KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Moody Centre Stormwater Management Servicing Plan

Final Report
October 2019
KWL Project No. 0310.055

Prepared for:

PORT MOODY
City of the Arts

Contents

Executive Summary i

1. Introduction 1-1
1.1 Project Tasks 1-1

2. Background Data Review and Low Impact Development Opportunities 2-1
2.1 Policy Updates 2-1
2.2 Intensity Duration Frequency (IDF) Curve Updates 2-3

3. Hydrological and Hydraulic Assessment 3-1
3.1 Capacity Assessment Results 3-1

4. Stormwater Management and Servicing Plan 4-1
4.1 Cost Estimate 4-1
4.2 Capital Plan 4-5

5. Urban Ditch Management Strategy 5-1
5.1 Ditch Values 5-1
5.2 Ditch Mapping Exercise and Ditch Classification System 5-1
5.3 Ditch Management Policy Gaps 5-3
5.4 Potential Strategies for Ditch Management 5-3
5.5 Case Studies 5-4

6. Recommendations 6-1
6.1 Policy and Bylaw Recommendations 6-1
6.2 Hydrologic and Hydraulic Assessment Recommendations 6-1
6.3 Stormwater Management and Servicing Plan Recommendations 6-2
6.4 Ditch Management Strategy Recommendations 6-3

Report Submission

Figures

Figure 1: Study Area and Drainage Network 1-3
Figure 2: Updated IDF Curve for PT11 Rain Gauge (January 1, 1994 – December 31, 2017) 2-4
Figure 3: Estimated IDF Curve for PT11 Rain Gauge Climate Change Condition (Year 2050-2100) 2-6
Figure 4: Existing Conditions Capacity Assessment (10-Year Design Storm) 3-4
Figure 5: Future Conditions Capacity Assessment (10-Year Design Storm with Climate Change) 3-5
Figure 6: Existing Conditions Capacity Assessment (100-Year Design Storm) 3-6
Figure 7: Future Conditions Capacity Assessment (100-Year Design Storm with Climate Change) 3-7
Figure 8: Future Conditions Capacity Assessment (100-Year Design Storm with Climate Change) and Overland Flow Path – Overall 3-8
Figure 9: Future Conditions Capacity Assessment (100-Year Design Storm with Climate Change) and Overland Flow Path – West Area 3-9
Figure 10: Future Conditions Capacity Assessment (100-Year Design Storm with Climate Change) and Overland Flow Path – East Area 3-10
Figure 11: Recommended Capital Projects and Developer Projects 4-2
Figure 12: Recommended Green Infrastructure Locations 4-4
Figure 13: Moody Centre Ditch Map 5-2

Tables

Table 1: Recommended Stormwater Management Criteria for Policy Areas 2-1
Table 2: Proposed Stormwater Management Criteria 2-2
Table 3: IDF Frequency Interpolation Equation 2-3
Table 4: Updated Rainfall Intensity (mm/hr) using 1994-2017 Data 2-3
Table 5: Estimated Rainfall Intensity (mm/hr) for RCP 8.5 Climate Change (Year 2050-2100) 2-5
Table 6: Changes in Design Storm Depths for Moody Centre 2-7
Table 7: LID Measures Applied in Model 3-2
Table 8: Summary of BMP Benefits, and Limitations 3-2
Table 9: Capacity Assessment Summary of Undersized Infrastructure 3-3
Table 10: Continuous Simulation Model Results 3-11
Table 11: Effective Impervious Area Summary 3-11
Table 12: Cost Estimate Summary for Conveyance Infrastructure 4-1
Table 13: Unit Cost Estimate for Municipal ROW Green Infrastructure 4-3
Table 14: Summary of Capital Budget 4-6
Table 15: Summary of Developer Costs 4-6

Appendices

Appendix A: Tech Memo #1 – Background Data Review and Low Impact Development Opportunities
Appendix B: Tech Memo #2 – Hydrological and Hydraulic Assessment
Appendix C: Tech Memo #3 – Stormwater Management and Servicing Plan
Appendix D: Tech Memo #4 – Urban Ditch Management Strategy

Executive Summary

The Moody Centre Stormwater Servicing Plan was completed in four technical memoranda, which form the appendices of the final report.

The City of Port Moody (City) is undergoing rapid redevelopment and densification. The purpose of this stormwater management servicing plan is to develop stormwater management guidelines and to provide a 20-year capital and servicing plan for the City. It serves as a supplementary document to the City's existing Subdivision and Development Servicing Bylaw (2010) to support the redevelopment occurring in Moody Centre. Major findings and results are summarized as follows:

- An analysis of the City's existing infrastructure data was completed, and field surveys completed to update the existing infrastructure data and the City's GIS database.
- A review of the existing stormwater management criteria was conducted to identify existing stormwater management criteria and existing policy gaps. Three major policy issues were identified including a lack of specific stormwater management criteria or targets in place requiring water quality treatment, rate control, or volume reduction; no guidance is provided on the need for or use of low impact development (LID) and green infrastructure practices; and sediment and erosion control measures lack detail in requirements to minimize erosion and sediment transport during construction.
- The Intensity Duration Frequency (IDF) curve was updated for existing (2018) conditions and for the future climate change (2050-2100 moderate change) scenario. The 2018 update resulted in changes from the current IDF parameters from –10% to +15% (average +4.0%). Applying a 2050-2100 moderate climate change scenario resulted in an increase in predicted intensities ranging from +23% to +49% (average +34%) from the current IDF parameters in the Subdivision and Development Servicing Bylaw.
- The hydrological and hydraulic assessment evaluated capacity issues in the drainage network in existing conditions, future conditions (updated land use cover as per OCP land use changes and climate change IDF parameters), and future conditions with LID practices. During the major (100-year) storm event, approximately 20% of the drainage system is undersized in existing conditions, increasing to 22% in future conditions, and reducing slightly to 21% with the implementation of LIDs. During the minor (10-year) storm event, approximately 11% of the drainage system is undersized in existing conditions, increasing to 16% in future conditions, and reducing slightly to 14% with the implementation of LIDs.
- Results of the hydrologic analysis were combined with CCTV pipe condition data which identified the location of 104 sewers requiring upgrades due to capacity conditions, 32 new sewer installations to address areas in the study area which are presently un-serviced, and 6 sewers requiring immediate replacement due to condition issues.
- Prioritization of upgrades was completed based on the level of drainage capacity, condition severity and risk ratings in the unserviced areas. The total capital budget for the Moody Centre drainage servicing plan is estimated to be $20.5M for the next 20 years (2019-2039). The capital program identifies the 0-5 year (2019-2024) capital budget of $9.2 M (including markups), a 5-10 year (2025-2029) capital budget of $5.4 M (including markups), and a 10-20 year (2030-2039) capital budget of $6.0 M (including markups).
- The total developer cost for the Moody Centre drainage servicing plan is estimated to be $11.2M. The developer costs include 0-5 year (2019-2024) cost of $3.0 M (including markups), a 5-10 year (2025-2029) cost of $2.5 M (including markups), a 10-20 year (2030-2039) cost of $0.2 M (including markups), and the "at the time of development costs" of $5.5 M.

- Green infrastructure was proposed on the municipal right-of-ways (ROWs) and intersections. This includes rain gardens, soil cells and bio-swales. The approximate unit cost for each type of green infrastructure was provided.
- A dual drainage model was created to assess the drainage system and roadway capacity to convey the 100-year storm event overland as an alternative level of service scenario. Under future OCP land use conditions (with climate change), a majority of the overland flows follow road ROWs. The City can reduce the capital cost by allowing for strategic safe overland flow paths. One of the overland flows cuts through private property where the inlet capacity becomes a critical factor.
- An urban ditch management strategy was proposed to aid decision making on ditch enclosure and compensation for loss of hydrologic function and wildlife habitat during the review of development permit applications. A ditch classification system was proposed. And three case studies were examined to explore the potential outcomes of development and the use of the ditch management strategy.

Several recommendations were made for further study, bylaw updates, and implementation of the plan.

1. Introduction

Kerr Wood Leidal Associates Ltd. (KWL) was retained by the City of Port Moody (the City) to complete a Stormwater Management Servicing Plan for Moody Centre. The Moody Centre study area is bounded by Burrard Inlet to the north, the steep slopes in the Chines Area to the south, Albert Street to the west, and Moray Street to the east. The drainage system consists of stormwater infrastructure that is owned by both the City and Metro Vancouver. See Figure 1 for a map of the study area and the layout of the drainage network. The Moody Centre area is fully urbanized with little to no drainage infrastructure and is the oldest part of Port Moody. Since the completion of the Skytrain Evergreen Line Extension, Moody Centre has been undergoing rapid re-development and densification to accommodate the increasing population growth.

Port Moody's Official Community Plan (OCP) identifies areas where changing land use and redevelopment will result in increased impervious areas. An increase in impervious area will significantly affect the volume and intensity of stormwater runoff in future development conditions. In addition, projected climate change impacts will exacerbate the effect of increased impervious area.

1.1 Project Tasks

Five major tasks and three additional tasks were undertaken for the stormwater management and servicing plan. These tasks included:

- Task 1 – Collect and review background information;
- Task 2 – Identify new stormwater measures, retrofits, and improvement opportunities for low impact development (LID);
- Task 3 – Hydrological and hydraulic assessment;
- Task 4 – Stormwater management and servicing plan;
- Task 5 – Reporting;
- Additional Task 1 – Update of City's IDF curves;
- Additional Task 2 – Urban ditch management strategies; and
- Additional Task 3 – 100-year drainage system assessment and overflow path.

The findings of the tasks were presented in detail in four technical memoranda, see Appendices A – D. Major findings of the technical memoranda have been summarized in the body of this report.

These include:

- Appendix A – Technical Memorandum #1 summarizes background material and identifies gaps in existing drainage data. It presents a review of existing stormwater management policies and recommendations of new low impact development (LID) stormwater management measures to mitigate the impact of densification and climate change. The memo also presents the results of Additional Task #1 which provided an update to the City's IDF curves for current and future (climate change) conditions.

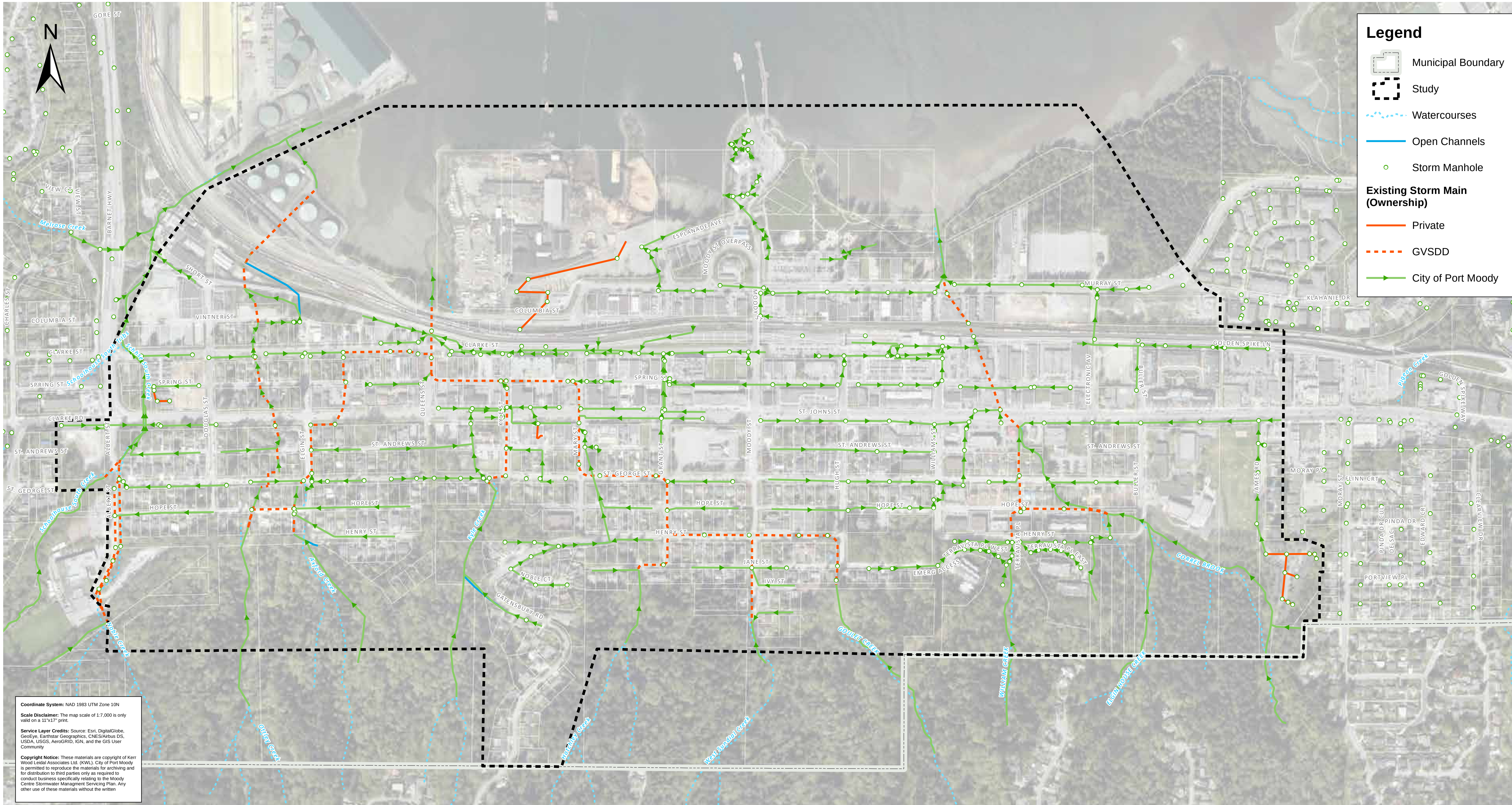
- Appendix B – Technical Memorandum #2 was completed to summarize the findings of the hydrological and hydraulic assessment including an evaluation of the existing conditions, unmitigated future conditions, and mitigated future conditions. Single event and continuous simulation was completed to evaluate the ability of proposed low impact development measures to mitigate the impact of land use change and development.
- Appendix C – Technical Memorandum #3 summarizes the proposed capital upgrade plan, project prioritization, and cost estimates.
- Appendix D – Technical Memorandum #4 was completed to provide a gap analysis of the City's current bylaws and policies relevant to ditches, propose a classification system for the City's ditches, and recommend a ditch management strategy. The study also examines three case studies to explore the potential outcomes of development and the ditch management strategy.

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig1_StudyArea.mxd Date Saved: 2019-02-22 1:58:18 PM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date May 2019

Scale 1:7,000

100 50 0 100 m

Study Area & Drainage Network

Figure 1

2. Background Data Review and Low Impact Development Opportunities

The following presents a brief summary of Technical Memo #1, the final version of which is included in Appendix A. The City's drainage data was updated with the field survey results and a database is included with this final report.

2.1 Policy Updates

Existing Policy Gaps

The City's existing stormwater management policy was reviewed to identify existing criteria and data gaps. Key stormwater management policy gaps are as follows:

1. No specific stormwater management criteria or targets are in place which require water quality treatment, rate control, or volume reduction.
2. No guidance is provided on the need for or use of low impact development and green infrastructure practices, including selection, operation and maintenance measures.
3. Sediment and erosion control measures lack detail in requirements to minimize erosion and sediment transport during construction.

Stormwater Criteria and Policy Recommendations

Two different policy areas have been identified in the study area as the stormwater management criteria differ for each of these areas. In general, the two policy areas differentiate between (1) Areas Draining to the Ocean; and (2) Areas Draining to Remnant Estuaries or Creeks. Table 1 indicates which criteria are required in each area.

Table 1: Recommended Stormwater Management Criteria for Policy Areas

Policy Area	Stormwater Management Criteria Required
(1) Areas Draining to Ocean (via ditches/storm sewers)	• Minor and major drainage system conveyance criteria • Water quality targets • Erosion control threshold and targets for erosion protection of ditches
(2) Areas Draining to Remnant Estuaries or Creeks	• Minor and major drainage system conveyance criteria • Volume reduction targets • Water quality targets • Environmental rate control targets • Erosion control thresholds and targets for erosion protection of ditches and creeks • Environmental criteria for environmentally sensitive watercourses

Table 2 summarizes the current and proposed stormwater management criteria to address each of the identified policy gaps.

Table 2: Proposed Stormwater Management Criteria

Issue	Criteria
Flood and Erosion Protection	
Minor and Major Drainage System Criteria	• Minor system designed to 1 in 10-year event.[1] • Major system designed to 1 in 100-year event.[1] • Major flow routing shall normally be provided along roads and in natural watercourses.[1] • No major flow permitted on arterial roads.[1]
Watercourse Protection and Riparian Protection	
Water Quality *(Issue 1)*	Minimum target:[2] Treat 90% of annual runoff from all impervious surfaces to provide 80% removal (by mass) of TSS loading. Equivalent to treating 72% of the 2-year, 24-hour rainfall depth = 58 mm of rainfall.
Rate Control *(Issue 1)*	Control post-development runoff rate to the lesser of pre-development condition or current zoning condition for up to the 5-year return period flow.[5] Creeks that have been identified by the City with a potential for daylighting or other enhancements may require additional studies to identify rate control targets for the contributing areas.[3]
Volume Reduction *(Issue 1)*	• Single-family residential: onsite rainfall capture and infiltration of a minimum of 40% of the 2-year 24-hour rainfall depth (32 mm in 24 hours) for the entire lot area.[2] • All other land uses: onsite rainfall capture and infiltration of 72% of the 2-year 24-hour rainfall depth (58 mm) for the increased impervious area from pre- to post-development conditions.[4]
Development Impervious Targets *(Gap 2)*	Maximum impervious cover targets: • Single-family residential: maximum impervious cover of 70%.[2] • Multi-Family Residential maximum impervious cover of 80%. • Industrial maximum impervious cover of 90%. • Mixed Use/Employment maximum impervious cover of 85%. • Public and institutional maximum impervious cover of 85%.
Erosion and Sediment Controls During Construction *(Issue 3)*	• TSS level less than 25 mg/L above background levels during normal weather conditions (less than 25 mm of rain in the 24 hours prior).[3] • TSS level less than 75 mg/L above background levels during significant rainfall events (equal to or greater than 25 mm of rain in the 24 hours prior).[3]

Notes:
1. Requirements from City of Port Moody “Subdivision and Development Servicing Bylaw, 2010.
2. Consistent with Metro Vancouver Baseline.
3. Land Development Guidelines for Protection of Aquatic Habitat, DFO 1992.
4. Stormwater Source Control Guidelines, Metro Vancouver 2012.
5. Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat, DFO 2001.

2.2 Intensity Duration Frequency (IDF) Curve Updates

The IDF curve provided in the City's "Subdivision and Development Servicing Bylaw, 2010" utilizes 38 years of rainfall data (1959-1979, 1982-1983, and 1994-2008) from the Metro Vancouver PT 11 rain gauge. An update was completed to incorporate recent years of rainfall data from 2008 to 2017.

Updated IDF Curve

Table 3 summarizes the interpolated values for the IDF equations. The coefficients support the following equation:

$I = A*T^B$
I = intensity (mm/h)
T = storm duration (h).

Table 3: IDF Frequency Interpolation Equation

Coefficient	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
A	14.739	20.131	23.648	28.068	31.310	34.562
B	-0.458	-0.493	-0.507	-0.520	-0.527	-0.533

The interpolation equation and updated coefficients were used to revise the IDF parameters for the PT11 rain gauge. Table 4 presents the updated IDF intensity for the 1994-2017 time period.

Table 4: Updated Rainfall Intensity (mm/hr) using 1994-2017 Data

Duration	Return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	46.0	68.6	83.4	102.2	116.1	130.0
15 min	27.8	39.9	47.8	57.7	65.0	72.4
30 min	20.2	28.3	33.6	40.3	45.1	50.0
1 h	14.7	20.1	23.6	28.1	31.3	34.6
2 h	10.7	14.3	16.6	19.6	21.7	23.9
6 h	6.5	8.3	9.5	11.1	12.2	13.3
12 h	4.7	5.9	6.7	7.7	8.4	9.2
24 h	3.4	4.2	4.7	5.4	5.9	6.3

The updated 2018 Rainfall IDF Curve for the PT11 rain gauge is presented in Figure 2.

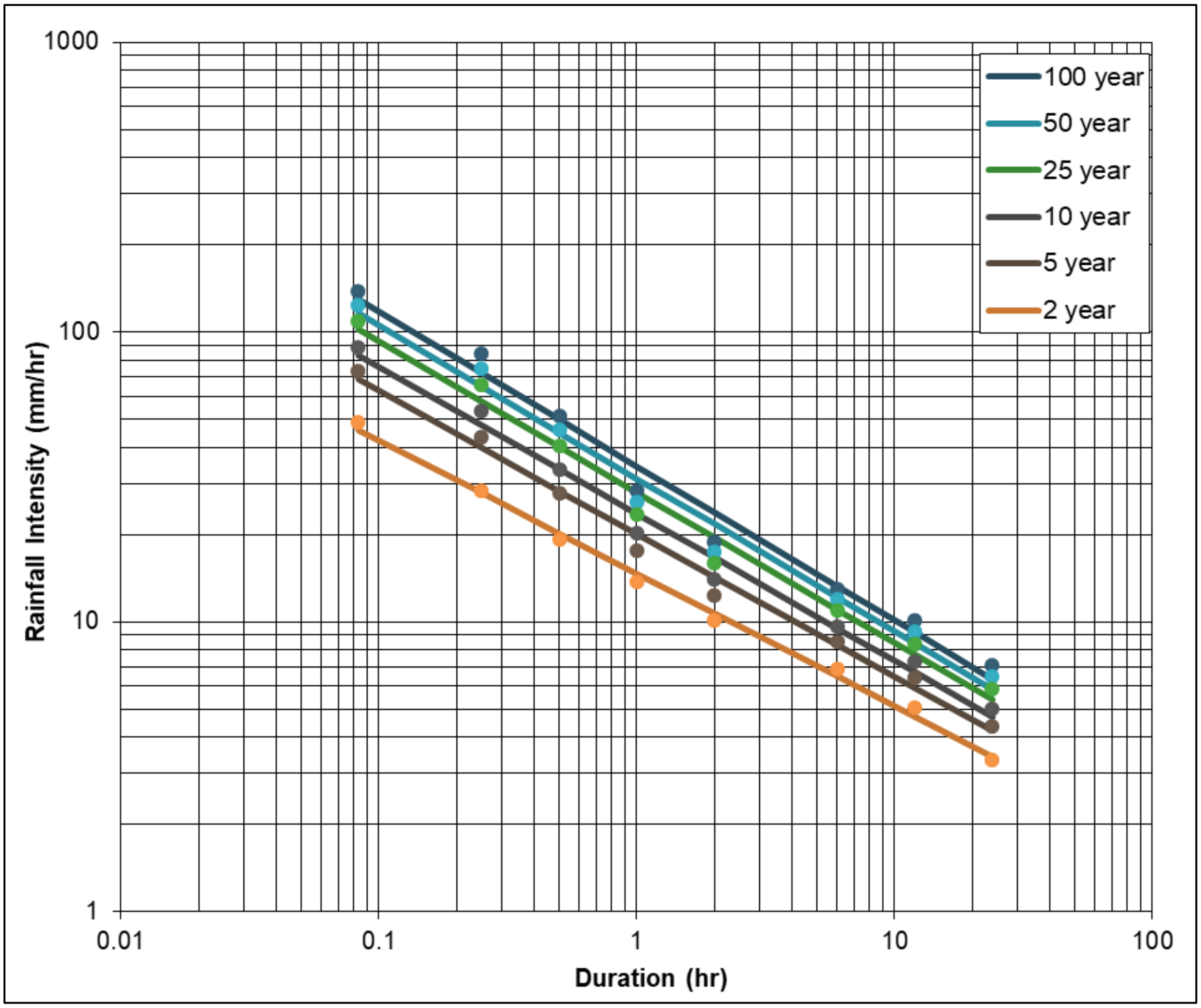


Figure 2: Updated IDF Curve for PT11 Rain Gauge (January 1, 1994 – December 31, 2017)

It should be noted that the updated IDF curve using 1994-2017 data resulted in some rainfall totals being less than the previous IDF values. Consistent with the GVRD's most recently published IDF curve (1994-2014) for the PT11 rain gauge, years 1959-1979 and 1982-1983 are no longer being used to develop the IDF values. Removing these record years impacts the data that is input into the statistical analysis tool and removes some years which contribute to larger rainfall depths for some of the IDF values. In general, the decreases are seen in the higher return period, longer duration values. The years from 1994 – 2017 contain rainfall years that represent both El Nino and La Nina conditions and are believed to be representative. In general, the IDF values increased for the IDF update.

Climate Change IDF Curve

A climate change IDF curve was also created to account for the effects of future climate change on the IDF parameters and to be used to represent future rainfall conditions. The University of Western Ontario IDF_CC Tool was used to generate predictions for 9 Global Circulation Models (GCMs). The future conditions climate change IDF values were generated by applying a factor to the existing IDF values. The factor was based on a Relative Concentration Pathway (RCP) 8.5 emission option which is the worst-case greenhouse gas scenario. The median value from the 9 GCMs for a time horizon of 2050 – 2100 were used to develop the climate change conditions. The approach used to generate climate change projections is consistent with the methodology proposed in the "GVS&DD DRAFT Study of the Impacts of Climate Change on Precipitation and Stormwater Management Final Report" (GHD, 2018).

Table 5 presents the estimated IDF intensity for Year 2050-2100 RCP 8.5 climate change scenario and median climate change value from 9 GCM projections.

Table 5: Estimated Rainfall Intensity (mm/hr) for RCP 8.5 Climate Change (Year 2050-2100)

Duration	Return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	55.2	86.6	114.5	154.1	181.6	210.7
15 min	33.5	48.7	66.2	91.6	110.8	132.5
30 min	24.4	31.2	41.6	56.8	68.4	81.6
1 h	17.6	21.2	26.0	33.1	37.4	42.0
2 h	12.9	15.6	18.2	21.7	24.1	25.8
6 h	7.8	10.7	12.5	14.8	16.3	17.5
12 h	5.7	8.0	9.5	11.3	12.6	13.6
24 h	4.1	5.4	6.5	8.0	9.0	9.8

Figure 3 presents the climate change IDF Curve (Year 2050-2100) for the PT11 rain gauge.

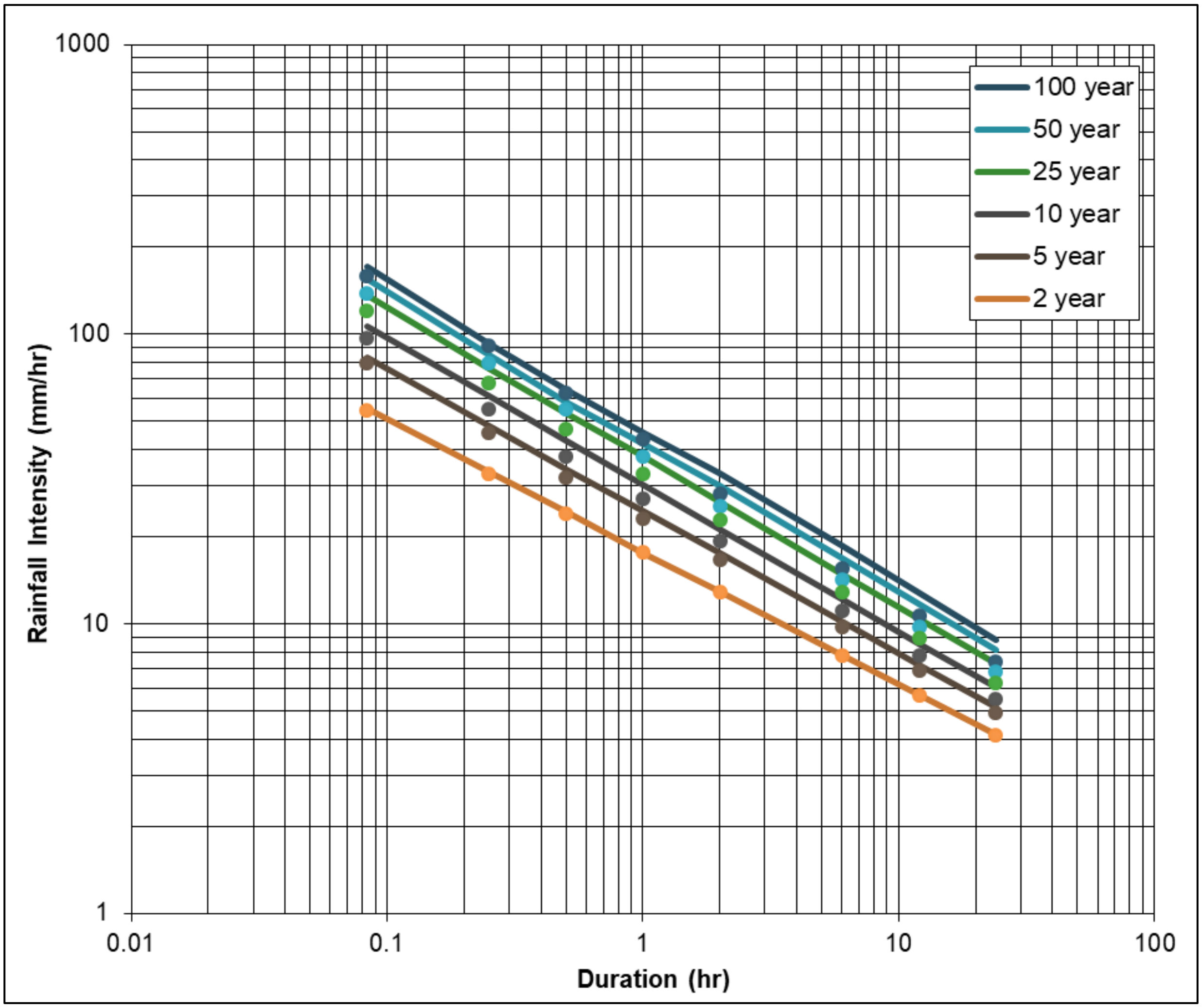


Figure 3: Estimated IDF Curve for PT11 Rain Gauge Climate Change Condition (Year 2050-2100)

The climate change projections for the IDF values result in an increase in storm depth for all durations and return periods. The percent increase from City's current IDF (i.e., IDF from Year 1959-1979, 1982-1983, & 1994-2008) to climate change IDF values range from 23-49% with an average increase of 34%. The largest increases occur during higher return period and shorter duration storm events.

Table 6 compares the design storm depths in the City's current IDF (in the Subdivision and Development Servicing Bylaw), 2018 IDF and climate change IDF. Percentage changes between in the existing condition and the climate change condition are provided for 10-year and 100-year design storms.

Table 6: Changes in Design Storm Depths for Moody Centre

Duration	10-year Total Rainfall (mm) and [% Increase][4]	100-year Total Rainfall (mm) and [% Increase][4]
1-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	22.5	34.1
Year 1994-2017[2]	23.6	34.6
Year 2050-2100[3]	30.3 [+35%]	45.9 [+35%]
2-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	32.2	48.3
Year 1994-2017[2]	33.3	47.8
Year 2050-2100[3]	42.6 [+32%]	66.5 [+38%]
6-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	56.9	83.9
Year 1994-2017[2]	57.2	79.8
Year 2050-2100[3]	73.1 [+28%]	111.5 [+33%]
12-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	81.5	118.9
Year 1994-2017[2]	80.4	110.3
Year 2050-2100[3]	102.9 [+26%]	154.2 [+30%]
24-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	116.7	168.5
Year 1994-2017[2]	113.2	152.4
Year 2050-2100[3]	144.8 [+24%]	211.1 [+25%]

Notes:
1. Year 1959-1979, 1982-1983, & 1994-2008 = Depths based on IDF Curve in City's 2010 Bylaw
2. Year 1994-2017 = Existing Condition
3. Year 2050-2100 = Moderate Climate Change Condition for the time horizon 2050 to 2100. All increases are based on the University of Western Ontario IDF CC Tool – Ensemble (9 GCMs) for Western North America, RCP 8.5.
4. Percent increase from IDF Curve in City's existing Subdivision Development Bylaw to Climate Change Year 2050-2100

Refer to Appendix A for full details on methodology and additional climate change discussion.

3. Hydrological and Hydraulic Assessment

The rapid redevelopment and densification of Moody Centre will result in increased impervious area as indicated by the OCP land use changes. The increase in impervious area, if unmitigated, will significantly affect the volume and intensity of stormwater runoff in future development conditions and these impacts will be exacerbated by climate change. A hydrologic and hydraulic assessment was completed to assess these impacts on the drainage system.

Technical Memorandum #2 in Appendix B summarizes the development of the detailed model, the results of the existing, future, and future mitigated (with LID) scenarios, and provides a capacity assessment for the 10- and 100-year storm events for the Moody Centre drainage system. Continuous simulation was completed to evaluate the ability of low impact development measures to mitigate the impact of land use change and development. The assessment included only City-owned infrastructure and does not include the infrastructure owned by GVS&DD which was assessed previously in the Chines ISMP.

The following sections summarize the major findings from the hydrological and hydraulic assessment.

3.1 Capacity Assessment Results

Model Development

The drainage system was assessed using PCSWMM software and the study area was modelled based on infrastructure, DEM, and land use information obtained from the City. Existing land use and future OCP land use with climate change conditions were assessed for the minor (10-year) and major (100-year) design storms.

Existing conditions were simulated using the updated 2018 IDF parameters as presented above. The future conditions simulation used the design storms developed using the climate change IDF (2050-2100). Land use changes were incorporated using the OCP future total impervious cover. In addition, the assessment of the existing drainage system indicated that there were numerous areas (mostly residential) in the study area which did not have municipal storm servicing infrastructure. In the future, it is proposed that storm sewers be provided to these lots and this expanded storm sewer network was included in the future conditions model.

Low Impact Development Measures

In addition to simulating future conditions with OCP land use and climate change, a second mitigated future conditions model was created with low impact development practices incorporated. The intent of incorporating LID measures was to quantify the benefits of including best management practices in redeveloped areas on both volume reduction (capture) of small storms and on major and minor peak flows. The LIDs were included based on discussion with the City and represent a reasonable uptake of best management practices given the current stormwater policies and land use. Table 7 summarizes the assumed LID measures for each land use type.

Table 7: LID Measures Applied in Model

OCP Land Use Type	Assumed LID Measures
Single Family Residential	Absorbent landscape[1]
Multi-Family Residential	Absorbent landscape[1]
Mixed Use – Moody Centre Mixed Employment Moody Centre Transit Oriented Development	Absorbent landscape[1] 25% Extensive Green Roof Coverage
General Industrial	None
Oceanfront District	None
Public & Institutional	Absorbent landscape[1]
Parks and Open Space	None (impervious to pervious flow redirection)
Rights of way (ROWs)	Absorbent landscape[1]

Notes:
1. With impervious area redirected to the absorbent landscape area.

A summary of the benefits and limitations of the assumed LID measures is summarized in Table 8.

Table 8: Summary of BMP Benefits, and Limitations

Best Management Practice	Benefits	Limitations
Absorbent landscape	• Water quality improvements • Volume reduction • Groundwater recharge • Biodiversity benefits • Green space and aesthetic benefits	• Limited by impervious / pervious ratio
Green roofs	• Runoff rate control • Volume reduction • Green space and aesthetic benefits • Building energy savings • Air quality benefits	• Not appropriate or practical for all land use types • Require structural costs and considerations
Impervious to pervious flow redirection	• Runoff rate control • Volume reduction	• Not appropriate or practical for all land use types

Capacity Assessment

A capacity assessment was completed to assess the City's infrastructure performance for the existing and future conditions model for the City's infrastructure. The minor drainage system was assessed based on its ability to convey the 10-year minor design flow. The major system was assessed based on its ability to covey the 100-year storm event. Both the major and minor systems considered the instantaneous peak flow, pipe capacity, total pipe surcharging time, and depth of surcharge. Table 9 summarizes the results of the capacity assessment for Moody Centre.

During the major (100-year) storm event, approximately 20% of the major drainage system is undersized in existing conditions, increasing to 22% undersized in future conditions, and reducing slightly to 21% with the implementation of LIDs. During the minor (10-year) storm event, approximately 11% of the minor drainage system is undersized in existing conditions, increasing to 16% undersized in future conditions, and reducing slightly to 14% with the implementation of LIDs.

Table 9: Capacity Assessment Summary of Undersized Infrastructure

Undersized Infrastructure	Existing	Future	Future with LID
Total length of undersized storm infrastructure	3.7 km	4.63 km	4.34 km
Major storm system length % undersized	20%	22%	21%
Minor storm system length % undersized	11%	16%	14%

Refer to Appendix B for a full description of the assessment criteria and detailed results. Figure 4, Figure 5, Figure 6 and Figure 7 highlight the undersized storm sewers in red.

Dual-Drainage Overland Flow Assessment

A dual drainage model was created to represent the cross-sections of the roadways and to evaluate the capacity of the arterial roads (St. Johns Street, Murray Street, and Clarke Street) to convey the flow that exceeds the capacity of the existing storm sewer network.

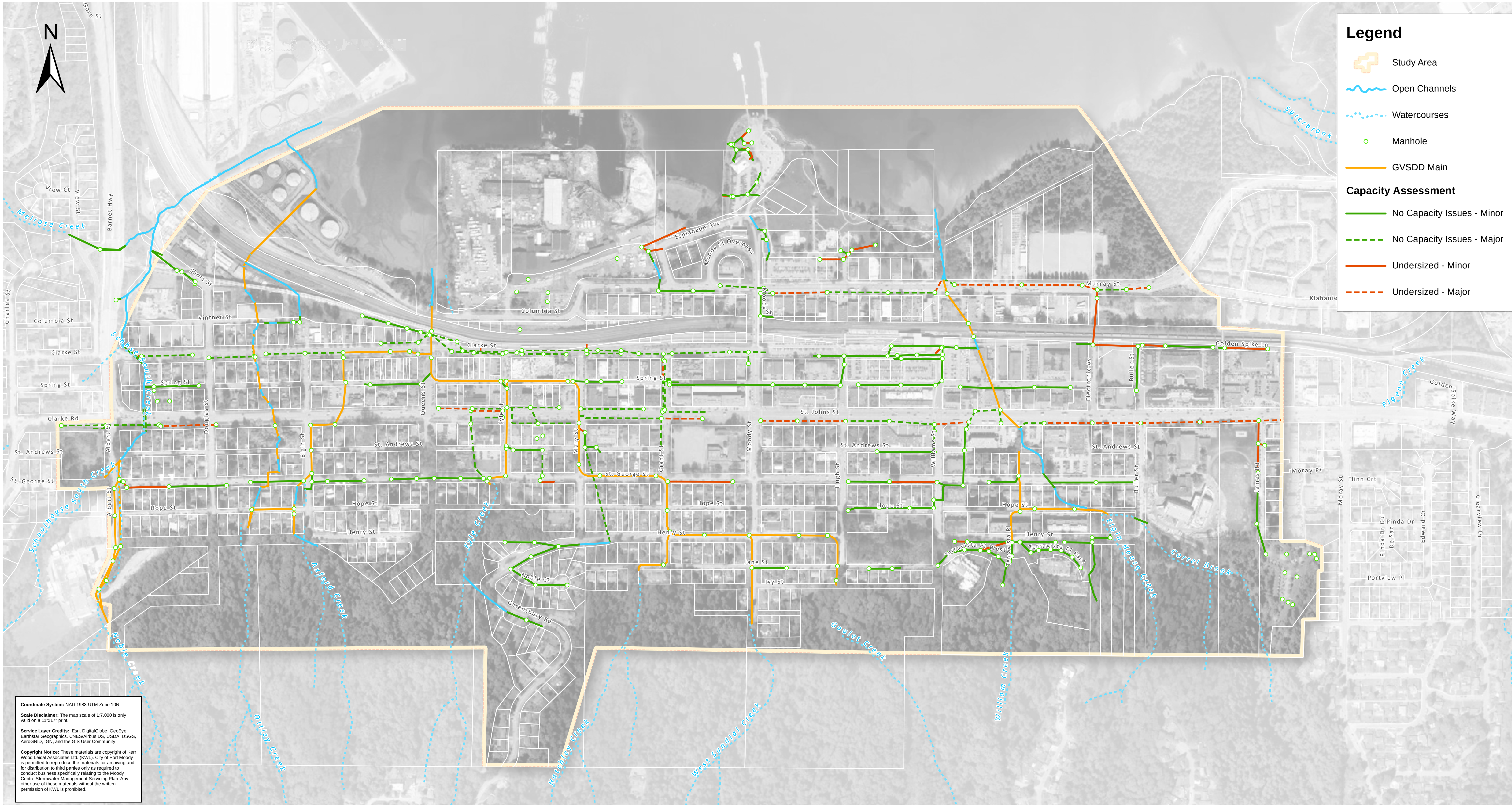
The results of the assessment indicated that the roadways had capacity to convey the 100-year future OCP land use conditions (with climate change) without overtopping the curb in the case where the inlets into the major storm system pipes (GVSSDD storm sewers in these areas) were assumed to be unrestricted (i.e., catch basins have adequate capacity to intercept the overland flows). However, to evaluate a scenario where this was not the case, overland flow pathways were mapped based on known contours to determine locations where overland flow may occur if catch basin does not have adequate capacity or are plugged by debris. A majority of the overland flows follow road ROWs. However, one of the overland flows cuts through private property (based on the contours) in the 3000 block of St. Johns Street. This is the area of highest concern where the inlet capacity of catch basins should be estimated in detail, and if found to be insufficient, additional catch basins added. Figure 8 provides the overall overland flow map for the study area. Figure 9 and Figure 10 show details of the contours and flow pathways for the west and east areas of Moody Centre, respectively.

