OPUS

SQUAMISH

District of Squamish

Sanitary Sewer Master Plan

Final Report

March 20, 2018

OPUS

SQUAMISH

District of Squamish

Sanitary Sewer Master Plan

Prepared By:

Fofo Deng-Ke Fan, E.I.T.

PROFESSIONAL PROVINCE OF C. W. LEUNG # 41265 BRITISH COLUMBIA ENGINEER March 21, 2018

Reviewed By:

Clive Leung, P.Eng.

Approved for Release By:

Paramjeet Mankoo, C.Eng.

Opus International Consultants (Canada) Ltd.
North Vancouver Office
210-889 Harbourside Drive
North Vancouver BC V7P 3S1
Canada

Telephone: +1 604 990 4800
Facsimile: +1 604 990 4805

Reference: D-03692.00
Current Version: Final

Previous Version(s): Final Draft – October 16, 2017
First Draft – March 21, 2017

Third Party Disclaimer

Executive Summary

Introduction

The District of Squamish (District) currently provides wastewater collection services to a population of 19,512 residents (2016 Census) as well as a number of Squamish Nation Reserves. As the District continues to face increasing development pressures and issues relating to aging infrastructure, the development of a comprehensive Sanitary Sewer Master Plan (SMP) is critical to help understand the system's current capacity and identify the required improvements to accommodate rapid growth in Squamish.

In 2015, the District commissioned Opus International Consultants (Canada) Ltd. (Opus) to undertake this master planning study with the primary objective of developing a prioritized Improvement Works Plan for the District's sanitary sewer system to guide planning efforts for the next 33 years (until 2050).

Growth Planning

The design horizon for this master plan is between 2015 and 2050, with a residential population increase from approximately 19,000 to 52,000 over the 35-year period (~2.9% per annum) – beyond that of the District's Official Community Plan. This SMP considers the 2050 buildout of Squamish and includes all the proposed developments, known to the District at the time of writing, slated to occur. Notable developments include the Waterfront Landing and Squamish Oceanfront Developments in Downtown, the Cheema (DL 509/510), Garibaldi Springs (2100 Newport Ridge Drive), and Holborn Group (DL 510/511) Developments in the Tantalus Road area, the Cheekeye River Development in Brackendale, and industrial developments at the Rail Marshalling Yard in the Industrial Park. Finally, densification by way of infill developments in Garibaldi Highlands, Garibaldi Estates, and Dentville have also been included in this SMP.

Sanitary Sewer System

The District currently owns and operates a sanitary-only sewer collection system that consists of approximately 98 km of gravity sewers, 22 lift stations with 12 km of forcemains, and the Mamquam Wastewater Treatment Plant (WWTP). Over the past 5-year period, the District has systematically completed CCTV inspections for the entire gravity sewer network to better understand its conditions and to help identify sources of inflow and infiltration (I&I). The vast majority of the gravity sewers are in good condition – with more than 85% of them having a PACP score of less than 3.

I&I Reduction/Monitoring

Having already completed flow monitoring and CCTV inspection for the entire sanitary sewer network, plus vapour testing and manhole testing for most of the network, the District is currently in the process of implementing the manhole and sewer rehabilitation programs developed between 2014 and 2016. To assist the District in prioritizing which areas to focus on, Opus completed a catchment-level I&I assessment, which incorporated findings from previous CCTV inspections, smoke testing, manhole condition inspections, and flow monitoring activities, and found Downtown and East Brackendale to be the highest priority for I&I reduction efforts. This SMP identifies further monitoring and inspection activities, including groundwater level monitoring, to evaluate the effectiveness of the rehabilitation programs and to better identify the most appropriate measures for I&I reduction moving forward.

System Capacity Assessment

Opus built and calibrated a hydraulic model of the District's sanitary sewer system in PCSWMM. It was used to identify capacity issues in the system and to verify proposed improvement projects. No major issues are anticipated for the 2015 scenario – minor surcharging of gravity sewers is predicted only at Scott Crescent immediately upstream of the Scott lift station.

Under the buildout (2050) scenario however, 7.1 km of gravity sewers, mainly the 350 mm Government Road/Meadow Avenue sewers in Brackendale and the 250 mm Tantalus Road sewers, are deficient. Also, deficient under the 2050 buildout scenario are six (6) lift stations: North Yards, Centennial, Easter Seal, Buckley, Queens Way, and Mamquam (SM11). These deficient assets cause sewage to back up into the upstream network and, in extreme cases, manholes to overflow – a total of 16 manholes are expected to overflow due to these deficient assets.

Capital Projects

A total of nine (9) gravity sewer and seven (7) lift station and forcemain projects are recommended in this SMP to address the capacity deficiencies identified our assessments. In addition, we have also identified nine (9) O&M projects to enhance operations of the District's sewer utility moving forward. The total capital cost for implementing these Capital Projects is approximately **$15.6 million** (2017 Canadian Dollars), $10.6 million (68%) of which is attributed to growth-related improvement works.

The critical projects to implement in the short term (2017-2021) include sewer upgrades along Tantalus Road and the construction of a new Chief View Road Highway Crossing to alleviate the bottleneck that currently exists. Major projects recommended for implementation after 2021 include the Easter Seal lift station gravity bypass and, the Queens Way forcemain twinning. The capital cost of these major projects is approximately $5.7 million, which accounts for more than one third of the total Capital Projects cost.

Sewer Main Renewal

As part of this SMP, Opus developed a Sewer Main Renewal Tool with the primary intent to identify those sewer mains, gravity sewers and forcemains, that are needed to be renewed prior to 2050 and post-2050 – critical to helping us recommend reserve balance in 2050 to mitigate financial shortfalls post-2050 in relation to the replacement of the District's entire sewer main network. In essence, the Tool provides the District with an indicative cost/budget required to meet the District's sewer main renewal needs. The budget required to renew those sewer mains that are scheduled for renewal before 2050 is approximately **$40.8 million** (2017 Canadian Dollars), $36.6 million and $4.2 million of which are attributed to gravity sewer renewal and forcemain renewal, respectively.

Capital Investment Plan

The District's Sewer Utility Capital Investment Plan (CIP) lays out a sustainable plan to implement all the required capital and renewal projects by 2050. A financial model for the District's entire sewer utility was developed to assess the affordability of the **$56.4 million** (2017 Canadian Dollars) capital expenditure identified by this CIP. It was found that the District needs to maintain, until at least 2040, an annual revenue increase of 5% to fund the long-term operating, renewal, and new infrastructure costs of the sanitary sewer utility. This increase in revenues will need to occur through population growth and/or utility rate increases.

Table ES-1 below breaks down the cost of implementing the CIP's various project categories into three time periods.

Table ES-1: Capital Investment Plan – Cost Breakdown (2017 Dollars)

Project Category	2017-2021	2022-2031	2032-2050	*Sub-Total*
Capital Projects List – Gravity Sewer Projects	$1,667,800	$5,182,100	$1,100,100	*$7,950,000*
Capital Projects List – Lift Station & Forcemain Projects	$754,600	$247,500	$2,402,800	*$3,404,900*
Capital Projects List – O&M Projects	$160,000	$1,330,000	$2,770,000	*$4,260,000*
Forcemain Renewals	$3,422,000	$783,000	$-	*$4,205,000*
Gravity Sewer Renewals	$2,127,800	$5,041,600	$29,428,700	*$36,595,000*
Sub-Total	*$8,132,200*	*$12,584,200*	*$35,701,600*	**$56,414,900**

Table of Contents

Appendices

List of Figures

List of Tables

1 Introduction

The District of Squamish (District) retained Opus International Consultants (Canada) Ltd. (Opus) to develop a Sanitary Sewer Master Plan (SMP). The plan assesses the capacity of the District's sanitary sewer conveyance network under the existing (2015) and future buildout (2050) scenarios with the objective of identifying a phased Improvement Works Plan to guide the District's capital and infrastructure planning efforts moving forward. The plan identifies improvements to the District's sewer infrastructure, except for the Waste Water Treatment Plant, to meet current level of service and to accommodate the rapid growth and developments slated to occur in the District over the next 33 years.

1.1 Scope of Work

The terms of reference prepared by the District identified the key issues to be addressed. The following summarizes the scope of work undertaken for this SMP assignment:

- Gather and review all existing information related to the sanitary system, such as sewer asset GIS shapefiles, historical studies, reports, drawings, operational data, etc. from the District;
- Develop a hydraulic model of the sanitary sewer network;
- Implement a flow monitoring program for calibrating the hydraulic model;
- Determine the full buildout scenario in terms of developments, population growth and allocation;
- Develop an Inflow & Infiltration Reduction Strategy for the District;
- Assess the current system's capacity to accommodate sewer flows under the existing and full buildout scenarios (i.e. to identify all capacity deficiencies);
- Identify Capital Projects to address identified capacity deficiencies;
- Develop a Sewer Main Renewal Plan to identify those gravity sewers and forcemains that require renewal by 2050;
- Develop a phased Capital Investment Plan with Class 'D' cost estimates, integrating both the Capital Projects and the Sewer Main Renewal Plan; and finally,
- Sewer utility financing review (i.e. financial modelling) and utility rate structure review.

1.2 Data Collection & Information Review

Historical data, sanitary sewer system information and previous studies were collected and reviewed during the development of this report. Opus completed a *Data Collection, Review & Gap Analysis* exercise at the beginning of the SMP project and the findings are detailed in our *Technical Memorandum #1 – Project Inception Report* (see Appendix A).

In summary, the review of the District's GIS database of sanitary assets revealed several data gap issues (<5% of system) including missing pipe size and manhole invert elevation. As-built drawings, and engineering judgement (data inference) where drawings were not available, were used to resolve the GIS data gap issues to build the hydraulic model.

In terms of historical studies and documents, the following key documents and reports were reviewed:

- 2009 Official Community Plan Bylaw 2100
- 2011 Public Works Asset Management Plan (Kerr Wood Leidal)
- 2012 & 2015 Development Cost Charge Bylaw Updates (Kerr Wood Leidal)

- 2012 Review of Alternative Sanitary Sewer Conveyance Strategies from Downtown Squamish (Kerr Wood Leidal)
- 2012 Technical Memorandum #2 – Wastewater Treatment (Urban Systems)
- 2013-2017 Financial Plan
- 2013 Assessment and Evaluation of Sanitary Sewer – CCTV Inspections (Opus)
- 2015 Liquid Waste Management Plan: Stage 2 – 3 Report (Urban Systems)
- 2016 M1 LS Assessment and I&I Reduction Study
- 2016 Valleycliffe and Garibaldi Estates Sanitary Sewer Condition Assessment & Rehabilitation Plan (Kerr Wood Leidal)
- 2016 Buckley Avenue (SM23) Lift Station Replacement – Technical Memorandum (Opus)

1.3 Presentations & Workshops

Throughout the project, Opus has organized several presentations and workshops at the municipal hall to engage District staff and keep them informed of the project progress at key milestones, such as the following:

- Performance Review Workshop (February 13, 2015)
- Model Build Workshop (August 31, 2015)
- Model Calibration & Existing System Assessment Workshop (June 20, 2016)
- Improvement Works Plan Workshop (November 22, 2016)

A few key assumptions and decisions came out of these workshops, including that which led to the commission of flow monitoring at three (3) additional sites with the intent to improve confidence in the hydraulic model.

1.4 Acknowledgements

Opus acknowledges the support and cooperation of the District of Squamish and extends its appreciation to David Roulston – Municipal Engineer, John Grainger – Municipal Engineer, Matt Simmons – Capital Projects Manager, Laura Princic – Municipal Engineer, Dan Ricciuti – Utility Supervisor, and Dan Arnold – Chief Operator Wastewater Collections, for their assistance to the project team at Opus in preparing this report and completing this project.

The model development, calibration and analyses, and report were prepared by Fofo Deng Ke Fan, E.I.T., Nima Najafi, P.Eng., Peter Hutchins, E.I.T., and Clive Leung, P.Eng., for Opus with supervision and direction from Paramjeet Mankoo, C.Eng.

1.5 Abbreviations

AC	Asbestos-Cement
ADWF	Average Dry Weather Flow
AMP	Asset Management Plan
CCTV	Closed-Circuit Television
CHI	Computational Hydraulics International
COF	Consequence of Failure
DCC	Development Cost Charge
DI	Ductile Iron

FOG	Fat, Oil, and Grease
GIS	Geographic Information System
GS	Gravity Sewer
GWI	Groundwater Infiltration
I&I	Inflow & Infiltration
ICI	Industrial, Commercial, Institutional
IDF	Intensity-Duration-Frequency
LID	Low-Impact Development
LS	Lift Station
MMCD	Master Municipal Constructions Document
NPV	Net Present Value
OCP	Official Community Plan
O&M	Operational and Maintenance
PACP	Pipeline Assessment and Certification Program
POF	Probability of Failure
PVC	Polyvinyl Chloride
PWWF	Peak Wet Weather Flow
RDII	Rainfall Dependent Inflow & Infiltration
RUL	Remaining Useful Life
SMP	Sewer Master Plan
TZ	Traffic Zone
WaPUG	Wastewater Planning Users Group (in the UK)
WRc	Water Research Center

2 Existing Sanitary Sewer System

The District of Squamish currently owns and operates a sanitary-only sewer collection system that consists of approximately 98 km of gravity sewers and 22 lift stations with 12 km of forcemains. There are two (2) siphons in the system, one is located on Maple Drive with the other on Cleveland Avenue and Main Street in Downtown. The District's sanitary system also collects sewage from Squamish Nation Reserves including Stawamus I.R 24, Kowtain I.R. 17, Yekwaupsum I.R. 18, and Wai'wakum I.R. 14. All of the sewage is ultimately conveyed to and being treated at the Mamquam Wastewater Treatment Plant (WWTP).

