-use efficiency and optimize infrastructure investments for water and wastewater systems.*
- *Foster the enjoyment and protection of social, cultural, and recreational values and amenities in our watersheds to maintain well-being and quality of life.*
- *Mitigate and better prepare for climate change impacts on the region's water resources*

Actions specific to stormwater management include:

- Incentivizing sustainable practices (rebates) such as rainwater harvesting, soil improvements, raingardens and infiltration swales and wellhead protection upgrades.
- Coordinating with water services providers to support regional water conservation plans.
- Analyzing and interpreting data to generate richer understanding of the Region's water through water budget and rainwater management modelling, trend analysis, and quantifying natural assets and ecosystem services.
- Developing targets to maintain watershed function, potentially related to infiltration, soil depth/retention, riparian vegetation, water quality, and tree cover.
- Advancing innovative policies and practices to improve water sustainability, including topics related to alternate water sources (reuse), green infrastructure and erosion and sediment control.

Provincial Regulation and Plans

The ***Stormwater Planning – A Guidebook for British Columbia*** (Province of British Columbia, 2002) outlines the purpose and steps to developing integrated stormwater management plans within the province of British Columbia. It addresses the stormwater component of the Liquid Waste Management Plans required by each municipality or regional district. The approach highlights adaptation and solutions that focus on stormwater as a resource, including a full spectrum of rainfall events within the planning sphere, developing appropriately prioritized implementation plans, identifying the level of planning required (this plan is at the site level) and incorporating adaptive management into the plan. Key components of stormwater planning highlighted in this guidebook include addressing stormwater impacts due to climate change and development pressure in ways that holistically manage the volume, rate and quality of stormwater discharged.

The ***Develop with Care 2014: Environmental Guidelines for Urban & Rural Land Development in BC*** is intended for use by local governments developing community plans and local bylaws, reviewing and approving officers and consultants involved in design and construction of new development in the province. These guidelines outline sensitive ecosystems, species and habitats to be protected within each region of the province, including the West Coast region of Vancouver Island. The intent of these guidelines is to provide context for development requirements throughout the province, and to summarize, in an accessible format, the key environmental concerns that need to be considered when developing local regulations and permitting within each region. The guidelines recommend tools and policies that may be considered to align with provincial approach to integrated rainwater management. Suggestions for managing rainwater include promoting integrated rainwater management, conducting water quality monitoring, improving the quality and reducing the quantity of runoff, protecting groundwater quality and recharge, and controlling erosion and sedimentation during construction activities.

The ***Draft Environmental Best Management Practices for Urban & Rural Land Development in BC*** recommends integrated stormwater management using best management practices for urban stormwater management, referring to Stormwater Planning – A Guidebook for British Columbia (Province of British Columbia, 2002). Best management practices listed for municipalities include enacting bylaws or permitting processes to emulate pre-development watershed function and reduce imperviousness; and leading by example on public land by implementing 'naturescape' principles, stormwater best management practices, and green buildings, facilities and transportation. Stormwater best management practices include using pervious surfaces and infiltration where possible, preserving or improving water quality at the source and retaining and detaining stormwater runoff at the source, and erosion and sediment control. Protection of existing functional ecosystems such as wetlands, vernal pools and lakeshores, are identified as key areas requiring protection.

The ***Riparian Areas Protection Act,*** formerly the *Fish Protection Act,* (SBC 1997, Chapter 21) requires local government to include riparian area protection provisions within zoning and land use bylaws, where applicable, and to provide a level of protection comparable to, or exceeding the provincial requirements in all permits and bylaws. This act also defers to the federal Fisheries Act for the protection of aquatic life.

Rainwater Reuse

The ***Municipal Wastewater Regulation*** (Municipal Wastewater Regulation, 2018) defines reclaimed water as water that has been treated at a municipal wastewater treatment facility and is of an acceptable quality to be reused(Municipal Wastewater Regulation, 2018). Rainwater harvesting does not fit neatly into this category, however there are not yet municipal regulations differentiating handling of captured rainwater from treated wastewater for applications in public space and therefore harvested rainwater falls into the category of reclaimed water in BC. The Regional District of Nanaimo has published the Rainwater Harvesting Best Practices Guidebook for residential use, however it explicitly states that it is not applicable to publicly operated systems (Regional District of Nanaimo, 2012).

The ***Reclaimed Water Guideline*** (Province of British Columbia, 2013) standards for using reclaimed water are based on the exposure potential of the end use. Reclaimed rainwater used for irrigation in a public space is expected to meet the "Greater Exposure Potential" quality guidelines, and to be monitored for compliance on the schedule outlined in the Municipal Wastewater Regulation and summarized in Table (Municipal Wastewater Regulation, 2018).

Table 17 - Reclaimed water quality and monitoring requirements for uses with Greater Exposure Potential (adapted from (Municipal Wastewater Regulation, 2018))

Parameters	Municipal Effluent Quality Requirements	Monitoring Requirements
pH	6.5 to 9	Weekly
BOD5, TSS	10 mg/L	Weekly (also includes flow monitoring)
turbidity	average 2 NTU, maximum 5 NTU	Continuous monitoring
fecal coliform (/100 mL)	median < 1 CFU or < 2.2 MPN; maximum 14 CFU	Daily (reduce to weekly with confirmation of compliance over 60 days)

Properly treated non-potable water is permitted for use in lawn and landscape irrigation in Parksville Community Park as long as it complies with the standards set within the ***Reclaimed Water Guideline*** (Province of British Columbia, 2013) and confirmed through consultation with Vancouver Island Health Authority. The design considerations outlined in the Reclaimed Water Guideline include:

- There must be at least a 3.0m horizontal and a 450mm vertical separation between all pipelines transporting reclaimed water and those transporting domestic water.
- Domestic water lines must be located above reclaimed water lines.
- Plans for dual-distribution systems in buildings and irrigation systems must pass local inspections conducted by local building inspectors before they are approved.
- Adequate cross-connection control measures must be installed, including an approved backflow prevention device at the potable water connection to reduce the risk of unintended cross-connections.
- An automated irrigation system must be used where irrigation is used to apply reclaimed water to urban landscape or turf areas not supervised by a landscape professional.
- Irrigation equipment must be operated to prevent spray drift onto adjacent properties and the irrigation system application rate must not exceed the infiltration rate of the soil or cause any surface runoff.
- The irrigation controller must have a minimum of two start times per day, seven days per week. The "on" time for each station must be able to be set in one-minute increments.
- The capability to chlorinate reclaimed water should be available and a residual level of chlorine should be maintained.

Federal Regulations and Guidelines

There is currently no federal legislation that relates directly to stormwater management, although the federal government has legislation focused on its constitutional responsibility for protecting fisheries, and guidelines related to land development and the protection of aquatic life.

The ***Federal Fisheries Act*** (RSC 1985, c F-14) (Fisheries Act., 2016), administered by the Department of Fisheries and Oceans (DFO) prohibits the release of deleterious substances into fish habitat, which is defined very broadly in the Act and can include roadside ditches and watercourses that are only intermittently wet.

The ***Land Development Guidelines for the Protection of Aquatic Life*** (Department of Fisheries and Oceans, 1993)contains minimum recommendations for stormwater management with respect to the protection of aquatic life, including limiting the 1:2 year storm runoff rate to the pre-development 1:2 year rate and mimicking predevelopment flow patterns and water quality as much as possible. Infiltration systems are encouraged where feasible and quality control through source control and treatment control are required to protect fish and fish habitat, when applicable.

The ***Canadian Environmental Protection Act*** (SC 1999, c 33) (Canadian Environmental Protection Act, 2000) also relates to stormwater management by mandating emergency planning for industrial accidents and the guidelines for the Act include treatment of stormwater before runoff containing toxic substances reaches ecosystems.

Appendix B: Rainfall & Climate Change Report

DILLON
CONSULTING

EMMONS & OLIVER RESOURCES CANADA INC.

City of Parksville – Rainfall Design & Climate Change Guidance

Final Technical Report

April 2020 - 20-2568

April 27, 2020

Emmons and Oliver Resources Canada, Inc.
Toronto Office
Suite 200
20 Camden Street
Toronto, ON M5V 1V1
Canada

Attention: Kerri Robinson, P.Eng.
Water Resources Engineer
krobinson@eorinc.com

Final Report for City of Parksville Design Rainfall Climate Change Guidance

We are pleased to deliver this final technical report in association with our analysis of current and future design rainfall values for the City of Parksville. This technical report provides a summary of information sources, analytical methods, and a review of final results, including key considerations for use and interpretation.

Please do not hesitate to contact us with any questions.

Sincerely,

DILLON CONSULTING LIMITED

Simon L. Eng,
Consultant, Project Manager
SLE:jrb

Encls. 2 Microsoft Excel Files, Appendices B and C

cc: Michael Lonsdale, Engineering Technologist III, City of Parksville
Olivia Sparrow, P.Eng., Ontario Offices Lead, EOR

Our file: 20-2568

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Executive Summary

The climate team at Dillon Consulting was tasked with providing design guidance for stormwater drainage infrastructure for the City of Parksville, located on the eastern coast of Vancouver Island, British Columbia. This analysis consisted of a review of existing rainfall design guidance, recent historical events resulting in riverine and overland flooding in the area, and a detailed analysis to provide guidance on potential impacts of climate change, both generally on extreme rainfall in the region, and specifically on how existing design requirements may change by the mid- and late-century (i.e., 2050s and 2080s, respectively). Identification and review of recent high impact rainfall events was conducted to help guide interpretation of existing design guidance. A review of available historical climate information, including the City's own rainfall monitoring stations, were coupled with the review of historical events. Current intensity-duration-depth tables were also extended to include multi-day rainfall events up to 10-days in length. Finally, projections were developed to adjust existing and newly developed current design information to understand future changes, and projection results were checked against rainfall design data for climate analogues for locations representative of Parksville's future climate for mid- and late-century time periods.

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1.0 Scope & Project Background

The climate team at Dillon Consulting was tasked with providing extreme rainfall design guidance for the City of Parksville, British Columbia, taking into account the potential effects of climate change on extreme rainfall amounts used to support municipal infrastructure design. A review of existing design guidance and historical rainfall information was used to characterise and understand current conditions and to identify current and historically used rainfall design values. Additionally, recent and historical impacts from heavy and extreme rainfall were obtained through media and other sources to provide context for the severity and types of impacts associated with different storm types, including event duration, time of year and aerial extent.

Analyses and climate change projections for design storms and water balance calculations included the following:

- All IDF durations and return-periods, including the addition of multi-day rainfall events;
- Review of a 1-hour, 100 mm synthetic storm, intended for use in the design process for land drainage retention facilities; and
- Identification and extraction of monthly precipitation variables for use in water balance calculations.

Deliverables for the project included an extension of the current IDF curve to include multi-day rainfall events (2-10 days) for standard return periods (2-100 year events), and development of future projected rainfall design tables. Future design values were projected for mid- and late-century, representing the 2050s and 2080s under the "worst case" representative concentration pathway (RCP) 8.5 (IPCC, 2013), representing a "business as usual" carbon-intensive future emissions pathway with little greenhouse gas mitigation. We note that RCP 8.5 is also the emissions pathway that global GHG emissions are currently following (e.g., Smith and Myers, 2018) and that emissions have also already exceeded some of the lower emissions pathways (e.g., RCP 2.6). This report provides additional context for these analyses, describing analytical methods, data and data sources, and analytical results. This report includes a comparison of different projection methods, as well as a discussion of interpretation and important caveats associated with considered methods.

1.1 Review of Design Data and Historical Events

Design data review consisted of an examination of City of Parksville drainage design guidelines, consultation with City of Parksville staff, and review of standard design information generated and updated by Environment and Climate Change Canada (ECCC), specifically of so-called "Intensity-Duration-Frequency" (IDF) curves and tables.

While all event durations and return periods found in standard ECCC IDF tables were updated through the projection work, only a sub-set of these events are currently used in stormwater-related drainage design, specifically:

- 10-year storm, used for minor drainage system;
- 100-year storm, used for major drainage system; and
- 1-hour, 100 mm event, used for rainfall retention facilities.

Available IDF tables for stations located in and around the City of Parksville were reviewed to determine the best available data for use in expansion of rainfall information and to form the baseline information used for climate change projections. The three IDF stations identified and reviewed were:

- Parksville South – Station I.D. 1025977 – 10 years of data ending in 1992;
- Nanaimo City Yard – Station I.D. 10253G0 – 25 years of data ending in 2007; and
- Nanaimo Airport – Station I.D. – 32 years of data ending in 2017.

Although Nanaimo Airport is located approximately 50 kilometers to the south-east of Parksville, it was chosen as the best available IDF station for analyses. The Parksville South station suffered from a very short observation period, reducing the confidence in any derived statistics. This station ended recording nearly 30 years ago, and did not contain any information on sub-hourly rainfall. This leaves the two Nanaimo stations as the remaining options, with the team opting for the station with the most recent and longest continuous data set for use in further analysis. Stations which have not collected information in the most recent decade will also not be representative of recent and ongoing changes in climate.

We note, however, that the City of Parksville is currently operating a rain gauge at the centrally located Community Park which has been recording data since 2009. This data was reviewed in the analysis of high impact rainfall events, and it is strongly recommended that this station be maintained and high resolution data continue to be recorded for eventual use in developing locally based IDF design information after several additional years of data have been collected.

1.1.1 Significant Historical Events

Historical research, including media sources, observational data from ECCC climate stations, as well as additional information available within IDF tables, was conducted to identify rainfall events resulting in impacts to the City of Parksville and/or nearby similar geographical areas. These were used to bolster analyses of IDF curves and other design storms, specifically:

- To identify important impacts associated with historical events; and
- To provide indications of the time of year and type of rainfall events resulting in important impacts to the community.

Identified events and their associated effects are described below in **Table 1**.

Table 1 - Historical heavy rainfall events in the Parksville area and adjacent portions of southern Vancouver Island.

Date	Impacts	Rainfall Notes	Source
Jan 31/Feb 1, 2020	Cowichan Valley (including Parksville Qualicum Beach) and District of Kent - Storm event, heavy precipitation, landslides and flooding, power outages; Flooding of Little Qualicum River Bridge at high tide.	*39.6 mm* on Jan 31, **47.4 mm** over the two days at Community Park, ***80.2 mm*** over previous week.	CP 2020; Logan, 2020
January 23, 2020	Cowichan Valley (~90 km S of Parksville) - Flooding due to heavy rain melting snow; roads closed due to flooding; ditches and pooling.	Cowichan North climate station reported *33.3 mm* on Jan 23, **57.5 mm** for two days, ***114.4 mm*** over the previous week.	Bainas, 2020
January 3, 2019	Parksville (Englishman River) - River flooding ; heavy rainfall with one road (Martindale Rd.) reported flooded, elsewhere "lots of localised flooding" ditches and culverts filling up, homes along creek and river banks monitored but no evacuations ordered.	*47.0 mm* on Jan 3, **56.6 mm** for Jan 3-4, ***65.8 mm*** over the previous week (Dec 29-Jan 4).	Kveton, 2019a & b
January 29, 2018	Parksville and surrounding - Heavy rainfall; high river levels, mudslides and road washouts; 200 m stretch of road flooded by Englishman River, 22 evacuated from RV park; Level 2 EOC open through Jan 30th, some contribution from snowmelt.	47mm fell at Victoria Airport in 36hrs; *43.8 mm* on Jan 28, **67.8 mm** for Jan 27-28, ***98.0 mm*** over the previous week (Jan 22-28)	Kines and Watts, 2018; Collins, 2018
November 19-21, 2017	Regional District of Nanaimo - Localized river flooding due to heavy rainfall (expected 100-150mm) High streamflow advisories for rivers and tributaries near Parksville (and Eastern Island);	Community Park reported 29.2 mm on Nov 19, 20.6 mm on Nov 21 and 10.8 mm on Nov 22.; Qualicum Bay are reported 40.3 mm (Nov 21), 37.0 mm (Nov 20), 58.6 mm (Nov 19) and 29.0 mm (Nov 18)	CHEK News, 2017; CTV News 2017

Date	Impacts	Rainfall Notes	Source
	French Creek, between Parksville and Qualicum Beach, breached bank on 19th; Cowichan Bay Rd closed further south, W of Duncan.	**Side Note –** 81.2 mm reported Nov 12-14 at Community Park, with 48.2 mm on Nov 14 alone, *no indications of impacts*; Qualicum Bay similar with 56.8 mm on Nov 14, 114.7 mm total Nov 12-14	
December 8-11, 2014	Comox Valley - Intense rainfall over several days (subtropical storm); boil water advisories. Landslides and flooding of roads/highways and homes Courtenay declared state of emergency due to flooding; Mud slides triggered by heavy rainfall at Little Qualicum Beach, with one home partially buried, triggering evacuation of 15 homes. Potential exacerbated impacts at Qualicum FN due to concurrent "king tide" event.	98.8 mm of rainfall recorded at Parksville Community Park over four days.	Harnett, 2014; CP 2014; City of Parksville staff (pers. comm.)
Sept 2, 2013	Parksville - City's sewer system backed up within minutes, multiple sewer covers removed due to water pressure, residential basement flooding reported, 30-45 cm depth of water reported on roads.	Heavy short duration rainfall 32 mm in 20 minutes) and thunderstorm.	CBC News, 2013; KWL, 2014; City of Parksville staff (internal report)
November 27, 2011	Coastal BC (including East Island) - Heavy rain and hazardous conditions on all roads north of Parksville; river flooding and road closures.	N/A	CBC News, 2011
2007	Nanaimo Airport	15, 30, 1 and 2 hour 100-year exceeded – likely occurred Sept 28.	IDF station data

Date	Impacts	Rainfall Notes	Source
2001	Nanaimo City Yard	20.8 mm in 30 min, exceeding 100-year rainfall depth (~106 year r.p. estimated); Exact date unknown.	IDF station data
March 17, 1997	Nanaimo City Yard	93.6 mm in one day, maximum value – Max temps at Nanaimo Airport just over 8°C, closer to 6°C during rainfall.	IDF station data
February 1, 1991	Nanaimo Airport	97.3 mm in one day, maximum value – Max air temp ~9.5°C during rainfall, lowest 8.4°C	IDF station data

1.1.1.1 Historical Event Findings

- The highest values for one-day and multi-day rainfall were found across most of the cool season, generally stretching from November to March. This was determine both through the media reports of flooding damage, as well as maximum station specific values for several climate stations across southern Vancouver Island.
    - However, significant flooding impacts were generally only reported when heavy multi-day rainfall events acted in concert with a pre-existing snow pack and/or high tides. The majority of these types of flooding events, resulting in reported impacts, occurred in January.
- Long-duration (one day to multi-day) events tended to result in conditions of ground saturation and riverine and creek flooding, with impacts to infrastructure and properties adjacent to creeks and the Englishman River.
    - In contrast, the only storm that was reported to overwhelm city drainage infrastructure was a short-duration, high-intensity event in September, 2013.
- Further evidence of inadequacy of IDF curves for extreme, long-return period events was noted when comparing the September 2, 2013 storm to existing and future projected IDF values.
    - For example, the 15 minute rainfall total of 29.4 mm produced an estimated return period of >60,000 years, likely a significant over-estimate of the true return period for short-duration, high-intensity events, even of this extreme intensity.

1.2 Review of Previous Climate Change Projection Analytics

Prior to the current analysis, Kerr Wood Leidal (KWL, 2014) conducted a review of available local IDF design information. This previous work made use of climate projections available from the Pacific

Climate Impacts Consortium (PCIC) Plan2Adapt tool (PCIC, 2013). The information required updating and adjustment due to the following:

- Plan2Adapt projection information is sourced based on climate change information associated with the previous generation of global models (AR4; IPCC 2007)[1];
- Adjustments were conducted on the Parksville South IDF, which is, as discussed above, inadequate compared to other IDF station options due to period of record and temporal resolution concerns; and
- Adjustments were only made to 5-25 year return period rainfall events, whereas the current analysis required the inclusion of 50 and 100-year events.

Given these considerations, an update to IDF future projection adjustments was recommended using both improved historical baseline information and updated projection modeling and methods.

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[1] In contrast, the current analysis makes use of the 5th Assessment (AR5) generation of models from the most recent IPCC global assessment (IPCC 2013). The results of the IPCC's 6th assessment (AR6) are slated for 2021-22.

2.0 Analytical Methods and Results

2.1 Selection and Updating of Current, Representative IDF Information

As discussed above, the Nanaimo Airport IDF station was selected as the best available source of design information for use in this analysis. As both the experience of City of Parksville staff and the historical event research clearly indicate, historically significant rainfall events resulting in riverine flooding and other drainage related impacts have often been the result of significant multi-day rainfall events. Therefore, an extreme value analysis using the Gumbel distribution (to remain consistent with ECCC's IDF methodology) was conducted on multi-day rainfall events to extend the current Nanaimo Airport IDF to include 2 to 10 day rainfall events for the standard return periods of 2, 5, 10, 25, 50 and 100 years (**Table 2**). It is recommended that the City use this updated design information in place of the now outdated/legacy Parksville South IDF station design information.

Table 2 - DDF Data for Nanaimo Airport using data from 1985-2017. Storm durations 5-minutes to 24-hours ECCC, 2- to 10-day analysis conducted for this study. All depths are provided in mm.

Nanaimo Airport (mm) - 1985 to 2017						
Duration	2 year	5 year	10 year	25 year	50 year	100 year
5-min	2.8	3.7	4.3	5	5.6	6.1
10-min	4.1	5.6	6.6	7.8	8.8	9.7
15-min	5	7.1	8.5	10.3	11.6	13
30-min	7.1	10.1	12.1	14.7	16.6	18.4
1-h	10	13.4	15.7	18.5	20.7	22.8
2-h	14.9	18.2	20.3	23.1	25.1	27.1
6-h	29.8	35.3	38.9	43.5	46.9	50.2
12-h	42	50.4	56	63	68.2	73.4
24-h	55.6	69.7	79	90.9	99.6	108.3
2-day	69.8	85.6	96.0	109.2	119.0	128.7
3-day	81.8	99.0	110.4	124.8	135.5	146.1
4-day	96.1	117.0	130.9	148.4	161.4	174.3
5-day	108.6	133.2	149.5	170.1	185.4	200.6
6-day	118.1	142.9	159.4	180.1	195.5	210.8
7-day	124.9	151.3	168.9	191.0	207.4	223.7
8-day	133.5	162.1	181.0	204.9	222.6	240.3
9-day	142.5	172.9	193.1	218.5	237.4	256.2
10-day	150.6	183.5	205.3	232.9	253.4	273.6

This expanded IDF table formed the basis for all subsequent climate change projection analyses moving forward.

2.2 Climate Change Projections

Climate Change projection analysis consisted of the use of multiple methods, needed for intercomparison of results to understand the associated levels of uncertainty.

- Raw climate information was extracted from an ensemble of 37 IPCC AR5 climate models (IPCC 2013), including seasonal and monthly air temperature projections, as well as monthly precipitation and potential evaporation. This guidance was used for both extreme rainfall projection work as well as longer-term seasonal water balance information.
- Two methods were used for subsequent projection and validation of projected IDF table values:
  - The Clausius-Clapeyron temperature scaling method; and
  - The Climate Analogue method.

The Clausius-Clapeyron (C-Clap) method makes use of the relationship between air temperature and maximum moisture holding capacity, which is roughly an increase of 7% total water capacity for every degree increase in temperature. Adjustments are needed to account for regional and storm type characteristics, and therefore change factors of 6% and 7% were used for long-duration (multi-hour to multi-day) events versus short-duration (1-hour or less) events, respectively. Projected changes in seasonal air temperature and late-summer daytime high air temperatures, respectively, were used for events of long-versus short-duration to correspond with time of year and event durations. Projected air temperatures were based on the multi-model mean, as well as 25th and 75th percentiles, to provide information on the potential range associated with projections.

The climate analogue method uses a combination of changes in average temperature and precipitation to locate other geographical locations with a current climate which is similar to the projected future climate of the Parksville location. Following the identification of these locations, equivalent extreme rainfall design data is obtained for eventual comparison to the results derived from the C-Clap method.

2.2.1 Water Balance Projections

Although the requirements for sub-hourly rainfall data precluded the use of several IDF stations which were physically located closer to Parksville, the water balance analyses were able to use station observations much closer to the study site. Sufficient data is available from the 6km distant Coombs, BC ECCC station (1984-2009). This is adequate to establish representative average conditions for the 1981-2010 normals period from which projections are based.

A detailed description of the water balance information is provided in Appendix A below. Raw statistical projection information supporting water balance calculations have been submitted under separate copy, within the MS Excel spreadsheet entitled ***Appendix B – Parksville BC Water Balance Calculation Information***.

3.0 Conclusions and Results

Analytical results for the mean climate change projections under RCP8.5 for the 2050s and 2080s are provided below in **Table 3** and **Table 4**, respectively. These tables, as well as results for 75th and 25th percentile projections are provided separately in **Appendix C**.

Table 3 - Future Projected DDF for 2050s under RCP8.5. All depths are provided in mm.

Future Projected DDF (mm) – 2050s - RCP8.5						
Duration	*2 year*	*5 year*	*10 year*	*25 year*	*50 year*	*100 year*
5-min	3.3	4.4	5.1	5.9	6.7	7.3
10-min	4.9	6.7	7.8	9.3	10.5	11.5
15-min	5.9	8.4	10.1	12.2	13.8	15.5
30-min	8.4	12.0	14.4	17.5	19.7	21.9
1-h	11.9	15.9	18.7	22.0	24.6	27.1
2-h	17.6	21.5	24.0	27.3	29.6	32.0
6-h	34.1	40.4	44.5	49.8	53.7	57.4
12-h	48.0	57.7	64.1	72.1	78.0	84.0
24-h	63.6	79.7	90.4	104.0	113.9	123.9
2-day	79.9	97.9	109.9	125.0	136.1	147.3
3-day	93.6	113.3	126.3	142.8	155.0	167.1
4-day	109.9	133.9	149.7	169.8	184.7	199.4
5-day	124.2	152.4	171.0	194.6	212.1	229.5
6-day	135.2	163.5	182.3	206.0	223.7	241.1
7-day	142.8	173.1	193.2	218.5	237.3	256.0
8-day	152.7	185.4	207.1	234.4	254.7	274.9
9-day	163.0	197.8	220.9	250.0	271.6	293.0
10-day	172.3	210.0	234.9	266.4	289.8	313.1

Table 4 - Future projected DDF table for 2080s under RCP8.5. All depths are provided in mm.

Future Projected DDF (mm) – 2080s - RCP8.5						
Duration	*2 year*	*5 year*	*10 year*	*25 year*	*50 year*	*100 year*
5-min	3.7	4.9	5.7	6.6	7.4	8.1
10-min	5.4	7.4	8.8	10.4	11.7	12.9
15-min	6.6	9.4	11.3	13.7	15.4	17.3
30-min	9.4	13.4	16.1	19.5	22.1	24.5
1-h	13.3	17.8	20.9	24.6	27.5	30.3
2-h	19.5	23.9	26.6	30.3	32.9	35.5

Future Projected DDF (mm) – 2080s - RCP8.5						
6-h	37.0	43.8	48.2	53.9	58.2	62.2
12-h	52.1	62.5	69.4	78.1	84.6	91.0
24-h	68.9	86.4	98.0	112.7	123.5	134.3
2-day	86.6	106.1	119.1	135.4	147.6	159.6
3-day	101.4	122.8	136.9	154.7	168.0	181.1
4-day	119.1	145.1	162.3	184.0	200.1	216.2
5-day	134.6	165.2	185.4	210.9	229.9	248.7
6-day	146.5	177.2	197.6	223.3	242.4	261.4
7-day	154.8	187.6	209.4	236.8	257.2	277.4
8-day	165.5	201.0	224.4	254.1	276.1	297.9
9-day	176.7	214.4	239.4	271.0	294.4	317.6
10-day	186.7	227.6	254.6	288.8	314.2	339.3

3.1 Current and Future Context for Design Storms

A comparison of projected changes in the 10-year and 100-year 24-hour design storm for minor and major drainage systems has been provided in **Table 5** below. These suggest moderate increases over time from the “current” design values based on Nanaimo Airport, but become significant when compared to change from historical values based on the legacy Parksville South IDF station design values.

Table 5 - Comparison of existing IDF design values to projected changes. Change indicated is change from baseline reference to change in total rainfall depth from Nanaimo Airport to projected IDFs.

Time Period	10-Year 24-Hour	Change from Current Baseline	100-Year 24-Hour	Change from Current Baseline
Historical – Parksville South	64.1 mm	*N/A*	87.4	*N/A*
Current – Nanaimo Airport	79.0 mm	*N/A*	108.3	*N/A*
Future – 2050s	90.4 mm	*+11.4 mm*	123.9 mm	*+15.6 mm*
Future – 2080s	98.0 mm	*+19.0 mm*	134.3 mm	*+26.0 mm*

3.1.1 Comparison to Climate Analogue Regions

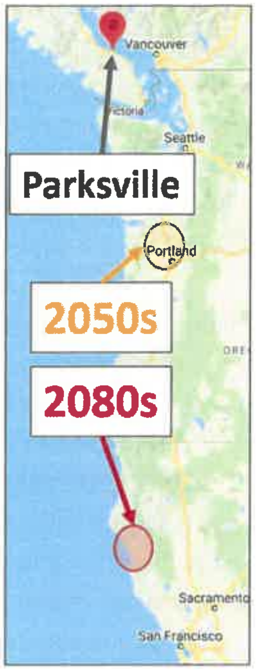

Figure 1 - Analogue regions selected for design rainfall data comparison for Parksville's future climate, based on projections for 2050s and 2080s under RCP8.5.

Climate analogue regions were identified based on projected changes in annual average precipitation and temperature, suggesting the best fit regions are the Portland, Oregon and portion of Northern California near the Mendocino National Forest, for the 2050s and 2080s, respectively (**Figure 1**). Selection of climate analogue locations for Parksville proved to be a challenge compared to other locations in the central and eastern portions of Canada and the United States. Challenges stem from the geography of the Vancouver Island location, as it is unique along the Pacific Northwest coastal region of North America. Central valleys running parallel to the Pacific Coast are analogous to the Strait of Georgia, but are not equivalent. This dynamic is why regions, rather than specific locations were selected for analogue comparison, and these factors are why we do not anticipate correlation to be as close between climate projections and analogue locations as has been demonstrated for other locations in central and eastern North America.

To further complicate the comparison, design rainfall calculations for Washington and Oregon, along with adjacent states to the east, have not been updated on a National level since the 1960s. This constraint means design rainfall depth tables are not immediately available, requiring examination of other sources (e.g., MGS & OCS, 2007) for the design comparison.

The comparison indicates that C-Clap method-based projections for short-duration (5 min to 6-hour) and 24-hour rainfall amounts are higher than the Portland, Oregon analogue region current design rainfall values (not shown), but differences for 5-minute to 2-hour events are generally 5 mm or less. This can be partially explained by restricted moisture access for longer duration (6-hour or longer) events for the Portland region compared to Parksville.

In contrast, C-Clap based projections for the 2080s align very well with the northern California analogue location for storm durations of 2-hours or less (i.e., the majority of C-Clap based projections are within the 90th percentile range for analogue location design values), but are *lower* than analogue location values for storm durations of 6-hours or longer. This can again be partially explained by access to moisture, since the California analogue region for the 2080s is closer to the Pacific coast. Parksville may experience a more pronounced rain shadow effect than locations immediately or very near the Pacific coast due to intervening topography.

3.1.2 1-Hour 100 mm Retention Facility Event

An analysis was conducted to determine the current and future projected changes in return-period for the retention facility design storm. However, results from IDF curve based calculations are likely unreliable due to the extreme nature of this design event. For example, using the current (unadjusted) Nanaimo Airport IDF results in an estimated return period of $1.04x10^{13}$ years, the Nanaimo City Yard station estimate is similar at $4.31x10^{13}$. For comparison, the Earth is estimated to be roughly $4.54x10^{9}$ years old. When comparing this rainfall depth with longer-duration events, these return periods become more reasonable and realistic, down to ~50 years for a 24-hour event and ~13 years for a 2-day event.

Southern Canada is located in what is occasionally referred to as a "mixed" climatic load region, meaning that for a specific location, a particular type of climatic load may be generated by different storm types depending on the time of year and meteorological conditions present on any given day. This has been discussed at length, for example, regarding extreme winds (e.g., Holmes, 2007) [2], which can be generated by any number of storm types. The different storm types, arising from very different sets of conditions, represent different statistical distributions, and one of the potential challenges associated with this is that IDF curves assume all events of the same duration are part of the same statistical population. With extreme winds, this "mixing" of different event types has been shown to *lower* estimated return period wind speeds for longer return periods typical of design values (e.g. 50 year+ return period events; Lombardo et al., 2009), and something similar is likely occurring here.

To better understand the risk posed by extreme short duration rainfall events, it is recommended that a separate, focused study be conducted on hourly and sub-hourly events, with consideration for key storm type characteristics such as time of year and spatial extent.

3.2 Caveats Regarding Use and Interpretation of Climate Projection Results

The new return period rainfall values assume that the current temperature to extreme rainfall scaling relationship will remain valid under changing climate conditions, and that the distribution and contribution of the different types of extreme rainfall events to the IDF curves remain essentially unchanged into the future. This assumes that, as informed by historical mean and standard deviation of rainfall events at each IDF station, the statistical characteristics of rainfall behaviour are unchanged; i.e. only the means of the extreme values for a given return period changes. The current IDF rainfall statistical distribution is entirely based on historical observations, which may not remain static under new climate conditions. Hence, the results of the Clausius-Clapeyron based method employed are considered less certain for projections of more distant future periods. Nevertheless, this methodology is solidly based

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[2] In reference to extreme winds, Holmes (2007) writes, "The need to separate the recorded data by storm type was recognised in the 1970s... These different event types will have different probability distributions and therefore should be statistically analysed separately..."

upon well-understood atmospheric principles and has been applied widely. This includes its use as the main future projection method used for flood planning and design in Australia (Ball et al. 2016), as well as acting as the main method recommended in the most recent version of CSA PLUS 4013:19 *Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information* (CSA, 2019).

Of particular importance to rainfall related impacts in the Pacific Northwest is the behaviour of so-called "atmospheric rivers", known locally as the "Pineapple Express" phenomenon. Research suggests that this, the main sources of moisture for multi-day rainfall events and generally record flooding events along the Pacific coast of North America, may fundamentally change under climate warming. Recent research by PCIC indicates an increase in the frequency and moisture content of individual atmospheric river events. Parksville currently has approximately 20 days per year which meet atmospheric river criteria, with increases projected to over 30 days per year by mid-century under RCP8.5 (Pinna 2014; Sharma & Dery, 2020). The C-Clap method only adjusts for changes in water-holding capacity of the atmosphere, it will not detect fundamental changes in atmospheric circulations which act as "ingredients" for the occurrence of individual weather events. As such, it is recommended that the City of Parksville keep up to date on emerging research on atmospheric rivers, and take steps to consider potential significant increase in multi-day rainfall totals by using atmospheric river events further south (e.g., Northern California) and model rainfall amounts to better understand potential impacts from such events.

4.0 Findings and Suggested Remedial Actions

- Continue to monitor and collect sub-hourly range gauge data within Community Park, with the goal of eventual development of locally-based IDF design information after several additional years of data have been collected.
    - Consider adding one or more additional rain gauges to other locations within of the municipality and/or in partnership with adjacent communities.
        - Maximise spatial coverage and include consideration of key geographical features contributing to flooding (e.g., monitor locations up-stream near or along the Englishman River). Improved spatial distribution of observations can also help compensate for shorter periods of record. When data from multiple representative observation stations are combined, it can increase confidence in results and lessen the impact of shorter observation periods (i.e., regional IDF design curves can be developed sooner if multiple station data sets are available).
- Until locally developed IDF design information is produced based on local monitoring, it is recommended that the City use the updated and expanded design information provided in Table 2 of this report.
- Consider also monitoring snow-water-equivalent values for the winter snow pack for upstream locations. When combined with rainfall monitoring, this information will greatly assist in flood forecasting during the winter season.
    - Monitoring can occur weekly during the winter season, and/or additional measurements can be triggered by the occurrence of heavy snowfall or rainfall events, as well as watches and warnings based on forecasts of particularly heavy rainfall events.
- Consider multi-hazard analysis (Gardoni & LaFave, 2016) to better understand winter flooding events. Events should be treated as either statistically inter-dependant (e.g., heavy rainfall on snow pack) or statistically independent (occurrence of tides concurrent with multi-day rainfall).
- Begin keeping records of flood event impacts, including information on the extent and severity of damage to public and private property and assets, as well as the performance of relevant infrastructure (stormwater drainage, bridge structures, culverts, etc.). These records can then be correlated with monitoring data to better understand linkages between specific impacts and associated rainfall amounts and durations.
- Consider additional study of localised short-duration, high-intensity rainfall events.
    - The Storm Drainage Master Plan (2016) indicates that most catchment areas within Parksville have an approximate 1-hour response time, suggesting extreme rainfall within this time frame is important for understanding overall drainage capacity and potential for overflow of municipal drainage systems.
    - IDF based estimates of return periods for major events (e.g., 1-hour rainfall in excess of ~30 mm, such as the September 2013 event) are likely unreliable due to reasons indicated above regarding the need to conduct statistical analyses on different storm types separately. A regional

study focusing on short-duration events is needed to better understand their true occurrence frequency and statistical characteristics.

- Climate analogues proved less useful for this study, mainly due to the extremely complex topography and associated interactions with weather systems present along North America's Pacific Northwest Coast. While a very good correlation was found between C-Clap based projections and analogue regions for short-duration rainfall events (2-hours or less), longer duration events (6-hours to multi-day events) appear to be much more sensitive to topographical and coastal proximity influences, likely related to moisture access.
- Monitor ongoing climate change research on atmospheric river events and their impacts on the British Columbia coastal region.
  - Changes in the extent and nature of the Pacific atmospheric rivers may fundamentally alter the statistical behaviour of multi-day rainfall events affecting Vancouver Island.
  - As an additional step to evaluate the potential impacts of changes in atmospheric river moisture availability, rainfall modeling could also include making direct use of analogue location design rainfall information. The closer proximity of analogue locations to tropical moisture sources may better replicate potential future changes in atmospheric river total moisture availability for the Parksville area. The purpose of this modeling would be for emergency planning (i.e., "worst case" scenario modeling) rather than for drainage design.
    - For example, modeling the impacts of multi-day rainfall events based on rainfall design data for locations such as Shelter Cove, California, to determine to what extent such an event would overwhelm the City's drainage system.

Appendix A

Parksville Water Balance Calculations and Methods

The following information is provided as a guide to assist in the interpretation and use of attached information for water balance calculations. Each page corresponds to each individual tab held within ***Appendix B***.

Page 1 – Information

The location of Parksville and the approximate location of the observation station used for this analysis are provided in **Figure 2.** Sufficient data is available from the 6km distant Coombs, BC ECCC station (1984-2009). This is adequate to establish average conditions for the 1981-2010 normals period from which projections are based.

Data from three Parksville stations and Qualicum were not deemed useful since they have closed outside of the 1981-2010 baseline or have insufficient data records of daily observations.