Path: O:\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig4_MinorExisting.mxd Date Saved: 2019-05-10 11:30:10 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date June 2019

Scale 1:7,000

100 50 0 100 m

Existing Conditions Capacity Assessment (10-year Design Storm)

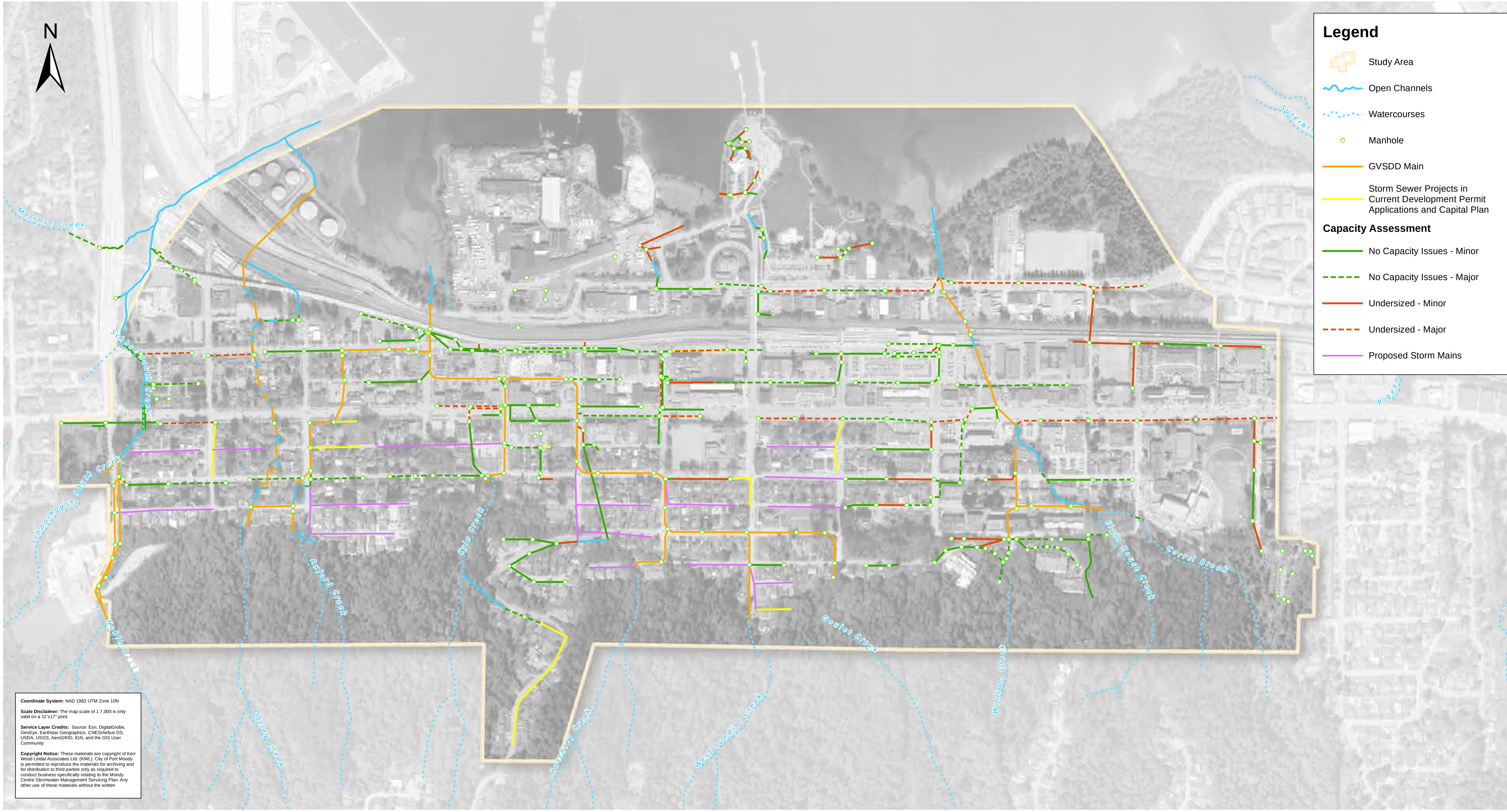
Figure 4

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig5_MinorFuture-rev1.mxd Date Saved: 2019-09-03 8:11:43 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Project No. 310-055

Date September 2019

Scale 1:7,000

100 50 0 100 m

Future Conditions Capacity Assessment (10-year Design Storm with Climate Change)

Figure 5

Path: O:\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig6_MajorExisting.mxd Date Saved: 2019-05-10 11:55:32 AM | Author: GOConnell

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055
Date June 2019
Scale 1:7,000

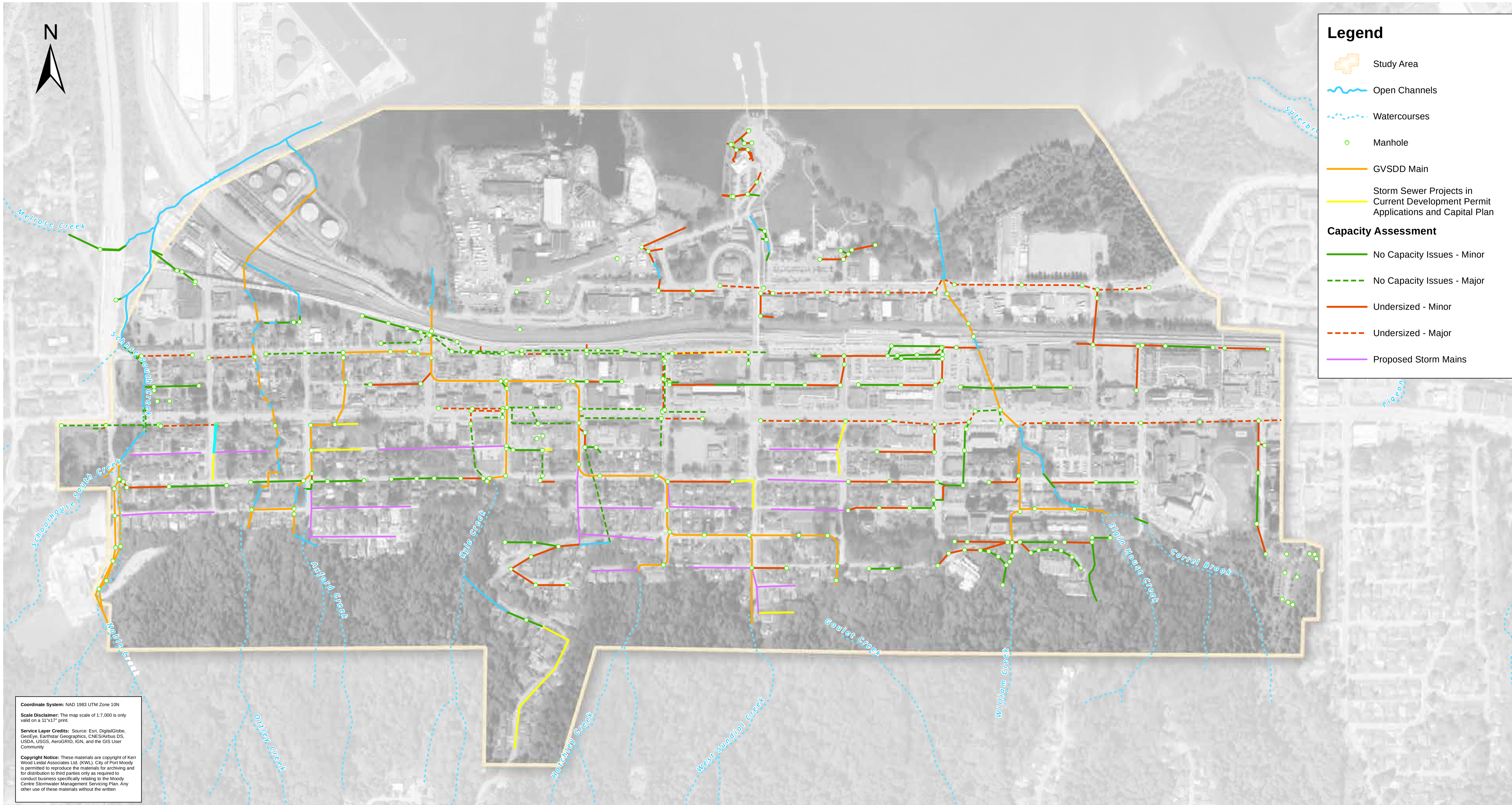
Existing Conditions Capacity Assessment (100-year Design Storm)

Figure 6

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Project No. 310-055

Date September 2019

Scale 1:7,000 (100 50 0 100 m)

Future Conditions Capacity Assessment (100-year Design Storm with Climate Change)

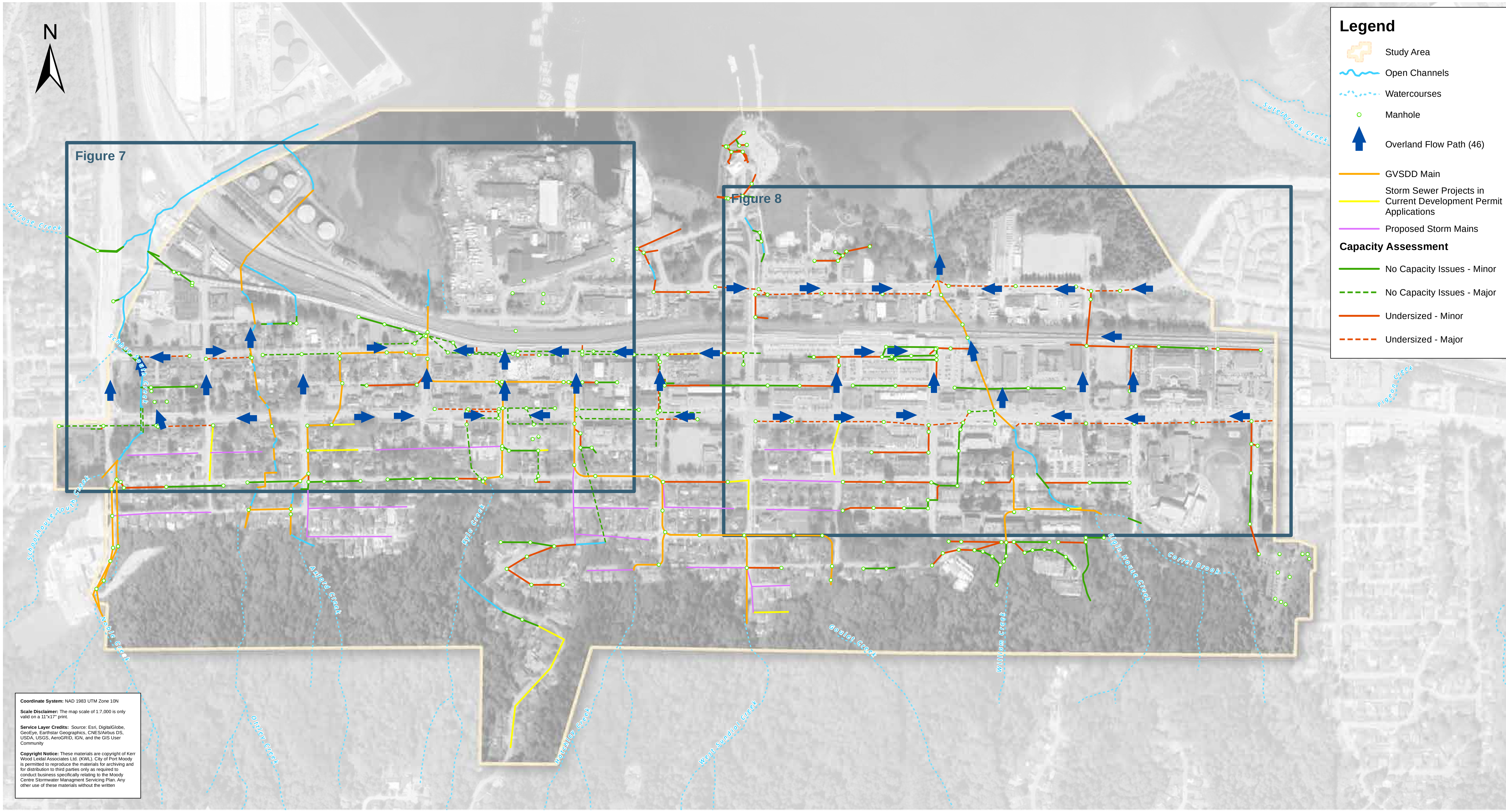
Figure 7

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig8_FutureConditions.mxd Date Saved: 2019-09-03 8:22:04 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Project No. 310-055

Date September 2019

Scale 1:7,000

100 50 0 100 m

Future Conditions Capacity Assessment (100-year Design Storm with Climate Change) and Overland Flow Path

Figure 8

City of Port Moody

Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL
consulting engineers

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:3,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date September 2019

Scale 1:3,000

50 25 0 50 m

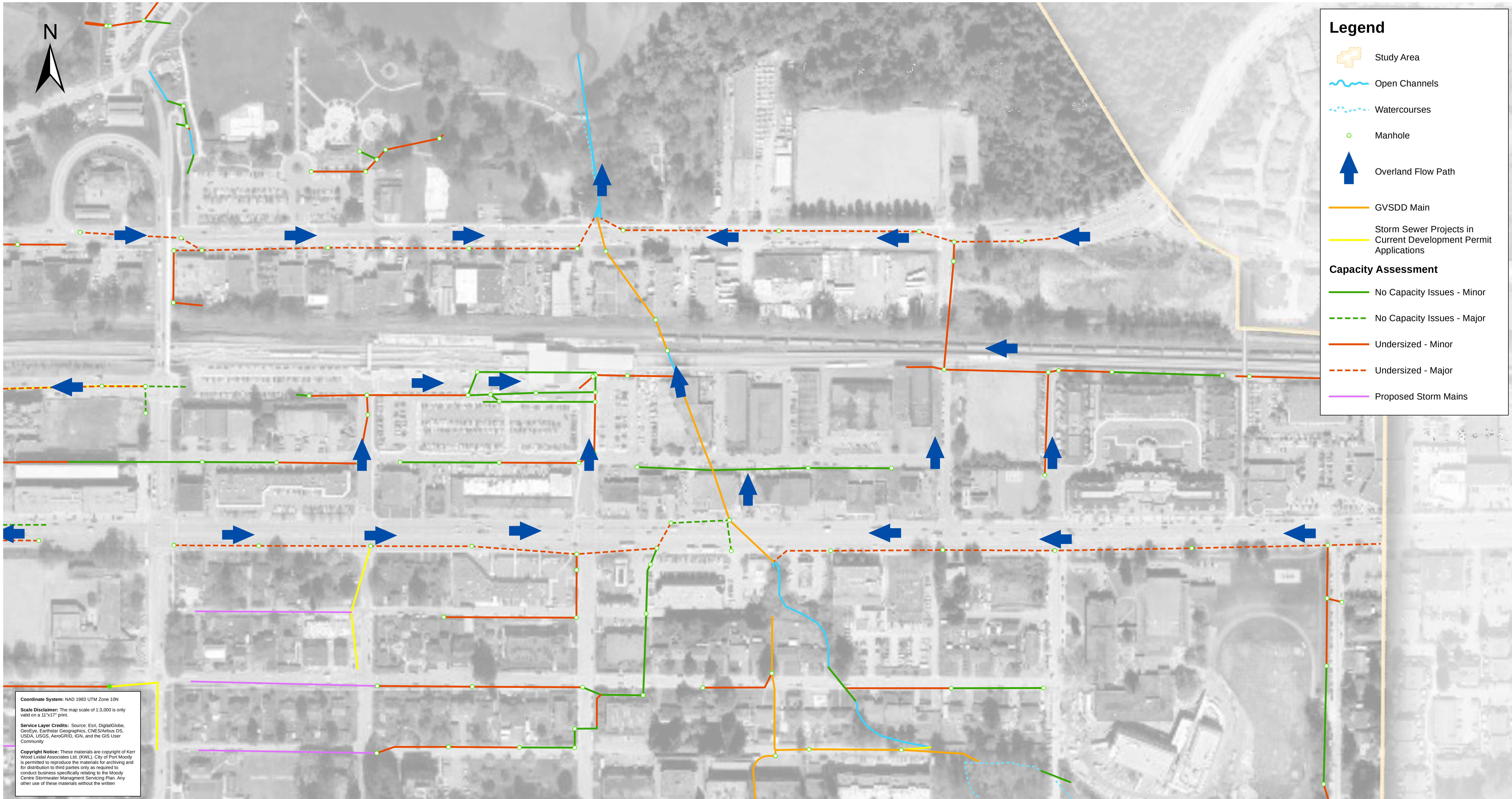
Future Conditions Capacity Assessment (100-year Design Storm with Climate Change) and Overland Flow Path

Figure 9

City of Port Moody

Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL consulting engineers



Project No. 310-055

Date September 2019

Scale 1:3,000

50 25 0 50 m

Future Conditions Capacity Assessment (100-year Design Storm with Climate Change) and Overland Flow Path

Figure 10

Continuous Simulation Model Results

In general, LIDs do not significantly mitigate increased peak flows during minor and major storm events. Benefits of LIDs are most effective during frequent, low-intensity storm events and to provide water quality treatment. A continuous simulation was conducted as an additional optional task to further quantify the benefits of the LIDs on reducing Effective Impervious Area (EIA).

The three model scenarios were run using one year of precipitation data. The year 2010 represents an average year of precipitation (1743 mm) based on the period of 1994 to 2017 and was used as input data to assess the system performance. Results were analyzed based on overall system performance including rainfall, runoff, surface infiltration, and surface evaporation. The ability of LID practices to reduce the effective impervious area (EIA) of the study area was assessed for each scenario. Table 10 summarizes the results of the continuous modelling: The results are summarized in depth of rain over the 212.88 ha study area.

Table 10: Continuous Simulation Model Results

Parameter	Existing Conditions Depths (mm)	Future Conditions Depths (mm)	Future Conditions with LIDs Depths (mm)
Rainfall	1743	1743	1743
Evaporation[1]	94	111	118
Infiltration[2]	869	715	948
Runoff	802	942	688

Notes:
1. Evaporation is determined based on the surface water balance and evaporation occurring from depression storage on the impervious and pervious surfaces. This does not include evapotranspiration from the subsurface.
2. Infiltration represents the surface infiltration on pervious areas.

The continuous simulation modelling results demonstrate the impacts of the increased impervious area on the runoff and infiltration volumes. Table 11 summarizes the impact of the LIDs on the EIA for the Moody Centre watershed.

Table 11: Effective Impervious Area Summary

Model Scenario	Effective Impervious Area (EIA)
Existing conditions	46%
Future Conditions – Unmitigated	54%
Future Conditions – With LIDs	39%
Target	47%

The effective impervious area is a metric to assess the percentage of rainfall that becomes runoff (EIA = Runoff / Rainfall) over a typical year or multiple years. In existing conditions, the study area EIA is 46%, and in the unmitigated future condition, the EIA is 54%. Implementing the LIDs into the future conditions model reduces the EIA to 39%. The continuous simulation results show that the LIDs implemented significantly reduce the watershed EIA, below both existing and mitigated future target levels.

The detailed modelling summary is presented in Appendix B.

4. Stormwater Management and Servicing Plan

The stormwater management and servicing plan was completed for the Moody Centre area to recommend drainage improvement projects based on the findings of the hydrologic and hydrologic analysis. The plan considers the storm sewer conveyance capacity, condition data and risk rating results to assign prioritization and timelines for capital planning. Cost estimates were completed for the storm infrastructure upgrades, repairs, and new installations. In addition, the plan provides the preferred LID drainage options based on discussion with the City and the unit cost estimates associated with those installations.

Technical Memorandum #3 is included in Appendix C and provides details of the methodology and results for the cost estimate and capital planning for Moody Centre.

4.1 Cost Estimate

Conveyance Infrastructure

A Class C cost estimate was completed for the Moody Centre Stormwater and Servicing Plan. The cost estimate was divided by installation type, including infrastructure upgrades, repairs, and new infrastructure installations. The cost estimate takes into account sewer characteristics (diameter, length, depth, manhole spacing), roadworks (excavation, pavement and sidewalk rehabilitation), and restoration and planting. A 68% project markup was applied to each of the identified projects which included bonding/insurance (2%), mobilization/demobilization (6%), engineering (15%), contingency (30%), market factor (10%), and project management by the City (5%).

A total of 104 segments of storm sewer require upgrades, 6 require immediate repairs, and 32 new storm sewers have been identified for installation to service the currently un-serviced lots. Table 12 provides a summary of the total length and overall cost estimates for conveyance infrastructure.

Table 12: Cost Estimate Summary for Conveyance Infrastructure

Items	Infrastructure Upgrades	Proposed New Servicing	Proposed Repairs
Number of Storm Sewers	104	32	6
Total Length of Storm Sewers (m)	4458	2490	211
Total Cost with Mark-ups	**$25,630,000**	**$5,300,000**	**$796,000**

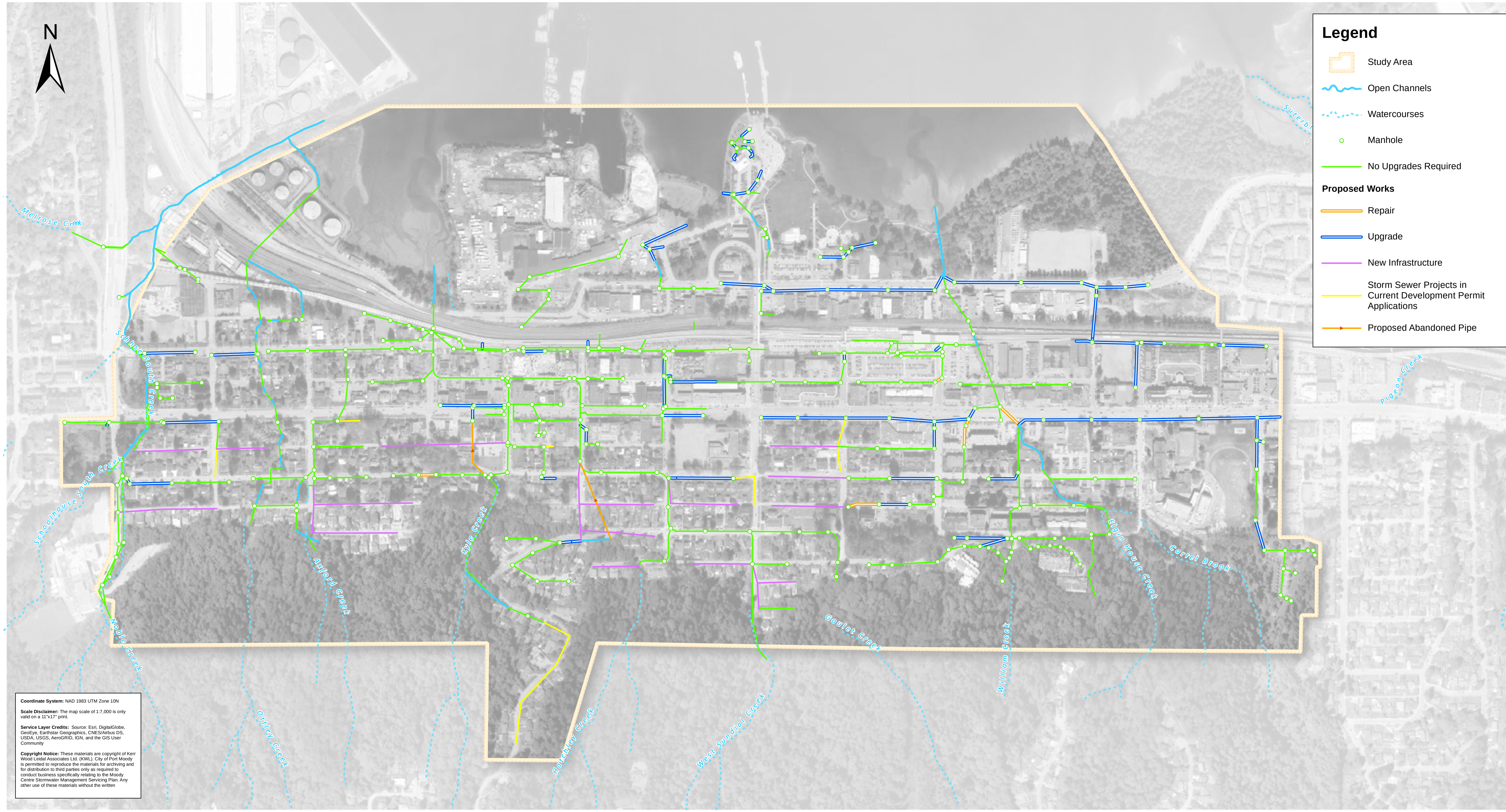
Figure 11 presents a map with the recommended capital projects and developer projects.

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig11_PipesNewUpgradeRepair.mxd Date Saved: 2019-06-05 3:28:33 PM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date September 2019

Scale 1:7,000

100 50 0 100 m

Recommended Capital Projects and Developer Projects

Figure 11

BMPs and LIDs

The Best Management Practices (BMPs) and Low Impact Development (LID) measures were proposed based on the recommendations in Technical Memorandum #2 and confirmed with further discussion with the City. The LID implementation plan focused on the uptake of absorbent landscape practices, installation of green roofs in multi-use land use blocks, and water quality measures. Water quality improvement opportunities have been identified as beneficial for all locations where the drainage system outfalls into a creek or ocean. Opportunities include erosion and sediment control measures and manufactured water quality devices (i.e., oil and grit separators, cartridge filters, etc.). Absorbent landscape and green roof have been identified for on-lot volume reduction and water quality measures. As these BMPs will be predominantly installed on private property, the cost estimates were not broken down by land use or property. The LID measures recommended for municipal ROWs include rain garden, bioswale and soil cells. Table 13 summarizes the approximate unit cost for each type of LIDs. Figure 12 shows the locations of the existing and proposed green infrastructure.

Table 13: Unit Cost Estimate for Municipal ROW Green Infrastructure

Green Infrastructure	Unit Cost (per m^2 of LID area)
Rain gardens	\$466 / m^2
Bioswales	\$250 / m^2
Soil cells	\$790/ m^2
Absorbent landscape (not including sump)	\$105 / m^2
Green roofs	\$415 / m^2

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig12_ReccomendedGreenInfra.mxd Date Saved: 2019-09-03 8:10:10 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date September 2019

Scale 1:7,000

100 50 0 100 m

Recommended Green Infrastructure Locations

Figure 12

4.2 Capital Plan

A 20-year capital plan was prepared based on the results of the drainage system capacity assessment, condition scoring, risk rating, and the Class C cost estimates.

Prioritization

The prioritization criteria for infrastructure upgrading take both conveyance and condition rating into consideration. The conveyance rating was based on the result of drainage assessment, detailed in Appendix B. The condition rating was based on the PACP scoring from the City's on-going CCTV program and includes high-priority upgrades. The prioritization criteria for new infrastructure in the currently-unserviced areas considered high-risk locations where stormwater servicing is critical. A comprehensive upgrading, repair and construction strategy was developed by combining the three criteria above.

Funding Sources

Capital Budget

- Existing storm sewers undersized for flow under the existing land use
- Infrastructure repairs made for the existing structural deficiencies identified by CCTV

Developer Costs

- Pipes adequately sized for the existing land use but undersized for future land use with climate change,
- Portion of cost for upsizing pipes beyond the size required to convey the existing land use flow,
- New storm sewers to be constructed to service the residential areas without existing drainage servicing,
- LIDs (rain gardens and tree cells) to be constructed in municipal ROWs (partially funded by capital budget), and
- LIDs required on private property to be funded entirely by developers.

Senior government grants may be sought to fund some of the capital programs.

Capital Budget and Developer Costs

The capital plan assembles findings from the prioritization to create a comprehensive upgrading, repair, and construction strategy for the City's drainage system. The above projects are categorized as 0 to 5 years (2019-2024), 6 to 10 years (2025-2029), and 10 to 20 years (2030-2039,or end of asset life) capital program and developer projects based on their prioritization. Table 14 and Table 15 provide a summary of the capital budget and developer cost amounts. The total capital budget for the Moody Centre drainage servicing plan is estimated to be $20.5M for the next 20 years (2019-2039), with an average annual cost approximately $1.0M. The total developer cost is estimated to be $11.2M, with an average annual cost of $0.6M.

Table 14: Summary of Capital Budget

Time Frame	Infrastructure Upgrade Cost	Infrastructure Repairs Cost	Total Cost
2019-2024	$8,369,000	$796,000	$9,165,000
2025-2029	$5,361,000	$0	$5,361,000
2030-2039	$5,995,000	$0	$5,995,000
Totals	**$19,725,000**	**$796,000**	**$20,521,000**
Note: All costs include markup.			

Table 15: Summary of Developer Costs

Time Frame	Infrastructure Upgrade Cost	New Infrastructure Cost	Total Cost
2019-2024 [1]	$79,000	$2,959,000	$3,038,000
2025-2029 [1]	$115,000	$2,343,000	$2,458,000
2030-2039 [1]	$225,000	$0	$225,000
At Time of Development	$5,492,000	$0[2]	$5,492,000
Totals	**$5,911,000**	**$5,302,000**	**$11,213,000**

Notes:
All costs include markup.
1. Developer portion of conveyance upgrades associated with upsizing the pipe for future conditions (as per current bylaw requirements).
2. Lump sum cost for the green infrastructure projects was not included. Unit costs were provided in Table 13 instead.

Individual projects and pipe upgrades are detailed in Table 9 to Table 12 in Appendix C.

5. Urban Ditch Management Strategy

The Urban Ditch Management Strategy considers both hydrological and ecological function of ditches and the implications of ditch enclosure associated with redevelopment. The strategy proposes a ditch classification system, provides a map of ditches in Moody Centre, includes a gap analysis of Port Moody's existing policy regarding the management of ditches, and provides several strategic options for the City to consider when managing redevelopment of ditches while retaining both hydrological function and ecological function.

5.1 Ditch Values

Ditches provide infrastructure values as a result of their hydrological and hydraulic functions. These functions are not always replaced when a ditch is enclosed. They include:

- interception and collection of runoff;
- conveyance;
- storage;
- water quality treatment; and
- infiltration.

From an ecological perspective, ditches provide habitat for aquatic and terrestrial species, including fish, amphibians, birds, small mammals, and pollinators. They also serve as movement corridors for urban wildlife, allowing them to avoid unvegetated areas and encounters with vehicle traffic, humans, and other traffic.

5.2 Ditch Mapping Exercise and Ditch Classification System

A map of Moody Centre ditches was developed using a combination of a desktop review of aerial imagery, Google Street View imagery and field visits (see Figure 13).

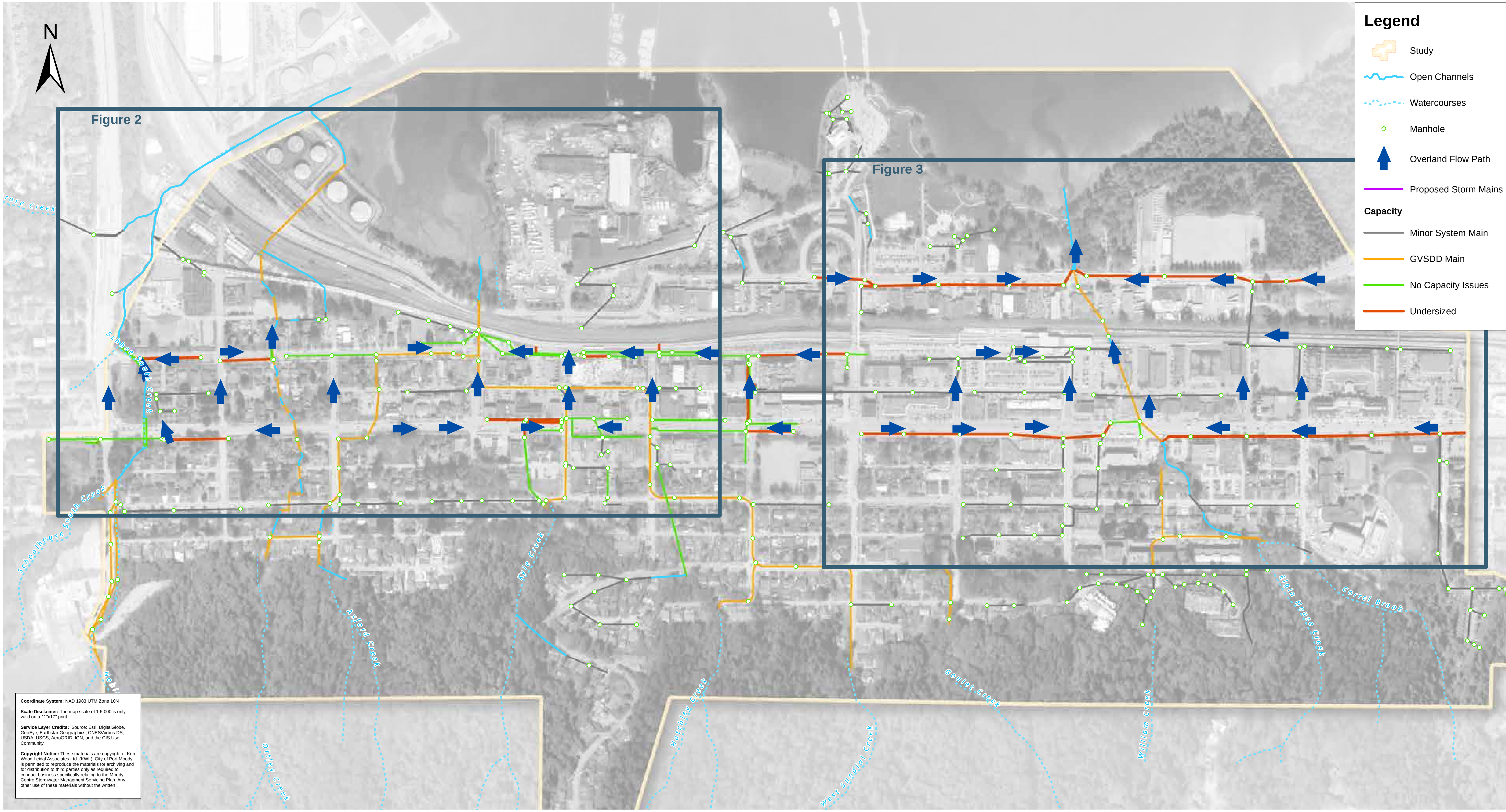
A two-part classification system was proposed for Port Moody's ditches. Part one of the system is to assign a watercourse class to a given ditch, using Port Moody's existing watercourse classification system (See Appendix D). The second part of the ditch classification system is to assign a ditch type based on its primary hydrological function (e.g., primarily surface capture; see Appendix D). Ditch categories are thus a combination of watercourse class and ditch type. For example, a ditch that is a Class C watercourse and its primary hydrologic function is surface runoff capture (ditch type 2) has a combined ditch category of C-2.

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\FinalReport\310055_Fig13_FutureConditions.mxd Date Saved: 2019-05-29 9:53:01 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:6,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date September 2019

Scale 1:6,000

100 50 0 100 m

Ditch Management

Figure 13

5.3 Ditch Management Policy Gaps

The Policy review looked at Port Moody's existing bylaws and policy documents related to ditches as well as those of other jurisdictions. The following gaps were identified:

- Inconsistencies exist in the descriptions of the watercourse classification system used in the City's OCP and the Chines ISMP.
- The Zoning Bylaw does not include a description of the City's watercourse classification system.
- The Port Moody Zoning Bylaw provides recommended setbacks (RPEAs) for Class A and Class B watercourses, but not Class C.
- Several classifiable watercourses are "unclassified" in the Chines ISMP.
- The City of Port Moody OCP does not include a watercourse classification map, nor does the City's web map application (ViewPort).
- Redevelopment and Servicing bylaw contains requirements for Class A or Class B watercourses, but does not refer to Class A(O) or Class C watercourses.
- No ditch enclosure policy, guidelines or bylaw exist.
- ViewPort, the City's web-based mapping application, is missing data on connection of ditches and catchbasins, to stormwater mains.

5.4 Potential Strategies for Ditch Management

Based on the gaps identified above and discussion with the City regarding its vision for ditch management, a list of goals was created to guide the development of potential strategies for ditch management and compensation. These goals are as follows:

- In the face of development permit applications, maintain or improve the hydrological function of Port Moody ditches while maintaining or improving the ecological function of ditches.
- Develop a clear explanation of the policy regarding a clear policy for compensation and ditch enclosure when a ditch is enclosed.
- Improve habitat connectivity in Port Moody for urban wildlife movement. Consider and value ditches as a component of the ecological network.

Eight potential strategies were identified:

1. Create a consistent inventory and classification of ditches within the city.
2. Update bylaws to include Class C watercourses and clarify that ditches are watercourses that can be different classes.
3. Adopt enhancement or no net loss policy for hydrological and ecological function of ditches.
4. Consider the potential of ditches as movement corridors for urban wildlife and their suitability for inclusion in the City's Environmentally Sensitive Areas (ESA) Development Permit Area, or inclusion in a future ecological network.
5. Establish guidance for ditch development planning/design.
6. Establish a ditch enclosure permitting process.

7. Increase knowledge of City staff that ditches are watercourses with ecological benefits and are potentially Fish habitat.
8. Increase public knowledge of the importance of ecological connectivity, the value of green infrastructure, and the services provided.

The Ditch Management Strategy memo (Appendix D) provides specific action items for achieving each of the above-mentioned strategies.

Of the eight strategies above, KWL recommends pursuing strategies 1, 2, 5, and 6 in the near term, followed by the remaining strategies.

5.5 Case Studies

Three ditches in Moody Centre were identified as case studies and examined more closely. These include:

1. Vintner St., 2200 block, south side ditch: Ditch category B-3 (Class B watercourse - Groundwater interception and surface capture ditch)
2. Hugh St. north of Jane St. east side ditch: Ditch category C-1: (Class C watercourse – Primarily surface capture ditch)
3. St. George St. 2600 block, south side ditch: Ditch Category C-3: (Class C watercourse – Groundwater interception and surface capture ditch)

Potential issues triggered by the development process were discussed and enhancement opportunities were identified for each case study.

6. Recommendations

6.1 Policy and Bylaw Recommendations

Based on the stormwater policy review, it is recommended that the City:

1) Develop a Stormwater Management Policy for new development and redevelopment. This will supplement the provisions of the City's Subdivision and Development Servicing Bylaw, 2010 (No. 2831).
2) Add high-level information for guidance such as the Infiltration Map and source control prescriptions for land use types. Add clear criteria for water quality treatment, rate control, and volume reduction.
3) Develop Source Control (Low Impact Development and Green Infrastructure) Examples and Standards to aid with education and implementation, or refer to Metro Vancouver documents.
4) Incorporate O&M procedures (source controls, detention, and BMPs) into the City's regular O&M activities.

Subdivision and Development Bylaw, 2010 (Bylaw No. 2070)

1) Under Storm Drainage System Design Criteria (Section 5), add a reference to the Stormwater Management Policy.
2) Add a requirement to incorporate climate change into analysis and design. Refer to the updated IDF curve under Section 5.4.4.
3) Require minimal removal and compaction of surficial soil during construction and development.

Stream and Drainage System Protection Bylaw, 2000 (Bylaw No. 2470)

1) Require Sediment Control Best Management Practices (BMPs) for all developments (including Single Family, or two-family dwelling units).
2) Develop a document of BMP Examples to supplement the Stream and Drainage System Protection Bylaw, 2000 (No. 2407).

6.2 Hydrologic and Hydraulic Assessment Recommendations

The major conclusions and findings from the hydraulic and hydrologic assessment are as follows. It is estimated that approximately 30% of the Moody Centre storm sewer infrastructure is undersized. To address these conveyance deficiencies the following are options to protect property and infrastructure.

1) **Upgrade pipes:** Upgrade storm sewers identified as undersized to provide the level of service recommended in the City's design criteria.
2) **Allow more surcharging and overland flows in safe areas:** This would reduce the upgrade program without significantly adversely impacting drainage in areas where a surcharged storm sewer does not negatively impact lot drainage (e.g., areas without basements and where lots are higher than the roads.

3) **Construct detention facilities upstream of undersized pipes:** Detention facilities would have a more significant effect on peak flow reduction than LIDs designed for everyday rainfall capture. The results of the capacity assessment can be used to inform the locations within the study areas where detention facilities would provide the most benefits.
4) **Provide servicing to un-serviced areas:** Currently, runoff from lots without a service connection will flow by gravity over land, either following the fronting roadway where a swale or ditch is present or onto downslope properties and be intercepted by a storm sewer farther downslope. Storm sewers intercepting overland flow from unintended areas are susceptible to being flagged as undersized due to this excess tributary area. Providing storm sewer servicing to the areas/lots without servicing may eliminate the need to upgrade some of these storm sewers in the short term (0-5 year).
5) **Provide safe overland flow pathways:** The overland flow pathway assessment identified areas where overland flow will occur on private property. Additional analysis should be completed to identify critical locations, catch basin inlet capacities, and options for providing safe overland flow pathways.
6) **Combination of options:** A combination of the above options can be used to address all undersized conveyance system components.

Low impact development measures are useful in a future mitigated scenario to reduce the runoff volume during frequent storm events. However, they have minimal impact on the capacity issues in the minor and major drainage systems during winter design storms when the LIDs may be saturated at the start of storm. Continuous simulation shows that the proposed LIDs are able to reduce the future TIA to an EIA value lower than the existing land use EIA thereby improving watershed/creek health. The LIDs would also improve water quality.

6.3 Stormwater Management and Servicing Plan Recommendations

The stormwater management and servicing plan summarizes the cost estimate and presents a phased stormwater servicing plan for the drainage infrastructure in Moody Centre. The following items are recommended for completion in Moody Centre:

1) **Update prioritization with complete CCTV results:** The servicing plan should be updated once the CCTV inspections are complete and data is available for the remainder of the study area.
2) **Complete asset management program for Moody Centre:** The proposed prioritization approach for capital planning considers the pipe condition and the capacity. However, there are other elements that are valuable in assigning timelines to projects such as repaving project schedules and development timing. For example, Port Moody's Pavement Asset Management Program (TetraTech, 2014) indicates that a large number of streets in Moody Centre are scheduled for pavement upgrades. From an asset management perspective, including this information would represent a holistic approach. The current assessment does not consider this detailed assessment of those factors, and it is recommended that future studies be completed to include all relevant factors to integrate the capital planning with an integrated utilities management approach.
3) **Provide cost estimates for pipe maintenance and minor rehabilitation:** The capital plan includes repairs of sewers identified as high severity (Grade 4 and 5). Sewers identified as minor repairs or operation and maintenance issues have not been included in the capital plan. There are multiple factors that influence the type of rehabilitation or maintenance to sewers with low severity ratings (Grades 1, 2, and 3). An overall asset management study should consider the rehabilitation and maintenance costs for these additional pipes

6.4 Ditch Management Strategy Recommendations

The following are recommended as ditch management priorities for near term implementation:

1) Strategy 1: Create a consistent inventory and classification of ditches within the City.
2) Strategy 2: Update bylaws to include Class C watercourses and clarify that ditches are watercourses that can be different classes.
3) Strategy 5: Establish guidance for ditch enclosure planning and design.
4) Strategy 6: Establish a ditch enclosure permitting process.

These strategies form the foundation for future implementation of the full set of proposed strategies. They represent the core strategies that will directly inform and affect decisions regarding development requests that propose changes to the City's ditches.

Report Submission

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

Caroline Charbonneau, M.A.Sc., P.Eng.
Project Engineer

Eva Li, M.A.Sc., P.Eng.
Project Manager

Reviewed by:

David Zabil, M.A.Sc., P.Eng.
Senior Water Resources Engineer
(Sections 1-4 and 6)

Reviewed by:

Patrick Lilley, M.Sc., R.P.Bio., BC-CESCL
Senior Biologist
(Sections 5 and 6)

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of Client Name for the Moody Centre Stormwater Management Servicing Plan. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Copyright Notice

Revision History

Revision #	Date	Status	Revision	Author
0	October 4, 2019	Final		EL

OQM CERTIFIED

KERR WOOD LEIDAL
consulting engineers

Appendix A

Technical Memorandum #1
Background Data Review and
Low Impact Development Opportunities

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: October 3, 2019

TO: Shashi Bandara, E.I.T
City of Port Moody

CC: Stephen Judd, P.Eng.

FROM: Eva Li, P.Eng.
Bryce Whitehouse, A.Ag.

RE: **MOODY CENTRE STORMWATER MANAGEMENT SERVICING PLAN**
Tech Memo #1 – Background Data Review and Low Impact Development Opportunities
Our File 310.055-300

1. Introduction

The Moody Centre area is the oldest part of Port Moody. The Moody Study area is bounded by Burrard Inlet to the north, the steep slopes in the Chines Area to the south, Albert Street to the west, and Moray Street to the east. Figure 1 shows the study area defined by drainage boundary, confirmed by the City of Port Moody (the City). Since the completion of the Evergreen Line Extension, the Moody Centre area has been undergoing rapid re-development from single-family residential to high-density lots.

The study area drainage system consists of stormwater infrastructure that is owned by both the City and Metro Vancouver. Based on the City's GIS data, there is approximately 17 km of storm drains in the Moody Centre area, of which the City owns approximately 13 km. The overall catchment area is estimated at approximately 220 ha. Figure 1 shows our overall understanding of the study area and stormwater infrastructure. Much of the infrastructure in the area is known to be old and predate current stormwater management standards. The network is also fragmented and much of the stormwater is conveyed through ditches and/or overland flow. A preliminary assessment was conducted in 2017 on the area south of St. Johns Street to identify priority infrastructure needs (KWL, 2017)[1].

Kerr Wood Leidal Associates Ltd. (KWL) was retained by the City of Port Moody to assess the capacity of the existing stormwater infrastructure, identify deficiencies, and establish a capital stormwater upgrade plan. The project also includes a review of existing stormwater management policies and recommendations of new low impact development (LID) stormwater management measures to mitigate the impact of densification and climate change.