Figure 2-1 provides an overview of the District's current sanitary system along with the nine (9) sewer catchment areas that it services.

2.1 Sanitary Sewer Infrastructure

2.1.1 Gravity Sewers

The District's gravity sewers were largely installed in the 1970s with roughly 57% and 37% of the existing sewers being AC and PVC pipes, respectively. Most of them (~85%) are between 200 mm and 250 mm in size as summarized in Table 2-1 below and illustrated in Figure 2-1.

Table 2-1: Gravity Sewer Summary

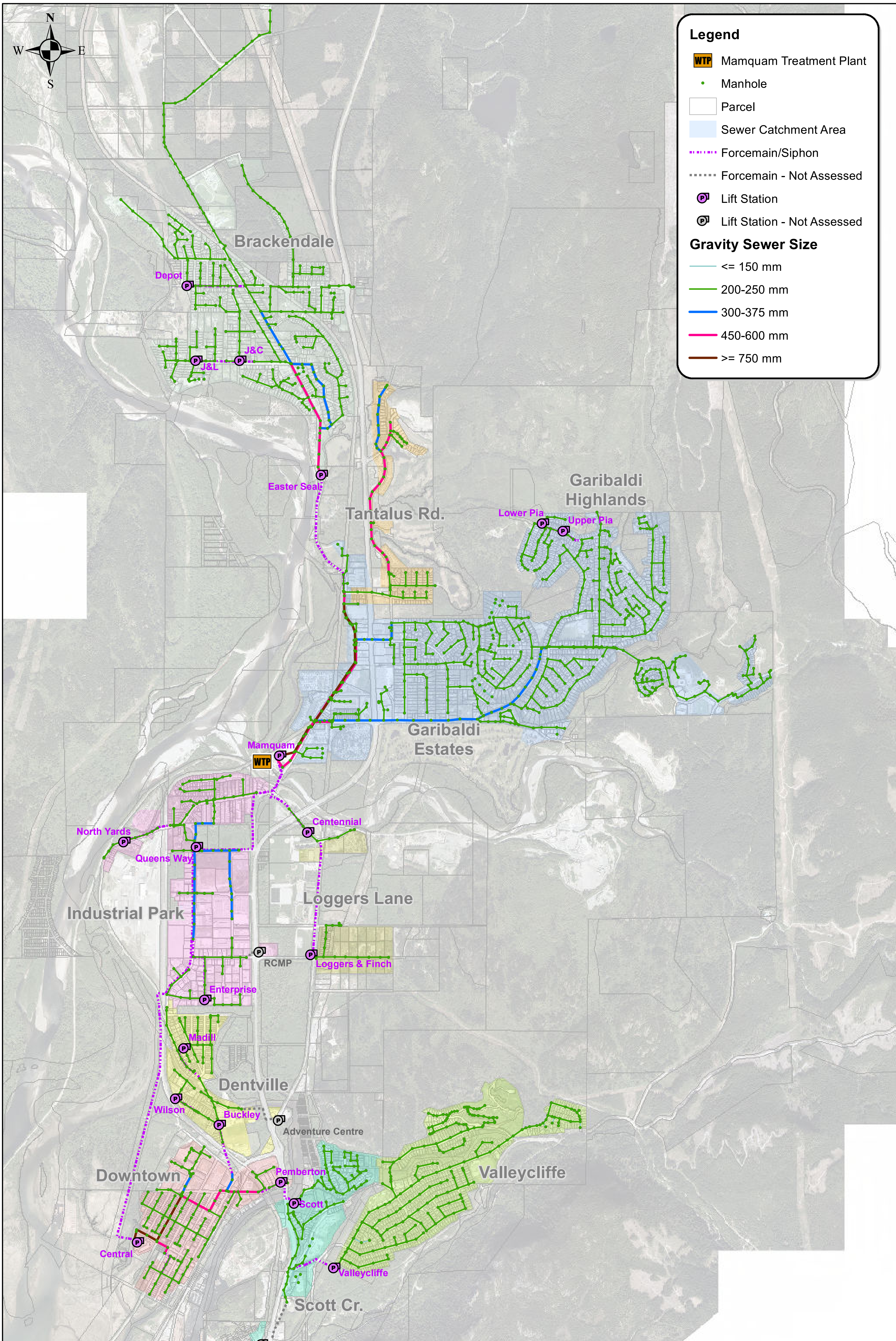
Diameter (mm)	Length (m)	%	Diameter (mm)	Length (m)	%
<=100	287	0.3%	450	3,988	4.1%
150	1,705	1.7%	525	248	0.3%
200	72,565	73.8%	600	474	0.5%
250	10,177	10.4%	750	1,769	1.8%
300	4,569	4.6%	1,050	421	0.4%
375	2,087	2.1%			
			Total	**98,289**	**100.0%**

Figure 2-2 and Figure 2-3 show the Material and Age, respectively, of the District's gravity sewers.

Over the last five-year period, the District completed CCTV inspections for the entire gravity sewer network. Figure 2-4 shows the PACP (Pipeline Assessment and Certification Program) scores of all the gravity sewers, illustrating their overall condition. It is noted that, although most of these sewers are more than 40 years of age, they are in good condition (PACP score of < 3).

2.1.2 Siphons

The District's sanitary system includes a short 150 mm low-pressure siphon that crosses the creek at Maple Drive. Another siphon (200 mm) was identified through CCTV inspections on Cleveland Avenue and Main Street in Downtown. It is located on the upstream end of the system and appears to be created due to crossing with other utilities. There are other siphons that have been found by District staff but are not updated in GIS. These siphons have minimal impact on system deficiencies and as such have not been included in the modelling and subsequent analyses.



OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

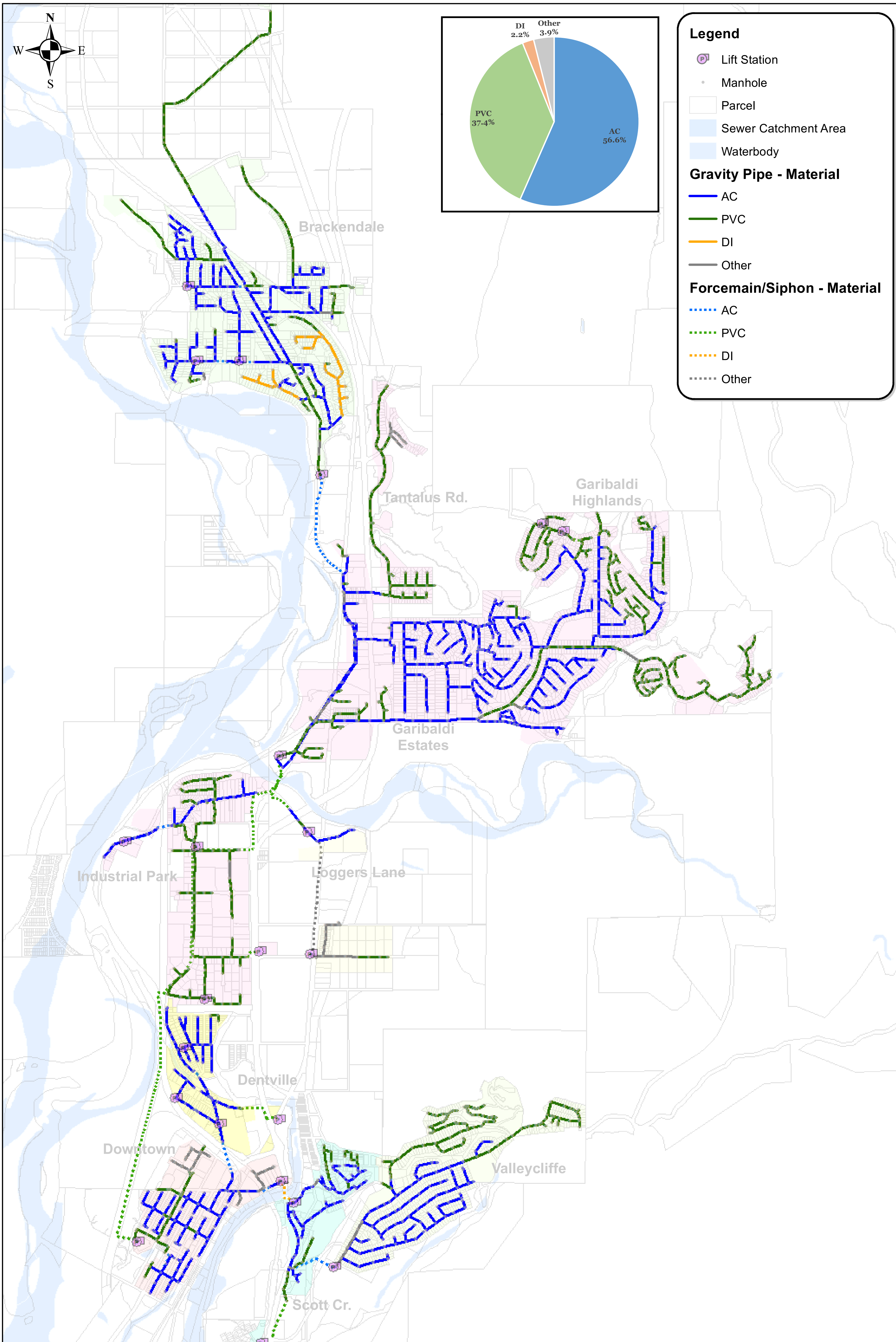
Client: District of Squamish

SQUAMISH

Figure 2-1
Squamish Sanitary Sewer System & Sewer Catchment Areas

Project No:	**D-03692**
Designed:	**DF**
Approved:	
Scale:	Meters 0 125 250 500
Date:	**Mar 2018**
Revision:	Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 2-1 Squamish Sanitary System.mxd



OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

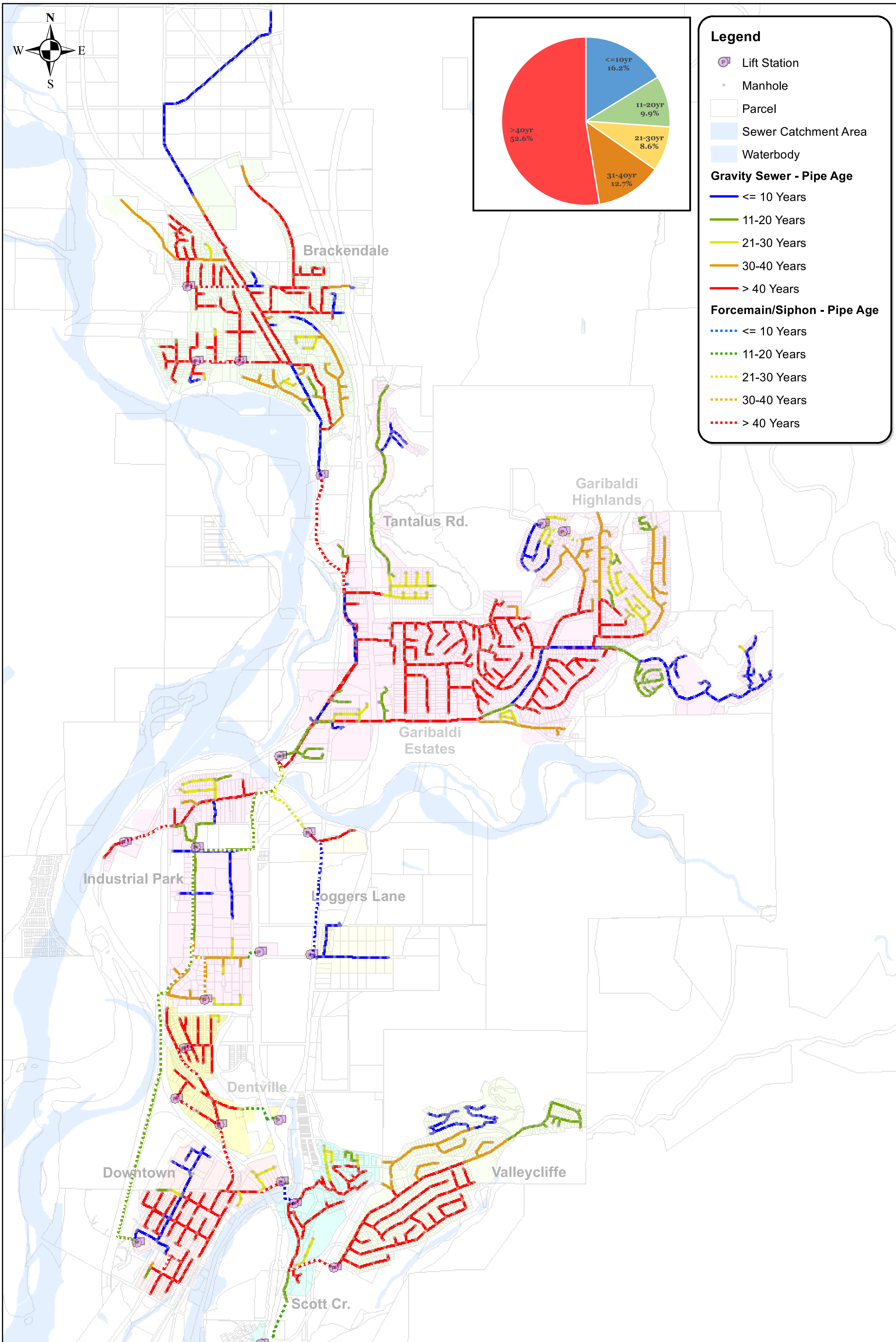
Client: District of Squamish

SQUAMISH

Figure 2-2
Sanitary Sewer Main - Pipe Material

Project No:	**D-03692**
Designed:	**DF**
Approved:	
Scale:	Meters 0 125 250 500
Date:	**Mar 2018**
Revision:	Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 2-2 Sani_Sewer_Material.mxd