Parksville 1915-1960
Parksville Northwest 1961-1965
Parksville South IDF 1967-1993
Qualicum Beach Airport 2006-2018

Figure 2 - Location of ECCC climate stations within and near Parksville. Of these, Coombs was selected as the most representative for monthly water balance calculations.

Page 2 – CoombsHistPrec

On this page we see the historical annual total precipitation for Coombs for the baseline period of 1981-2010. Years with missing data are blank (4 years of the 30 years). There is highly variable year to year variation with an increasing trend in annual precipitation over the period of about 12%.

Page 3 – Water Balance

The request for water balance is based upon the difference between monthly incoming precipitation (observed and projected) versus outgoing potential evaporation. The resulting 'P-PE' value represents the total available water to the system from the atmosphere. As is typical for all locations in Canada where evaporation is minimal in the winter months, P-PE is positive in the winter and negative in the summer, where potential evaporation exceeds incoming precipitation. Of interest for the study is the CHANGE in future P-PE from the existing 1981-2010 P-PE balance.

Coombs historical precipitation by month and individual months, potential evaporation (which is entirely dependent upon average temperature), and the resulting difference between these two variables are presented in tabular and graphical form.

Precipitation (P)

Historical precipitation is much higher in the winter months than the summer, with 1981-2010 maximum values found in November (194mm), and minimal values in July (24mm).

Of particular interest, the driest season summer average total historically is approximately 100mm of the total annual 1131mm.

Projections of precipitation from the ensemble of 38 GCMs shows an increase in annual precipitation of 6.7 and 9.6% for the 2050s and 2080s, respectively, but this is not at all uniform over all months. Projections indicate that the wetter months will become wetter (up to 18% by 2080s in the winter) and driest months will become even drier (up to a 22% decrease in the summer).

Potential Evaporation (PE)

Potential evaporation follows the monthly progression of average temperature, with minimum values in the winter (10mm/month) and maximum evaporation in the summer (over 100mm/month), under the warmest atmospheric conditions. This directly opposed the trend found in precipitation. Projections of potential evaporation from the model ensemble indicate increases in all months of the year since every month is expected to have warmer conditions than under historical/current day conditions.

Water Balance P-PE

The difference between P and PE is used as an indicator of the local water balance conditions. As stated earlier, the study area experiences positive P-PE values (surplus of water) in the cooler months (October to April) and deficits of water from May to September. Cooler months can have surpluses up to 175mm, while warmer months can have a deficit of 75mm historically.

Under climate change from the ensemble average of models, cooler season P-PE show generally increasing water availability. This is in contrast with warmer season deficits in P-PE, which become even greater under climate change projections. This poses an increased likelihood of summertime drought conditions than currently observed. May through September will continue to have deficits in P-PE and it will increase in the future.

Looking specifically at the summer season (Jun-Jul-Aug), P-PE values are projected to decrease by 20% in the 2050s and then 40% by the 2080s compared to the current 1981-2010 conditions. Overall annual change in P-PE is much less, decreasing by only 3.5% by the 2080s. This is because annually, increases in non-summer months offset summertime increased PE loss. This location is an important example of looking not simply at the annual P-PE balance (which is insignificant), but investigating monthly and seasonal changes.

Page 4 – Extreme Precipitation Trends

Extreme precipitation events are projected to increase globally at a larger rate than average precipitation amounts and this is also found here from the model projection ensemble. Two indicators of extreme precipitation are provided here:

1. Greater than 95th percentile daily precipitation (this represents the amount of daily precipitation in the TOP 5% of daily events). The change from the models between the baseline period of 1981-2010 and the 2050s and 2080s is shown in the chart provided. The increase in amounts of the 95th are projected to increase by up to 50% from current values, a value much larger than the average precipitation increase described above. This is consistent with other findings.
2. Greater than 99th percentile daily precipitation (this represents the amount of daily precipitation in the TOP 1% of daily events – the 'extreme' of extreme events). As with the 95th percentile, even larger increases are also projected here from the model ensemble. The extremes become even more extreme. Compared to current climate, the top 1% of daily events are projected to approximately double (increase by near 100%) by the 2080s.

A question often resulting from such large projected extremes is how is this possible if annual changes are much less? The explanation is the distribution of precipitation events must change. Simply put, small events will become less frequent, whereas larger events will become more frequent. When it does rain, these events are likely to be larger and smaller events will be less frequent. One may then deduce that the likelihood of longer dry periods is increased, particularly in the drier summer months.

Page 5 – Dry Periods

Dry periods observed historically are investigated on this page for Coombs, BC. The determination of a dry period requires an uninterrupted daily dataset. A single missing day eliminates a period from the analysis since it cannot be determined if that missing day was dry or not. However, the entire year was discarded if significant data was missing. In the baseline normals period of 1981-2010, the following years are discarded due to missing data: 1981, 1982, 1983, 1989, and 2010.

Projections of dry days are not sufficiently robust from the models to quantify. One might surmise from the large change in projected extremes, however with the small change in average events noted above, increased dry days going forward are likely.

Historically the dry periods are observed in the warmer months of June to September, and in the spreadsheet dry periods are provided for both ANNUAL and SUMMER periods (June-July-August). Annually, the number of consecutive dry days is 6, with the maximum average annual dry period of 23 days/year. The overall maximum dry period observed was 41 consecutive days in 1986, ending on August 27. There is no clear trend in annual number of maximum dry days.

In the summer period of June-July-August, the average dry period is longer, at 8 days, with the average length of the maximum period nearly the same as annual at 22 days. This value is not higher than the annual value, since some very long periods are found as well in September and even into October. These long periods are included in the annual summary just mentioned. Exceptional periods outside the summer period are found from the spreadsheet, for 1987: October, 1988: September, 1991: October, 1992: May, 1993: September, and in 1999: September.

Of interest is there appears to be a trend of increasing summer season dry period extremes, increasing from approximately 20 days in 1984 to 24 days by the end of the record. This is consistent with model projection trends going forward and suggests increasing drought challenges in future summer periods.

Appendix B

Parksville Water Balance: Raw Statistical Information

Appendix Submitted Under Separate Copy

Raw statistical information to support current and future water balance calculations for the City of Parksville has been submitted under separate copy. It is contained within the MS Excel spreadsheet entitled ***Appendix B – Parksville BC Water Balance Calculation Information***.

Appendix C

Parksville Future Design Rainfall Analysis Results

Appendix Submitted Under Separate Copy

Raw statistical information to support current and future design rainfall calculations for the City of Parksville has been submitted under separate copy. It is contained within the MS Excel spreadsheet entitled ***Appendix C – Parksville BC Future Design Rainfall Analysis Results***.

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Appendix C: Coastal Inundation Report

PARKSVILLE COMMUNITY PARK
STORM WATER MANAGEMENT MASTER PLAN
DESIGN CRITERIA DEVELOPMENT – COASTAL ENGINEERING

FINAL REPORT

Prepared for:

Emmons & Olivier Resources Canada Inc.
Toronto, ON

On behalf of:

City of Parksville
Parksville, BC

Prepared by:

Northwest Hydraulic Consultants Ltd.
Nanaimo, BC

10 July 2020

NHC Ref No. 3004985

Report Prepared by:

Laura Ramsden, EIT, M.Sc.
Coastal Engineer

Report Reviewed by:

{Electronic copy for client review

original to be stamped and sealed}

Grant Lamont, P.Eng.
Principal

DISCLAIMER

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1 INTRODUCTION

1.1 Purpose

The purpose of this report is to summarize the design criteria for coastal inundation due to storm events and allowing for future climate change at the Parksville Community Park. The results of this analysis will be used in the development of the Storm Water Management Master Plan (SWMMP). The objectives of this study are to:

- Develop coastal storm events for present day (Year 2020) and future (Year 2100) scenarios, and include the effects of regional sea level rise (RSLR), storm surge, and wave setup on the coastal still water level (SWL);
- Assess storm surge and coastal SWL for the 10-year and 100-year annual exceedance probability (AEP) events; and,
- Map coastal inundation within the existing Parksville Community Park for the above scenarios.

The methodology and results of the metocean assessment for Parksville Park including a background review of the project site (Section 1.2), the metocean assessment (Section 2), and coastal inundation mapping (Section 3) are discussed in the following sections.

1.2 Background

Parksville Community Park is located on the eastern shoreline of Vancouver Island in the City of Parksville, BC as shown in **Figure 1.1**. Parksville Community Park has a northerly exposure within Parksville Bay on the Strait of Georgia.

The park is directly exposed to Northwesterly storms and is sheltered from Southeasterly waves by the Englishman River Estuary. However, Southeasterly storms are the source of significant longshore sediment transport, moving sediment from the Englishman River Estuary into Parksville Bay. A secondary source of sediment may be transported from the bluffs to the northwest of Parksville Bay during Northwesterly wave events. This results in the large beach and long shallow foreshore fronting the park.

Previously, NHC (2015) was retained by the City of Parksville to develop preliminary erosion protection options for Arbutus Point and Sutherland Stairs (**Figure 1.2**). The scope of work for the previous study included the following:

- Significant erosion has occurred at Arbutus Point near the old hovercraft pad. The City required a plan to identify the erosion processes and to determine what steps should be taken to control the current erosion problem. A combination of riprap, anchored large woody debris (LWD) on the backshore and gravel fill on the seaward side of the riprap was recommended. Construction of the preferred option was completed in August 2017.

- Erosion was occurring at the Sutherland Stairs located at Southerland Place approximately 250m south of McMillan Street. Conceptual designs and sketches of erosion mitigation measures were prepared by NHC. This solution was not implemented by the City of Parksville.

- There was a public perception that the existing sandy beach and tidal flats were being covered over by coarse gravel and cobbles. An assessment of the dynamic nature of the beach and factors governing sediment transport along the shoreline was required, including an analysis of wave climate and tidal current conditions and the influence of the Englishman River.

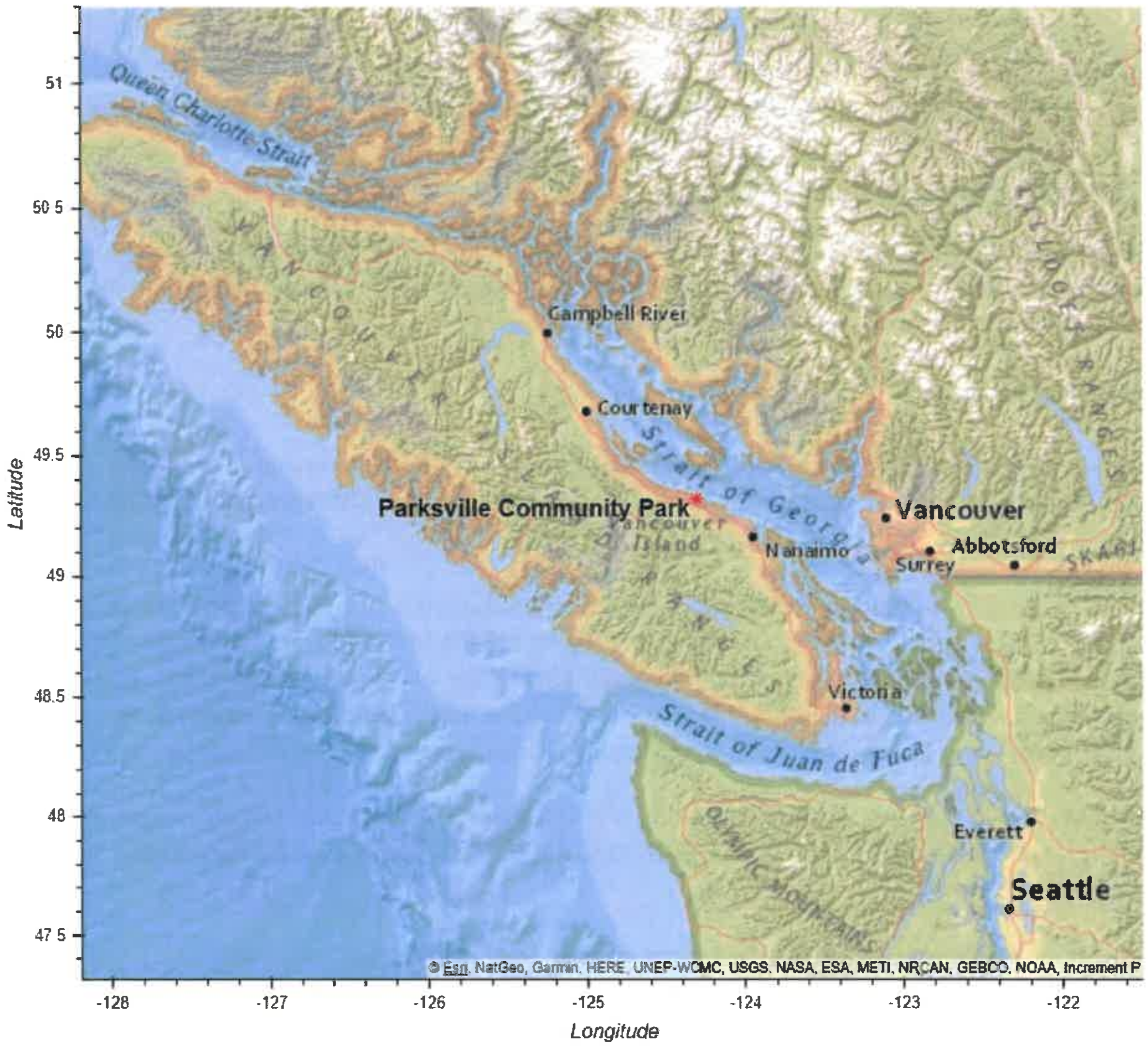

Figure 1.1 Project Location

Figure 1.2 Parksville Community Park and Parksville Bay shoreline

2 METOCEAN STUDY

The metocean assessment includes a review of the regional wind climate, design water levels, and wave modelling for Parksville Community Park. The locations of the metocean stations including wave buoys, wind stations, and tide gauges used in this analysis are shown in **Figure 2.1**.

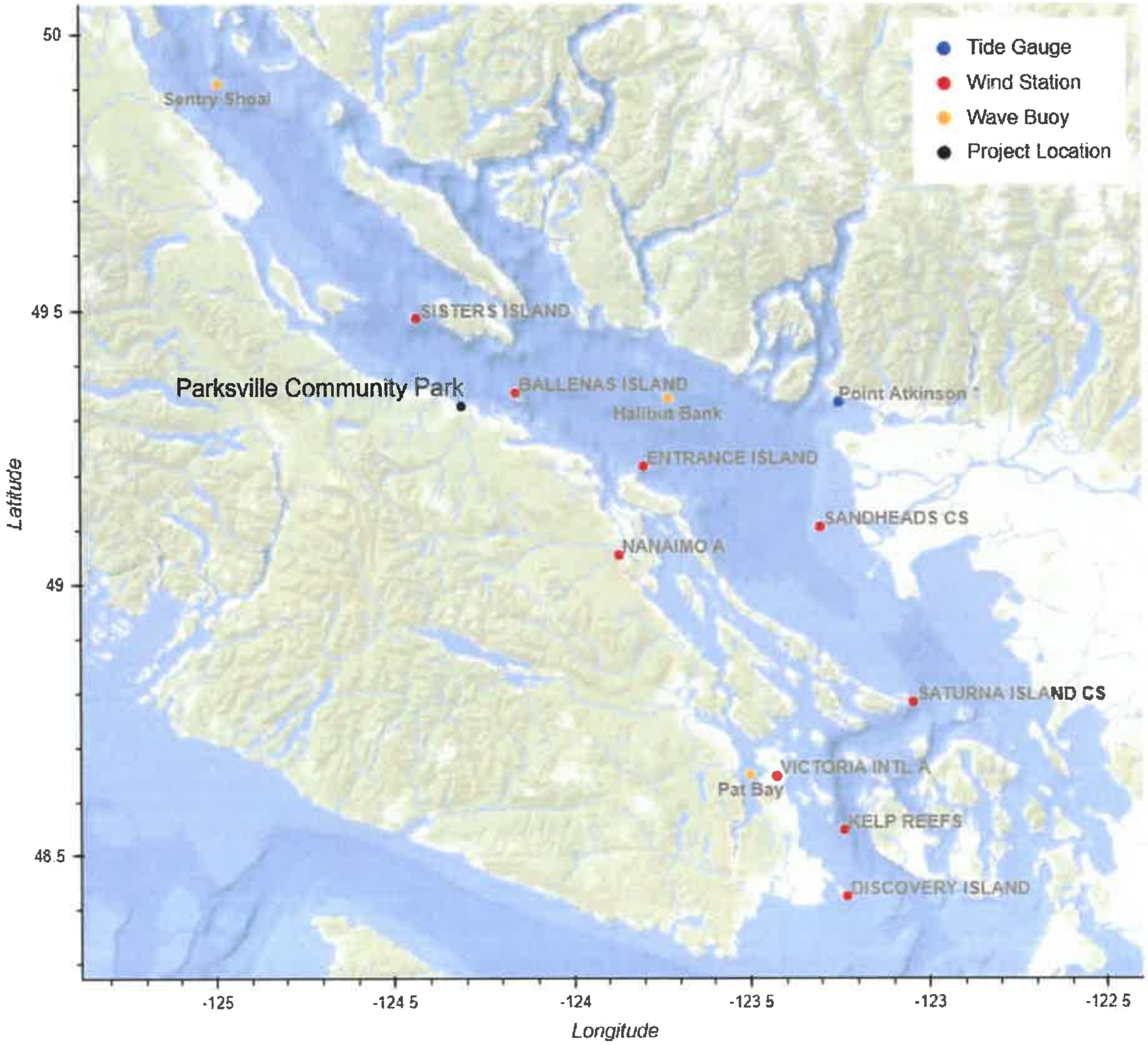

Figure 2.1 Locations of metocean stations used in the analysis and location of the project site

2.1 Water Levels

A water level assessment was completed to determine the range of water levels that the park shorelines may be exposed to over the life of the project. This assessment estimates the design water level using a probabilistic approach which is based on the joint occurrence of tides and storm surge. .

2.1.1 Astronomical Tides

Tide elevations at the project site are based on those predicted for Northwest Bay (CHS, 2019) which, it is noted are based on the Point Atkinson reference station[1]. Tidal ranges are provided in **Table 2.1**.

Table 2.1 – Summary of tides based on Northwest Bay (CHS, 2020)

Sea State	Tide Elevation (m, Chart Datum)	Tide Elevation (m, CGVD2013)
Higher High Water Large Tide (HHWLT)	5.20	2.18
Higher High Water Mean Tide (HHWMT)	4.70	1.68
Mean Water Level (MWL)	3.20	0.18
Lower Low Water Mean Tide (LLWMT)	1.30	-1.73
Lower Low Water Large Tide (LLWLT)	0.20	-2.83

2.1.2 Storm Surge

The Ministry of Environment (2011a) report estimates storm surges for various locations in BC based on water level measurements and tidal predictions at local tide stations. The joint probability of tides and surge or the total water level estimates for the Strait of Georgia are replicated below in **Table 2.2**.

Table 2.2 – Joint probability of tides and surge at Parksville Community Park based on Point Atkinson[2]

Return Period , T_R (years)	Total Water Level (m CGVD2013)
10	2.78
50	2.97
100	3.02
200	3.14

---

[1] The nearest tide predictions by the Canadian Hydrographic Service (CHS) to the project site are for Northwest Bay. Northwest Bay is a secondary station for which tides are based upon Point Atkinson (the primary CHS station for the central Strait of Georgia) and corrected based upon short term measurements at Northwest Bay.

[2] Storm surge predictions in the Strait of Georgia are based upon the long-term water level record from Point Atkinson.

2.1.3 Regional Sea Level Rise

This assessment follows the *Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use* published in 2011 by the BC MOE. The design guidelines recommend planning for 10 mm of Global Seal Level Rise (SLR) per year since 2000 (see **Figure 2.2**), which translates to 1.0 m by year 2100. It should be noted that there is significant uncertainty in sea level rise estimates as can be seen by the wide grey area, and that the level of uncertainty in SLR estimates has generally increased upwards in the time since the BC MOE Report was published.

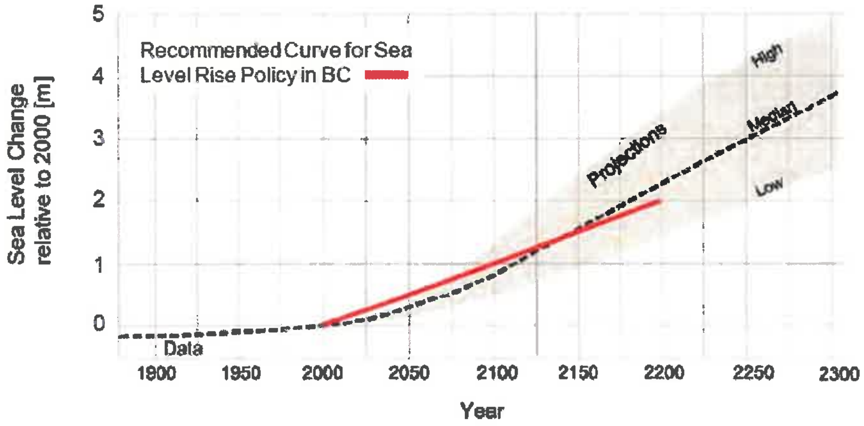

Figure 2.2 – Sea level rise projections recommended for planning and design in BC (MOE, 2011)

In addition to Global SLR, isostatic rebound, tectonic uplift, and/or sediment consolidation may influence the local relative sea level rise (RLSR). Although significant work has been completed to understand the causes and rates of vertical land movement in the Metro Vancouver region, the work generally does not extend to Vancouver Island. The MOE (2011c) does however provide rates of uplift/subsidence various stations across BC. The total vertical land movement for the closest relevant stations are as follows:

Little River Tide Gauge:	+3.0 mm/year
Nanoose Bay GPS:	+2.1 mm/year

These observations suggest that region may experience at least 2.1 mm/year of uplift, or 0.21 m of uplift by year 2100[3].

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[3] Based on year 2000 reference levels as per MOE, 2011.

2.1.4 Design Water Levels for Coastal Inundation Mapping

For the purposes of developing the storm water management master plan and determining coastal inundation limits, coastal still water levels are calculated for the Years 2020 and 2100 for the 10-year and 100-year AEP scenarios. The Coastal Design Water Levels (DWLs) scenarios include the joint probability of occurrence of tides and storm surge, and RSLR (global sea level rise and local uplift) as shown in **Table 2.3**.

Table 2.3 Design Water Levels during the 1-in-10 and 1-in-100 AEP storm event with RSLR for the Years 2020 and 2100

Component	Year 2020 10-year AEP (m CGVD2013)	 100-year AEP (m CGVD2013)	Year 2100 10-year AEP (m CGVD2013)	 100-year AEP (m CGVD2013)
Total Water Level (Storm Surge & Tide)	2.78	3.02	2.78	3.02
Global Sea Level Rise	0.00	0.00	1.00	1.00
Local Uplift	0.00	0.00	-0.21	-0.21
Coastal Design Water Level	**2.78**	**3.02**	**3.57**	**3.81**

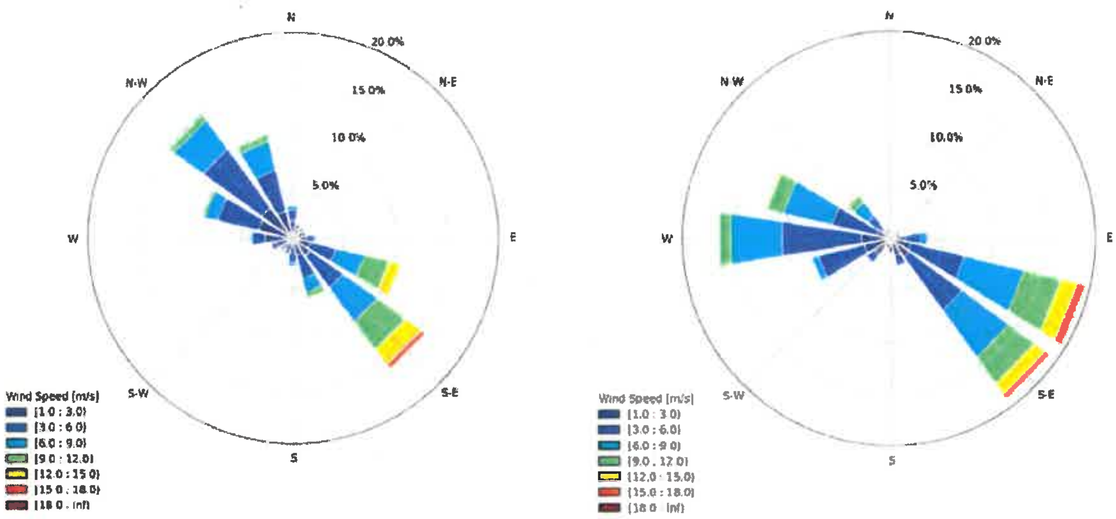
2.2 Wind Analysis

There are several wind stations (**Figure 2.1**) operated by Meteorological Service of Canada (MSC) and the Department of Fisheries and Oceans (DFO) that could be used to define the regional wind climate in the Strait of Georgia. The closest meteorological stations to Parksville Community Park with long-term records suitable for wind analysis are Sisters Island and Ballenas Island (**Table 3.4**). Wind data from these stations was used to define the local wind climate and estimate the annual exceedance probability (AEP) wind events at the project location. The Ballenas Island station is upwind of the project site during NW storm events and was therefore used to predict storm conditions from this direction. Similarly, the Sisters Island station is upwind during SE storm events and was used as a proxy for winds at the project site from this direction.

Table 2.4 – Local wind data sources

Station	Station ID	Period	Location
Sisters Island	1027403	1995 to 2020	49°29'11.800" N 124°26'05.800" W
Ballenas Island	1020590	1994 to 2020	49°21'01.000" N 124°09'37.000" W

The local wind climate can be assessed by the use of a wind rose, a graphic presentation of winds for specified areas, utilizing arrows at the cardinal and inter-cardinal compass points to show the direction from which the winds blow and the magnitude and frequency for a given period of time. Wind roses showing the direction and magnitude of the winds at Sisters Island and Ballenas Island are shown in **Figure 2.3**.



Sisters Island

Ballenas Island

Figure 2.3 Wind rose for Sisters Island (left) and Ballenas Island (right)

The wind roses show the greatest frequency and the greatest wind speeds occur in a southeast/northwest orientation, which corresponds with the orographic forcing from the Strait of Georgia. A frequency analysis was conducted on the Sisters Island data to obtain the design wind speed for the Northwesterly (NW) event, and the Ballenas Island data was used to obtain the design wind speed for the Southeasterly (SE) event. The AEP wind conditions were estimated by fitting the FT-I (Gumbel) extreme value distributions to the historical wind events. Historical wind events were chosen using a peak-over-threshold approach. The results are summarized in Table 2.5.

Table 2.5 Results of Extreme Value Analysis of Southeasterly and Northwesterly Wind Events for Ballenas Island and Sisters Island, respectively

Return Period	Wind Speed (m/s)	
	Southeasterly	Northwesterly
(years)	(Ballenas Island)	(Sisters Island)
1	18.7	15.8
2	19.3	16.7
5	20.1	17.7
10	20.6	18.4
20	21.1	19.2
50	21.9	20.2
100	22.4	20.9
200	22.9	21.6

2.3 Wave Climate

A wave model (Simulating Waves Nearshore or SWAN) of the Strait of Georgia was developed to model wave generation and propagation from deep water into coastal areas and shorelines. SWAN incorporates physical processes such as wave propagation, wave generation by wind, white-capping, shoaling, wave breaking, bottom friction, sub-sea obstacles, wave setup and wave-wave interactions in its computations. SWAN version 41.20 was used for this study.

The AEP of 1-in-10 event and 1-in-100 event for each design wind direction (northwesterly and southeasterly) was conducted for this study to calculate the wave climate in Parksville Bay. For each design AEP event, a spatially varying Strait of Georgia wind field was developed and applied to both the coarse and fine grid models (**Figure 2.4**). A spatially varying Strait of Georgia wind field was developed using wind data from regional wind stations (**Table 2.6**) and applied to the coarse and fine grid models though spatial interpolation of historical storm patterns.

Table 2.6 – Regional wind data sources

Station	Station ID	Period	Location
Entrance Island	EC ID 1022689	1994 – 2020 (Present)	49°12'31.195" N 123°48'38.001" W
Ballenas Island	EC ID 1020590	1994 – 2020 (Present)	49°21'01.000" N 124°09'37.000" W
Nanaimo Airport	EC ID 1025370	1954 – 2013	49°03'16.000" N 123°52'12.000" W
Nanaimo Airport	EC ID 1025365	2014 – 2020 (Present)	49°03'16.000" N 123°52'12.000" W
Sandheads CS	EC ID 1107010	1994 – 2020 (Present)	49°06’21.225" N 123°18'12.123" W
Saturna Island CS	EC ID 1017101	1994 – 2020 (Present)	48°47'02.067" N 123°02'41.082" W
Sisters Island	EC ID 2027403	1995 – 2020 (Present)	49°29'11.800" N 124°26’05.800" W
Victoria Int’l Airport	EC ID 1018620	1953 – 2013	48°38’50.010" N 123°25’33.000" W
Victoria Int’l Airport	EC ID 1018621	2013 – 2020 (Present)	48°38’50.000" N 123°25’33.000" W
Kelp Reefs	EC ID 1013998	1997 – 2020 (Present)	48°32’51.700" N 123°14’13.320" W
Halibut Bank	C46146	1992 – 2020 (Present)	49°20’24.000" N 123°43’48.000" W
Sentry Shoal	C46131	1992 – 2020 (Present)	49°54’36.000" N 124°59’24.000" W
Pat Bay	C46134	2001 – 2016	48°38’60.000" N 123°30’00.000" W

SWAN model results at the Parksville Community Park shoreline are provided in **Table 2.7** for all of the modelling scenarios. **Figure 2.5** shows the SWAN model results for the Strait of Georgia and Parksville Bay grids for the 1-in-100 AEP events for the Northwesterly wind direction for the Year 2100. **Figure 2.6** shows the SWAN model results for the Strait of Georgia and Parksville Bay grids for the 1-in-100 AEP events for the Southeasterly wind direction for the Year 2100. The wave model results for the Year 2020 and 1-in-10 AEP events for the Year 2100 are provided in **Appendix A**.

Table 2.7 SWAN model outputs at Parksville Park shoreline (P02)

Return Period (years)	Design Year	Wind Direction	Wind Speed @ Sisters Island (NW)/ Ballenas Island (SE) (m/s)	H_{m0} (m)	T_p (sec)	Mean Wave Direction (degrees from North)
10	2020	NW	18.4	1.16	7.20	335
100			20.9	1.26	7.20	337
10	2100	NW	18.4	1.45	7.20	338
100			20.9	1.56	7.20	339
10	2020	SE	20.6	0.41	7.98	4
100			22.4	0.49	7.98	7
10	2100	SE	20.6	0.55	7.20	14
100			22.4	0.65	7.98	17

An analysis was also undertaken of the joint occurrence of peak wave heights from storms and the corresponding residual (surge) at the time of the peak winds and waves. For the NW storms, it was found that surge elevations tended to be lower than for SE storms in which there was a positive correlation between the occurrence of the storm and the surge. For large storms from the NW with wave heights above 2.0 m, the corresponding surge was always less than 0.45 m in the record. This is most likely due to the fact that strengthening NW winds are associated with rising atmospheric pressure as noted by R.E. Thomson (1981).

The results of the wave model indicate that the wave effects will be limited to the beach during the present day (Year 2020) scenarios considered in this analysis. However, due to the limited freeboard provided by the pathway along the shoreline in some locations, there is potential for some isolated ponding caused by overtopping. Overtopping rates are provided in the following section for varying beach crest elevations along the shoreline.

During the climate change scenarios for the Year 2100, significant coastal inundation of the park is likely to occur. Wave heights within the inundated park area will likely be limited to less than 0.3 m based on the results of this model. However, the model does not account for the effects of wave breaking[4] on the shoreline, or the propagation of wave energy as wave bores through low lying sections of the shoreline. Detailed wave modelling within the park would need to be undertaken to understand wave energy transmission within the park boundaries, which is outside the scope of this study. Alternatively, future studies could consider how to mitigate climate change impacts caused by RSLR and reduce the potential for coastal inundation within the park in the future.

Potential wave transmission across the Englishman River Estuary during the climate change scenarios for Year 2100 Southeasterly events was not considered in this study. Analysis suggests that wave heights within the saltmarsh estuary will be small.

---

[4] Wave energy is dissipated by wave breaking. The location of wave breaking is typically controlled by the wave height to depth ratio of ~ 0.6 to 0.8. However, this ratio may vary depending on the shape of the cross-shore profile and steepness of the shoreline.

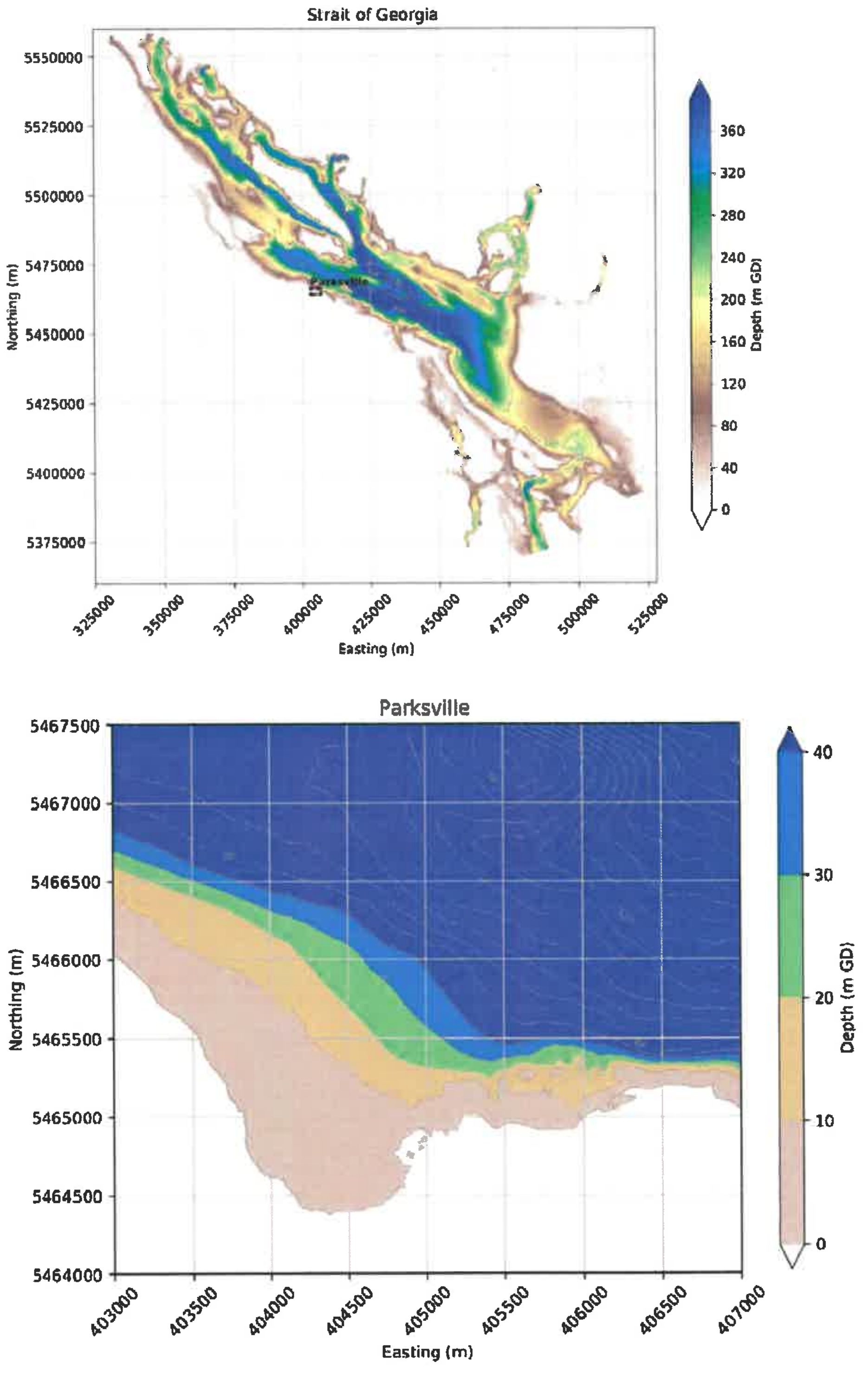
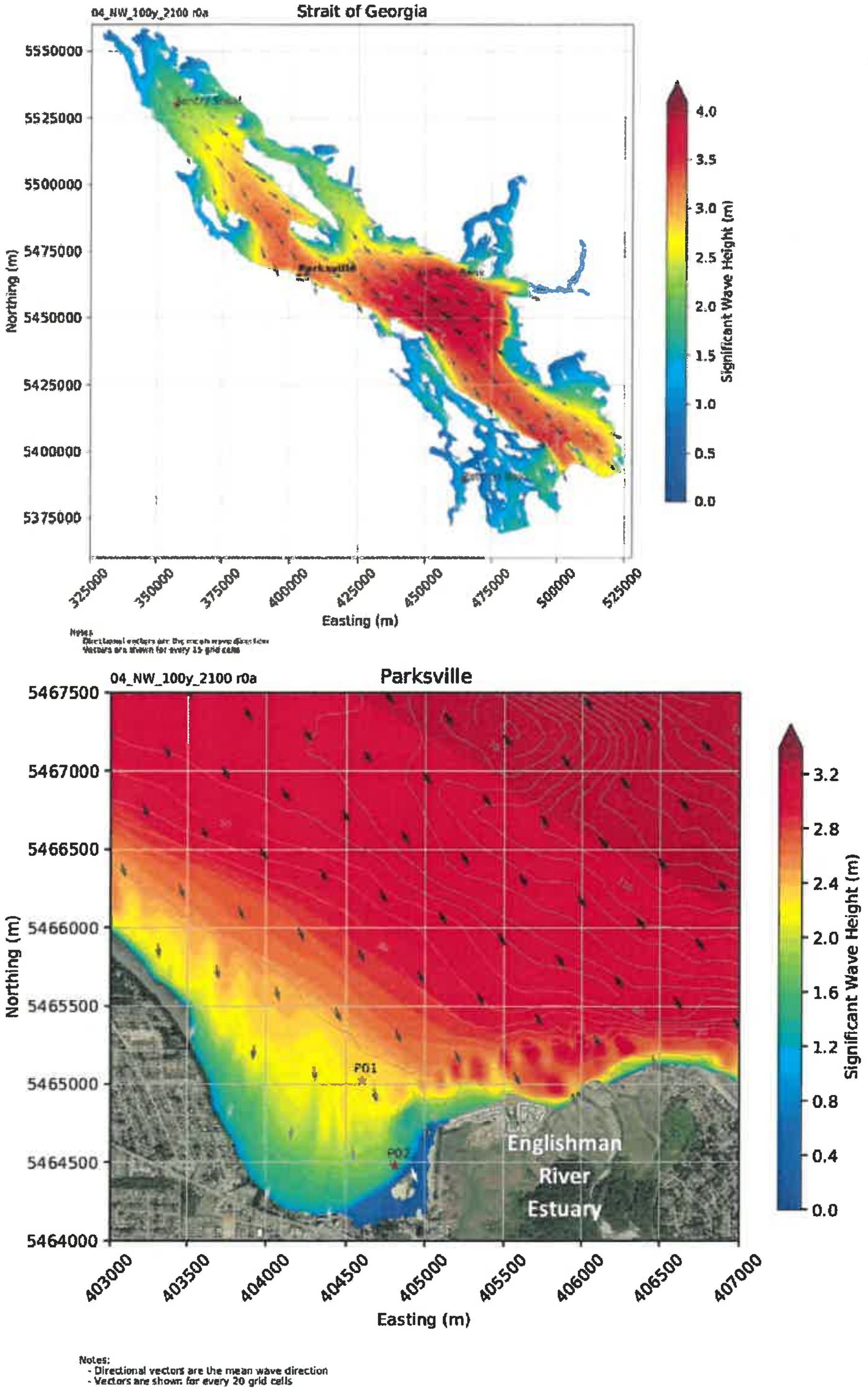


Figure 2.4 SWAN Model bathymetry for the Strait of Georgia (upper) and Parksville Bay (lower)



Notes:
Directional vectors are the mean wave direction
Vectors are shown for every 15 grid cells

Notes:
- Directional vectors are the mean wave direction
- Vectors are shown for every 20 grid cells

Figure 2.5 Northwesterly 1-in-100 AEP for the Year 2100

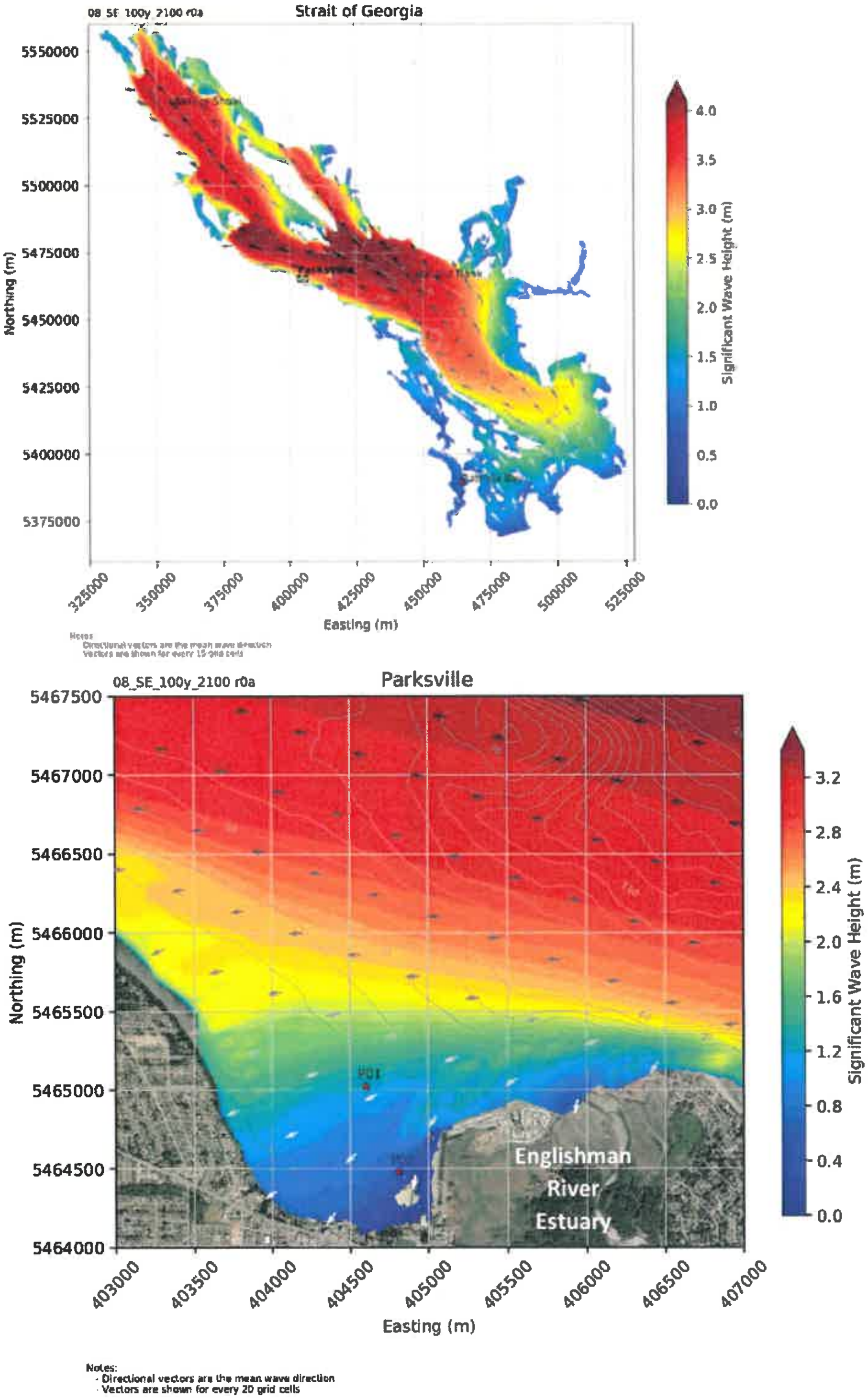


Figure 2.6 Southeasterly 1-in-100 AEP for the Year 2100

2.4 Wave Effects

Wave effects were estimated for the 1-in-10 and 1-in-100 AEP events along the Parksville Community Park shoreline for the Northwesterly events. Wave run-up is calculated for the Year 2020 and Year 2100 climate change scenario, and the calculation assumes the shoreline is raised to mitigate coastal flooding caused by overtopping and RSLR[5]. A one-dimensional section of the beach was considered using the Poate et al (2016) method for a gravel beach. The wave run-up results are provided in **Table 2.8.**

Possible mitigation options could include raising the elevation of the coastal pathway and maintaining the overall shape of the beach through beach nourishment and/or a green shores design that includes vegetation type features to attenuate wave energy.