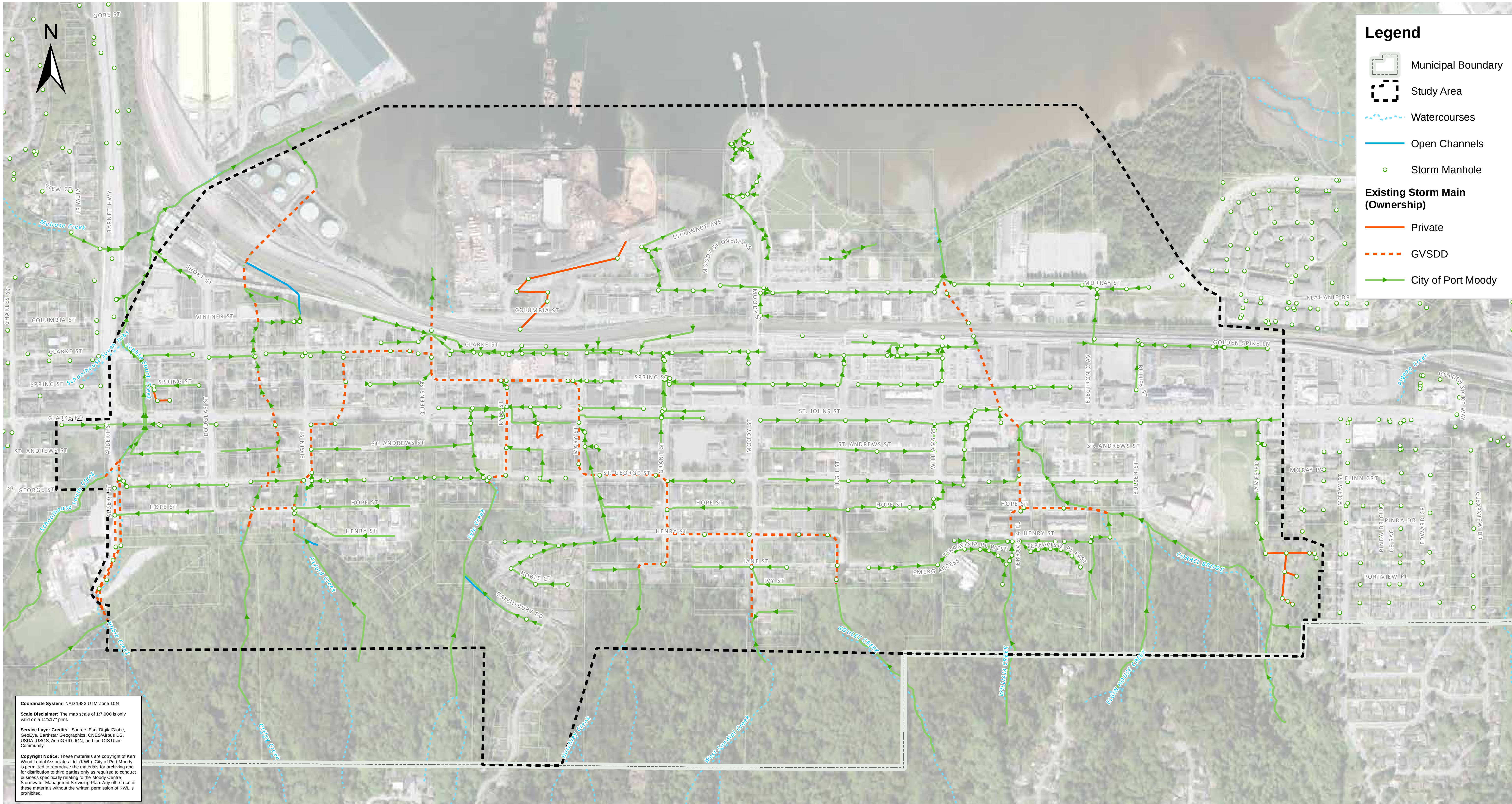
[1] Moody Centre Drainage Infrastructure Study, Preliminary Catchment Review, KWL, 2017

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo1\310055_Fig1_StudyArea.mxd Date Saved: 2018-09-11 12:49:12 PM | Author: CCharbonneau

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date February 2019

Scale 1:7,000

100 50 0 100 m

Study Area & Drainage Network

Figure 1

1.1 Technical Memorandum Contents

The purpose of this technical memorandum is to:

- Summarize the background data review and to identify gaps in the existing drainage data.
- Present the overland flow pathways and drainage sinks.
- Fill in the City's GIS drainage data gaps using as-built drawings. Document site survey work completed to fill in further missing data.
- Summarize existing stormwater criteria and policies and identify areas where policy and criteria could be improved.
- Provide stormwater management recommendations that could be added or appended to the City's existing criteria and policy.
- Identify retrofit and improvement opportunities using LID and green infrastructure measures.
- Provide an updated intensity-duration-frequency (IDF) curve based on data up to December 2017 that would be used to check the capacity of existing infrastructure.
- Provide an IDF curve that takes into account future climate change conditions that would be used when sizing new infrastructure.

2. Background Data Review

Prior to surveying, an analysis of the City's current stormwater infrastructure GIS data was undertaken to identify and fill in any missing data required for hydraulic modelling along with the identification of missing data, a desktop analysis and site walkover were performed to identify overland flow paths in unserviced areas and potential areas of ponding along surface flow paths.

2.1 Missing Drainage Data

Invert data at manholes, at inlets and at outlets, and conveyance/conduit shapes and sizes are the primary data required for modelling in this study. Invert and pipe size data in the City's GIS database was analyzed for the purpose of identifying all data gaps that would have to be filled to limit the number of assumptions made in the hydraulic model. Missing drainage data was filled with as-built drawings to the extent available and the remaining missing data was identified for field survey. In total there were 54 manholes identified with missing invert data required for the survey, those manholes are shown on Figure 2.

2.2 Field Survey

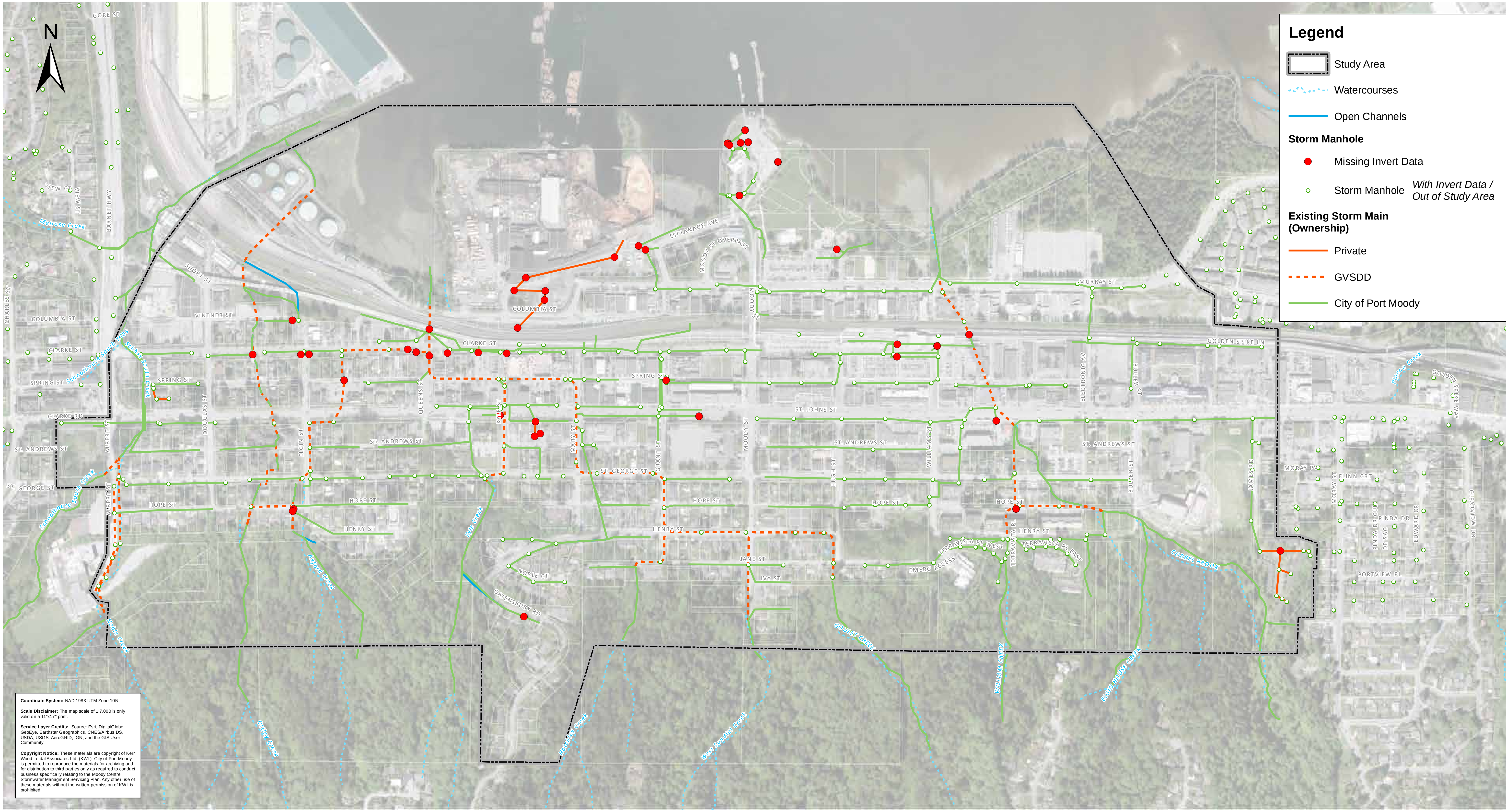
The field survey was completed to fill the data gaps identified on Figure 2. The survey was completed using a Trimble R8 GPS unit, as well as a Trimble S6 Robotic and other conventional total stations. These versatile survey instruments allow the team to perform detailed (sub-centimeter accuracy) topographic engineering surveys in a wide variety of circumstances. Traffic control plans were prepared for survey work along the Highway 7a/St. Johns Street corridor.

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo1\310055_Fig2_MissingData.mxd Date Saved: 2018-09-11 12:50:22 PM | Author: CCharbonneau

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date February 2019

Scale 1:7,000

100 50 0 100 m

Missing Data Collected by Survey Team

Figure 2

The survey crew in the field used an iPad with the ArcCollector application to update the missing manhole data as the survey was completed. The shapefile with the updated survey information was incorporated into the City's GIS and used to create figures and model inputs. For assets requiring survey that do not currently exist in shapefile format, survey data was exported from the survey equipment, reviewed for accuracy and then converted into GIS data and stored in a database.

Additionally, the City provided a list of additional assets they would like surveyed to complete their database for inventory purposes. The additional assets are 29 inlet inverts and headwalls along creeks that flow into the Metro Vancouver trunks and approximately 10 lawn/catch basins along Jane Street.

2.3 Drainage Issues and Overland Flow Paths

The "*Moody Centre Drainage Infrastructure Study*" (KWL, 2017) was completed to identify potential locations with drainage issues and to establish overland flow paths in the area south of St. Johns Street. In this study, the desktop analysis was revised and expanded to include the remainder of the Moody Centre study area. During the revision, additional potential drainage sinks (areas were overland flow could pond) were identified in the south area.

With the aid of contours, stormwater infrastructure layers, and orthophotography the revised desktop analysis identified the following (shown on Figure 3):

- Overland flow paths in areas without a minor system,
- Properties with known drainage issues,
- Areas where minor and major drainage systems crossed private property (without right-of-way or easement), and
- Potential drainage sinks/ponding areas.

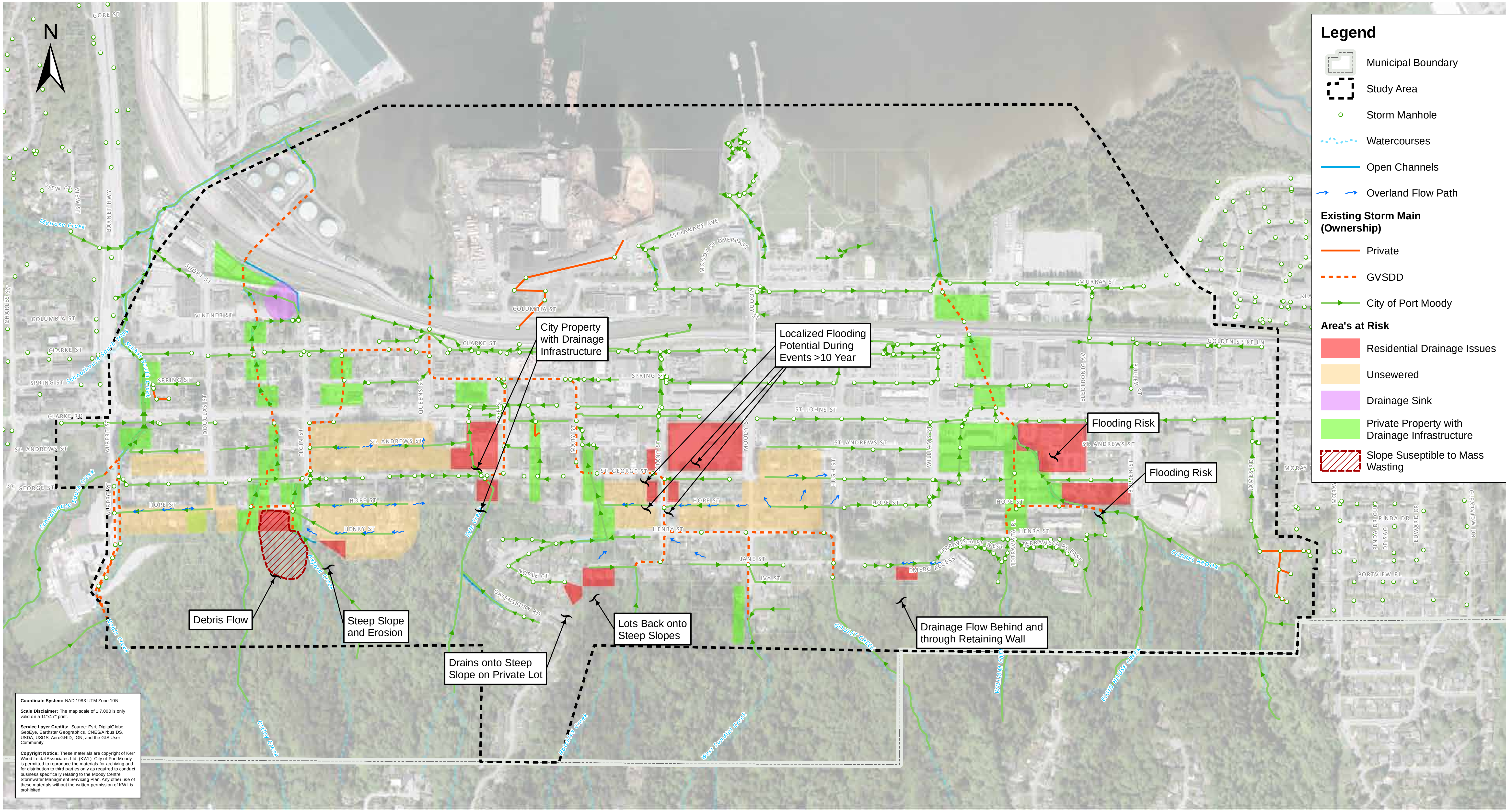
Overland flow paths and potential drainage sinks were confirmed in the field by KWL staff.

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo1\310055_Fig3_DrainageIssues.mxd Date Saved: 2018-09-11 11:46:42 AM | Author: CCharbonneau

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date February 2019

Scale 1:7,000

100 50 0 100 m

Potential Drainage Issues (as of September 2018)

Figure 3

3. Stormwater Policy Review & Recommendations

3.1 Stormwater Management Policy Review

Existing Stormwater Criteria and Policies

A stormwater management policy review was conducted to identify existing stormwater management criteria and existing policy gaps. As part of the policy review, the following documents were referenced:

- City of Port Moody "Official Community Plan Bylaw", 2014,
- City of Port Moody "Schedule E Specifications and Standard Drawings", January 2016,
- City of Port Moody "Subdivision and Development Servicing Bylaw", 2010,
- City of Port Moody "Zoning Bylaw" no. 2937, 2018,
- City of Port Moody "Stream and Drainage System Protection Bylaw", 2001,
- Associated Engineering "Chines Integrated Stormwater Management Plan, Final Report", May 2016,
- Associated Engineering "City of Coquitlam Qualitative Partial Risk Slope Analysis, Chines Escarpment and Corona Crescent Areas", June 2013,
- Fisheries and Oceans Canada "Urban Stormwater Guidelines and Best Management Practices for the Protection of Fish and Fish Habitat" (Draft Discussion Document),
- "Region-wide Baseline for On-site Stormwater Management", Metro Vancouver, February 2017,
- "Land Development Guidelines for the Protection of Aquatic Habitat", Department of Fisheries and Oceans, 1992, and
- "Stormwater Planning, A Guidebook for British Columbia", May 2002.

Existing stormwater criteria are summarized in Table 1.

Table 1: Summary of Existing Stormwater Criteria

Application	Criteria/Methodology
Flood and Erosion Protection	
Minor Drainage System	• Designed to 1 in 10-year event1
Major Drainage System	• Designed to 1 in 100-year event[1] • Major flow routing shall normally be provided along roads and in natural watercourses[1] • No major flow permitted on arterial roads
Watercourse Protection and Riparian Protection Bylaw	
Riparian Protection	• Consulting engineers shall refer to the latest best management practices and reference materials available from DFO and BC Ministry of Environment or Metro Vancouver[1] • Except for Daylighting a Stream, no development is permitted on lands with a Riparian Protection and Enhancement Area (RPEA)[2] • Minimum distance of an RPEA that is 20 m or greater can be reduced by no more than 20%[2] • No development is permitted on lands within a minimum Riparian Transition Area (RTA)[2] • Minimum riparian management setbacks are required as per Zoning Bylaw Section 5.4.5
Water Quality	• No prohibited material or water containing prohibited material is permitted to be discharged directly or indirectly into a drainage system o Prohibited material is defined as any sediment that will result in a total suspended solids concentration in excess of 75 mg/L above background levels or pH value outside of the range 6.5 – 8.0[3]
Sediment & Erosion Control	• Siltation basins and channels for erosion control at construction sites shall be designed so that the minimum detention time is 10 minutes[1] (Use 5-year return period storm to size sediment ponds[5]) • Depth of the basin shall not exceed 900mm[1] • This shall include such detailed plans, specifications and design calculations necessary to describe any works required to convey, control and treat suspended solids in run-off water from the site[3]
Chines Creek ISMP	
Rainwater criteria	• Source controls in the Chines watershed should be designed to limit the 2-year post-development peak flow to 50% of the 2-year pre-development peak flow[4] o Source controls to be designed on a detention rather than infiltration/capture basis

1. City of Port Moody “Subdivision and Development Servicing Bylaw”, 2010
2. City of Port Moody “Zoning Bylaw No. 2937”, 2018
3. City of Port Moody “Stream and Drainage System Protection Bylaw”, 2001
4. Associated Engineering “Chines Integrated Stormwater Management Plan, Final Report”, May 2016
5. DFO “Land Development Guidelines for the Protection of Aquatic Habitat”, 1992

Official Community Plan

The City of Port Moody Official Community Plan (OCP)[2] was reviewed to identify existing planning considerations for environmental and stormwater management concerns. The OCP identifies the City's long-term vision, goals, and objectives for future development. While the OCP is not a regulatory document, it provides insight on land use planning and guidance for policy for environmental and stormwater management best practices. Based on the classifications in the OCP, the study area can be divided into nine future land use types, as shown on Figure 4. The following briefly summarizes the relevant sections of the OCP as they relate to stormwater or environmental management:

- Tree preservation is valued by residents and there is support by Council to identify Significant Trees for preservation.
- Economic development and land conversion to support higher density is desired. There is to be no net increase in water pollution as a result of conversion.
- The City supports the development and implementation of Integrated Stormwater Management Plans to recognize the role of watercourses as providing drainage, flood control, and ecosystems. The City will, therefore, require water quality treatment of the "first-flush" runoff from impervious surfaces prior to discharge of runoff to the receiving systems.
- The City will consider the implementation of policy aimed at managing the extent of impervious areas through impervious coverage percentage targets. This includes the identification of maximum lot coverage and minimum landscaping coverage for specific land use types.
- The City recognizes current stormwater best management practices aimed at maintaining or improving biodiversity and improving overall watershed health. The City will, therefore, require use of source controls such as permeable pavement, natural infiltration basins, absorbent landscape, rain gardens, and green roofs.
- Stormwater Management Plans will be required for all subdivisions to identify parcel grading, major flood path routing, and detailed design information. All development applications must be in accordance with the Fisheries and Oceans Canada (DFO) Stormwater Guidelines[3].
- The City has identified neighbourhood plan areas to direct development within Port Moody. The plan areas span the city and provide direction on a range of features such land use, streetscaping goals, parks and recreational areas, and landscaping practices.
- The Moody Centre plan area, as shown on Figure 4, is envisioned to be a mix of residential, retail, office, employment, service, civic, institutional, recreational, and cultural land uses. Within this development area, the use of sustainable building practices including rooftop gardens and green roofs will be encouraged.
- The City will develop incentive programs to encourage the daylighting and enhancement of key drainage routes. The City specifically identified the enhancement or daylighting of Dallas/Slaughterhouse Creek, Kyle Creek, and South Schoolhouse Creek as priorities for incorporation in redevelopment proposals.

---

[2] City of Port Moody "Official Community Plan" schedule A to Bylaw No. 2955, 2014

[3] Fisheries and Oceans Canada "Urban Stormwater Guidelines and Best Management Practices for the Protection of Fish and Fish Habitat" (Draft Discussion Document)

- The Oceanfront District is included within the proposed study area. The Oceanfront District is a high-density mixed-use area. As part of the rezoning process for the site, a climate change risk assessment is to be undertaken which includes assessing flood risk, climate change risks and impacts (e.g., sea level rise, saltwater groundwater intrusion, loss/degradation of shoreline lands) and identifying adaptation measures to mitigate the impacts including stormwater management systems and landscape design standards.

Stormwater Policy Gaps Identified

The review of the City's current policies and bylaws has identified gaps in the existing policies. The following are key policy gaps and areas for improvement:

1. No specific stormwater management criteria or targets are in place which requires water quality treatment, rate control, or volume reduction.
2. No guidance is provided on the need for or use of low impact development and green infrastructure practices, including selection, operation and maintenance measures.
3. Details and requirements are lacking for sediment and erosion control measures to minimize erosion and sediment transport during construction.

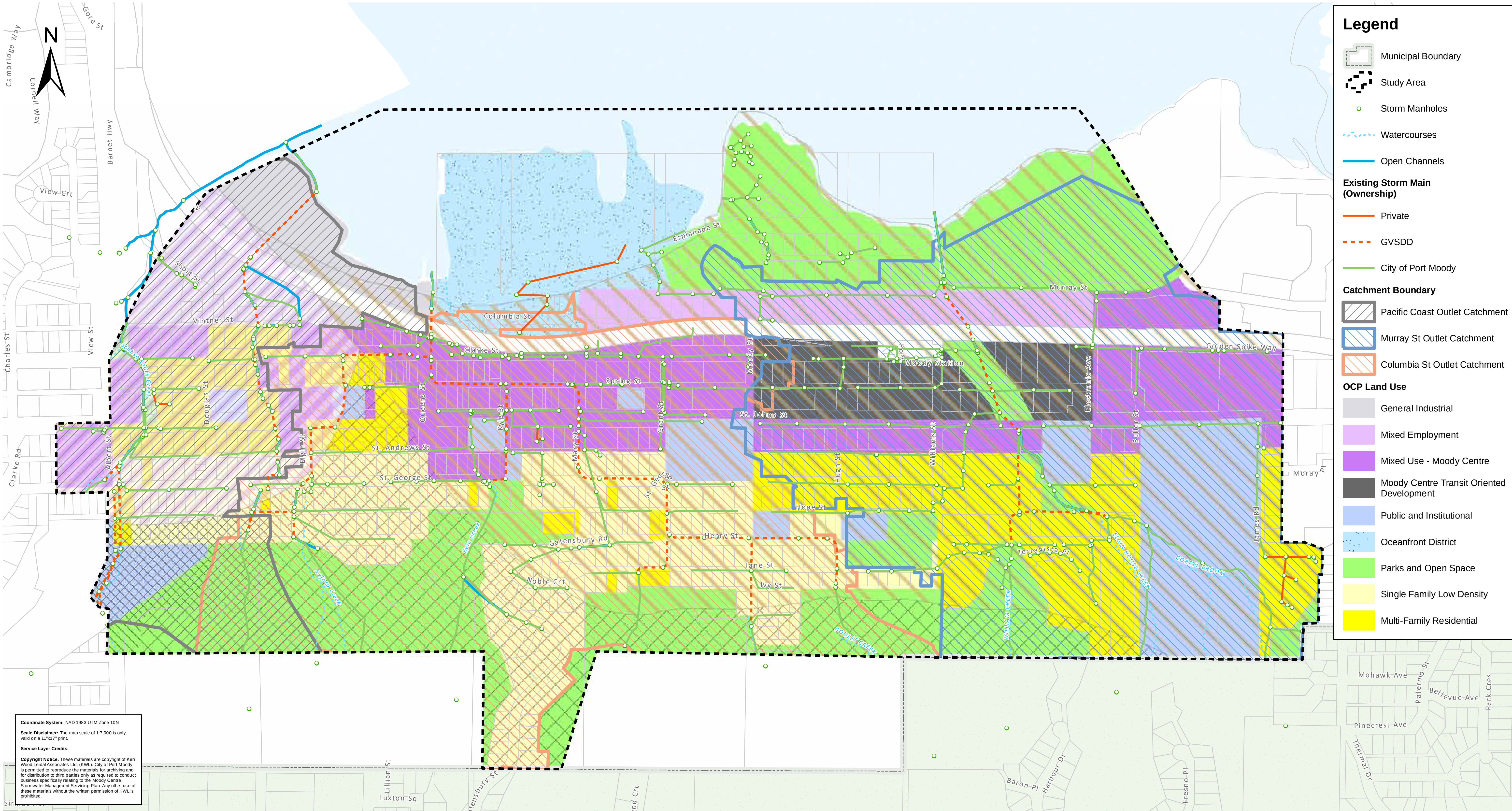
The existing criteria in the *City of Port Moody Subdivision and Development Servicing Bylaw, 2010* does not provide sufficient stormwater management criteria and guidance to support sustainable development in the future. While the OCP offers guidance and direction, it does not provide a regulatory framework to ensure the implementation of stormwater best management practices. New stormwater management criteria are therefore recommended for the Moody Centre. The proposed stormwater management criteria incorporate best management practices and requirements which are consistent with those of nearby municipalities, regional, Provincial, and Federal guidelines. These best management practices present a critical opportunity to achieve more sustainable development in the future.

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo1\310055_Fig4_Landuse.mxd Date Saved: 2018-09-11 12:53:50 PM | Author: CCharbonneau

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits:

Project No. 310-055

Date February 2019

Scale 1:7,000

100 50 0 100 m

Future Land Use & Catchment Boundaries

Figure 4

3.2 Stormwater Criteria and Policy Recommendations

These recommendations include stormwater management criteria, identification of retrofit opportunities, source control best management practices, and low impact development measures. The proposed land uses, typical soil types, and topographic conditions of the area have been taken into consideration in the recommendations. The proposed criteria are intended to support the 20-year servicing plan for Moody Centre.

The study area drains to three major drainage outlets, as shown on Figure 4. From west to east they are identified as the Pacific Coast Terminal Outlet, Columbia Street Outlet, and the Murray Street Outlet. It is proposed that the stormwater management criteria for each of these outlets is determined based on the environmental protection required for the receiving water.

Two different policy areas have been identified in the study area and the stormwater management criteria differ for these policy areas. In general, the two policy areas differentiate between (1) Areas Draining to the Ocean; and (2) Areas Draining to Remnant Creek Estuaries. Table 2 indicates which criteria are required in each area.

Table 2: Recommended Stormwater Management Criteria for Policy Areas

Policy Area	Stormwater Management Criteria Required
(1) Areas Draining to Ocean (via storm sewers)	• Minor and major drainage system criteria • Water quality targets • Erosion control threshold and targets for erosion protection of ditches
(2) Areas Draining to Remnant Estuaries or Creeks	• Minor and major drainage system criteria • Volume reduction targets • Water quality targets • Environmental rate control targets • Erosion control thresholds and targets for erosion protection of ditches and creeks • Environmental criteria for environmentally sensitive watercourses

Table 3 summarizes the recommendations and proposed criteria to address each of the identified policy gaps. As described in Table 2, recommendations vary by Policy Area.

Table 3: Proposed Stormwater Management Criteria

Issue	Objective	Recommendations	Criteria
Flood and Erosion Protection			
Minor and Major Drainage System Criteria Bylaw[1]		Continued use of the existing requirements for minor and major drainage system design with the addition of identifying major overland flow paths to allow safe conveyance within roadways and rights-of-way.	Minor system designed to 1 in 10-year event Major system designed to 1 in 100-year event Major flow routing shall normally be provided along roads and in natural watercourses No major flow permitted on arterial roads
Watercourse Protection and Riparian Protection			
Water Quality *(Gap 1)*	All areas: Identification of water quality targets which encourage a treatment train approach to remove sediment, sediment-bound metals, and hydrocarbons.	Source controls are to be used as the preferred method to achieve water quality targets, and end-of-pipe oil/grit interceptors or other structural and proprietary measures are also acceptable.	Minimum target:[2] Treat 90% of annual runoff from all impervious surfaces to provide 80% removal (by mass) of TSS loading Equivalent to treating 72% of the 2-year, 24-hour rainfall depth = 58 mm of rainfall.
Rate Control *(Gap 1)*	All areas: Determination of release rate targets to identify post-development peak-flow attenuation and detention or diversion requirements. These could be for the environmental protection of watercourses.	Infrastructure limitations within the study area are proposed to be addressed with the capital upgrade plan. Therefore, no stormwater management criteria recommendations for volume and rate control have been made to protect existing infrastructure.	Control post-development runoff rate to lesser of pre-development condition and post-development condition for up to the 5-year return period flow.[2] Creeks that have been identified by the City with a potential for daylighting or other enhancements may require additional studies to identify rate control targets for the contributing areas.
Volume Reduction *(Gap 1)*	Areas draining to watercourses: Volume reduction targets to provide a minimum retention volume to enhance infiltration (or provide slow baseflow release in areas where infiltration is prohibited) and creek baseflows via the use of source controls.	City should adopt targets as shown and pursue implementation through development and re-development opportunities. Targets vary depending on land use type.	Single-family residential: onsite rainfall capture and infiltration of a minimum of 40% of the 2 year 24-hour rainfall depth (32 mm in 24 hours) for the entire lot area[2] All other land uses: onsite rainfall capture and infiltration of 72% of the 2-year 24-hour rainfall depth (58 mm) for the lesser of the impervious area from pre- to post-development conditions[2]

Issue	Objective	Recommendations	Criteria
Development Impervious Limits *(Gap 2)*	All areas: Development and implementation of best management practice tool for the selection of appropriate best management practices or follow the Metro Vancouver Stormwater Source Control Design Guidelines. All areas: Development of total impervious area targets for each land use type	Adopt limit for Single-family consistent with the Metro Vancouver Baseline. All other land uses: In consultation with the City, target impervious areas are determined based on existing land use cover.	Maximum impervious cover targets: Single-family residential: maximum impervious cover of 70% [2] Multi-Family Residential maximum impervious cover of 80% Industrial maximum impervious cover of 90% Mixed Use/Employment maximum impervious cover of 85% Public and institutional maximum impervious cover of 85%
Erosion and Sediment Controls During Construction *(Gap 3)*	All areas: Improve Erosion and Sediment Control during construction to prevent and reduce water quality impacts to receiving waters.	All areas: Maintenance of the existing stream and drainage system protection bylaw with the addition of specific and measurable discharge requirements as per DFO Land Development Guidelines. All developments: Require minimal level of sediment control BMPs.	TSS level less than 25 mg/L above background levels during normal weather conditions (less than 25 mm of rain in the 24 hours prior).[3] TSS level less than 75 mg/L above background levels during significant rainfall events (equal to or greater than 25 mm of rain in the 24 hours prior)[3]

Notes:
1. Requirements from City of Port Moody "Subdivision and Development Servicing Bylaw, 2010.
2. Consistent with Metro Vancouver Baseline.
3. Consistent with DFO.

3.3 Recommendations on New Policy and Bylaw Updates

Based on the stormwater policy review, it is recommended that the City consider updating the following:

Stormwater Management Policy

- Develop a Stormwater Management Policy for new development and redevelopment. This will supplement the provisions of the City's Subdivision and Development Servicing Bylaw, 2010 (No. 2831).
- Add high-level information for guidance such as the Infiltration Map, source control prescriptions for land use types. Add clear criteria for water quality treatment, rate control, and volume reduction.
- Develop Source Control (Low Impact Development and Green Infrastructure) Examples and Standards to aid with education and implementation, or refer to Metro Vancouver documents.
- Incorporate O&M procedures (source controls, detention, and BMPs) into the City's regular O&M activities.

Subdivision and Development Bylaw, 2010 (Bylaw No. 2070)

- Under Section 5.0 – Storm Drainage System Design Criteria, add reference to the Stormwater Management Policy.
- Add requirement to incorporate climate change into analysis and design. Refer to the updated IDF curve under Bylaw Section 5.4.4.
- Require minimal removal and compaction of surficial soil during construction and development.

Stream and Drainage System Protection Bylaw, 2000 (Bylaw No. 2470)

- Require Sediment Control Best Management Practices (BMPs) for all developments (including Single Family, or two-family dwelling units).
- Develop a list of BMP Examples to supplement the Stream and Drainage System Protection Bylaw, 2000 (No. 2407).

3.4 Options for New Stormwater Measures

Stormwater source controls reduce the runoff that is discharged to the stream network by managing the water balance at the site level. Source controls play a key role in achieving Rainwater Management Criteria for volume reduction, water quality treatment, and runoff control and can be very effective at reducing runoff volumes and peak runoff rates depending on underlying soil characteristics. In gravel and sand soils, infiltrating source controls may be sized to infiltrate all runoff including the minor and major flows. If sized to capture the 6-month storm, a minor drainage system is also needed. Regardless of the design return period, even if it is the major 100-year event, a safe overland major flow route must be provided in case of infiltration facility failure.

Recommendations for stormwater management practices in Moody Centre will need to take into consideration the land use, soil type, topography, and geotechnical hazards of the subject lands. Future land use types will also influence source control selection. The total impervious area targets for proposed land uses will affect the range of best management practices (BMPs) that are appropriate for each redevelopment land use category. The following provides a summary and description of the low impact development and green infrastructure practices which are considered appropriate for Moody Centre:

- Absorbent landscaping (typically with disconnected roof leaders or impervious area run-on);
- Enhanced streetscapes (i.e., rain gardens, tree wells, soil cells);
- Surface infiltration facilities (i.e., pervious paving, bio-retention);
- Sub-surface infiltration facilities (i.e., underground infiltration chambers and rock trenches);
- Green roofs;
- Rainwater harvesting and reuse for non-potable uses;
- Water quality biofilters (i.e., vegetated filter strips, swales, rain gardens);
- Water quality structures (i.e., oil and grit separators); and
- Creek daylighting and channel improvements.

Heritage conservation policies in place suggest that there is a potential for development to consist of upgrades to existing buildings and infrastructure as re-development rather than new construction. Opportunities for stormwater management retrofits in these scenarios may potentially be limited heritage conservation goals.

Surficial geology in the study area is well-drained soils consisting mostly of gravel/sand/silt[4]. The post-glacial and fluvial sands are prominent within the redevelopment area and the hydrologic conductivity of this material is high and therefore suitable for the installation of volume retention practices which rely on infiltration as the primary outlet.

Surficial geology and topography are presented on Figure 5 and Figure 6, respectively. Table 4 identifies the potential source controls for each area based on the land uses and Table 5 summarizes the suitability of each source control based on the soil types found in the Moody Centre study area. A detailed description of each green infrastructure practice has been provided in Attachment 1.

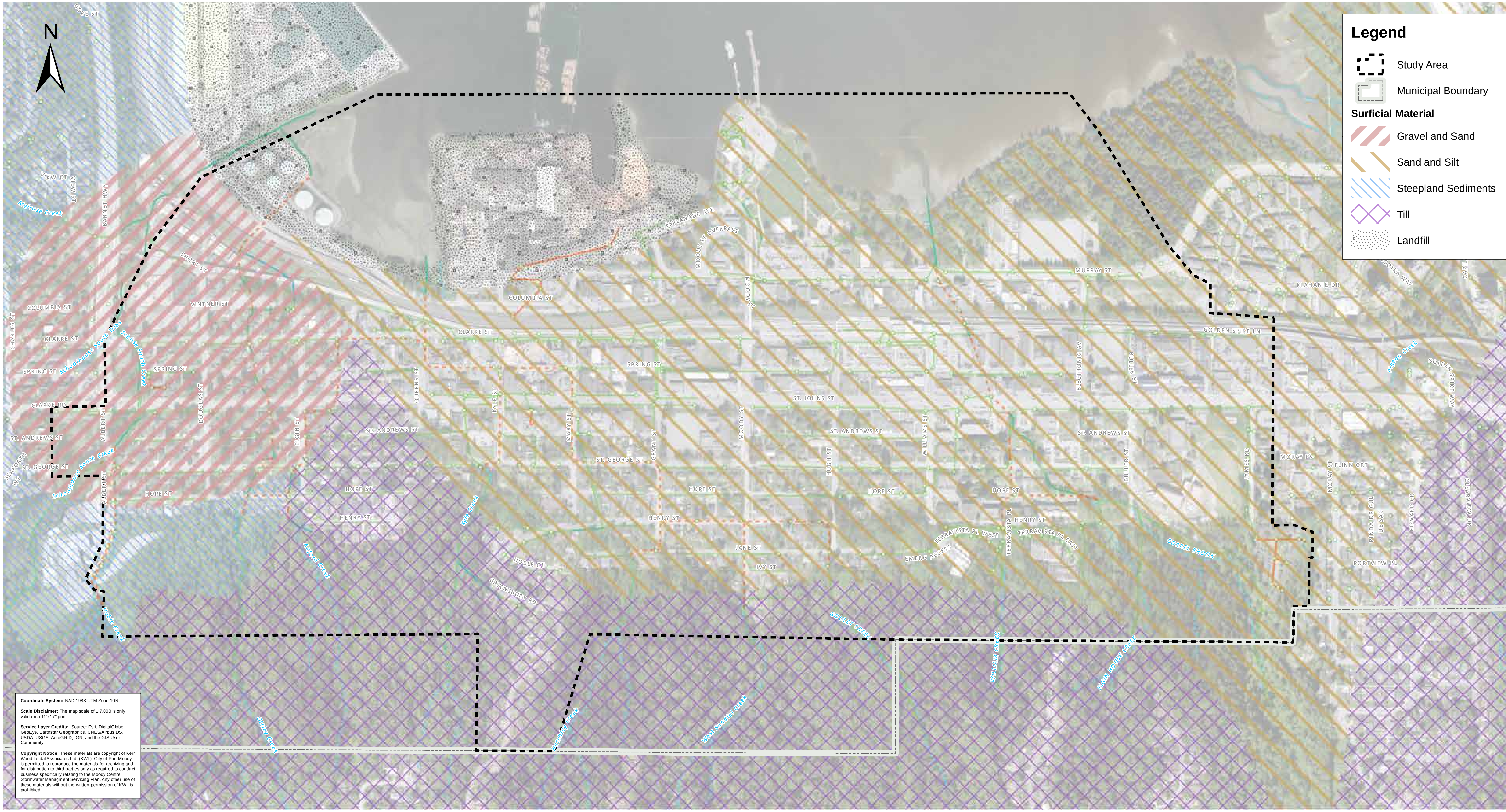
[4] "Chines Integrated Stormwater Management Plan". Associated Engineering, May 2016

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo1\310055_Fig5_SurficialGeology.mxd Date Saved: 2018-09-14 3:13:24 PM | Author: CCharbonneau

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date February 2019

Scale 1:7,000

100 50 0 100 m

Surficial Geology

Figure 5

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo1\310055_Fig6_Topography.mxd Date Saved: 2018-09-07 1:25:13 PM | Author: CCharbonneau

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055
Date February 2019
Scale 1:7,000

100 50 0 100 m

Topography

Figure 6

Table 4: Potential Source Controls for OCP Land Use Classifications

Future Land Use (OCP Zoning)	Typical Lot Coverage	Stormwater Best Management Practice						
		Absorbent Landscape	Surface Infiltration	Sub-surface Infiltration	Green Roofs	Rainwater Harvesting	Water Quality Structures	Bio-filtration
General Industrial	90%	🟢	🟠	🟢	🟠	🟠	🟢	🟢
Mixed Employment/	90%	🟢	🟠	🟢	🟢	🟢	🟢	🟢
Mixed Use – Moody Centre	90%	🟢	🟠	🟢	🟢	🟢	🟢	🟢
Moody Centre Transit Oriented	95%	🟢	🟠	🟢	🟢	🟢	🟢	🟢
Public and Institutional	85%	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Oceanfront District	80%	🟢	🔴	🔴	🟢	🟢	🟠	🟢
Park and Open Space	0-60%	🟢	🟢	🟠	🔴	🔴	🟠	🟢
Single-Family Low Density	65%	🟢	🟢	🟢	🔴	🟠	🔴	🟢
Multi-Family Residential	80%	🟢	🟢	🟢	🔴	🟠	🟠	🟢
Right-of-ways	85%	🟢	🟢	🟢	🔴	🔴	🟢	🟢

BMP Suitability Indicator & Description					
🟢	Recommended	🟠	Recommended with some limitations	🔴	Source control not recommended

BMP Suitability and Limitations

Limitations have been identified for each BMP based on both the land use type and the type of Source Control BMP. The limitations identified are consistent with those identified in the "Stormwater Source Control Design Guidelines" (KWL, May 2012) and the City of Vancouver "Best Management Practice Toolkit".

- Installation of infiltration practices in areas of hazardous slopes or potential slope instability is prohibited and a geotechnical engineer is required to determine adequate setbacks for infiltration in these areas
- Surface infiltration practices such as pervious pavers are only suitable on low traffic areas (1-2 vehicles per day per parking space)
- Overflows should be provided for all source control facilities to ensure that overflow is directed to the minor/major drainage system or a safe natural drainage path and does not discharge through adjacent sites
- Utility trenches that intercept source controls should be separated from the BMP materials with low permeability trench dams

Table 5: Summary of BMP Usage, Benefits, and Limitations

Best Management Practice	Benefits	Limitations
Absorbent landscape	• Water quality improvements • Volume reduction • Groundwater recharge • Biodiversity benefits • Green space and aesthetic benefits	• Limited by impervious/pervious ratio
Surface infiltration (rain garden, bioswales, permeable pavers)	• Water quality improvements • Runoff rate control • Volume reduction • Groundwater recharge • Green space and aesthetic benefits	• Dependent on the subsoil conditions • Limited by surface slope
Sub-surface infiltration (infiltration gallery, rock pits, soil cells)	• Water quality improvements (through pre-treatment devices) • Runoff rate control • Volume reduction • Groundwater recharge	• Dependent on the subsurface soil conditions
Green roofs	• Runoff rate control • Volume reduction • Green space and aesthetic benefits • Building energy savings • Air quality benefits	• Not appropriate or practical for all land use types • Require structural costs and considerations
Rainwater re-use	• Runoff rate control • Volume reduction	• Not appropriate or practical for all land use types

Best Management Practice	Benefits	Limitations
Water quality treatment devices and technologies	• Water quality improvements • Point source treatment • May be used where space is constrained	• Lose functionality without required maintenance
Note: Detailed descriptions of these BMPs may be found in Attachment 1.		