OPUS

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

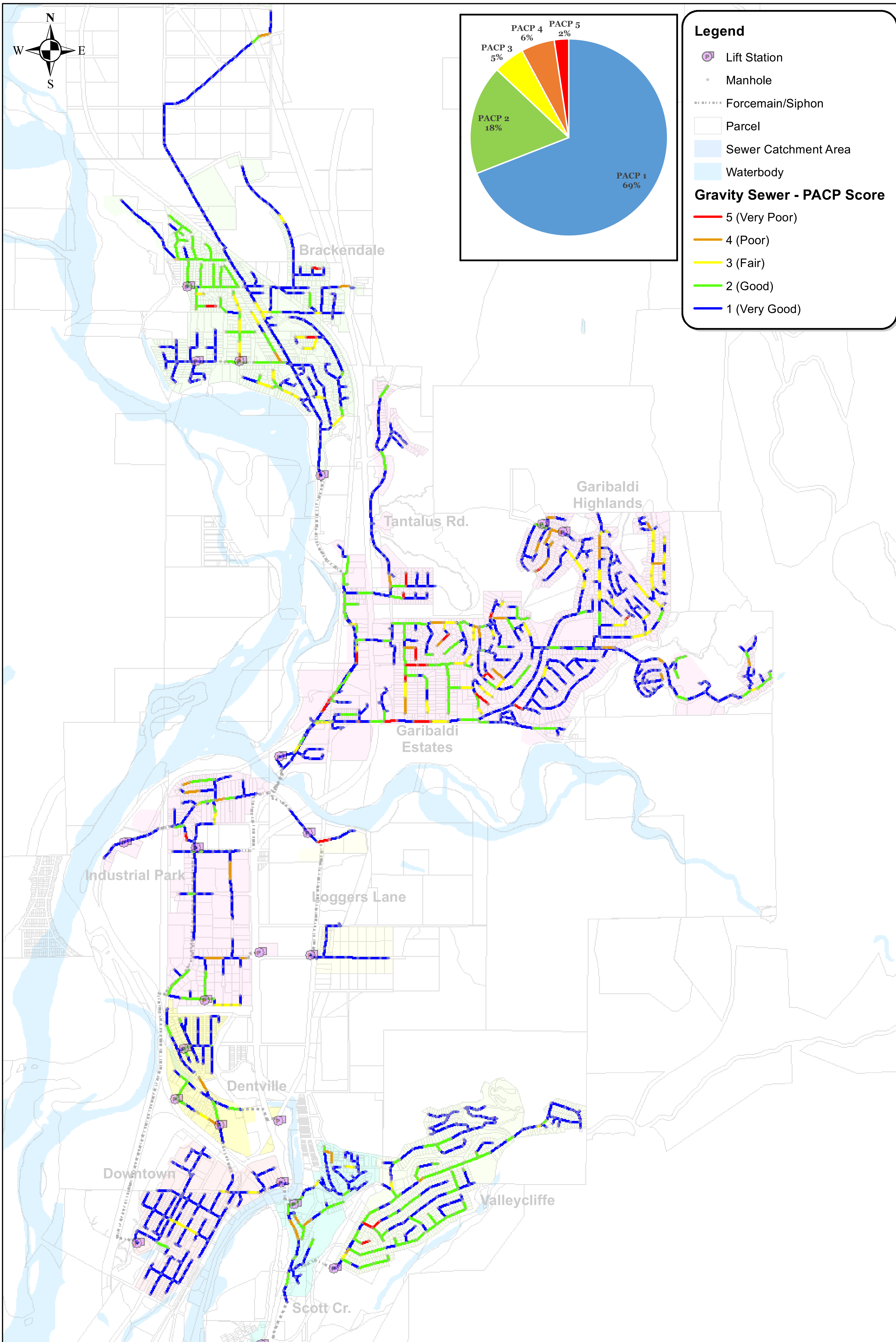
Client: District of Squamish

SQUAMISH

Figure 2-3
Sanitary Sewer Main - Pipe Age

Project No: **D-03692**	Scale: Meters 0 125 250 500
Designed: **DF**	
Approved:	Date: **Mar 2018**
	Revision: Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 2-3 Sani_Sewer_Age.mxd



OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: District of Squamish

SQUAMISH

Figure 2-4
Gravity Sewer Condition - PACP Score

Project No: **D-03692**	Scale: Meters 0 125250 500
Designed: **DF**	
Approved:	Date: **Mar 2018**
	Revision: Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 2-4 Gravity_Sewer_PACP.mxd

2.1.3 Lift Stations & Forcemains

The District currently operates twenty-two (22) lift stations and roughly 12 km of forcemains, details of which are shown in Table 2-2 below. As requested by the District, the naming convention for the lift stations have changed, from number-based to location-based.

Table 2-2: Lift Stations

Lift Station	Old ID	No. of Pumps	Lift Station Capacity (L/s) [1]	2015 PWWF (L/s)	Forcemain Size (mm)	Forcemain Length (m)
Easter Seal	SM01 / M1	2 x 35 hp	87.0	57.2	250	1,008
North Yards	SM02 / M2	2 x 10 hp	7.6	2.2	75	401
Centennial	SM05 / M5	2 x 9.4[5] hp	22.4	5.0	150	677
Judd & Lawson (J&L)	SM08 / M8	2 x 7.5 hp	32.6 (24.5) [2]	6.9	150	464
Judd & Cottonwood (J&C)	SM07 / M7	2 x 3 hp	37.9 (18.6) [2]	2.5	100 ties into 150	9
Depot	SM09 / M9	2 x 10 hp	27.3	13.3	150	463
Upper Pia	SM10 / M10	2 x 10 hp	12.2	22.7	150	180
Lower Pia	SM12 / M12	2 x 7.5 hp	22.7	2.7	150	204
Queens Way	SM13 / M13	4 x 47 hp	176.3	159.2	300	1,323
Loggers & Finch	SM15	2 x 20 hp	29.9	3.1	150	927
Scott	SM16 / C1	2 x 30 hp	96.6 (90.0) [3]	58.6	200 (250 on Bridge)	426
Pemberton	SM21 / C6	2 x 5 hp	39.7 (7.0) [3]	1.5	200	3
Valleycliffe	SM17 / C2	2 x 29 hp	71.9	11.4	200	393
Buckley	SM23 / C7	2 x 7.5 hp	46.4	18.5	200	402
Enterprise	SM26 / C10	2 x 10 hp	46.7	8.7	100 & 250	575
Central	SM28 / C11	2 x 60 hp 1 x 30 hp	170.0	117.5	400	3,452
Wilson	SM29 / C8	2 x 2 hp	10.1	3.1	100	213
Madill	SM30 / C9	2 x 5 hp	25.4	6.7	150	334
Mamquam	SM11 / M11	3 x 25 hp	143.0[4]	125.2	450	23
RCMP	SM14	2 x 2.2 hp	Not Modelled / Assessed as part of this SMP as agreed upon with the District in the early stages of the project to limit scope and modelling efforts. Inflows into these stations are allocated to the downstream gravity system.			
Adventure Centre	SM25	2 x 2.2 hp				
Stawamus Reserve	SM22	2 x 5 hp				

[1] When all but the largest pump is running.
[2] Lift stations share common forcemain. Values in bracket are the capacities when both lift stations are operating.
[3] Lift stations share common forcemain. Values in bracket are the capacities when both lift stations are operating.
[4] Field measured by District staff when two of three pumps are operating.
[5] Information regarding the second pump had been upgraded to 10 hp in 2012 was received at the final report review stage. The impact to the SMP would be marginal and was thus decided to include this in the next SMP update.

2.1.4 Mamquam Wastewater Treatment Plant

The Mamquam WWTP was originally constructed in 1973 to service North Squamish. There was a second WWTP servicing South Squamish (Central WWTP). Upgrades to the Mamquam WWTP were completed in 1996 and 2006, and by 2006, all flows from South Squamish were diverted to Mamquam WWTP and Central WWTP was decommissioned. Mamquam WWTP is currently operating under the provisions of a Ministry of Environmental Discharge Permit (#PE-01512), amended on April 5, 2001, which allows up to 17,850 m^3/day of sewage to be discharged. The treated effluent discharges to the Squamish River through a submerged outfall pipe. Although the full assessment of Mamquam WWTP is outside the scope of this SMP, we assessed the capacity of the pumps at the Mamquam WWTP (SM11) and found that they are not adequate in servicing 2050 buildout flows (see Section 7).

2.2 Sewer Catchment Areas

In agreement with District staff, we have identified nine main sewer catchment areas in the District and a brief description of each is outlined below.

2.2.1 Downtown

Downtown Squamish is the main commercial hub in the District and consists of a mixture of industrial, commercial, and institutional (ICI) and residential customers. Currently, there is a 750 mm trunk sewer running through Downtown conveying all of Downtown's, and upstream catchment areas', sewage to the Central lift station. Central pumps to the Queens Way lift station, in the Industrial Park catchment area, which then pumps to the Mamquam WWTP. Most of the gravity sewers in Downtown are Asbestos-Cement (AC) pipes and more than 40 years of age, except for the newer PVC trunk sewer. Based on the CCTV inspections completed, the pipes are mostly in good condition (PACP score < 3).

The Downtown catchment area is anticipated to experience the largest population growth in the District as it is slated for large developments such as the Squamish Oceanfront Development and the Waterfront Landing Development, which is estimated to accommodate a total population growth of 11,200.

2.2.2 Industrial Park

The Industrial Park catchment area consists mainly of light to medium industrial customers with a small portion of residential area north of Government road. It is home to the Queens Way lift station, one of District's largest in terms of capacity. It collects and pumps almost all of south Squamish's sewage to the Mamquam WWTP. There is a mixture of PVC and AC pipes in the Industrial Park area. The PVC pipes are relatively newer (<= 20 years). CCTV inspections have revealed some pipes to be in poor condition (PACP score > 3).

The Industrial Park catchment area is anticipated to experience the largest ICI growth, with an estimated equivalent population increase of 3,300. This is largely due to the potential industrial buildout at the Rail Marshalling Yard and on Pioneer Street. There is also the proposed Great Wolf Lodge, which consists of a 400-room hotel as well as a water park.

2.2.3 Dentville

The Dentville catchment area consists mainly of single-family homes, and is home to the Howe Sound Secondary School, the Capilano University Squamish Campus, and the Squamish Adventure Centre. The Buckley lift station collects and pumps sewage from the catchment area to the trunk sewer in Downtown.

Most of the gravity sewers are AC pipes of more than 40 years of age. There are some pipes near the Buckley lift station in poor conditions (PACP score = 4).

The Dentville catchment area is slated for large-scale re-development in the Wilson Crescent area, from single-family to multi-family homes, and densification by way of subdividing existing single-family lots in the Dentville area, all of which is estimated to yield a population growth of 2,000 people.

2.2.4 Scott Crescent

The Scott Crescent catchment area is home to the Squamish General Hospital and the Stawamus Elementary, there are some single-family homes in the Clarke Drive and Vista Crescent areas. The sewage from the catchment is collected and conveyed to the Downtown system via the Scott lift station. The catchment also collects and conveys sewage from the Squamish Nation Lands (Stawamus Reserve) by way of the Stawamus lift station. There is a mixture of PVC and AC gravity sewers in the area with a few pipes in poor conditions (PACP score = 4).

Scott Crescent is slated for new residential developments east of Highway 99 and infill developments with a total population growth of roughly 1,600 people.

2.2.5 Valleycliffe

The Valleycliffe catchment area consists mainly of single-family residential areas. The catchment's sewage is conveyed purely by gravity to the Valleycliffe lift station at the southern end of Westway Avenue. The Valleycliffe lift station pumps to the gravity system in the Scott Crescent catchment area. Valleycliffe has relatively more PVC gravity sewer compared to other areas due to large-scale new development that has occurred over the last decade (e.g. Crumpit Woods). Conditions in the older AC pipes are good (PACP < 3), in general, with a couple of pipes in critical condition (PACP score = 5) at the Cedar Drive and Chestnut Avenue intersection.

The Valleycliffe catchment area will experience relatively smaller population growth compared to the rest of the District. It is slated for the Crumpit Woods – Phase 2 development as well as some infill developments. The total estimated population growth for the area is roughly 1,200 people.

2.2.6 Loggers Lane

The Loggers Lane catchment area is the smallest catchment in the District in terms of developed land. It is located south of the Mamquam River and east of Highway 99, and is home to institutional customers such as the Brennan Park and the Brennan Park Arena, the Squamish Montessori School, and the Ministry of Forests, Lands & Natural Resource Operations office. The sewage is collected at the Centennial lift station, which pumps to the Mamquam WWTP directly. Loggers Lane can be split into two parts: Centennial Way with older AC pipes; and Finch Drive with new PVC pipes. There is only one sewer section with a PACP score of 4.