Wave overtopping was calculated for varying beach crest elevations using the EurOtop manual (2018). Wave overtopping rates for varying beach crest elevations are shown in **Figure 2.7**. These wave overtopping rates would only occur for a short duration during the peak of the storm event, likely lasting only 2 to 3 hours. Wave overtopping and ponding of sea water will likely be the greatest along the western half of the park shoreline, primarily to the southwest of the rock groyne where the beach crest elevation drops to approximately 3.1 m CGVD2013.

Table 2.8 Wave Runup for present day and Year 2100

Return Period (years)	Design Year	Wave Runup R2% (m)	Wave Runup R2% (m)
		SW	NW
10	2020	0.3	1.0
100		0.4	1.1
10	2100	0.4	1.2
100		0.5	1.3

---

[5] Wave runup calculations assume a constant slope that extends above the maximum height of the wave runup. As such, the provide guidance to engineers and planners on how high a shoreline must be raised to remain above the height of wave runup. For example, if the berm along the shoreline is to be raised to prevent coastal flood inundation, it would need to be raised to accommodate 1.3 m of wave runup elevation. This amount of wave runup is not possible on the existing shoreline profile, as the crest elevation is actually submerged with 1m of sea level rise and waves would break as on a reef before washing into the flooded park.

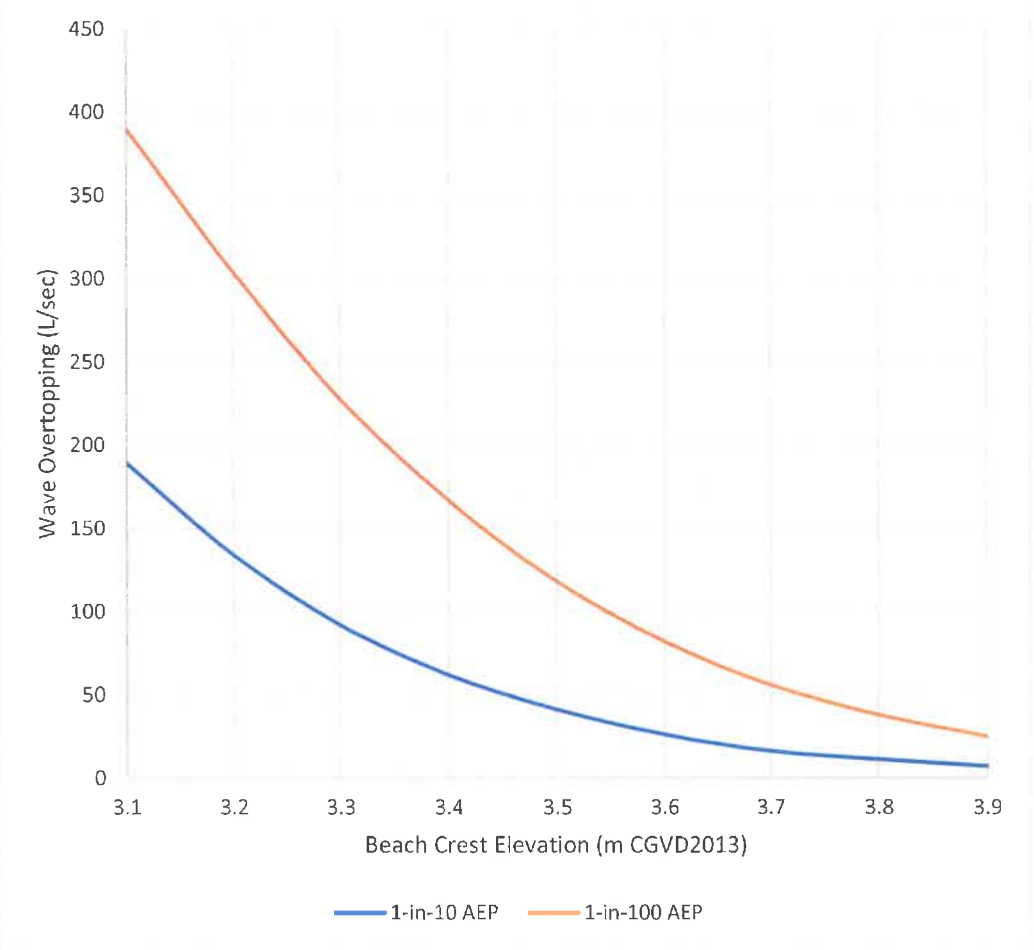


Figure 2.7 Wave overtopping rates for the Northwesterly events for the Year 2020 for varying beach crest elevations measured along the existing shoreline

2.5 Future Natural Boundary

The Flood Construction Level (FCL) is defined as the elevation above which habitable spaces in buildings should be constructed (BC MOE, 2011b). Historically, FCL's were determined based on the location of the Natural Boundary, which is defined by law and can be interpreted as the visible high-water mark, where the presence and action of water has left a distinct variation in the bank, soil, and vegetation characteristics of the shore.

For present day water levels, the Natural Boundary can be established by a Professional Land Surveyor; however, it is not possible to survey the future location of the Natural Boundary due to the effects of sea level rise and other climate change related factors. To overcome this issue, the BC MOE (2011b; 2018) developed a method to estimate the future Natural Boundary based on the Designated Flood Level (DFL) and the wave effects during the designated storm event.

The DFL incorporates the combined effects of tides, storm surge, wind set-up, and local relative sea level rise. The BC MOE guidelines (MOE, 2011b) and subsequent amendment (MOE, 2018) state that either a probabilistic or an additive (combined) method may be used to calculate the DFL and the FCL. The probabilistic (or joint probability) method to determine the estimated Future Natural Boundary uses the following approach:

1. Design Flood Level:
    a. 1/200 AEP total water level (probabilistic analyses of tides and storm surge)
    b. Local relative sea level rise
2. Estimated wave effects (0.5 x R2%)

The estimated Future Natural Boundary elevation for Parksville Community Park is provided in **Table 2.9**.

Table 2.9 Estimated Elevation of Future Natural Boundary (year 2100 climate scenario)

Component	Elevation (m CGVD 2013)
Total Water Level (Storm Surge and Tide)	3.14
Regional Sea Level Rise	0.79
Designated Flood Level (DFL)	**3.93**
Wave Effects (0.5 x Wave Run-Up)	0.25
Estimated Future Natural Boundary Elevation	**4.2**

Note: The estimated future natural boundary has been calculated using a southeasterly storm wave, in which wave runup is estimated at 0.5m. Storms with winds from the SE are more likely to coincide with storm surge based upon correlation analysis of water levels and wind data.

Of note, the estimation of wave runup used above assumes that the shoreline is either presently at or raised to be at this elevation. If the shoreline is not raised in the future in response to sea level rise, then the waves will break along the shoreline and propagate as bores into the generally flat areas of the park and the location of the future natural boundary will become dependent upon the frequency of inundation, land use, soil types, vegetation cover, and other such factors.

3 COASTAL INUNDATION MAPPING

Coastal inundation mapping is shown in **Figure 3.1** for the current and future (Year 2100) timeframes for the 1-in-10 year and 1-in-100 year AEP storm events for the design water levels calculated in Section 2.1. The year 2100 scenario of sea level rise results in significant coastal inundation of the park. Based upon the inundation model:

- It is expected that ocean waves will break upon the park shoreline near to the area of the existing shoreline pathways, and
- wave heights will be generally less than 0.3 m further inland based upon the generally shallow water depths within the park.

The mapping of future inundation assumes that the topography of the park remains unchanged. Also, erosion or loss of elevation at the shoreline could result in increased wave energy penetrating into the park. Future changes in the topography of the park would change the extend of inundation, and if the shoreline elevations change would also change how and where waves break along the shoreline. The coastal inundation analysis would need to be updated should significant changes to topography be proposed.

The coastal inundation mapping completed for this project does not include any potential flooding from the Englishman River. Potential wave transmission across the Englishman River Estuary during the climate change scenarios was not modelled for this study. Desktop review of the incident wave directions and expected wave attenuation within the estuary suggests that wave heights will be small in the estuary adjacent to the park property.

The coastal inundation mapping presented in this report does not account for any upland flows (such as from precipitation runoff) into the park during coastal flood events.

The duration of coastal flooding is typically only on the order of two to three hours due to the astronomical tides. However, the ability of flood waters to recede within the park depends upon proper drainage. The effects of flooding such as the deposition of debris and damage to park infrastructure and vegetation has not been estimated. These effect could persist much longer than the period of coastal flooding.

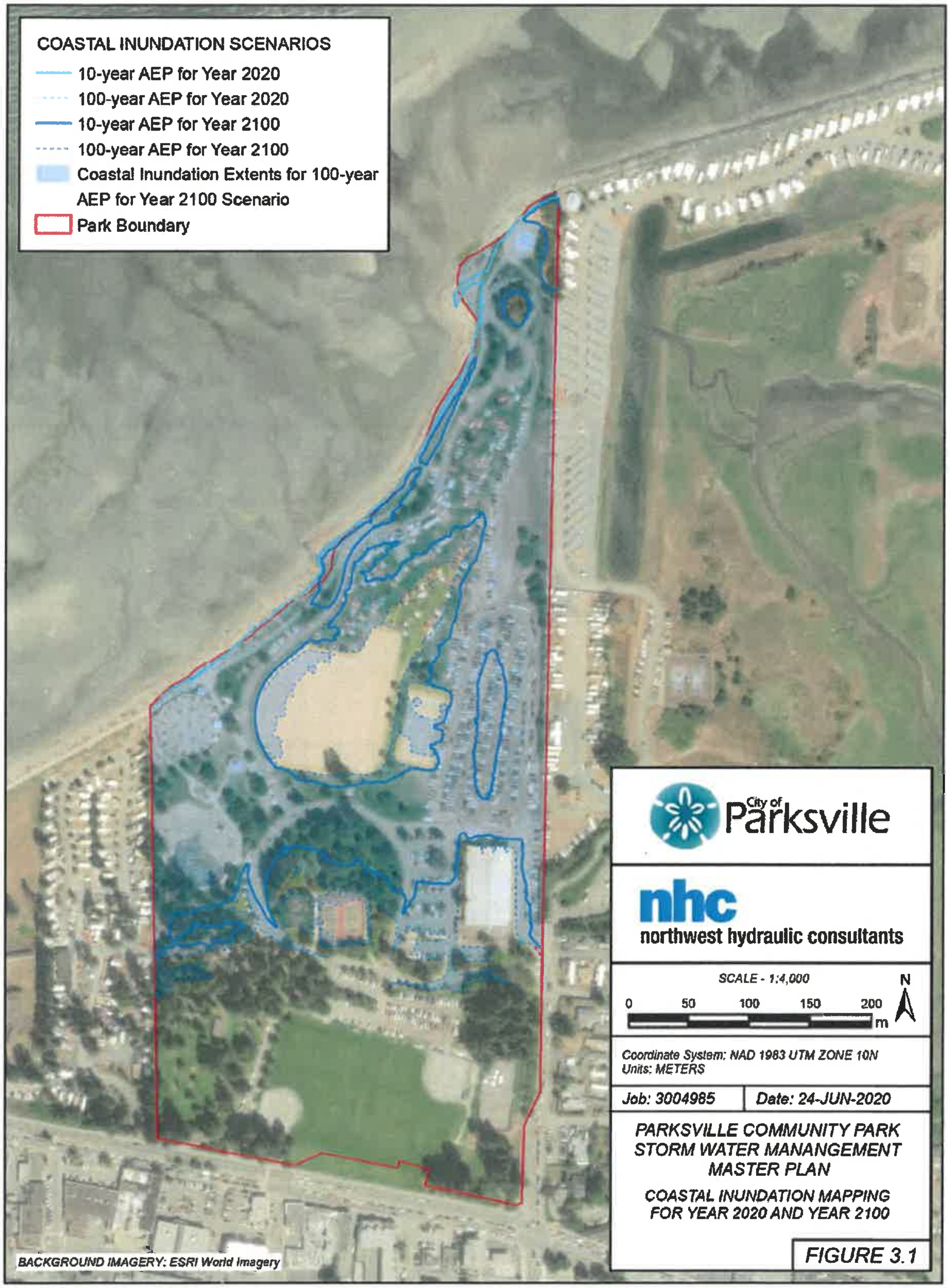

COASTAL INUNDATION SCENARIOS
10-year AEP for Year 2020
100-year AEP for Year 2020
10-year AEP for Year 2100
100-year AEP for Year 2100
Coastal Inundation Extents for 100-year AEP for Year 2100 Scenario
Park Boundary
City of Parksville
nhc
northwest hydraulic consultants
SCALE - 1:4,000
0
50
100
150
200
m
N
Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS
Job: 3004985
Date: 24-JUN-2020
PARKSVILLE COMMUNITY PARK STORM WATER MANANGEMENT MASTER PLAN
COASTAL INUNDATION MAPPING FOR YEAR 2020 AND YEAR 2100
BACKGROUND IMAGERY: ESRI World Imagery

FIGURE 3.1

4 RECOMMENDATIONS

The study indicates that the present park is expected to be inundated from coastal flood events under the year 2100 climate scenario. Ocean waves from the Strait of Georgia will break upon the shoreline and wash into the flooded park areas. Within the park, away from the shoreline, wave heights are expected to be small (typically less than 0.3 m).

Raising areas of the shoreline would provide protection against wave energy penetrating into the park. Not all of the shoreline need be raised, as keeping several select areas at a lower elevation would allow improved drainage for flood water as well as connectivity with the beach. However, redevelopment plans for which parts of the shoreline are kept lower should anticipate and consider coastal flooding and penetration of some wave energy at those locations.

The analysis gives the coastal designated flood level as 3.93 m (CGVD 2013). Allowing for 0.5 m of wave runup (southeasterly storm), and 0.6 m of freeboard as per provincial dike guidelines gives a target elevation for any shoreline berms of 5.0 m CGVD 2013. Lands away from the shoreline should also be raised above the designated future flood level (~ 4.0 m elevation), or alternatively designed with the intention to tolerate temporary periods of inundation from sea water.

5 REFERENCES

BC Ministry of Environment (2011b). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use.

BC Ministry of Environment (2018). Amendment – Section 3.5 and 3.6 – Flood Hazard Area Land Use Management Guidelines.

EurOtop (2018). Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B. [online] Available from: www.overtopping-manual.com.

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Poate, T. G., McCall, R. T., and Masselink, G. (2016). A new parameterisation for runup on gravel beaches. Coastal Engineering, 117, 176–190.

Thomson, R.E. (1981). *Oceanography of the British Columbia Coast*. Canadian Special Publication of Fisheries and Aquatic Sciences 56.

nhc
northwest hydraulic consultants

30 Gostick Place
North Vancouver, BC V7M 3G3
Tel: 604.980.6011
Fax: 604.980.9264

TRANSMITTAL

To: **Kerri Robinson, P.Eng.**

Date: 17-Jul-2020

From: Grant Lamont, P.Eng - NHC

NHC Ref. No. 3004985

Cc: Jessica Wilson, P.Eng - NHC

Via email: krobinson@eorinc.com

Company: **Emmons & Olivier Resources, Inc.**
7030 6th Street North
Oakdale, MN, USA, 55128

Re: Water Level Timeseries for Modeling Purposes
Parksville Community Park STWMP

This document is:
☒ as requested ☒ for your use ☐ for approval
☐ for review and comment ☐ returned to you ☐ for your records

---

Dear Kerry Robinson,

Please find attached an excel spreadsheet entitled *"17072020 3004985 NHC Parksville Water Level Timeseries R0.xlsx"*. The spreadsheet includes a timeseries of water levels from Sept 2019 to April 2020 for the purpose of modeling coastal water levels near Parksville Community Park.

The timeseries is based on measured total water levels at Point Atkinson, which includes the measured astronomical tide as well as residuals from storm surge and wind/wave set-up. These measured water levels have been transformed to the project site (Parksville Community Park) based on adjustments between Point Atkinson and Northwest Bay provided by CHS (CHS, 2020, Canadian Current and Tide Tables, Volume 5 – Juan de Fuca and Strait of Georgia) and adjusted to CGVD2013.

Sincerely,

Northwest Hydraulic Consultants Ltd.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA
J. L. WILSON
48237

17-July-2020

Jessica Wilson, P.Eng – Coastal Engineer

Reviewed by: Grant Lamont, P.Eng - Principal, Senior Coastal Engineer

ENCLOSURE

Appendix D: Geotechnical Report

THURBER ENGINEERING LTD.

CITY OF PARKSVILLE COMMUNITY PARK
STORMWATER MANAGEMENT MASTER PLAN
GEOTECHNICAL REPORT

Report

to

EOR Inc.

Stephen Bean, M.Eng., P. Eng.
Review Principal

Brian Webster
B. R. WEBSTER
41000
July 20/20

Brian Webster, B.Eng., P.Eng.
Project Engineer

Date: July 20, 2020
File: 26367

2302, 4464 Markham Street, Victoria, BC V8Z 7X8 T: 250 727 2201 F: 250 727 3710
thurber.ca

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APPENDIX A

APPENDIX B

1. INTRODUCTION

This report provides the results of our geotechnical investigation carried out in support of a storm water management master plan to be developed for the Parksville Community Park in Parksville, BC. The report is based on the results of a test pit investigation that was undertaken on May 14, 2020 to delineate the subsurface conditions in accessible park areas where the proposed storm water management infrastructure is to be located. The report has been revised to include comments by EOR Inc. (EOR) and the City of Parksville (the City) and supersedes all previous reports.

The scope for the geotechnical services was provided in Thurber's proposal to EOR dated June 4, 2019. Authorization to proceed with the geotechnical investigation was given by the signed Agreement for Services dated July 9, 2019.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions

2. PROJECT UNDERSTANDING

We understand that the City of Parksville (the City) wants to develop a Stormwater Management Plan (SMP) for the Parksville Community Park based on the feasibility of using various green infrastructure options such as infiltration galleries, and underground cisterns to control stormwater in the park. A SMP would also include the evaluation of climate change forecasts, the impact of rising sea levels, storm surges and wave setups for low, medium and high probability storm events.

Thurber Engineering Ltd. (Thurber) has been engaged to provide geotechnical input and recommendations for design and construction of the proposed storm water management systems.

3. SITE GEOLOGY AND SITE DESCRIPTION

Surficial geology in the area (NTS map 92F/08) is characterized by Salish Sediments consisting of shore, deltaic and fluvial deposits of sand, gravel, silt and clay. The park area consists of green space, playing fields and parking areas. The terrain is generally flat at about 5 m elevation rising gradually to the south.

4. GEOTECHNICAL INVESTIGATION

4.1 Field Coordination

On January 30, 2020, Thurber was notified by EOR that an archaeological investigation would be undertaken prior to the geotechnical investigation. On April 27, 2020, EOR notified us that the archaeological investigation had been completed and an updated test pit location plan would be provided based on the findings of the report. A proposed test pit location plan was provided by EOR on May 5, 2020.

In accordance with Thurber's ground disturbance procedures, we initiated a BC One Call to obtain records of buried underground utilities in the vicinity of the test pit locations. Kelly's 1st Call Locating of Lantzville, BC checked for the presence of buried utilities at each test pit location on May 7, 2020.

As requested by the City, a markup of Figure 7.11 of the BC MOTI Traffic Management Manual was prepared on May 12, 2020 to show how pedestrian and vehicle traffic would be controlled while excavating at TP20-1 (TP#6) located in the boulevard on Ravenhill Road. On May 8, 2020, the City provided Thurber with the Archaeological Chance Find Procedure. A copy of this manual was kept onsite by our field personnel during the test pit investigation.

4.2 Test Pit Investigation

Seven test pits (TP20-1 to TP20-7) were excavated on May 14, 2020 using a Yanmar VIO35 mini-excavator operated by Parksville Heavy Equipment to obtain sub-surface information on the thickness and consistency of soils within reach of the excavator at each test pit location. The test pits were excavated to about 3 m depth except at TP20-6 (2.6 m) and at TP20-7 (2.0 m) due to pit walls caving in. Groundwater seepage was encountered in all test pits at the time of excavation, except for TP20-4 to -6. All test pits were backfilled with excavated material and tamped with the excavator bucket.

All test pits were logged in the field by a Thurber representative and were located using a handheld GPS and measurement from existing site features. UTM ground coordinates shown on the test pit logs are approximate based on a hand-held GPS device. The results from the test pit investigation and laboratory testing were used to compile the test pit logs which are included in Appendix A. The test pit locations are shown on Drawing No. 26367-1 and are also included in Appendix A. An environmental assessment was not undertaken as part of the scope of work for this geotechnical investigation. A summary of the test pits is provided in Table 1 below.

TABLE 1
Summary of Test Pits

Test Pit Number	Approximate Location	Pit Depth (m)	Depth to Seepage (m)	Anticipated Stripping Thickness to Acceptable Drainage Layer (m)
TP20-1	Boulevard – Ravenhill Road	3.0	2.3	0.3 m to 0.5m / sand (fill)
TP20-2	Sports Field Gravel Parking	3.0	2.4	0.3 m to 0.5m / sand (fill)
TP20-3	Greenspace near Lacrosse Box	3.0	2.7	0.5 m to 2.3 m / sand
TP20-4	Near Arboretum	3.0	N/A	0.3 m to 1.7 m / sand
TP20-5	Near Skate Park	3.0	N/A	0.2 m to 2.1 m / gravelly sand
TP20-6	Near Kite Field	2.6	N/A	0.2 m to 1.3 m / gravelly sand
TP20-7	Dry Basin	2.0	1.3	0.2 m to 0.4 m / sand

4.3 Laboratory Testing

Disturbed soil grab samples obtained from the test pit investigation were returned to our laboratory for routine visual identification (ASTM D2488) and moisture content (ASTM 4959) determination. Grain size sieve analyses (ASTM C117 / C136) were performed on eight selected samples from TP20-1, -4, -5, and -6. The gradation test results are shown on the test pit logs and are attached in Appendix B. Table 2 below provides a summary of the field and laboratory testing carried out.

TABLE 2
Summary of Field and Laboratory Testing

Test Pit Number	Number of Tests		
	Moisture Content	Visual Identification	C117 / C136
TP20-1	3	3	1
TP20-2	3	3	-
TP20-3	3	3	-
TP20-4	3	3	2
TP20-5	3	3	3
TP20-6	3	3	2
TP20-7	3	3	-

5. SUBSURFACE CONDITIONS

5.1 Soil Conditions

A generalized description of the soil and groundwater conditions encountered in the test pits is provided below. The reader should, however, refer to the test pit logs in Appendix A for a detailed description of the soil and groundwater conditions.

Fill Soils

Organic silt up to about 450 mm thickness was encountered at the surface at all test pit locations and was underlain by granular material consisting of sand, gravelly sand, or sandy gravel to depths up to about 2.4 m below the ground surface. The fill soils also contained variable amounts of organic material, cobble and boulder sized pieces. Brick and metal debris were encountered in the soil sample obtained at about 0.6 m depth in TP20-4. Organic silt with some sand and gravel was encountered at TP20-3 and continued to a depth of about 2.3 m below the ground surface.

Moisture contents ranged between about 5% and 15%. Zones with a higher silt content generally have a higher moisture content. The gravelly sand fill encountered at TP20-3 had a higher silt and organic content resulting in moisture contents generally between 15% and 25%.

The results from the grain size sieve analyses on the samples obtained in TP20-1 and -4 indicates that the material is a medium grained sand with trace gravel and fines content. Sample 1 obtained from TP20-5 and -6 indicate a sandy gravel with trace to some silt (some silt in TP20-5 sample).

Granular Soils

The native granular soils encountered within the test pits generally consisted of gravelly sand, or sand and gravel containing variable amounts of cobbles and silt. Moisture contents of samples ranged between about 5% and 15%. The grain size sieve analyses performed on the samples obtained from TP20-5 at about 2.5 m depth and from TP20-6 at about 1.8 m depth indicated a medium to coarse grained gravelly sand.

Refusal / Bedrock

The test pits were excavated to the extent of the excavator generally about 3 m below the ground surface. Collapsing of pit walls occurred at TP20-5 and -6 inhibiting further excavation. No bedrock or impermeable soils were encountered to the depths excavated within the test pits.

5.2 Groundwater Conditions

Groundwater seepage was observed in all test pits (except for TP20-4 to -6) at depths ranging from 1.3 m (TP20-7) to 2.7 m below the ground surface. Based on historical tide charts available for the Parksville area, a high tide of about 2.7 m occurred at about 6:15 am on May 14, 2020 then dropped to a low tide of about 0.83 m at 1:19 pm. The groundwater table was encountered at a shallower depth in TP20-7 (closest to the ocean) compared to TP20-1 to -TP20-3.

No standpipe piezometers were installed to monitor seasonal fluctuations in the groundwater table. The installation of 2 or 3 standpipe piezometers between the south end and the north end of the park could be implemented to monitor groundwater levels over time (at least 1 year). The data would provide a better indicator of fluctuations that could occur and that could be tied into tidal fluctuations to assess their influence on the readings. Groundwater seepage may rise seasonally and with tidal fluctuations and should be anticipated within and directly above the silty sand and gravel deposits and in closer proximity to the ocean.

6. GEOTECHNICAL COMMENTARY

The geotechnical commentary provided below is based on the results of the test pit investigation, and our understanding of the infrastructure options currently being considered for storm water management at Parksville Community Park. Any changes to the proposed design, or site usage may require modifications to the comments provided herein. It should be noted we have assumed that seismic design is not required for this project. We have not evaluated the potential for widespread liquefaction at this site.

The test pit investigation was developed to obtain sub-surface information on the thickness of overburden soils and to assess the underlying soil and groundwater conditions for possible drainage and detention facilities. The results of the test pit investigation and laboratory testing indicate that the soils are generally representative of free-draining, granular soils that are suitable for the installation of stormwater infrastructure in the areas investigated.

Stormwater management options such as infiltration galleries, cisterns, and detention tanks are considered to be feasible in the areas selected. Grain sieve analyses provide a general indication of the potential infiltration ability of the soil in the zone where the material was sampled. A material with a higher % fines (silt) content would generally be indicative of a lower infiltration rate compared to a material with a lower relative silt content.

An infiltration rate can be estimated from grain size analysis depending on the facility to be installed and the material through which infiltration is desired. Provided the soil particle diameter for 10% of the soil (D_{10}) ranges between 0.1 mm and 2.5 mm, then the infiltration rate (K) can be estimated using various empirical correlations such as Hazen's formula as follows:

$$K = C\,(D_{10})^2$$

As no stormwater infiltration testing has been undertaken at this time, there may be zones that have a variable rate of infiltration. The permeability of soils can vary significantly, even when the soil gradation appears consistent. It is recommended that a conservative approach be employed when sizing infiltration chambers or rock pits. In-situ infiltration testing should be conducted during the design stage where stormwater facilities relying upon infiltration are to be located.

6.1 Site Stripping and Base Preparation

Areas where proposed stormwater infrastructure (ie. pipes, manholes, tanks) is to be located should be stripped of all loose soil, organic material, mixed fill, and construction debris (if present) to expose gravelly sand, sand or sandy gravel. Based on the results from the test pits, excavation below grade to attain acceptable soils could range between 0.3 m and 2.1 m depending on the location.

All softened, disturbed and organic soil will need to be stripped out and wasted prior to placing engineered fill. Some localized sub-excavation may be required depending on the extent of organic and softened or disturbed soils. The subgrade surface will likely consist of silty sand to sandy gravel material.

The approved subgrade should be surface compacted with at least 4 to 6 passes of a vibratory steel drum roller having a minimum weight of 10 tonnes. The prepared subgrade should then be proof-rolled with a loaded gravel truck to check for weak areas prior to placing the sub-base layer. Localized sub-excavation may be required to remove mixed organic fill, or loose, wet, and softened / disturbed soil. A non-woven geotextile fabric (Nilex 4545 or equivalent) could be placed on the subgrade to facilitate compaction and mitigate the migration of fines.

If the excavation width does not permit the use of a drum roller or a gravel truck, then the subgrade surface should be compacted with a heavy diesel plate tamper or a hoe-pak to identify any soft or weak areas prior to placing engineered fill.

No bedrock was encountered to the depths investigated in the test pits. Bedrock is anticipated to be deeper than is required to install the proposed stormwater infrastructure at the site. However, as the bedrock surface can be quite variable, if bedrock is encountered it should be removed to at least 300 mm below the underside of the infrastructure base and backfilled with engineered fill.

All bearing surfaces should be inspected by a qualified geotechnical engineer to confirm that the surface has been adequately prepared and is acceptable prior to placing engineered fill or concrete.

6.2 Temporary Excavations

The existing fill materials and organic deposits, silty sand and gravels should be sloped no steeper than 1H:1V. Excavation at these slopes will usually remain stable during the construction period. The cut slopes may need to be flattened given the potential for granular soils to slough and ravel and particularly if loose soil or groundwater / tidal seepage is encountered.

If it is not feasible to slope soils as described above, then shoring may be required for temporary excavations. Shoring would be subject to Part 20 of the Occupational Health and Safety Regulation. The contractor should be made responsible for all temporary excavations and shoring.

Groundwater is expected to be found within the silty sand, and sand layers. The water level could rise seasonally and with tidal fluctuations. Moderate to heavy groundwater seepage could be encountered during construction depending on the time of year and the depth of excavation. Temporary sumps and pumps are typically adequate to control groundwater inflow during construction of shallow trenches or excavations. Deeper excavations may require more sophisticated dewatering such as well points. The contractor should be responsible for all groundwater control required to allow the installation of stormwater infrastructure construction to proceed in accordance with the project requirements.

6.3 Trench Backfill

Provided the trench bottom is prepared as outlined above, backfill material will likely consist of excavated soils but could also consist of imported fill materials consisting of 25 mm and 75 mm minus crushed gravel. The thickness of backfill will vary depending on the depth of the excavation below invert elevation. Excavated clay (if encountered) should not be used as backfill material within the trench or around manholes, or infiltration galleries.

Where seepage causes difficulties in maintaining a ‘dry’ excavation, it may be necessary to place a material that does not require compaction (such as pea-gravel or drain rock), until conventional backfill can be suitably compacted. If silty sand is encountered in the trench, a non-woven geotextile fabric (ie. Nilex 4545 or equivalent) could be required between the pea-gravel (or drain rock) and the native soils in the excavation, as well as overlying backfill, to prevent the migration of fines.

All backfill materials should be compacted in lifts using vibratory equipment. A maximum lift thickness of 300 mm is recommended, although thinner lifts may be required if small plate packers or jumping jack units are employed, particularly around the duct / conduit zone. Heavy compactive equipment such as hoe-paks should not be utilized around the pipe zone.

Backfill should be compacted to at least 95% of the Modified Proctor Maximum Dry Density (MPMDD) as per the City's 2018 Engineering Standards and Specifications for trench backfill.

6.4 Infiltration Gallery, Detention Tanks

The gallery surrounding the drain pipe or detention tank should consist of drain rock or 25 mm clear crush gravel on all sides. The drain rock should be surrounded with a non-woven geotextile fabric (such as Nilex 4545 or equivalent) to mitigate the transfer of fines into the drainage zone that could impede infiltration.

If there is no piping required to convey water such as in a rock pit or open drainage channel that is designed to infiltrate into the subsurface soils, then it is possible that fines could filter down and potentially clog the fabric. Further assessment would be required to determine if it is feasible to eliminate the fabric layer and would depend on the location and type of stormwater infrastructure that is being installed.

Care should be taken when constructing drainage features to confirm that low permeability fill zones are not located directly below the proposed base of the drainage control feature. The infiltration basins and detention tanks should be adequately sized for the anticipated inflow rate.

In regards to buoyancy, obtaining regular groundwater level readings over a specified design period (at least 1 year) and the type of structure to be installed would be required to assess whether buoyancy would be an issue. The structural implications of fluctuating groundwater levels would need to be assessed by others.

6.5 Re-use of Excavated Soils

Excavated granular soils can be re-used as general site backfill provided the material is clean, free of organics, debris and is not excessively wet. Some moisture conditioning may be required to achieve specified compaction levels. Excavated fine grained soils (silt and clay) are moisture sensitive and should not be used as backfill if encountered.

6.6 Use of Permeable Pavers

We understand that the City Parks department prefers to use permeable pavers where possible. Based on the limited information gathered from the test pit investigation, it is likely that permeable pavers can be used in areas where stormwater management infrastructure could be located. Additional field investigation such as test pitting or drilling would likely be required in the proposed areas to provide the geotechnical recommendations required for design of the pavers.