4. Intensity Duration Frequency (IDF) Analysis

The most recent version of the City's "Subdivision and Development Servicing Bylaw, 2010" includes an IDF curve that utilizes 38 years of rainfall data (1959-1979, 1982-1983, and 1994-2008) from Metro Vancouver rain gauge PT11 at the Port Moody Pump Station. To update the IDF curve to current values, an analysis was completed to incorporate precipitation data to 2017. A new IDF curve was created using 24 years of 5-minute rainfall data for the time period of 1994-2017 (the older data was excluded to be consistent with the most recent IDF values provided by GVRD). This period is representative as it captures El Nino and La Nina years.

To account for climate change, predicted increases up to Year 2100 were presented as percentage increase in intensity for each duration and return period. The percentage increases were derived using the Western University IDF CC Tool and the 1994-2017 PT11 maxima data.

4.1 Updated IDF Curve

The rainfall data were used to create a summary of the 5-, 15-, and 30-minute and 1-, 2-, 6-, 12-, and 24-hour annual maxima. Metro Vancouver reported maxima for the PT11 gauge were used for years 1994-2014 and the raw continuous data were used to extract annual maxima for 2015-2017. A frequency analysis was completed using the 5-minute rainfall data from 1994 - 2017 in Hyfran+[5] and the IDF curve values were estimated using the Gumbel Extreme Value Type 1 (EV1) Distribution. Gumbel Extreme Value Type 1 has been widely adopted for rainfall frequency analysis and is consistent with the standard distribution used by Environment Canada for extreme precipitation event predictions. The analysis was completed for the 2-, 5-, 10-, 25-, 50-, and 100-year return periods. The updated IDF values are greater than the values used to generate the published IDF curve for 1959-1979, 1982-1983, and 1994-2008. Table 6 summarizes the IDF values for depth of precipitation produced by the Gumbel EV1 analysis:

[5]Bobee, B & El Adlouni, S., Hydrological Frequency Analysis (HYFRAN) PLUS version 2,2 [computer software]. INRS-ETE, Quebec, QU, Canada

Table 6: Predicted Rainfall Intensity (mm/hr) Computed using the Gumbel EV1 Distribution

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	49.0	73.1	89.0	109.0	124.0	139.0
15 min	28.3	43.3	53.2	65.7	75.0	84.2
30 min	19.3	27.9	33.5	40.7	46.0	51.2
1 h	13.7	17.7	20.3	23.6	26.0	28.5
2 h	10.1	12.4	14.0	16.0	17.4	18.9
6 h	6.9	8.5	9.6	11.0	12.0	13.0
12 h	5.1	6.4	7.3	8.4	9.3	10.1
24 h	3.3	4.4	5.0	5.9	6.5	7.1

The results of the frequency analysis were plotted on a log-log graph. The IDF equations were developed by utilizing the equation of the line of best fit for each return period. Table 7 summarizes the interpolated values for the IDF equations. The coefficients support the following equation:

$$I = A * T^{B}$$

I = intensity (mm/h)
T = storm duration (h).

Table 7: IDF Frequency Interpolation Equation

Coefficient	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
A	14.739	20.131	23.648	28.068	31.310	34.562
B	-0.458	-0.493	-0.507	-0.520	-0.527	-0.533

The interpolation equation and updated coefficients were used to revise the IDF parameters for the PT11 rain gauge. Table 8 and Table 9 present the updated IDF intensity and depths for the 1994-2017 time period. Table 10 summarizes the percent change in IDF values between the existing Bylaw and the update (1994-2017).

Table 8: Updated Rainfall Intensity (mm/hr) Computed from the Interpolation Equation

Duration	Return period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	46.0	68.6	83.4	102.2	116.1	130.0
15 min	27.8	39.9	47.8	57.7	65.0	72.4
30 min	20.2	28.3	33.6	40.3	45.1	50.0
1 h	14.7	20.1	23.6	28.1	31.3	34.6
2 h	10.7	14.3	16.6	19.6	21.7	23.9
6 h	6.5	8.3	9.5	11.1	12.2	13.3
12 h	4.7	5.9	6.7	7.7	8.4	9.2
24 h	3.4	4.2	4.7	5.4	5.9	6.3

Table 9: Updated Rainfall Depth (mm) Computed from Intensity

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	3.8	5.7	7.0	8.5	9.7	10.8
15 min	7.0	10.0	11.9	14.4	16.3	18.1
30 min	10.1	14.2	16.8	20.1	22.6	25.0
1 h	14.7	20.1	23.6	28.1	31.3	34.6
2 h	21.5	28.6	33.3	39.1	43.4	47.8
6 h	38.9	49.9	57.2	66.3	73.0	79.8
12 h	56.7	70.9	80.4	92.5	101.3	110.3
24 h	82.5	100.7	113.2	129.0	140.6	152.4

Table 10: Percent Change in Updated IDF Values (Updated IDF / existing Bylaw values)

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	15.4%	12.7%	11.8%	11.2%	10.9%	10.7%
15 min	14.3%	10.3%	8.8%	7.6%	6.9%	6.5%
30 min	13.6%	8.7%	6.9%	5.4%	4.5%	3.9%
1 h	12.9%	7.2%	5.1%	3.2%	2.1%	1.3%
2 h	12.2%	5.7%	3.2%	1.0%	-0.2%	-1.1%
6 h	11.1%	3.4%	0.4%	-2.3%	-3.8%	-5.0%
12 h	10.5%	2.0%	-1.3%	-4.3%	-6.0%	-7.3%
24 h	9.8%	0.6%	-3.0%	-6.3%	-8.1%	-9.6%

Figure 7 presents the updated rainfall IDF Curve for the PT11 rain gauge.

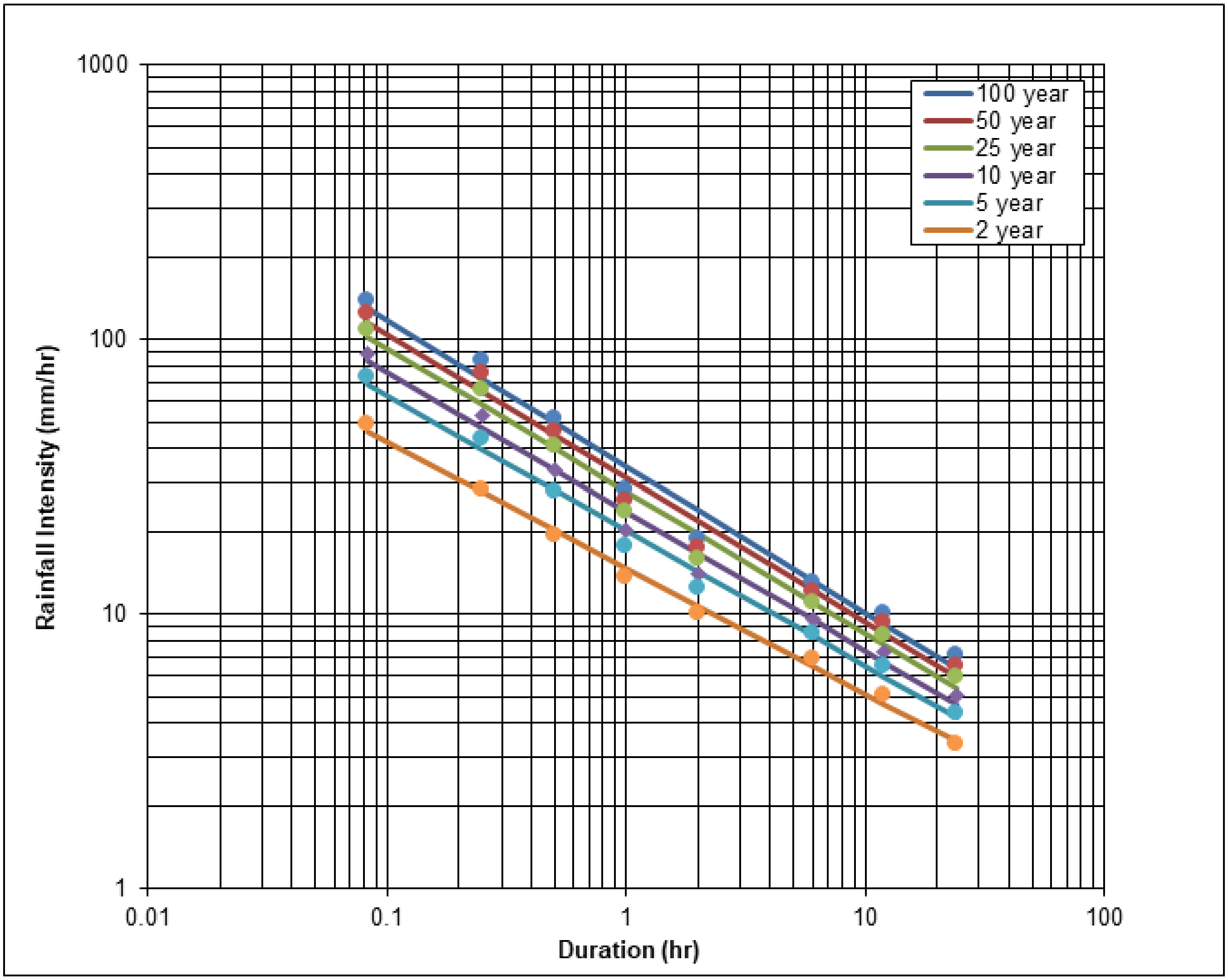


Figure 7: Updated IDF Curve for PT11 Rain Gauge (January 1, 1994 – December 31, 2017)

It should be noted that the updated IDF curve using 1994-2017 data resulted in some rainfall totals being less than the historical IDF values in the Development Bylaw. To be consistent with the GVRD's most recently published IDF curve (1994-2014) for the PT11 rain gauge, years 1959-1979 and 1982-1983 are no longer being used to develop the IDF values. Removing these record years impacts the data that is inputted into the statistical analysis tool and removes some years which contribute to larger rainfall depths for some of the IDF values. In general, the decreases are seen in the higher return period, longer duration values. The years from 1994–2017 contain rainfall years that represent both El Nino and La Nina conditions and are believed to be representative.

4.2 Climate Change IDF Curve

In addition to providing an update to the current IDF curves to predicted large rainfall events based on data up to 2017, the effect of future climate change on rainfall was also considered. An analysis was completed to evaluate a climate change scenario for the time range from Year 2050 – 2100 for the PT11 rain gauge. The *Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change – Version 3.0 (IDF_CC Tool 3.0)* was utilized to adjust the updated IDF curves to represent future climate change[6]. The Port Moody Pump Station PT11 location was added as user-input station within the IDF_CC Tool and the annual maxima data were imported.

Consistent with Environment Canada and the methodology described previously, the IDF_CC Tool uses the Gumbel EV1 Distribution to calculate the IDF table for historical data prior to applying climate change scenarios. The Climate Change Tool was used to estimate the climate change factor to apply to the design rainfall intensities based on a future Relative Concentration Pathway (RCP) 8.5 scenario. There are 12 Global Circulation Models (GCMs) recommended by Pacific Climate Impact Consortium (PCIC) for the Western North America region, the IDF climate change tool simulates an ensemble of the models which includes nine of the GCMs; the ensemble prediction was used in this study for the climate change analysis. The estimations from the GCMs were applied to the rainfall data at the PT11 gauge, and the percentage increase in rainfall intensity was estimated for a Year 2050 – 2100 time-horizon. The median value of the nine recommended models was used to represent a "Moderate" climate change scenario for the Moody Centre area. This approach is consistent with the methodology GHD utilized in their 2018 report *"Study of the Impacts of Climate Change on Precipitation and Stormwater"*. Uncertainties in the future prediction were addressed by incorporating the RCP 8.5 Green House Gas (GHG) emission option, which is the worst-case GHG pathway assuming radiative forcing increases throughout the century (i.e., business as usual).

Table 11: Rainfall Volumes (mm) Adjusted for Climate Change (2050-2100, RCP8.5, Moderate (Medians), 9 GCMs)

Duration	Return Period					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	4.6	7.0	8.9	11.4	12.9	14.3
15 min	8.4	12.1	15.3	19.1	21.2	23.1
30 min	12.2	17.1	21.5	26.6	29.3	32.3
1 h	17.6	24.6	30.3	38.0	42.1	45.9
2 h	25.8	35.0	42.6	52.9	60.3	66.5
6 h	46.8	61.2	73.1	89.5	101.6	111.5
12 h	68.2	86.9	102.9	124.8	141.0	154.2
24 h	99.2	123.4	144.8	174.6	194.2	211.1

[6] Simonovic, S.P., Schardong, A., Gaur, A., & D. Sandink. "IDF_CC Tool 3.0". Facility for Intelligent Decision Support (FIDS), Western University, 2018. Web. 22 August 2018. http://www.idf-cc-uwo.ca/

Figure 8 presents the climate change IDF Curve for the PT11 rain gauge for the projected period of year 2050-2100.

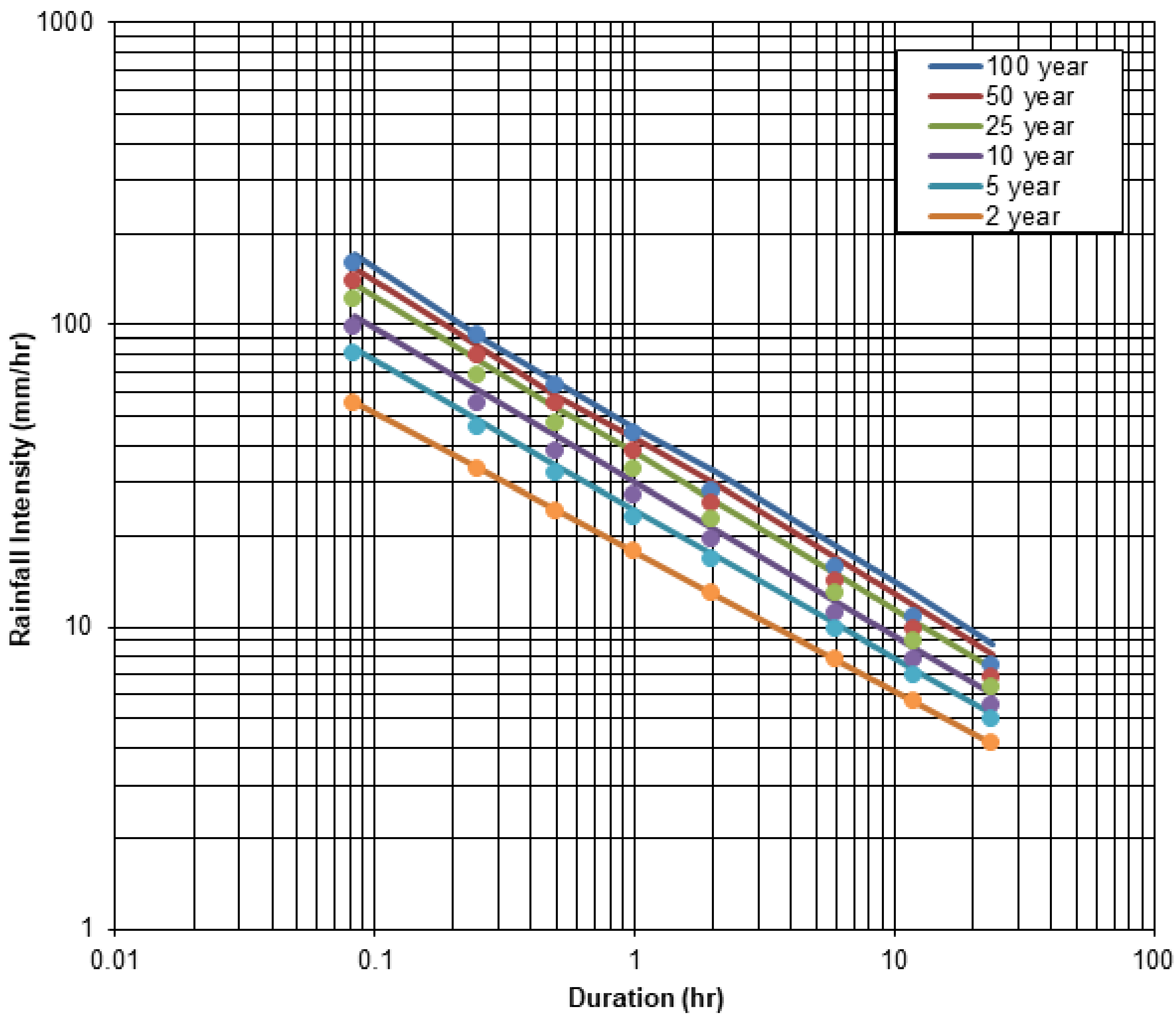


Figure 8: Updated IDF Curve for PT11 Rain Gauge Year 2050-2100 Climate Change Condition

The climate change projections for the IDF values result in an increase in storm depth for all durations and return periods. The percent increase from historical (i.e., IDF from Year 1959-1979, 1982-1983, & 1994-2008) to climate change IDF values range from 23-49% with an average increase of 34%. The largest increases occur during larger return periods and shorter duration storm events.

The existing design storms and their projected future climate change conditions increases are provided in Table 12.

Table 12: Changes in Design Storm Depths for Moody Centre

Duration	10-year Total Rainfall (mm) and [% Increase][4]	100-year Total Rainfall (mm) and [% Increase][4]
1-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	22.5	34.1
Year 1994-2017[2]	23.6	34.6
Year 2050-2100[3]	30.3 [+35%]	45.9 [+35%]
2-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	32.2	48.3
Year 1994-2017[2]	33.3	47.8
Year 2050-2100[3]	42.6 [+32%]	66.5 [+38%]
6-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	56.9	83.9
Year 1994-2017[2]	57.2	79.8
Year 2050-2100[3]	73.1 [+28%]	111.5 [+33%]
12-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	81.5	118.9
Year 1994-2017[2]	80.4	110.3
Year 2050-2100[3]	102.9 [+26%]	154.2 [+30%]
24-hour		
Year 1959-1979, 1982-1983, & 1994-2008[1]	116.7	168.5
Year 1994-2017[2]	113.2	152.4
Year 2050-2100[3]	144.8 [+24%]	211.1 [+25%]

Notes:
1. Year 1959-1979, 1982-1983, & 1994-2008 = Depths based on IDF Curve in City's 2010 Bylaw
2. Year 1994-2017 = Existing Condition
3. Year 2050-2100 = Moderate Climate Change Condition for the time horizon 2050 to 2100. All increases are based on the University of Western Ontario IDF CC Tool – Ensemble (9 GCMs) for Western North America, RCP 8.5.
4. Percent increase from IDF Curve in City's existing Subdivision Development Bylaw to Climate Change Year 2050-2100

To validate the climate change predictions for the PT11 rain gauge, climate change predictions on a nearby rain gauge were also assessed. The Port Moody Glenayre (Environment Canada Station 1106CL2) gauge is located approximately 4 km to the southeast, within the same isohyetal zone as PT11. The IDF for Port Moody Glenayre station utilizes 29 years of data (1971-2001) to generate IDF values for the 1-, 2-, 6-, 12-, and 24-hour duration storms. The same approach used for the PT11 station was used and the RCP 8.5 scenario was assessed to develop the adjusted IDF parameters. The percentage increases of rainfall depth were found in the similar range for the climate change conditions.

4.3 Climate Change Discussion

As model uncertainty is one of the biggest challenges in climate change projections, KWL reviewed recent climate change guidance documents from other Metro Vancouver municipalities to ensure consistency. Specific references to precipitation intensity from each document are provided below:

- GVS&DD DRAFT Study of the Impacts of Climate Change on Precipitation and Stormwater Management Final Report (GHD, 2018): The study used an ensemble of 12 GCMs to estimate the expected change to existing IDF curves due to climate change. All 12 GCMs were recommended by PCIC for analysis in Western North America. The median and 95th percentile of the anticipated deltas (percent increases) for each of the 12 evaluated GCMs were utilized to develop moderate and high climate change IDFs, respectively. By applying this methodology, under the "Moderate" future climate change scenario, an average 21% increase in IDF parameters were estimated for Year 2050 and an average 41% increase estimated for Year 2100. These results are specific to Zone 4, that closest to the Moody Centre area.
- City of Vancouver Climate Change Strategy (2012) anticipates that peak precipitation intensity by the 2050s will result in the amount of precipitation on 'very wet days' (>95th percentile) to increase by 21% and on 'extremely wet days (>99th percentile) to increase by 28%[7].
- City of Surrey Climate Change Strategy (2013) predicts that by mid-century, precipitation during wet days (with precipitation above the 99th percentile of wet days in the past) is expected to increase 28% relative to the baseline (average change based on eight regional climate model projections)[8].

The review shows that the approach utilized in the climate change analysis in this study is similar to that used in the GVS&DD study by GHD. The climate change factors predicted using a consistent methodology (see Table 12) are also within the reasonable range predicted by the GVS&DD document. The City of Vancouver and City of Surrey climate change strategies were developed using Plan2Adapt, an alternative tool which reports annual precipitation and temperature increases intended to be utilized from an adaptation and planning perspective. The City of Vancouver and City of Surrey do not publish IDF value increases.

---

[7] City of Vancouver Climate Change Strategy, November 2012

[8] City of Surrey Climate Change Adaptation Plan, November 2013

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

Bryce Whitehouse, A.Ag.
Stormwater Engineer

Caroline Charbonneau, M.A.Sc., P.Eng.
Project Engineer

Reviewed by:

David Zabil, M.A.Sc., P.Eng.
Senior Water Resources Engineer

Attachment: Mitigation Measures

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the intended recipient. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Copyright Notice

Revision History

Revision #	Date	Status	Revision Description	Author
0	October 3, 2019	Final	Issued as Final	EL/CEC

Attachment 1

Mitigation Measures

Stormwater Source Control Technologies

Stormwater source controls reduce the runoff that is discharged to the stream network by managing the water balance at the site level. Source controls play a key role in achieving Rainwater Management Criteria for volume reduction, water quality treatment, and runoff control and can be very effective at reducing runoff volumes and peak runoff rates from events smaller than the 50% of 2-year storm. Though they do provide some flow-detention benefits for the 2-year storms, source controls have limited ability to reduce peak runoff rates from large storms and must be designed with adequate overflow capacity. Additional stormwater infrastructure must be provided to safely convey stormwater offsite for the larger events.

Several standard source control technologies are described below. The Metro Vancouver Stormwater Source Control Design Guidelines[1] is an excellent reference for source control best management practices (BMP) design advice.

Absorbent Landscaping

Natural topsoil is generally permeable. The vegetation on topsoil provides a layer of organic matter which is mixed into the soil by worms and micro-organisms, creating voids, which allow rain water to percolate through, and making the soil more structurally capable of providing storage in the void spaces when saturated.

Standard construction practice is often to strip the existing topsoil, compact or excavate a site surface to the desired grade, and then cover it with a thin layer of imported topsoil. Although lawns and other ornamental landscaping will establish a vegetated surface, both the original surface and subsurface flows and storage capacities have been altered and surface runoff will be increased. Instead of stripping and removing, original topsoil it should be replaced on the site and augmented with organic matter and sand to improve soil structure and increase macropore development.

To increase absorbency, surface soils should have a minimum organic content to facilitate plant growth and a soil depth sufficient to meet the 50% of 2-year rainfall capture target. Increased soil depths also provide retention for runoff from adjacent hard surfaces. Surface vegetation should include herbaceous groundcovers with a thickly matted rooting zone, deciduous trees, or evergreens.

Absorbent Landscaping

Some maintenance over the long term is required for the absorbent landscape to continue to provide stormwater benefits. Maintenance activities may include replacing soils that have eroded and replanting dead or dying vegetation.

1 Metro Vancouver, Stormwater Source Control Design Guidelines, 2005 http://www.gvrd.bc.ca/sewerage/stormwater_reports.htm

Surface Infiltration Facilities

Rainfall runoff is stored at or near the surface in a layer of absorbent soil, sand, gravel, or rock, and/or on the ground surface in a ponding area. The stored runoff that infiltrates into the soil becomes interflow and augments groundwater in the sub-surface.

Surface infiltration facilities can look like normal vegetated swales or ponds, and can be aesthetically landscaped and integrated into the design of open spaces. They include bioretention facilities and rain gardens. Both surface and sub-surface infiltration facilities can be effective at the lot level, as well as at the neighbourhood level, where individual lot sizes or layouts don't support on-lot facilities or where more permeable soils or groundwater recharge areas are located off-site. Surface infiltration facilities can, depending on their design, provide some level of water quality treatment as well.

Surface infiltration can be combined with detention, where the detention release rate allows sufficient time for infiltration through the pond. Infiltration facilities are highly dependent on the hydrologic properties of the sub-surface soils.

Surface infiltration can also be promoted by the used of permeable pavers or other pervious surfacing materials.

Bio-Retention Facilities

If infiltration rates are low, such as is likely in clay and till soils, bio-retention facilities can be designed to store the volume reduction target in soil and rock trench voids and infiltrate it slowly over time.

Where applicable, a retention facility may also be designed as a baseflow augmentation facility that retains the design capture volume in a tank or pond and releases it at baseflow rates. These rates are very low, and are based on measured summer baseflows in a watercourse divided by the contributing watershed area, and then applied to the area of the site contributing runoff. Baseflow augmentation facilities discharge the capture volume to the downstream stormwater system or watercourse at a maximum of the determined baseflow rates. Any volumes above the capture volume must be allowed to bypass the baseflow augmentation facility.


Bio-Retention Swale

Sub-surface Infiltration Facilities

A similar design process is used for sub-surface infiltration as for surface infiltration facilities. The main advantage of sub-surface facilities is that they often have vertical walls and do not require as much dedicated ground area, allowing them to be located beneath paved impervious areas.

Sub-surface facilities must be located at least 0.5 m above the level of the water table so that they can discharge through the sides and bottom of the structure and will not merely store infiltrated groundwater. Generally, the deeper an infiltration facility is located, the less-effective it will be. Subsurface infiltration facilities can be as simple as a trench filled with clean, free-draining rock that is protected from soil by a permeable membrane. There are numerous products available commercially for subsurface infiltration as well.

Sub-Surface Infiltration

Green Roofs

Installing a green roof rather than a conventional impervious roof can significantly reduce the volume and rate of runoff from a building lot particularly for the smaller, more frequent storm events.

A green roof is essentially a roof with a layer of absorbent soil and vegetation on top of a drainage collection layer or system. Rainfall is absorbed or stored by the soil and vegetation for later evapotranspiration. The green roof has a limited storage capacity, so any excess rainfall percolates through and is collected by a drainage system. The excess rainfall is then routed to the ground for detention and conveyance.

Green roofs are more expensive to build as they have structural costs as well as landscaping costs and do require maintenance to ensure their ongoing functionality. However, when compared with land costs for alternate facilities in high density urban areas, the costs for a green roof may be favourable. Green roofs also have other benefits, in addition to stormwater benefits, that can include heating or cooling cost savings by insulating the building, aesthetic benefits, air quality benefits, and reduced solar gain that decreases the urban heat island effect. Green roofs should only be designed and constructed by qualified professionals as structural engineering, building envelope and landscape design as well as stormwater engineering are all critical components. Green roofs are the preferable source control in areas where ground surface controls are not possible.

Green Roof

Rainwater Re-use

Rainwater re-use is commonly afforded by residential rain barrels which are effectively retention facilities for roof runoff. Limitations of rain barrels are that rainfall is seldom a reliable source for water during the dryer seasons and rain barrels are often not large enough to store the 50% of 2-year capture target. The most significant reductions in runoff volume from re-use are achieved by capturing and re-using rainwater for indoor grey-water uses, or for commercial and industrial applications with high water consumption rates or where water supplies are limited. Recycling rainwater reduces demands from surface waters and reservoirs and can reduce supply infrastructure costs. Rainwater re-use can also be combined with infiltration facilities.

Re-Use Tank

Re-Use Barrel

Water Quality Best Management Practices

Changes in land use, loss of natural biofiltration capacity, increases in impervious area, and pollutant laden runoff associated with urban development can contribute to reduced water quality which impacts fish and fish habitat. BMPs designed to capture and treat runoff need to be incorporated into RWMPs.

Water Quality BMPs are physical, structural or management practices that reduce or prevent water quality degradation. Many of these are the same as, or similar to those used for runoff volume reduction and rate control and but have ancillary benefits for water quality. Source control remains the key means of reducing introduction of toxic and hazardous materials or organic and inorganic contaminants, originating from land and water use or as a result of commercial or industrial spills. Without source control, runoff water quality is limited by the effectiveness of treatment technology.

Treatment controls are point-source water quality management measures. They are generally constructed facilities and are often individual installations incorporated into the stormwater management infrastructure. They should be designed on a site-specific basis, after examining all alternative treatment technologies, and selecting the best available options based on cost and effectiveness. These controls should be designed and constructed by appropriately qualified environmental professionals.

Water Quality Best Practical Technologies

Several technologies have the ability to provide both water quality benefits and runoff control. Water quality benefits are derived from contaminant removal mechanisms that use biological and physical processes. Runoff control is accomplished by improving stormwater detention and retention which reduces peak runoff discharge rates and volumes.

Biofilters

Biofilters are vegetated filter strips, swales and rain gardens that remove deleterious substances, notably particulate contaminants, though some combination of physical (e.g.: adsorption) and biological (biodegradation) removal mechanisms. Biofilter technology is suitable for sheet flow runoff, typical of large linear impervious developments like roadways and parking lots.

Urban Forests and Leave Strips

Depending on the extent of tree canopy and ground cover retained, runoff reduction and pollutant removal can be achieved by maintaining natural well functioning urban forested areas. The contaminant removal processes forests and natural vegetation provide include: filtration, adsorption, absorption, and biological uptake and conversion by plant life. Urban forests also provide habitat refuges for many species whose habitats have been fragmented while riparian leave strips along watercourses, provide critical fish and wildlife habitat.

Infiltration Systems

Infiltration systems generally require pre-treatment for water quality to prevent clogging and binding-off of the permeable materials and contamination of underlying aquifers. Physical removal of deleterious substances by filtration and adsorption, as well as conversion of soluble pollutants by bacteria, also occurs within the infiltrating soils.

Oil and Grit Separators

Oil and grit separators are suitable for spill control and removal of floatable petroleum-based contaminants as well as coarse grit and sediment from small areas, such as gas stations, automotive service areas and parking lots. Oil and grit separators have limited application in large-scale stormwater runoff applications, and should be limited to small area generation sites.


Oil Grit Separator

Construction Best Practices

Construction Best Practices for instream stormwater management works include timing of the works to minimize impacts. Timing windows should be adhered to in order to minimize impacts to fish and wildlife and specifically to avoid sensitive periods for certain life history stages of fish (e.g.; adult spawning, egg and alevin intergravel incubation). Where information is available on critical life history stages and timing for any identified Species at Risk, these times should also be avoided. Clearing should only be undertaken immediately in advance of work, and only during vegetation clearing timing windows, where these have been identified for protection of nesting birds. To the extent possible, work should be restricted to cells and undertaken in a systematic manner to limit the area disturbed at any given time. Works should only be undertaken during favourable weather conditions and low water conditions.

Measures must be taken to prevent the release, from any work site, of silt, sediment, sediment-laden water, raw concrete, concrete leachate, or any other deleterious substance into any ditch, watercourse, stream, or storm sewer system. The work area should be isolated from flowing water as much as possible and diversions around the site should be provided for overland flow paths. Ensuring that all equipment used on-site is in good working order, and having a ready spill containment kit and staff trained in its use, are also critical measures.

For further information on managing erosion and sediment discharges during construction, see the Erosion and Sediment Control section of the Land Development Guidelines and the Standards and Best Practices for Instream Works.[2]

[2] BC Ministry of Water, Land and Air Protection's *Standards and Best Practices for Instream Works* (draft March 2004) http://wlapwww.gov.bc.ca/sry/iswstdsbpsmarch2004.pdf.

Appendix B

Technical Memorandum #2
Hydrological and Hydraulic Assessment

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: October 3, 2019

TO: Shashi Bandara, E.I.T
City of Port Moody

CC: Stephen Judd, P.Eng.

FROM: Eva Li, P.Eng., Project Manager
Bryce Whitehouse, A.Ag., Project Engineer

RE: **MOODY CENTRE STORMWATER MANAGEMENT SERVICING PLAN**
Tech Memorandum #2 – Hydrological and Hydraulic Assessment
Our File 310.055-300

1. Introduction

The City of Port Moody (the City) maintains separated storm sewers and sanitary sewer systems. Rainfall runoff is captured in storm sewers and released into major watercourses or receiving waterbodies. The regional district, through the Greater Vancouver Sewerage and Drainage District (GVS&DD), maintains waterway and trunk storm sewers within the Moody Centre area which encompasses the area from Schoolhouse Creek East to Dallas Creek, including a portion of the Chines Escarpment. The City maintains the local storm sewer system that discharges to the GVS&DD trunk sewers.

Moody Centre is a fully urbanized area and is expecting rapid re-development and densification to accommodate the increasing population growth. Port Moody's Official Community Plan (OCP) identifies areas where changing land use and redevelopment will result in increased impervious areas. An increase in impervious area will significantly affect the volume and intensity of stormwater runoff in future development conditions. In addition, projected climate change impacts will exacerbate the effect of increased impervious area. This memo outlines the development of a detailed hydrologic and hydraulic model to assess the Moody Centre stormwater drainage system. The existing and future conditions were simulated and the drainage system performance was assessed in existing land use conditions and future OCP land use conditions (with climate change impacts). Selected low impact development (LID) measures were incorporated in the future conditions model to determine the mitigation impacts on the frequent storm event (6-month 24-hour) volume and peak flow, and their effect on the minor event (10-year) peak flows. As per the City's design manual[1], the 10- and 100-year design storms were used to evaluate the system performance in minor and major storm sewers. In addition, an overland flow pathway assessment was completed to evaluate the major overland flow routes in the study area.

[1] City of Port Moody "Subdivision and Development Servicing Bylaw, 2010

The results of the hydrologic and hydraulic modelling summarized in this memorandum will inform the development of Stormwater Management and Servicing Plan in the next phase of this study. The drainage system assessment is focused on the City-maintained drainage infrastructure; the waterways and trunk storm sewers operated and maintained by GVS&DD have already been assessed in the Chines ISMP[2] and therefore were not assessed in this study.

2. Model Development

2.1 Subcatchments

The Moody Centre study area was modelled lot by lot with cadastral data received from the City. As a starting point, an automated nearest-node process was used to assign each lot subcatchment to a storm network node based on their proximity. If it was found that the nearest-node connection was incorrect (i.e. subcatchments connected to node upslope) they were reconnected to an appropriate downslope node. In total, the model includes 168 ha of cadastral lot subcatchments and 44 ha of right-of-way subcatchments that are delineated around manholes. Subcatchments were assigned the following attributes:

- slopes, using 2012 DEM information;
- groundwater parameters, based on surficial geology mapping (Geological Survey of Canada, 1976);
- infiltration parameters and initial abstraction parameters based on known soil types, land use, and consistent with calibrated models KWL created for other municipalities within Metro Vancouver;
- existing land use impervious area, using 2012 orthophoto received from the City; and
- future land use impervious area, using a combination of the City's OCP, development permit, and consultation information.

Un-serviced Lots

Un-serviced lots in the existing conditions model were not connected to the storm sewer directly. Any runoff from impervious areas was directed to pervious areas and runoff in excess of the infiltration rate of these pervious areas was connected to the nearest catch basin or manhole downhill.

In the future conditions model, a conceptual future storm sewer was added along the un-serviced lots and connected to existing storm sewers. The new pipes were assumed to follow the direction of the road slopes. The un-serviced lots were connected to these new pipes.

The City provided drawings for the current development permits in Moody Centre. These development permits were reviewed and any proposed pipes and incorporated into the future conditions model.

[2] Associated Engineering, May 2016. *"Chines Integrated Stormwater Management Plan"*.

2.2 Total Impervious Area

For the existing condition, a range of Total Impervious Area (TIA) values for each land use type was determined using 2012 orthophotos received from the City. For the future land use conditions, typical TIA values were proposed to reflect the anticipated future land use conditions outlined in the 2014 OCP. Table 1 summarizes the range of existing impervious percentages and proposed future impervious values.

Table 1: Total Impervious Area (TIA) Assumptions

OCP Future Land Use	Estimated Existing TIA %	Design Criteria TIA %[1]	Proposed Future TIA %[2]
General Industrial	60 – 90	90	90
Mixed Employment	81 – 95	78	90
Mixed Use – Moody Centre	60 – 100	78	90
Moody Centre Transit Oriented	95 – 100	N/A	95
Multi-Family Residential	50 – 90	65	80
Oceanfront District	90	N/A	80
Neighbourhood Park and Open Space	0 – 60	5 – 20	No change
Public and Institutional	60 – 75	90	85
Single-Family Low Density	40 – 75	40	65
Single-Family Low Density DADU[3]	40 – 75	N/A	80

1. As per Table 5.1 of Schedule C of the City of Port Moody “Subdivision and Development Servicing Bylaw, 2010”
2. Minimum TIA value. Higher TIAs, matching the Existing Land Use values, used where existing land use TIA is higher.
3. As per layouts provided in “A Guide to Detached Accessory Dwelling Units in port Moody” (City of Port Moody)

Assumptions were made for the future conditions land use based on the OCP as well as in coordination with City staff:

- **Single-Family Low Density**: impervious percentage was determined based on lot size as per the layouts in the Guide to Detached Accessary Dwelling Units (DADU) document provided by the City. Even though the DADU document recommends permeable driveways, this study conservatively assumes impermeable driveway areas due to lack of enforcement by the City.
- **Single-Family Low Density Laneway**: Redevelopment guidelines for single-family will allow laneway homes, which are anticipated to have a higher lot impervious area due to layout and use.
- **Ocean Front District**: based on park and setback coverage information from the Ocean Front Concept Plan.
- **Park and Open Space**: The parks and open spaces are scattered through the City and include some escarpment areas. Existing impervious areas were representative of the future condition; inner-city parks had a higher imperviousness to account for anticipated use (parking lots, courts, pools, etc.) and the park areas along the ocean and the escarpment were generally lower TIA.
- **Public and Institutional**: an 85% TIA was conservatively assumed for all the public and institutional land use types.

In all cases, if the existing impervious cover for a parcel was higher than the proposed future impervious percentage, the existing impervious percentage was carried forward into the future scenario. Table 2 summarizes study area land use and impervious area in existing and future conditions with the above conditions applied.

Table 2: Summary of Land Use

OCP Land Use	Area (ha)	% of Total Area	Existing Impervious Area (ha)	Future Impervious Area (ha)	Increase in Impervious Area (ha)
General Industrial	8.3	3.9%	6.6	7.5	0.9
Mixed Employment	6.8	3.2%	5.9	6.2	0.3
Mixed Use - Moody Centre	27.6	13.0%	21.3	25.3	4.0
Moody Centre Transit Oriented Development	7.9	3.7%	7.5	7.7	0.2
Multi-Family Residential	26.7	12.5%	15.3	21.9	6.6
Oceanfront District	11.0	5.2%	9.8	9.8	0.0
Parks and Open Space	50.3	23.6%	9.3	9.6	0.3
Public and Institutional	15.1	7.1%	8.5	12.9	4.4
Single Family Low Density	28.4	13.4%	19.2	22.1	2.9
Special Study Area	2.1	1.0%	1.8	1.8	0.0
Other/Not Identified	28.7	13.5%	10.5	13.9	3.3
Total	**212.9**	**100.0%**	**115.7**	**138.7**	**23.0**

Overall, the Moody Centre study area has an existing TIA of 54% and is assumed to increase to 65% once built-out to the OCP land use.

2.3 Hydraulic Network

The Moody Centre hydraulic model includes manholes, City of Port Moody storm sewers, GVSDD trunk sewers, culvert crossings, natural streams, and outfalls. Trunk sewer, natural streams, and outfalls were obtained from the Chines Integrated Stormwater Management Plan (ISMP) model (AE, 2016). Data on the City-owned storm sewers were obtained from the City's GIS database, supplemented with field survey. Where new developments are completed or on-going, such as the Skytrain Corridor and Gatensbury Street upgrade, the GIS database received from the City was updated using record drawings; approximately 40 manhole inverts and pipe inverts were updated from drawings. In addition, KWL updated the Moody Centre storm sewer database with survey data of 49 manholes and 27 inlet structures along open channels. The Moody Centre storm sewer data and the Chines ISMP trunk network were merged in the model and new FID labels were assigned to all the storm sewers to coincide with the City's GIS database. The hydraulic network is shown in Figure 1.

In the future conditions model, the storm sewer network was extended to cover the un-serviced areas that were noted in the background review phase. The extended storm sewer network pipes were assumed to have a 0.5% slope for conceptual level pipe sizing purposes.

Boundary Conditions

In this study, the model has been developed for the purpose of assessing storm sewer conveyance capacity of the City of Port Moody infrastructure only. To assess only the Port Moody system, it is assumed that the GVSDD trunk sewers will have capacity to convey the 100-year flow without surcharging and outfalls into the ocean are unconstrained by tides. This avoids backwater effects in the pipes which tend to reduce peak flows generated in the model, thereby simulating maximum flow peaks for more conservative capacity assessment.

2.4 Minor and Major Drainage System

The stormwater drainage system was categorized into two groups:

- The **minor system**: consists of storm sewers that are within local road rights-of-way. The minor system is assessed using the 10-year event.
- The **major system**: consists of storm sewers that are within arterial road rights-of-way (which should not flood during a major rain event), creeks, culverts, and storm sewers with no safe overland flow paths (e.g., storm sewers through private property). The major system is assessed using the 100-year event.

Figure 1 shows the major and minor drainage system.

2.5 Model Scenarios

The 10- & 100-year design events were used in three modelling scenarios to assess storm sewer capacity in the identified major and minor systems. The three scenarios are as follows:

Existing land use condition

- To assess the existing storm sewer capacity under the current land use conditions and estimated rainfall from historical data.

Future land use condition

- To assess the existing storm sewer capacity under future OCP land use conditions and with the impacts of climate change applied to the 10- and 100-year design storms.