The Loggers Lane catchment area is slated for large-scale residential and ICI growth including residential developments such as the Maples Development, the Anthem Development, the Forestry Road Development, and the potential developments in the Loggers Lane South Land. The estimated total population growth for the area is 6,000.

2.2.7 Garibaldi

The Garibaldi catchment area is the largest catchment area in the District in terms of developed land. It consists mainly of single-family homes. It is also home to institutions such as Garibaldi Highlands Elementary, and Quest University Canada. There is also a large commercial complex along Highway 99 that consists of Canadian Tire and London Drugs. The sewage from the catchment is collected in the 750-1,050 mm trunk sewers on Government Road and conveyed to the Mamquam lift station before being pumped to the WWTP for treatment. The gravity sewers in this catchment are predominantly AC pipes of more than 40 years of age. There are relatively more poor condition pipes (PACP > 3) in Garibaldi compared to other areas due to its age.

The Garibaldi catchment area is slated for some new developments, such as the buildout of the University Heights and Aristotle developments, but population growth will largely come from infill developments in the area. The estimated total population growth for the area is 4,500.

2.2.8 Brackendale

The Brackendale catchment area is the second largest catchment area in the District in terms of developed land. It consists largely of single-family homes. It is also home to the Don Ross Middle School, Brackendale Elementary School, and the District’s Landfill. The sewage from the catchment is ultimately collected at the Easter Seal lift station before being pumped to the Government Road trunk sewers. The gravity sewers in this catchment consists of a mixture of PVC, AC, and DI (Ductile Iron) pipes. They are mostly greater than 30 years of age with a few sewer sections in critical condition (PACP = 5).

The Brackendale catchment area is slated for a large-scale development – the Cheekeye River Development, which is proposed to house 3,800 people.

2.2.9 Tantalus Road

The Tantalus Road catchment area is a small catchment with great development potential. There are currently small-scale residential and ICI developments along Tantalus Road. The sewage in this area is conveyed down Tantalus Road before crossing Highway 99 and discharging into the Government Road trunk sewers. There is a sewer size reduction from 450 mm to 200 mm on Tantalus Road and the highway crossing, creating a severe bottleneck in the gravity system. The Tantalus Road catchment area is a new area, with predominantly PVC pipes of less than 30 years of age. Some of the older pipes near the Tantalus Road and Newport Ridge Drive intersection are in poor condition (PACP > 3).

The Tantalus Road catchment area is slated for the second largest total population growth in the District, after the Downtown catchment area. Large-scale developments such as the Garibaldi Springs Development, the Holborn Group Development, and finally, the largest of them all, the Cheema Development. It is estimated that the catchment area will accommodate a total population growth of 7,000.

3 Population Projection

3.1 Existing (2015) Scenario

The District's population, based on 2011 Census[1], sits at 17,674. Between 2006 and 2011, the District has experienced an average annual population growth of 3.4% over the 5-year period (Census). Between 2011 and 2014, the District's population further increased a 2.9% on average a year based on BC Stats.

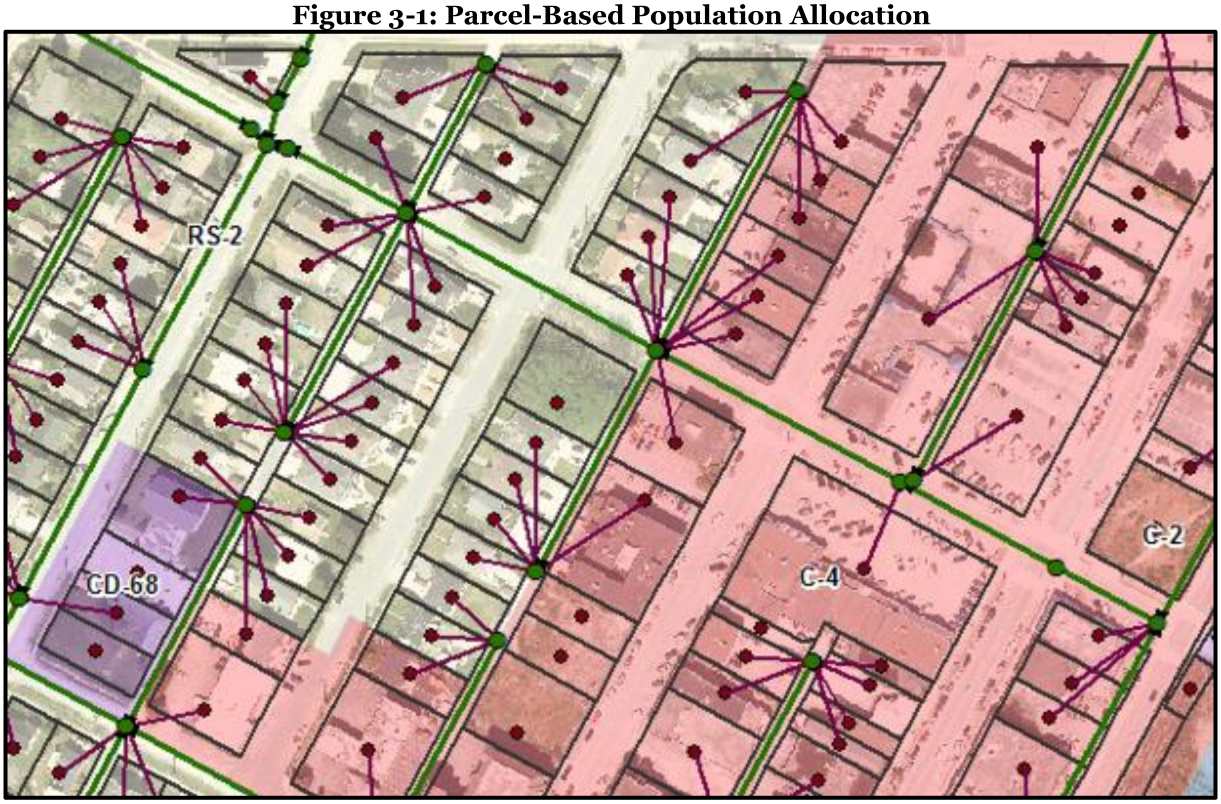
In addition to the Census and BC Stats sources, the District has provided Traffic Zone (TZ) data, which consists of zone boundaries and 2010 and 2031 residential and ICI equivalent population estimates for each zone. The annualized growth rates for the residential and ICI equivalent populations are 2.6% and 1.7%, respectively.

It was agreed upon with the District that the higher growth rate of 2.9% (between BC Stats and TZ data) was applied to estimate the 2015 (Existing Scenario) residential population number of 19,457. For the ICI equivalent population, the TZ growth rate of 1.7% was applied to estimate the 2015 ICI equivalent population of 8,462.

3.1.1 Existing Population Allocation

Opus adopted a detailed population allocation approach (parcel-based) that involved the allocation of population estimates from the TZ level down to the individual parcel level based on the zoning of each parcel. Then, the estimates were allocated spatially from the parcels to the closest sanitary manholes for hydraulic modelling purposes. Figure 3-1 below helps illustrate the allocation process.

Figure 3-1: Parcel-Based Population Allocation



[1] The reader should note that the model development and population projections were completed prior to the release of the 2016 Census.

3.2 2050 Buildout Scenario

The original design horizon for this SMP was set to 2031, which is aligned with the District's OCP. However, any system improvement recommendations that come out of this SMP are expected to accommodate and meet the level of service for a period beyond the 2031 OCP horizon (e.g. new pipes will last far beyond 2031). Therefore, in agreement with the District, we have decided to consider the 2050 buildout scenario in Squamish as the design horizon for this SMP. It incorporates full buildout of all currently known developments and infill.

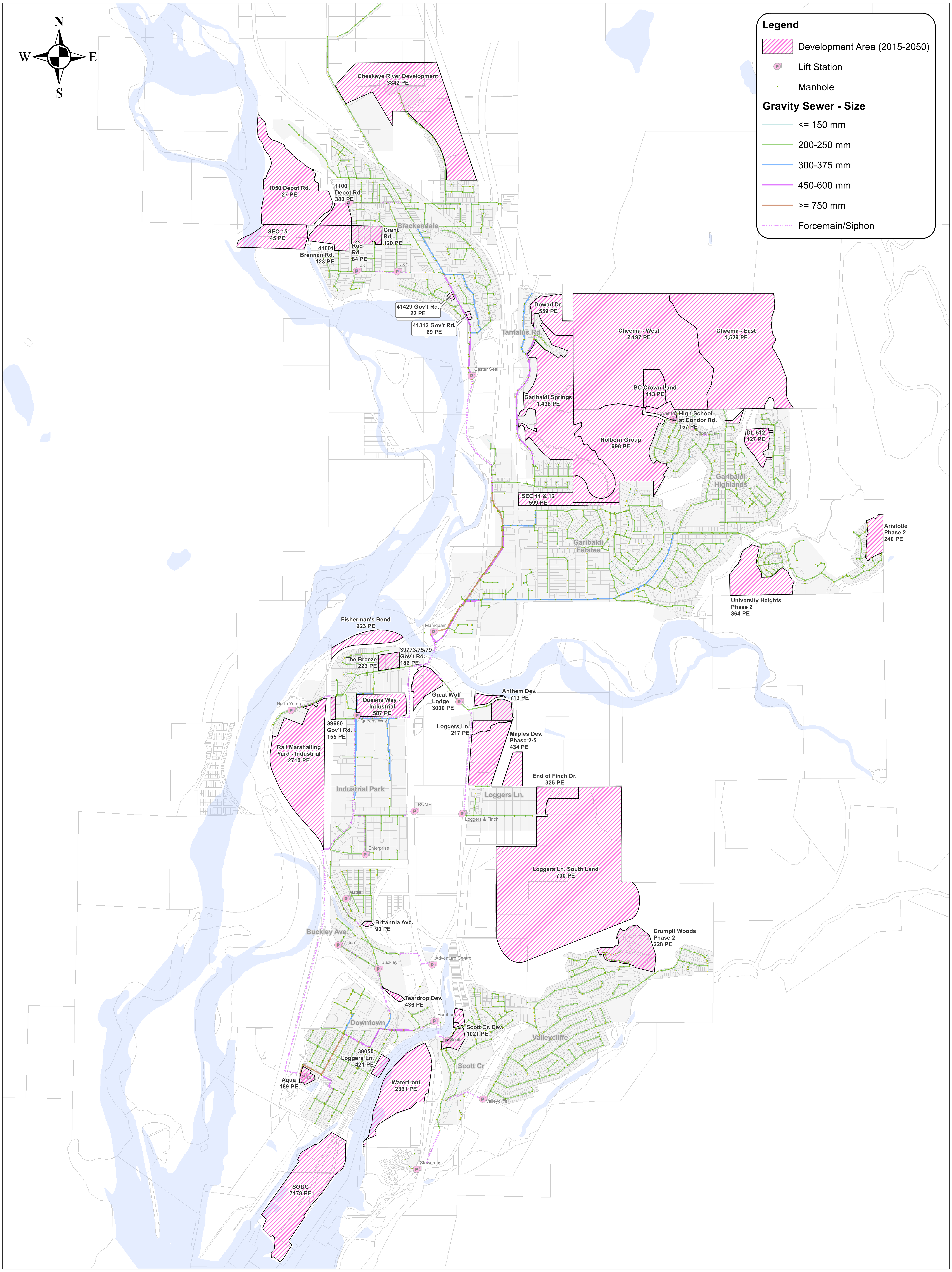
Figure 3-2 represents our collaborative efforts with District staff to identify most, if not all, of the potential developments slated to occur in the District based on current knowledge. A few larger developments that are already in the planning phases, and are expected to be completed in the coming years, include the Squamish Oceanfront Development, the Waterfront Landing Development, the Cheekeye River Development, and the Garibaldi Springs Development. In the longer-term, we are also anticipating the development of Lots 509 & 510 (a.k.a. Cheema Lands) and the Loggers Lane South Lands. All these developments, and other smaller ones, are included in this SMP. A detailed estimate of the population increase due to each of these developments are presented in Appendix B of this report.

In addition to the growth due to developments (such as those shown in Figure 3-2), the District is also expected to undergo infill re-developments and densification in some of the catchment areas. The growth data from the TZ database was used to determine which areas will experience densification by comparing it with growth anticipated from new developments in the same area. If TZ growth is larger than development growth, the additional growth will be attributed to infill/densification and is apportioned equally to the whole catchment. Catchment areas slated for both new developments and infill/densification include Garibaldi (Highlands and Estates), Valleycliffe, Tantalus Road, and Dentville.

Table 3-1 below summarizes the 2015 (Existing) and 2050 (Buildout) population estimates for each of Squamish's catchment areas. 2050 was chosen as the buildout year because the average annual residential growth rate from 2015 would equate to 2.9%, which is in line with the rate (from BC Stats) used to estimate the 2015 residential population.