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

THURBER

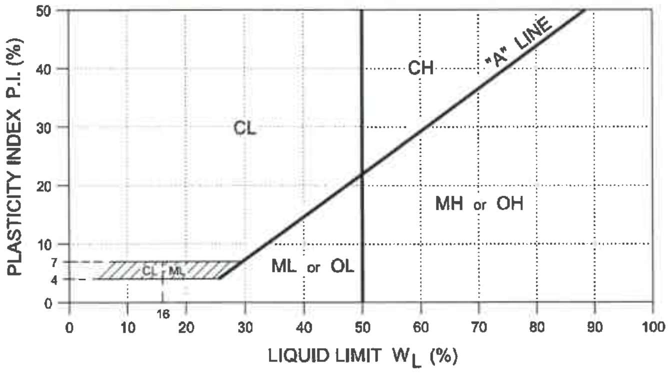
APPENDIX A

THURBER

UNIFIED CLASSIFICATION SYSTEM FOR SOILS (ASTM D2487)

MAJOR DIVISION			SYMBOLS		TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
			GROUP	GRAPH		
COARSE-GRAINED SOILS (MORE THAN 50% BY WEIGHT RETAINED ON No. 200 SIEVE)	GRAVELS MORE THAN 50% COARSE FRACTION RETAINED ON No. 4 SIEVE	CLEAN GRAVELS (< 5% FINES)	**GW**	▨	WELL GRADED GRAVEL and WELL GRADED GRAVEL with SAND.	$C_U = \frac{D_{60}}{D_{10}} \geq 4 \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			GP	▨	POORLY GRADED GRAVEL and POORLY GRADED GRAVEL with SAND.	NOT MEETING ABOVE REQUIREMENTS
		GRAVELS WITH FINES (> 12% FINES)	**GM**	▨	SILTY GRAVEL, GRAVEL - SAND - SILT MIXTURES.	FINES CLASSIFY AS ML or MH $^{(3)}$
			GC	▨	CLAYEY GRAVEL, GRAVEL - SAND - CLAY MIXTURES.	FINES CLASSIFY AS CL or CH $^{(3)}$
	SANDS MORE THAN 50% COARSE FRACTION PASSES No. 4 SIEVE	CLEAN SANDS (< 5% FINES)	**SW**	▨	WELL GRADED SAND and WELL GRADED SAND with GRAVEL	$C_U = \frac{D_{60}}{D_{10}} \geq 6 \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			SP	▨	POORLY GRADED SAND and POORLY GRADED SAND with GRAVEL.	NOT MEETING ABOVE REQUIREMENTS
		SANDS WITH FINES (> 12% FINES)	**SM**	▨	SILTY SAND, SAND - SILT MIXTURES.	FINES CLASSIFY AS ML or MH $^{(3)}$
			SC	▨	CLAYEY SAND, SAND - CLAY MIXTURES.	FINES CLASSIFY AS CL or CH $^{(3)}$
FINE-GRAINED SOILS (MORE THAN 50% BY WEIGHT PASSES No. 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	**ML**	▨	INORGANIC SILTS, SILTS with SAND and SILTS with GRAVEL and SANDY or GRAVELLY SILTS.	P.I. < 4 or PLOTS BELOW THE "A" LINE
		$W_L > 50\%$	**MH**	▨	INORGANIC SILTS, SILTS with SAND & SILTS with GRAVEL & SANDY or GRAVELLY SILTS, FINE SANDY or SILTY SOILS.	P.I. PLOTS BELOW THE "A" LINE
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	**CL**	▨	INORGANIC CLAYS of LOW PLASTICITY, GRAVELLY, SANDY, or SILTY CLAYS, LEAN CLAYS.	P.I. > 7 and PLOTS ON OR ABOVE THE "A" LINE
		W_L near 50%	**CL-CH**	▨	BORDERLINE INORGANIC CLAYS and SILTY CLAYS with LIQUID LIMITS NEAR 50%.	(only used for visual identification)
		$W_L > 50\%$	**CH**	▨	INORGANIC CLAYS of HIGH PLASTICITY, FAT CLAYS.	P.I. PLOTS ON OR ABOVE THE "A" LINE
	ORGANIC SILTS and CLAYS	$W_L < 50\%$	**OL**	▨	ORGANIC SILTS and ORGANIC SILTY CLAYS of LOW PLASTICITY.	$\frac{W_L \text{ (oven dried)}}{W_L \text{ (not dried)}} < 0.75$
		$W_L > 50\%$	**OH**	▨	ORGANIC CLAYS OF HIGH PLASTICITY.	$\frac{W_L \text{ (oven dried)}}{W_L \text{ (not dried)}} < 0.75$
HIGHLY ORGANIC SOILS			**PT**	▨	PEAT and other HIGHLY ORGANIC SOILS.	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE.

PLASTICITY CHART FOR SOILS PASSING No. 40 SIEVE



NOTES:

1. ALL SIEVE SIZES ARE U.S. STANDARD, A.S.T.M. E11-04.
2. COARSE GRAINED SOILS WITH 5 TO 12% FINES REQUIRE DUAL SYMBOLS (GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC).
3. IF FINES CLASSIFY CL-ML USE DUAL SYMBOL (GC-GM or SC-SM).
4. WHERE TESTING IS NOT CARRIED OUT, THE IDENTIFICATIONS ARE DETERMINED BY VISUAL-MANUAL PROCEDURES DESCRIBED IN ASTM D2488-06.

Client: TEL Standard Detail
File No.: n/a
E-File: UCSFS-20140807.dwg

Revised: August 07, 2014

THURBER

SYMBOLS AND TERMS USED ON TEST LOGS

1. PARTICLE SIZE CLASSIFICATION OF MINERAL SOILS

DESCRIPTION		APPARENT PARTICLE SIZE
BOULDERS		> 200 mm
COBBLES		75 mm to 200 mm
GRAVEL	coarse	19 mm to 75 mm
	fine	4.75 mm to 19 mm
SAND	coarse	2 mm to 4.75 mm
	medium	0.475 mm to 2 mm
	fine	0.075 mm to 0.475 mm
SILT		Non-plastic particles, not visible to the naked eye
CLAY		Plastic particles, not visible to the naked eye

NOTE: Metric Conversion is approximate only

2. TERMS DESCRIBING CONSISTENCY (Cohesive Soils Only)

DESCRIPTION	APPROXIMATE UNDRAINED SHEAR STRENGTH
Very Soft	Less than 10 kPa (250 psf)
Soft	10 to 25 kPa (250 - 500 psf)
Firm	25 to 50 kPa (500 - 1000 psf)
Stiff	50 to 100 kPa (1000 - 2000 psf)
Very Stiff	100 to 200 kPa (2000 - 4000 psf)
Hard	Greater than 200 kPa (4000 psf)

NOTE: Metric Conversion is approximate only

3. TERMS DESCRIBING DENSITY (Cohesionless Soils Only)

DESCRIPTION	STANDARD PENETRATION TEST Number of blows per foot (300 mm) *
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	over 50

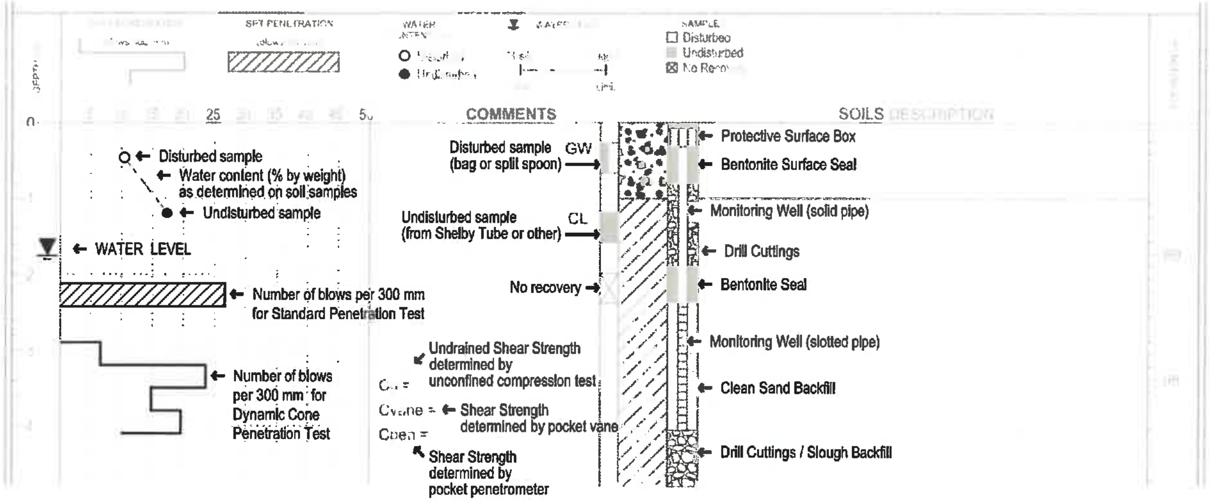
** Directly applicable to sands and, with interpretation, to gravels*

4. PROPORTION OF MINOR COMPONENTS BY WEIGHT

DESCRIPTION	PERCENT BY WEIGHT
and	35 to 50 %
y / ey	20 to 35 %
some	10 to 20 %
trace	less than 10 %

EXAMPLE: Silty SAND, trace of gravel = Sand with 20 to 35% silt and up to 10% gravel, by dry weight. (Percentages of secondary materials are estimates based on visual and tactile assessment of samples).

5. LEGEND FOR TEST HOLE LOGS *(Typical only showing commonly included elements)*



Client: TEL Standard Detail
File No.: n/a
E-File: UCSFS-20140807.dwg

Revised: August 07, 2014

Sheet 1 of 1

LOG OF TEST PIT

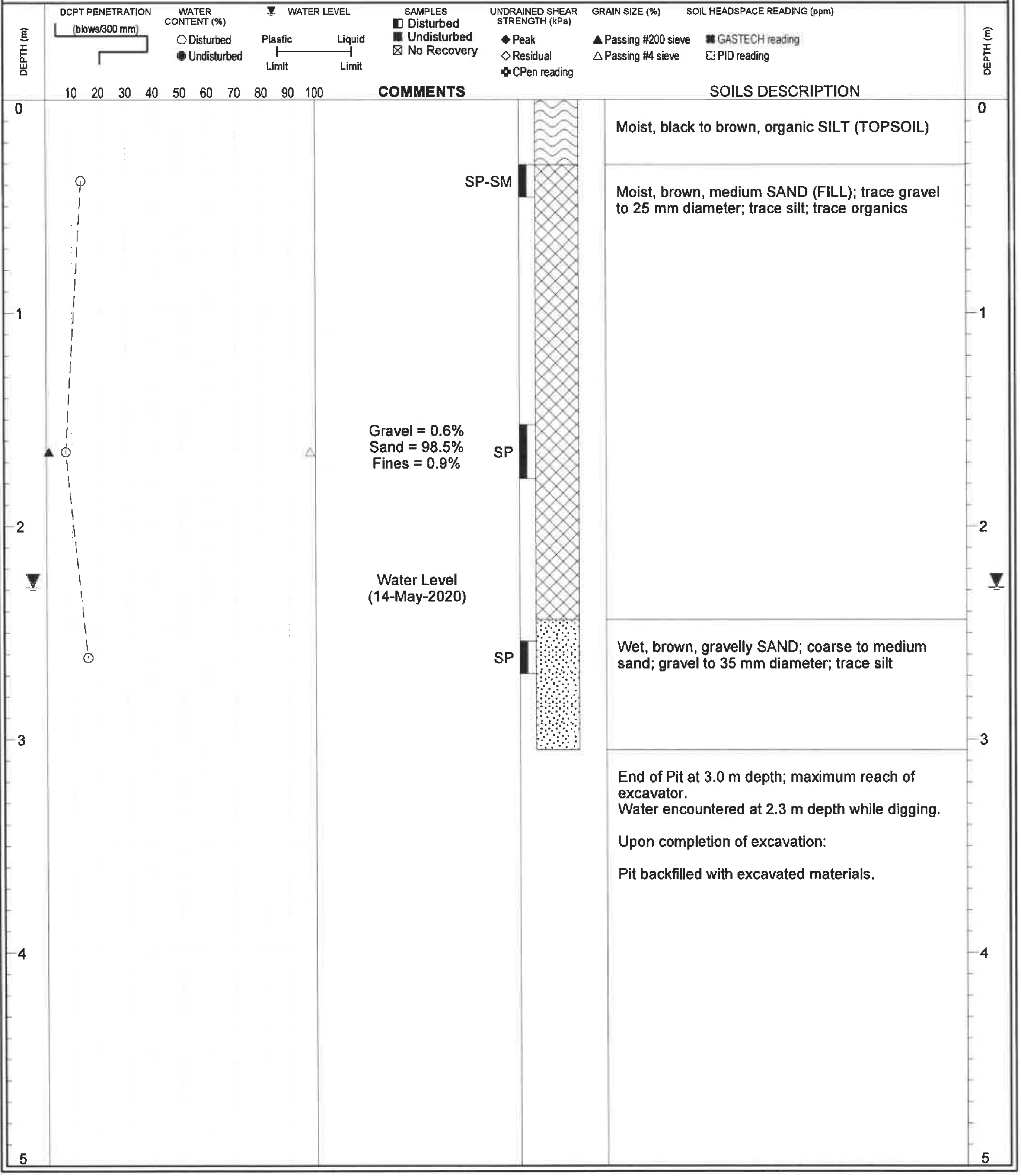
TEST PIT NO.
TP20-1

THURBER

LOCATION: See Drawing No. 26367-1
N 5464024 E 404791 (Approx.)
UTM NAD 83 Zone 10U
TOP OF HOLE ELEV:
METHOD: Yanmar VIO35 Mini-Excavator
DRILLING CO.: Parksville Heavy Equipment
INSPECTOR: BTS

CLIENT: EOR INC.
PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation
DATE: 14-May-2020
FILE NO.: 26367

DCPT PENETRATION (blows/300 mm)
WATER CONTENT (%): ○ Disturbed ● Undisturbed
WATER LEVEL: Plastic Limit ├──┤ Liquid Limit
SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery
UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ✚ CPen reading
GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve
SOIL HEADSPACE READING (ppm): ■ GASTECH reading ☐ PID reading



COMMENTS

Gravel = 0.6%
Sand = 98.5%
Fines = 0.9%

Water Level
(14-May-2020)

SOILS DESCRIPTION

Moist, black to brown, organic SILT (TOPSOIL)

Moist, brown, medium SAND (FILL); trace gravel to 25 mm diameter; trace silt; trace organics

Wet, brown, gravelly SAND; coarse to medium sand; gravel to 35 mm diameter; trace silt

End of Pit at 3.0 m depth; maximum reach of excavator.
Water encountered at 2.3 m depth while digging.

Upon completion of excavation:

Pit backfilled with excavated materials.

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP20-2**

THURBER

LOCATION: See Drawing No. 26367-1
N 5464084 E 404945 (Approx.)
UTM NAD 83 Zone 10U

TOP OF HOLE ELEV:

METHOD: Yanmar VIO35 Mini-Excavator

DRILLING CO.: Parksville Heavy Equipment

INSPECTOR: BTS

CLIENT: EOR INC.

PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation

DATE: 14-May-2020

FILE NO.: 26367

DEPTH (m)

DCPT PENETRATION (blows/300 mm)

WATER CONTENT (%): ○ Disturbed ● Undisturbed

Plastic Limit — Liquid Limit

WATER LEVEL

SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery

UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ✤ CPen reading

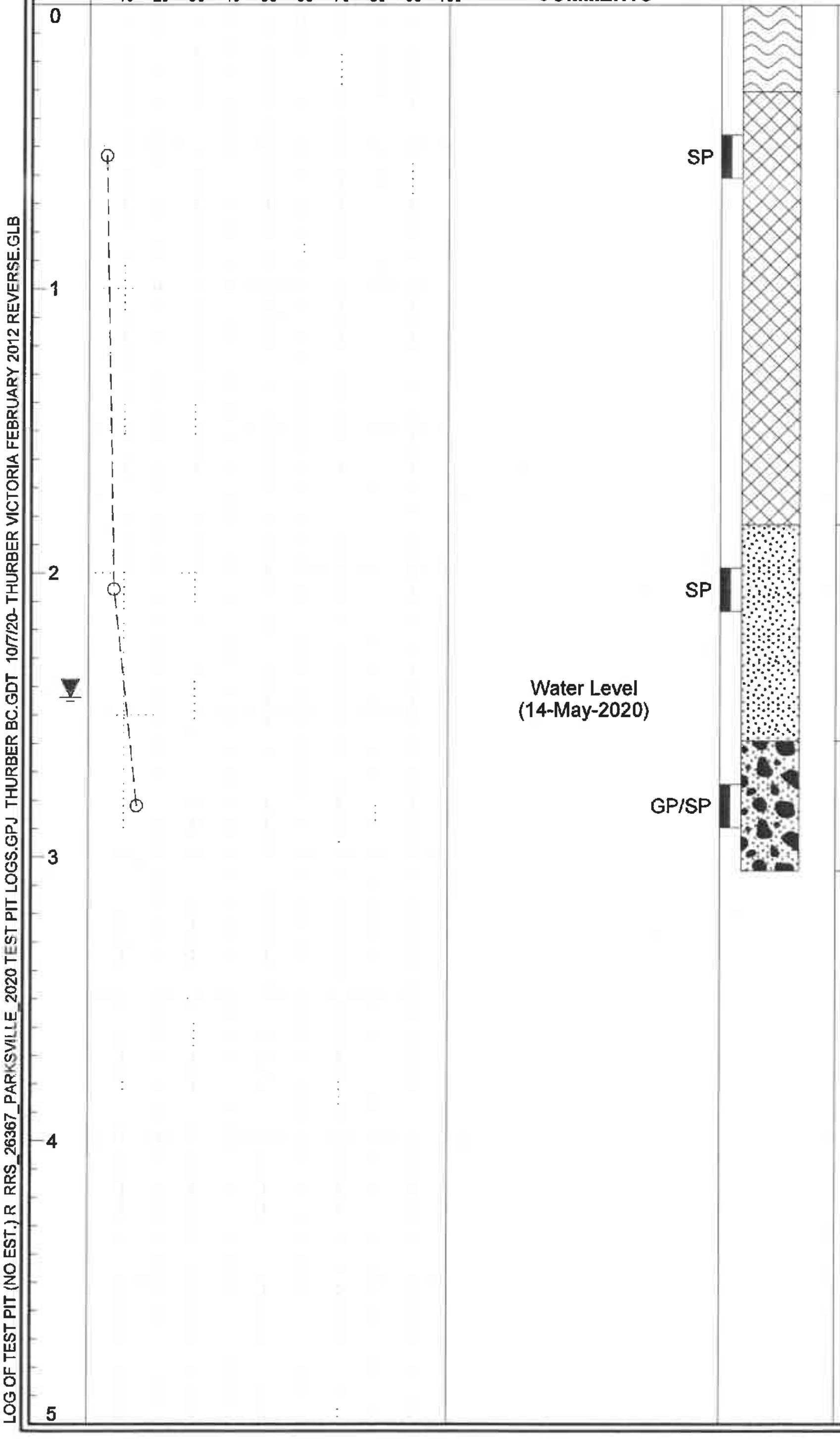
GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve

SOIL HEADSPACE READING (ppm): GASTECH reading PID reading

10 20 30 40 50 60 70 80 90 100

COMMENTS

SOILS DESCRIPTION



Moist, black to brown, organic SILT (TOPSOIL)

Moist, brown, medium SAND (FILL); trace to some gravel to 25 mm diameter; trace silt; trace organics

Moist to wet, brown, gravelly SAND; gravel to 25 mm diameter; trace silt

Wet, brown SAND and GRAVEL; gravel to 30 mm diameter; coarse to medium sand; trace silt

End of Pit at 3.0 m depth; maximum reach of excavator.
Water encountered at 2.4 m depth while digging.

Upon completion of excavation:

Pit backfilled with excavated materials.

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP20-3**

LOCATION: See Drawing No. 26367-1
N 5464007 E 404997 (Approx.)
UTM NAD 83 Zone 10U

TOP OF HOLE ELEV:

METHOD: Yanmar VIO35 Mini-Excavator

DRILLING CO.: Parksville Heavy Equipment

INSPECTOR: BTS

THURBER

CLIENT: EOR INC.

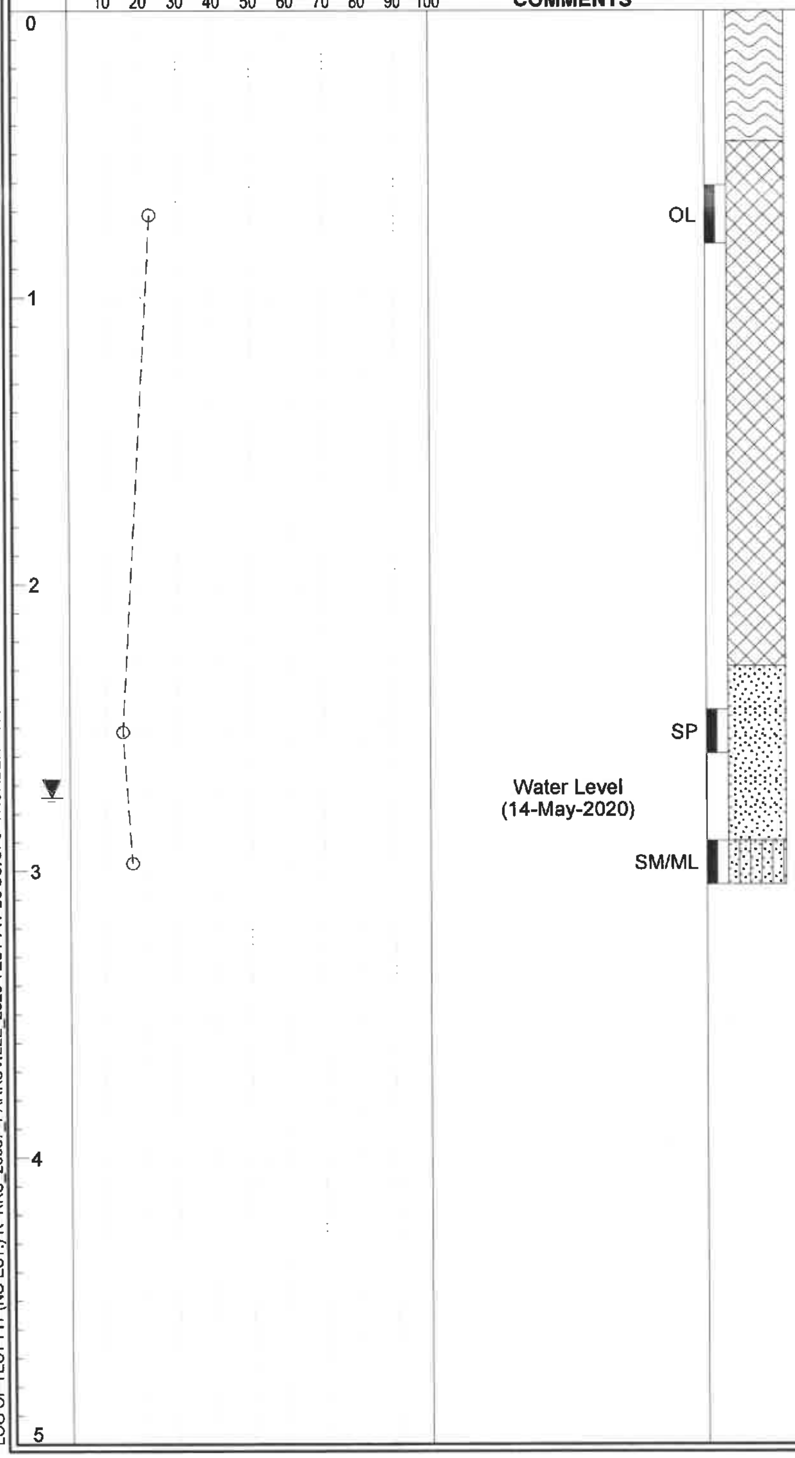
PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation

DATE: 14-May-2020

FILE NO.: 26367

DEPTH (m) | DCPT PENETRATION (blows/300 mm) | WATER CONTENT (%) ○ Disturbed ● Undisturbed | ⊻ WATER LEVEL | Plastic Limit — Liquid Limit | SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual ✚ CPen reading | GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm) ▩ GASTECH reading ☒ PID reading

10 20 30 40 50 60 70 80 90 100 **COMMENTS** SOILS DESCRIPTION



Water Level
(14-May-2020)

Moist, black to brown, organic SILT (TOPSOIL)

Moist, dark brown, organic SILT (FILL); some gravel to 30 mm diameter; some sand; contains roots

Wet, brown SAND; medium to coarse sand; some gravel to 40 mm diameter; trace silt

Wet, brown, silty SAND; some gravel to 25 mm diameter

End of Pit at 3.0 m depth; maximum reach of excavator.
Water encountered at 2.7 m depth while digging.

Upon completion of excavation:

Pit backfilled with excavated materials.

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO.
TP20-4

THURBER

LOCATION: See Drawing No. 26367-1
N 5464113 E 404880 (Approx.)
UTM NAD 83 Zone 10U

TOP OF HOLE ELEV:

METHOD: Yanmar VIO35 Mini-Excavator

DRILLING CO.: Parkesville Heavy Equipment

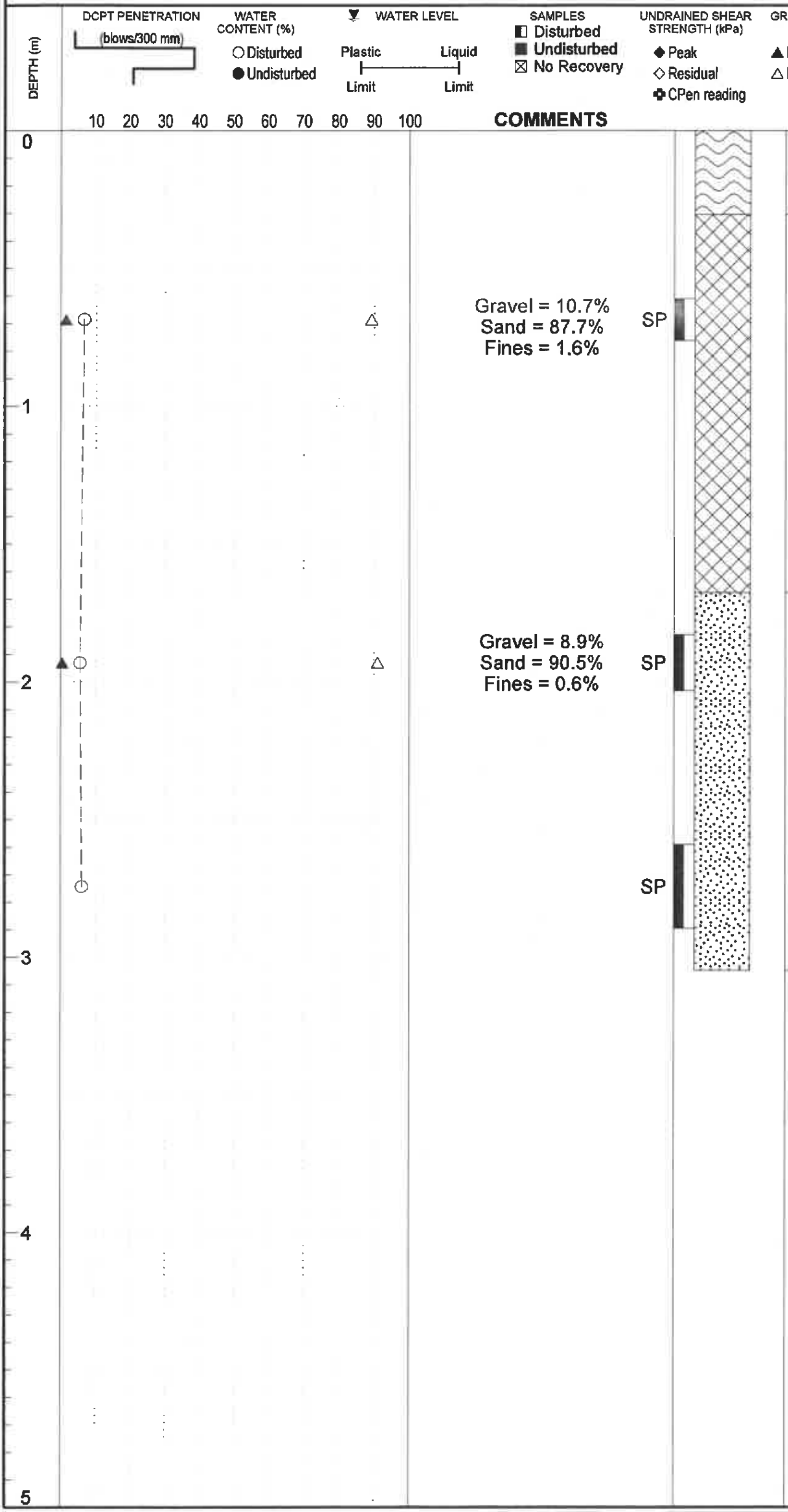
INSPECTOR: BTS

CLIENT: EOR INC.

PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation

DATE: 14-May-2020

FILE NO.: 26367



SOIL HEADSPACE READING (ppm)
✖ GASTECH reading
☒ PID reading

COMMENTS

Gravel = 10.7%
Sand = 87.7%
Fines = 1.6%

Gravel = 8.9%
Sand = 90.5%
Fines = 0.6%

SOILS DESCRIPTION

Moist, black to brown, organic SILT (TOPSOIL)

Moist, brown, medium SAND (FILL); trace gravel to 35 mm diameter; contains pieces of brick and metal debris

Moist, brown, medium to coarse SAND; trace gravel to 40 mm diameter

End of Pit at 3.0 m depth; maximum reach of excavator.
No water encountered while digging.

Upon completion of excavation:

Pit backfilled with excavated materials.

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP20-5**

THURBER

LOCATION: See Drawing No. 26367-1
N 5464239 E 404910 (Approx.)
UTM NAD 83 Zone 10U

TOP OF HOLE ELEV:

METHOD: Yanmar VIO35 Mini-Excavator

DRILLING CO.: Parksville Heavy Equipment

INSPECTOR: BTS

CLIENT: EOR INC.

PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation

DATE: 14-May-2020

FILE NO.: 26367

DCPT PENETRATION (blows/300 mm)

WATER CONTENT (%)
○ Disturbed
● Undisturbed

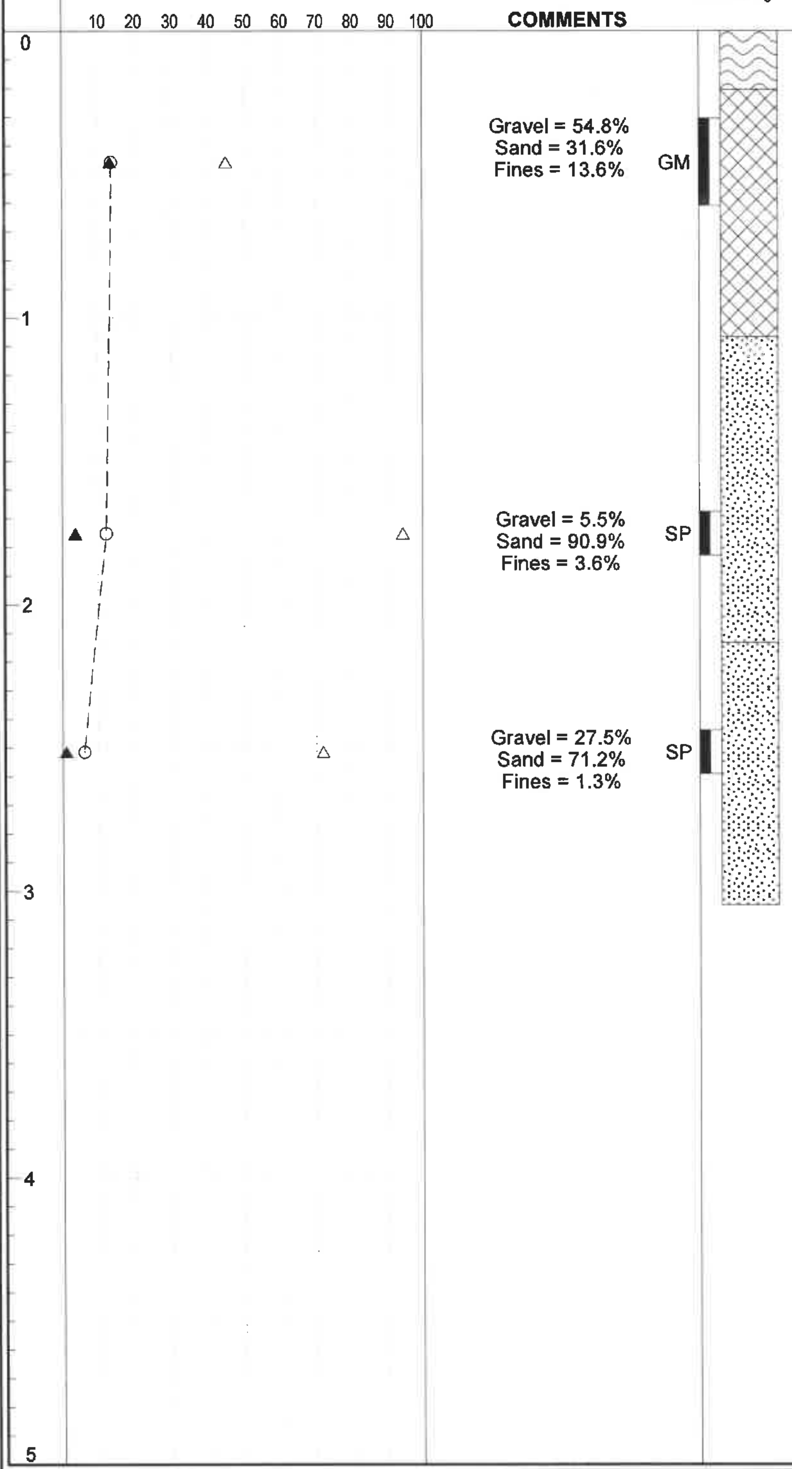
WATER LEVEL
Plastic Limit | Liquid Limit

SAMPLES
◧ Disturbed
■ Undisturbed
☒ No Recovery

UNDRAINED SHEAR STRENGTH (kPa)
◆ Peak
◇ Residual
✚ CPen reading

GRAIN SIZE (%)
▲ Passing #200 sieve
△ Passing #4 sieve

SOIL HEADSPACE READING (ppm)
■ GASTECH reading
☒ PID reading



COMMENTS	SOILS DESCRIPTION
	Moist, black to brown, organic SILT (TOPSOIL)
Gravel = 54.8% Sand = 31.6% Fines = 13.6%	Moist, brown, sandy GRAVEL (FILL); some silt; trace clay; contains cobbles and boulders to 350 mm diameter
Gravel = 5.5% Sand = 90.9% Fines = 3.6%	Moist, dark brown to black, fine SAND; trace gravel to 30 mm diameter; trace silt; contains organics
Gravel = 27.5% Sand = 71.2% Fines = 1.3%	Moist, brown, gravelly SAND; gravel to 25 mm diameter; medium to coarse sand
	End of Pit at 3.0 m depth; maximum reach of excavator. No water encountered while digging. Upon completion of excavation: Pit backfilled with excavated materials.

DEPTH (m)
0
1
2
3
4
5

LOG OF TEST PIT (NO EST.) R RRS_26367_PARKSVILLE_2020 TEST PIT LOGS.GPJ THURBER BC.GDT 10/7/20- THURBER VICTORIA FEBRUARY 2012 REVERSE.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO. **TP20-6**

THURBER

LOCATION: See Drawing No. 26367-1
N 5464574 E 404969 (Approx.)
UTM NAD 83 Zone 10U

TOP OF HOLE ELEV:

METHOD: Yanmar VIO35 Mini-Excavator

DRILLING CO.: Parkseville Heavy Equipment

INSPECTOR: BTS

CLIENT: EOR INC.

PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation

DATE: 14-May-2020

FILE NO.: 26367

DCPT PENETRATION (blows/300 mm)

WATER CONTENT (%): ○ Disturbed ● Undisturbed; Plastic Limit, Liquid Limit

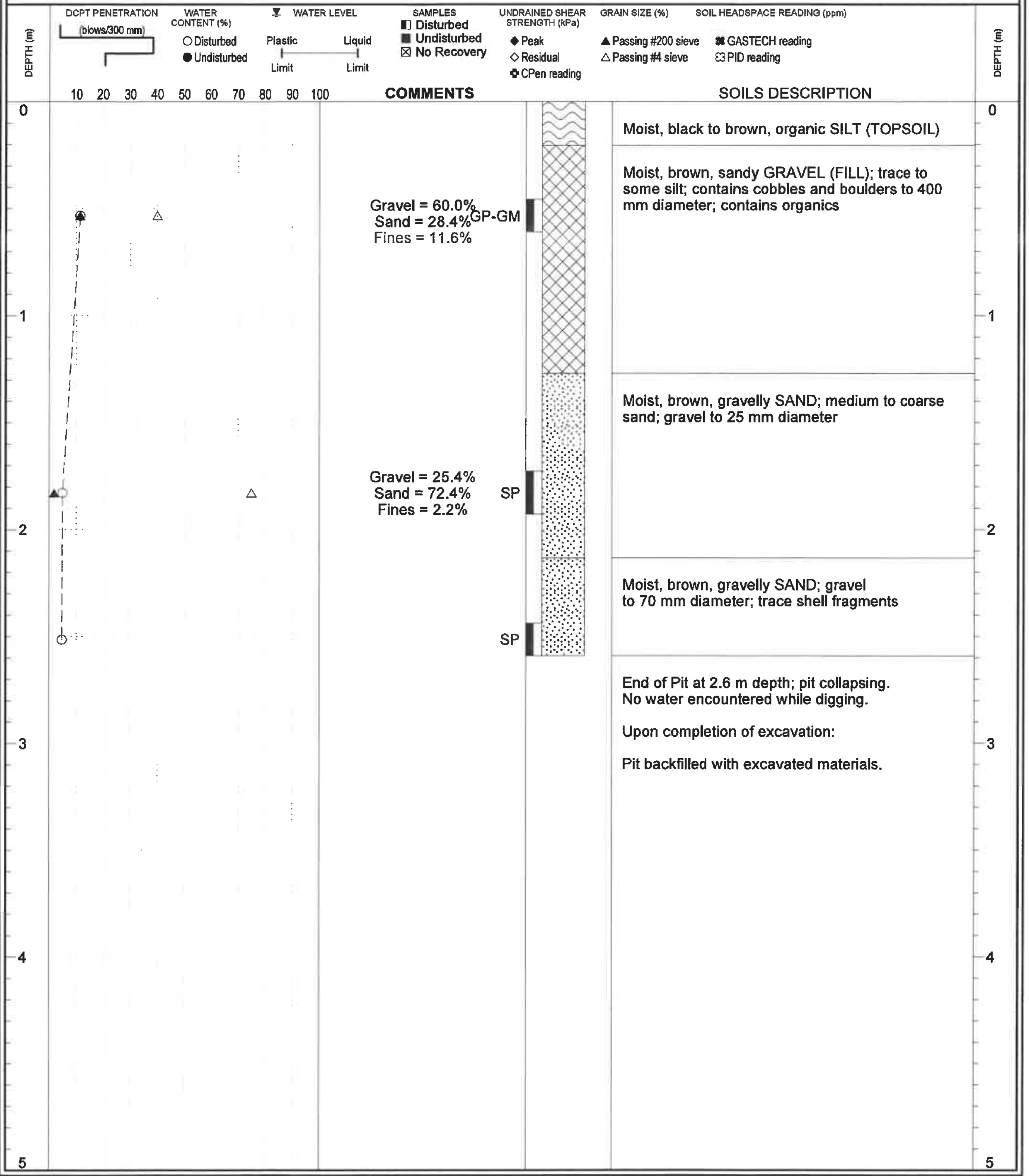
▼ WATER LEVEL

SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery

UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ✚ CPen reading

GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve

SOIL HEADSPACE READING (ppm): ✖ GASTECH reading ☒ PID reading



COMMENTS

Gravel = 60.0%
Sand = 28.4%
Fines = 11.6%

Gravel = 25.4%
Sand = 72.4%
Fines = 2.2%

SOILS DESCRIPTION

Moist, black to brown, organic SILT (TOPSOIL)

Moist, brown, sandy GRAVEL (FILL); trace to some silt; contains cobbles and boulders to 400 mm diameter; contains organics

Moist, brown, gravelly SAND; medium to coarse sand; gravel to 25 mm diameter

Moist, brown, gravelly SAND; gravel to 70 mm diameter; trace shell fragments

End of Pit at 2.6 m depth; pit collapsing.
No water encountered while digging.