Future land use condition with LIDs

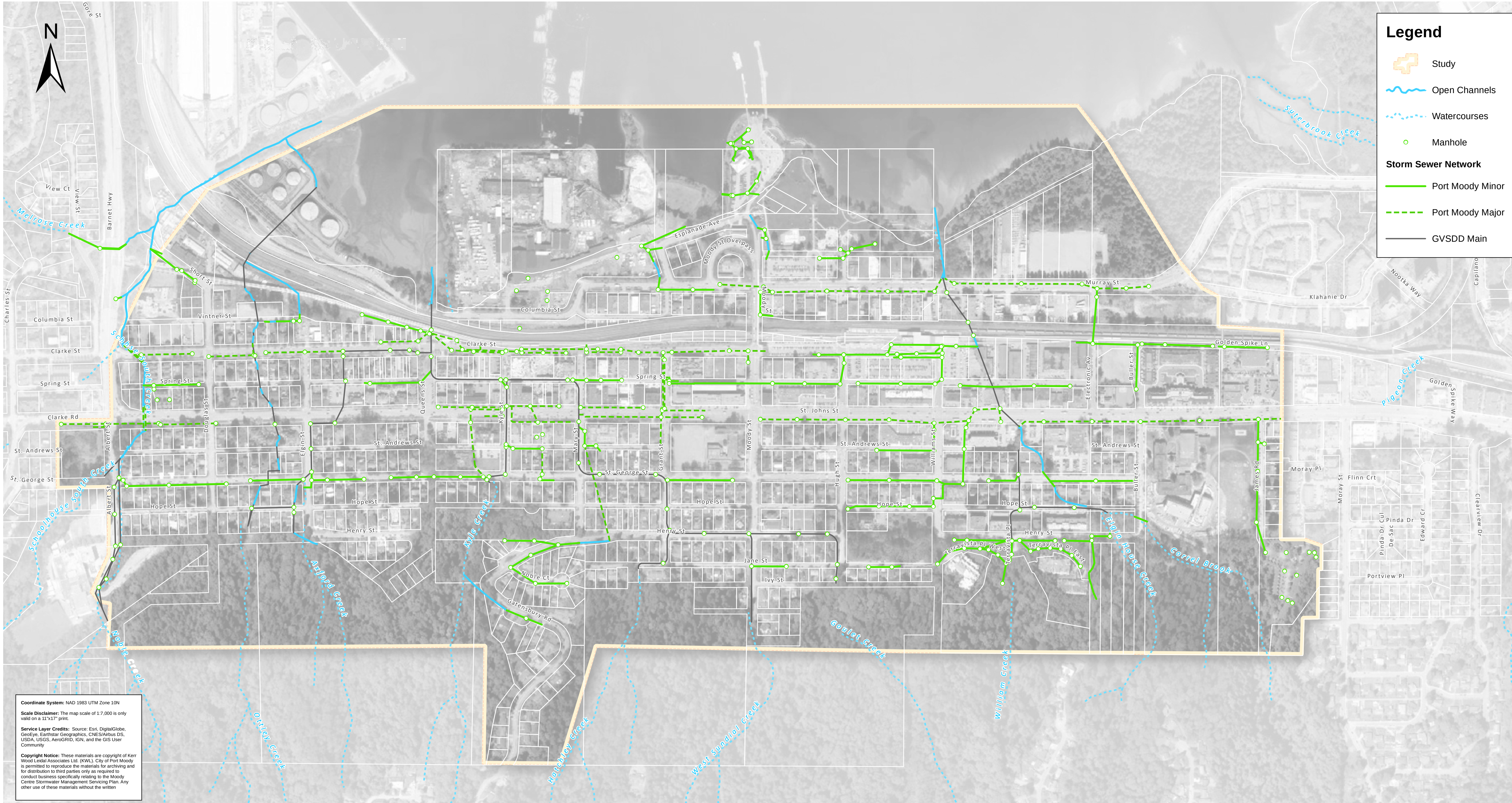
- To assess the effect of proposed LID strategies on storm sewer capacity with the impacts of climate change applied to the 10- and 100-year design storms. LIDs applied based on future OCP land use type.

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo2\310055_Fig1_MinorMajorDainage.mxd Date Saved: 2019-05-08 1:53:12 PM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date October 2019

Scale 1:7,000

100 50 0 100 m

Major and Minor Storm Sewers

Figure 1

Model Validation

In absence of flow data for model calibration, model validation was conducted to check the design flows against KWL's database of calibrated model design flows. A calibrated model developed in the Wagg watershed within the District of North Vancouver was used to validate runoff in the Moody Centre model. The Wagg catchment has a similar physiography as the Moody Centre catchment and has a similar 1-hour rainfall intensity at 43 mm/hr compared to the Moody Centre intensity of 39 mm/hr. A representative catchment unit flow was taken from the Wagg Creek model and compared to a unit flow from an equivalent area with similar properties in the Moody Centre model. In addition, a catchment from the overall; Chines watershed was included for comparison. The comparison is shown in Table 4.

Table 3: Unit Flow Comparison

	Wagg	Moody Centre	Chines
Area (ha)	4.58	4.76	4.66
Impervious %	57	56	54
Peak Rainfall Intensity (mm/hr)	43.8	39.7	39.7
Flow (m^3/s)	0.414	0.372	0.342
Unit Flow ($m^3/s/ha$)	**0.090**	**0.078**	**0.073**

The unit flow in Table 4 shows that the Moody Centre model is estimating flows within an acceptable range of a calibrated model with similar inputs and physiography.

2.6 Low Impact Development (LID) Measures

To assess the effect of LID mitigation measures on the stormwater drainage system, LID practices were incorporated into a copy of the future conditions model. The intent of incorporating LID practices into the model is to understand the benefits of best management practices incorporated into redeveloped areas on the model runoff. The LID practices are applied in the future conditions model in accordance with the assumption that all parcels will redevelop with the proposed LID measures.

Specific LID practices and level of application were assumed for each land use to represent a reasonable level of uptake for LID in redevelopment conditions given current development processes and policies. The model parameters were modified to simulate the mitigation effects of the selected LIDs on flow volumes and peaks and compare the resulting flows to the existing conditions model results. At this level of LID implementation, there were no on-lot detention facilities assumed.

A summary of the land use types and assumed LID measures is shown in Table 5.

Table 4: LID Measures Applied in Model

OCP Land Use Type	Assumed LID Measures
Single Family Residential	Absorbent landscape
Multi-Family Residential	Absorbent landscape
Mixed Use – Moody Centre Mixed Employment Moody Centre Transit Oriented Development	Absorbent landscape 25% Extensive Green Roof Coverage
General Industrial	None
Oceanfront District	None
Public & Institutional	Absorbent landscape
Parks and Open Space	None
Right of Way (ROW)	Absorbent landscape

In general, the LID best management practices (BMPs) applied are the use of absorbent landscape (with impervious area run-on) and green roofs, where appropriate, as indicated in Table 5. For single family residential land uses, the application of absorbent landscaping is assumed to meet the standard of Metro Vancouver's Region-Wide Baseline for On-Site Stormwater Management (capture 40% of the 2-year 24-hour storm). For all other land uses, the LIDs are sized to capture the 72% of the 2-year 24-hour design storm.

A single catchment model was created for each land use type listed above using the LID Module in PCSWMM. Given the current limitations of efficient application of the LID Module in PCSWMM given the 1173 catchments in the entire study area, a simplified model was created and calibrated to mimic the results of the LID module model. Instead of applying LIDs, interception, redirection, infiltration, and groundwater parameters were adjusted until the simplified model rainfall response matched that of the model using the LID Module.

Absorbent landscape is assumed on all Single-Family Residential land use as the primary BMP, where the small lot area and lower impervious cover allows for redirection of impervious area to pervious area as a practical and effective approach. In addition, rooftop disconnection for these lots is reasonable and achievable.

The Multi-Family Residential and Public and Institutional land uses utilized the same methodology, where absorbent landscape was assumed as the primary BMP. Application of absorbent landscape is achievable in the form of either enhanced topsoil coverage or tree box planters in landscaped areas. A portion of the impervious area is routed to the absorbent landscape (approximately at a 2:1 impervious to pervious area ratio) to help achieve volumetric capture for small storm events.

Mixed Use, Mixed Employment, and Transit Oriented Development land use types had absorbent landscaping and green roof LIDs applied. A portion of the impervious area is routed to the absorbent landscape (approximately at a 2:1 ratio). The installation of green roofs on each of these land use classifications was also deemed realistic based on anticipated development types. The green roof was assumed to cover 25% of the total building footprint (assumed to make up approximately 80% of the total lot impervious area). An extensive green roof was assumed as it is the most typical implementation.

All rights-of-way in the study area were assumed to remain unchanged from their existing condition with no LID measures applied with the exception of an enhanced streetscape in the Transit Oriented Development area. The enhanced streetscape was assumed for St. John's Street from Moody Street to Electronic Avenue. With the ROW TIA at 85%, the remaining 15% pervious area was assumed to be tree-planters or absorbent landscape. A portion of the impervious area along the ROW (approximately equal to the pervious area) was assumed to drain to the absorbent landscape/planters to provide an opportunity for additional volumetric capture. As per discussions with the City, rain gardens and soil cells are desirable on ROWs as BMPs. The rain gardens and soil cells will be incorporated for water quality purposes only and therefore were not included in the model as they provide minimal impact from a quantity perspective.

The General Industrial lands identified in the OCP are not anticipated to see any major redevelopment and therefore no LIDs were applied to that land use.

The Oceanfront District drains directly to the Burrard Inlet and does not discharge to any of the City's infrastructure. BMPs to improve water quality are recommended for this area but as they would not affect downstream infrastructure or creeks they were not modelled.

The areas classified as Parks and Open Space land use are predominantly areas within the escarpment or draining directly to Burrard Inlet. In future conditions these areas are not anticipated to increase in impervious cover from existing land use, therefore, BMPs were not applied in these areas.

Limitations of LID Application

The intent of the LID scenario proposed is to represent a reasonable application of BMPs and their effects on the drainage system. The effects of the LID were incorporated into the model based on available pervious areas and potential opportunities for the installation of green roofs in appropriate land uses. No detention facilities are assumed in the future mitigated scenario.

In the absence of on-lot detention, LID practices generally do not significantly mitigate the increased peak flows during minor and major design storm events. The benefits of LID are most prominent in frequent, low-intensity storms. LID practices also provide water quality benefits which are not simulated within the model. It is intended that the targets proposed for this area (presented in Technical Memorandum #1) are met on a watershed scale or for the overall study area. In some cases, the individual lots or developments may not fully meet the targets, while in other cases they may exceed the targets. Overall however, the volume reduction and water quality targets are to be met.

3. Storm Sewer Capacity Assessment

Minor System Conditions

The minor drainage system was assessed based on its ability to convey the minor flow estimated in the model from the 10-year return period design event. The following three criteria were used to determine whether each minor storm sewer is undersized:

- modelled instantaneous peak flow is larger than pipe capacity under unconstrained conditions,
- pipe surcharging occurs longer than 15 minutes, and
- surcharging higher than 0.3 m above the crown of a pipe.

It should be noted that in the event that a downstream undersized pipe is causing backwater effects or flow restrictions to upstream infrastructure, the upstream infrastructure is not flagged as undersized unless it meets the above three criteria.

Major System Conditions

The major system is the conveyance system that carries large storms up to the 100-year event. The Background Review Phase has identified 5.4 km of storm sewer that qualifies as part of the major system. The same criterion as the minor system was used to determine whether each major system pipe is flagged as undersized.

The surcharging threshold in the above criteria was incorporated in the assessment to avoid flagging pipes that are likely adequate for the design flow with only minor surcharging. It also eliminates small model instabilities reporting a false high peak flow as a reason for flagging a pipe.

3.1 Capacity Assessment

Table 6 summarizes the details of the hydrotechnical assessment of the City's storm system. Under the existing conditions, 3.7 km of storm sewer (major + minor) was identified as undersized and an additional 0.93 km of storm sewers do not meet the criteria in the future conditions model. Under a future conditions scenario with LIDs applied, there is a reduction of 0.29 km of undersized storm sewer when compared to the future condition without LIDs. Figure 2 to Figure 5 highlight the storm sewers undersized in red.

Due to timing of flow peaks and interception of catchment runoff in previously un-serviced areas, there are conduits in the future conditions model that experience less runoff than in the existing conditions model. Addition of storm sewer servicing in un-serviced residential areas results in a reduction of flow in downslope pipes. This effect can be seen by comparing the results in Figure 2 with Figure 3 and the results in Figure 4 compared to Figure 5.

Table 6 summarizes the lengths of pipes that do not meet the criteria.

3.2 100-Year Drainage System Assessment

An overland flow pathway evaluation was completed to evaluate the performance of the storm system in Moody Centre during the 100-year (with climate change) storm event with future OCP land use conditions. To assess the 100-year drainage system, two additional model scenarios were completed:

1. **Model scenario #1**: The 1-D hydraulic model was updated to simulate the 100-year storm in the existing storm sewers and the proposed new storm sewers in the un-serviced areas. All of the storm sewers (under local, collector and arterial roads) were sized to accommodate the 100-year storm with HGL in pipe.
2. **Model scenario #2:** Existing contour mapping of the Moody Centre area was used to identify overland flow pathways and drainage sinks. A dual-drainage model was used to simulate the existing and proposed storm sewer and overland flow path system within the roadway. Storm sewers under the local and collector roads were sized to accommodate the 100-year storm with HGL in pipe. Storm sewers under the arterial roads remained at existing sizes and mapping of overland flooding and pathways was prepared for the arterial road and downstream areas.

Dual-Drainage Overland Flow Assessment

A dual drainage model was created to represent the cross-sections of the roadways and to evaluate the capacity of the arterial roads to convey the flow above the capacity of the existing storm sewer network. Dual-drainage was included on the major arterial roads in the study area: St. Johns Street, Murray Street, and Clarke Street. The cross-sections were based on known roadway slopes and widths, and typical road cross sections. A free outfall condition was assumed into the downstream GVSDD infrastructure.

The results of the assessment indicated that the roadways had capacity to convey the 100-year future OCP land use conditions (with climate change) without overtopping the curb in the case where the inlets into the major storm system pipes (GVSSDD storm sewers in these areas) were assumed to be unrestricted (i.e. catch basins have adequate capacity to intercept the overland flows). However, to evaluate a scenario where this was not the case, overland flow pathways were mapped based on known contours to determine locations where overland flow may occur if catch basin do not have adequate capacity or are plugged by debris. Figure 6-1 provides the overall map for the study area and Figures 6-2 and 6-3 show the details of the contours and flow pathways for the west and east areas of Moody Centre, respectively.

As shown in Figures 6-1, 6-2, and 6-3, a majority of the overland flows follow road ROWs. However, one of the overland flows cuts through private property (based on the contours) in the 3000 block of St. Johns Street. This is the area of highest concern where the inlet capacity of catch basins should be estimated in detail, and if found to be insufficient, additional catch basins added.

Table 5: Summary of Undersized Storm Sewers

				Existing Land Use Summary				Future Land Use with Climate Change				Future Land Use with LIDs Summary			
				100-yr Major System		10-yr Minor System		100-yr Major System		10-yr Minor System		100-yr Major System		10-yr Minor System	
		Total Length (m)	% of Total System	Length Undersized (m)	% of Total System Undersized	Length Undersized (m)	% of Total System Undersized	Length Undersized (m)	% of Total System Undersized	Length Undersized (m)	% of Total System Undersized	Length Undersized (m)	% of Total System Undersized	Length Undersized (m)	% of Total System Undersized
Pipe Size (mm)	< 200	673	5.4%	43	0.3%	130	1.0%	46	0.4%	157	1.3%	46	0.4%	157	1.3%
	200	813	6.5%	141	1.1%	173	1.4%	141	1.1%	321	2.6%	141	1.1%	321	2.6%
	250	3934	31.6%	569	4.6%	369	3.0%	695	5.6%	636	5.1%	680	5.5%	550	4.4%
	300	2085	16.7%	473	3.8%	416	3.3%	473	3.8%	447	3.6%	473	3.8%	447	3.6%
	375	726	5.8%	193	1.6%	0	0.0%	275	2.2%	26	0.2%	275	2.2%	11	0.1%
	450	2190	17.6%	690	5.5%	214	1.7%	775	6.2%	347	2.8%	690	5.5%	263	2.1%
	525	119	1.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	600	688	5.5%	315	2.5%	0	0.0%	315	2.5%	0	0.0%	315	2.5%	0	0.0%
	> 750	1224	9.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Total	**12453**	**100.0%**	**2423**	**19.5%**	**1302**	**10.5%**	**2720**	**21.8%**	**1934**	**15.5%**	**2620**	**21.0%**	**1749**	**14.0%**

1) Future scenarios includes assumed servicing extensions into single family residential areas without existing service. This causes some pipe flow in single family residential areas to decrease from existing to future scenarios.

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo2\310055_Fig2_MinorExisting.mxd Date Saved: 2019-05-10 11:30:10 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers

Project No. 310-055

Date May 2019

Scale 1:7,000

100 50 0 100 m

Existing Conditions Capacity Assessment (10-year Design Storm)

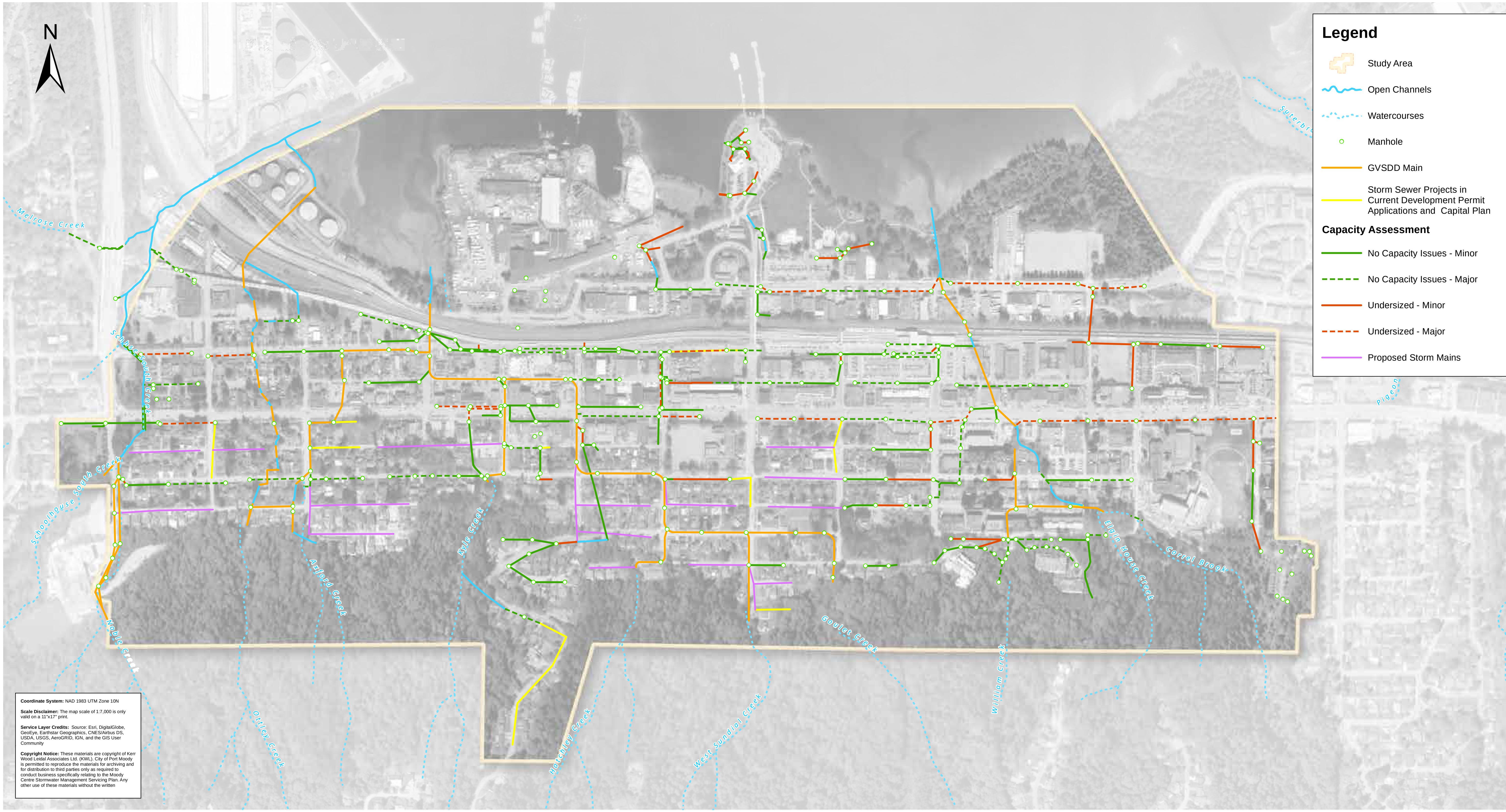
Figure 2

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo2\310055_Fig3_MinorFuture-rev1.mxd Date Saved: 2019-09-03 10:50:58 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Project No. 310-055

Date September 2019

Scale 1:7,000

100 50 0 100 m

Future Conditions Capacity Assessment (10-year Design Storm with Climate Change)

Figure 3

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo2\310055_Fig4_MajorExisting.mxd Date Saved: 2019-05-10 11:36:43 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers

Project No. 310-055

Date May 2019

Scale 1:7,000

100 50 0 100 m

Existing Conditions Capacity Assessment (100-year Design Storm)

Figure 4

City of Port Moody
Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL
consulting engineers

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055
Date September 2019
Scale 1:7,000

100 50 0 100 m

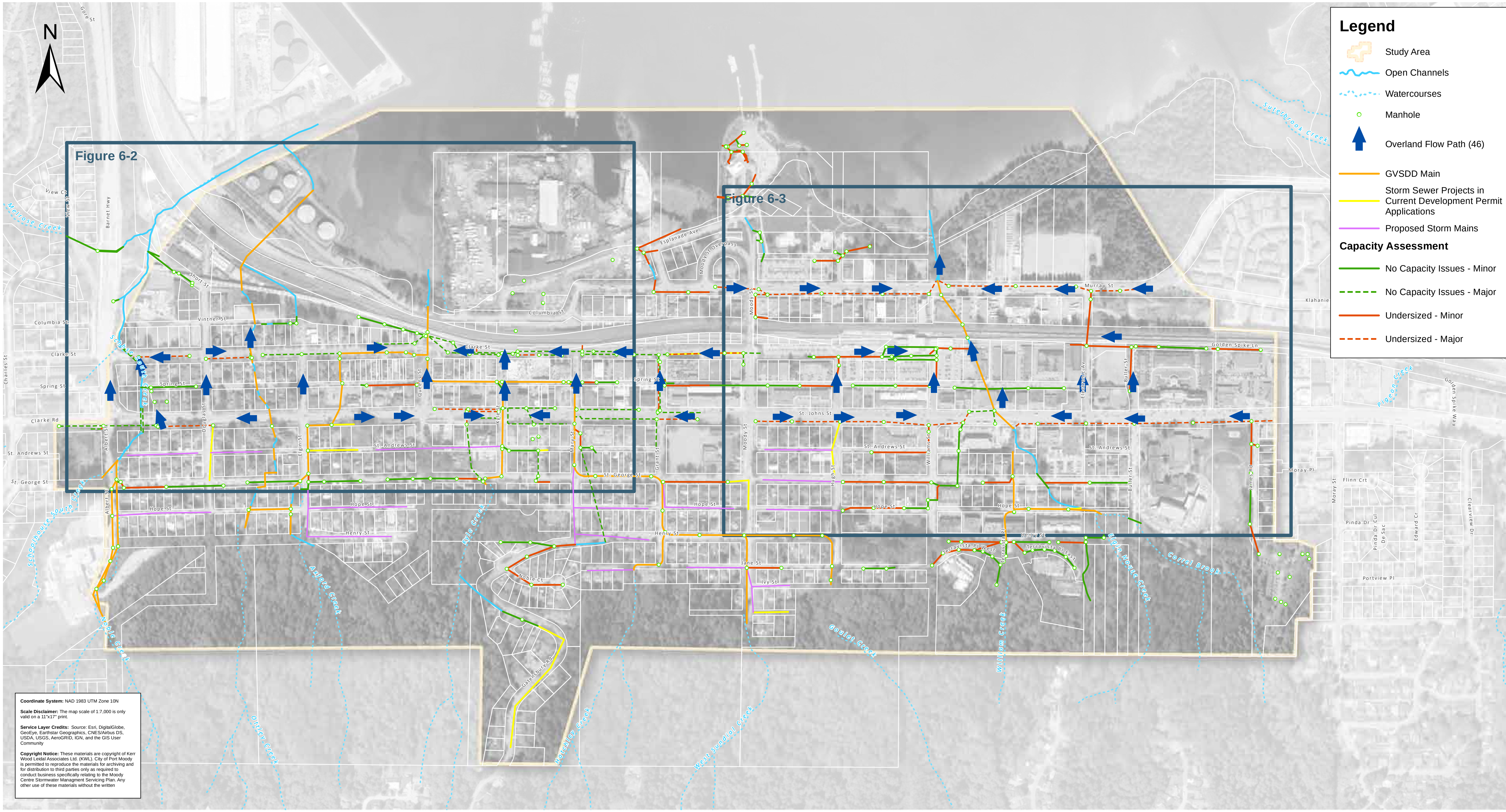
Future Conditions Capacity Assessment (100-year Design Storm with Climate Change)

Figure 5

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo2\310055_Fig6-1_FutureConditions.mxd Date Saved: 2019-05-29 9:21:04 AM | Author: GOConnell

City of Port Moody
Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Project No.	310-055
Date	May 2019
Scale	1:7,000

100 50 0 100 m

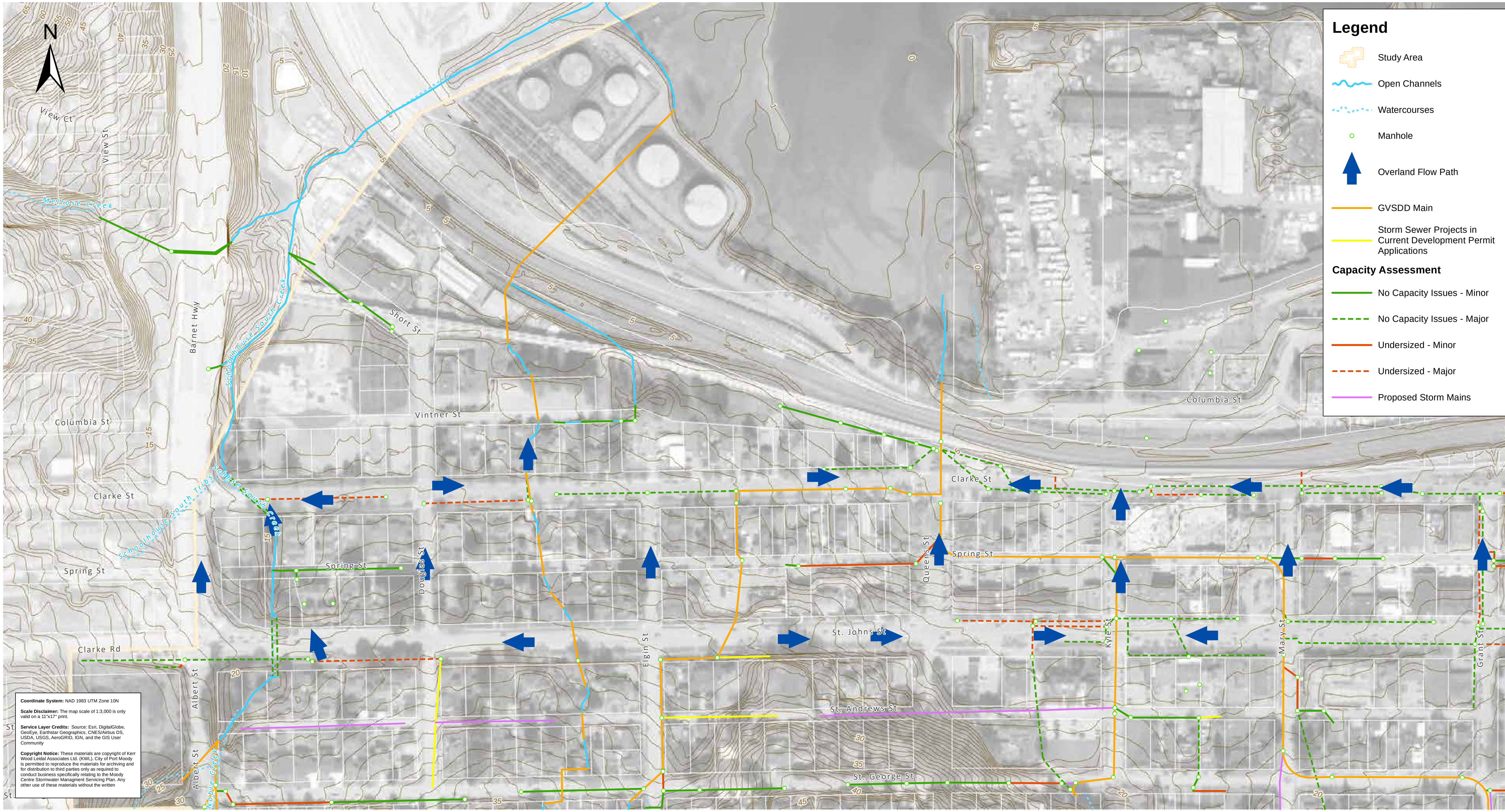
Future Conditions Capacity Assessment (100-year Design Storm with Climate Change) and Overland Flow Path

Figure 6-1

City of Port Moody

Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Project No. 310-055

Date May 2019

Scale 1:3,000

50 25 0 50 m

Future Conditions Capacity Assessment (100-year Design Storm with Climate Change) and Overland Flow Path

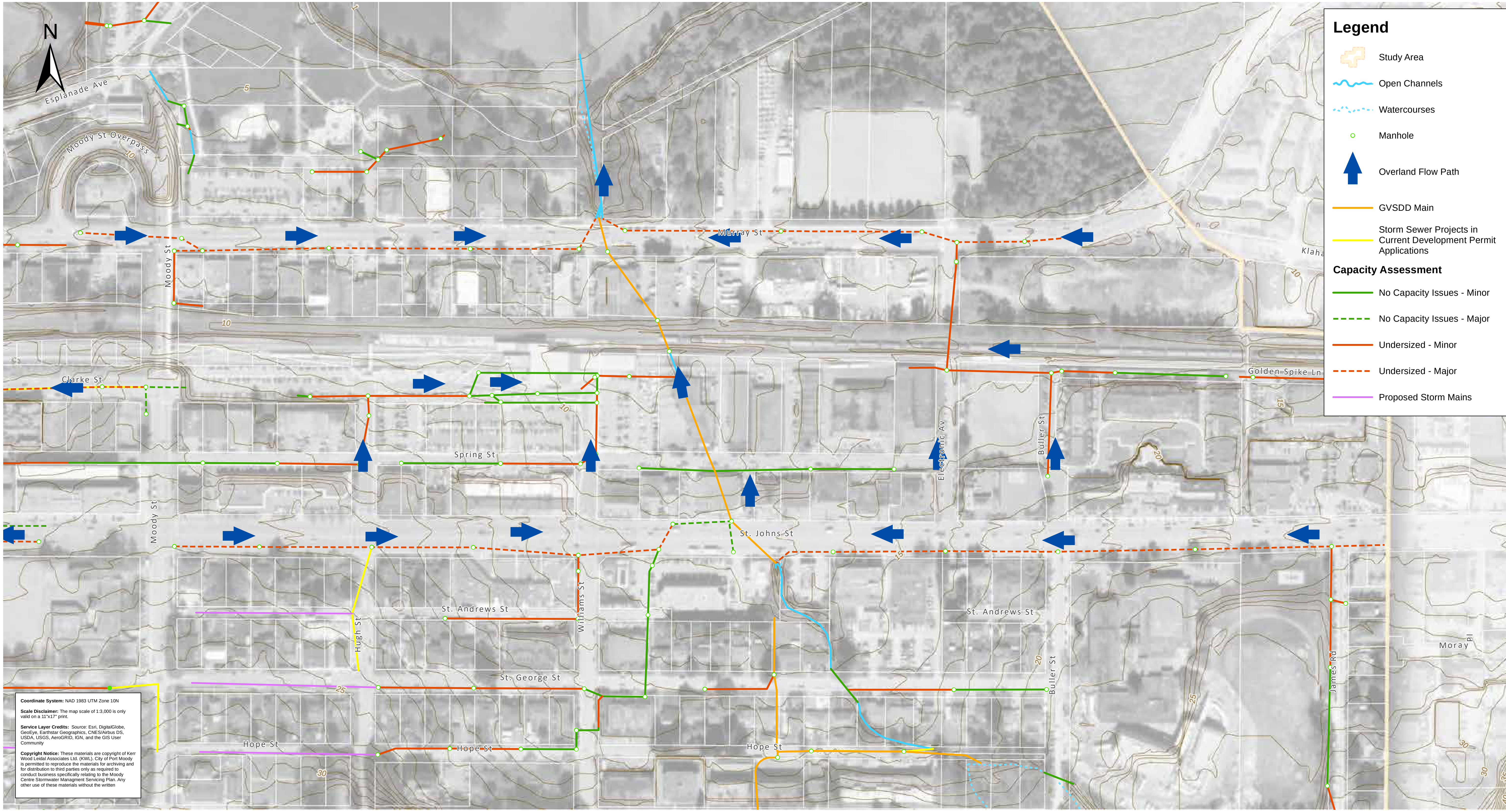
Figure 6-2

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo2\310055_Fig6-2_6-3_FutureConditions_Section.mxd Date Saved: 2019-05-29 9:21:48 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Managment Servicing Plan

KERR WOOD LEIDAL
consulting engineers



Project No. 310-055

Date May 2019

Scale 1:3,000

50 25 0 50 m

Future Conditions Capacity Assessment (100-year Design Storm with Climate Change) and Overland Flow Path

Figure 6-3

3.3 Mitigated Future Conditions Assessment

A mitigated future conditions scenario was developed by simulating effects of LID measures applied to the parcels in the study area. Low impact development measures were applied to each land use as described in Section 2.6. The proposed LIDs are intended to capture, at a minimum, the increased runoff volume from the 6-month 24-hour storm as a result of the increased impervious areas in future conditions. The effect of the LIDs was quantified by the percentage reduction in peak flow and runoff volume. The future condition model with LID measures was run with 6-month 24-hour, 10- and 100-year design rainfall with climate change. The study area has seven outlet points which were used to quantify the total runoff volume and the mitigated future scenario was compared to the unmitigated future scenario.

LID Effects on Pipe Capacities

LIDs provide the most benefit to high-frequency, low return period events. In the absence of on-lot detention and given the likely wet antecedent moisture conditions during the minor and major design events, it is not anticipated that the proposed LIDs would have a significant impact on the peak flows for the 10- and 100-year design storms. The conveyance capacity of the storm system (as discussed in Section 3.1) was reassessed using the future condition with LID model 10-year and 100-year peak flows. The results indicated that the addition of the LID measures had limited benefit of reducing peak flows used for sizing the drainage system. As summarized in Table 6, above, the addition of LIDs would result in the percentage of the minor system undersized sewers decreasing from 15.5% to 14.0%, and a reduction in the major system from 21.8 to 21.0%

LID Effects on Volume Reduction

The effects of the LIDs on the 6-month 24-hour event are summarized in Table 7 by comparing the model results with and without LIDs.

Table 6: LID Effects During 6-Month 24-Hour Storm

	Future Conditions	Future Conditions with LID
Study Area (ha)	212.88	212.88
Total Impervious Area (%)	65%	65%
Rainfall Volume (m^3)	153,120	153,120
Runoff Volume (m^3)	86,610	71,900
Capture Volume (m^3)[1]	66,514	81,220
Increase in Capture Volume (m^3)[2]	-	9,390
Target Capture Volume (m^3)[3]	-	2,203
Effective Impervious Area (%)	57%	47%

1. Capture volume refers to the volume retained in the landscape and LIDs.
2. Increase in capture volume as a result of LIDs
3. Target capture is calculated as a percentage of the runoff from the total impervious areas on single family residential areas (40% of 2-year 24-hour runoff) and additional impervious areas all other land use areas (72% of 2-year 24-hour = 6-month 24-hour runoff).

The purpose of the target capture volume is to mitigate the increase in runoff volume as a result of the increase in impervious area in future conditions. The target capture for the study area is based on providing volumetric capture of 40% of the 2-year 24-hour storm volume for single-family residential total impervious area and 72% of the 2-year 24-hour storm volume for all other land uses for the increased imperviousness on the lot. With these capture targets, it is expected that the future mitigated watershed Effective Impervious Area (EIA) would be approximately 47%.

The LIDs modelled for Moody Centre were chosen based on reasonable uptake in the study area. The modelled LID measures were summarized in Table 5 in Section 2.6. These measures were implemented based on available space and not sized for individual lots to capture the target amount. As a result, in many cases the single-family residential lots exceed their target capture and the remaining land uses do not reach their target capture. However, the proposed future LID conditions scenario results in the target capture being surpassed on the whole of the study area, yielding an EIA of 47% (based on the 6-month 24-hour design storm simulation).

The 6-month 24-hour storm is assumed to be representative of approximately 90% of the average annual rainfall volume and can, therefore, be used as a metric to demonstrate the impacts of LIDs on the average annual runoff volume. The following section summarizes the continuous simulation modelling to quantify and confirm the LID effects on an average annual basis.

3.4 Continuous Simulation Results

The results presented above, assessed the LID performance during the 6-month 24-hour design storm under current IDF parameters and future (climate change) IDF parameters. Low impact development practices were proposed for some land uses within the study area. LID practices aimed at reducing runoff during small storm events provide minimal benefit for volume and peak flow reduction during wet initial condition design storms. Continuous simulation is required to determine the performance of the LIDs on a yearly basis.

Model Set-up

To assess the system performance, precipitation and climatology data from 2010 was summarized to be input into the model. The year 2010 represents an average year of precipitation (1743 mm) based on the period of 1994 to 2017. Climatology data was downloaded from the NASA online climate tool[3] (wind speed, relative humidity, ambient temperature, and radiation) and used to calculate evapotranspiration for the study area. An input file was created for the PCSWMM simulation which included precipitation (PT11 rain gauge) and evaporation.

Model Scenarios

Existing land use condition

The existing land use condition was simulated to provide a base comparison scenario and demonstrate how the Moody Centre stormwater management system is performing in its current state.

[3] NASA POWER (Prediction of Worldwide Energy Resources) https://power.larc.nasa.gov/#page-top

Future land use condition

The future land use condition scenario was simulated to demonstrate the system behaviour with the OCP land use cover changes, and the new servicing layout implemented.

Future land use condition with LIDs

The future conditions model with low impact development practices was simulated with the continuous rainfall data set. The future conditions with LID model utilizes the same parameters as the future conditions scenario however it incorporates the low impact development practices proposed in Section 2.6. These practices include absorbent landscape, disconnection of impervious areas, and green roofs.

Model Results

The three model scenarios were run with the same climate and precipitation data set. Results were analyzed based on overall system performance including rainfall, runoff, infiltration loss, evaporation loss, and system storage. The ability of proposed LIDs to reduce the effective impervious area (EIA) of the study area was assessed for each scenario. Table 8 summarizes the results of the continuous modelling: The results are summarized in volume and depth for the study area, which has a total area of 212.88 ha.

Table 7: Continuous Simulation Model Results

Monthly Summary	Existing Conditions Runoff Volume (mm)	Future Conditions Runoff Volume (mm)	Future Conditions with LIDs Runoff Volume (mm)
Rainfall	1743	1743	1743
Evaporation[1]	94	111	118
Infiltration[2]	869	715	948
Runoff	802	942	688

Notes:
1. Evaporation is determined based on the surface water balance and evaporation occurring from depression storage on the impervious and pervious surfaces. This does not include evapotranspiration from the subsurface.
2. Infiltration represents the surface infiltration on pervious areas.

The continuous simulation modelling results demonstrate the impacts of the increased impervious area on the runoff and infiltration volumes. Table 9 summarizes the impact of the LIDs on the EIA for the Moody Centre watershed.

Table 8: Effective Impervious Area Summary

Model Scenario	Effective Impervious Area (EIA)
Existing conditions	46%
Future Conditions – Unmitigated	54%
Future Conditions – With LIDs	39%
Target	47%

The effective impervious area is a metric to assess the percentage of rainfall that becomes runoff (EIA = Runoff / Rainfall). In existing conditions, the study area EIA is 46%, and in the unmitigated future condition, the EIA is 54%. Implementing the LIDs into the future conditions model reduces the EIA to 39%. The target EIA is based on the based on the anticipated capture target capture amounts for each of the land use types as summarized in Appendix A. The continuous simulation results show that the LIDs implemented significantly reduce the watershed EIA, below both existing and mitigated future target levels.

A flow duration comparison was also completed for the three modelling scenarios. Figure 7 summarizes the comparison between existing, future, and future with LIDs implemented for the overall Moody Centre watershed.

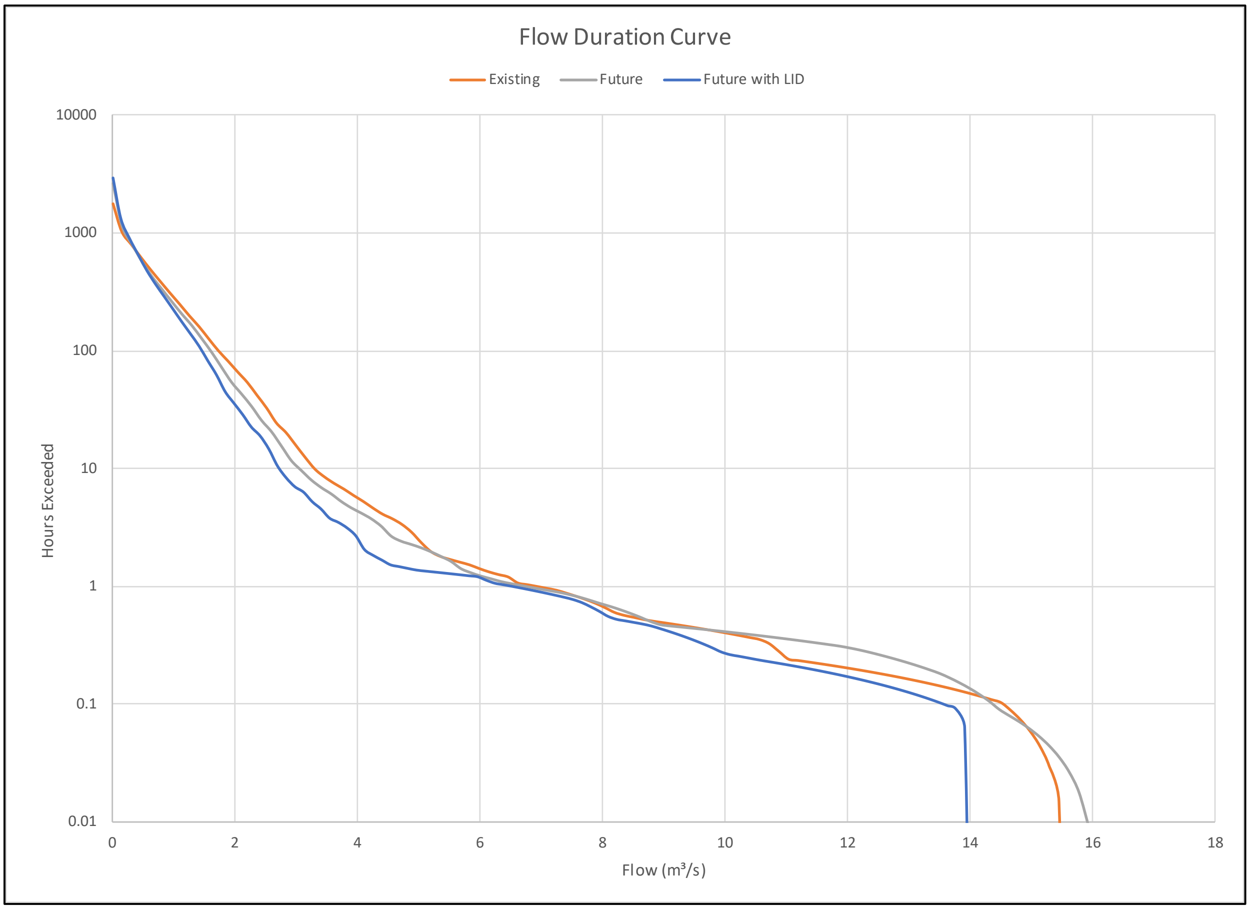


Figure 7: Flow Duration Curve Comparison

The results of the continuous simulation demonstrate the benefit of the LID implementation at reducing the EIA for the Moody Centre Study area. The impact of land use changes and increases in impervious area results in an increase in EIA for the study area. By incorporating LIDs into the Moody Centre servicing plan, the EIA can be decreased to below existing conditions. The flow duration results indicate that the future with LID scenario reduces the overall flows to below existing conditions, mitigating the impacts of land use changes.

3.5 Conclusion and Recommendations

It is estimated that approximately 30% of the Moody Centre storm sewer infrastructure is undersized. To address these conveyance deficiencies the following option can be applied to protect property and infrastructure.

1) **Upgrade pipes:** Upgrade storm sewers identified as undersized to provide the level of service recommended in the City's design criteria.