Table 3-1: Population Summary

Sewer Catchment Area	Residential Population		ICI Population Equivalent		Combined Population Equivalent	
	2015	2050	2015	2050	2015	2050
Brackendale	3,234	7,910	899	935	4,134	8,845
Dentville	1,273	3,353	1,474	2,042	2,747	5,395
Downtown	2,000	11,471	1,657	3,397	3,656	14,868
Garibaldi	7,051	10,402	1,876	3,086	8,927	13,489
Industrial Park	1,233	2,021	1,313	4,610	2,546	6,631
Loggers Ln.	184	3,066	237	3,283	420	6,349
Scott Cr.	625	2,231	436	745	1,061	2,976
Tantalus Rd.	790	7,449	287	619	1,077	8,068
Valleycliffe	3,067	4,302	283	286	3,351	4,588
Total	**19,457**	**52,205**	**8,462**	**19,004**	**27,919**	**71,208**



OPUS

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

This drawing and its contents are the property of Opus International Consultants Limited. Any unauthorised employment of reproduction, in full or in part, is forbidden.

Client:

SQUAMISH

Figure 3-2
Squamish 2050 Buildout Scenario

Project No: D-03692

Drawn: DF

Note:

Scale: 0 125 250 500 Meters

Date: Mar 2018

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 3-2 2050 Buildout Scenario [A1].mxd

4 Hydraulic Modelling

As part of this SMP Opus developed a hydraulic model in PCSWMM (by CHI) to represent the District's sanitary sewer network. A flow monitoring program, consisting of ten (10) sites, was developed and completed to obtain rainfall and flow data for calibrating the model. Opus adhered to the Wastewater Planning Users Group (WaPUG) Code of Practice for the Hydraulic Modelling of Sewer Systems throughout the calibration process, and concludes that the model is calibrated.

The following sections describe the flow monitoring program, and the model development and calibration processes. For more details, refer to *Technical Memorandum #2 – Model Calibration* in Appendix A of this report.

4.1 Model Development

The first task in developing the District's hydraulic model was to construct the physical network of the sanitary system which includes manholes, gravity sewers, forcemains, low-pressure siphon, lift stations (pumps and wet wells), and outfalls. The Mamquam WWTP was modelled as outfalls to the District's sanitary system. Various modeling elements in PCSWMM were used to represent these different components of the sanitary system and are summarized in Table 4-1.

Table 4-1: Summary of Model Elements

PCSWMM Model Element	Used to Represent	Count
Junction	• Manhole • Pressure Pipe Joint	1,648
Conduit	• Gravity Sewer • Forcemain	1,652
Pump	• Individual Pump Unit	44
Storage Unit	• Wet Well	20
Outfall	• Mamquam WWTP	3

Each modeling element has a specific set of input data requirements, most of the data are available in the District's GIS database and as-built drawings. Any assumptions made in addressing data gaps and discrepancies are described in the following subsections. In general, for the purposes of hydraulic modelling, the data provided was complete and additional field surveying was not required.

4.1.1 Junctions

Model Junctions in PCSWMM require the following key input parameters:

- Junction ID
- Invert Elevation
- Rim Elevation
- Sanitary Flow

The modelled Junction ID is kept the same as the GIS Sanitary Manhole ID ("G_ID"), wherever possible. The invert elevation was set to correspond to the lowest invert elevation of the connected sanitary sewers. Rim elevations were mostly derived from contour data. Finally, the sanitary inflow at each manhole is determined by the population allocation process (see Section 3) and the model calibration process (see Section 4.3).

4.1.2 Conduits

Model Conduits in PCSWMM require the following key input parameters:

- Model Conduit ID
- Length
- Upstream and Downstream Invert Elevations
- Size and Type (Gravity Sewer or Forcemain)
- Roughness

The modelled Conduit ID is kept the same as the GIS Sanitary Main ID ("G_ID"), wherever possible. The length is calculated automatically based on the GIS polyline. Pipe size data is considered complete in the GIS database (<1 % data gap). Similarly, the upstream and downstream invert elevations data are fairly complete (<5% data gap) in the GIS database. As-built drawings were used to resolve these data gaps.

The roughness factors used for gravity sewers and forcemains are the Manning's Roughness and Hazen-Williams C-Factor, respectively. A Manning's Roughness of 0.013 and C-Factor of 130 were applied globally to all the conduits respectively. Note that this means that the model treats all the sanitary sewer mains in the District to be "clean" with full capacity. This is rarely the case in real life and is a limitation of the model, which the District may wish to improve on in future model updates using the CCTV inspection data that is now available for the entire District.

4.1.3 Pumps & Storage Units

Model Pumps and Storage Units are used to model lift stations located in the Squamish sanitary sewer system. Only 19 out of the 22 lift stations were modelled. The key modeling input parameters for these include:

- Model Pump and Storage Unit IDs
- Pump Curve
- Pump Start & Stop Levels
- Wet Well Rim & Invert Elevations
- Wet Well Dimension

A lift station in the model is represented, typically, by one Storage Unit (the wet well) and Pumps. The naming convention for both the model pumps and storage units is a prefix consisting of the lift station ID. For example, the Mamquam lift station wet well and pumps would have the IDs "SM11-WWL" and "SM11-1/2/3", respectively.

The pump curves were provided by the District and are attached in Appendix C of this report. The pump start/stop levels were provided by District's operation staff. Finally, as-built drawings were used to determine the wet well dimensions, and rim and invert elevations.

4.1.4 Outfalls

Model Outfalls are used to represent a system discharge point and in this case, the Mamquam WWTP's influent chamber. Based on the latest WWTP drawings, the invert elevation of the chamber is at 3.63 m. The internal components of the WWTP and the sewage outfall to the river are not modelled.

4.2 Short-Term Flow & Rainfall Survey

Opus implemented a short-term sewage flow and rainfall monitoring program, consisting of ten (10) flow monitoring sites and one rain gauge installed at the Municipal Hall. The Area-Velocity flow meters were installed and maintained by SFE Global at the locations shown in Figure 4-1.

The flow monitoring program was performed in two periods, with the first beginning in March 2015, and the second in November 2015:

- Flow Monitoring Sites 1 to 7: March 10, 2015 to June 8, 2015 (Spring 2015); and,
- Flow Monitoring Sites 8 to 10: November 3, 2015 to January 5, 2016 (Fall 2015).

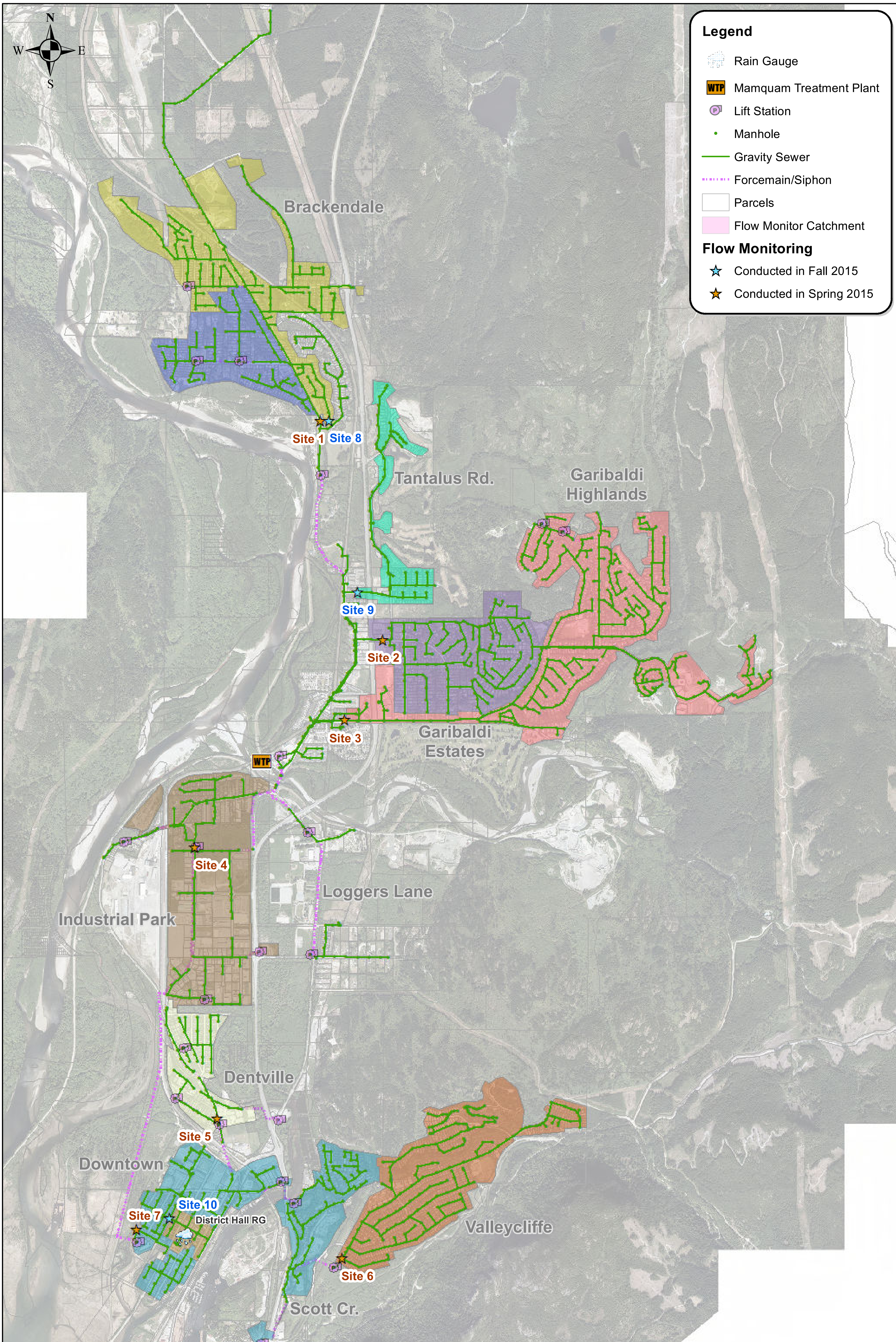
Opus has completed a detailed quality review of the collected rainfall and sewage flow data for compliance with the WaPUG Code of Practice criteria. The findings are documented in our *Technical Memorandum #2 – Model Calibration* (see Appendix A). In summary, the key findings are as follows:

- For the rainfall data, it was observed that the rainfall intensities of the rain events in the first monitoring period (Spring 2015) were low (< 10 mm/hr) due to seasonal variation. This limits the confidence in the model calibration, and subsequent analyses, of the respective seven (7) flow monitoring catchments.
- There are periods in the Spring 2015 program when **Site 2** had debris build up on the sensor, causing the flow data to be erroneous. The flow data for the periods of March 24 – April 3 and Apr 28 – May 1, were subsequently discarded from the model calibration process.
- The flow data from **Site 4** was of poor quality, indicated by the variability in the velocity-depth scatter plot. This was probably caused by the site's proximity to the Queens Way lift station; the flow monitor was likely influenced by the pumping cycles, reporting large peak flows during operation, and negative values when the wet well was filling. The unsteady flows were not suitable for model calibration. Only minimum night time flows could be used from this site to estimate groundwater infiltration.
- A portion of the flow data at **Site 6** suffered from poor data quality from May 19 to June 8. The depth-velocity scatter plot became unsteady, likely due to silt or debris blocking one of the sensors. The corresponding flow data was discarded from the model calibration process.
- In conclusion, apart from Site 4, flow data from all the other nine (9) sites were utilized to calibrate the model.

4.2.1 Dry Weather Analysis

In preparation for the model calibration, Opus completed a Dry Weather Analysis of the collected flow data to determine the Average Dry Weather Flow (ADWF) and to obtain a representative diurnal pattern for each of the nine (9) sites. The observed diurnal patterns are shown in Figure 4-2

Most of the sites' patterns are similar in nature due to the land use types within the catchments. Site 10 is the one exception since the land use within the flow monitored catchment is predominantly Industrial/Commercial/Institutional (ICI). The flow monitor further downstream at Site 7 has a pattern that is a hybrid of ICI flow from Site 10 and residential flows from Sites 5 and 6.



OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

This drawing and its contents are the property of Opus International Consultants Limited. Any unauthorised employment of reproduction, in full or in part, is forbidden.

Client: District of Squamish

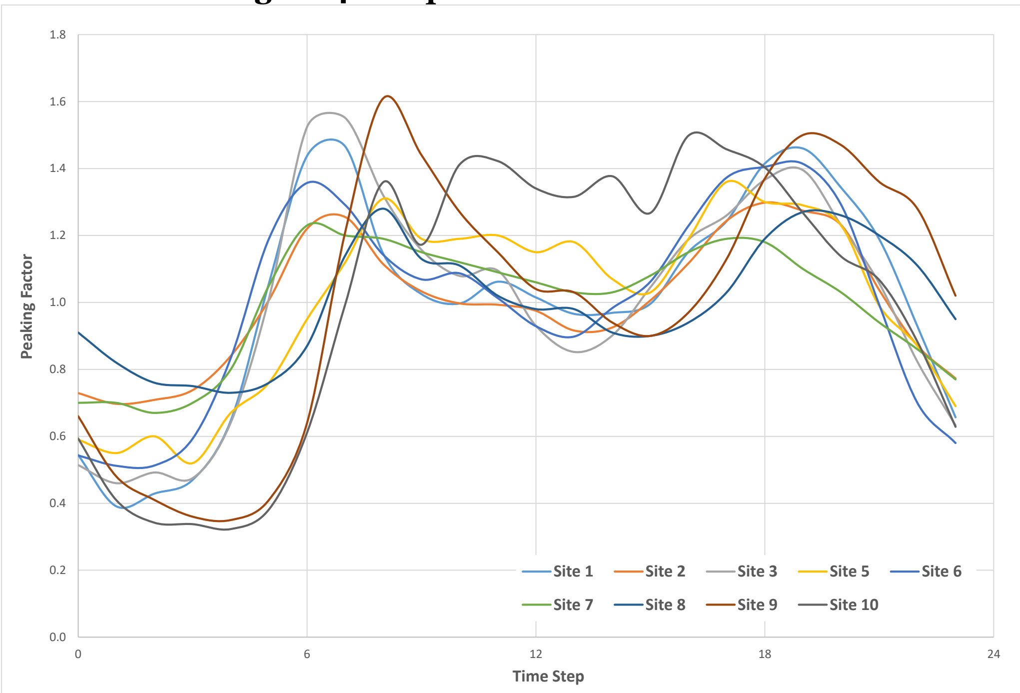
SQUAMISH

Figure 4-1
Flow Monitoring & Rainfall Data Collection

Project No:	D-03692
Designed:	DF
Approved:	
Scale: Meters	0 125250 500
Date:	Mar 2018
Revision:	Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 4-1 Flow Monitoring & Rainfall Data Collection.mxd

Figure 4-2: Squamish Diurnal Patterns



The dry weather flow statistics for each flow monitored area are summarized in Table 4-2 below. The ADWF and the corresponding per capita rate (L/c/day) include all residential, ICI, and GWI flow components.