Upon completion of excavation:

Pit backfilled with excavated materials.

LOG OF TEST PIT (NO EST.) R RRS_26367_PARKSVILLE_2020 TEST PIT LOGS.GPJ THURBER BC.GDT 10/7/20- THURBER VICTORIA FEBRUARY 2012 REVERSE.GLB

Sheet 1 of 1

LOG OF TEST PIT

TEST PIT NO.
TP20-7

LOCATION: See Drawing No. 26367-1
N 5464487 E 405011 (Approx.)
UTM NAD 83 Zone 10U

TOP OF HOLE ELEV:

METHOD: Yanmar VIO35 Mini-Excavator

DRILLING CO.: Parksville Heavy Equipment

INSPECTOR: BTS

THURBER

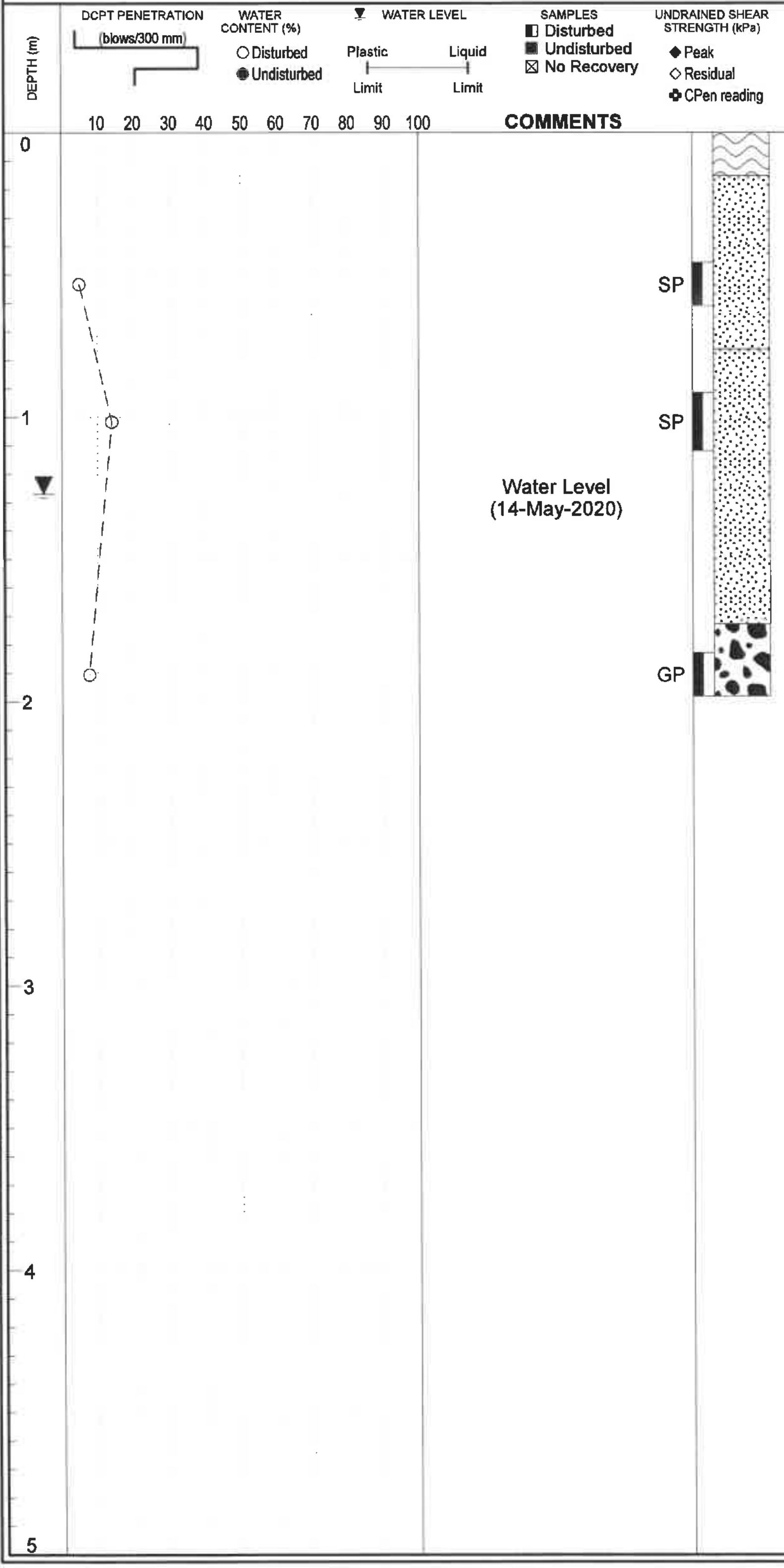
CLIENT: EOR INC.

PROJECT: City of Parksville Community Park
Stormwater Management Master Plan
Geotechnical Investigation

DATE: 14-May-2020

FILE NO.: 26367

DCPT PENETRATION (blows/300 mm)
WATER CONTENT (%) ○ Disturbed ● Undisturbed
▼ WATER LEVEL
Plastic Limit — Liquid Limit
SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery
UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual ✚ CPen reading
GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve
SOIL HEADSPACE READING (ppm) ✱ GASTECH reading ✱ PID reading



COMMENTS

Water Level
(14-May-2020)

SOILS DESCRIPTION

Moist, black to brown, organic SILT (TOPSOIL)

Moist, brown, medium SAND; trace gravel to 30 mm diameter

Moist to wet, grey, gravelly SAND; medium to coarse sand; gravel to 60 mm diameter

Wet, grey, sandy GRAVEL; gravel to 70 mm diameter; trace silt

End of Pit at 2.0 m depth; pit collapsing.
Water encountered at 1.3 m depth while digging.

Upon completion of excavation:

Pit backfilled with excavated materials.

26367-CAD001.dwg This copyrighted drawing forms part of a Thurber report and its use is subject to Thurber's Statement of Limitations and Conditions Plotted: July 10, 2020

NOTES:

1. Test Pits were located by hand-held GPS unit; locations are approximate only.
2. 2018 aerial imagery from the Regional District of Nanaimo.

THURBER ENGINEERING LTD.

EOR INC.

TEST PIT LOCATION PLAN

STORMWATER MANAGEMENT MASTER PLAN
GEOTECHNICAL INVESTIGATION

PARKSVILLE, B.C.

DESIGNED	DRAWN	APPROVED	DATE	SCALE	PROJECT No.	DWG. NO.	REV.
BRW	RRS	BRW	JULY 10, 2020	1:2000	26367	- 1	1

THURBER

APPENDIX B

APPENDIX A

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-1, Sa. 2, 5'-0" - 5'10"

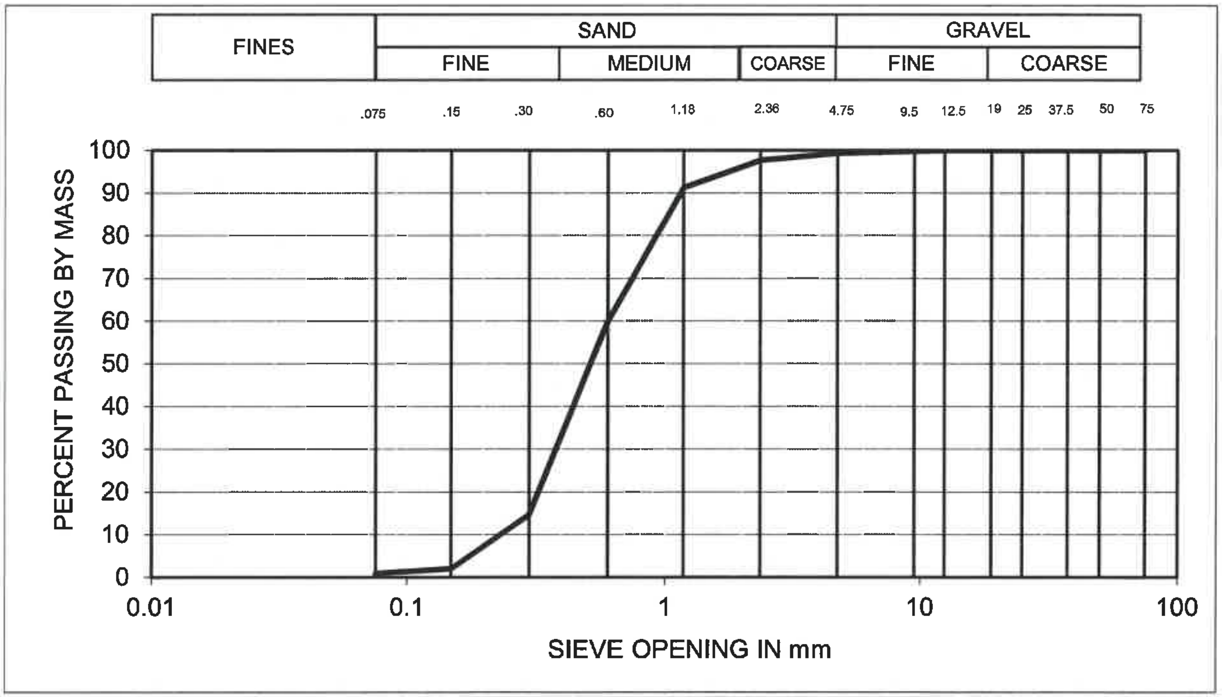
File Number: 26367
Date Reported: 01-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 29-Jun-2020 By: BTS
Checked By:

Sample Source: Test Pit
Description: SAND, with a trace of gravel and fines
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 0.6 % Sand = 98.5 % Fines = 0.9 %
As Received Moisture Content = 7.7 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	100				#4	4.75	99			
2	50	100				#8	2.36	98			
1.5	37.5	100				#16	1.18	91			
1	25	100				#30	0.6	60			
.75	19	100				#50	0.3	15			
.5	12.5	100				#100	0.15	2			
.375	9.5	100				#200	0.075	0.9			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-4 (Site 4) Sa 1, 2'-0" - 2'-6"

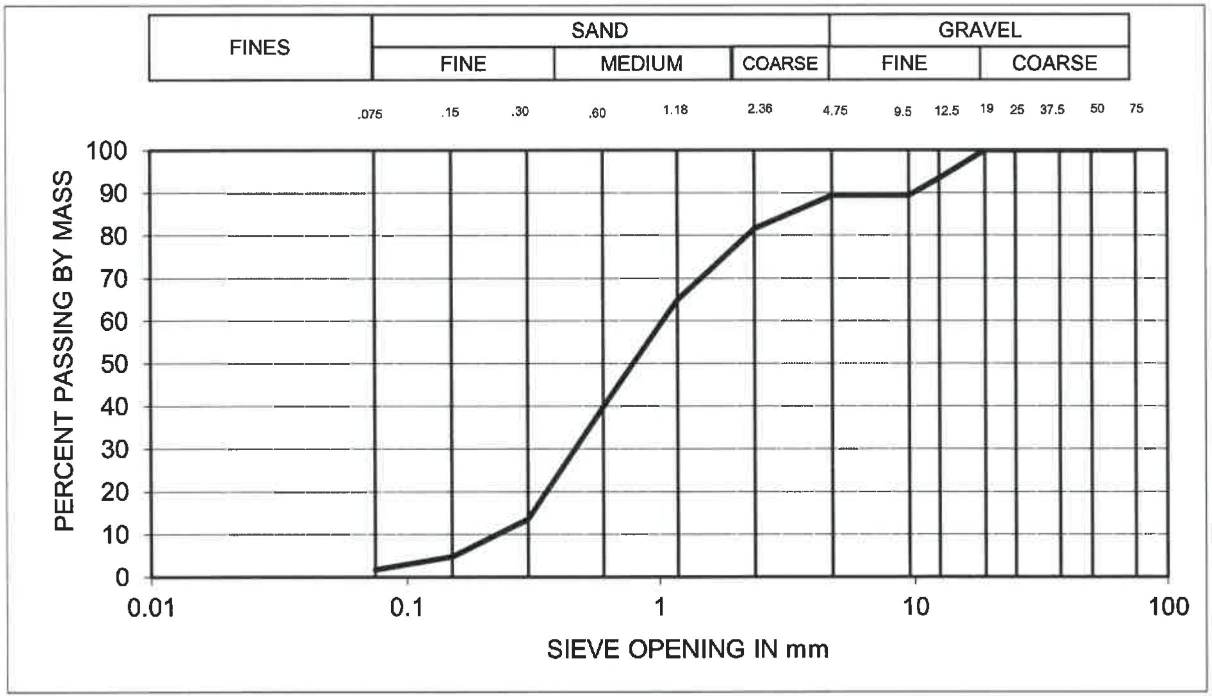
File Number: 26367
Date Reported: 25-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 23-Jun-2020 By: BDB/JSH
Checked By: JSH

Sample Source: Test Pit
Description: SAND, trace - some gravel with a trace of silt
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 10.7 % Sand = 87.7 % Fines = 1.6 %
As Received Moisture Content = 6.1 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	100				#4	4.75	89			
2	50	100				#8	2.36	82			
1.5	37.5	100				#16	1.18	65			
1	25	100				#30	0.6	40			
.75	19	100				#50	0.3	14			
.5	12.5	93				#100	0.15	5			
.375	9.5	89				#200	0.075	1.7			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-4 (Site 4) Sa 2, 6'-0" - 6'-8"

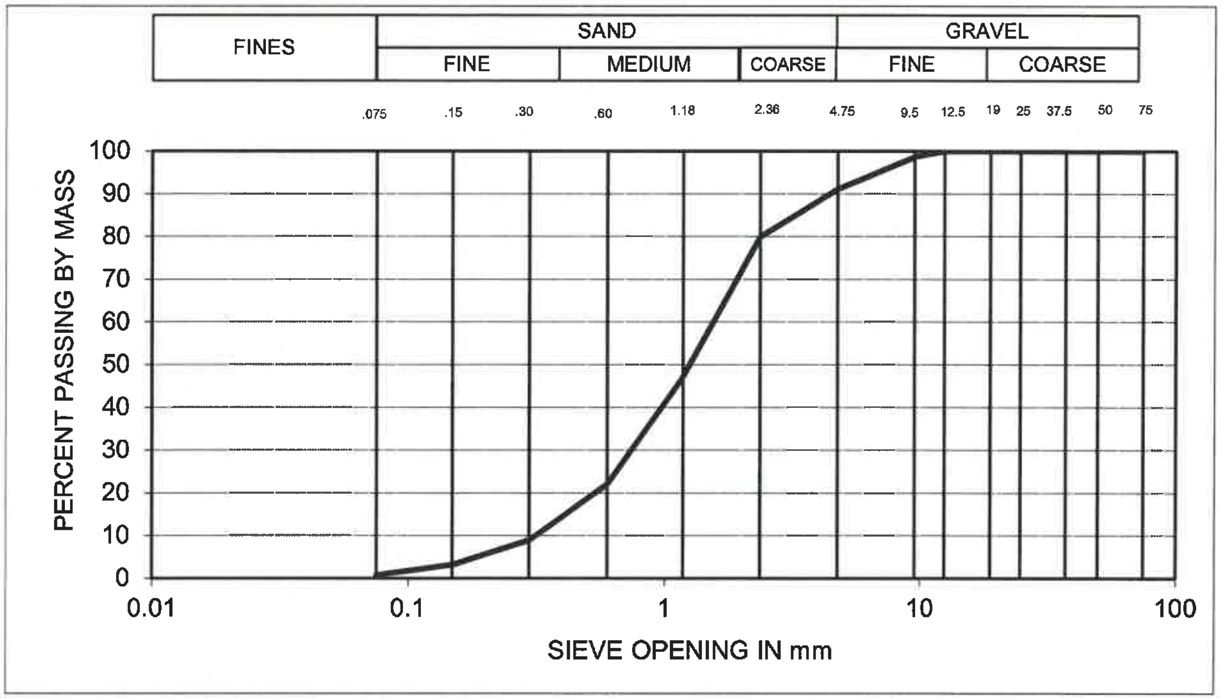
File Number: 26367
Date Reported: 25-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 23-Jun-2020 By: BDB/JSH
Checked By:

Sample Source: Test Pit
Description: SAND, with a trace of gravel and silt
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 8.9 % Sand = 90.5 % Fines = 0.6 %
As Received Moisture Content = 5.4 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	100				#4	4.75	91			
2	50	100				#8	2.36	80			
1.5	37.5	100				#16	1.18	47			
1	25	100				#30	0.6	22			
.75	19	100				#50	0.3	9			
.5	12.5	100				#100	0.15	3			
.375	9.5	99				#200	0.075	0.8			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-5 Sa 1, 1'-0" - 2'-0"

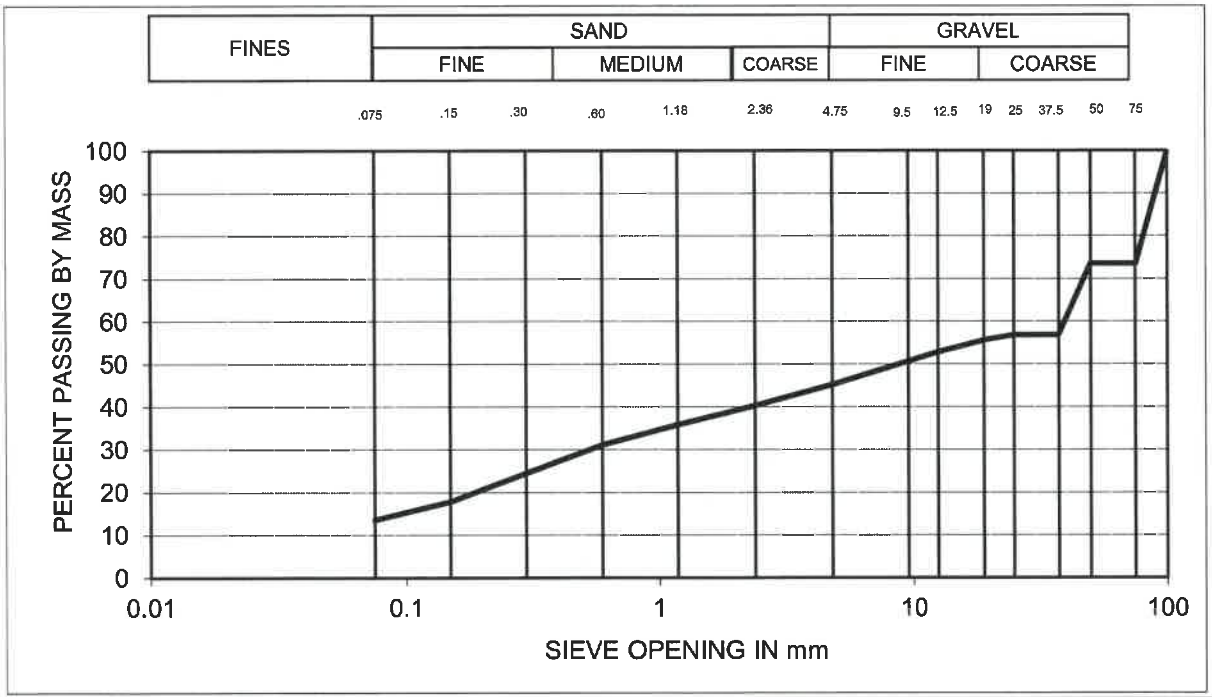
File Number: 26367
Date Reported: 25-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 23-Jun-2020 By: BDB/JSH
Checked By: JSH

Sample Source: Test Pit
Description: sandy GRAVEL, some silt
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 54.8 % Sand = 31.6 % Fines = 13.6 %
As Received Moisture Content = 7.7 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	74				#4	4.75	45			
2	50	74				#8	2.36	40			
1.5	37.5	57				#16	1.18	36			
1	25	57				#30	0.6	31			
.75	19	56				#50	0.3	24			
.5	12.5	53				#100	0.15	18			
.375	9.5	51				#200	0.075	13.6			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-5 Sa 2, 5'-6" - 6'-0"

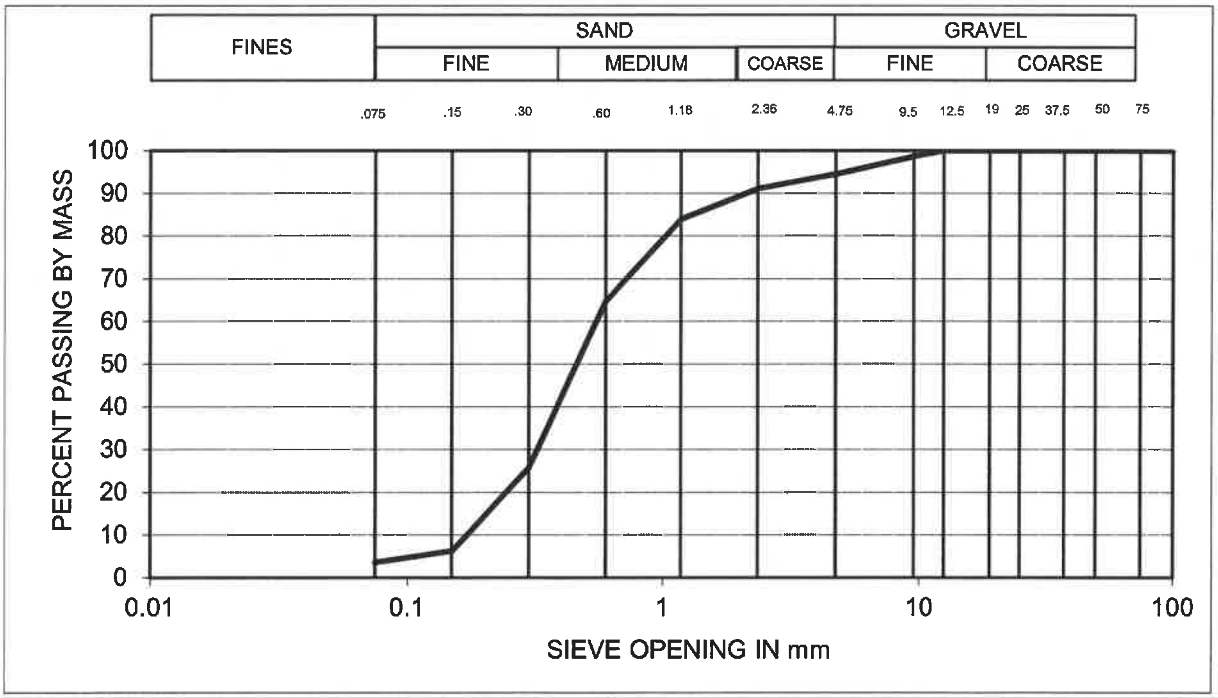
File Number: 26367
Date Reported: 25-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 23-Jun-2020 By: BDB/JSH
Checked By: JSH

Sample Source: Test Pit
Description: SAND, trace of gravel and silt
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 5.5 % Sand = 90.9 % Fines = 3.6 %
As Received Moisture Content = 11.7 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	100				#4	4.75	95			
2	50	100				#8	2.36	91			
1.5	37.5	100				#16	1.18	84			
1	25	100				#30	0.6	65			
.75	19	100				#50	0.3	26			
.5	12.5	100				#100	0.15	6			
.375	9.5	99				#200	0.075	3.6			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-5 Sa. 3, 8'-0" - 8'-6"

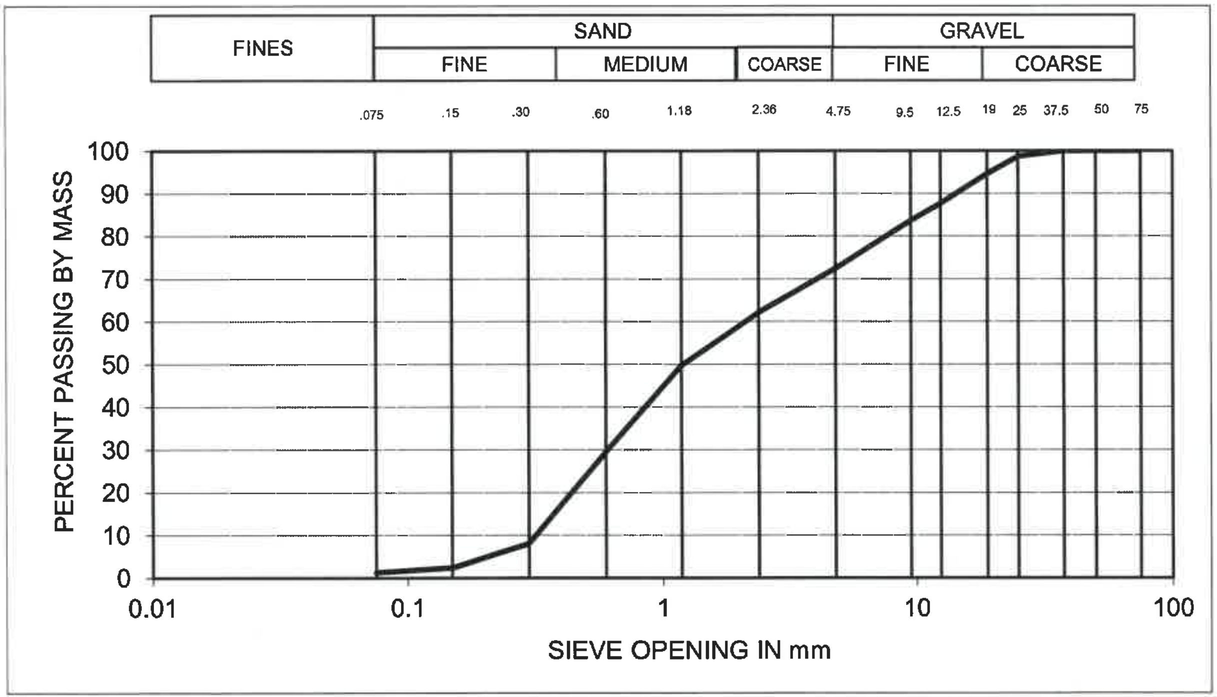
File Number: 26367
Date Reported: 01-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 29-Jun-2020 By: BTS
Checked By:

Sample Source: Test Pit
Description: gravelly SAND, with a trace of fines
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 27.5 % Sand = 71.2 % Fines = 1.3 %
As Received Moisture Content = 6.3 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	100				#4	4.75	72			
2	50	100				#8	2.36	62			
1.5	37.5	100				#16	1.18	50			
1	25	99				#30	0.6	30			
.75	19	95				#50	0.3	8			
.5	12.5	88				#100	0.15	2			
.375	9.5	84				#200	0.075	1.3			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-6 Sa 1, 1'-6" - 2'-0"

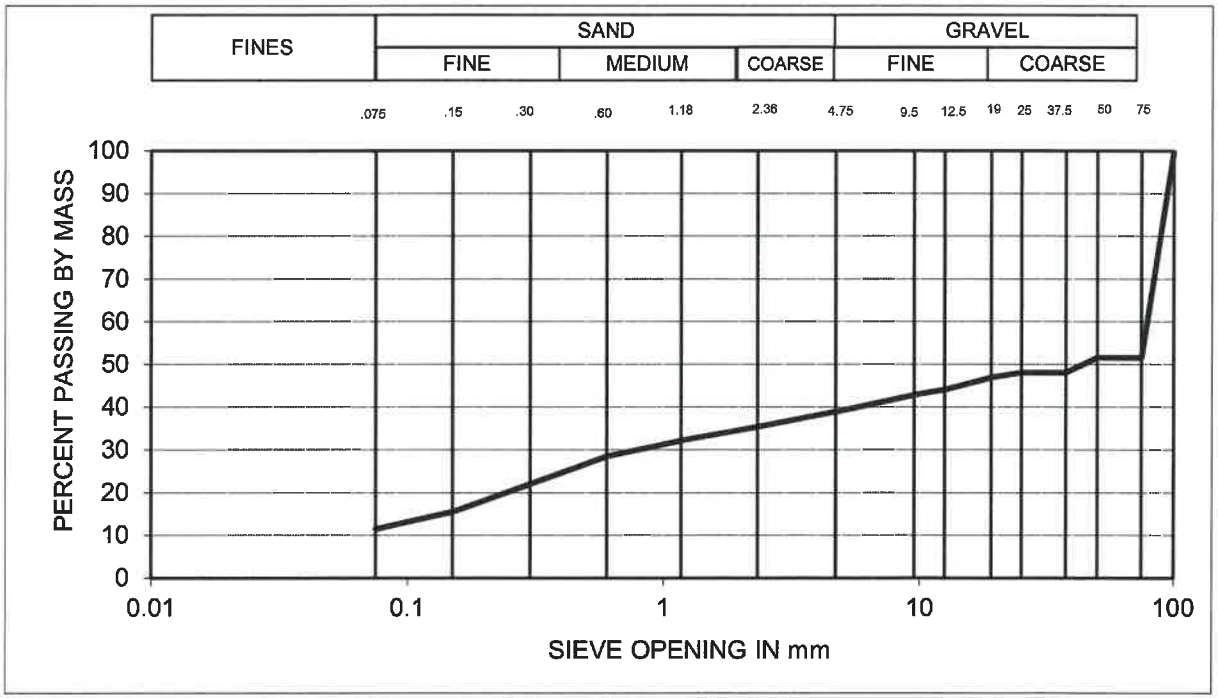
File Number: 26367
Date Reported: 25-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 23-Jun-2020 By: BDB/JSH
Checked By:

Sample Source: Test Pit
Description: sandy GRAVEL, some silt
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 61.0 % Sand = 28.4 % Fines = 11.5 %
As Received Moisture Content = 5.5 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	52				#4	4.75	39			
2	50	52				#8	2.36	35			
1.5	37.5	48				#16	1.18	32			
1	25	48				#30	0.6	28			
.75	19	47				#50	0.3	22			
.5	12.5	44				#100	0.15	16			
.375	9.5	43				#200	0.075	11.5			

THURBER ENGINEERING LTD.

SIEVE ANALYSIS REPORT
PARKSVILLE COMMUNITY PARK
TP20-6 Sa. 2, 5'-8" - 6'-4"

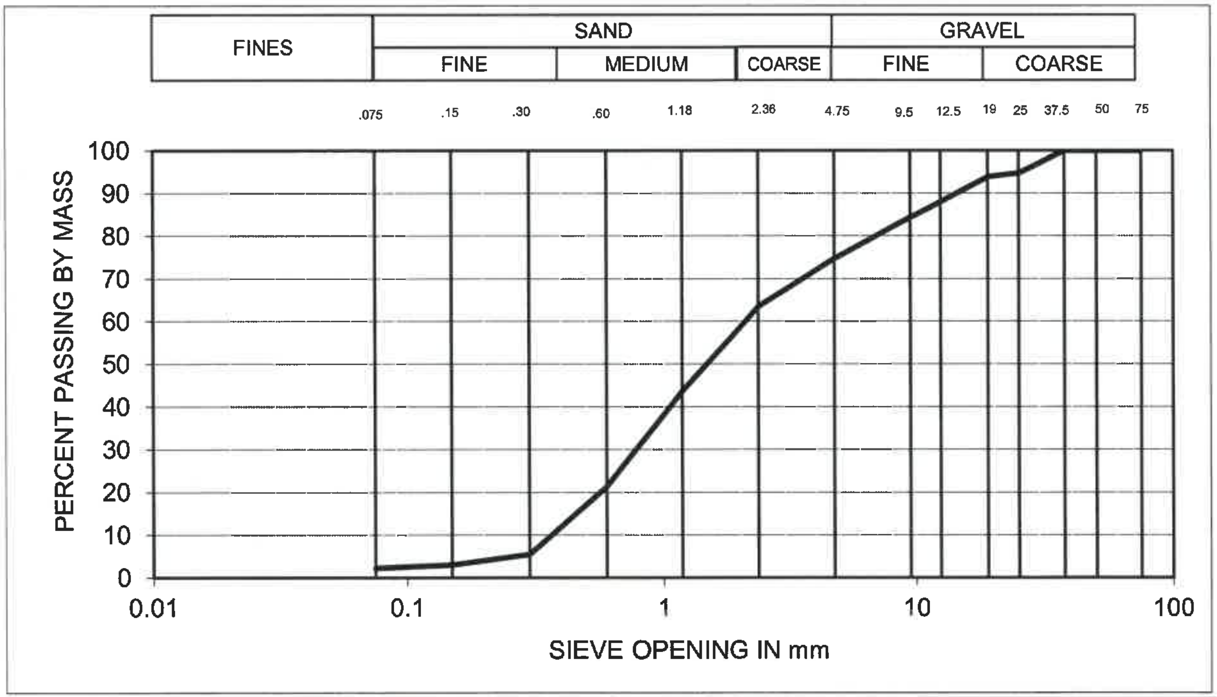
File Number: 26367
Date Reported: 01-Jun-20

EOR

Sampled: 14-May-2020 By: BTS
Received: 15-May-2020 By: BTS
Tested: 29-Jun-2020 By: BTS
Checked By:

Sample Source: Test Pit
Description: gravelly SAND, with a trace of fines
Test Method: ASTM C 136 & C 117

Remarks: Gravel = 25.4 % Sand = 72.4 % Fines = 2.2 %
As Received Moisture Content = 5.1 %



Gravel Size		Percent	Specifications			Sand Size		Percent	Specifications		
Inches	mm	Passing	Upper	Lower	Check	Inches	mm	Passing	Upper	Lower	Check
3	75	100				#4	4.75	75			
2	50	100				#8	2.36	63			
1.5	37.5	100				#16	1.18	44			
1	25	95				#30	0.6	21			
.75	19	94				#50	0.3	5			
.5	12.5	88				#100	0.15	3			
.375	9.5	84				#200	0.075	2.2			

Appendix E: Design Infiltration Rates

Grain size analysis, either alone or in conjunction with hydrometer analysis, should be used to verify the ASTM classification of the soil material controlling the rate of infiltration (the least permeable material within 1.5 m of the bottom of the proposed practice). Table summarizes the soil lab tests and identifies when each should be used.

Table 18. Soil Analysis – Lab Tests

Lab Test	Description	Use It When
Grain Size Analysis	Provides a distribution of particle size greater than 0.075 mm (No. 200 sieve)	Always
Hydrometer Analysis	Provides a distribution of particle size less than 0.075 mm (No. 200 sieve)	Sample has greater than 5% fines

Table shows the typical design infiltration rates for different soils. The table generally follows the Unified Soil Classification System with a few exceptions. Soil tests such as the Plasticity Index are avoided because they are not typically done along with the grain size analysis. Refer to ASTM D2487 for more information on the soil classifications. In-situ infiltration testing is recommended to support detailed design of infiltration practices.

Table 19. Design Infiltration Rates

Major Divisions				Letter Symbol	Group Name	Design Rate (mm/hr)
Gravel and Gravelly Soils. *More than 50% retained on No. 4 sieve*	Gravel with <5% fines	Well graded		GW	Well graded gravel	41.4
		Poorly graded		GP	Poorly graded gravel	
	Gravel with between 5% and 12% fines	Well graded	Silty	GW-GM	Well graded gravel with silt	
		Well graded	Clayey	GW-GC	Well graded gravel with clay	
		Poorly graded	Silty	GP-GM	Poorly graded gravel with silt	
		Poorly graded	Clayey	GP-GC	Poorly graded gravel with clay	
	Gravel with >12% fines		Silty	GM	Silty gravel	
			Clayey	GC	Clayey gravel	
			Both	GC-GM	Silty, clayey gravel	
Sand and Sandy Soils. *More than 50% passing No. 4 sieve and less than 50% passing No. 200 sieve*	Sand with <5% fines	Well graded		SW	Well graded sand	41.4
		Poorly graded		SP	Poorly graded sand	20.3
	Sand with between 5% and 12% fines	Well graded	<5% Clay	SW-SM	Well graded sand with silt	17.8
		Well graded	>5% Clay	SW-SC	Well graded sand with clay	5.1
		Poorly graded	<5% Clay	SP-SM	Poorly graded sand with silt	17.8
		Poorly graded	>5% Clay	SP-SC	Poorly graded sand with clay	5.1
	Sand with >12% fines	<5% Clay	12-25% fines	SM	Silty sand	15.2
			>25% fines	SM	Silty sand	7.6
		>7% Clay		SC	Clayey sand	1.5
		5-7% Clay		SC-SM	Silty, clayey sand	1.5
Fine Grained Soils. *More than 50% passing No. 200 sieve*	Liquid Limit <50	Inorganic	>7% Clay	CL	Lean clay	1.5
			5-7% Clay	CL-ML	Silty clay	1.5
			<5% Clay	ML	Silt	5.1
		Organic		OL	Organic soils	**
	Liquid Limit >50	Inorganic	>5% Clay	CH	Fat clay	1.5
			<5% Clay	MH	Elastic silt	7.6
		Organic		OH	Organic soils	**

** Organic soils are generally not suitable for infiltration due to high water table conditions. In some cases, they may be suitable if further permeability testing is conducted.