2) **Allow more surcharging and overland flows in safe areas:** This would reduce the upgrade program without significantly adversely impacting drainage in areas where a surcharged storm sewer does not negatively impact lot drainage (e.g. areas without basements and where lots are higher than the roads.

3) **Construct detention facilities upstream of undersized pipes:** Detention facilities would have a more significant effect on peak flow reduction than LIDs designed for everyday rainfall capture. The results of the capacity assessment can be used to inform the locations within the study areas where detention facilities would provide the most benefits.

4) **Provide servicing to un-serviced areas:** Currently runoff from lots without a service connection will flow by gravity over land, either following the fronting roadway where a swale or ditch is present or onto downslope properties and be intercepted by a storm sewer farther downslope. Storm sewers intercepting overland flow from unintended areas are susceptible to being flagged as undersized due to this excess tributary area. Providing storm sewer servicing to the areas/lots without servicing may eliminate the need to upgrade some of these storm sewers in the short term.

5) **Provide safe overland flow pathways:** The overland flow pathway assessment identified areas where overland flow will occur on private property. Additional analysis should be completed to identify critical locations, catch basin inlet capacities, and options for providing safe overland flow pathways.

6) **Combination of options:** A combination of the above options can be used to address all undersized conveyance system components.

Low impact development measures are useful in a future mitigated scenario to reduce the runoff volume during frequent storm events. However, they have minimal impact on the capacity issues in the minor and major drainage systems during winter design storms when the LIDs may be saturated at the start of storm. Continuous simulation shows that the proposed LIDs are able to reduce the future TIA to an EIA value lower than the existing land use EIA thereby improving watershed/creek health. The LIDs would also improve water quality.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

Bryce Whitehouse, A.Ag.
Stormwater Engineer

Caroline Charbonneau, M.A.Sc., P.Eng.
Project Engineer

Reviewed by:

David Zabil, M.A.Sc., P.Eng.
Senior Water Resources Engineer

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the intended recipient. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Copyright Notice

Revision History

Revision #	Date	Status	Revision Description	Author
0	October 3, 2019	Final	Issued as final for client	BW/CEC

OQM CERTIFIED

KERR WOOD LEIDAL
consulting engineers

Appendix C

Technical Memorandum #3 Stormwater Management and Servicing Plan

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum #3

DATE: October 3, 2019

TO: Shashi Bandara, E.I.T
City of Port Moody

CC: Stephen Judd, P.Eng.

FROM: Eva Li, P.Eng., Project Manager
Caroline Charbonneau, P.Eng., Project Engineer

RE: **MOODY CENTRE STORMWATER MANAGEMENT SERVICING PLAN**
Tech Memorandum #3 - Stormwater Management and Servicing Plan
Our File 310.055-300

1. Introduction

This technical memorandum outlines the development of City of Port Moody's (the City) Stormwater Management Servicing Plan for the Moody Centre area. The plan was developed based on four guiding principles:

1. Provide major and minor flow conveyance and safe localized overland flow paths;
2. Environmental protection of surface watercourses;
3. Surface water quality and treatment prior to infiltration; and
4. Cost efficiency.

The plan focuses on the future land use conditions outlined in the Official Community Plan (OCP). It identifies drainage improvement projects in the next 20 years with the purpose of minimizing potential flooding/surcharge in the major and minor drainage systems as well as improving stormwater quality using Low Impact Development (LID) measures. The plan considers storm sewer condition data, risk rating, and conveyance capacity results from hydrologic/hydraulic modelling.

This memorandum provides the preferred drainage options and LID measures, Class C cost estimates for upgrades, new infrastructure, repairs, and LID installations, prioritization criteria, and a 20-year phased capital plan.

2. Preferred Drainage Options

The hydraulic modelling has shown increased stormwater runoff in both peak flows and volumes due to future development and climate change. The service plan development focused on managing the full spectrum of rainfall-runoff events using the following drainage solutions:

- Volume reduction and water quality treatment for the 6-month 24-hour design storm event using source controls, such as absorbent landscape, green roofs, tree cells, and rain gardens (validated with continuous simulation that future effective impervious area (EIA) is less than existing EIA), and
- Safe conveyance of 10-year and 100-year flood flows using storm sewers, swales and overland flow routes.

KWL discussed proposed drainage options and LID measures with the City. The following measures were preferred by the City and applied to the capital plan:

- Undersized major and minor storm sewers will be upgraded to convey the design flows under the future land use condition with a climate change allowance.
- New storm sewers will be installed in the currently unserviced areas. The new storm sewers are sized to convey future land use design flows with a climate change allowance.
- Existing storm sewers that run through private properties will be abandoned and new pipes will be constructed in the right-of-way (ROW).
- Rock pits are not acceptable as an alternative for a minor servicing connection by the City. Although they are currently widely used across Moody Centre to service properties that have no storm sewer connection, future servicing is required in these areas to connect to an overflow from the existing rock pits. Future installation of rock pits will not be considered sufficient as the exclusive minor flow servicing for single-family lots, but may be used for volume reduction.
- Absorbent landscape is a preferred LID measure to receive and infiltrate runoff from impervious areas, wherever possible. Source controls such as rain gardens, and permeable pavement may be used if designed by a qualified professional to meet the 6-month 24-hour capture.
- As per the OCP (2014), the City encourages the creation and integration of green spaces via green roofs and community gardens. Green roofs are also a preferred LID option for mixed-use, mixed employment and Moody Centre Transit-oriented development land use types.
- Rain gardens are the preferred LID measure for arterial roads and collector roads. Due to space constraints on St. Johns Street, tree cells and soil cells are proposed.
- Creek daylighting to be an opportunity, consistent with locations identified by the Chines ISMP.

3. Cost Estimate for Conveyance Infrastructure

Cost estimates for conveyance infrastructure were prepared based on the results of the capacity assessment, the CCTV condition data, and the proposed LID application. The cost estimates are broken down into three separate categories:

1. Infrastructure requiring upgrades;
2. New infrastructure required for currently-unserviced lots; and
3. Infrastructure requiring immediate spot repair.

3.1 Infrastructure Upgrades

Undersized storm sewers were identified in the capacity assessment completed for Technical Memorandum #2. The results of the hydrologic modelling were used to determine the undersized infrastructure based on a variety of factors. The assessment was completed using both existing conditions (i.e., current land use and IDF rainfall parameters) and future conditions (i.e., future land use and climate change IDF parameters). The required pipe upgrade diameter was determined based on the OCP land use cover and future conditions flow (2050-2100 moderate climate change IDF parameters). Storm sewers that were identified in KWL's Drainage Infrastructure Study[1] as "to be abandoned" were removed from the cost estimate.

A Class C Cost Estimate was completed for the proposed upgrades. The estimate has been prepared based on limited site information and is based on probable and assumed conditions for the project. The estimate considers the general site requirements and conditions for upgrading. The following factors were considered in the cost estimate:

- pipe sizing, length and depth;
- manhole spacing and installation;
- roadworks (including excavation, pavement rehabilitation, and sidewalk replacement); and
- restoration and planting.

The cost estimate did not consider the following factors affecting construction:

- relocation of adjacent services (water, hydro, etc.);
- special permitting requirements (contaminated sites, etc.);
- geotechnical issues requiring special construction such as pile-supported piping, buoyancy problems or rock blasting; and
- critical market shortages of materials.

As the factors above have not been included in the cost estimates, a 68% markup was applied to all projects. A breakdown of the markup is provided as follows:

- Bonding/Insurance – 2%;
- Mobilization/Demobilization – 6%;
- Engineering – 15%;
- Contingency – 30%;
- Market factor – 10%; and
- Project management (City) – 5%.

[1] *Moody Centre Drainage Infrastructure Study, Preliminary Catchment Wide Review,* Kerr Wood Leidal (March, 2017)

The unit prices represent the best prediction of actual (2018) costs as of the date prepared, based on tendered prices from other construction projects completed this year in the proximity of the study area. Actual tendered costs will depend on market conditions, location factors, time of year, contractors' workloads, any perceived risk exposure associated with the work and unknown conditions. Surveys and more detailed assessments of the proposed upgrades should be conducted prior to design and construction.

The capacity upgrades are assumed as pipe replacement projects where a pipe is replaced one-to-one for a larger diameter pipe. The analysis does not include consideration of realignment, interconnection of parallel sewers, or diversion projects to redirect flow into existing or new storm sewers. The recommended upgrades for storm sewers that require a larger diameter as well as any sewers that need rehabilitation that cannot be solved through trenchless methods are assumed to be constructed via conventional open excavation. Grades are assumed to be unchanged from existing and should be verified at the detailed design stage for improvements that can affect the pipe diameter selection.

3.2 New Infrastructure

The City has identified currently-unserviced residential areas that will be serviced in the future. The future infrastructure layout is provided in Figure 1. Where possible, the future infrastructure has been laid out to connect to the Port Moody storm network. There are some cases where there is no reasonable solution to connect to the Port Moody system and a connection to the Metro Vancouver sewers is required. During the detailed design of the new infrastructure, it may be determined that parallel installation to the Metro Vancouver system is required.

All new infrastructure is part of the minor system and is sized for future conditions flow and OCP land use cover. The storm sewers are assumed to be installed at a depth of 1.2 m with a slope of 1%. New storm leads to connect to the adjacent properties were also considered. The cost estimate took into consideration earthworks (excavation volume), roadworks, and restoration planting. Only restoration and planting within the ROW was included in the cost estimate if the ROW had existing boulevards and sidewalks, such as the new infrastructure proposed in St. George Street. The same allowances (i.e., bonding/insurance, contingency) that were applied to the upgrades were also applied to the new infrastructure costs.

3.3 Infrastructure Repairs

The City has an on-going CCTV program to inspect storm sewer conditions throughout the City. The CCTV inspection reports provided quantities of defects, and structural and Operation & Maintenance (O&M) grade information.

The major findings from the condition data indicate that there are either minor pipe defects (i.e., joint displacements) which would be considered operation and maintenance repairs or major defects (i.e., break or collapse) which would result in a high priority repair and replacement. In either case, the rehabilitation would be done without replacing the entire pipe using trenchless methods wherever possible.

A cost estimate was completed for the repairs identified as high priority repairs (pipe condition rating of 4 and 5) that would occur within the 20-year capital planning timeframe. These repairs are assumed to be single day repairs and take into consideration increased traffic management requirements, crew personnel, and elevated rates for equipment and material. The mark-up allowances applied to the infrastructure repair projects include mobilization/demobilization (6%), bonding and insurance (2%), a market factor (10%), and project management by the City (5%).

3.4 Cost Estimate Summary for Conveyance Infrastructure

Table 1 provides a summary of the overall cost estimates for conveyance infrastructure, including existing infrastructure upgrades, proposed new infrastructure and repairs. Detailed costs associated with individual pipe segments for the capital upgrades, new infrastructure, and repairs are detailed in Section 5.

Table 1: Cost Estimate Summary for Conveyance Infrastructure

Items	Upgraded Infrastructure	Proposed New Servicing	Proposed Repairs
Number of Storm Sewer Segments	104	32	6
Total Length of Storm Sewers (m)	**4458**	**2490**	**211**
Earthworks ($)	$5,310,000	$970,000	$148,000
Roadworks ($)	$6,170,000	$850,000	$148,000
Restoration and Planting ($)	$470,000	$5,000	$0
Pipe/Manhole Cost ($)[1]	$3,320,000	$1,350,000	$291,000
Traffic Management /Crew ($)	n/a[2]	n/a[2]	$40,000
Total Cost	**$15,260,000**	**$3,180,000**	**$674,000**
Total Cost with Mark-ups	**$25,630,000**	**$5,300,000**	**$796,000**

Notes:
1. Pipe/Manhole Costs include crew and equipment rates for Upgrades and New Servicing Installations.
2. Traffic Management/Crew costs are included in the Earthworks/Roadworks costs for upgrades and new services.

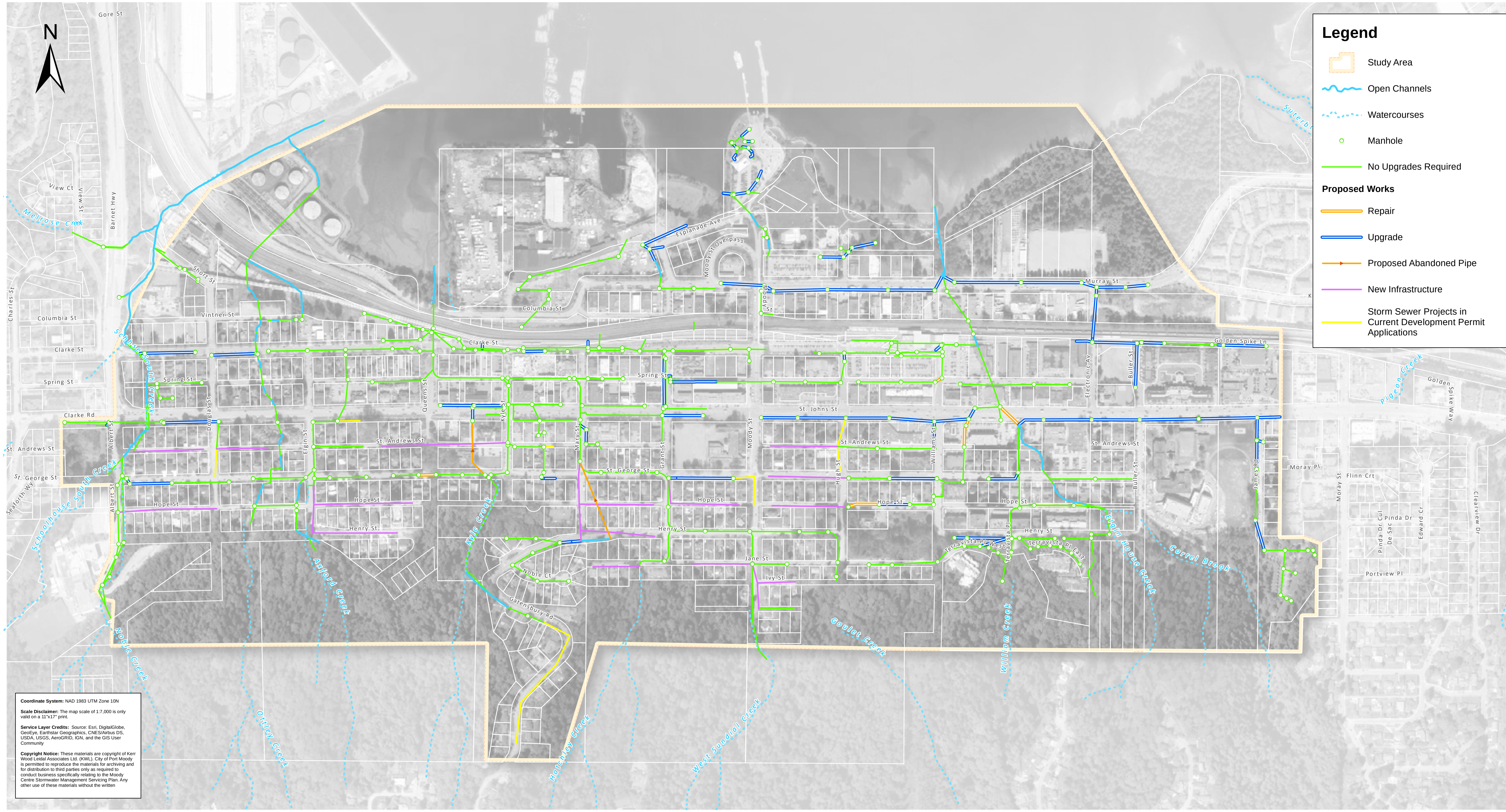
Figure 1 includes a map with the location of the proposed conveyance upgrades, new infrastructure, and repairs. The cost summary provided in Table 1 includes the costs for the infrastructure upgrades to their service levels consistent with the City's current bylaw (i.e., minor sewer system sized to the 10-year service level).

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo3\310055_Fig1_PipesNewUpgradeRepair.mxd Date Saved: 2019-06-05 7:53:49 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:7,000 is only valid on a 11"x17" print.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project No. 310-055

Date June 2019

Scale 1:7,000

100 50 0 100 m

Identified Pipes for Upgraded (to current bylaw requirements), New, and Repaired Infrastructure

Figure 1

4. Cost Estimate for BMPs and LIDs

Best management practices (BMP) were costed based on the recommendations and proposed implementation in Technical Memorandum #2, as well as additional discussions with the City. The cost estimate for the BMPs were intended for budgeting purposes and the infrastructure proposed in the ROWs was the primary focus. Figure 2 outlines the locations of the proposed green infrastructure and BMPs. A detailed discussion of each application and the assumptions is provided in the next sections.

4.1 Water Quality Opportunities

Water quality improvement opportunities have been identified as beneficial for all locations where the drainage system outfalls into a creek or ocean. Figure 2 shows the location of each of the creek outfalls in the drainage area. Water quality improvement opportunities at these locations include erosion and sediment control measures and manufactured water quality devices (i.e., oil and grit separators, cartridge filters, etc.)

4.2 Municipal ROWs

Rain Gardens

Rain gardens are intended to provide water quality treatment for the water quality storm (6-month 24-hour storm of 58.4 mm). The City has identified locations in the study area where rain garden implementation would be feasible. Figure 2 summarizes all the locations which include intersections and along the ROWs. A typical cross-section is provided in Figure 3.

A unit cost estimate for a rain garden installation was determined based on typical rain garden sizing. A typical ROW cross-section and contributing impervious area was used to determine the required treatment footprint and volume for the rain garden. The rain gardens were sized for treatment of the water quality storm. The sizing was checked to ensure a maximum Impervious to Pervious (I/P) ratio of 20:1 (or minimum rain garden area of 5% of the tributary pervious area) which is required to minimize clogging of rain gardens due to the pollutants running off collector and arterial roads and to reduce maintenance requirements. The implementation cost estimate includes the required excavation and placement of filter fabric, rock, perforated pipe, drainage sump/manhole, growing medium, and plantings.

Operation and maintenance costs were also estimated to account for the maintenance (approximately six times per year) of the rain gardens by City staff. Costs are estimated at $\$40/m^2$ of rain garden area based on current maintenance cost of existing rain gardens in Rocky Point Park.

Bioswales

Bioswales have a similar cross-section to rain gardens however they are primarily used along ROWs to provide water quality via filtration, rather than infiltration, and conveyance of stormwater. The unit cost presented is based on recently completed projects in Moody Centre, based on a typical bioswale cross-section. A typical cross-section is provided in Figure 4.

Tree cells / Soil cells

In areas where there is limited pervious area available in the ROW to accommodate rain gardens, tree cells are a viable option due to their smaller footprint. Tree cells are proposed to be constructed with soil cells[2] which provide stormwater management through the incorporation of modular storage units installed beneath the sidewalk or pavement surface. The cost estimate was based on preliminary sizing guidelines for soil cells that provide the footprint, soil cell volume, and a number of trees, based on the tributary catchment area of the ROWs. A typical cross-section is provided in Figure 5

4.3 Private Property On-Lot LIDs

The LID implementation plan focused on the uptake of absorbent landscape practices, installation of green roofs in multi-use land use blocks, and water quality measures. As these BMPs will be predominantly installed on private property and outside of the municipal ROW, the cost estimates were not broken down by land use or property.

4.4 Unit Costs for Green Infrastructure Implementation

Table 2 summarizes the approximate unit cost for each type of best management practice incorporated in Moody Centre.

Table 2: Unit Cost for Green Infrastructure

Green Infrastructure	Unit Cost (per m^2 of LID area)
Rain gardens	\$466 / m^2
Bioswales	\$250 / m^2
Soil cells	\$790/ m^2
Absorbent landscape (not including sump)	\$105 / m^2
Green roofs	\$415 / m^2

[2] DeepRoot Green Infrastructure “Silva-Cells”. Deeproot Green Infrastructure, 2018. Web. 28 November 2018 https://www.deeproot.com/products/silva-cell.html

Path: \\kwl.ca\bby\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo3\310055_Fig2_ProposedGreenInfra.mxd Date Saved: 2019-09-03 8:31:53 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers

Project No. 310-055

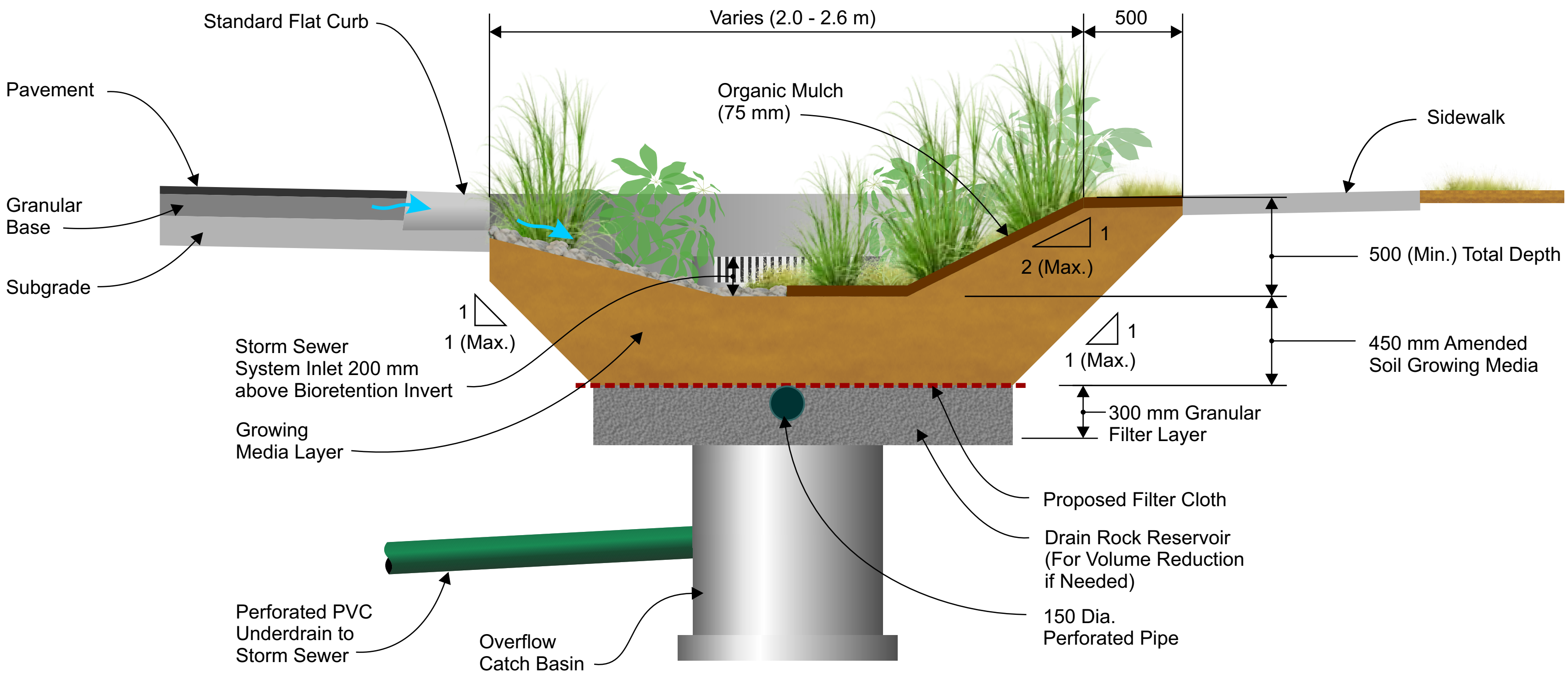
Date September 2019

Scale 1:7,000

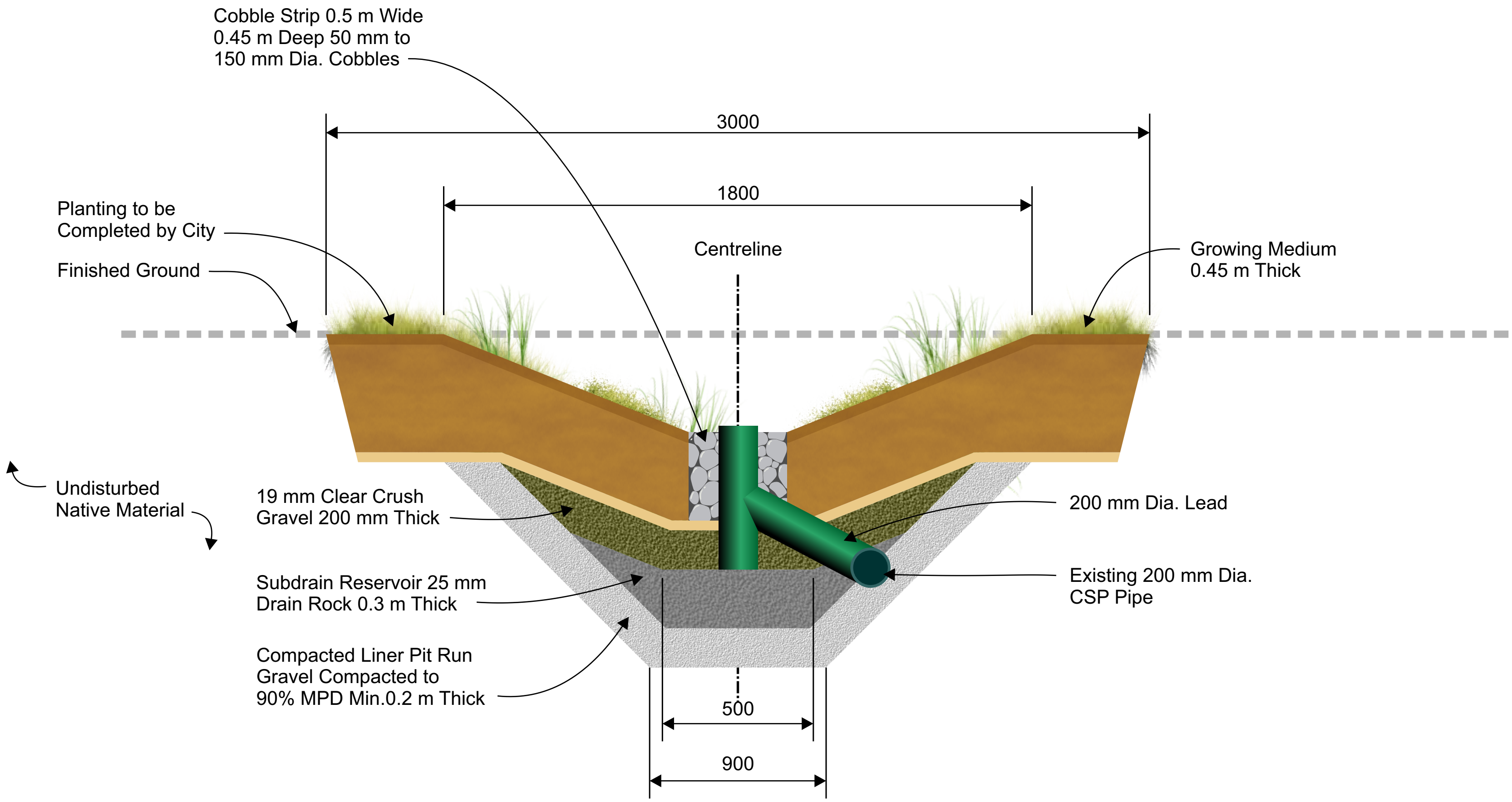
100 50 0 100 m

Existing, Proposed and Opportunities for Green Infrastructure

Figure 2



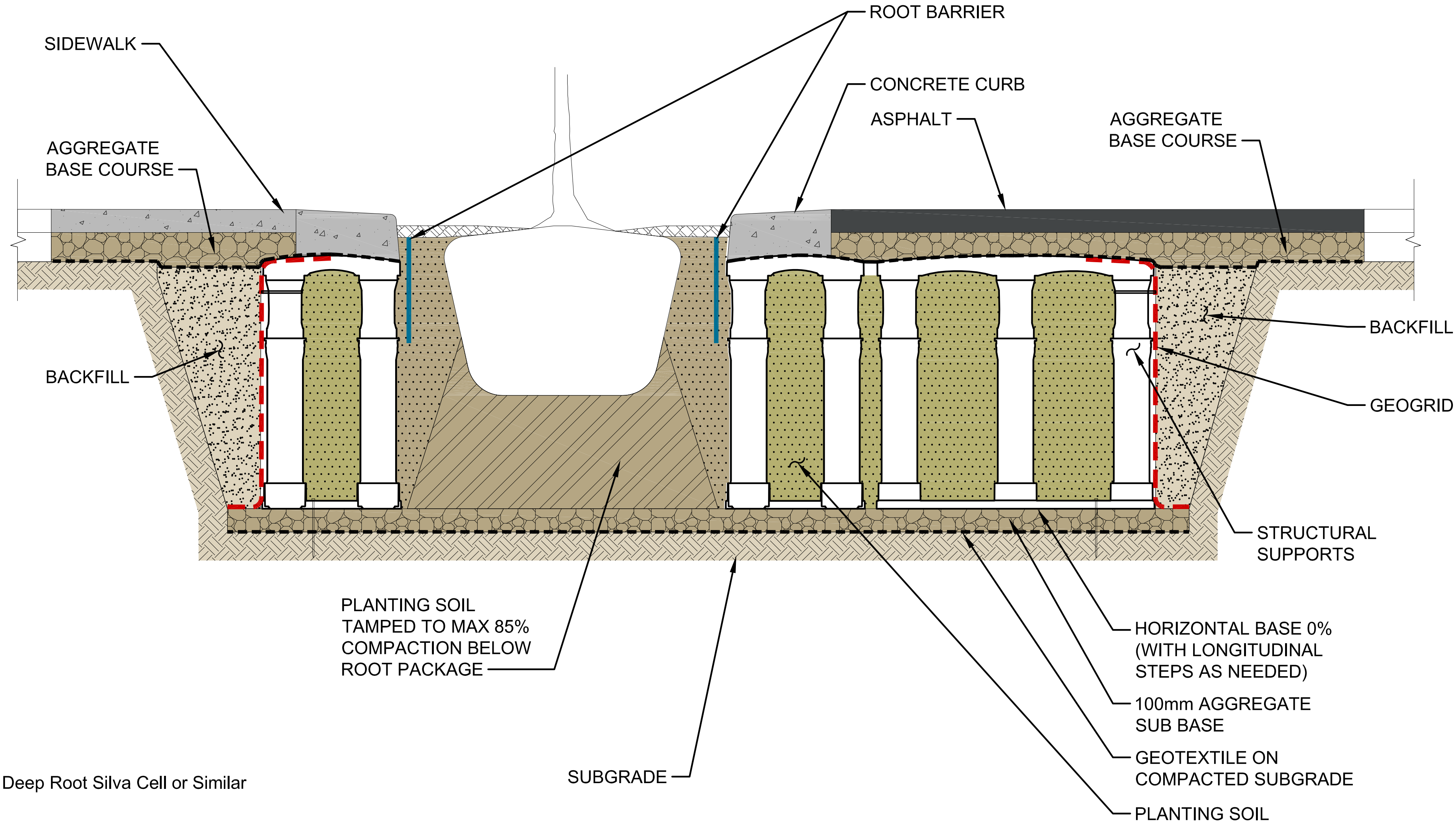
Typical Rain Garden Section



Project No.	310.055
Date	June 2019
Scale	Not to Scale

Typical Bioswale Section

Figure 4



Deep Root Silva Cell or Similar

Structural Soil Cell - Section View

Figure 5

5. 20-Year Capital Plan

A 20-Year capital plan was prepared based on the results of the drainage system capacity assessment, condition scoring, risk rating, and the Class C cost estimates. This section describes prioritization criteria, timeline, and proposed funding sources for the drainage projects in the Moody Centre study area.

5.1 Prioritization Criteria for Conveyance Infrastructure Upgrading

In a typical drainage plan, conveyance rating takes precedence over the other assessment criteria because the system must be designed to function adequately and mitigate flooding from the major and minor storm events. However, the City is in a unique position due to the availability of findings from the condition assessment work. The prioritization criteria for infrastructure upgrading take both conveyance and condition rating into consideration. The conveyance rating was based on the result of drainage assessment, detailed in the Phase 2 memorandum. The condition rating was based on the PACP scoring from the City's on-going CCTV program.

Conveyance Rating

As detailed in the Technical Memorandum #2 (Hydrological and Hydraulic Assessment), the drainage system was assessed for its capacity to convey the major design storm event (100-year return period) for the major drainage system and the minor design storm event (10-year return period) for minor drainage system. Using the results, each pipe was assigned a grade based on its performance. Table 3 summarizes the prioritization criteria based on the conveyance rating.

Table 3: Prioritization Criteria for Conveyance

Conveyance Rating	Upgrade Priority	Conveyance Rating Description
5	0-5 year	Major storm sewers and culverts that are not adequate to convey the 10-year **existing** flow, are sized to meet the 100-year **future** flow.
4	6-10 year	Major storm sewers and culverts that are adequate to convey the 10-year **existing** flow but are not adequate to convey the 100-year **existing** flow, are sized to meet the 100-year **future** flow.
3	10-20 year	Minor storm sewer pipes that are not adequate to convey the 10-year **existing** flow and require two or more incremental pipe diameter increases, are sized to meet the 10-year **future** flow.
2		Minor storm sewer pipes that are not adequate to convey the 10-year **existing** flow and require one incremental pipe diameter increases, are sized to meet the 10-year **future** flow. (this category can also be upgraded at end of the life span)
1	Developer Project (at the time of development)	Major storm sewers and culverts that are not adequate to convey the 100-year **future** flow, are sized to meet the 100-year **future** flow *OR* Minor storm sewers that are not adequate to convey the 10-year **future** flow, are sized to meet the 10-year **future** flow. *OR* Minor storm sewers that require 100-year servicing if desired by development.

Please note that in addition to the pipes that fit the above criteria for upgrade, the pipes downstream of those requiring upgrades may need to be upsized to avoid having smaller pipe sizes downstream in the system increasing the potential for sewer blockage. The cost estimate does not include the costing for the downstream infrastructure.

Condition Rating

The City runs an on-going CCTV program to identify storm sewers that are likely to fail from breaks, holes, collapses, deformations and joint separations. Available CCTV results were used to identify pipes which are high priority for rehabilitation. Any high priority rehabilitation (i.e., structure defect rating 4 and 5) results in the upgrade being prioritized to near future (0-5 years). If the pipe requires rehabilitation and also requires upgrade for capacity reasons, the pipe is classified as a conveyance upgrade. However, if the pipe requires repair but does not need to be upgraded for capacity reasons, the pipe is classified as a repair, not an upgrade. Table 4 summarizes the prioritization criteria based on the conveyance rating.

Table 4: Prioritization Criteria for Condition

Structure Defect Rating	Upgrade Priority	Condition Rating Description
5	0-5 year	Defects requiring immediate attention
4		Severe defects that will become Grade 5 in the near future
3	O&M program	Moderate defects that will continue to deteriorate
2		Defects that have not begun to deteriorate
1		Minor defects
Note: The Peak Score (highest recorded structural rating) was used for prioritization of the storm sewers for the 20-year capital plan.		

Only the storm sewers with a Grade of 4 or 5 were selected to be costed for the 20-year capital plan due to their higher severity. The other storm sewers that require repair or rehabilitation are considered as part of the operations and maintenance program and should be completed outside of the capital plan timeframe.

For those storm sewers that have not yet been assessed by the CCTV program, the pipe condition was assumed to be Grade 2. The plan can be updated should any Grade 4 or 5 pipes be discovered, once additional CCTV information is collected.

5.2 Prioritization Criteria for New Infrastructure

The prioritization criteria for new infrastructure in the currently-unserviced areas considered high-risk locations where stormwater servicing is critical. A background report by KWL, *Moody Centre Drainage Infrastructure Study, Preliminary Catchment Wide Review* (2017), summarizes the results of a risk assessment for Moody Centre and identifies where infrastructure was at high risk of failure. The report recommends location for immediate or priority action based on infrastructure age or location in the drainage system. The pipes identified as areas of concern and require actions are summarized in Table 5. The locations identified are taken from KWL's infrastructure study.

Table 5: Prioritization Criteria for New Infrastructure

Risk Rating	Priority	Risk Locations	Risk Assessment Description
5	0-5 year	Southeast of intersection of Henry Street and Hope Street	Unserviced very high-risk area prioritized as an immediate action
4		South of intersection of Gatensbury Road and Henry Street South of St. George Street between Mary Street and Kyle Street Southwest of Kyle Street and St. Andrews Street intersection Southwest of St. Johns Street and Kyle Street intersection	Unserviced high-risk areas that require priority action in the short-term
1-3	6-10 year	Other unserviced areas	Other unserviced areas that require planned action in the mid-term

5.3 Overall Prioritization

Based on the conveyance, condition and risk ratings, the overall prioritization criteria are summarized in Table 6 below.

Table 6: Overall Prioritization

Priority	Rating Description
0-5 year	**Conveyance**: Major storm sewers and culverts that are not adequate to convey the 10-year existing flow, are sized to meet the 100-year future flow. **Condition**: Grade 5 defects requiring immediate attention & severe defects that will become Grade 5 in the near future **New Infrastructure**: Unserviced very high-risk area and high-risk area prioritized as an immediate and short-term action, respectively.
5-10 year	**Conveyance**: Major storm sewers and culverts that are adequate to convey the 10-year existing flow but are not adequate to convey the 100-year existing flow, are sized to meet the 100-year future flow. **New Infrastructure**: Other unserviced areas that require planned action in the mid-term.
10-20 year	**Conveyance**: Minor storm sewer pipes that are not adequate to convey the 10-year existing flow and require two or more incremental pipe diameter increases, are sized to meet the 10-year future flow. OR Minor storm sewer pipes that are not adequate to convey the 10-year existing flow and require one incremental pipe diameter increases, are sized to meet the 10-year future flow (this category can also be upgraded at end of the life span).

Priority	Rating Description
Developer Project (at the time of development)	**Conveyance**: Major storm sewers and culverts that are not adequate to convey the 100-year future flow, are sized to meet the 100-year future flow *OR* Minor storm sewers that are not adequate to convey the 10-year future flow, are sized to meet the 10-year future flow.

5.4 Project Timelines

This plan assembles findings from the prioritization to create a comprehensive upgrading, repair, and construction strategy for the City's drainage system. The above projects are categorized as short-, mid-, and long-term program and developer projects based on their prioritization. The timing of individual upgrades will be determined with consideration of all other utility upgrade and repaving projects in the Moody Centre area.

- **Short-term Program** (2019-2024): includes existing storm sewer upgrades that were given a conveyance rating of 5 or a condition rating of 4 or 5, and new storm sewers for the currently-unserviced areas that were identified in the background report and given a risk grade of 4 and 5 (very high and high priority).
- **Mid-term Program** (2025-2029): includes existing storm sewer upgrades that were given a conveyance rating of 4, and new storm sewers for the currently-unserviced areas that were given a risk grade of 1 to 3 (medium to low priority).
- **Long-term Program** (2030-2039): includes existing storm sewer upgrades that were given a conveyance grade of 2 or 3 (medium to low priority). Existing storm sewer upgrades with a conveyance grade of 2 (low priority) can also be upgraded at the end of the life span.
- **Developer Projects** (at time of development): includes infrastructure upgrades and construction required by new development and re-development.

Figure 6 shows the recommended capital upgrades and developer projects.

5.5 Funding Sources

As discussed in Section 3, four types of projects were included in this servicing plan. The proposed funding sources for each type is provided below:

- Existing Storm Sewer Upgrades:
  - (a) Pipes undersized for flow under the existing land use - mostly funded by capital budget with the increase in pipe size required for future conditions funded by developer
  - (b) Pipes adequately sized for the existing land use but undersized for future land use with climate change – 100% funded by developer
- New Storm Sewers: to be constructed to service the residential areas without existing drainage servicing - 100% funded by developer
- Infrastructure Repairs: repairs made for the existing structural deficiencies identified by CCTV - 100% funded by capital budget
- BMPs and LIDs for Municipal ROWs: rain gardens and tree cells to be constructed on arterial and collector roads - funded by capital and developer

Senior government grants may be sought to fund some of the capital program.

5.6 Capital Budget and Developer Costs

Table 7 and Table 8 provide a summary of the capital budget and developer costs . The total capital budget for the Moody Centre drainage servicing plan is estimated to be $20.5M for the next 20 years (2019-2039), with an average annual cost of approximately $1.03M. The total developer cost is estimated to be $11.2M, with an average annual cost of $0.87M. Figure 7 shows the total project cost distributed over the 20-year planning period.

Table 7: Summary of Capital Budget

Time Frame	Infrastructure Upgrade Cost	Infrastructure Repairs Cost	Total Cost
2019-2024	$8,369,000	$796,000	$9,165,000
2025-2029	$5,361,000	$0	$5,361,000
2030-2039	$5,995,000	$0	$5,995,000
Totals	**$19,725,000**	**$796,000**	**$20,521,000**
Note: All costs include markup noted in Section 3.1.			

Table 8: Summary of Developer Costs

Time Frame	Infrastructure Upgrade Cost	New Infrastructure Cost	Total Cost
2019-2024 [1]	$79,000	$2,959,000	$3,038,000
2025-2029 [1]	$115,000	$2,343,000	$2,458,000
2030-2039 [1]	$225,000	$0	$225,000
At Time of Development	$5,492,000	$0[2]	$5,492,000
Totals	**$5,911,000**	**$5,302,000**	**$11,213,000**

Notes:
All costs include markup noted in Section 3.1.
1. Developer portion of conveyance upgrades associated with upsizing the pipe for future conditions (as per current bylaw requirements).
2. Lump sum cost for the green infrastructure projects was not included. Unit costs were provided in Table 2, instead.

The costs associated with individual pipe segments for the capital upgrades, developer upgrades, new infrastructure, and repairs are detailed in Table 9, Table 10, Table 11, and Table 12 respectively.