Table 4-2: Observed DWF Summary

Site	Gross Area (ha)	Net Area (ha)	2015 Total Pop.[1]	ADWF (L/s)	ADWF (L/c/day)	GWI (L/s)	GWI Rate (L/ha/day)
Site 1	63.2	63.2	1,550	6.4	355	0.75	1,023
Site 2	100.6	95.2	1,923	6.8	304	3.65	3,309
Site 3	185.6	176.2	4,853	17.1	304	4.89	2,397
Site 4	114.5	69.2	2,546	*13.3* [2]	*450**	6.8	8,485
Site 5	36.3	35.4	2,440	3.4	121	0.81	1,978
Site 6	110.1	92.8	3,351	5.5	142	2.01	1,868
Site 7-Net**	98.7	68.8	3,952	20.8	454	8.91	11,194
Site 7 (Total)	259.6	204.7	10,316	31.0	259	11.82	4,987
Site 8	89.8	74.8	2,231	4.4	169	1.81	2,092
Site 9	31.5	31.5	1,077	3.8	301	0.81	2,215
Site 10	9.4	7.7	573	0.5	71	0.09	954
Unmonitored Areas	90.2	70.5	3,423	*11.9* [2]	*300****	--	--
Total	**929.9**	**785.3**	**27,919**	**94**	**290**	**--**	**--**

* Assumed to be similar to Site-7-Net.
** Site-7-Net represents the area directly upstream of the Site 7 monitor, flows from further upstream Sites 5, 6, and 10 were removed.
*** Assumed to be close to the Squamish average.
[1] Residential and equivalent population.
[2] Derived values from assumed ADWF per capita rate.

Unmonitored catchment areas were loaded in the model using the 300 L/c/d rate, which is similar to the average rate observed for the entire District. Site 4 was the only flow monitor that could not be used to generate ADWF due to data issues, therefore the rate from Site-7-Net, which has a similar mixture of ICI and residential land use, was applied instead.

4.3 Model Calibration

4.3.1 Calibration Process & Limitations

Model calibration is a key component of the modelling exercise. Once model construction is completed it is important to calibrate the model against known/recorded hydraulic responses in the sanitary sewer system in order to prove the model's reliability. A good correlation between the model simulation results and the known/recorded hydraulic responses indicates a verified/calibrated model. In general, there are two sources of data available for verifying the sewer model:

- Historical (Anecdotal) Data; and,
- Short-Term Flow Monitoring Data.

Calibration of the model using historical data involves the use of known, recorded, past system performance data; whereas calibration using flow monitoring data involves the use of data obtained from a purposely-commissioned flow survey contract. For this SMP, only the implemented short-term flow monitoring data was used to calibrate the model as historical data was not available.

Opus' calibration process involves comparing the predicted **flow and depth** hydrographs from computer model simulations against the recorded/observed flow and depth hydrographs obtained from a flow meter for the same location in the sanitary sewer system.

For a model to be considered calibrated, the variance between predicted and recorded hydrographs is expected to fall within acceptable limits as set out in the WaPUG Code of Practice, summarized below:

- Peak Depth -100 mm to +100 mm
- Peak flow rate +25 % to -15 %;
- Volume of flow + 20 % to -10 % over the period for which the observed flows are expected to be accurate;
- The general shape of the two hydrographs (modelled versus observed) should be similar and should continue until substantial recession has occurred.
- If the above criteria are satisfied for two out of the three selected rainfall events (or where a satisfactory explanation can be given for disparity in the results), the model is considered calibrated.

It should be noted that due to the inherent limitations of the flow monitoring equipment, a complete calibration for all the events cannot be achieved. For example, accurate data cannot be obtained when the depth of flow is less the 50 mm. This is because an unacceptable disturbance is caused by the flow passing over the depth sensor. Similarly, if the velocity data recorded by the velocity sensor is less than 0.2 m/s, the data is unreliable.

4.3.2 Calibration Results

A detailed description of the calibration process as well as the calibration results and comparison graphs between model predicted and field observed flow, depth, and velocity hydrographs are presented in *Technical Memorandum #2 – Model Calibration* (see Appendix A).

In summary, except for Site 5, all other sites are considered calibrated in terms of "Peak Flow" per the WaPUG criteria (i.e. 2 of 3 events must satisfy the "Peak Flow" criteria). For Site 5, the model generally over-predicts the peak flows when compared to observed values. This leads to higher conservatism in the system analysis and the subsequent recommendations for system improvement works. Finally, Opus provided an added value by calibrating the model to not just the observed flow data, but also to the flow depths and velocities data. Flow depth prediction is particularly crucial as the capacity of gravity sewers are evaluated on a depth-based criterion (see Section 5).

4.3.3 Model Predicted I&I Rates

Opus used the calibrated model to predict Rainfall Dependent Inflow & Infiltration (RDII) rates for the various monitored catchments under a 5-year 24-hour design storm (see Section 6.1). In addition, as part of our calibration approach (the RTK method), we were able to quantify the amount of rainfall (in percentages) that enters the District's sanitary system during a storm event. Moreover, the primary mechanism (inflow-driven or infiltration-driven) for I&I could also be determined. These findings are summarized in Table 4-3 below, and were taken into consideration when developing the District's I&I Reduction Strategy in Section 5 of this SMP.

Table 4-3: Model Predicted I&I Rates

Monitored Catchment	Area Description	Peak RDII Rate[1] (L/s/ha)	Total "R"[2]	Dominant I&I Source
Site 10	Victoria St. east of 4th Ave.	0.58	1.4%	Inflow-Driven
Site 8	East Brackendale	0.4	1.5%	Both
Site 7	Areas upstream of Central Lift Station	0.28	1.8%	Inflow-Driven
Site 5	Dentville	0.22	0.8%	Inflow-Driven
Site 9	Tantalus Rd.	0.17	0.5%	Inflow-Driven
Site 1	West Brackendale	0.09	0.4%	Inflow-Driven
Site 2	Garibaldi Estates	0.05	0.5%	Inflow-Driven
Site 3	Garibaldi Highlands	0.04	0.5%	Inflow-Driven
Site 6	Valleycliffe	0.03	0.7%	Infiltration-Driven

[1] Coincides with a 5-year 24-hour duration design storm event (see Section 6.1).
[2] Represents the percentage of rainfall that enters the sanitary system during a storm event.

5 I&I Assessment

Like other municipalities, I&I exists in the District's sanitary sewer system. The high groundwater table, old-aged pipes, and cross connections in the District are prime culprits of I&I. In order to address the I&I problem, it is important to first identify its sources and, if possible, quantify I&I on a catchment level. This section of the SMP report focuses on the work that the District and Opus project team has completed to identify I&I sources, quantify I&I on a catchment level, and prioritize catchment areas for the implementation of their respective sewer rehabilitation program.

5.1.1 Field Investigations

Over the past 5-year period, the District has systematically completed CCTV inspections for the entire gravity sewer network to better understand its conditions and to help identify sources of I&I. Completed alongside the CCTV inspections were manhole inspections and vapour testing. The extent of all the CCTV inspections completed thus far is shown in Figure 5-1. It also shows the year in which they were completed, and the engineering consultant firm that completed the I&I reduction studies and developed the subsequent rehabilitation programs.

Table 5-1 below provides a reference to all the I&I reduction study reports and rehabilitation programs.

Table 5-1: I&I Reduction Study References

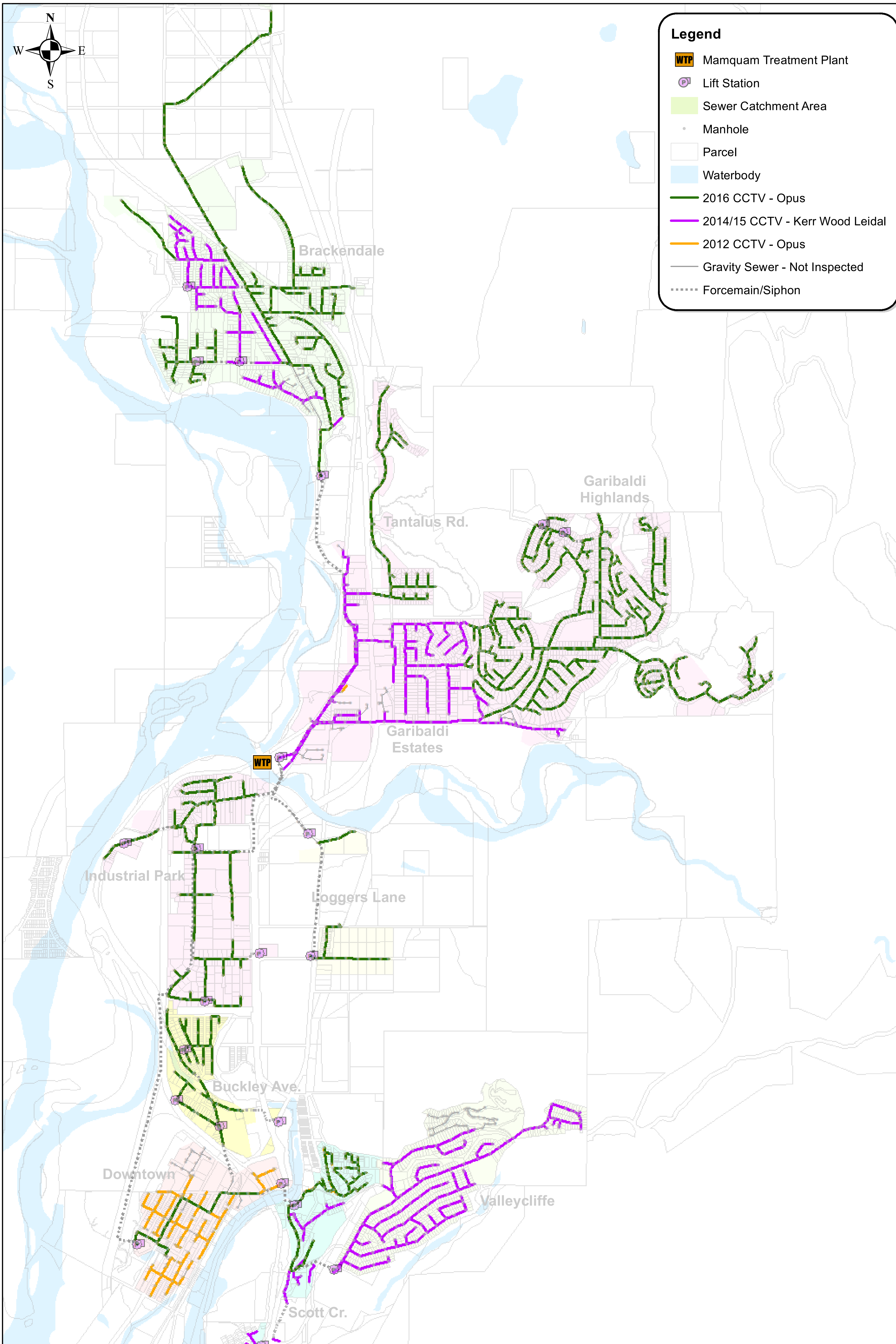
Year of Study	Study Completed by	Report Name	Version	Rehab. Cost
2016	Opus	I&I Reduction Study – Contract No. 2016-002	Draft - 2016	$586,600[1]
2015	Kerr Wood Leidal	Valleycliffe and Garibaldi Estates Sanitary Sewer – Condition Assessment & Rehabilitation Program	Draft - 2016	$1,401,000[2]
2014	Kerr Wood Leidal	M1 LS Assessment and I&I Reduction Study	Final - 2016	$1,512,000
2012	Opus	Assessment and Evaluation of Sanitary Sewer CCTV Inspections	Final - 2013	$133,300

[1] Includes recommendations resulted from manhole inspection and smoke testing
[2] Rehab. Cost for the remaining work as of the end of 2015

5.1.2 I&I Assessment – Catchment-Level Prioritization

Pipe condition is but one of the many factors that impacts I&I in the system. Other factors include manhole conditions, number of cross connections, and the high groundwater table in Squamish. In an effort to "paint a more complete picture" of the I&I situation in the District, we have gathered all the relevant data and information and created Figure 5-2, which illustrates locations of all the likely I&I sources based on field observations (e.g. smoke testing, CCTV inspection, manhole inspection, flow monitoring) and model predictions (e.g. catchment peak RDII rates).