Appendix F: Tree Inventory

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
3300	Douglas Fir	Pseudotsuga menziesii	49.3217595	-124.3078369	Good	6	55	Alive	$ 100.91	$ 28.16	2607.45	$ 41.65	$ 10.03	157.71	$ 12.58	13.87	$ 4.09	2.04	$ 4.40	586.86	297.39	347.78
3299	Douglas Fir	Pseudotsuga menziesii	49.3217426	-124.3078416	Good	10	56	Alive	$ 102.02	$ 28.75	2661.81	$ 41.60	$ 10.25	161.15	$ 12.75	14.06	$ 4.22	2.10	$ 4.45	592.75	298.00	355.35
3298	Douglas Fir	Pseudotsuga menziesii	49.3217268	-124.3078503	Good	10	58	Alive	$ 104.24	$ 29.92	2770.55	$ 41.51	$ 10.69	168.02	$ 13.09	14.44	$ 4.49	2.23	$ 4.53	604.52	299.22	370.50
3297	Douglas Fir	Pseudotsuga menziesii	49.3217426	-124.3079355	Fair	8	47	Alive	$ 90.50	$ 23.46	2172.54	$ 40.04	$ 8.62	135.52	$ 11.34	12.51	$ 3.12	1.58	$ 3.91	521.80	266.88	298.84
3296	Douglas Fir	Pseudotsuga menziesii	49.3217347	-124.307959	Good	8	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
3295	Douglas Fir	Pseudotsuga menziesii	49.3216927	-124.3079596	Good	9	61	Alive	$ 107.58	$ 31.68	2933.64	$ 41.38	$ 11.34	178.32	$ 13.61	15.01	$ 4.90	2.43	$ 4.67	622.18	301.06	393.22
3294	Douglas Fir	Pseudotsuga menziesii	49.321649	-124.3078262	Fair	6	49	Alive	$ 93.20	$ 24.64	2281.26	$ 40.57	$ 8.95	140.72	$ 11.64	12.84	$ 3.35	1.69	$ 4.04	539.24	276.18	310.31
3293	Douglas Fir	Pseudotsuga menziesii	49.3216394	-124.3078269	Poor	6	49	Alive	$ 93.20	$ 24.64	2281.26	$ 40.57	$ 8.95	140.72	$ 11.64	12.84	$ 3.35	1.69	$ 4.04	539.24	276.18	310.31
3292	Douglas Fir	Pseudotsuga menziesii	49.3216429	-124.3077726	Good	8	43	Alive	$ 85.09	$ 21.11	1955.09	$ 38.99	$ 7.96	125.12	$ 10.73	11.84	$ 2.65	1.36	$ 3.65	486.91	248.27	275.90
3291	Douglas Fir	Pseudotsuga menziesii	49.3216079	-124.3078282	Fair	9	48	Alive	$ 91.85	$ 24.05	2226.90	$ 40.31	$ 8.78	138.12	$ 11.49	12.67	$ 3.24	1.64	$ 3.98	530.52	271.53	304.58
3290	Douglas Fir	Pseudotsuga menziesii	49.3216106	-124.3078021	Fair	10	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	3.35	$ 5.06	674.00	270.24	512.47
3289	Douglas Fir	Pseudotsuga menziesii	49.3215564	-124.3077987	Fair	9	57	Alive	$ 103.13	$ 29.33	2716.18	$ 41.56	$ 10.47	164.58	$ 12.92	14.25	$ 4.36	2.17	$ 4.49	598.63	298.61	362.93
3288	Douglas Fir	Pseudotsuga menziesii	49.3216403	-124.307668	Good	10	76	Alive	$ 119.72	$ 40.41	3741.45	$ 35.67	$ 15.06	236.77	$ 16.55	18.26	$ 6.96	3.41	$ 5.06	675.12	264.72	522.10
3287	Douglas Fir	Pseudotsuga menziesii	49.3216377	-124.3076096	Fair	8	57	Alive	$ 103.13	$ 29.33	2716.18	$ 41.56	$ 10.47	164.58	$ 12.92	14.25	$ 4.36	2.17	$ 4.49	598.63	298.61	362.93
3234	Stump	Brevi Truncus	49.3209079	-124.3109623				Stump														
3233	Limber Pine	Pinus flexilis	49.3209106	-124.3108379	Good	5	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
3232	Dogwood sp	Cornus sp	49.3208948	-124.3108457	Excellent	4	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
3231	Japanese Maple	Acer palmatum	49.3209036	-124.3107645	Excellent	2	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
3230	Mountain Hemlock	Tsuga mertensiana	49.3209219	-124.3107974	Excellent	4	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
3229	Japanese Maple	Acer palmatum	49.3209613	-124.3107042	Fair	3	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
3228	Japanese Maple	Acer palmatum	49.320935	-124.310729	Poor	3	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
3227	Dogwood sp	Cornus sp	49.3208826	-124.310672	Good	5	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
3226	Douglas Fir	Pseudotsuga menziesii	49.3209245	-124.3104983	Good	14	122	Alive	$ 112.86	$ 53.45	4949.17	$ 0.07	$ 22.37	351.71	$ 22.23	24.52	$ 10.40	5.08	$ 4.35	579.53	0.46	775.56
3225	Magnolia sp	Magnolia sp	49.3208319	-124.3102589	Good	7	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70
3224	Magnolia sp	Magnolia sp	49.3207933	-124.3099675	Good	5	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
3223	Douglas Fir	Pseudotsuga menziesii	49.3216408	-124.3075363	Fair	6	45	Alive	$ 87.79	$ 22.29	2063.81	$ 39.51	$ 8.29	130.32	$ 11.04	12.17	$ 2.88	1.47	$ 3.78	504.35	257.57	287.37
3222	Douglas Fir	Pseudotsuga menziesii	49.3216479	-124.3074495	Good	7	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
3221	Douglas Fir	Pseudotsuga menziesii	49.321703	-124.307367	Good	5	44	Alive	$ 86.44	$ 21.70	2009.45	$ 39.25	$ 8.12	127.72	$ 10.88	12.01	$ 2.77	1.41	$ 3.72	495.63	252.92	281.63

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
3220	Douglas Fir	Pseudotsuga menziesii	49.3216566	-124.3073878	Good	10	78	Alive	$ 120.72	$ 41.56	3848.11	$ 34.22	$ 15.61	245.50	$ 17.00	18.75	$ 7.24	3.55	$ 5.08	677.37	253.67	541.37
3219	Douglas Fir	Pseudotsuga menziesii	49.3217463	-124.307295	Good	6	50	Alive	$ 94.55	$ 25.22	2335.63	$ 40.84	$ 9.12	143.33	$ 11.79	13.00	$ 3.47	1.75	$ 4.11	547.96	280.83	316.05
3218	Douglas Fir	Pseudotsuga menziesii	49.3217585	-124.3073051	Fair	10	51	Alive	$ 95.90	$ 25.81	2389.99	$ 41.10	$ 9.28	145.93	$ 11.94	13.17	$ 3.59	1.80	$ 4.18	556.68	285.49	321.78
3217	Douglas Fir	Pseudotsuga menziesii	49.3217795	-124.3073071	Good	12	84	Alive	$ 123.99	$ 45.01	4167.83	$ 30.12	$ 17.29	271.92	$ 18.34	20.23	$ 8.08	3.95	$ 5.15	686.06	222.18	599.61
3216	Douglas Fir	Pseudotsuga menziesii	49.3218424	-124.3073453	Good	12	83	Alive	$ 123.22	$ 44.44	4114.76	$ 30.61	$ 17.00	267.35	$ 18.11	19.97	$ 7.94	3.88	$ 5.12	682.98	226.06	589.53
3215	Douglas Fir	Pseudotsuga menziesii	49.3218363	-124.307413	Good	10	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52
3214	Douglas Fir	Pseudotsuga menziesii	49.3219045	-124.307513	Excellent	12	74	Alive	$ 118.72	$ 39.26	3634.79	$ 37.12	$ 14.50	228.03	$ 16.11	17.77	$ 6.69	3.28	$ 5.05	672.88	275.76	502.84
3213	Douglas Fir	Pseudotsuga menziesii	49.3219508	-124.3074419	Excellent	9	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37
3212	Douglas Fir	Pseudotsuga menziesii	49.3219176	-124.3072843	Fair	7	43	Alive	$ 85.09	$ 21.11	1955.09	$ 38.99	$ 7.96	125.12	$ 10.73	11.84	$ 2.65	1.36	$ 3.65	486.91	248.27	275.90
3211	Douglas Fir	Pseudotsuga menziesii	49.3219316	-124.3072756	Good	10	87	Alive	$ 129.98	$ 46.69	4323.47	$ 31.82	$ 18.34	288.41	$ 19.16	21.13	$ 8.55	4.18	$ 5.42	722.00	232.92	635.98
3210	Douglas Fir	Pseudotsuga menziesii	49.3219482	-124.3073057	Good	8	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37
3209	Douglas Fir	Pseudotsuga menziesii	49.3220305	-124.3072839	Fair	8	36	Alive	$ 75.55	$ 17.01	1574.86	$ 37.19	$ 6.71	105.57	$ 9.60	10.58	$ 1.91	1.00	$ 3.14	418.56	212.54	232.80
3208	Douglas Fir	Pseudotsuga menziesii	49.3220419	-124.3073181	Good	11	77	Alive	$ 120.22	$ 40.98	3794.78	$ 34.95	$ 15.34	241.14	$ 16.78	18.51	$ 7.10	3.48	$ 5.07	676.25	259.19	531.73
3207	Douglas Fir	Pseudotsuga menziesii	49.3220533	-124.307351	Good	12	74	Alive	$ 118.72	$ 39.26	3634.79	$ 37.12	$ 14.50	228.03	$ 16.11	17.77	$ 6.69	3.28	$ 5.05	672.88	275.76	502.84
3206	Douglas Fir	Pseudotsuga menziesii	49.3220611	-124.3074945	Good	13	83	Alive	$ 123.22	$ 44.44	4114.76	$ 30.61	$ 17.00	267.35	$ 18.11	19.97	$ 7.94	3.88	$ 5.12	682.98	226.06	589.53
3205	Douglas Fir	Pseudotsuga menziesii	49.3220375	-124.30752	Fair	11	72	Alive	$ 117.72	$ 38.10	3528.13	$ 38.56	$ 13.95	219.29	$ 15.67	17.28	$ 6.41	3.14	$ 5.03	670.63	286.80	483.57
3204	Cherry sp	Prunus sp (cherry)	49.3206971	-124.3076168	Good	12	37	Alive	$ 76.94	$ 17.59	1629.07	$ 37.43	$ 6.92	108.81	$ 9.79	10.79	$ 1.99	1.04	$ 3.23	430.75	218.70	239.94
3203	Cherry sp	Prunus sp (cherry)	49.3206429	-124.3076899	Good	10	48	Alive	$ 91.85	$ 24.05	2226.90	$ 40.31	$ 8.78	138.12	$ 11.49	12.67	$ 3.24	1.64	$ 3.98	530.52	271.53	304.58
3201	Oak sp	Quercus sp	49.3206036	-124.3078014	Excellent	9	47	Alive	$ 90.50	$ 23.46	2172.54	$ 40.04	$ 8.62	135.52	$ 11.34	12.51	$ 3.12	1.58	$ 3.91	521.80	266.88	298.84
3200	Horse Chestnut	Aesculus hippocastanum	49.3206298	-124.3074129	Excellent	11	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
3199	Palm sp.	Palm sp.	49.3205345	-124.3074162	Excellent	2	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
3198	Palm sp.	Palm sp.	49.3205432	-124.3074639	Excellent	3	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
3197	Palm sp.	Palm sp.	49.3205188	-124.307462	Excellent	3	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
3195	Douglas Fir	Pseudotsuga menziesii	49.3207244	-124.3074507	Fair	11	80	Alive	$ 121.72	$ 42.71	3954.77	$ 32.78	$ 16.17	254.24	$ 17.44	19.24	$ 7.52	3.68	$ 5.10	679.62	242.63	560.63
3194	Douglas Fir	Pseudotsuga menziesii	49.3207287	-124.3074936	Fair	14	82	Alive	$ 122.72	$ 43.86	4061.43	$ 31.33	$ 16.73	262.98	$ 17.89	19.73	$ 7.80	3.82	$ 5.11	681.86	231.58	579.90
3193	Douglas Fir	Pseudotsuga menziesii	49.3208498	-124.3075174	Fair	4	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
3192	Douglas Fir	Pseudotsuga menziesii	49.320841	-124.3075214	Good	10	57	Alive	$ 103.13	$ 29.33	2716.18	$ 41.56	$ 10.47	164.58	$ 12.92	14.25	$ 4.36	2.17	$ 4.49	598.63	298.61	362.93

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
3190	Douglas Fir	Pseudotsuga menziesii	49.3208166	-124.3075469	Good	8	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
3189	Douglas Fir	Pseudotsuga menziesii	49.320869	-124.3074456	Good	12	80	Alive	$ 121.72	$ 42.71	3954.77	$ 32.78	$ 16.17	254.24	$ 17.44	19.24	$ 7.52	3.68	$ 5.10	679.62	242.63	560.63
3188	Douglas Fir	Pseudotsuga menziesii	49.3208515	-124.3075751	Good	7	49	Alive	$ 93.20	$ 24.64	2281.26	$ 40.57	$ 8.95	140.72	$ 11.64	12.84	$ 3.35	1.69	$ 4.04	539.24	276.18	310.31
3187	Douglas Fir	Pseudotsuga menziesii	49.320908	-124.3075972	Good	7	57	Alive	$ 103.13	$ 29.33	2716.18	$ 41.56	$ 10.47	164.58	$ 12.92	14.25	$ 4.36	2.17	$ 4.49	598.63	298.61	362.93
3186	Douglas Fir	Pseudotsuga menziesii	49.320915	-124.3076783	Good	9	74	Alive	$ 118.72	$ 39.26	3634.79	$ 37.12	$ 14.50	228.03	$ 16.11	17.77	$ 6.69	3.28	$ 5.05	672.88	275.76	502.84
3185	Douglas Fir	Pseudotsuga menziesii	49.3209919	-124.3077668	Fair	9	47	Alive	$ 90.50	$ 23.46	2172.54	$ 40.04	$ 8.62	135.52	$ 11.34	12.51	$ 3.12	1.58	$ 3.91	521.80	266.88	298.84
3184	Douglas Fir	Pseudotsuga menziesii	49.321005	-124.3077434	Good	8	47	Alive	$ 90.50	$ 23.46	2172.54	$ 40.04	$ 8.62	135.52	$ 11.34	12.51	$ 3.12	1.58	$ 3.91	521.80	266.88	298.84
3183	Douglas Fir	Pseudotsuga menziesii	49.3210085	-124.3076937	Fair	7	56	Alive	$ 102.02	$ 28.75	2661.81	$ 41.60	$ 10.25	161.15	$ 12.75	14.06	$ 4.22	2.10	$ 4.45	592.75	298.00	355.35
3182	Douglas Fir	Pseudotsuga menziesii	49.3210059	-124.3076193	Good	8	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
3181	Douglas Fir	Pseudotsuga menziesii	49.3210269	-124.3076629	Good	8	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
3180	Bigleaf Maple	Acer macrophyllum	49.3209589	-124.3075355	Good	11	84	Alive	$ 123.99	$ 45.01	4167.83	$ 30.12	$ 17.29	271.92	$ 18.34	20.23	$ 8.08	3.95	$ 5.15	686.06	222.18	599.61
3179	Douglas Fir	Pseudotsuga menziesii	49.3209924	-124.3078254	Good	12	70	Stump														
3178	Douglas Fir	Pseudotsuga menziesii	49.3220752	-124.3076681	Good	10	123	Alive	$ 112.86	$ 53.45	4949.17	$ 0.07	$ 22.37	351.71	$ 22.23	24.52	$ 10.40	5.08	$ 4.35	579.53	0.46	775.56
3177	Douglas Fir	Pseudotsuga menziesii	49.3221661	-124.3076989	Good	10	73	Alive	$ 118.22	$ 38.68	3581.46	$ 37.84	$ 14.22	223.66	$ 15.89	17.53	$ 6.55	3.21	$ 5.04	671.76	281.28	493.20
3175	Douglas Fir	Pseudotsuga menziesii	49.3222338	-124.3108097				Stump														
3174	Douglas Fir	Pseudotsuga menziesii	49.3222863	-124.3108265	Excellent			Stump														
3173	Douglas Fir	Pseudotsuga menziesii	49.3223256	-124.3107936	Fair	10	79	Alive	$ 121.22	$ 42.14	3901.44	$ 33.50	$ 15.89	249.87	$ 17.22	18.99	$ 7.38	3.62	$ 5.09	678.49	248.15	551.00
3172	Atlas Cedar	Cedrus atlantica	49.3224397	-124.3107653	Excellent	7	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
3171	Douglas Fir	Pseudotsuga menziesii	49.3225044	-124.3107378	Excellent	12	35	Alive	$ 74.16	$ 16.42	1520.65	$ 36.95	$ 6.51	102.34	$ 9.41	10.38	$ 1.83	0.96	$ 3.05	406.36	206.38	225.67
3170	Douglas Fir	Pseudotsuga menziesii	49.3225061	-124.3106372	Good	12	66	Alive	$ 113.14	$ 34.62	3205.48	$ 41.15	$ 12.43	195.49	$ 14.47	15.96	$ 5.58	2.75	$ 4.89	651.61	304.11	431.09
3169	Douglas Fir	Pseudotsuga menziesii	49.3225097	-124.3105868	Fair	11	45	Alive	$ 87.79	$ 22.29	2063.81	$ 39.51	$ 8.29	130.32	$ 11.04	12.17	$ 2.88	1.47	$ 3.78	504.35	257.57	287.37
3168	Douglas Fir	Pseudotsuga menziesii	49.3225194	-124.3105781	Fair	9	73	Alive	$ 118.22	$ 38.68	3581.46	$ 37.84	$ 14.22	223.66	$ 15.89	17.53	$ 6.55	3.21	$ 5.04	671.76	281.28	493.20
3167	Douglas Fir	Pseudotsuga menziesii	49.3225281	-124.3105626	Good	0	77	Stump														
3166	Douglas Fir	Pseudotsuga menziesii	49.3225001	-124.310507	Fair	6	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
3165	Douglas Fir	Pseudotsuga menziesii	49.3224197	-124.3105573	Fair	11	88	Alive	$ 131.98	$ 47.25	4375.36	$ 32.39	$ 18.69	293.91	$ 19.43	21.44	$ 8.71	4.26	$ 5.50	733.98	236.50	648.10
3164	Douglas Fir	Pseudotsuga menziesii	49.3220634	-124.3104575	Good	14	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	3.35	$ 5.06	674.00	270.24	512.47
3163	Grand Fir	Abies grandis	49.3220206	-124.3104488	Good	10	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
3162	Douglas Fir	Pseudotsuga menziesii	49.3219944	-124.3104475	Fair	13	58	Alive	$ 104.24	$ 29.92	2770.55	$ 41.51	$ 10.69	168.02	$ 13.09	14.44	$ 4.49	2.23	$ 4.53	604.52	299.22	370.50
3161	Douglas Fir	Pseudotsuga menziesii	49.3220022	-124.3105085	Good	8	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52
3160	Douglas Fir	Pseudotsuga menziesii	49.3220634	-124.3105916	Good	12	74	Alive	$ 118.72	$ 39.26	3634.79	$ 37.12	$ 14.50	228.03	$ 16.11	17.77	$ 6.69	3.28	$ 5.05	672.88	275.76	502.84
3159	Douglas Fir	Pseudotsuga menziesii	49.3220494	-124.3105769	Good	6	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
3158	Douglas Fir	Pseudotsuga menziesii	49.322032	-124.3106104	Good	9	62	Alive	$ 108.69	$ 32.27	2988.01	$ 41.33	$ 11.56	181.76	$ 13.78	15.20	$ 5.04	2.49	$ 4.71	628.06	301.67	400.79
3157	Douglas Fir	Pseudotsuga menziesii	49.3219909	-124.310597	Good	12	69	Alive	$ 116.22	$ 36.38	3368.14	$ 40.73	$ 13.11	206.19	$ 15.00	16.55	$ 5.99	2.94	$ 5.00	667.26	303.37	454.67
3156	Douglas Fir	Pseudotsuga menziesii	49.3219533	-124.3105662	Good	12	93	Alive	$ 141.96	$ 50.06	4634.77	$ 35.22	$ 20.44	321.40	$ 20.80	22.94	$ 9.48	4.64	$ 5.95	793.88	254.41	708.71
3155	Douglas Fir	Pseudotsuga menziesii	49.3219787	-124.3106857	Good	13	99	Alive	$ 153.93	$ 53.42	4946.06	$ 38.62	$ 22.54	354.38	$ 22.44	24.75	$ 10.42	5.09	$ 6.49	865.76	275.89	781.45
3154	Grand Fir	Abies grandis	49.3219962	-124.310683	Good	8	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
3153	Douglas Fir	Pseudotsuga menziesii	49.3220714	-124.3107165	Good	14	83	Alive	$ 123.22	$ 44.44	4114.76	$ 30.61	$ 17.00	267.35	$ 18.11	19.97	$ 7.94	3.88	$ 5.12	682.98	226.06	589.53
3072	Stump	Brevi Truncus	49.3221686	-124.310519				Stump														
3071	Douglas Fir	Pseudotsuga menziesii	49.3222279	-124.3104016	Fair	8	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
3070	Douglas Fir	Pseudotsuga menziesii	49.3222436	-124.3103821	Fair	12	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
3069	Douglas Fir	Pseudotsuga menziesii	49.3222523	-124.3104311	Good	5	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
3068	Douglas Fir	Pseudotsuga menziesii	49.3222567	-124.3104713	Fair	11	70	Alive	$ 116.72	$ 36.95	3421.47	$ 40.01	$ 13.39	210.56	$ 15.22	16.79	$ 6.13	3.01	$ 5.01	668.39	297.85	464.31
3067	Dogwood sp	Cornus sp	49.3221973	-124.3104338	Excellent	3	4	Alive	$ 34.98	$ 0.48	44.02	$ 33.72	$ 0.24	3.75	$ 0.33	0.36	$ 0.03	0.02	$ 0.19	24.88	18.09	8.26
3066	Douglas Fir	Pseudotsuga menziesii	49.322199	-124.3105028	Fair	11	76	Alive	$ 119.72	$ 40.41	3741.45	$ 35.67	$ 15.06	236.77	$ 16.55	18.26	$ 6.96	3.41	$ 5.06	675.12	264.72	522.10
3065	Douglas Fir	Pseudotsuga menziesii	49.3222025	-124.310582	Good	14	80	Alive	$ 121.72	$ 42.71	3954.77	$ 32.78	$ 16.17	254.24	$ 17.44	19.24	$ 7.52	3.68	$ 5.10	679.62	242.63	560.63
3064	Bigleaf Maple	Acer macrophyllum	49.3222108	-124.3103695	Excellent	5	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
3063	Douglas Fir	Pseudotsuga menziesii	49.3221654	-124.3103362	Good	9	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
3062	Douglas Fir	Pseudotsuga menziesii	49.3222143	-124.3103053	Excellent	15	90	Alive	$ 135.97	$ 48.37	4479.12	$ 33.52	$ 19.39	304.90	$ 19.98	22.04	$ 9.02	4.41	$ 5.68	757.94	243.66	672.35
3061	Douglas Fir	Pseudotsuga menziesii	49.3222859	-124.3103861	Excellent	6	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
3060	Douglas Fir	Pseudotsuga menziesii	49.3223252	-124.3104136	Excellent	6	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
3059	Western Red Cedar	Thuja plicata	49.3223366	-124.3104706	Excellent	6	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
3058	Grand Fir	Abies grandis	49.3224253	-124.3103153	Good	7	47	Alive	$ 90.50	$ 23.46	2172.54	$ 40.04	$ 8.62	135.52	$ 11.34	12.51	$ 3.12	1.58	$ 3.91	521.80	266.88	298.84
3057	Grand Fir	Abies grandis	49.3224297	-124.3104125	Fair	7	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52
3056	Douglas Fir	Pseudotsuga menziesii	49.322462	-124.3103991	Good	10	68	Alive	$ 115.37	$ 35.79	3314.21	$ 41.06	$ 12.87	202.36	$ 14.81	16.34	$ 5.85	2.88	$ 4.98	663.38	305.34	446.23
3055	Douglas Fir	Pseudotsuga menziesii	49.32249	-124.3103186	Excellent	5	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
3054	Douglas Fir	Pseudotsuga menziesii	49.322282	-124.3102381	Excellent	7	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
3053	Douglas Fir	Pseudotsuga menziesii	49.3223662	-124.3102135	Good	10	55	Alive	$ 100.91	$ 28.16	2607.45	$ 41.65	$ 10.03	157.71	$ 12.58	13.87	$ 4.09	2.04	$ 4.40	586.86	297.39	347.78
3052	Douglas Fir	Pseudotsuga menziesii	49.322333	-124.3101619	Good	10	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
3051	Douglas Fir	Pseudotsuga menziesii	49.3223122	-124.3099583	Good	13	77	Alive	$ 120.22	$ 40.98	3794.78	$ 34.95	$ 15.34	241.14	$ 16.78	18.51	$ 7.10	3.48	$ 5.07	676.25	259.19	531.73
3050	Douglas Fir	Pseudotsuga menziesii	49.3222711	-124.3100166	Fair	13	72	Alive	$ 117.72	$ 38.10	3528.13	$ 38.56	$ 13.95	219.29	$ 15.67	17.28	$ 6.41	3.14	$ 5.03	670.63	286.80	483.57
3049	Douglas Fir	Pseudotsuga menziesii	49.322244	-124.3100119	Fair	14	87	Alive	$ 129.98	$ 46.69	4323.47	$ 31.82	$ 18.34	288.41	$ 19.16	21.13	$ 8.55	4.18	$ 5.42	722.00	232.92	635.98
3048	Western Red Cedar	Thuja plicata	49.3222578	-124.3101297	Excellent	9	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
3047	Douglas Fir	Pseudotsuga menziesii	49.3222106	-124.3101314	Poor	11	88	Alive	$ 131.98	$ 47.25	4375.36	$ 32.39	$ 18.69	293.91	$ 19.43	21.44	$ 8.71	4.26	$ 5.50	733.98	236.50	648.10
3046			49.3221922	-124.3100095	Good	2	4	Alive														
3045	Douglas Fir	Pseudotsuga menziesii	49.3221581	-124.3100705	Fair	11	78	Alive	$ 120.72	$ 41.56	3848.11	$ 34.22	$ 15.61	245.50	$ 17.00	18.75	$ 7.24	3.55	$ 5.08	677.37	253.67	541.37
3044	Western Red Cedar	Thuja plicata	49.3221172	-124.3102206	Excellent	5	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
3043	White Pine	Pinus strobus	49.3221406	-124.3101684	Excellent	8	23	Alive	$ 57.46	$ 9.40	870.08	$ 34.07	$ 4.04	63.49	$ 7.13	7.87	$ 0.87	0.48	$ 1.95	259.99	132.44	140.01
3042	Dogwood sp	Cornus sp	49.3220751	-124.3101393	Good	6	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
3041	Western Red Cedar	Thuja plicata	49.3221216	-124.3103615	Excellent	5	12	Alive	$ 43.96	$ 3.54	327.62	$ 33.05	$ 2.00	31.42	$ 4.05	4.46	$ 0.39	0.22	$ 0.93	124.46	60.12	69.29
3040	Grand Fir	Abies grandis	49.3220823	-124.3103038	Fair	9	61	Alive	$ 107.58	$ 31.68	2933.64	$ 41.38	$ 11.34	178.32	$ 13.61	15.01	$ 4.90	2.43	$ 4.67	622.18	301.06	393.22
3039	Western Hemlock	Tsuga heterophylla	49.3220508	-124.3102542	Excellent	5	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	0.19	$ 0.84	112.08	54.16	62.31
3038	Douglas Fir	Pseudotsuga menziesii	49.3220314	-124.3101925	Good	14	84	Alive	$ 123.99	$ 45.01	4167.83	$ 30.12	$ 17.29	271.92	$ 18.34	20.23	$ 8.08	3.95	$ 5.15	686.06	222.18	599.61
3037	Western Red Cedar	Thuja plicata	49.3219755	-124.3103152	Excellent	6	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
3036	Douglas Fir	Pseudotsuga menziesii	49.3219982	-124.3102354	Excellent	1	81	Removed														
3035	Douglas Fir	Pseudotsuga menziesii	49.3219528	-124.3102441	Good	12	89	Alive	$ 133.97	$ 47.81	4427.24	$ 32.95	$ 19.04	299.40	$ 19.71	21.74	$ 8.86	4.33	$ 5.59	745.96	240.08	660.22
2966	Douglas Fir	Pseudotsuga menziesii	49.3219093	-124.3100653	Good	15	77	Alive	$ 120.22	$ 40.98	3794.78	$ 34.95	$ 15.34	241.14	$ 16.78	18.51	$ 7.10	3.48	$ 5.07	676.25	259.19	531.73
2965	Oak sp	Quercus sp	49.3218105	-124.3100914	Excellent	8	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
2964	Oak sp	Quercus sp	49.3217178	-124.3101363	Excellent	11	27	Alive	$ 63.03	$ 11.74	1086.93	$ 35.03	$ 4.86	76.44	$ 7.89	8.70	$ 1.19	0.64	$ 2.32	308.78	157.09	168.56
2963	Oak sp	Quercus sp	49.3215869	-124.3101849	Excellent	11	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70
2962	Oak sp	Quercus sp	49.3214851	-124.3102277	Excellent	9	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	0.40	$ 1.67	223.04	112.76	120.65
2961	Oak sp	Quercus sp	49.3214027	-124.3102512	Good	9	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2960	Pine sp	Pine sp	49.3219157	-124.3104803	Good	9	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
2959	Maple	Acer sp	49.3218932	-124.3103493	Poor	2	7	Alive	$ 38.32	$ 1.59	147.19	$ 33.43	$ 0.91	14.25	$ 1.76	1.95	$ 0.17	0.09	$ 0.47	62.25	33.55	31.42
2958	Torulosa white pine	Pinus strobus â€˜Torulosaâ€™	49.3218355	-124.3102944	Excellent	5	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
2957	Ginkgo	Ginkgo biloba	49.3218005	-124.3104164	Excellent	8	24	Alive	$ 58.85	$ 9.98	924.29	$ 34.31	$ 4.24	66.73	$ 7.32	8.08	$ 0.95	0.52	$ 2.04	272.18	138.60	147.15

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2956	Maple	Acer sp	49.321389	-124.3107029	Excellent	3	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
2955	Douglas Fir	Pseudotsuga menziesii	49.3214921	-124.3106627	Good	15	88	Alive	$ 131.98	$ 47.25	4375.36	$ 32.39	$ 18.69	293.91	$ 19.43	21.44	$ 8.71	4.26	$ 5.50	733.98	236.50	648.10
2954	Western Red Cedar	Thuja plicata	49.3214519	-124.3105621	Good	9	64	Alive	$ 110.92	$ 33.44	3096.74	$ 41.24	$ 12.00	188.63	$ 14.12	15.58	$ 5.31	2.62	$ 4.80	639.84	302.89	415.94
2953	Douglas Fir	Pseudotsuga menziesii	49.321396	-124.3105232	Fair	12	80	Alive	$ 121.72	$ 42.71	3954.77	$ 32.78	$ 16.17	254.24	$ 17.44	19.24	$ 7.52	3.68	$ 5.10	679.62	242.63	560.63
2952	Western Red Cedar	Thuja plicata	49.32134	-124.3105594	Good	9	67	Alive	$ 114.25	$ 35.21	3259.84	$ 41.11	$ 12.65	198.93	$ 14.64	16.15	$ 5.72	2.81	$ 4.93	657.49	304.72	438.66
2951	Douglas Fir	Pseudotsuga menziesii	49.3212771	-124.3106734	Fair	15	90	Alive	$ 135.97	$ 48.37	4479.12	$ 33.52	$ 19.39	304.90	$ 19.98	22.04	$ 9.02	4.41	$ 5.68	757.94	243.66	672.35
2950	Sweetgum	Liquidambar syraciflua	49.3211844	-124.3106587	Excellent	10	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2949	Atlas Cedar	Cedrus atlantica	49.3212246	-124.3107914	Excellent	10	37	Alive	$ 76.94	$ 17.59	1629.07	$ 37.43	$ 6.92	108.81	$ 9.79	10.79	$ 1.99	1.04	$ 3.23	430.75	218.70	239.94
2948	Atlas Cedar	Cedrus atlantica	49.3212054	-124.3109456	Excellent	10	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
2947	Golden Desert Ash	Fraxinus excelsior 'Golden Desert'	49.3213435	-124.310838	Good	3	5	Alive	$ 36.09	$ 0.85	78.41	$ 33.62	$ 0.46	7.25	$ 0.80	0.89	$ 0.08	0.04	$ 0.28	37.33	23.24	15.98
2946	Atlas Cedar	Cedrus atlantica	49.3212998	-124.3110368	Excellent	11	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2945	Western Red Cedar	Thuja plicata	49.3211197	-124.3112662	Good	13	81	Alive	$ 122.22	$ 43.29	4008.10	$ 32.05	$ 16.45	258.61	$ 17.66	19.48	$ 7.66	3.75	$ 5.11	680.74	237.11	570.26
2944	Dogwood sp	Cornus sp	49.3212386	-124.3112917	Excellent	4	5	Alive	$ 36.09	$ 0.85	78.41	$ 33.62	$ 0.46	7.25	$ 0.80	0.89	$ 0.08	0.04	$ 0.28	37.33	23.24	15.98
2943	Littleleaf Linden	Tilia cordata	49.321431	-124.3110172	Good	6	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2942	Oak sp	Quercus sp	49.321367	-124.3111973	Excellent	3	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2941	Red Maple	Acer rubrum	49.3212935	-124.3113917	Excellent	8	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
2940	Red Maple	Acer rubrum	49.3213722	-124.3114118	Excellent	6	14	Alive	$ 46.41	$ 4.60	426.12	$ 33.23	$ 2.37	37.24	$ 4.61	5.09	$ 0.47	0.26	$ 1.12	149.10	73.28	82.13
2939	Red Maple	Acer rubrum	49.3214614	-124.3114078	Excellent	6	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2938	Maple	Acer sp	49.3216419	-124.3114315	Good	7	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
2937	Catalpa (Indian Bean Tree)	Catalpa bignonioides	49.3215282	-124.3111486	Good	8	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	0.40	$ 1.67	223.04	112.76	120.65
2936	Douglas Fir	Pseudotsuga menziesii	49.3215466	-124.3108722	Good	14	94	Alive	$ 143.95	$ 50.62	4686.65	$ 35.79	$ 20.79	326.89	$ 21.07	23.25	$ 9.64	4.71	$ 6.04	805.86	257.99	720.84
2935	London Plane	Platanus x acerifolia	49.321617	-124.3104736	Excellent	16	73	Alive	$ 118.22	$ 38.68	3581.46	$ 37.84	$ 14.22	223.66	$ 15.89	17.53	$ 6.55	3.21	$ 5.04	671.76	281.28	493.20
2934	London Plane	Platanus x acerifolia	49.321589	-124.3107009	Excellent	15	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
2933	Larch sp	Larix sp	49.3216852	-124.3108	Excellent	9	40	Alive	$ 81.04	$ 19.35	1792.00	$ 38.19	$ 7.46	117.31	$ 10.28	11.34	$ 2.30	1.19	$ 3.46	460.74	234.31	258.69
2932	Tulip Tree	Liriodendron tulipifera	49.3217228	-124.3109415	Good	8	35	Alive	$ 74.16	$ 16.42	1520.65	$ 36.95	$ 6.51	102.34	$ 9.41	10.38	$ 1.83	0.96	$ 3.05	406.36	206.38	225.67
2931	Oak sp	Quercus sp	49.3218006	-124.3109877	Good	8	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
2930	Pacific silver (Amabilis) fir	Abies amabilis	49.3218509	-124.3111134	Good	8	27	Alive	$ 63.03	$ 11.74	1086.93	$ 35.03	$ 4.86	76.44	$ 7.89	8.70	$ 1.19	0.64	$ 2.32	308.78	157.09	168.56
2929	Spruce sp	Picea sp	49.3217268	-124.311061	Good	2	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
2927	Empress Tree	Paulownia tomentosa	49.3216936	-124.3113654	Good	11	46	Alive	$ 89.15	$ 22.88	2118.17	$ 39.78	$ 8.45	132.92	$ 11.19	12.34	$ 3.00	1.52	$ 3.85	513.07	262.23	293.11
2926	Red Maple	Acer rubrum	49.3217478	-124.3114452	Excellent	9	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2925	Douglas Fir	Pseudotsuga menziesii	49.3217653	-124.3113279	Excellent	8	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23