Table 9: Moody Centre Stormwater Infrastructure Capital Projects

Conduit ID	Overall Priority	Replacement Timeline	Length (m)	Existing Diameter (m)	Upgrade Diameter (m)	Capital Cost with Mark-ups ($)
SDNMN-963	5	2019-2024	10.2	0.250	0.675	$77,000
SDNMN-960	5	2019-2024	104.4	0.250	0.375	$335,000
SDNMN-959	5	2019-2024	4.0	0.250	0.450	$51,000
SDNMN-935	5	2019-2024	60.7	0.200	0.375	$149,000
SDNMN-918	5	2019-2024	102.4	0.450	0.900	$746,000
SDNMN-915	5	2019-2024	126.5	0.600	1.050	$1,044,000
SDNMN-914	5	2019-2024	114.1	0.600	1.050	$840,000
SDNMN-913	5	2019-2024	29.7	0.600	0.900	$230,000
SDNMN-911	5	2019-2024	42.4	0.250	0.600	$212,000
SDNMN-896	5	2019-2024	68.9	0.200	0.375	$218,000
SDNMN-895	5	2019-2024	91.0	0.300	0.525	$592,000
SDNMN-890	5	2019-2024	65.3	0.450	0.750	$286,000
SDNMN-864	5	2019-2024	91.6	0.450	0.750	$439,000
SDNMN-530433	5	2019-2024	11.6	0.200	0.250	$127,000
SDNMN-4316	5	2019-2024	4.9	0.250	0.300	$79,000
SDNMN-4311	5	2019-2024	2.0	0.300	0.450	$54,000
SDNMN-4211_2	5	2019-2024	9.8	0.250	0.375	$54,000
SDNMN-2231	5	2019-2024	91.2	0.375	0.675	$579,000
SDNMN-2230	5	2019-2024	111.2	0.300	0.450	$329,000
SDNMN-2229	5	2019-2024	110.5	0.250	0.900	$498,000
SDNMN-2228	5	2019-2024	42.8	0.150	0.250	$181,000
SDNMN-2111	5	2019-2024	77.0	0.300	0.525	$274,000
SDNMN-1635	5	2019-2024	28.1	0.450	0.750	$227,000
SDNMN-926	5	2019-2024	35.3	0.300	0.375	$297,000
SDNMN-962	4	2025-2029	96.0	0.250	0.375	$390,000
SDNMN-956	4	2025-2029	84.6	0.300	0.600	$359,000
SDNMN-936	4	2025-2029	54.2	0.250	0.600	$358,000
SDNMN-919	4	2025-2029	19.6	0.375	0.525	$146,000
SDNMN-917	4	2025-2029	114.7	0.450	0.600	$690,000
SDNMN-916	4	2025-2029	88.1	0.450	0.600	$612,000
SDNMN-912	4	2025-2029	54.9	0.450	0.600	$312,000
SDNMN-894	4	2025-2029	82.3	0.375	0.525	$371,000
SDNMN-891	4	2025-2029	23.6	0.600	1.500	$159,000
SDNMN-513071	4	2025-2029	6.7	0.450	0.600	$148,000
SDNMN-4312_2	4	2025-2029	59.9	0.450	0.675	$449,000
SDNMN-2097	4	2025-2029	49.0	0.450	0.600	$145,000
SDNMN-1652	4	2025-2029	57.2	0.300	0.375	$864,000

Table 9: Moody Centre Stormwater Infrastructure Capital Projects

Conduit ID	Overall Priority	Replacement Timeline	Length (m)	Existing Diameter (m)	Upgrade Diameter (m)	Capital Cost with Mark-ups ($)
SDNMN-1636	4	2025-2029	20.7	0.600	0.750	$163,000
SDNMN-1617	4	2025-2029	28.9	0.450	0.600	$195,000
SDNMN-958	3	2025-2029	12.4	0.300	0.450	$207,000
SDNMN-884	3	2025-2029	23.8	0.150	0.250	$89,000
SDNMN-862	3	2025-2029	54.9	0.300	0.525	$360,000
SDNMN-530505	3	2025-2029	8.0	0.450	0.600	$70,000
SDNMN-530504	3	2025-2029	84.8	0.450	0.675	$471,000
SDNMN-530500	3	2025-2029	9.2	0.450	1.200	$112,000
SDNMN-516193	3	2025-2029	19.0	0.150	0.250	$134,000
SDNMN-516192	3	2025-2029	7.0	0.150	0.300	$80,000
SDNMN-435	3	2025-2029	48.0	0.250	0.675	$269,000
SDNMN-4140	3	2025-2029	81.0	0.300	0.450	$390,000
SDNMN-2801	3	2025-2029	2.9	0.200	0.300	$50,000
SDNMN-2794	3	2025-2029	18.9	0.150	0.250	$71,000
SDNMN-2791	3	2025-2029	15.5	0.150	0.300	$179,000
SDNMN-2761	3	2025-2029	16.4	0.200	0.300	$87,000
SDNMN-2293	3	2025-2029	53.7	0.250	0.375	$237,000
SDNMN-2264	3	2025-2029	16.1	0.300	0.450	$101,000
SDNMN-2083	3	2025-2029	16.6	0.450	0.600	$127,000
SDNMN-2082	3	2025-2029	80.0	0.450	0.600	$509,000
SDNMN-1998	3	2025-2029	51.8	0.250	0.600	$327,000
SDNMN-1997	3	2025-2029	26.4	0.200	0.375	$170,000
SDNMN-1663	3	2025-2029	126.2	0.250	0.375	$388,000
SDNMN-1611	3	2025-2029	12.4	0.150	0.250	$61,000
SDNMN-516373	3	2025-2029	13.6	0.200	0.375	$100,000
SDNMN-516374	3	2025-2029	10.4	0.200	0.375	$71,000
SDNMN-526705	3	2025-2029	45.0	0.200	0.375	$142,000
SDNMN-957	5	2019-2024	79.9	0.300	0.375	$451,000
SDNMN-530488	2	2030-2039 or EOL	14.6	0.200	0.250	$143,000
SDNMN-2798	2	2030-2039 or EOL	20.6	0.150	0.200	$223,000
SDNMN-2621	2	2030-2039 or EOL	16.6	0.300	0.375	$110,000
SDNMN-2263	2	2030-2039 or EOL	89.7	0.250	0.300	$281,000
SDNMN-1996	2	2030-2039 or EOL	14.9	0.450	0.525	$118,000
SDNMN-1612	2	2030-2039 or EOL	43.1	0.300	0.375	$145,000
SDNMN-516372	2	2030-2039 or EOL	44.2	0.200	0.250	$173,000

Note: Highlighted blue cells are minor sewers sized to 10-year capacity, white cells are major and sized to 100-year capacity.
Upgrade diameter to existing land use and 2018 IDF curve.

Table 10: Moody Centre Stormwater Infrastructure Developer Projects

Conduit ID	Replacement Timeline	Length (m)	Existing Diameter (m)	Upgrade Diameter (m)	Developer Cost with Mark-ups ($)
SDNMN-963	2019-2024	10.2	0.250	0.675	$1,000
SDNMN-918	2019-2024	102.4	0.450	0.900	$21,000
SDNMN-914	2019-2024	114.1	0.600	1.050	$38,000
SDNMN-911	2019-2024	42.4	0.250	0.600	$5,000
SDNMN-890	2019-2024	65.3	0.450	0.750	$6,000
SDNMN-2111	2019-2024	77.0	0.300	0.525	$5,000
SDNMN-1635	2019-2024	28.1	0.450	0.750	$3,000
SDNMN-956	2025-2029	84.6	0.300	0.600	$11,000
SDNMN-919	2025-2029	19.6	0.375	0.525	$1,000
SDNMN-917	2025-2029	114.7	0.450	0.600	$13,000
SDNMN-912	2025-2029	54.9	0.450	0.600	$6,000
SDNMN-894	2025-2029	82.3	0.375	0.525	$6,000
SDNMN-891	2025-2029	23.6	0.600	1.500	$16,000
SDNMN-3618	2025-2029	2.9	0.150	0.200	$60,000
SDNMN-1636	2025-2029	20.7	0.600	0.750	$2,000
SDNMN-530505	2025-2029	8	0.450	0.600	$1,000
SDNMN-530504	2025-2029	84.79	0.450	0.675	$6,000
SDNMN-530500	2025-2029	9.23	0.450	1.200	$2,000
SDNMN-435	2025-2029	48.024	0.250	0.675	$3,000
SDNMN-4140	2025-2029	81	0.300	0.450	$3,000
SDNMN-2293	2025-2029	53.68	0.250	0.375	$1,000
SDNMN-2264	2025-2029	16.141	0.300	0.450	$1,000
SDNMN-2083	2025-2029	16.6	0.450	0.600	$2,000
SDNMN-1998	2025-2029	51.847	0.250	0.600	$6,000
SDNMN-526705	2025-2029	45.018	0.200	0.375	$1,000
SDNMN-2762	2030-2039 or EOL	12.722	0.150	0.200	$150,000
SDNMN-3621	2030-2039 or EOL	2.8	0.300	0.375	$49,000
SDNMN-924	2030-2039 or EOL	11.513	0.250	0.450	$59,000
SDNMN-903	2030-2039 or EOL	27.25	0.450	0.525	$236,000
SDNMN-889	2030-2039 or EOL	38.942	0.300	0.375	$175,000
SDNMN-887	2030-2039 or EOL	57.633	0.250	0.300	$187,000
SDNMN-883	2030-2039 or EOL	76.03	0.250	0.300	$245,000
SDNMN-860	2030-2039 or EOL	59.527	0.300	0.375	$471,000
SDNMN-530501	2030-2039 or EOL	9.75	0.250	0.300	$78,000
SDNMN-530489	2030-2039 or EOL	1.83	0.200	0.200	$59,000

Table 10: Moody Centre Stormwater Infrastructure Developer Projects

Conduit ID	Replacement Timeline	Length (m)	Existing Diameter (m)	Upgrade Diameter (m)	Developer Cost with Mark-ups ($)
SDNMN-4209	2030-2039 or EOL	86.928	0.250	0.525	$211,000
SDNMN-4139	2030-2039 or EOL	11	0.375	0.450	$88,000
SDNMN-2802	2030-2039 or EOL	18.517	0.200	0.250	$76,000
SDNMN-2799	2030-2039 or EOL	18.159	0.200	0.300	$82,000
SDNMN-2787	2030-2039 or EOL	12.415	0.150	0.200	$61,000
SDNMN-2756	2030-2039 or EOL	14.835	0.150	0.200	$69,000
SDNMN-2754	2030-2039 or EOL	28.814	0.200	0.250	$109,000
SDNMN-2752	2030-2039 or EOL	27.717	0.200	0.250	$128,000
SDNMN-2234	2030-2039 or EOL	16.02	0.300	0.600	$106,000
SDNMN-2096	2030-2039 or EOL	52.229	0.200	0.300	$157,000
SDNMN-2084	2030-2039 or EOL	83.64	0.450	0.525	$1,378,000
SDNMN-1995	2030-2039 or EOL	22.683	0.450	0.525	$162,000
SDNMN-1763	2030-2039 or EOL	12.831	0.300	0.375	$67,000
SDNMN-1654	2030-2039 or EOL	15.29	0.375	0.525	$113,000
SDNMN-1653	2030-2039 or EOL	24.284	0.250	0.375	$163,000
SDNMN-931	2030-2039 or EOL	40.2	0.250	0.375	$161,000
SDNMN-925	2030-2039 or EOL	12.9	0.250	0.375	$93,000
SDNMN-920	2030-2039 or EOL	82.1	0.375	0.450	$336,000
SDNMN-893	2030-2039 or EOL	85.3	0.450	0.525	$202,000
SDNMN-4335	2030-2039 or EOL	22.8	0.250	0.300	$119,000
SDNMN-1755	2030-2039 or EOL	14.8	0.250	0.525	$101,000

Note: Highlighted blue cells are minor sewers sized to 10-year capacity, white cells are major and sized to 100-year capacity.
Upgrade diameter to future OCP land use and climate change (2050-2100) IDF curve.
Note 2: Developer costs are based on incremental increase to size pipes to the future conditions.

Table 11: Moody Centre New Stormwater Infrastructure - Developer Projects

Conduit ID	Replacement Timeline	Length (m)	Existing Diameter (m)	10-yr Upgrade Diameter (m)	Total Cost with Mark-ups ($)
C1	2025-2029	96.3	N/A	0.250	$197,000
KWLEX_01	2025-2029	92.1	N/A	0.200	$190,000
KWLEX_02	2025-2029	40.7	N/A	0.250	$113,000
KWLEX_03	2025-2029	109.1	N/A	0.250	$214,000
KWLEX_05	2019-2024	127.0	N/A	0.250	$248,000
KWLEX_06	2019-2024	59.5	N/A	0.300	$139,000
KWLEX_07	2019-2024	114.3	N/A	0.250	$226,000
KWLEX_08	2019-2024	45.6	N/A	0.300	$110,000
KWLEX_09	2019-2024	113.4	N/A	0.250	$225,000
KWLEX_10	2019-2024	71.7	N/A	0.250	$159,000
KWLEX_11	2019-2024	130.0	N/A	0.250	$252,000
KWLEX_12	2019-2024	144.3	N/A	0.250	$271,000
KWLEX_13	2019-2024	151.2	N/A	0.250	$306,000
KWLEX_14	2019-2024	126.5	N/A	0.250	$242,000
KWLEX_16	2019-2024	103.4	N/A	0.200	$205,000
KWLEX_17	2019-2024	83.3	N/A	0.300	$175,000
KWLEX_18	2019-2024	140.5	N/A	0.250	$276,000
KWLEX_19	2019-2024	56.0	N/A	0.525	$125,000
KWLEX_20	2025-2029	66.0	N/A	0.300	$147,000
KWLEX_21	2025-2029	88.1	N/A	0.250	$186,000
KWLEX_22	2025-2029	68.8	N/A	0.250	$156,000
KWLEX_23	2025-2029	71.6	N/A	0.300	$150,000
KWLEX_25	2025-2029	49.1	N/A	0.200	$113,000
KWLEX_26	2025-2029	37.0	N/A	0.300	$93,000
KWLEX_27	2025-2029	48.0	N/A	0.250	$107,000
KWLEX_29	2025-2029	63.4	N/A	0.375	$145,000
KWLEX_30	2025-2029	49.8	N/A	0.525	$116,000
KWLEX_31	2025-2029	19.7	N/A	0.450	$71,000
KWLEX_32	2025-2029	25.6	N/A	0.525	$81,000
KWLEX_33	2025-2029	53.4	N/A	0.300	$115,000
KWLEX_34	2025-2029	36.7	N/A	0.375	$93,000
KWLEX_35	2025-2029	8.4	N/A	0.450	$56,000

Table 12: Moody Centre Stormwater Infrastructure Spot Repairs - Capital Projects

Asset ID	Replacement Timeline	Length (m)	Repair Diameter (m)	Total Cost with Mark-ups ($)
SDNMN-940	2019-2024	33.1	0.250	$79,000
SDNMN-1681	2019-2024	59.2	0.250	$214,000
SDNMN-1667	2019-2024	14.8	0.300	$52,000
SDNMN-1672	2019-2024	14.1	0.900	$58,000
SDNMN-4218	2019-2024	40.8	0.900	$204,000
SDNMN-1764	2019-2024	49.3	1.500	$189,000

Path: \\bbyfs1.kwl.ca\0000-0999\0300-0399\310-055\430-GIS\MXD-Rp\TechMemo3\310055_Fig6_CapitalWorks.mxd Date Saved: 2019-06-05 7:57:22 AM | Author: GOConnell

City of Port Moody

Moody Centre Stormwater Management Servicing Plan

KERR WOOD LEIDAL consulting engineers

Project No.	310-055
Date	June 2019
Scale	1:7,000

100 50 0 100 m

Recommended Capital and Developer Projects

Figure 6

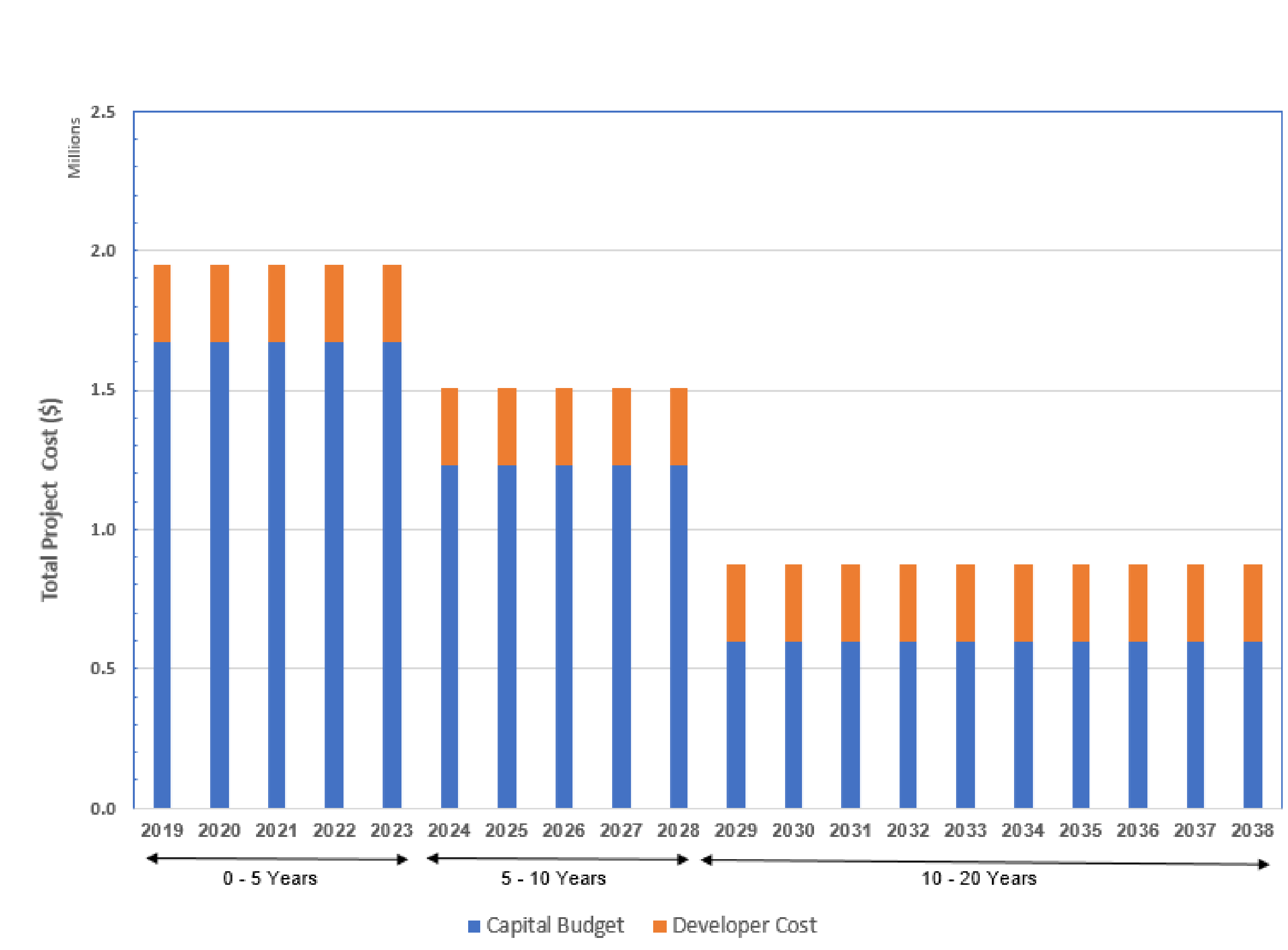


Figure 7: 20-Year Capital Plan Expenditure Allocations

6. Minor System Upgrades for 100-Year Conveyance

Additional consideration was given in the cost estimate to a potential update to the servicing bylaw which would require the minor storm system to be serviced to the 100-year service level. These costs have been included for information purposes only and are not included in the capital cost program.

6.1 Existing Infrastructure Upgrades

The City's current stormwater and servicing guidelines size the minor storm sewer system for the 10-year design storm. However, the City has expressed interest to assess the upgrades required in the minor sewer system to convey the 100-year design storm (in OCP conditions with climate change). This would alleviate drainage concerns for redevelopment areas (i.e., basement flooding, overland flow through private property). Upgrading the minor system to the 100-year capacity is outside of the scope of a capital project and therefore would be funded on an as-needed basis by development.

This system capacity assessment was therefore completed to evaluate all pipes in the study area for the 100-year design storm. This was a high-level assessment aimed at evaluating the potential upgrades needed and costs across the entire system and did not take into account site-specific conditions of where such an upgrade would be desired. The results of this assessment identified 71 segments of storm sewers that would require upgrades to convey the 100-year storm, 32 of which were already identified in the minor system assessment, and 39 which only require upgrades to support 100-year capacity if desired by development.

The cost estimate for the upgraded infrastructure was completed using the same methodology as described previously. The costs presented are the total costs of upgrading the pipe from its existing size to the 100-year size, not the incremental cost of upsizing the pipe from the required 10-year size to the 100-year size. Furthermore, for simplicity, these costs are not broken down into capital costs and developer costs.

6.2 New Infrastructure

Consistent with the request of the City to evaluate the existing minor sewer system for 100-year conveyance, a cost estimate was also completed to size the new infrastructure for the 100-year service level.

Table 13 and Table 14 summarizes the costs to upgrade the minor system to the 100-year service level for existing and proposed infrastructure, respectively. The costs associated with upgrading the minor sewer system and proposed new servicing to a 100-year service level (as shown in Table 13 and Table 14) have not been included in the summary in Section 5 as at this time they are being provided for information purposes only.

The cost to upsize existing minor pipes to 100-year capacity is $13,311,000. The cost of constructing new pipes in currently-unserviced areas to 100-year capacity is $5,383,000. All of these costs would be borne by the developers.

Table 13: Cost Breakdown for Development Upgrades (Costs to Upgrade Minor System to 100-year capacity)

Conduit ID	Length (m)	Existing Diameter (m)	100 year Upgrade Diameter (m)	Total Cost with Mark-ups ($)
Development Upgrades - Not included in Capital Plan				
SDNMN-958	12.4	0.300	0.525	$208,000
SDNMN-957	79.9	0.300	0.450	$454,000
SDNMN-884	23.8	0.150	0.300	$89,000
SDNMN-862	54.9	0.300	0.525	$360,000
SDNMN-530505	8.0	0.450	0.600	$71,000
SDNMN-530504	84.8	0.450	0.675	$477,000
SDNMN-530500	9.2	0.450	1.200	$114,000
SDNMN-950	15.9	0.300	0.375	$128,000
SDNMN-949	29.5	0.250	0.250	$0
SDNMN-530488	14.6	0.200	0.300	$143,000
SDNMN-924	11.5	0.250	0.600	$61,000
SDNMN-516193	19.0	0.150	0.300	$134,000
SDNMN-516192	7.0	0.150	0.375	$81,000
SDNMN-435	48.0	0.250	0.675	$273,000
SDNMN-4140	81.0	0.300	0.450	$393,000
SDNMN-2762	12.7	0.150	0.200	$150,000
SDNMN-2801	2.9	0.200	0.375	$50,000
SDNMN-2798	20.6	0.150	0.250	$223,000
SDNMN-907	55.0	0.250	0.375	$599,000
SDNMN-903	27.3	0.450	0.600	$239,000
SDNMN-2794	18.9	0.150	0.300	$71,000
SDNMN-2791	15.5	0.150	0.375	$179,000
SDNMN-3621	2.8	0.300	0.450	$41,000
SDNMN-2761	16.4	0.200	0.375	$87,000
SDNMN-2621	16.6	0.300	0.450	$111,000
SDNMN-2293	53.7	0.250	0.450	$239,000
SDNMN-883	76.0	0.250	0.375	$246,000
SDNMN-882	30.9	0.250	0.375	$277,000
SDNMN-881	30.9	0.250	0.375	$200,000
SDNMN-2264	16.1	0.300	0.450	$101,000
SDNMN-2263	89.7	0.250	0.300	$281,000

Table 13: Cost Breakdown for Development Upgrades (Costs to Upgrade Minor System to 100-year capacity)

Conduit ID	Length (m)	Existing Diameter (m)	100 year Upgrade Diameter (m)	Total Cost with Mark-ups ($)
SDNMN-860	59.5	0.300	0.375	$471,000
SDNMN-2083	16.6	0.450	0.600	$129,000
SDNMN-2082	80.0	0.450	0.675	$515,000
SDNMN-530501	9.8	0.250	0.300	$78,000
SDNMN-1998	51.8	0.250	0.675	$336,000
SDNMN-530489	1.8	0.200	0.250	$59,000
SDNMN-1997	26.4	0.200	0.450	$171,000
SDNMN-1996	14.9	0.450	0.600	$119,000
SDNMN-526706	3.6	0.200	0.300	$51,000
SDNMN-1663	126.2	0.250	0.375	$388,000
SDNMN-1612	43.1	0.300	0.375	$145,000
SDNMN-1611	12.4	0.150	0.250	$61,000
SDNMN-516372	44.2	0.200	0.300	$173,000
SDNMN-516373	13.6	0.200	0.450	$101,000
SDNMN-4333	23.9	0.250	0.450	$113,000
SDNMN-4322	39.0	0.250	0.375	$156,000
SDNMN-516374	10.4	0.200	0.450	$72,000
SDNMN-4209	86.9	0.250	0.675	$228,000
SDNMN-4139	11.0	0.375	0.450	$88,000
SDNMN-2802	18.5	0.200	0.250	$76,000
SDNMN-2799	18.2	0.200	0.375	$83,000
SDNMN-2796	0.8	0.200	0.450	$42,000
SDNMN-2793	6.4	0.200	0.300	$54,000
SDNMN-2789	2.0	0.200	0.250	$44,000
SDNMN-2788	20.6	0.150	0.450	$74,000
SDNMN-2787	12.4	0.150	0.200	$61,000
SDNMN-2757	12.7	0.150	0.200	$62,000
SDNMN-2756	14.8	0.150	0.250	$69,000
SDNMN-2754	28.8	0.200	0.300	$110,000
SDNMN-2752	27.7	0.200	0.300	$129,000
SDNMN-2262	77.3	0.250	0.300	$299,000
SDNMN-2234	16.0	0.300	0.750	$108,000

Table 13: Cost Breakdown for Development Upgrades (Costs to Upgrade Minor System to 100-year capacity)

Conduit ID	Length (m)	Existing Diameter (m)	100 year Upgrade Diameter (m)	Total Cost with Mark-ups ($)
SDNMN-2096	52.2	0.200	0.300	$157,000
SDNMN-2084	83.6	0.450	0.675	$1,395,000
SDNMN-1995	22.7	0.450	0.600	$164,000
SDNMN-1763	12.8	0.300	0.375	$67,000
SDNMN-1668	10.7	0.300	0.675	$68,000
SDNMN-1656	45.4	0.250	0.300	$293,000
SDNMN-1654	15.3	0.375	0.600	$114,000
SDNMN-1653	24.3	0.250	0.450	$164,000
SDNMN-526705	45.0	0.200	0.450	$144,000

Table 14: Costs Breakdown for New Infrastructure (100-year sizing)

Asset ID	Length (m)	Existing Diameter (m)	100 year Upgrade Diameter (m)	Total Cost with Mark-ups ($)
C1	96.3	N/A	0.200	$196,000
KWLEX_01	92.1	N/A	0.250	$192,000
KWLEX_02	40.7	N/A	0.375	$114,000
KWLEX_03	109.1	N/A	0.300	$215,000
KWLEX_05	127.0	N/A	0.375	$251,000
KWLEX_06	59.5	N/A	0.450	$142,000
KWLEX_07	114.3	N/A	0.300	$227,000
KWLEX_08	45.6	N/A	0.375	$110,000
KWLEX_09	113.4	N/A	0.300	$226,000
KWLEX_10	71.7	N/A	0.300	$160,000
KWLEX_11	130.0	N/A	0.375	$255,000
KWLEX_12	144.3	N/A	0.375	$274,000
KWLEX_13	151.2	N/A	0.300	$308,000
KWLEX_14	126.5	N/A	0.300	$243,000
KWLEX_16	103.4	N/A	0.250	$206,000
KWLEX_17	83.3	N/A	0.375	$177,000
KWLEX_18	140.5	N/A	0.300	$278,000
KWLEX_19	56.0	N/A	0.750	$144,000
KWLEX_20	66.0	N/A	0.375	$148,000
KWLEX_21	88.1	N/A	0.375	$188,000
KWLEX_22	68.8	N/A	0.300	$156,000
KWLEX_23	71.6	N/A	0.375	$150,000
KWLEX_25	49.1	N/A	0.300	$114,000
KWLEX_26	37.0	N/A	0.375	$94,000
KWLEX_27	48.0	N/A	0.375	$108,000
KWLEX_29	63.4	N/A	0.450	$147,000
KWLEX_30	49.8	N/A	0.675	$127,000
KWLEX_31	19.7	N/A	0.600	$75,000
KWLEX_32	25.6	N/A	0.750	$89,000
KWLEX_33	53.4	N/A	0.375	$116,000
KWLEX_34	36.7	N/A	0.525	$97,000
KWLEX_35	8.4	N/A	0.525	$56,000

7. Conclusion and Recommendations

The technical memorandum summarizes the cost estimate and presents a phased stormwater servicing plan for the drainage infrastructure in Moody Centre. The following items are recommended for completion following this report submission:

1) **Update prioritization with complete CCTV results:** The servicing plan should be updated once the CCTV inspections are complete and data is available for the remainder of the study area.
2) **Complete asset management program for Moody Centre:** The proposed prioritization approach for capital planning considers the pipe condition and the capacity. However, there are other elements that are valuable in assigning timelines to projects such as repaving project schedules and development timing. For example, Port Moody's Pavement Asset Management Program (Tetra Tech, 2014) indicates that a large number of the streets in Moody Centre are scheduled for pavement upgrades. From an asset management perspective, including this information would represent a holistic approach. The current assessment does not consider this detailed assessment of those factors, and it is recommended that future studies be completed to include all relevant factors to integrate the capital planning with an integrated utilities management approach.
3) **Provide cost estimates for pipe maintenance and minor rehabilitation:** The capital plan includes repairs of sewers identified as high severity (Grade 4 and 5). Sewers identified as minor repairs or operation and maintenance issues have not been included in the capital plan. There are multiple factors that influence the type of rehabilitation or maintenance to sewers with low severity ratings (Grades 1, 2, and 3). An overall asset management study should consider the rehabilitation and maintenance costs for these additional pipes.

Submission

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL PROVINCE OF BRITISH COLUMBIA C. E. CHARBONNEAU # 47741 ENGINEER

Caroline Charbonneau, M.A.Sc., P.Eng.
Project Engineer

Eva Li, M.A.Sc., P.Eng.
Project Manager

Reviewed by:

David Zabil, M.A.Sc., P.Eng.
Senior Water Resources Engineer

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the intended recipient. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Copyright Notice

Revision History

Revision #	Date	Status	Revision Description	Author
0	October 3, 2019	Final	Issued as final.	CEC/EL

OQM CERTIFIED

KERR WOOD LEIDAL
consulting engineers

Appendix D

Technical Memorandum #4
Urban Ditch Management Strategy

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum #4

DATE: October 4, 2019

TO: Shashi Bandara, E.I.T.
City of Port Moody

CC: Stephen Judd, P.Eng.

FROM: Daniel Brown B.Sc., B. Tech., B.I.T., Biologist
Patrick Lilley, M.Sc., R.P.Bio., Project Biologist
Laurel Morgan, M.Sc., P.Eng., Senior Stormwater Engineer

RE: **MOODY CENTRE STORMWATER MANAGEMENT SERVICING PLAN**
Technical Memorandum #4 – Urban Ditch Management Strategy
Our File 310.055-300

1. Introduction

Since the completion of the Evergreen Line extension, the Moody Centre area has been undergoing rapid redevelopment. Enclosure of ditches is often a component of such development, however, ditches provide hydrological and ecological services that may be lost as a result of an enclosure. The City of Port Moody (the City) retained Kerr Wood Leidal (KWL) to develop an Urban Ditch Management Strategy to aid in making decisions on ditch enclosure and compensation for loss of hydrologic function and wildlife habitat during the review of development permit applications.

This report provides the following:

- a recommendation for incorporating ditches into the City’s watercourse classification system;
- a proposed classification system for ditches within the watercourse classification system;
- a map of Moody Centre ditches with ditches classified using the proposed system;
- a gap analysis of the City’s current bylaws and policies applicable to ditches; and
- proposed strategies for ditch management.

Also, three case studies (Attachment 1) are examined to explore the potential outcomes of development and use of the ditch management strategy.

2. Background

2.1 Ditches in Moody Centre

The ditch network in Port Moody was previously more extensive than it currently is and the ditches in the area have been gradually enclosed over time in an incremental manner as lots adjacent to ditches have been developed or redeveloped. Thus, the existing ditches in the Moody Centre area are somewhat fragmented, and some ditches are isolated between sections of piped drainage or at the upper edges of the drainage catchments.

As the ditches are lost from the stormwater system, the environmental and hydrologic functions that the ditches provide and the replacement pipes do not, are also lost. The proposed ditch management strategy is intended to provide a route for the City to maintain these functions even when ditches are enclosed.

2.2 Values of Ditches in the Urban Environment

Infrastructure Value

Ditches have infrastructure value due to the hydrologic functions that they provide. Typically, development and re-development result in the enclosure of ditches with the hydraulic function of the ditches being replaced by buried pipes. However, pipes do not replace all of the hydrologic functions that ditches provide, and the changes in all of those functions should be considered when a ditch enclosure is proposed. These hydrologic and hydraulic functions include:

- **Interception and collection of runoff –** Ditches typically collect runoff from adjacent areas including adjacent impervious areas such as roads. When ditches are enclosed this function must be replaced by drainage structures such as catchbasins and inlets.
- **Conveyance –** Ditches provide conveyance of flows from one point to another. Conveyance can be provided by a pipe when a ditch is enclosed.
- **Storage –** As open channels, ditches have a larger cross-section than is required for conveyance and can provide storage of runoff in the drainage system. This storage can help to attenuate the peaks of runoff flowing from adjacent impervious surfaces.
- **Water quality treatment –** While treatment is not a primary function of ditches, the vegetation in ditches slows down the runoff flows and ditches provide an opportunity for sediment to settle out of runoff. When ditches are enclosed, this function is typically lost, as pipe systems are typically designed to drain faster and to not allow for significant settlement of sediment in the system. Some settling of sediment may occur in catchbasin or inlet sumps, but the degree of sediment removal in sumps would likely be less than the sediment removal achieved in the ditches.
- **Infiltration –** Infiltration of runoff into the subsurface soils provides volumetric capture (reduction) of runoff flows. This is a secondary function of ditches, and the magnitude of this function that a ditch provides depends on the soils underlying the ditch and how effective they are at allowing water to infiltrate and flow through the soil. This capacity of the soil to infiltrate is typically measured as hydraulic conductivity.

Ecological Value

Ditches provide important habitat for aquatic and terrestrial species in the urban environment. Depending on their substrate and the length of time that they are wetted in a year, ditches with fish-passable connections to fish-bearing watercourses can provide habitat for breeding or overwintering salmon or other fish. Where fish passage is not possible, ditches can provide food and nutrients to fish-bearing watercourses downstream. In addition to their value for fish, low gradient seasonally or permanently wetted ditches can provide breeding habitat for native (and non-native) amphibian species. If shrubs are present on the banks of ditches, they can provide nesting habitat for songbirds and cover habitat for small mammals and amphibians. Ditches can also provide movement corridors for wildlife (e.g., birds, amphibians, pollinators, etc.) allowing them to avoid unvegetated areas and encounters with vehicle traffic, humans, and other predators.

In acknowledgment of the infrastructure and ecological value of ditches, some municipalities have begun using natural asset value calculations to quantify the value of their ditches. Natural asset value assigns a dollar value to the services offered by natural infrastructure. It can be in the form of storage benefits, flood protection, stormwater services. While ditches are not entirely natural features, they do provide ecological functions that are generally not associated with piped infrastructure.

2.3 Definitions

Below is a list of key definitions for terms used for the purposes of this report:

A **watercourse** is a natural or artificial channel through which water flows.

A **stream,** as defined in both the provincial *Water Sustainability Act*, is “a natural watercourse or source of water supply, whether usually containing water or not, ground water, and a lake, river, creek, spring, ravine, swamp and gulch.” The definition of the stream found within the provincial *Riparian Areas Regulation* is generally consistent with this definition.

A **channelized** watercourse or stream, also sometimes called a modified watercourse, is a natural watercourse that has had its alignment or configuration altered by land development but still provides surface flow and aquatic habitat connectivity within a watershed. Channelized watercourses meet the definition of a stream under the *Water Sustainability Act*.

A **ditch** is any channel or water-conveying feature (i.e., watercourse) that was constructed for the purposes of stormwater or groundwater management and was not a pre-existing natural watercourse or the re-alignment of a pre-existing watercourse (see channelized watercourse above). Despite not being a pre-existing watercourse, a ditch can provide fish habitat. Some constructed ditches, such as those in floodplain areas and those that provide fish habitat, are considered streams under the *Water Sustainability Act*.

A **swale** is a type of ditch that is typically shallow and may have more gradually sloping sides than a ditch. Swales capture and convey water and allow water to infiltrate into the ground. They are generally less deeply incised into the surrounding topography than other ditches. Swales function similarly to other ditches in terms of interception and capture of surface flows but provide less storage capacity and are less likely to intercept groundwater because they are generally above the water table. Swales are not typically considered streams under the provincial *Water Sustainability Act*.

Ditches identified in the ditch mapping exercise (presented below) have been classified as either a ditch or a swale (Attachment 2) but for the purposes of discussion in this report, “ditch” will be used as a general term to describe all ditches including swales.

A **permanent watercourse** typically contains continuous surface waters or flows for periods more than 6 months in duration. A **non-permanent** watercourse typically contains surface water or flows for a period less than six months in duration and does not contain fish. **Fish habitat** means spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes. This includes watercourses that provide food and nutrients to watercourses inhabited by fish but may not contain fish themselves. Fish habitat is protected from harmful alteration, disruption, or destruction under the newly amended federal *Fisheries Act*.

Note: Certain reference documents, including City of Port Moody Official Community Plan (OCP: 2014) and Chines Watershed ISMP (2016) use the terms **stream** and **watercourse** interchangeably. This document uses the term watercourse exclusively except when referencing the title of a Port Moody document (e.g., Port Moody Stream and Drainage System Protection Bylaw)

3. Ditch Mapping and Classification

3.1 Ditch Mapping Methodology

A map of the ditches in the Moody Centre study area (Figure 1) was created using information gathered from a combination of desktop review of aerial photos, Google Streetview imagery, and field verification. Table 1 presents the information that was collected and used to classify the ditches:

Table 1: Data Collected in Ditch Mapping Exercise

Data	Values Assigned
Ditch Type	Ditch/Swale
Capture Type	Surface/Groundwater/Both
Connection to stormwater system	Yes/No
Permanence	Permanent/Non-permanent
Relative Urban Wildlife Habitat Value	Nil/Low/Moderate/High
Relative Natural Aesthetic Value	Nil/Low/Moderate/High
Relative Conveyance Value	Nil/Low/Moderate/High
Relative Infiltration Value	Nil/Low/Moderate/High
Relative Water Quality Treatment/Filtration Value	Nil/Low/Moderate/High
Relative Storage Value	Nil/Low/Moderate/High
Relative Enhancement Potential	Nil/Low/Moderate/High

Ratings of Low, Moderate and High were assigned to multiple ditch characteristics. These ratings were assigned based on the function of each ditch for each of these categories relative to all the ditches in the study area. They are based on visual observation of the ditches, interpretation of existing Google Streetview imagery, data collected during site visits, and topography.

3.2 Ditch Classification

Proposed Ditch Classification System

A two-part ditch classification system that considers both habitat value and infrastructure value is proposed. The system includes: 1) watercourse class, which considers fish habitat value and will determine which existing legislation and policy is applicable (e.g., *Fisheries Act,* City of Port Moody OCP, etc.); and 2) a ditch class that is more relevant to the infrastructure or hydrologic services the ditch provides.

Part 1: Watercourse Classes

Port Moody already uses a four-class system (Table 2) to categorize its natural and channelized watercourses. This system is proposed to be extended to include the City's ditches. This system is based on habitat value for salmon species and is similar to the system used by a number of jurisdictions in Metro Vancouver. Watercourse class can be used to determine which federal, provincial, and municipal legislation applies to a given ditch and thus what approvals are required prior to making any changes to the ditch or if enclosure of the ditch should not be pursued.

Table 2: Port Moody Watercourse Classification System

Classification	Description
Class A	Watercourses inhabited by salmonids and/or rare or endangered fish species, or potentially inhabited by such fish with access enhancement (e.g., removal of culverts).
Class A (O)	Watercourses inhabited by salmonids and/or rare or endangered fish species, during the overwintering period only, or potentially inhabited during the overwintering period, with access enhancement.
Class B	Watercourses that are a significant source or a potentially significant source of food and nutrients to downstream fish populations. These watersheds are characterized by no fish presence and no reasonable potential for fish presence through flow or access enhancement.
Class C	Watercourses that provide an insignificant contribution of food or nutrients to downstream areas supporting or potentially supporting fish populations.
(Unclassified)	Watercourses for which there is a lack of adequate fisheries or flow information to permit classification.

Note: Table 2 was copied from *Table 3-1: Watercourse Classification System* from the Chines ISMP (AE 2016). The Port Moody OCP presents a slightly different classification system in its OCP bylaw. This inconsistency is discussed in more detail in Sections 4 and 5, below.

Part 2: Ditch Type

Next, ditches can be divided into types based on primary hydrologic function. These categories relate directly to the type of infrastructure that would be required to replace their hydrologic functions. The proposed ditch types are presented in Table 3:

Table 3: Proposed Ditch Types

Ditch Type	Hydrologic Function	Description
1	Primarily Surface Capture Ditch	A ditch or swale that has a primary function to capture surface flow (e.g., a ditch that runs down a slope and that captures sheet flow from an adjacent road surface).
2	Primarily Groundwater Interception Ditch	A ditch or swale that has a primary function interception of groundwater flow (e.g., a ditch oriented across a slope on the uphill side of a road).
3	Groundwater Interception and Surface Capture Ditch	A ditch or swale that functions both to intercept groundwater and to collect surface sheet flow (e.g., a lowland ditch that intercepts groundwater from a high water table but it also adjacent to a road or parking lot and receive sheet flow).
4	Disconnected Ditch	A ditch or swale without a connection to existing stormwater pipes or a watercourse but collects, stores, and infiltrates runoff.

Ditch Categories (Watercourse Class + Ditch Type)

Ditch categories are thus a combination of watercourse class and ditch type. For example, a ditch that is a Class C watercourse and its primary hydrologic function in surface runoff capture (ditch type 2) has a combined ditch category of C-2.

Ditch categories were assigned to all Moody Centre ditches based on data collected in the field and review of existing stormwater and drainage spatial data and are shown on the Moody Centre ditch map (Figure 1). Due to gaps in the Port Moody stormwater data, determining connections of ditches to the stormwater system or to watercourses was not always possible. In some situations, a connection to a nearby Class B watercourse was assumed to exist. If these assumed connections do not exist, the ditches may be, in fact, Class C watercourses. Further investigation is required to confirm these.

NOTE: It was assumed that if a culvert inlet is present at the downstream end of a ditch, that ditch connects somehow to the Port Moody stormwater system. KWL was unable to confirm this for some ditches as available stormwater system spatial data is not complete.

Table 4 presents Ditch categories assigned to several example ditches in Moody Centre. Three ditches were selected as case studies and are described in detail in Attachment 1. These ditches are shown in bold in the table.