Finally, Figure 5-2 also shows the locations of high I&I, high groundwater level, and structural deficiencies, identified by the District's engineering and operations staff during the Performance Review Workshop at the beginning of this SMP assignment. They may not represent all observed data.



OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

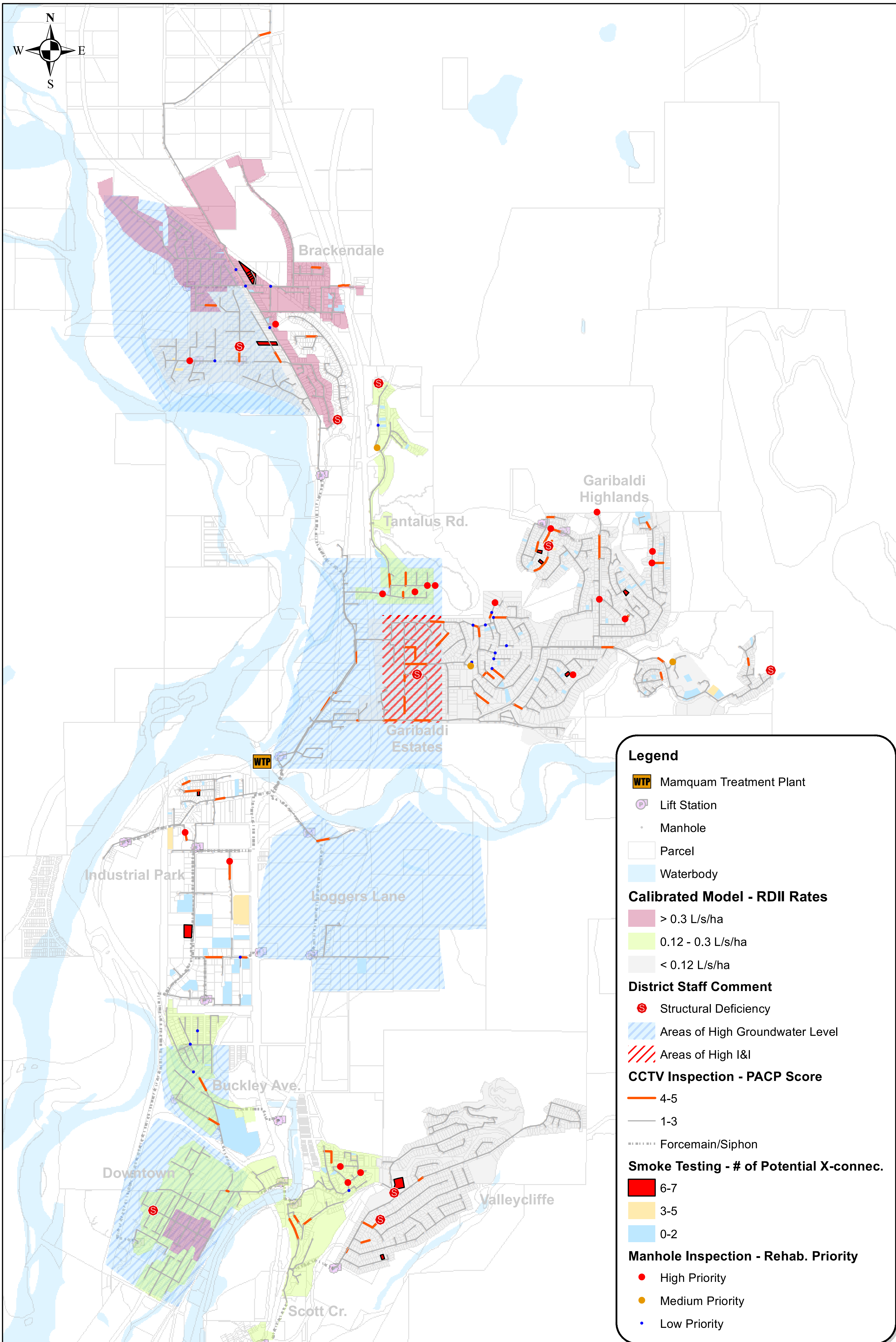
Client: District of Squamish

SQUAMISH

Figure 5-1
Extent of CCTV Inspections

Project No: D-03692	Scale: Meters 0 125250 500
Designed: DF	
Approved:	Date: Mar 2018
	Revision: Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 5-1 CCTV Inspections.mxd



OPUS

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: District of Squamish

SQUAMISH

Figure 5-2
I&I Assessment

Project No: **D-03692**
Designed: **DF**
Approved:

Scale: Meters 0 125250 500

Date: **Mar 2018**
Revision: Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 5-2 I&I Assessment.mxd

Based on Table 4-3, the flow monitored catchment of Victoria Street east of 4th Avenue in Downtown is predicted to have the highest I&I and warrants the highest priority in I&I reduction efforts. It should be noted that this does not necessarily mean that the entire Downtown is experiencing high I&I, however it is assumed as such given that the monitored catchment is representative of other parts of Downtown.

Another catchment area that is of concern in terms of high I&I is Brackendale, especially East Brackendale. The flow monitoring completed in the Fall of 2015, and the subsequent calibrated model, both suggest that the eastern and northwestern portions of Brackendale are experiencing large I&I (~ 0.4 L/s/ha). This is further supported by the smoke testing completed in late 2016, which identified at least six (6) lots with a relatively high number of inflow points (6 or more). There are also at least seven (7) gravity sewer sections with PACP scores of 4 or 5 in Brackendale, second only to the Garibaldi catchment. Finally, in addition to half of Brackendale experiencing high groundwater levels, District staff has identified two (2) structural deficiencies in the gravity sewers in Brackendale. Based on the above, we would also flag Brackendale as a high I&I catchment and would recommend the District focus on the rehabilitation programs that have been developed for this area.

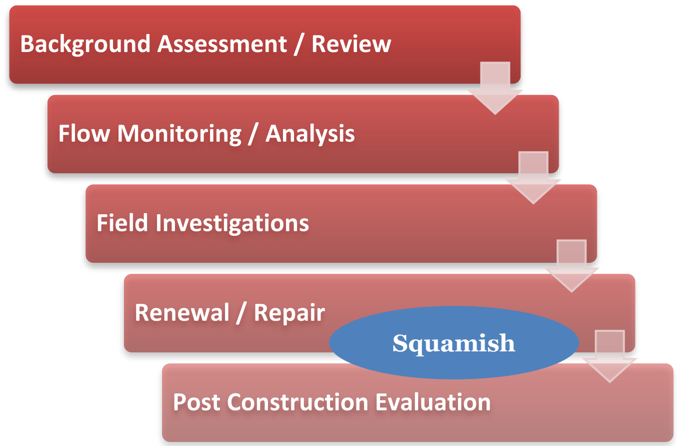
Based on Figure 5-2, the Garibaldi catchment area has the most number of pipes with PACP scores of 4 or 5 (i.e. poorest gravity sewer conditions). Manhole inspection, completed in late 2016, found numerous manholes with poor conditions that warranted high rehabilitation priorities. At the same time, smoke testing completed in area has identified at least four (4) houses with a relatively high number of inflow points (6 or more). Based on the above information, Opus would still consider Garibaldi as a high I&I priority catchment, from a deteriorating asset condition standpoint, despite the low I&I rates predicted in Table 4-3. Pipes with poor conditions are susceptible to introducing more I&I into the network if repairs and/or rehabilitation are not completed in a timely manner.

The other catchment areas are prioritized based on the rationale described in Table 5-2 below.

Table 5-2: Catchment-Level I&I Prioritization

<table>
<tr><th>Catchment Area</th><th>I&I Priority</th><th>Rationale</th></tr>
<tr><td>Downtown</td><td rowspan="3">High</td><td rowspan="3">• Very poor pipe condition (PACP = 4 or 5)
• High number of inflow points identified in smoke testing
• Poor manhole condition
• I&I is magnified by the high groundwater levels
• High I&I observed in Brackendale and Downtown</td></tr>
<tr><td>East Brackendale</td></tr>
<tr><td>Garibaldi</td></tr>
<tr><td>Industrial Park</td><td rowspan="3">Medium</td><td rowspan="3">• Some pipes with poor condition
• Some points of inflow identified in smoke testing
• Poor manhole condition
• Few structural deficiencies noted
• Mid-level I&I (0.12 – 0.3 L/s/ha) observed in Scott Cr. and Tantalus Rd.</td></tr>
<tr><td>Tantalus Rd.</td></tr>
<tr><td>Scott Crescent</td></tr>
<tr><td>Valleycliffe</td><td rowspan="4">Low</td><td rowspan="4">• Generally good pipe condition (PACP = 1 or 2)
• Very few points of inflow identified in smoke testing
• Generally, very good manhole condition</td></tr>
<tr><td>West Brackendale</td></tr>
<tr><td>Dentville</td></tr>
<tr><td>Loggers Lane</td></tr>
</table>

5.1.3 I&I Reduction Strategy



Typically, the process of I&I reduction consists of the tasks illustrated in the flow chart on the right. Having already completed flow monitoring and CCTV inspection for the entire sanitary sewer network, plus vapour testing and manhole testing for most of the network, the District is currently in the process of implementing the manhole and sewer rehabilitation programs developed between 2014 and 2016.

Through this SMP, we have developed a Sewer Main Renewal Tool, discussed further in Section 9, where one of the objectives is to help refine the rehabilitation programs by way of identifying the renewal/repair year and selecting the most cost-effective renewal method for each gravity sewer. The District should note that the intent of the tool (and the resultant Sewer Main Renewal Plan) is not to replace the rehabilitation programs already in place, but rather to reinforce decision making in relation to "when to renew" and "what renewal method to use".

Table 5-2 identifies Downtown, East Brackendale, and Garibaldi as the areas that the District should focus its rehabilitation efforts first. Then, move onto Scott Crescent, Industrial Park, and Tantalus Road catchment areas. The Dentville, Valleycliffe, and Loggers Lane catchment areas can be placed on a "continue-to-monitor" status. The following sections describe the continuous monitoring and inspections to implement moving forward with the objective to reducing I&I.

5.1.3.1 Implement Sanitary Flow Monitoring Program

This work has been included in our Capital Projects List (Section 8) as an O&M project with the ID "OM-03".

The District wants to conduct flow monitoring as part of future updates to the sanitary model and master plan, which is recommended to be completed every 5 years. According to the standard pricing provided by our flow monitoring contractor, the cost for each site is approximately $7,000 for four months of flow data. Flow monitoring a total of ten (10) sites, similar to those monitored as part of this SMP, would cost $70,000 (2017 dollars). This cost is provided for budgetary purposes and does not include scope for I&I assessment and model calibration.

5.1.3.2 Recurring CCTV Inspections, Manhole Inspections, and Vapour Testing

This work has been included in our Capital Projects List (Section 8) as an O&M project with the ID "OM-06".

The District's financial plan has included a budget item for CCTV under the Operating Account Code 3024221202. This was a recommendation from the District's *2015 Liquid Waste Management Plan: Stage 2-3 Report*. We have updated the required budget based on the following rationale.

The District has already CCTV inspected its entire gravity sewer network in a period of 5 years, between 2012 and 2016. In addition, most of the sewer network has also been vapour tested and the manholes inspected. Starting in 2023 (10 years after the first CCTV inspection in Downtown), we would recommend the District inspect 10% of its gravity sewers each year as per recommendation from the Water Research Center (WRc). The area we would recommend the District start with is Downtown as it was lasted inspected in 2012. After Downtown, the District should then focus on Garibaldi Estates, West Brackendale, and then Valleycliffe. Basically, in the same order as the previous cycle. Simultaneous to the CCTV inspection, the District should also complete manhole condition assessments and vapour testing for the same area.

Opus has delineated the District's sanitary sewer system into ten (10) CCTV catchments, each with approximately 10 km of gravity sewers (~10% of network), as shown in Figure 5-3. The intent of doing this is such that the District can now cycle through these gravity sewers in each CCTV catchment every year to meet the suggested CCTV inspection frequency of 10% of the system. This delineation should be revised if and when the District has installed more than 5 km of new gravity sewers.

According to our experience, it costs approximately $10 per meter of gravity sewers to flush and CCTV inspect them, inspect manholes, complete vapour testing, analyze the data, and deliver a report with recommendations (i.e. the rehabilitation program). Based on the recommended yearly schedule to inspect 10% of the District's gravity sewer network (~100 km), the annual budget comes to $100,000 (2017 dollars). This is more than the allocated $63,000 as proposed in the Flow Reduction Program as outlined in the District's *2015 Liquid Waste Management Plan: Stage 2-3 Report*.

5.1.3.3 Develop a Groundwater Monitoring Strategy

This work has been included in our Capital Projects List (Section 8) as an O&M project with the ID "OM-05".

It is a well-known fact that the District has high groundwater levels in some areas but the effects on I&I in gravity sewers are not very well understood. Groundwater monitoring would greatly complement the sanitary flow monitoring program in that the effects of groundwater on I&I, more so infiltration, can be correlated. Opus recommends the District commission a project to develop a Groundwater Monitoring Strategy to assist the District's ongoing effects to reducing I&I.