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2924	Douglas Fir	Pseudotsuga menziesii	49.3218011	-124.3113996	Excellent	8	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2923	Noble fir	Abies procera	49.3218405	-124.3113426	Good	7	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2922	Red Maple	Acer rubrum	49.3218221	-124.3114539	Excellent	8	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
2921	Douglas Fir	Pseudotsuga menziesii	49.3218859	-124.3113674	Fair	13	92	Alive	$ 139.96	$ 49.50	4582.89	$ 34.65	$ 20.09	315.90	$ 20.53	22.64	$ 9.33	4.56	$ 5.86	781.90	250.83	696.59
2920	Douglas Fir	Pseudotsuga menziesii	49.321894	-124.3114849	Good	14	83	Alive	$ 169.13	$ 44.44	4114.76	$ 76.52	$ 17.00	267.35	$ 18.11	19.97	$ 7.94	3.88	$ 5.12	682.98	226.06	589.53
2919	Red Maple	Acer rubrum	49.3218853	-124.311444	Excellent	4	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
2918	Douglas Fir	Pseudotsuga menziesii	49.3219639	-124.3114728	Excellent	5	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	0.19	$ 0.84	112.08	54.16	62.31
2917	Douglas Fir	Pseudotsuga menziesii	49.3220015	-124.3114574	Good	11	78	Alive	$ 120.72	$ 41.56	3848.11	$ 34.22	$ 15.61	245.50	$ 17.00	18.75	$ 7.24	3.55	$ 5.08	677.37	253.67	541.37
2916	Douglas Fir	Pseudotsuga menziesii	49.3219569	-124.3114299	Excellent	11	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	3.35	$ 5.06	674.00	270.24	512.47
2915	Littleleaf Linden	Tilia cordata	49.3219764	-124.3112312	Good	10	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
2914	Blue Atlas Cedar	Cedrus atlantica 'Glauca'	49.3219404	-124.3111585	Excellent	10	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
2913	Grand Fir	Abies grandis	49.3219886	-124.311041	Fair	9	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52
2912	Grand Fir	Abies grandis	49.322007	-124.3110059	Fair	8	66	Alive	$ 113.14	$ 34.62	3205.48	$ 41.15	$ 12.43	195.49	$ 14.47	15.96	$ 5.58	2.75	$ 4.89	651.61	304.11	431.09
2911	Douglas Fir	Pseudotsuga menziesii	49.3219317	-124.3110733	Excellent	6	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2910	Western Hemlock	Tsuga heterophylla	49.3219759	-124.3109402	Excellent	4	12	Alive	$ 43.96	$ 3.54	327.62	$ 33.05	$ 2.00	31.42	$ 4.05	4.46	$ 0.39	0.22	$ 0.93	124.46	60.12	69.29
2909	Western Red Cedar	Thuja plicata	49.3219222	-124.3109324	Good	10	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	3.35	$ 5.06	674.00	270.24	512.47
2907	Western Red Cedar	Thuja plicata	49.3220073	-124.3109168	Fair	7	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37
2906	Grand Fir	Abies grandis	49.3220498	-124.3109187	Fair	8	74	Alive	$ 118.72	$ 39.26	3634.79	$ 37.12	$ 14.50	228.03	$ 16.11	17.77	$ 6.69	3.28	$ 5.05	672.88	275.76	502.84
2905	Douglas Fir	Pseudotsuga menziesii	49.3221326	-124.3109177	Good	15	107	Alive	$ 132.55	$ 53.45	4949.17	$ 18.52	$ 22.46	353.15	$ 22.34	24.64	$ 10.41	5.09	$ 5.38	716.73	132.26	778.73
2904	Western Red Cedar	Thuja plicata	49.3220801	-124.3109646	Excellent	7	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2903	Atlas Cedar	Cedrus atlantica	49.3221221	-124.311033	Excellent	6	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2902	Giant Sequoia	Sequoiadendron giganteum	49.3220595	-124.3111691	Excellent	4	34	Alive	$ 72.77	$ 15.84	1466.43	$ 36.71	$ 6.30	99.10	$ 9.22	10.17	$ 1.75	0.92	$ 2.96	394.16	200.21	218.53
2901	White Pine	Pinus strobus	49.3220576	-124.3112774	Excellent	9	27	Alive	$ 63.03	$ 11.74	1086.93	$ 35.03	$ 4.86	76.44	$ 7.89	8.70	$ 1.19	0.64	$ 2.32	308.78	157.09	168.56
2900	Douglas Fir	Pseudotsuga menziesii	49.3220663	-124.3114194	Fair	13	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
2899	Mountain Ash	Sorbus aucuparia	49.3220671	-124.3114819	Excellent	4	7	Alive	$ 38.32	$ 1.59	147.19	$ 33.43	$ 0.91	14.25	$ 1.76	1.95	$ 0.17	0.09	$ 0.47	62.25	33.55	31.42
2898	Douglas Fir	Pseudotsuga menziesii	49.3221091	-124.3115053	Good	7	45	Alive	$ 87.79	$ 22.29	2063.81	$ 39.51	$ 8.29	130.32	$ 11.04	12.17	$ 2.88	1.47	$ 3.78	504.35	257.57	287.37
2897	Western Red Cedar	Thuja plicata	49.3221117	-124.3115006	Excellent	9	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
2896	Douglas Fir	Pseudotsuga menziesii	49.3221178	-124.3114597	Fair	13	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37
2895	Douglas Fir	Pseudotsuga menziesii	49.3221563	-124.3114202	Fair	13	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
2894	Douglas Fir	Pseudotsuga menziesii	49.3221501	-124.3113967	Good	13	69	Alive	$ 116.22	$ 36.38	3368.14	$ 40.73	$ 13.11	206.19	$ 15.00	16.55	$ 5.99	2.94	$ 5.00	667.26	303.37	454.67
2893	Douglas Fir	Pseudotsuga menziesii	49.3221536	-124.311341	Good	14	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	3.35	$ 5.06	674.00	270.24	512.47
2892	Douglas Fir	Pseudotsuga menziesii	49.3221292	-124.3113022	Good	14	78	Alive	$ 120.72	$ 41.56	3848.11	$ 34.22	$ 15.61	245.50	$ 17.00	18.75	$ 7.24	3.55	$ 5.08	677.37	253.67	541.37
2891	Pacific Yew	Taxus brevifolia	49.3221432	-124.3112087	Good	7	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
2890	Douglas Fir	Pseudotsuga menziesii	49.3221546	-124.3111349	Good	13	95	Alive	$ 145.95	$ 51.18	4738.53	$ 36.35	$ 21.14	332.39	$ 21.35	23.55	$ 9.80	4.79	$ 6.13	817.84	261.57	732.96
2889	Western Red Cedar	Thuja plicata	49.322159	-124.3110678	Excellent	6	14	Alive	$ 46.41	$ 4.60	426.12	$ 33.23	$ 2.37	37.24	$ 4.61	5.09	$ 0.47	0.26	$ 1.12	149.10	73.28	82.13
2888	Douglas Fir	Pseudotsuga menziesii	49.322207	-124.3110295	Good	11	61	Alive	$ 107.58	$ 31.68	2933.64	$ 41.38	$ 11.34	178.32	$ 13.61	15.01	$ 4.90	2.43	$ 4.67	622.18	301.06	393.22
2887	Spruce sp	Picea sp	49.322221	-124.3112725	Fair	5	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	0.19	$ 0.84	112.08	54.16	62.31
2886	Western Red Cedar	Thuja plicata	49.3222297	-124.3111632	Excellent	7	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2885	White Pine	Pinus strobus	49.3222448	-124.3110756	Excellent	7	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
2884	Douglas Fir	Pseudotsuga menziesii	49.3221984	-124.3109127	Good	10	42	Alive	$ 83.74	$ 20.53	1900.72	$ 38.72	$ 7.79	122.52	$ 10.58	11.67	$ 2.53	1.30	$ 3.59	478.19	243.62	270.16
2883	Douglas Fir	Pseudotsuga menziesii	49.3222496	-124.3109898	Fair	8	51	Alive	$ 95.90	$ 25.81	2389.99	$ 41.10	$ 9.28	145.93	$ 11.94	13.17	$ 3.59	1.80	$ 4.18	556.68	285.49	321.78
2882	Douglas Fir	Pseudotsuga menziesii	49.3222508	-124.3114202	Good	12	65	Alive	$ 112.03	$ 34.03	3151.11	$ 41.20	$ 12.22	192.06	$ 14.29	15.77	$ 5.44	2.68	$ 4.84	645.72	303.50	423.51
2881	Douglas Fir	Pseudotsuga menziesii	49.3222962	-124.3114202	Good	12	64	Alive	$ 110.92	$ 33.44	3096.74	$ 41.24	$ 12.00	188.63	$ 14.12	15.58	$ 5.31	2.62	$ 4.80	639.84	302.89	415.94
2880	Douglas Fir	Pseudotsuga menziesii	49.3221887	-124.3114973	Excellent	5	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	0.19	$ 0.84	112.08	54.16	62.31
2879	Noble fir	Abies procera	49.3223218	-124.3113355	Poor	3	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
2878	Douglas Fir	Pseudotsuga menziesii	49.3222902	-124.3112021	Good	4	7	Alive	$ 38.32	$ 1.59	147.19	$ 33.43	$ 0.91	14.25	$ 1.76	1.95	$ 0.17	0.09	$ 0.47	62.25	33.55	31.42
2877	Atlas Cedar	Cedrus atlantica	49.3222955	-124.3111277	Good	7	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2876	Douglas Fir	Pseudotsuga menziesii	49.3223225	-124.3111611	Good	11	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37
2875	Western Red Cedar	Thuja plicata	49.3223207	-124.3112503	Excellent	6	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
2874	Douglas Fir	Pseudotsuga menziesii	49.3223226	-124.311088	Fair	14	69	Alive	$ 116.22	$ 36.38	3368.14	$ 40.73	$ 13.11	206.19	$ 15.00	16.55	$ 5.99	2.94	$ 5.00	667.26	303.37	454.67
2873	Douglas Fir	Pseudotsuga menziesii	49.322355	-124.3113637	Good	12	68	Alive	$ 115.37	$ 35.79	3314.21	$ 41.06	$ 12.87	202.36	$ 14.81	16.34	$ 5.85	2.88	$ 4.98	663.38	305.34	446.23
2872	Atlas Cedar	Cedrus atlantica	49.3224094	-124.311397	Good	8	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
2871	Stump	Brevi Truncus	49.3224522	-124.3115144				Stump														
2870	Stump	Brevi Truncus	49.3224732	-124.3114842				Stump														
2869	Coast redwood	Sequoia sempervirens	49.3224544	-124.3114047	Excellent	7	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
2868	Pacific silver (Amabilis) fir	Abies amabilis	49.3224197	-124.311339	Excellent	5	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2867	Douglas Fir	Pseudotsuga menziesii	49.3224722	-124.311349	Excellent	6	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2864	Douglas Fir	Pseudotsuga menziesii	49.3224768	-124.31129	Fair	13	96	Alive	$ 147.94	$ 51.74	4790.41	$ 36.92	$ 21.49	337.89	$ 21.62	23.85	$ 9.95	4.87	$ 6.22	829.82	265.15	745.08

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
2862	Dogwood sp	Cornus sp	49.3223606	-124.3112146	Good	2	4	Alive	$ 34.98	$ 0.48	44.02	$ 33.72	$ 0.24	3.75	$ 0.33	0.36	$ 0.03	0.02	$ 0.19	24.88	18.09	8.26
2861	Douglas Fir	Pseudotsuga menziesii	49.3224223	-124.311288	Excellent	4	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
2860	Douglas Fir	Pseudotsuga menziesii	49.3223886	-124.3112133	Poor	12	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
2859	Douglas Fir	Pseudotsuga menziesii	49.3223711	-124.3110657	Fair	10	80	Alive	$ 121.72	$ 42.71	3954.77	$ 32.78	$ 16.17	254.24	$ 17.44	19.24	$ 7.52	3.68	$ 5.10	679.62	242.63	560.63
2858	Douglas Fir	Pseudotsuga menziesii	49.3224009	-124.310992	Fair	9	68	Alive	$ 115.37	$ 35.79	3314.21	$ 41.06	$ 12.87	202.36	$ 14.81	16.34	$ 5.85	2.88	$ 4.98	663.38	305.34	446.23
2857	Dogwood sp	Cornus sp	49.3224358	-124.3110966	Good	5	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
2856	Pacific silver (Amabilis) fir	Abies amabilis	49.3224711	-124.3109787	Excellent	4	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2855	Dogwood sp	Cornus sp	49.3224952	-124.3111066	Good	5	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
2854	Atlas Cedar	Cedrus atlantica	49.3225354	-124.3111481	Good	6	14	Alive	$ 46.41	$ 4.60	426.12	$ 33.23	$ 2.37	37.24	$ 4.61	5.09	$ 0.47	0.26	$ 1.12	149.10	73.28	82.13
2853	Mountain Ash	Sorbus aucuparia	49.3225424	-124.311069	Good	2	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
2852	Douglas Fir	Pseudotsuga menziesii	49.3225336	-124.3110087	Fair	10	49	Alive	$ 93.20	$ 24.64	2281.26	$ 40.57	$ 8.95	140.72	$ 11.64	12.84	$ 3.35	1.69	$ 4.04	539.24	276.18	310.31
2851	Douglas Fir	Pseudotsuga menziesii	49.3225651	-124.310951	Fair	10	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
2850	Western Red Cedar	Thuja plicata	49.3225099	-124.3109245	Excellent	8	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70
2849	Western Red Cedar	Thuja plicata	49.3225659	-124.3109024	Excellent	10	34	Alive	$ 72.77	$ 15.84	1466.43	$ 36.71	$ 6.30	99.10	$ 9.22	10.17	$ 1.75	0.92	$ 2.96	394.16	200.21	218.53
2848	Douglas Fir	Pseudotsuga menziesii	49.3225667	-124.3108528	Fair	12	76	Alive	$ 119.72	$ 40.41	3741.45	$ 35.67	$ 15.06	236.77	$ 16.55	18.26	$ 6.96	3.41	$ 5.06	675.12	264.72	522.10
2847	Douglas Fir	Pseudotsuga menziesii	49.3225982	-124.3108031	Fair	13	99	Alive	$ 153.93	$ 53.42	4946.06	$ 38.62	$ 22.54	354.38	$ 22.44	24.75	$ 10.42	5.09	$ 6.49	865.76	275.89	781.45
2846	Atlas Cedar	Cedrus atlantica	49.3226122	-124.3107083	Excellent	8	23	Alive	$ 57.46	$ 9.40	870.08	$ 34.07	$ 4.04	63.49	$ 7.13	7.87	$ 0.87	0.48	$ 1.95	259.99	132.44	140.01
2845	Katsura Tree	Cercidiphyllum japonicum	49.3226354	-124.3109172	Good	7	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2844	Sweetgum	Liquidambar syraciflua	49.3226554	-124.311002	Excellent	5	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
2843	Dogwood sp	Cornus sp	49.322594	-124.3111186	Fair	3	4	Alive	$ 34.98	$ 0.48	44.02	$ 33.72	$ 0.24	3.75	$ 0.33	0.36	$ 0.03	0.02	$ 0.19	24.88	18.09	8.26
2842	Douglas Fir	Pseudotsuga menziesii	49.3226027	-124.3110917	Good	9	58	Alive	$ 104.24	$ 29.92	2770.55	$ 41.51	$ 10.69	168.02	$ 13.09	14.44	$ 4.49	2.23	$ 4.53	604.52	299.22	370.50
2841	Douglas Fir	Pseudotsuga menziesii	49.3225834	-124.3111737	Good	12	71	Alive	$ 117.22	$ 37.53	3474.80	$ 39.29	$ 13.67	214.93	$ 15.45	17.04	$ 6.27	3.08	$ 5.02	669.51	292.33	473.94
2840	Douglas Fir	Pseudotsuga menziesii	49.322572	-124.3112327	Fair	8	45	Alive	$ 87.79	$ 22.29	2063.81	$ 39.51	$ 8.29	130.32	$ 11.04	12.17	$ 2.88	1.47	$ 3.78	504.35	257.57	287.37
2839	Douglas Fir	Pseudotsuga menziesii	49.3225651	-124.3112877	Fair	13	58	Alive	$ 104.24	$ 29.92	2770.55	$ 41.51	$ 10.69	168.02	$ 13.09	14.44	$ 4.49	2.23	$ 4.53	604.52	299.22	370.50
2838	Norway Maple	Acer platanoides	49.3220718	-124.3093794	Good	8	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2837	Maple	Acer sp	49.3220423	-124.3092505	Fair	10	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52
2836	Norway Maple	Acer platanoides	49.3220182	-124.3091551	Good	10	37	Alive	$ 76.94	$ 17.59	1629.07	$ 37.43	$ 6.92	108.81	$ 9.79	10.79	$ 1.99	1.04	$ 3.23	430.75	218.70	239.94
2835	Norway Maple	Acer platanoides	49.3220042	-124.3090619	Good	9	34	Alive	$ 72.77	$ 15.84	1466.43	$ 36.71	$ 6.30	99.10	$ 9.22	10.17	$ 1.75	0.92	$ 2.96	394.16	200.21	218.53
2834	Cherry sp	Prunus sp (cherry)	49.322196	-124.3075104	Good	10	36	Alive	$ 75.55	$ 17.01	1574.86	$ 37.19	$ 6.71	105.57	$ 9.60	10.58	$ 1.91	1.00	$ 3.14	418.56	212.54	232.80
2833	Cherry sp	Prunus sp (cherry)	49.3221864	-124.3074212	Good	10	37	Alive	$ 76.94	$ 17.59	1629.07	$ 37.43	$ 6.92	108.81	$ 9.79	10.79	$ 1.99	1.04	$ 3.23	430.75	218.70	239.94

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
2832	Cherry sp	Prunus sp (cherry)	49.3221794	-124.3073374	Good	9	36	Alive	$ 75.55	$ 17.01	1574.86	$ 37.19	$ 6.71	105.57	$ 9.60	10.58	$ 1.91	**1.00**	$ 3.14	418.56	212.54	232.80
2831	Cherry sp	Prunus sp (cherry)	49.3221732	-124.3072442	Good	9	48	Alive	$ 91.85	$ 24.05	2226.90	$ 40.31	$ 8.78	138.12	$ 11.49	12.67	$ 3.24	**1.64**	$ 3.98	530.52	271.53	304.58
2830	Cherry sp	Prunus sp (cherry)	49.3222244	-124.3072382	Fair	8	34	Alive	$ 72.77	$ 15.84	1466.43	$ 36.71	$ 6.30	99.10	$ 9.22	10.17	$ 1.75	**0.92**	$ 2.96	394.16	200.21	218.53
2829	Cherry sp	Prunus sp (cherry)	49.3222419	-124.3073301	Good	9	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	**0.88**	$ 2.86	381.96	194.05	211.39
2827	Cherry sp	Prunus sp (cherry)	49.3222533	-124.3074186	Good	6	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	**0.68**	$ 2.41	320.98	163.25	175.70
2826	Cherry sp	Prunus sp (cherry)	49.3222577	-124.3075085	Good	7	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	**0.38**	$ 1.58	210.72	106.18	114.23
2825	Douglas Fir	Pseudotsuga menziesii	49.3222513	-124.3076431	Excellent	14	91	Alive	$ 137.96	$ 48.93	4531.00	$ 34.09	$ 19.74	310.40	$ 20.25	22.34	$ 9.17	**4.49**	$ 5.77	769.92	247.24	684.47
2824	Norway Maple	Acer platanoides	49.3222	-124.3078162	Excellent	10	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	**0.88**	$ 2.86	381.96	194.05	211.39
2823	Norway Maple	Acer platanoides	49.3221798	-124.307912	Excellent	10	40	Alive	$ 81.04	$ 19.35	1792.00	$ 38.19	$ 7.46	117.31	$ 10.28	11.34	$ 2.30	**1.19**	$ 3.46	460.74	234.31	258.69
2822	Norway Maple	Acer platanoides	49.3220409	-124.3079167	Good	9	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	**0.88**	$ 2.86	381.96	194.05	211.39
2821	Norway Maple	Acer platanoides	49.3220889	-124.3079268	Excellent	8	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	**0.76**	$ 2.59	345.37	175.57	189.98
2820	Mountain Ash	Sorbus aucuparia	49.3221265	-124.307957	Fair	5	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	**0.45**	$ 1.86	247.68	125.92	133.49
2819	Mountain Ash	Sorbus aucuparia	49.3220879	-124.3080997	Fair	2	4	Alive	$ 34.98	$ 0.48	44.02	$ 33.72	$ 0.24	3.75	$ 0.33	0.36	$ 0.03	**0.02**	$ 0.19	24.88	18.09	8.26
2818	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3221421	-124.3081808	Good	2	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	**0.19**	$ 0.84	112.08	54.16	62.31
2816	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3221141	-124.3084008	Good	4	24	Alive	$ 58.85	$ 9.98	924.29	$ 34.31	$ 4.24	66.73	$ 7.32	8.08	$ 0.95	**0.52**	$ 2.04	272.18	138.60	147.15
2815	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3221176	-124.308498	Good	4	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	**0.40**	$ 1.67	223.04	112.76	120.65
2814	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3221281	-124.3086073	Good	3	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	**0.40**	$ 1.67	223.04	112.76	120.65
2813	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3221485	-124.3087087	Good	3	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	**0.33**	$ 1.40	186.07	93.02	101.39
2812	Douglas Fir	Pseudotsuga menziesii	49.3221083	-124.3088354	Fair	12	72	Alive	$ 117.72	$ 38.10	3528.13	$ 38.56	$ 13.95	219.29	$ 15.67	17.28	$ 6.41	**3.14**	$ 5.03	670.63	286.80	483.57
2811	Norway Maple	Acer platanoides	49.3221992	-124.3090158	Excellent	8	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	**0.88**	$ 2.86	381.96	194.05	211.39
2810	Norway Maple	Acer platanoides	49.3222124	-124.3091251	Good	8	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	**0.76**	$ 2.59	345.37	175.57	189.98
2809	Norway Maple	Acer platanoides	49.3222298	-124.309233	Excellent	7	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	**0.76**	$ 2.59	345.37	175.57	189.98
2808	Norway Maple	Acer platanoides	49.322243	-124.3093195	Good	6	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	**0.72**	$ 2.50	333.17	169.41	182.84
2807	Douglas Fir	Pseudotsuga menziesii	49.3225531	-124.3113478	Good	13	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	**3.35**	$ 5.06	674.00	270.24	512.47
2806	Douglas Fir	Pseudotsuga menziesii	49.3225479	-124.3113974	Fair	7	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	**1.97**	$ 4.36	580.98	296.78	340.21
2805	European Hornbeam	Carpinus betulus	49.3225146	-124.3114027	Poor	4	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	**0.07**	$ 0.37	49.79	28.39	23.70
2804	White Pine	Pinus strobus	49.3225496	-124.3115134	Good	5	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	**0.36**	$ 1.49	198.39	99.60	107.81
2803	Douglas Fir	Pseudotsuga menziesii	49.3226458	-124.311451	Good	8	75	Alive	$ 119.22	$ 39.83	3688.12	$ 36.39	$ 14.78	232.40	$ 16.33	18.02	$ 6.83	**3.35**	$ 5.06	674.00	270.24	512.47
2802	Arbutus	Arbutus menziesii	49.3227075	-124.3115195	Good	16	49	Alive	$ 93.20	$ 24.64	2281.26	$ 40.57	$ 8.95	140.72	$ 11.64	12.84	$ 3.35	**1.69**	$ 4.04	539.24	276.18	310.31
2801	Black Locust	Robinia sp	49.322753	-124.3114084	Fair	4	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	**0.14**	$ 0.65	87.16	43.85	46.87

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2800	Red Maple	Acer rubrum	49.3227373	-124.3111496	Excellent	6	23	Alive	$ 57.46	$ 9.40	870.08	$ 34.07	$ 4.04	63.49	$ 7.13	7.87	$ 0.87	0.48	$ 1.95	259.99	132.44	140.01
2799	Douglas Fir	Pseudotsuga menziesii	49.3227775	-124.3113145	Fair	16	103	Alive	$ 143.38	$ 53.45	4949.17	$ 28.66	$ 22.51	353.93	$ 22.40	24.71	$ 10.42	5.09	$ 5.94	792.17	204.72	780.46
2798	Douglas Fir	Pseudotsuga menziesii	49.3228759	-124.3112623	Good	9	80	Alive	$ 121.72	$ 42.71	3954.77	$ 32.78	$ 16.17	254.24	$ 17.44	19.24	$ 7.52	3.68	$ 5.10	679.62	242.63	560.63
2797	Douglas Fir	Pseudotsuga menziesii	49.3228567	-124.3112341	Good	14	123	Alive	$ 112.86	$ 53.45	4949.17	$ 0.07	$ 22.37	351.71	$ 22.23	24.52	$ 10.40	5.08	$ 4.35	579.53	0.46	775.56
2796	Douglas Fir	Pseudotsuga menziesii	49.3228357	-124.3111952	Good	8	46	Alive	$ 89.15	$ 22.88	2118.17	$ 39.78	$ 8.45	132.92	$ 11.19	12.34	$ 3.00	1.52	$ 3.85	513.07	262.23	293.11
2795	Oak sp	Quercus sp	49.3227805	-124.3110315	Excellent	12	55	Alive	$ 100.91	$ 28.16	2607.45	$ 41.65	$ 10.03	157.71	$ 12.58	13.87	$ 4.09	2.04	$ 4.40	586.86	297.39	347.78
2794	Cherry sp	Prunus sp (cherry)	49.3227298	-124.310888	Excellent	8	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
2792	Deodar Cedar	Cedrus deodara	49.3235017	-124.3097812	Excellent	4	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
2791	Dogwood sp	Cornus sp	49.3235035	-124.3098409	Good	5	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	0.19	$ 0.84	112.08	54.16	62.31
2790	Giant Sequoia	Sequoiadendron giganteum	49.3235078	-124.3099059	Excellent	10	139	Alive	$ 112.86	$ 53.45	4949.17	$ 0.07	$ 22.37	351.71	$ 22.23	24.52	$ 10.40	5.08	$ 4.35	579.53	0.46	775.56
2789	Spruce sp	Picea sp	49.3235175	-124.3099857	Excellent	6	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2788	Horse Chestnut	Aesculus hippocastanum	49.3236454	-124.3099876	Good	3	11	Alive	$ 42.78	$ 3.08	284.76	$ 33.04	$ 1.80	28.26	$ 3.68	4.06	$ 0.34	0.19	$ 0.84	112.08	54.16	62.31
2787	Oak sp	Quercus sp	49.3236839	-124.3098361	Excellent	8	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2786	Oak sp	Quercus sp	49.3235772	-124.3095745	Good	10	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
2785	Black Cottonwood	Populus trichocarpa	49.323745	-124.3094954	Good	13	78	Alive	$ 120.72	$ 41.56	3848.11	$ 34.22	$ 15.61	245.50	$ 17.00	18.75	$ 7.24	3.55	$ 5.08	677.37	253.67	541.37
2784	Oak sp	Quercus sp	49.3236594	-124.3093492	Excellent	9	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2783	Blue Atlas Cedar	Cedrus atlantica 'Glauca'	49.3236821	-124.3091306	Good	6	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2782	Maple	Acer sp	49.3235562	-124.3090998	Good	5	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2781	Sweetgum	Liquidambar syraciflua	49.3235388	-124.3088892	Excellent	14	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
2780	Sweetgum	Liquidambar syraciflua	49.3234848	-124.3086905	Good	6	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
2779	Maple	Acer sp	49.323712	-124.3089654	Good	8	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
2778	Maple	Acer sp	49.3237208	-124.3087152	Good	6	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
2777	Maple	Acer sp	49.3237855	-124.3088319	Fair	7	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2776	Ash sp	Fraxinus sp	49.3238939	-124.3089244	Excellent	6	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2775	Ash sp	Fraxinus sp	49.3241526	-124.3088721	Excellent	6	24	Alive	$ 58.85	$ 9.98	924.29	$ 34.31	$ 4.24	66.73	$ 7.32	8.08	$ 0.95	0.52	$ 2.04	272.18	138.60	147.15
2774	Ash sp	Fraxinus sp	49.324212	-124.3087635	Good	5	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
2773	Ash sp	Fraxinus sp	49.324254	-124.3088922	Good	5	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2772	Ash sp	Fraxinus sp	49.3242872	-124.3087688	Excellent	6	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
2771	Ash sp	Fraxinus sp	49.3243781	-124.3088077	Excellent	6	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2770	Ash sp	Fraxinus sp	49 3245157	-124.3085955	Excellent	8	27	Alive	$ 63.03	$ 11.74	1086.93	$ 35.03	$ 4.86	76.44	$ 7.89	8.70	$ 1.19	0.64	$ 2.32	308.78	157.09	168.56
2769	Ash sp	Fraxinus sp	49.3245594	-124.3084681	Excellent	7	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
2768	Ash sp	Fraxinus sp	49.3244563	-124.3085016	Excellent	7	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2767	Ash sp	Fraxinus sp	49.3244772	-124.3083742	Excellent	6	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49

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2766	Coast redwood	Sequoia sempervirens	49.3226708	-124.3112676	Excellent	4	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2765	Western Hemlock	Tsuga heterophylla	49.322816	-124.3114981	Good	8	37	Alive	$ 76.94	$ 17.59	1629.07	$ 37.43	$ 6.92	108.81	$ 9.79	10.79	$ 1.99	1.04	$ 3.23	430.75	218.70	239.94
2764	Western Hemlock	Tsuga heterophylla	49.3228501	-124.3114223	Excellent	8	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2763	Western Red Cedar	Thuja plicata	49.322934	-124.311376	Excellent	4	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2762	Western Hemlock	Tsuga heterophylla	49.322886	-124.3115111	Excellent	7	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	0.88	$ 2.86	381.96	194.05	211.39
2761	Red Maple	Acer rubrum	49.3229579	-124.3114959	Good	6	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
2760	Norway Maple	Acer platanoides	49.3230147	-124.3114644	Excellent	8	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
2759	Oak sp	Quercus sp	49.3231604	-124.311472	Excellent	15	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
2758	Paperbark Maple	Acer griseum	49.3232382	-124.3114811	Fair	4	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
2757	Douglas Fir	Pseudotsuga menziesii	49.322796	-124.3107854	Good	14	91	Alive	$ 137.96	$ 48.93	4531.00	$ 34.09	$ 19.74	310.40	$ 20.25	22.34	$ 9.17	4.49	$ 5.77	769.92	247.24	684.47
2756	Fir sp	Abies sp	49.3227086	-124.310754	Good	5	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	0.40	$ 1.67	223.04	112.76	120.65
2755	Dogwood sp	Cornus sp	49.3226347	-124.3103673	Good	5	14	Alive	$ 46.41	$ 4.60	426.12	$ 33.23	$ 2.37	37.24	$ 4.61	5.09	$ 0.47	0.26	$ 1.12	149.10	73.28	82.13
2754	Oak sp	Quercus sp	49.3228323	-124.3106315	Good	7	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
2753	Pin Oak	Quercus palustris	49.3229756	-124.3106195	Excellent	12	35	Alive	$ 74.16	$ 16.42	1520.65	$ 36.95	$ 6.51	102.34	$ 9.41	10.38	$ 1.83	0.96	$ 3.05	406.36	206.38	225.67
2752	Japanese Snowbell	Styrax japonicus	49.3231738	-124.3104224	Excellent	5	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2751	Pink Dawn Chitalpa	x Chitalpa tashkentensis 'pink dawn'	49.3231957	-124.3104673	Good	5	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2750	Birch sp	Betula sp	49.32344	-124.3101148	Fair	7	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2749	Cypress sp	Cupressus sp	49.3234277	-124.3101517	Excellent	4	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
2748	Hinoki cypress	Chamaecyparis obtusa	49.3233725	-124.3101629	Excellent	3	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
2747	Oak sp	Quercus sp	49.3233678	-124.3103372	Proposed Site Medium	12	59	Alive	$ 105.36	$ 30.51	2824.91	$ 41.47	$ 10.90	171.45	$ 13.27	14.63	$ 4.63	2.30	$ 4.58	610.41	299.83	378.07
2746	Oak sp	Quercus sp	49.3232978	-124.310478	Excellent	10	48	Alive	$ 91.85	$ 24.05	2226.90	$ 40.31	$ 8.78	138.12	$ 11.49	12.67	$ 3.24	1.64	$ 3.98	530.52	271.53	304.58
2745	Oak sp	Quercus sp	49.3234167	-124.3105652	Excellent	18	58	Alive	$ 104.24	$ 29.92	2770.55	$ 41.51	$ 10.69	168.02	$ 13.09	14.44	$ 4.49	2.23	$ 4.53	604.52	299.22	370.50
2743	Japanese Snowbell	Styrax japonicus	49.3235045	-124.3104149	Excellent	3	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
2742	Oak sp	Quercus sp	49.323607	-124.3103779	Good	12	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
2740	Trembling Aspen	Populus tremuloides	49.3237041	-124.3104661	Good	5	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2739	Norway Maple	Acer platanoides	49.3238304	-124.310456	Good	8	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2738	Pink Horse Chestnut	Aesculus x carnea	49.323542	-124.3106934	Good	11	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
2737	Littleleaf Linden	Tilia cordata	49.323446	-124.3114558	Good	10	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2736	Norway Maple	Acer platanoides	49.3235334	-124.3115571	Excellent	8	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70
2735	Maple	Acer sp	49.3236164	-124.3115631	Excellent	5	24	Alive	$ 58.85	$ 9.98	924.29	$ 34.31	$ 4.24	66.73	$ 7.32	8.08	$ 0.95	0.52	$ 2.04	272.18	138.60	147.15
2734	Norway Maple	Acer platanoides	49.3237036	-124.3115544	Good	8	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
2733	Shore Pine	Pinus contorta	49.3239532	-124.3116073	Excellent	5	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2732	Norway Maple	Acer platanoides	49.3236266	-124.3114181	Good	8	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
2731	Norway Maple	Acer platanoides	49.3237035	-124.3113195	Good	7	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70
2730	Norway Maple	Acer platanoides	49.323769	-124.3112049	Good	6	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
2729	London Plane	Platanus x acerifolia	49.3237146	-124.3109254	Excellent	12	40	Alive	$ 81.04	$ 19.35	1792.00	$ 38.19	$ 7.46	117.31	$ 10.28	11.34	$ 2.30	1.19	$ 3.46	460.74	234.31	258.69
2728	Norway Maple	Acer platanoides	49.3238012	-124.3110816	Good	7	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2727	Norway Maple	Acer platanoides	49.3238405	-124.3109509	Good	6	23	Alive	$ 57.46	$ 9.40	870.08	$ 34.07	$ 4.04	63.49	$ 7.13	7.87	$ 0.87	0.48	$ 1.95	259.99	132.44	140.01
2726	Palm sp.	Palm sp.	49.3239929	-124.3105644	Excellent	2	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
2725	Palm sp.	Palm sp.	49.3240173	-124.3105771	Excellent	2	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2723	Palm sp.	Palm sp.	49.3240357	-124.3105784	Excellent	2	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
2722	Sycamore maple	Acer pseudoplatanus	49.3240747	-124.3106992	Good	12	73	Alive	$ 118.22	$ 38.68	3581.46	$ 37.84	$ 14.22	223.66	$ 15.89	17.53	$ 6.55	3.21	$ 5.04	671.76	281.28	493.20
2721	Norway Maple	Acer platanoides	49.3242747	-124.3106221	Excellent	4	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
2720	Oak sp	Quercus sp	49.3243612	-124.3107019	Excellent	7	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
2719	Norway Maple	Acer platanoides	49.324404	-124.310547	Excellent	4	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
2718	Maple	Acer sp	49.3244976	-124.3104927	Good	5	14	Alive	$ 46.41	$ 4.60	426.12	$ 33.23	$ 2.37	37.24	$ 4.61	5.09	$ 0.47	0.26	$ 1.12	149.10	73.28	82.13
2717	Oak sp	Quercus sp	49.3245664	-124.3103307	Good	9	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2716	Maple	Acer sp	49.3249067	-124.3098439	Good	8	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2715	Oak sp	Quercus sp	49.3249207	-124.3097521	Excellent	4	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
2714	Maple	Acer sp	49.3250256	-124.3096253	Excellent	8	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	0.88	$ 2.86	381.96	194.05	211.39
2713	Maple	Acer sp	49.3257001	-124.3086209	Fair	7	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2712	Sweetgum	Liquidambar syraciflua	49.3256817	-124.308757	Good	7	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	0.88	$ 2.86	381.96	194.05	211.39
2711	Maple	Acer sp	49.3256188	-124.3088435	Good	6	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
2710	Oak sp	Quercus sp	49.3257701	-124.3085265	Excellent	6	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2709	Maple	Acer sp	49.3258243	-124.308554	Good	7	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2708	Oak sp	Quercus sp	49.3258767	-124.3086512	Excellent	6	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2707	Maple	Acer sp	49.3260935	-124.3083991	Good	6	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
2706	Maple	Acer sp	49.3264616	-124.3081352	Excellent	6	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2705	Maple	Acer sp	49.3267278	-124.3078789	Good	9	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
2704	Oak sp	Quercus sp	49.3268126	-124.3077951	Excellent	6	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
2703	Maple	Acer sp	49.3269147	-124.307763	Good	8	37	Alive	$ 76.94	$ 17.59	1629.07	$ 37.43	$ 6.92	108.81	$ 9.79	10.79	$ 1.99	1.04	$ 3.23	430.75	218.70	239.94
2702	Maple	Acer sp	49.3270161	-124.3078381	Good	9	35	Alive	$ 74.16	$ 16.42	1520.65	$ 36.95	$ 6.51	102.34	$ 9.41	10.38	$ 1.83	0.96	$ 3.05	406.36	206.38	225.67
2701	Cherry sp	Prunus sp (cherry)	49.3267412	-124.3076093	Good	9	39	Alive	$ 136.58	$ 18.77	1737.63	$ 94.82	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
2700	Maple	Acer sp	49.3268015	-124.3075523	Good	11	43	Alive	$ 85.09	$ 21.11	1955.09	$ 38.99	$ 7.96	125.12	$ 10.73	11.84	$ 2.65	1.36	$ 3.65	486.91	248.27	275.90
2699	Cherry sp	Prunus sp (cherry)	49.3268862	-124.3075127	Good	9	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
2698	Frans Fontaine Hornbeam	Carpinus betulus 'Frans Fontaine'	49.3270164	-124.3073799	Excellent	3	12	Alive	$ 43.96	$ 3.54	327.62	$ 33.05	$ 2.00	31.42	$ 4.05	4.46	$ 0.39	0.22	$ 0.93	124.46	60.12	69.29
2697	Pine sp	Pine sp	49.327182	-124.3071948	Excellent	6	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
2696	Pine sp	Pine sp	49.3272335	-124.3071981	Excellent	5	34	Alive	$ 72.77	$ 15.84	1466.43	$ 36.71	$ 6.30	99.10	$ 9.22	10.17	$ 1.75	0.92	$ 2.96	394.16	200.21	218.53
2695	Birch sp	Betula sp	49.3271844	-124.3076083	Excellent	7	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
2693	Pine sp	Pine sp	49.3271407	-124.3076942	Poor	9	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
2692	Paper Birch	Betula papyrifera	49.3271984	-124.3077297	Excellent	6	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
2691	Paper Birch	Betula papyrifera	49.3272578	-124.3077639	Excellent	6	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42
2690	Paper Birch	Betula papyrifera	49.3272613	-124.3076694	Excellent	6	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2689	Paper Birch	Betula papyrifera	49.3272465	-124.3075976	Excellent	6	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2688	Paper Birch	Betula papyrifera	49.3272193	-124.3074977	Excellent	6	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2687	Pine sp	Pine sp	49.3271651	-124.3074729	Good	7	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
2686	Pine sp	Pine sp	49.3272289	-124.3074213	Good	8	53	Alive	$ 98.60	$ 26.99	2498.71	$ 41.63	$ 9.61	151.13	$ 12.24	13.50	$ 3.82	1.91	$ 4.31	574.13	294.79	333.26
2685	Paper Birch	Betula papyrifera	49.327263	-124.307489	Excellent	4	14	Alive	$ 46.41	$ 4.60	426.12	$ 33.23	$ 2.37	37.24	$ 4.61	5.09	$ 0.47	0.26	$ 1.12	149.10	73.28	82.13
2684	Paper Birch	Betula papyrifera	49.3272945	-124.3076063	Excellent	6	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
2683	Paper Birch	Betula papyrifera	49.3273303	-124.3076767	Excellent	7	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	0.40	$ 1.67	223.04	112.76	120.65
2682	Paper Birch	Betula papyrifera	49.3273402	-124.3075992	Excellent	6	20	Alive	$ 53.76	$ 7.79	721.63	$ 33.78	$ 3.48	54.71	$ 6.30	6.95	$ 0.73	0.40	$ 1.67	223.04	112.76	120.65
2681	Arbutus	Arbutus menziesii	49.3273312	-124.3074863	Fair	11	66	Alive	$ 113.14	$ 34.62	3205.48	$ 41.15	$ 12.43	195.49	$ 14.47	15.96	$ 5.58	2.75	$ 4.89	651.61	304.11	431.09
2680	Deodar Cedar	Cedrus deodara	49.3273559	-124.3078312	Good	4	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
2679	Spruce sp	Picea sp	49.3274372	-124.3077327	Good	4	5	Alive	$ 36.09	$ 0.85	78.41	$ 33.62	$ 0.46	7.25	$ 0.80	0.89	$ 0.08	0.04	$ 0.28	37.33	23.24	15.98
2678	Cypress sp	Cupressus sp	49.3274136	-124.3077172	Excellent	3	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
2279	Cherry sp	Prunus sp (cherry)	49.321231	-124.3072441	Good	9	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
2278	Cherry sp	Prunus sp (cherry)	49.3213053	-124.307226	Good	10	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
2277	Cherry sp	Prunus sp (cherry)	49.3213919	-124.3072133	Excellent	11	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
2276	Cherry sp	Prunus sp (cherry)	49.3214592	-124.3072059	Excellent	10	47	Alive	$ 90.50	$ 23.46	2172.54	$ 40.04	$ 8.62	135.52	$ 11.34	12.51	$ 3.12	1.58	$ 3.91	521.80	266.88	298.84
2275	Cherry sp	Prunus sp (cherry)	49.3215475	-124.3071945	Excellent	9	44	Alive	$ 86.44	$ 21.70	2009.45	$ 39.25	$ 8.12	127.72	$ 10.88	12.01	$ 2.77	1.41	$ 3.72	495.63	252.92	281.63
2274	Cherry sp	Prunus sp (cherry)	49.3216454	-124.307167	Excellent	10	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	0.88	$ 2.86	381.96	194.05	211.39
2273	Cherry sp	Prunus sp (cherry)	49.3217171	-124.307169	Excellent	10	28	Alive	$ 64.42	$ 12.32	1141.15	$ 35.27	$ 5.07	79.68	$ 8.08	8.91	$ 1.27	0.68	$ 2.41	320.98	163.25	175.70
2272	Cherry sp	Prunus sp (cherry)	49.3217931	-124.3071549	Excellent	7	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
2271	Cherry sp	Prunus sp (cherry)	49.3218753	-124.3071543	Excellent	9	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
2270	Cherry sp	Prunus sp (cherry)	49.3219444	-124.3071415	Excellent	8	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
2269	Cherry sp	Prunus sp (cherry)	49.3220388	-124.3071476	Excellent	9	26	Alive	$ 61.63	$ 11.15	1032.72	$ 34.79	$ 4.66	73.20	$ 7.70	8.49	$ 1.11	0.60	$ 2.22	296.58	150.93	161.42