Table 4: Ditch Categories and Representative Examples/Case Studies

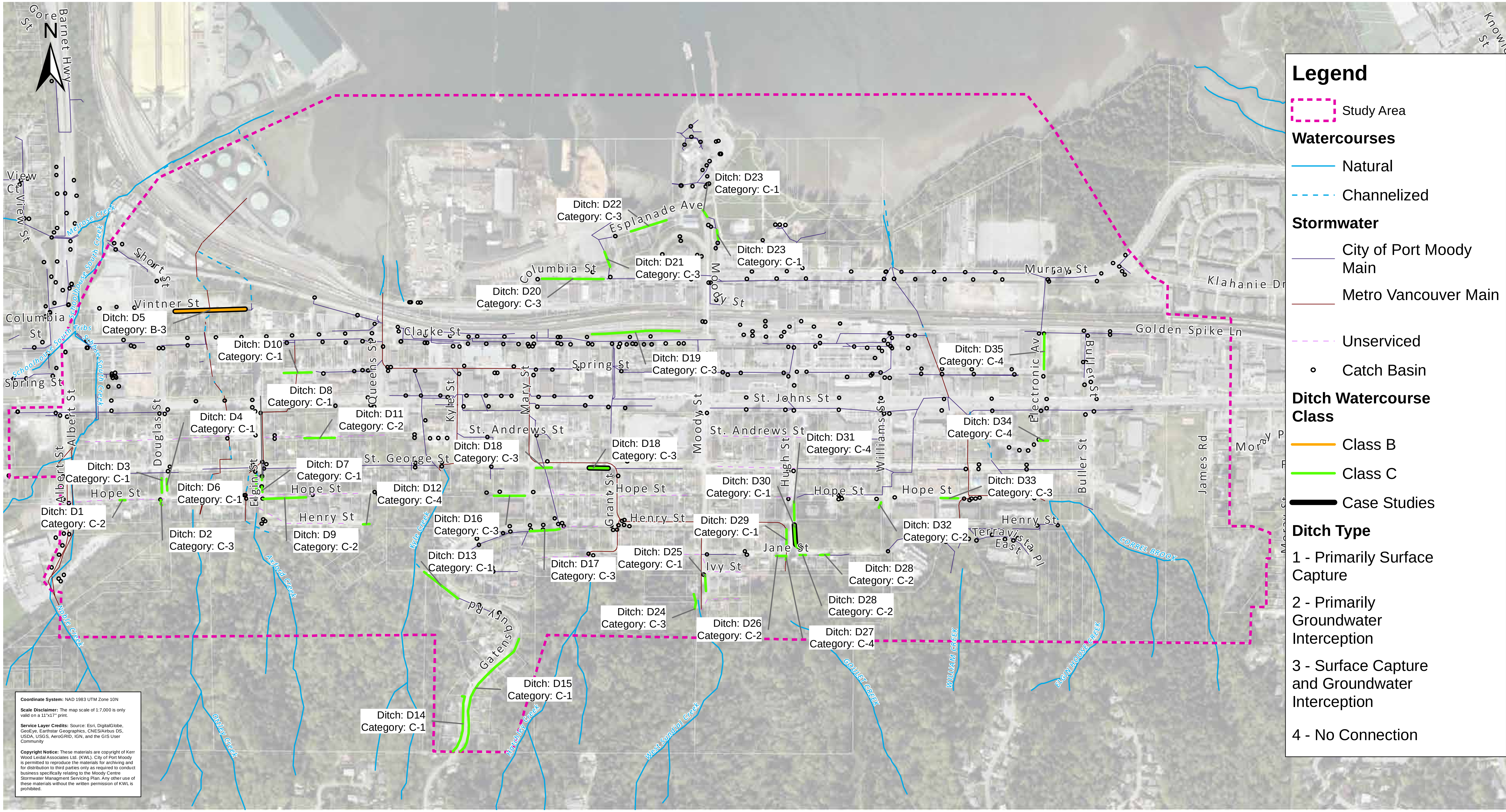
Ditch Category	Watercourse Class	Ditch Type	Representative Examples (Case Studies shown in **bold** text)
B-3	Class B	Type 3 - Groundwater Interception and Surface Capture Ditch	**Vintner St., 2200 Block, South Side**
C-1	Class C	Type 1 - Primarily Surface Capture Ditch	**Hugh St. north of Jane St., East Side** Hugh St. north of Jane St., West Side Elgin St. south of St. George St., East Side Elgin St. south of St. George St., West Side
C-2	Class C	Type 2 - Primarily Groundwater Interception Ditch	St. Andrews St. 2300 Block., South Side Hope St. 2100 Block, South Side Hope St. 2300 Block, South Side Jane St., 2900 Block, South Side
C-3	Class C	Type 3 - Groundwater Interception and Surface Capture Ditch	**St. George St., 2600 Block, South Side** Hope St., 3000 Block, South Side Murray St., 2600 Block, South Side Esplanade St., South Side
C-4	Class C	Type 4 - Disconnected Ditch	Electronic Ave. north of Spring St., East Side Hugh St. south of Jane St., West Side Hugh St. south of Hope St., East Side Henry St., 2300 Block, South Side

Path: O:\0300-0399\310-055\430-GIS\MXD-Rp\Ditch Management Strategy\310055_Fig1_DitchMap.mxd Date Saved: 2019-05-01 3:03:40 PM | Author: DBrown

City of Port Moody

Ditch Management Strategy

KERR WOOD LEIDAL consulting engineers



Project No. 310-055

Date May 2019

Scale 1:7,000

100 50 0 100 m

Moody Centre Ditch Map

Figure 1

4. Current Policy Review and Gap Analysis

A review of current legislation and policy applicable to Port Moody ditches was completed by KWL. Subsequently, a gap analysis was conducted to identify areas where current ditch management policy is lacking or could be enhanced.

4.1 Current Policy Review - Existing Legislation and Policies

Federal and Provincial Legislation

The federal *Fisheries Act* protects fish and fish habitat from destructive activities in marine and inland waters. Under the recently amended Act, it is prohibited to cause the death of fish or the harmful alteration, disruption or destruction of fish habitat, unless authorized by the federal Fisheries Minister.

The provincial *Riparian Areas Regulation* requires a Qualified Environmental Professional (QEP) to conduct an assessment and determine a Stream Protection and Enhancement Area (SPEA) for a given watercourse. A SPEA (also called a Riparian Protection and Enhancement Area; RPEA, in the Port Moody Zoning Bylaw) is an area where new development is not permitted.

The provincial *Water Sustainability Act* is intended to ensure the sustainable diversion and use of BC's freshwater resources. Approval is required to use, divert, or make changes in and about a stream (as defined above, see section 2.3).

Consistent with the definitions found in the legislation listed above, natural watercourses, channelized watercourses, and some constructed ditches, such as those in floodplain areas, are considered streams and/or fish habitat and are protected by one or more of the laws listed above.

Current Ditch Management Policy in Port Moody

As part of the policy review, the following documents were referenced:

1. City of Port Moody "Official Community Plan Bylaw", 2014;
2. City of Port Moody "Zoning Bylaw", 2018;
3. City of Port Moody "Stream and Drainage System Protection Bylaw", 2001;
4. City of Port Moody "Subdivision and Development Servicing Bylaw", 2010;
5. City of Port Moody "Third Party Utility Construction Guidebook", undated;
6. City of Burnaby Engineering Department "Street and Lane Ditch Enclosures Guidelines", undated
7. City of Burnaby "Design Criteria Manual", 2014;
8. City of Surrey "Driveway Culverts & Ditch Enclosures", 2018;
9. City of Surrey Zoning Bylaw 12000, 1993;
10. "Land Development Guidelines for the Protection of Aquatic Habitat", Department of Fisheries and Oceans, 1993;
11. Associated Engineering (AE) "Chines Integrated Stormwater Management Plan, Final Report", 2016;
12. Fisheries and Oceans "Projects near water", 2018; AND
13. Riparian Areas Regulation Assessment Methods – Schedule of Riparian Areas Regulation. (B.C. Reg. 376/2004).

Existing ditch-related policy is summarized in Table 5, below.

Table 5: Summary of existing Ditch Management-Related Policies in Port Moody

Application	Criteria/Methodology
City of Port Moody Bylaws	
Design	• Design parameters of constructed ditches (e.g. dimensions, slope, maximum flow velocity, etc.) are specified[1] • Installation of culverts is not permitted in Class A or B watercourses unless no reasonable alternatives area available[1, 4] • Culverts must be designed to accommodate 1:100 year flows[1] • Trash racks and riprap must meet specific design requirements[1] • Clean storm runoff from perimeter drains, roofs, lawn basins, ditches or interceptor trenches shall be directed to ground infiltration facilities where feasible[1]
Habitat Protection	• Riparian Protection and Enhancement Areas (RPEA) of watercourses, (including ditches) are protected in alignment with provincial *Riparian Areas Regulation* (*Riparian Areas Protection Act*). This includes "ditches".[2] • Four-category watercourse classification system is used to classify watercourses in the City. The system presented in OCP is not consistent with system used in the Chines ISMP and by other jurisdictions. Current policy covers two of the four categories (Class A and Class B)[1,4,5] • Flow in ditches may not be obstructed[3] • Prohibited material and sediment may not be discharged into the drainage systems (includes ditches)[3] • The City is committed to the application of the latest stormwater management best practices to maintain or improve biodiversity in watercourses and to meet objectives of overall improvement to watershed health[4]
Stormwater Management	• The City requires treatment of all "first-flush" waters from impervious surfaces prior to discharge for newly created parking facilities (e.g., oil water separators, treatment rain gardens)[4] • A reduction in the amount of effective (i.e., directly connected) impervious surfaces, and overall impact of urban development on watershed health, is encouraged[4] • The use of permeable pavement systems and vegetated Best Management Practices such as vegetated buffers or swales, and natural infiltration basins are required and the used of green roofs is encouraged to reduce stormwater runoff from developed sites[4]
Chines Creek ISMP	
Ditch Management	• Watercourses in the Chines Creek watershed, including several Moody Centre ditches, are classified using a four-category system (mentioned above)[5] • The ISMP recommends that if Class B watercourses are to be altered, appropriate measures must be taken to avoid harm to watershed health and offset the loss of habitat[5] • The ISMP recommends that if Class C watercourses are enclosed, their equivalent hydrologic function (e.g., conveyance, flow regulation, infiltration) should be replaced[5]

1. City of Port Moody "Subdivision and Development Servicing Bylaw", 2010
2. City of Port Moody "Zoning Bylaw" no. 2937, 2018
3. City of Port Moody "Stream and Drainage System Protection Bylaw, 2001
4. City of Port Moody "Official Community Plan Bylaw" no. 2955, 2014
5. Associated Engineering "Chines Integrated Stormwater Management Plan, Final Report", May 2016

4.2 Policy and Management Gaps

Based on the policy review, the following gaps were identified:

- Inconsistencies exist in the descriptions of the watercourse classification system used in the City's OCP and the Chines ISMP. The Classification system in the OCP omits watercourses that provide habitat for salmon in the overwintering period only (Class A(O)), and incorrectly assigns a class (Class D) to watercourses that are, by definition, unclassified (See Tables 1 and 2 in Attachment 3).
- The Zoning Bylaw does not include a description of the City's watercourse classification system.
- The Port Moody Zoning Bylaw provides recommended setbacks (RPEAs) for Class A and Class B watercourses, but not Class C. Instead of Class C, it provides recommended setbacks (RPEAs) for "ditches". This approach is flawed because not all ditches are Class C watercourses. Ditches that are Class A, A(O), or B watercourses may be protected by provincial and federal legislation and larger RPEAs that otherwise would have been assumed were not applicable.
- Several classifiable watercourses are "unclassified" in the Chines ISMP.
- The City of Port Moody OCP does not include a watercourse classification map, nor does the City's web map application (ViewPort).
- The Redevelopment and Servicing Bylaw contains requirements for Class A or Class B watercourses, but does not refer to Class A(O) or Class C watercourses.
- No ditch enclosure policy, guidelines, or bylaw exist.
- Viewport, the City's web-based mapping application, is missing data on connection of ditches and catchbasins, to stormwater mains.

5. Urban Ditch Management and Compensation Strategies

5.1 Ditch Management Goals

Based on the gaps identified above and discussion with the City regarding its vision for ditch management, a set of goals was created to guide development of potential strategies for ditch management and compensation. The goals are:

- Maintain or improve the hydrological functions provided by Port Moody ditches while maintaining or improving the ecological functions of ditches;
- Improve habitat connectivity in Port Moody for urban wildlife movement by considering and valuing ditches as a component of the ecological network; and
- Develop a clear policy for guiding decisions on ditch enclosure and compensation for lost ecological and hydrologic functions when a ditch is enclosed.

5.2 Potential Ditch Management Strategies

Potential strategies for ditch management and compensation are presented in Table 6 were identified based on the above goals and review of existing policy in Port Moody and in other jurisdictions.

Table 6: Potential Ditch Management Strategies

Actionable Strategy	Comment	Advantages	Disadvantages
Municipal Policy-related Strategies			
1. Create a consistent inventory and classification of ditches within the city			
a) Adopt two-part ditch classification system described in Section 3 of this report.	Two-part Classification System Part 1: Watercourse Class (i.e., A, A(O), B, C) Part 2: Ditch Category/Type (e.g. surface capture, groundwater interception, etc.) See Table 1 in Attachment 4	System takes into consideration existing watercourse classification system used to assess habitat value. Removes potential for development of ditches that are Class B watercourses and should not be enclosed according to existing City policy.	Two-part classification system may not be intuitive.
b) Classify and map all Port Moody Ditches.	Map ditches with LiDAR and classify with ground truthing.	Will remove uncertainty about legislative requirements for ditches. Will remove the need and cost for ditches to be assessed by developers. Will streamline the evaluation process when enclosure of or impacts to a ditch are proposed. Will remove potential for enclosure of ditches that are Class B watercourses and according to current City bylaws, should be protected.	Requires additional work to inventory and classify all ditches prior to or concurrent with development applications. May be done by a consultant or by City environmental staff.
c) Update ViewPort web map application to include all connections between ditches, catch basins, and piped drainage network.	Existing mapping available online is missing many connections between ditches and other infrastructure in the storm drainage network.	Will provide valuable information that is required to determine connection of ditches to fish habitat and thus watercourse class.	Requires effort/cost to City staff to investigate and update mapping of ditch connectivity. May require field verification.
d) Update revised watercourse classification and add watercourse classification map to the OCP that includes all ditches.	Includes natural watercourses, channelized watercourses, and ditches of all types.	Will document classification system and provide a reference for staff and public use.	Requires update to OCP.
e) Make map publicly available (OCP update, ViewPort web map application).	Include in a future update to the OCP, and as a spatial layer in ViewPort.	Will facilitate the development permit process as developers and City staff will have a quick reference to know what type of ditch they are dealing with.	Will require City staff time and effort.
2. Update bylaws to include Class C watercourses and clarify that ditches are watercourses that can be different classes			
a) Update OCP with classification system consistent with other jurisdictions and Chines ISMP.	Tables 1 and 2 in Attachment 3 show the inconsistency in the descriptions of watercourse classification systems in the PM OCP and the Chines ISMP.	This will clarify any confusion that may arise if both Chines ISMP and the City OCP are reviewed. Classification system will be consistent with other jurisdictions (i.e., City of Surrey). Professionals and others will be more familiar with the standard.	Updating bylaw requires significant effort by City staff.
b) Update Zoning bylaw to include Class A(O) and Class C watercourses and remove “ditches” from the “Minimum Riparian Management Setbacks” table.	The Port Moody Zoning Bylaw provides recommended setbacks (RPEAs) for Class A and Class B watercourses, but not Class C. Instead of Class C, it Provides recommended setbacks (RPEAs) for “ditches”.	Will remove potential for incorrect setback distance used on ditches that are Class B watercourses.	Updating bylaw requires significant effort by City staff.
c) Update Redevelopment and Servicing bylaw to include reference to Class A(O) and Class C watercourses and that ditches are classified in the same system.	The Redevelopment and Servicing bylaw contains requirements for Class A or Class B watercourses but does not refer to Class A(O) or Class C watercourses. Text should also be added to convey that that watercourse class will need to be considered prior to development.	Will provide more complete coverage of all potential watercourse classes and the required approach to development for each one.	Updating bylaw requires significant effort by City staff.

Actionable Strategy	Comment	Advantages	Disadvantages
d) Add open watercourse policy in Stream and Drainage Protection Bylaw.	The wording in this bylaw should be reconciled with references to enclosure of watercourses in the Redevelopment and Servicing bylaw and references to daylighting watercourses in the OCP.	Recognizes that ditches, as open watercourses, provide ecological benefits not provided by piped systems.	Updating bylaw requires significant effort from City staff.
3. Adopt enhancement or no net loss policy for hydrological and ecological function of ditches			
a) Require that hydrological and ecological function be maintained or improved for any watercourse, including Class C watercourses (ditches) where development is proposed. Compensation options to be listed in Development Permit Application guidelines.	Would require quantification of hydrological and ecological functions and determination of equivalency of these functions in the proposed replacement infrastructure (i.e., compensation infrastructure).	Will result in maintained or improved ecological function of City's drainage system.	Would require effort (by developer) to determine equivalency and there may be uncertainty or disagreement about equivalency.
b) If strategy component 1 b) is not done, or if it is done, to confirm ratings assigned by the City, require habitat assessment by QEP of ditches prior to development (as part of development permit application).	A habitat assessment completed by a QEP would involve characterization of the existing habitat and assessment of habitat function.	Ensures habitat value is considered in development process.	Cost for developers.
4. Consider the potential of ditches as movement corridors for urban wildlife and their suitability for inclusion in the City's Environmentally Sensitive Areas (ESA) Development Permit Area, or inclusion in a future ecological network			
a) Include ditches in. City's ecological network.	This will ensure their ecological value is considered in development.	Will acknowledge ecological value of ditches.	Will require City staff time and effort.
b) Update OCP ESA map to include (a) and (b) above.	Keep ESA map current.	Will document updated extent of ESAs and make reference to them easily accessible.	Will require City staff time and effort.
Municipal Process-related Strategies			
5. Establish guidance for ditch enclosure planning/design			
a) Create a "Construction near watercourses" guide/pamphlet similar to City of Surrey's.	Guide will explain the watercourse classification system, and the legislated/policy requirements for each watercourse class. Guide will refer developers and consultants to applicable City policy and guidance documents. Guide could describe green infrastructure requirements, culvert requirements, etc.	Will help make the process transparent and reduce confusion for applicants. Will make assessment of applications easier for city staff.	Will require a consultant to develop the guide, or City staff time and effort.
b) Develop a list of compensation measures (i.e., grey or green infrastructure) needed to replace ecological and hydrological functions of a given ditch category/type.	This list is provided in Table 2 in Attachment 4.	Will provide a starting point for developers and reduce time spent on investigating potential options. May be revised and updated as City staff develop preferences for types or approaches of compensation.	Will require ongoing effort keep current new infrastructure types and City preferences.
c) Implement a ditch replacement hierarchy for guiding re-development options and require justification if top priority options cannot be done.	Proposed hierarchy is as follows: 1. Avoid replacement and improve ecological function. 2. Replace with green infrastructure. 3. Replace with a combination of green infrastructure and grey infrastructure. 4. Replace with grey infrastructure.	Will provide a system to encourage installation of green infrastructure.	May face resistance from developers as green infrastructure may require higher cost and effort.

Actionable Strategy	Comment	Advantages	Disadvantages
6. Establish a ditch enclosure permitting process			
a) Develop a ditch evaluation process/checklist for case-by-case assessment, decision-making, and compensation. This would include assessing habitat value/function and hydrological value/function and reviewing options for replacing or improving these values.	Possible checklist is as follows: a) Determine or confirm if the ditch is considered a Fisheries protected watercourse (i.e., Class A, A(O), or B). b) Determine drainage pattern within the area. c) Determine capacity of the existing system. d) Determine drainage history of the area. e) Determine potential impacts due to the infill. f) Determine City's Stormwater Servicing Plan.	Will help make the process transparent and reduce confusion for applicants. Will make assessment of applications easier for City staff (i.e., have all boxes been checked? yes or no).	Will require consultant or City staff time and effort to develop a checklist for determining ditch enclosure compensation.
b) Consider specifying existing ditches or areas of the city where ditch enclosure may be minimized.	Would list ditches with high hydrological or ecological value where enclosure is not allowed.	Will provide protection for specific areas.	Will require City staff time and effort to determine which ditches or areas should be so identified.
c) Update subdivision and servicing bylaw to incorporate standard ditch design details.	Would provide standard for design of ditches.	Will provide guidance for ditch design and result in consistent ditch design.	Will require City staff time and effort to update bylaw.
Education and outreach			
7. Increase knowledge of City staff that ditches are watercourses with ecological benefits and are potentially fish habitat			
a) Do internal workshop for planning, engineering, inspections, and operations staff.	Would present "Construction Near Watercourses" guide and provide all relevant information on ditch classification and enclosure.	Allow for consistency in approach to redevelopment of ditches. Create awareness that ditches can be fish habitat and have ecological and hydrological values.	City staff or consultant effort required to present workshop.
8. Increase public knowledge of the importance of ecological connectivity, the value of green infrastructure, and the services provided			
a) Create a document or web page on the City's website outlining the ditch enclosure application process.	Will allow for easy access to ditch enclosure guidance for developers, property owners, and City staff. Reference "Construction near Watercourses" document on City's website.	Will help make the process transparent and reduce confusion for applicants. Will reduce time spent by City staff on incorrectly completed applications.	Effort required to add to website and maintain.
a) Require educational signage where green infrastructure projects have been completed	Signs would describe projects, explain benefits of green infrastructure, provide recommendations for residents to do their part to improve city drainage (e.g., keep catch basin inlets free of leaves, minimizing impervious surfaces on their property, avoiding dumping deleterious substances into storm system).	Will promote green infrastructure and demonstrate that the City considers it important.	Some cost to project; possible additional cost for maintenance of signs.
b) Publish information about green infrastructure projects on the City's website.	Will expand on information provided on signage and could include web links to ditch enclosure guidance.	Will promote green infrastructure and demonstrate that the City values it. Will increase ease of access to information about ditch enclosure.	Effort required to add to website and maintain.

5.3 Near-term Priorities

Of the strategies proposed above, the following are recommended as priorities for near-term implementation:

1) Strategy 1: Create a consistent inventory and classification of ditches within the city.
2) Strategy 2: Update bylaws to include Class C watercourses and clarify that ditches are watercourses that can be different classes.
3) Strategy 5: Establish guidance for ditch enclosure planning and design.
4) Strategy 6: Establish a ditch enclosure permitting process.

These strategies form the foundation for future implementation of the full set of proposed strategies. They represent the core strategies that will directly inform and affect decisions regarding development requests that propose changes to the City's ditches.

Submission

We trust that the enclosed information meets your requirements. If you have any questions, please do not hesitate to contact the undersigned at dbrown@kwl.ca or 604-349-5988.

Prepared by:

Daniel Brown, B.Sc., B.Tech., B.I.T.
Biologist

Reviewed by:

COLLEGE OF APPLIED BIOLOGY
Patrick Lilley
OCTOBER 4, 2019
R.P. Bio
#1969
CAB

Patrick Lilley, M.Sc., R.P.Bio., BC-CESCL
Senior Biologist

Attachments: Attachment 1: Case Studies
Attachment 2: Ditch Mapping Data Table
Attachment 3: Watercourse Classification System Inconsistencies
Attachment 4: Ditch Category Tables & Legislation and Policy Application

Statement of Limitations

Copyright Notice

Revision History

Revision #	Date	Status	Revision Description	Author
0	October 4, 2019	Final	Issued as final for client.	DRB

OQM CERTIFIED

References

Associated Engineering (AE). 2016. Chines Integrated Stormwater Management Plan, Final Report. Prepared for the City of Port Moody, The City of Coquitlam and Metro Vancouver.

City of Burnaby Engineering Department. Undated. Street and Lane Ditch Enclosures Guidelines. 2pp.

City of Burnaby Engineering Department. 2014. Design Criteria Manual. Accessed November 2018. URL https://www.burnaby.ca/Assets/our+city+hall/city+departments/engineering/Engineering+Design+Criteria.pdf

City of Port Moody. Undated. Third Party Utility Construction Guidebook. Accessed November 2018. URL http://www.portmoody.ca/modules/showdocument.aspx?documentid=14533

City of Surrey. 2018. Driveway Culverts & Ditch Enclosures. Accessed October 2018. URL https://www.surrey.ca/city-services/3644.aspx

Erickson. A., Weis. P, Gulliver.,J. 2013. Optimizing Stormwater Treatment Practices. Springer Science+Business Media. New York. 337 pp.

Fisheries and Oceans (DFO). 1993. Land Development Guidelines for the Protection of Aquatic Habitat. Accessed October 2018. URL http://www.dfo-mpo.gc.ca/Library/165353.pdf

Fisheries and Oceans (DFO). 2018. Projects near water. Accessed October 2018. URL http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html

Molnar. M., 2018. Natural Asset Management is Proving its Value in the Field. Accessed October 2018. URL https://davidsuzuki.org/expert-article/natural-asset-management-is-proving-its-value-in-the-field/

Riparian Areas Regulation. B.C. Reg. 376/2004. Schedule: Riparian Areas Regulation Assessment Methods. Accessed October 2018. URL https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/rar_assessment_methods.pdf

Attachment 1

Case Studies

Case Study 1: Vintner St., 2200 Block, South Side

Ditch Category B-3 (Class B Watercourse - Groundwater Interception and Surface Capture Ditch)

Description

The Vintner St. 2200 Block, south side ditch is oriented east to west and is directly connected to Ottley Creek (Class B watercourse) via a surface connection. The ditch runs perpendicular to Ottley Creek, which flows north under Vintner St. towards Burrard Inlet. Because of its surface connection to Ottley Creek this ditch is also considered a Class B watercourse. This situation where a ditch is directly connected to a channelized watercourse represents a unique situation in Moody Centre but may be present elsewhere in Port Moody.

Vintner St. Ditch, Behind 2218 Clarke St.
View looking East

Vintner St. Ditch, Behind 2222 Clarke St.
View looking West

Ecological and infrastructure services provided

From a hydrological perspective, this ditch is providing groundwater interception, surface water capture from the adjacent road and driveways, storage, and infiltration of stormwater.

This ditch contributes significant nutrients to downstream fish habitat. The ditch is not permanently wetted, and water quality treatment value is low. Habitat quality for urban wildlife is low here due to the low amount of vegetative cover.

Issues triggered by the development process

According to Port Moody policy (Subdivision and Servicing Bylaw, Official Community Plan Bylaw) this ditch may not be enclosed without approval from all applicable federal and provincial authorities as well as city council. If enclosure of this ditch was pursued, habitat offsetting would likely be required by the *Fisheries Act*.

In addition to habitat offsetting, the groundwater interception, surface water capture functions, infiltration and storage capacity of this ditch would need to be replaced.

If the ditch is enclosed in a pipe, the pipe will provide conveyance of flows. An infiltration trench with an overflow/perforated pipe system can be used instead of a pipe alone in order to replace the infiltration capacity of the ditch. Inlet structures will need to be provided to intercept surface flows and direct them into the pipe.

Storage could also be provided in an infiltration facility. The volume of storage needed should be evaluated to determine if the volume can be accommodated in an infiltration facility or if additional storage would be necessary. An open chamber infiltration gallery could be used instead of a rock-filled infiltration trench in order to provide greater storage volume.

Policy or management gaps encountered

Class B watercourses are well-covered by existing policy. They are protected by the federal *Fisheries Act* and provincial *Water Sustainability Act* and *Riparian Areas Regulations*. The Port Moody OCP requires approval from City Council prior to enclosure of Class B watercourses. Also, the City's Subdivision and Development Servicing Bylaw prohibits installation of culverts on these watercourses (ditches). The City's Zoning Bylaw provides required RPEA setbacks for Class B watercourses.

There is, however, an existing ditch management gap. Publicly available Port Moody mapping does not include the watercourse class of ditches (and other watercourses) within its jurisdiction. If this information was easily accessible, it would facilitate determination of watercourse class of ditch and thus feasibility of enclosure.

Potential outcomes

Due to its surface connection to Ottley Creek, this ditch provides an excellent opportunity for enhancement. While it is Class B, it could be improved to have a more beneficial impact on downstream fish habitat as well as stormwater management.

Alternatively, this ditch could be enclosed, but habitat loss will have to be offset as per the *Fisheries Act* as well as any stormwater management functions replaced.

Case Study 2: Hugh St. North of Jane St., East Side

Ditch Category C-1 (Class C Watercourse – Primarily Surface Capture Ditch)

View Looking North along Hugh Street from Jane St.

View Looking North along Hugh Street from Jane St.

Description

This ditch is oriented downslope on the east side of Hugh St. It captures surface runoff from Jane St., Hugh St., and Ava Park. The grass-covered ditch conveys captured stormwater into the stormwater system through a vertical grated inlet at its downstream end.

Ecological and infrastructure services provided

This ditch has limited habitat value for urban wildlife. There is no woody vegetation to provide cover for small animals or nesting habitat for birds. This ditch is not permanently wetted and does not provide a significant source of nutrients to downstream fish habitat. It is thus considered a Class C watercourse.

The main stormwater function of this ditch is surface water capture. It is also a permeable surface allowing stormwater infiltration. It does not provide significant storage value due to its slope and provides some water quality treatment.

Issues triggered by the development process

Removing this ditch would remove stormwater capture, infiltration, and water quality treatment functions.

Because of its limited habitat value, the main issues associated with development of this ditch are related to stormwater management. Because it is a Class C watercourse, enclosure of this ditch would not require authorization under the *Fisheries Act*.

Policy or management gaps encountered

According to the Port Moody Zoning Bylaw, a minimum 5 m RPEA exists on either side of ditches. The bylaw does not consider the watercourse class of ditch when offering this setback distance.

Apart from this, no policy currently exists for management of these ditches or compensation for their enclosure.

Potential outcomes

This particular ditch is located within a City-owned right-of-way and is adjacent to Ava Park. There is high potential for the green infrastructure value of this site to be enhanced. The existing ditch currently captures surface runoff but has limited values for water quality treatment, infiltration, or wildlife habitat value. Enhancement of this ditch could take the form of redevelopment as a bio-swale with additional vegetation, engineered growing media, and an underdrain system, or as an underground stepped infiltration system with inlets to collect runoff from the paved street areas.

Alternatively, this ditch could be enclosed and catch basins and curbs installed on the sides of Hugh St. to direct stormwater into the stormwater pipe. The catchbasins would need to be designed with sumps to capture sediment and the City would need to plan a maintenance program to clean sediment from the catchbasin sumps on a regular basis. This would not result in the addition of any green infrastructure values.

Case Study 3: St. George St. 2600 Block, South Side

Ditch Category C-3 (Class C Watercourse – Groundwater Interception and Surface Capture Ditch)

St. George St. and Grant St. View Looking West

View Looking East Towards St. George St. and Grant St.

Description

This roadside ditch is oriented east to west across a shallow slope. It intercepts groundwater moving downslope and captures surface flow from St. George St. which is then conveyed into the stormwater system via what appear to be grated manhole covers.

Ecological and infrastructure services provided

This ditch intercepts groundwater and captures surface flow, reducing sheet flow across St. George St. The ditch also provides some infiltration capacity and is expected to have some water quality treatment function.

This Class C ditch provides limited urban wildlife habitat value. It is vegetated with mowed grasses and does not offer cover habitat for small animals or nesting habitat for birds. The ditch is not permanently wetted and does not provide significant nutrients to fish habitat downstream.

Issues triggered by the development process

Because it is a Class C watercourse, an authorization is not required under the *Fisheries Act* to enclose it. Development/enclosure of this ditch would require consideration of the ditch's stormwater function and provide an equivalent function.

Policy or management gaps encountered

According to the Port Moody Zoning Bylaw, a minimum 5 m RPEA exists on either side of ditches. The bylaw does not consider the watercourse Class of ditch when offering this setback distance.

Apart from this, no policy currently exists for management of these ditches or compensation for their enclosure.

Potential outcomes

This ditch is located within the St. George St. right-of-way. There is potential for the green infrastructure value of this site to be enhanced. The existing ditch currently captures surface runoff but does not offer much in terms of water quality treatment, or urban wildlife habitat value. Enhancement of this ditch could take the form of a roadside rain garden or bio-swale that provides a similar conveyance and storage function to the existing ditch but would provide increased infiltration, treatment and habitat value.

Alternatively, this ditch could be enclosed and catch basins and curbs installed on the sides of St. George St. to direct stormwater. A perforated pipe may be needed to intercept groundwater, but the value of this should be reviewed and confirmed prior to design. This action would require installation of pipe large enough to meet the required capacity. In this scenario, a minimum level of water quality treatment should be provided by ensuring that all catchbasins have a sump for settling out particulate and that the City has a maintenance program for cleaning out the sediment from catchbasin sumps. If the road is expected to see increased traffic overt time due to development or re-development, grit or high-velocity separators would increase the treatment level vs. catch basin sumps. This approach would not result in the addition of any green infrastructure values.

Attachment 2

Ditch Mapping Data Table

Ditch ID	Ditch Name	Drainage Type	Capture Type	Stormwater Connection	Permanence	Relative Habitat Value	Relative Natural Aesthetics Value	Relative Conveyance Value	Relative Infiltration Value	Relative Water Quality Treatment / Filtration Value	Relative Storage Value	Relative Enhancement Potential	Ditch Category	Watercourse Class	Ditch Type
D1	Hope St. 2100 Block South Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Low	C-2	Class C	2. Primarily Groundwater Interception
D2	Douglas St. South of Hope St. West Side	Swale	Surface and Groundwater	Yes	Non-permanent	Moderate	Moderate	High	Nil	Low	Nil	Nil	C-3	Class C	3. Surface Capture and Groundwater Interception
D3	Douglas St. South of St. George St. West Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Moderate	C-1	Class C	1. Primarily Surface Capture
D4	Douglas St. South of St. George St., East Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Moderate	C-1	Class C	1. Primarily Surface Capture
D5	Vinter St. 2200 Block, South Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Low	Low	Moderate	Low	Moderate	Low	High	B-3	Class B	3. Surface Capture and Groundwater Interception
D6	Elgin St. South of St. George St., West Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Low	C-1	Class C	1. Primarily Surface Capture
D7	Elgin St. North of Hope St., East Side	Ditch	Surface	Yes	Non-permanent	Nil	Nil	High	Nil	Nil	Nil	Moderate	C-1	Class C	1. Primarily Surface Capture
D8	Elgin St. South of St. George St., East Side	Swale	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Low	C-1	Class C	1. Primarily Surface Capture
D9	Hope St. 2300 Block South Side	Ditch	Groundwater	Yes	Non-permanent	Moderate	Low	High	Nil	Low	Nil	Low	C-2	Class C	2. Primarily Groundwater Interception
D10	Spring St. 2300 Block, South Side	Ditch	Surface	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Low	High	C-1	Class C	1. Primarily Surface Capture
D11	St. Andrews St. 2300 Block. South Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Low	C-2	Class C	2. Primarily Groundwater Interception
D12	Henry St. 2300 Block South Side	Ditch	No Connection	No	Non-permanent	High	High	Low	Nil	Low	Nil	Nil	C-4	Class C	4. No Connection
D13	Gatensbury Road West of Noble Ct., West Ditch,	Ditch	Surface	Yes	Non-permanent	Nil	Low	High	Nil	Nil	Low	Low	C-1	Class C	1. Primarily Surface Capture
D14	Gatensbury Road at Coquitlam Boundary, West Side	Ditch	Surface	Yes	Non-permanent	Nil	Nil	High	Nil	Nil	Nil	High	C-1	Class C	1. Primarily Surface Capture
D15	Gatensbury Road at Coquitlam Boundary, East Side	Ditch	Surface	Yes	Non-permanent	Nil	Nil	High	Nil	Nil	Nil	High	C-1	Class C	1. Primarily Surface Capture
D16	Hope St. 2500 Block, South Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Low	Moderate	C-3	Class C	3. Surface Capture and Groundwater Interception
D17	Henry St. 2600 Block South Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Moderate	Moderate	High	Nil	Moderate	Low	Moderate	C-3	Class C	3. Surface Capture and Groundwater Interception
D18	St. George St. 2600 Block, South Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Low	Low	Low	Low	Low	Low	Low	C-3	Class C	3. Surface Capture and Groundwater Interception
D19	Clark St. 2700 Block, North Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Moderate	Moderate	Moderate	Low	Low	Low	Low	C-3	Class C	3. Surface Capture and Groundwater Interception
D20	Murray St. 2600 Block, South Side	Ditch	Surface and Groundwater	Yes	Permanent	Low	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	C-3	Class C	3. Surface Capture and Groundwater Interception
D21	Esplanade St. at Columbia St., West Side	Ditch	Surface and Groundwater	Yes	Permanent	Low	Low	High	Nil	Low	Low	Moderate	C-3	Class C	3. Surface Capture and Groundwater Interception
D22	Esplanade St. South Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Low	High	C-3	Class C	3. Surface Capture and Groundwater Interception
D23	Rocky Point Park, East of Moody St.	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Moderate	Low	Nil	C-1	Class C	1. Primarily Surface Capture
D24	Moody St. South of Ivy St., West Ditch	Ditch	Surface and Groundwater	Yes	Non-permanent	High	High	High	Nil	Moderate	Low	Nil	C-3	Class C	3. Surface Capture and Groundwater Interception
D25	Moody St. South of Ivy St., East Side	Swale	Surface	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Nil	Moderate	C-1	Class C	1. Primarily Surface Capture
D26	Jane St 2800 Block, South Side	Swale	Groundwater	Yes	Non-permanent	Nil	Nil	Nil	Low	Low	Nil	Nil	C-2	Class C	2. Primarily Groundwater Interception
D27	Hugh St. South of Jane St., West Side	Swale	No Connection	No	Non-permanent	Moderate	Low	Nil	Nil	Nil	Nil	Nil	C-4	Class C	4. No Connection
D28	Jane St. 2900 Block South Side	Ditch	Groundwater	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Low	Low	C-2	Class C	2. Primarily Groundwater Interception
D29	Hugh St. South of Henry St., West Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Moderate	C-1	Class C	1. Primarily Surface Capture
D30	Hugh St. South of Henry St., East Side	Ditch	Surface	Yes	Non-permanent	Low	Low	High	Nil	Low	Nil	Moderate	C-1	Class C	1. Primarily Surface Capture
D31	Hugh St. South of Hope St. East Side	Swale	No Connection	No	Non-permanent	Nil	Nil	Moderate	Nil	Nil	Nil	Nil	C-4	Class C	4. No Connection
D32	Ava Park, North East Corner	Swale	Surface	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Nil	Moderate	C-2	Class C	2. Primarily Groundwater Interception
D33	Hope St. 3000 Block South Side	Ditch	Surface and Groundwater	Yes	Non-permanent	Low	Low	Moderate	Low	Low	Moderate	Moderate	C-3	Class C	3. Surface Capture and Groundwater Interception
D34	St. Andrews St. 3100 Block, South Side	Swale	No Connection	No	Non-permanent	Low	Low	Nil	Low	Low	Nil	Low	C-4	Class C	4. No Connection
D35	Electronic Ave. North of Spring St., East Side	Ditch	No Connection	No	Non-permanent	Low	Low	Nil	Moderate	Nil	High	Moderate	C-4	Class C	4. No Connection

KERR WOOD LEIDAL
consulting engineers

Attachment 3

Watercourse Classification System Inconsistencies

Watercourse Classification Inconsistencies

Tables 1 and 2 are presented to demonstrate the inconsistency between the two descriptions of the City of Port Moody's watercourse classification system, in the Chines Integrated Stormwater Management Plan and the City's Official Community Plan respectively.

Table 1 reflects the more commonly used system that is used by the City of Surrey and is commonly used by Environmental Professionals in BC.

Table 2 Does not include Class A(O) ditches, which are occupied by overwintering salmon only. It also Considers Unclassified ditches as Class D. This is inappropriate as by definition a class cannot be Assigned to a watercourse where "there is a lack of adequate fisheries or flow information to permit classification."

Table 1: Chines ISMP Watercourse Classification System (same as City of Surrey)

Classification	Description
Class A – Solid red	Watercourses inhabited by salmonids and/or rare or endangered fish species, or potentially inhabited by such fish with access enhancement (e.g. removal of culverts).
Class A (O) – Red dashed	Watercourses inhabited by salmonids and/or rare or endangered fish species, during the overwintering period, or potentially inhabited during the overwintering period, with access enhancement
Class B - Yellow	Watercourses that are a significant source or potentially significant source of food and nutrients to downstream fish populations. These watersheds are characterized by no fish presence and no reasonable potential for fish presence through flow or access enhancement. These watercourses are characterized by no fish presence and no reasonable potential for fish presence through flow or access enhancement.
Class C - Green	Watercourses that provide an insignificant contribution of food or nutrients to downstream areas supporting or potentially supporting fish populations.

Table 2: Port Moody OCP Watercourse Classification System

Classification	Description
Class A	Watercourses inhabited by salmonids and/or rare or endangered fish species, or potentially inhabited by such fish with access enhancement (e.g. removal of culverts).
Class B	Watercourses that are a significant source or potentially significant source of food and nutrients to downstream fish populations. These watersheds are characterized by no fish presence and no reasonable potential for fish presence through flow or access enhancement. These watercourses are characterized by no fish presence and no reasonable potential for fish presence through flow or access enhancement.
Class C	Watercourses that provide an insignificant contribution of food or nutrients to downstream areas supporting or potentially supporting fish populations.
Class D	Watercourses for which there is a lack of adequate fisheries or flow information to permit classification.

Attachment 4

Ditch Category Tables & Legislation and Policy Application

Table 1: Watercourse Classification and Legislation and Current Port Moody Policy Application

Watercourse Classification	Habitat Function	Compensation as per Senior Level Legislation & City
Class A, A(O), B	Fish Habitat Provide habitat for salmon species Can provide habitat for amphibians and birds, both aquatic and riparian. Provide movement corridor for urban wildlife	*Fisheries Act:* request for review and habitat offsetting likely required *Riparian Areas Regulations:* Riparian area setbacks in place (see Port Moody Zoning Bylaw, requires update to include Class A(O)) *Water Sustainability Act*: Approval under the act may be required if the ditch is a natural watercourse or a modified natural watercourse. Port Moody Policy discourages enclosure of these watercourses (Subdivision and Development Servicing Bylaw, Official Community Plan Bylaw)
Class C	Not considered fish habitat Depending on vegetation present can provide habitat for amphibians and birds. Provide movement corridor for urban wildlife	*Riparian Areas Regulation:* Riparian area setbacks in place (Port Moody Zoning Bylaw requires update to include Class C) *Water Sustainability Act*: Approval under the act may be required if the ditch is a natural watercourse or a modified natural watercourse.No Port Moody Policy currently existing for Class C watercourses See proposed strategies in Ditch Management Strategy, Table 6.

Table 2: Ditch Types and ompensation Options

Ditch Type	Hydrologic Function	Description	Compensation – Replacement Infrastructure Options
1	Primarily Surface Capture Ditch	A ditch or swale that's primary function is to capture surface flow. (e.g., a ditch that runs down a slope and that captures sheet flow from an adjacent road surface)	**To Replace Water Quality Treatment:** • Direct flows to Rain Garden or Bioswale • Direct flows to tree wells/Soil Cells • Incorporate structural stormwater treatment units in system • Cash in lieu is permitted **To Replace Infiltration/Volume Reduction:** • Infiltration from the surface through Rain Garden or Bioswale • Infiltration into the sub-surface from tree well, infiltration gallery, or soakaway trench • Attenuation of flows through storage and slow-release from a storage tank or chamber Cash in lieu is permitted **To Replace Collection and Conveyance:** • Storm pipe with inlets and catchbasins
2	Primarily Groundwater Interception Ditch	A ditch or swale that's primary function is interception of groundwater flow. (e.g. a ditch oriented across a slope on the uphill side of a road)	**To Replace Infiltration/Volume Reduction:** • Perforated pipe to allow collection and/or infiltration of groundwater • Cash in lieu is permitted **To Replace Collection and Conveyance:** • Storm pipe – may be perforated to collect groundwater - with inlets and catchbasins for collecting surface flows
3	Surface Capture and Groundwater Interception Ditch	A ditch or swale that functions both to intercept groundwater and to collect surface sheet flow (e.g. a lowland ditch that intercepts groundwater from a high-water table but it also adjacent to a road or parking lot and receive sheet flow)	**To Replace Water Quality Treatment:** • Direct flows to Rain Garden or Bioswale • Direct flows to tree wells/Soil Cells • Incorporate structural stormwater treatment units in system • Cash in lieu is permitted **To Replace Infiltration/Volume Reduction:** • Infiltration from the surface through Rain Garden or Bioswale • Infiltration into the sub-surface from tree well, infiltration gallery, or soakaway trench • Cash in lieu is permitted

Ditch Type	Hydrologic Function	Description	Compensation – Replacement Infrastructure Options
			<u>To Replace Collection and Conveyance:</u> • Storm pipe with inlets and catchbasins • Use perforated storm pipe if groundwater is a concern and treatment is via structural units
4	Disconnected Ditch	A ditch or swale without a connection to existing stormwater pipes or a watercourse but collects, infiltrates, and may store surface runoff	**<u>To Replace Water Quality Treatment:</u>** • Direct flows to Rain Garden • Direct flows to tree wells/Soil Cells • Incorporate structural stormwater treatment units in system • Cash in lieu is permitted **<u>To Replace Infiltration/Volume Reduction:</u>** • Infiltration from the surface through Rain Garden • Infiltration into the sub-surface from tree well, infiltration gallery, or soakaway trench • Cash in lieu is permitted **<u>To Replace Storage:</u>** • Replace storage provided in ditch with storage in rain garden or infiltration system • Replace storage with an attenuation tank with slow release directed to storm drainage network