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
394	Evergreen Oak	Quercus ilex	49.3220972	-124.3097248	Fair	5	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
393	Douglas Fir	Pseudotsuga menziesii	49.3220302	-124.3098303	Good	13	105	Alive	$ 173.35	$ 53.45	4949.17	$ 58.98	$ 22.49	353.54	$ 22.37	24.67	$ 10.42	5.09	$ 5.66	754.45	168.49	779.60
392	Douglas Fir	Pseudotsuga menziesii	49.322252	-124.3098151	Fair	10	76	Alive	$ 173.23	$ 40.41	3741.45	$ 89.18	$ 15.06	236.77	$ 16.55	18.26	$ 6.96	3.41	$ 5.06	675.12	264.72	522.10
391	Grand Fir	Abies grandis	49.3222652	-124.3097672	Good	11	79	Alive	$ 171.47	$ 42.14	3901.44	$ 83.75	$ 15.89	249.87	$ 17.22	18.99	$ 7.38	3.62	$ 5.09	678.49	248.15	551.00
390	Japanese Snowbell	Styrax japonicus	49.3222828	-124.309685	Excellent	3	7	Alive	$ 88.46	$ 1.59	147.19	$ 83.57	$ 0.91	14.25	$ 1.76	1.95	$ 0.17	0.09	$ 0.47	62.25	33.55	31.42
389	Paperbark Maple	Acer griseum	49.3222647	-124.3095818	Good	4	17	Alive	$ 100.35	$ 6.20	573.87	$ 83.77	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
388	London Plane	Platanus x acerifolia	49.3221201	-124.3098021	Excellent	17	30	Alive	$ 120.83	$ 13.50	1249.58	$ 89.37	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
387	Douglas Fir	Pseudotsuga menziesii	49.3221548	-124.3096524	Good	17	92	Alive	$ 191.94	$ 49.50	4582.89	$ 86.63	$ 20.09	315.90	$ 20.53	22.64	$ 9.33	4.56	$ 5.86	781.90	250.83	696.59
386	Douglas Fir	Pseudotsuga menziesii	49.3221087	-124.309652	Good	10	91	Alive	$ 190.34	$ 49.18	4553.83	$ 85.84	$ 19.90	312.82	$ 20.37	22.47	$ 9.24	4.52	$ 5.81	775.19	248.82	689.80
385	Pin Oak	Quercus palustris	49.32198	-124.3096385	Good	16	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
384	European Ash	Fraxinus excelsior	49.3219782	-124.3098522	Fair	9	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
383	Douglas Fir	Pseudotsuga menziesii	49.3220132	-124.30996	Good	12	82	Alive	$ 169.72	$ 43.86	4061.43	$ 78.33	$ 16.73	262.98	$ 17.89	19.73	$ 7.80	3.82	$ 5.11	681.86	231.58	579.90
378	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.3264578	-124.3073098	Excellent	3	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
377	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.3265317	-124.3073126	Excellent	4	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
376	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.326937	-124.3072402	Excellent	4	10	Alive	$ 42.22	$ 2.89	267.56	$ 33.09	$ 1.69	26.51	$ 3.44	3.80	$ 0.32	0.18	$ 0.79	105.85	51.58	58.45
375	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.3266221	-124.307302	Excellent	4	12	Alive	$ 43.96	$ 3.54	327.62	$ 33.05	$ 2.00	31.42	$ 4.05	4.46	$ 0.39	0.22	$ 0.93	124.46	60.12	69.29
374	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.326708	-124.3072868	Excellent			Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
373	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.3267783	-124.3072622	Excellent	4	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
372	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3264751	-124.3077439	Excellent	5	27	Alive	$ 63.03	$ 11.74	1086.93	$ 35.03	$ 4.86	76.44	$ 7.89	8.70	$ 1.19	0.64	$ 2.32	308.78	157.09	168.56
371	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3262093	-124.3080604	Excellent	6	63	Alive	$ 109.80	$ 32.86	3042.38	$ 41.29	$ 11.78	185.19	$ 13.95	15.39	$ 5.17	2.55	$ 4.75	633.95	302.28	408.37
370	Pacific Sunset Maple	Acer truncatum x Acer platanoides 'Pacific Sunset'	49.3268708	-124.307236	Excellent	4	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
89	Pin Oak	Quercus palustris	49.3230525	-124.3109921	Dead	2	5	Removed														
87	Flamingo Boxelder Maple	Acer negundo 'Flamingo'	49.3230788	-124.3099266	Good	9	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
86	Norway Spruce	Picea abies	49.3231623	-124.3101009	Fair	10	56	Alive	$ 102.02	$ 28.75	2661.81	$ 41.60	$ 10.25	161.15	$ 12.75	14.06	$ 4.22	2.10	$ 4.45	592.75	298.00	355.35

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85	Purple Fastigiate Beech	Fagus sylvatica 'Purpurea Fastigiata'	49.3230945	-124.3101921	Good	6	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
84	Himalayan White Birch	Betula utilis var. jacquemontii	49.3230967	-124.3100741	Fair	9	30	Alive	$ 67.20	$ 13.50	1249.58	$ 35.75	$ 5.48	86.15	$ 8.46	9.33	$ 1.43	0.76	$ 2.59	345.37	175.57	189.98
83	Himalayan White Birch	Betula utilis var. jacquemontii	49.3230412	-124.3100513	Fair	11	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
82	Himalayan White Birch	Betula utilis var. jacquemontii	49.3230451	-124.3101371	Poor	10	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
81	Spindle Tree	Euonymus europaeus 'Red Cascade'	49.3230053	-124.3102323	Fair	3	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
80	Honey Locust	Gleditsia triacanthos	49.3229494	-124.3099587	Good	16	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
79	Milky Way Chinese Dogwood	Cornus kousa 'Milky Way'	49.3228843	-124.3100164	Fair	5	21	Alive	$ 54.99	$ 8.33	770.88	$ 33.87	$ 3.66	57.63	$ 6.58	7.26	$ 0.78	0.43	$ 1.77	235.36	119.34	127.07
78	Pink Flowering Dogwood	Corpus Florida 'Rubra'	49.3229153	-124.3102927	Good	5	28	Alive														
77	Douglas Fir	Pseudotsuga menziesii	49.3229262	-124.3102384	Fair	13	110	Alive	$ 124.43	$ 53.45	4949.17	$ 10.91	$ 22.42	352.55	$ 22.29	24.59	$ 10.40	5.09	$ 4.95	660.15	77.90	777.42
76	Douglas Fir	Pseudotsuga menziesii	49.3228865	-124.3101726	Good	11	70	Alive	$ 116.72	$ 36.95	3421.47	$ 40.01	$ 13.39	210.56	$ 15.22	16.79	$ 6.13	3.01	$ 5.01	668.39	297.85	464.31
75	Douglas Fir	Pseudotsuga menziesii	49.3228493	-124.3102692	Good	13	112	Alive	$ 119.02	$ 53.45	4949.17	$ 5.84	$ 22.40	352.16	$ 22.26	24.55	$ 10.40	5.08	$ 4.67	622.43	41.67	776.55
74	Purple Indian Bean Tree	Catalpa x erubescens 'Purpurea'	49.3228476	-124.3101083	Good	5	18	Alive	$ 51.31	$ 6.73	623.13	$ 33.60	$ 3.11	48.89	$ 5.74	6.33	$ 0.65	0.36	$ 1.49	198.39	99.60	107.81
73	Kwansan Japanese Flowering Cherry	Prunus serrulata 'Kwanzan'	49.3227794	-124.3102182	Poor	13	60	Alive	$ 106.47	$ 31.10	2879.28	$ 41.42	$ 11.12	174.89	$ 13.44	14.82	$ 4.77	2.36	$ 4.62	616.29	300.44	385.65
72	Red Sunset Maple	Acer rubrum 'Red Sunset'	49.3226588	-124.3101378	Excellent	6	25	Alive	$ 60.24	$ 10.57	978.51	$ 34.55	$ 4.45	69.97	$ 7.51	8.29	$ 1.03	0.56	$ 2.13	284.38	144.77	154.29
71	Black Lace Elderberry	Sambucus nigra 'Eva'	49.3227584	-124.3100949	Good	5	40	Alive	$ 81.04	$ 19.35	1792.00	$ 38.19	$ 7.46	117.31	$ 10.28	11.34	$ 2.30	1.19	$ 3.46	460.74	234.31	258.69
70	Milky Way Chinese Dogwood	Cornus kousa 'Milky Way'	49.3227497	-124.31006	Good	5	12	Alive	$ 43.96	$ 3.54	327.62	$ 33.05	$ 2.00	31.42	$ 4.05	4.46	$ 0.39	0.22	$ 0.93	124.46	60.12	69.29
69	Serbian Spruce	Picea omorika	49.3227969	-124.3100573	Fair	5	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
68	Serbian Spruce	Picea omorika	49.3228353	-124.3099903	Fair	5	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
67	Victoria Evergreen Magnolia	Magnolia grandiflora 'Victoria'	49.3228441	-124.3099393	Good	2	5	Alive	$ 36.09	$ 0.85	78.41	$ 33.62	$ 0.46	7.25	$ 0.80	0.89	$ 0.08	0.04	$ 0.28	37.33	23.24	15.98
66	Serbian Spruce	Picea omorika	49.322838	-124.3098937	Fair	5	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
65	Serbian Spruce	Picea omorika	49.3228213	-124.3098293	Fair	5	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
64	Serbian Spruce	Picea omorika	49.322803	-124.309781	Fair	5	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
63	Rose Marie Magnolia	Magnolia 'Rose Marie'	49.3226618	-124.3097194	Excellent	1	4	Alive	$ 34.98	$ 0.48	44.02	$ 33.72	$ 0.24	3.75	$ 0.33	0.36	$ 0.03	0.02	$ 0.19	24.88	18.09	8.26
62	Rose Marie Magnolia	Magnolia 'Rose Marie'	49.3226216	-124.3097194	Excellent	1	5	Alive	$ 36.09	$ 0.85	78.41	$ 33.62	$ 0.46	7.25	$ 0.80	0.89	$ 0.08	0.04	$ 0.28	37.33	23.24	15.98

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61	Rose Marie Magnolia	Magnolia 'Rose Marie'	49.3225748	-124.3097113	Excellent	1	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
60	Deodar Cedar	Cedrus deodara	49.3224595	-124.309824	Fair	16	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
59	Deodar Cedar	Cedrus deodara	49.3224018	-124.3095665	Fair	18	69	Alive	$ 116.22	$ 36.38	3368.14	$ 40.73	$ 13.11	206.19	$ 15.00	16.55	$ 5.99	2.94	$ 5.00	667.26	303.37	454.67
58	Red Sunset Maple	Acer rubrum 'Red Sunset'	49.3224315	-124.3093626	Fair	12	33	Alive	$ 71.38	$ 15.25	1412.22	$ 36.47	$ 6.10	95.86	$ 9.03	9.96	$ 1.67	0.88	$ 2.86	381.96	194.05	211.39
57	Red Sunset Maple	Acer rubrum 'Red Sunset'	49.3224367	-124.3092634	Good	12	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
56	Red Sunset Maple	Acer rubrum 'Red Sunset'	49.3224367	-124.3091615	Good	12	42	Alive	$ 83.74	$ 20.53	1900.72	$ 38.72	$ 7.79	122.52	$ 10.58	11.67	$ 2.53	1.30	$ 3.59	478.19	243.62	270.16
55	Ginkgo	Ginkgo biloba	49.3223615	-124.3092902	Excellent	5	15	Alive	$ 47.63	$ 5.13	475.37	$ 33.33	$ 2.55	40.16	$ 4.89	5.40	$ 0.52	0.29	$ 1.21	161.43	79.86	88.55
54	Ginkgo	Ginkgo biloba	49.3223441	-124.3091266	Good	6	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
53	Golden Oriental Spruce	Picea orientalis 'Aurea'	49.3223685	-124.3089764	Excellent	2	8	Alive	$ 39.44	$ 1.96	181.58	$ 33.33	$ 1.13	17.75	$ 2.24	2.47	$ 0.21	0.12	$ 0.56	74.71	38.70	39.15
52	Douglas Fir	Pseudotsuga menziesii	49.3224009	-124.3088745	Fair	11	81	Alive	$ 122.22	$ 43.29	4008.10	$ 32.05	$ 16.45	258.61	$ 17.66	19.48	$ 7.66	3.75	$ 5.11	680.74	237.11	570.26
51	Dragon's Eye White Pine	Pinus parviflora 'Ogon Janome'	49.3224402	-124.3090193	Good	5	10	Alive	$ 41.67	$ 2.70	250.36	$ 33.14	$ 1.57	24.76	$ 3.20	3.53	$ 0.30	0.17	$ 0.75	99.62	49.00	54.59
50	Paperbark Maple	Acer griseum	49.3225075	-124.3090354	Excellent	6	22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
49	Forest Pansy Redbud	Cercis canadensis 'Forest Pansy'	49.3225591	-124.3090434	Poor	5	16	Alive	$ 48.86	$ 5.67	524.62	$ 33.42	$ 2.74	43.07	$ 5.17	5.71	$ 0.56	0.31	$ 1.30	173.75	86.44	94.97
48	Emperor Tree	Quercus dentata 'Carl Ferris Miller'	49.3224708	-124.3089227	Excellent	3	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
47	Empress Tree	Paulownia tomentosa	49.3225416	-124.3088986	Fair	4	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
46	Pride of India	Koelreuteria paniculata	49.3226605	-124.3088181	Fair	3	9	Alive	$ 40.55	$ 2.33	215.97	$ 33.24	$ 1.35	21.25	$ 2.72	3.00	$ 0.26	0.14	$ 0.65	87.16	43.85	46.87
45	London Plane	Platanus x acerifolia	49.3226386	-124.3089469	Good	15	45	Alive	$ 87.79	$ 22.29	2063.81	$ 39.51	$ 8.29	130.32	$ 11.04	12.17	$ 2.88	1.47	$ 3.78	504.35	257.57	287.37
44	Tall Stewartia	Stewartia monadelpha	49.3226465	-124.3090595	Excellent	3	7	Alive	$ 38.32	$ 1.59	147.19	$ 33.43	$ 0.91	14.25	$ 1.76	1.95	$ 0.17	0.09	$ 0.47	62.25	33.55	31.42
43	Paperbark Maple	Acer griseum	49.3227156	-124.3090408	Excellent	6	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
42	Japanese Wing Nut	Pterocarya rhoifolia	49.3227811	-124.3090703	Fair	7	35	Alive	$ 74.16	$ 16.42	1520.65	$ 36.95	$ 6.51	102.34	$ 9.41	10.38	$ 1.83	0.96	$ 3.05	406.36	206.38	225.67
41	Persian Silk Tree	Albizia julibrissin	49.3227715	-124.3088959	Poor	2	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
40	Persian Ironwood	Parrotia persica	49.3227427	-124.3087967	Fair	8	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
39	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3228563	-124.30879	Excellent	5	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
38	Purple Fastigiate Beech	Fagus sylvatica 'Purpurea Fastigiata'	49.3229612	-124.3087913	Good	5	41	Alive	$ 82.39	$ 19.94	1846.36	$ 38.46	$ 7.63	119.92	$ 10.43	11.51	$ 2.41	1.25	$ 3.52	469.47	238.97	264.43
37	Dove Tree	Davidia involucrata	49.3230241	-124.3088302	Excellent	4	13	Alive	$ 45.18	$ 4.07	376.87	$ 33.14	$ 2.18	34.33	$ 4.33	4.78	$ 0.43	0.24	$ 1.03	136.78	66.70	75.71
36	Tulip Tree	Liriodendron tulipifera	49.3229149	-124.3089348	Good	8	42	Alive	$ 83.74	$ 20.53	1900.72	$ 38.72	$ 7.79	122.52	$ 10.58	11.67	$ 2.53	1.30	$ 3.59	478.19	243.62	270.16
35	Tulip Tree	Liriodendron tulipifera	49.3228419	-124.3090045	Fair	12	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
34	Tulip Tree	Liriodendron tulipifera	49.3229463	-124.3090971	Fair	11	52	Alive	$ 97.25	$ 26.40	2444.35	$ 41.37	$ 9.45	148.53	$ 12.09	13.34	$ 3.71	1.86	$ 4.24	565.41	290.14	327.52
33	Dawyck Beech	Fagus sylvatica 'Dawyck'	49.3228664	-124.3092044	Good	7	39	Alive	$ 79.69	$ 18.77	1737.63	$ 37.93	$ 7.30	114.71	$ 10.13	11.17	$ 2.18	1.14	$ 3.39	452.02	229.66	252.95
32	Fern Leaved Beech	Fagus sylvatica 'Asplenifolia'	49.322876	-124.3093076	Good	11	29	Alive	$ 65.81	$ 12.91	1195.36	$ 35.51	$ 5.27	82.92	$ 8.27	9.12	$ 1.35	0.72	$ 2.50	333.17	169.41	182.84
31	Sweetgum	Liquidambar syraciflua	49.3229393	-124.3094122	Poor	6	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
30	Seiryu Japanese Maple	Acer palmatum 'Seiryu'	49.322963	-124.3092486	Good	7	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
29	Pin Oak	Quercus palustris	49.3231107	-124.3092459	Good	15	46	Alive														
28	Perkins Pink Yellowwood	Cladrastis kentukea 'Perkins Pink'	49.3231072	-124.3091185	Excellent	3	7	Alive	$ 38.32	$ 1.59	147.19	$ 33.43	$ 0.91	14.25	$ 1.76	1.95	$ 0.17	0.09	$ 0.47	62.25	33.55	31.42
27	Red Oak	Quercus rubra	49.3231238	-124.3089308	Good	17	65	Alive	$ 112.03	$ 34.03	3151.11	$ 41.20	$ 12.22	192.06	$ 14.29	15.77	$ 5.44	2.68	$ 4.84	645.72	303.50	423.51
26	Village Green Zelkova	Zelkova serrata 'Village Green'	49.3232322	-124.3090273	Good	11	36	Alive	$ 75.55	$ 17.01	1574.86	$ 37.19	$ 6.71	105.57	$ 9.60	10.58	$ 1.91	1.00	$ 3.14	418.56	212.54	232.80
25	Tupelo	Nyssa sylvatica	49.3232208	-124.309191	Good	6	24	Alive	$ 58.85	$ 9.98	924 29	$ 34.31	$ 4.24	66.73	$ 7.32	8.08	$ 0.95	0.52	$ 2.04	272.18	138.60	147.15
24	Bur Oak	Quercus macrocarpa	49.3233406	-124.3092071	Excellent	8	32	Alive	$ 69.98	$ 14.67	1358.00	$ 36.23	$ 5.89	92.63	$ 8.84	9.75	$ 1.59	0.84	$ 2.77	369.77	187.89	204.25
23	Golden Spanish Fir	Abies pinsapo 'Aurea'	49.3232387	-124.3094136	Good	1	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
22	Douglas Fir	Pseudotsuga menziesii	49.3233296	-124.3094605	Poor	18	138	Alive	$ 112.86	$ 53.45	4949.17	$ 0.07	$ 22.37	351.71	$ 22.23	24.52	$ 10.40	5.08	$ 4.35	579.53	0.46	775.56
21	Douglas Fir	Pseudotsuga menziesii	49.3234144	-124.3093841	Good	12	108	Alive	$ 129.85	$ 53.45	4949.17	$ 15.98	$ 22.45	352.95	$ 22.32	24.62	$ 10.41	5.09	$ 5.23	697.87	114.14	778.29
20	Epaulette Tree	Pterostyrax sp	49.3234127	-124.3095732	Good			Alive														
19	Emerald Queen Norway Maple	Acer platanoides 'Emerald Queen'	49.3233279	-124.3096684	Fair	10	61	Alive	$ 107.58	$ 31.68	2933.64	$ 41.38	$ 11.34	178.32	$ 13.61	15.01	$ 4.90	2.43	$ 4.67	622.18	301.06	393.22
18	Emerald Queen Norway Maple	Acer platanoides 'Emerald Queen'	49.3232484	-124.309718	Good	10	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
17	Fastigiate English Oak	Quercus robur 'Fastigiata'	49.3233694	-124.3097676	Excellent	5	35	Alive	$ 74.16	$ 16.42	1520.65	$ 36.95	$ 6.51	102.34	$ 9.41	10.38	$ 1.83	0.96	$ 3.05	406.36	206.38	225.67
16	Willow Oak	Quercus phellos	49.3233109	-124.3098602	Excellent	9	38	Alive	$ 78.33	$ 18.18	1683.29	$ 37.66	$ 7.13	112.05	$ 9.98	11.00	$ 2.07	1.08	$ 3.32	442.95	224.86	247.08
15	Dawn Redwood	Metasequoia glyptostoboides	49.3231998	-124.3098481	Excellent	8	54	Alive	$ 99.79	$ 27.57	2553.08	$ 41.69	$ 9.81	154.28	$ 12.41	13.69	$ 3.95	1.97	$ 4.36	580.98	296.78	340.21
14	Dawn Redwood	Metasequoia glyptostoboides	49.3232357	-124.3100345	Excellent	9	55	Alive	$ 100.91	$ 28.16	2607.45	$ 41.65	$ 10.03	157.71	$ 12.58	13.87	$ 4.09	2.04	$ 4.40	586.86	297.39	347.78
13	Dawn Redwood	Metasequoia glyptostoboides	49.3231526	-124.3099393	Excellent	9	44	Alive	$ 86.44	$ 21.70	2009.45	$ 39.25	$ 8.12	127.72	$ 10.88	12.01	$ 2.77	1.41	$ 3.72	495.63	252.92	281.63
12	Antarctic Beech	Nothofagus antarctica	49.3230976	-124.3098253	Fair	5	19	Alive	$ 52.53	$ 7.26	672.38	$ 33.69	$ 3.29	51.80	$ 6.02	6.64	$ 0.69	0.38	$ 1.58	210.72	106.18	114.23
11	Norway Globe Maple	Acer platanoides 'Globosum'	49.3231535	-124.3097475	Good		22	Alive	$ 56.21	$ 8.86	820.13	$ 33.96	$ 3.85	60.54	$ 6.86	7.57	$ 0.82	0.45	$ 1.86	247.68	125.92	133.49
10	American Hornbeam	Carpinus caroliniana	49.3231815	-124.3095785	Fair	6	12	Alive	$ 43.96	$ 3.54	327.62	$ 33.05	$ 2.00	31.42	$ 4.05	4.46	$ 0.39	0.22	$ 0.93	124.46	60.12	69.29
9	European Beech	Fagus sylvatica	49.3231225	-124.309431	Excellent	14	44	Alive	$ 86.44	$ 21.70	2009.45	$ 39.25	$ 8.12	127.72	$ 10.88	12.01	$ 2.77	1.41	$ 3.72	495.63	252.92	281.63
8	European Beech	Fagus sylvatica	49.3230018	-124.3094753	Excellent	16	65	Alive	$ 112.03	$ 34.03	3151.11	$ 41.20	$ 12.22	192.06	$ 14.29	15.77	$ 5.44	2.68	$ 4.84	645.72	303.50	423.51
7	River's Purple Beech	Fagus sylvatica 'Riversii'	49.3230543	-124.3095919	Excellent	11	43	Alive	$ 85.09	$ 21.11	1955.09	$ 38.99	$ 7.96	125.12	$ 10.73	11.84	$ 2.65	1.36	$ 3.65	486.91	248.27	275.90

Tree ID	Common Name	Latin Name	Latitude	Longitude	Condition	Canopy Width (m)	DBH (cm)	Status	Overall Monetary Benefit	Stormwater Monetary Benefit	Runoff Prevention (Gallons)	Property Value Total	Energy Savings	Energy Saved (kWh)	Natural Gas Savings	Heat Preventions (Therms)	Air Quality Monetary Benefit	Pollutants Removed (lb)	Carbon Monetary Benefit	Carbon Stored (lb)	Carbon Sequestered (lb)	Carbon Avoided (lb)
6	Evergreen Oak	Quercus Ilex	49.3230442	-124.3097368	Poor	4	17	Alive	$ 50.08	$ 6.20	573.87	$ 33.51	$ 2.92	45.98	$ 5.46	6.02	$ 0.60	0.33	$ 1.40	186.07	93.02	101.39
5	Sunsation Magnolia	Magnolia X 'Sunsation'	49.3229826	-124.3097676	Excellent	1	6	Alive	$ 37.21	$ 1.22	112.80	$ 33.53	$ 0.68	10.75	$ 1.28	1.42	$ 0.12	0.07	$ 0.37	49.79	28.39	23.70
4	Northern Pin Oak	Quercus ellipsoidalis	49.3228812	-124.3097422	Good	9	24	Alive	$ 58.85	$ 9.98	924.29	$ 34.31	$ 4.24	66.73	$ 7.32	8.08	$ 0.95	0.52	$ 2.04	272.18	138.60	147.15
3	Weeping Purple Beech	Fagus sylvatica 'Purpurea Pendula'	49.3229433	-124.3096322	Good	7	31	Alive	$ 68.59	$ 14.08	1303.79	$ 35.99	$ 5.69	89.39	$ 8.65	9.54	$ 1.51	0.80	$ 2.68	357.57	181.73	197.11
2	Dawyck Gold European Beech	Fagus sylvatica 'Dawyck Gold'	49.3228764	-124.3096161	Good	6	40	Alive	$ 81.04	$ 19.35	1792.00	$ 38.19	$ 7.46	117.31	$ 10.28	11.34	$ 2.30	1.19	$ 3.46	460.74	234.31	258.69
1	Japanese Snowbell	Styrax japonicus	49.322886	-124.3094793	Fair	6	16	Alive														
								SUMMARY	$ 40,341.21	$ 9,820.05	909263.93	$ 18,747.74	$ 3,834.79	60295.47	$ 4,978.96	5491.90	$ 1,442.38	724.96	$ 1,517.30	202306.23	91800.84	132958.68
											Gal			kWh		Therms		lb		lb	lb	lb

Appendix G: Reuse Assessment

Background

Included in the RFP for the Community Park Stormwater Management Master Plan (CPSMMP) was investigating the feasibility of using a cistern to capture and reuse stormwater runoff for irrigation in the park. Community Park is highly maintained with considerable irrigation required to keep it vibrant throughout the dry summer months. Annual rainfall of 1138.5 mm occurs primarily during the winter months (862.4 mm), followed by a much drier climate from April until September (276.2 mm). The opportunity to capture and retain winter rains for reuse in spring and summer irrigation is an intriguing idea. This memo outlines the feasibility of capturing winter rains in a cistern to offset irrigation demands. Recommendations for other reuse options requiring further examination beyond the scope of this project are also provided.

Water Balance

EOR used a Stormwater Reuse Model that uses a water budget approach to assess the feasibility of stormwater capture and use/reuse for irrigation at Parksville Community park. A harvest and use/reuse ("reuse") system is based on a water balance, comparing the harvested water supply (rainfall runoff), the storage (cistern), along with the demand (irrigation). In this way the system can be evaluated for its benefits of addressing increased urban runoff and in order to determine how much reduction in the current water source (treated municipal water) can be achieved. Once the source of water has been identified, the ability to capitalize on the new water source depends on the storage available at the times the runoff is occurring. These three factors, water supply, water demand and storage, are the key aspects determining the performance and effectiveness of any reuse system. EOR compiled data from the City to characterize the three factors within the Stormwater Reuse Model.

- Water Supply/Source
    - Location & Size of contributing catchment
    - Precipitation records
- Water Demand
    - Irrigation coverage
    - Irrigation depth (estimate from records)
    - Precipitation records (when is irrigation needed)
    - Reuse Regulations (level of treatment needed)
- Potential Storage Options
    - Surface or subsurface cistern

Sources of Water

The easiest source of runoff for capture is the curling club roof. As an impervious surface, 100% of the rainfall is expected to runoff. Existing downspouts can be easily redirected to a central storage facility (cistern). The roof runoff would be relatively clean as a water source. The area of the rooftop that would be redirected to a cistern is 2906 m^2.

Surface runoff from the areas draining to the dry pond along the eastern edge of the park could be stored in the dry pond and reused for irrigation. This use would require installation of an impermeable liner in that area. This changes both the ability of the site to naturally manage stormwater and reduces the facility's availability to mitigate nuisance ponding in the Park. The management required for this facility as a flood reduction measure would be in competition with reuse and therefore it was not further evaluated.

Water Demand

Water use estimates and zones for irrigation in the park were provided by parks operations staff (see Appendix G1). The irrigation demand for the Arboretum (covered by Unit 600) and the Battery Zone were used within this assessment due to the proximity of these areas to the potential cistern location. Irrigation is assumed to occur year round and that irrigation does not occur immediately following a rainfall event. Each area was evaluated separately and as a combined option. The current irrigation characteristics of these areas, as well as the entire park as a point of reference, are summarized in Table 1.

Table 1 - Existing irrigation of park areas considered to receive harvested rainwater

Option	Irrigation Area (m2)	Pumped To Irrigation (m^3/yr)	Average Weekly Irrigation Depth (mm)	% Reduction of Potable Water for Irrigation	% of Surface Runoff Diverted from Contributing Area
Arboretum	9,253	1,758	3.7	0%	0%
Battery	2,775	710	4.9	0%	0%
Combined	12,028	2,468	4.0	0%	0%
Park Total	94,790	38,265	7.8	0%	0%

Under current park operations, the arboretum irrigation is combined in a zone with the kite field. Due to the dense tree canopy in the Arboretum, we predict that the area is able to uptake more water than the kite field. Since a separate irrigation system for harvested water would be required, average irrigation estimates (depth) for the Park were used for the Arboretum irrigation area for the purposes of this assessment. The volume required for irrigation at the Arboretum has been updated in Table 2 to reflect this assumption.

Table 2 - Irrigation demands of proximal zones in Community park

Option	Irrigation Area (m^2)	Required for Irrigation (m^3/yr)	Average Weekly Irrigation Depth (mm)
Arboretum	9,253	3,735*	7.8
Battery	2,775	710	4.9
Combined	12,028	4,445	7.1
Park Total	38,265	38,265	7.8

Due to its location in the park, and high water usage, the splash pad is a potential end-use for captured runoff water. The timing of stormwater runoff from the site would require storage of most of the annual rainfall runoff for use during the dry season, from June to August, when the splash pad is operational. Additionally, harvested water would need to be treated to drinking water standards due to the intended human contact level of water in the splash pad. In consideration of the costs of high volume storage on site, and the level of treatment required for reuse, the splash pad did not emerge as a viable option for reuse of stormwater runoff.

Storage Options

Cisterns can be located on rooftops, at ground level or below ground. The weight of a rooftop cistern makes retrofitting an existing building, such as the curling rink, unadvisable. Given the shallow and fluctuating groundwater levels, an underground cistern also may be impractical. A surface cistern, located along the north wall of the curling club is considered the most viable option for this assessment.

During a reuse assessment, storage is sized to optimize capture in an average precipitation year, allowing some larger events to overflow while capturing the bulk of the runoff. Sizing a cistern to capture the full runoff from all events increases costs considerably. Actual precipitation records within Community Park, for the period 2009-2019, were used in the analysis, with representative dry, average and wet years assigned from the available records. Table 3 summarizes the optimized cistern size and related reductions in runoff and potable water for irrigation possible through the use of harvested rainwater. The estimated annual cost savings related to reduced reliance on potable water are also summarized in Table 3.

Table 3 – Summary of reuse model assessment results

Option	Cistern Capacity (m^3)	Captured for Reuse to Irrigation (m^3/yr)	% of Surface Runoff Diverted from Contributing Area	% Reduction of Potable Water for Irrigation in Area	% Reduction of Potable Water for Irrigation in Park	Annual Savings
Arboretum	500	1,062	74%	28%	2.8%	$ 2,028.00
Battery	75	289	20%	40%	0.8%	$ 542.33
Combined	400	1,071	74%	24%	2.8%	$ 2,045.18

Reuse Regulations

In British Columbia, the ***Municipal Wastewater Regulation*** (Municipal Wastewater Regulation, 2018) defines reclaimed water as water that has been treated at a municipal wastewater treatment facility and is of an acceptable quality to be reused (Municipal Wastewater Regulation, 2018). Rainwater harvesting does not fit neatly into this category, however there are not yet municipal regulations differentiating handling of captured rainwater from treated wastewater for applications in public space and therefore harvested rainwater falls into the category of reclaimed water in BC. The Regional District of Nanaimo has published the ***Rainwater Harvesting Best Practices***

Guidebook for residential use, however it explicitly states that it is not applicable to publicly operated systems (Regional District of Nanaimo, 2012).

The ***Reclaimed Water Guideline*** (Province of British Columbia, 2013) standards for using reclaimed water are based on the exposure potential of the end use. Reclaimed rainwater used for irrigation in a public space is expected to meet the "Greater Exposure Potential" quality guidelines, and to be monitored for compliance on the schedule outlined in the ***Municipal Wastewater Regulation*** and summarized in Table (Municipal Wastewater Regulation, 2018).

Table 4 - Reclaimed water quality and monitoring requirements for uses with Greater Exposure Potential [adapted from (Municipal Wastewater Regulation, 2018)]

Parameters	Municipal Effluent Quality Requirements	Monitoring Requirements
pH	**6.5 to 9**	**Weekly**
BOD5, TSS	**10 mg/L**	**Weekly (also includes flow monitoring)**
turbidity	**average 2 NTU, maximum 5 NTU**	**Continuous monitoring**
fecal coliform (/100 mL)	**median < 1 CFU or < 2.2 MPN; maximum 14 CFU**	**Daily (reduce to weekly with confirmation of compliance over 60 days)**

Properly treated non-potable water is permitted for use in lawn and landscape irrigation in Parksville Community Park as long as it complies with the standards set within the ***Reclaimed Water Guideline*** (Province of British Columbia, 2013) and confirmed through consultation with Vancouver Island Health Authority (L. Magee, personal communication, July 20, 2020). The design considerations outlined in the Reclaimed Water Guideline include:

- There must be at least a 3.0m horizontal and a 450mm vertical separation between all pipelines transporting reclaimed water and those transporting domestic water.
- Domestic water lines must be located above reclaimed water lines.
- Plans for dual-distribution systems in buildings and irrigation systems must pass local inspections conducted by local building inspectors before they are approved.
- Adequate cross-connection control measures must be installed, including an approved backflow prevention device at the potable water connection to reduce the risk of unintended cross-connections.
- An automated irrigation system must be used where irrigation is used to apply reclaimed water to urban landscape or turf areas not supervised by a landscape professional.
- Irrigation equipment must be operated to prevent spray drift onto adjacent properties and the irrigation system application rate must not exceed the infiltration rate of the soil or cause any surface runoff.
- The irrigation controller must have a minimum of two start times per day, seven days per week. The "on" time for each station must be able to be set in one-minute increments.

- The capability to chlorinate reclaimed water should be available and a residual level of chlorine should be maintained.

Vancouver Island Health Authority suggested that if the City wishes to pursue stormwater reuse for irrigation at Parksville Community Park, a trickle irrigation system should be considered as it does not require the same level of treatment due to the limited risk of direct human contact (L. Magee, personal communication, July 20, 2020). Longer term, the Park could seek more appropriate standards or guidance from Vancouver Island Health Authority and/or BC Ministry of Environment to consider runoff, especially roof runoff, to be regulated differently than wastewater.

Alternate Options

Dry Pond

The existing dry pond could serve dual purposes as both a stormwater management facility to alleviate flooding during storm events and to use that water for irrigation. The same treatment requirements as discussed for a cistern capture and irrigation system apply to reuse from a stormwater pond. The dry pond is not currently intended to maintain a volume of water however if the City is interested in this option, considerations such a installing an impermeable liner in all or part of the pond to maintain a volume to use for irrigation, and implementing a trickle irrigation system for using stormwater runoff for irrigation, may be beneficial.

Aquifer Recharge and Shallow Well Withdrawal

Given the above constraints, such as costs of cisterns and seasonal wet and dry cycles, an interesting option may exist for the City's consideration related to the high infiltration capacity of the subsurface soils at Parksville Community Park. In essence, there is a natural reservoir at the site, which is often accessed as a water source, the groundwater. Groundwater also has the advantage of being filtered through the soils, which is one reason it is a popular water source.

Other jurisdictions in coastal areas in the past have begun recharging the surficial aquifers with stormwater with the intent to draw on those aquifers for other uses at a later time. In the case of Community Park, passive irrigation that directs runoff from impervious surfaces into low lying areas or rock pits to infiltrate into that subsurface sand layer during the winter rainy season, may allow a shallow well to be used for irrigation purposes during the dry season. This option would require additional geotechnical investigation to determine the quality of water currently in the shallow sandy aquifer, the natural fluctuations of groundwater levels across the parks, and the intrusion of salt water (if any) into this underlying layer. Due to the complexity of subsurface water movement and underlying soils, a robust examination of existing conditions by hydrogeologists would be required to validate the feasibility of such a reuse system.

Splash Pad Greywater Reuse

Based on water use estimates provided by the City of Parksville, the volume of water used in the splash pad meets approximately half of the annual irrigation demand of the park. While not a stormwater management strategy since that water comes from a potable water supply, storing, treating and reusing splash pad greywater for irrigation would be an excellent water conservation project. A separate conservation assessment to look at the costs of storing and treating the splash pad water to the level required by the Municipal Wastewater Regulation is recommended if the City wishes to assess the financial feasibility of this option.

Conclusions & Recommendations

Treatment requirements for reclaimed water are costly both from a capital expenditure and an operations and maintenance point of view. While specific cost estimates of installing a cistern and treatment system were not generated, the limited savings realized through reduced potable water consumption does not warrant further investigation of this option at this time. So, while physically feasible, it does not seem fiscally prudent to pursue in the current regulatory climate/framework. In terms of cost effectiveness and feasibility, the site has relatively permeable soils appropriate for infiltration, which would provide a much more straightforward and cost-effective way to address stormwater runoff, both volumes and quality.

Based on this assessment, we recommend the following:

1. Revisit the rainwater harvesting and reuse concept if (1) the province alters the treatment requirements for using rainwater for irrigation in public spaces; or (2) the cost of potable water increases considerably.
2. Consider the public and municipal appetite for pursuing the alternate reuse options (dry pond, aquifer recharge or splash pad reuse) for water conservation and/or public relations/demonstration reasons. These options may become more attractive if the cost of potable water increases.

References

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APPENDIX G1 - Parksville Community Park Irrigation Zone Map

Date: 2021-04-06T15:03:58.581 Author: Kerri Robinson Layout: RM_Irrigation
Document Path: C:\Users\Kerri Robinson\Documents\WesternCanada\Parksville SWMMP\GIS\Parksville.qgz

Irrigation Zones

- 🟪 Battery
- 🟥 Unit 400
- 🟧 Unit 500
- 🟨 Unit 550
- 🟩 Unit 600
- 🟦 Unit 700

Parksville Community Park Stormwater Management Master Plan

Irrigated Areas

N

0 75 150 m

Appendix H: Interim Final Report of the Archaeological Impact Assessment and Inventory of Parksville Community Park, Parksville, British Columbia, HCA Permit 2018-0412

REDACTED