Our understanding is that the Province of British Columbia2 operates a provincial observation well network of over 180 wells, which was established in 1961 to monitor groundwater availability in areas of high human use. There is an observation well (#454) located in Squamish (3800 Paradise Valley Road)3 with real-time groundwater level data, however it is too removed from the District system to provide representative data.

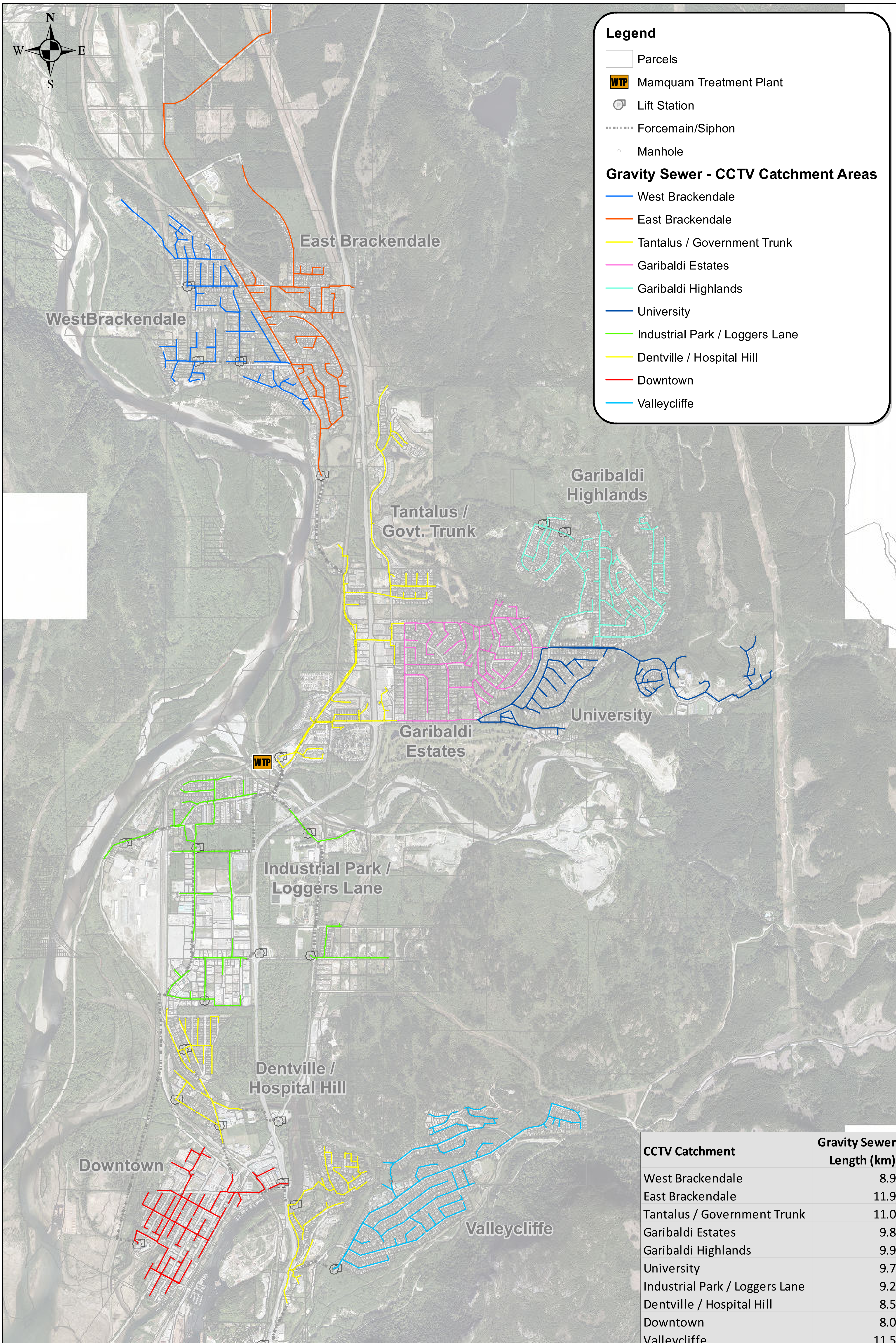
The District has some level probes in place at Hendrickson field well and cemetery well that can be used to initiate the development of a groundwater monitoring strategy for the District of Squamish. The District has installed several permanent groundwater piezometers near lift stations/PRV's for long-term testing and they are tied in with the District's SCADA system. The District aims to continue expanding its monitoring well system in the future as part of this Strategy/Program, the data and results can then be incorporated into future flow monitoring studies.

For budgeting purposes, we have estimated a cost of $50,000 for developing the strategy. In addition, based on a quote from our contractor, the cost to install a groundwater well plus data logging for a 1-year period ranges between $17,000 and $50,000 for one site, depending on site conditions.

---

[2] http://www.env.gov.bc.ca/soe/indicators/water/groundwater-levels.html

[3] http://www.env.gov.bc.ca/wsd/data_searches/obswell/map/index.html?ID=454



CCTV Catchment	Gravity Sewer Length (km)
West Brackendale	8.9
East Brackendale	11.9
Tantalus / Government Trunk	11.0
Garibaldi Estates	9.8
Garibaldi Highlands	9.9
University	9.7
Industrial Park / Loggers Lane	9.2
Dentville / Hospital Hill	8.5
Downtown	8.0
Valleycliffe	11.5

OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: District of Squamish

SQUAMISH

Figure 5-3
CCTV Catchments

Project No: **D-03692**
Designed: **DF**
Approved:
Scale: Meters 0 125 250 500
Date: **Mar 2018**
Revision: Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 5-3 CCTV Catchments.mxd

6 Evaluation Criteria

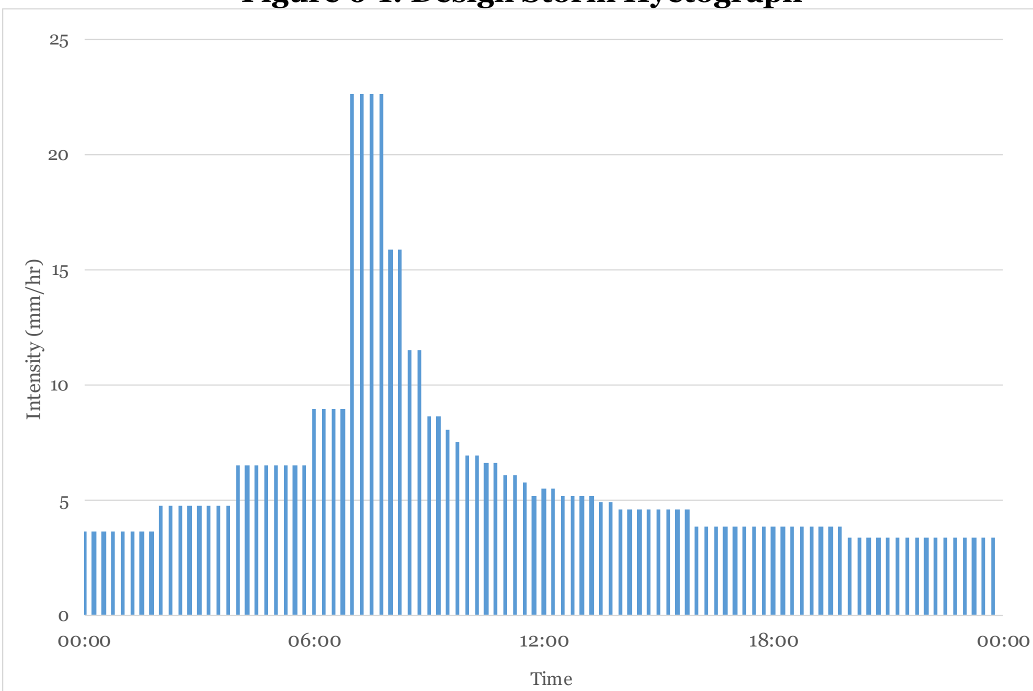
The following describes the key criteria used to assess the District's sanitary sewer system.

6.1 Design Storm

The sanitary system is assessed under Peak Wet Weather Flow ($PWWF_5$) that coincides with a 5-year 24-hour storm event. Based on the District's Intensity-Duration-Frequency (IDF) curves, the total rainfall for a 5-year 24-hour storm is 144 mm. The SCS Type-1A storm distribution, applicable to Coastal British Columbia, was applied in the model to simulate a design rainfall event.

Figure 6-1 illustrates the design storm hyetograph used to assess the District's sanitary system.

Figure 6-1: Design Storm Hyetograph



6.2 Key Design Rates – Buildout Scenario

The following key rates were applied to assess the District's sanitary system under the buildout scenario:

- ADWF Rate = 350 L/c/day – applied globally to both residential and ICI equivalent populations.
- ICI Rate = 25,000 L/ha/day – only applied to new developments with ICI components.
- Inflow & Infiltration (I&I) Allowance = 0.12 L/s/ha (10,368 L/ha/day)– only applied to new developments. The I&I characteristics and responses of the existing system continue to be governed by the calibrated I&I parameters.

The above rates are based on Master Municipal Constructions Document (MMCD) guidelines and were used in agreement with the District.

6.3 Gravity Sewers

It was agreed with the District that the maximum Depth-to-Full Depth ratio (d/D) for gravity sewers must not exceed 0.8 (80% full) as per the MMCD guidelines; any gravity sewers that have d/D > 0.8 are considered deficient. The d/D ratio is one of the most commonly used sewer capacity indicators as it identifies sewers that are, or are close to, surcharging (d/D > 0.95). It gives an indication as to how much capacity is left in the gravity sewer before it is anticipated to surcharge. Deficient gravity sewers should be upsized for Peak Wet Weather Flow ($PWWF_5$) that coincides with a 5-year 24-hour storm under the buildout scenario.

6.4 Siphons

Under pressure, sanitary sewer siphons have different evaluation criteria when compared to gravity sewers. Two criteria were used to assess the capacity of the District's existing siphons:

- A minimum cleansing velocity of 0.75 m/s (MMCD) must be achieved at least once per day; and,
- The siphon must not cause upstream gravity sewers that discharge directly into the siphon to become deficient (d/D > 0.8).

6.5 Lift Stations

The pumps in a lift station must be able to convey $PWWF_5$ with the largest pump in failure mode (MMCD), otherwise, the lift station is considered deficient and the pumps should be upsized to handle $PWWF_5$ under the buildout scenario. At minimum, a duplex pump configuration must be considered.

6.6 Forcemains

Per the District's Bylaw No. 2373, 2015 – Section 2.14, a minimum cleansing velocity of 1.0 m/s should be maintained within forcemains and the maximum velocity should not exceed 2.5 m/s. If velocities exceed 2.5 m/s, twinning or upsizing of the forcemain may be recommended depending on the circumstances.

7 System Capacity Assessment

This section covers the hydraulic analysis of the existing District sanitary sewer system under both the existing (2015) and future (2050) buildout conditions. The objective of the analysis is to assess the system's performance with respect to compliance with the design criteria outlined in Section 5; and, to highlight existing and future deficiencies in the system. A table summarizing the capacity assessment is shown in Table 7-1. Capacity-based and other system improvements are subsequently proposed in Section 8.

7.1 Scenario Development

The following flow conditions were modelled to assess the District's existing sewer system:

- 2015 Average Dry Weather Flow **(2015 ADWF)**: to understand the performance of the current system under the average day flow condition and to identify issues (i.e. low velocities), if any.
- 2015 Peak 5-year Wet Weather Flow **(2015 PWWF$_5$):** to assess system performance under the peak wet weather flow condition. This scenario is used to identify any capacity issues that the current system is susceptible to under the **existing** flow condition coinciding with a 5-year storm event.
- 2050 Peak 5-year Wet Weather Flow **(2050 PWWF$_5$):** to assess system performance under the peak wet weather flow condition. This scenario is used to identify any anticipated capacity issues that the current system is susceptible to under the **future** flow condition coinciding with a 5-year storm event. It will also be used to verify the proposed system improvements (i.e. sizing upgrades).

7.2 Existing (2015) ADWF Analysis

Under the existing ADWF condition, all the District's gravity sewers have d/D less than 0.8, providing a general indication that the sanitary sewer network has sufficient capacity to convey the ADWF. However, it is noted that the siphon crossing at Maple Drive does not meet the minimum self-cleansing velocity of 0.75 m/s. In the short term, it is recommended that siphons be flushed regularly to avoid siltation and buildup in the pipe. The eventual buildout of the sewer system through growth and new development upstream will resolve these low velocities identified and therefore long-term recommendations for the siphon are not required.

7.3 Existing (2015) PWWF$_5$ Analysis

Overall, the District's existing sanitary system is adequate in accommodating the existing peak wet weather flows. All gravity sewers have d/D less than 0.8, except for 130 metres of 200 mm gravity sewer upstream of the Scott lift station, as shown in Figure 7-1. Furthermore, all twenty (20) lift stations, that were assessed in this SMP, have adequate capacities to accommodate existing peak flows.

Based on discussions with District staff, there seems to be a discrepancy between the flows observed by District staff and flows predicted by the model at the Central lift station when the one 30-hp pump is running. The model is predicting higher flows than observed (~20 L/s more), indicating a high potential of increased downstream headlosses. After reviewing the record drawings for the 3.5 km of 400 mm HDPE forcemain, we suspect there could be significant grease buildup along the forcemain, especially at various low points along the alignment. We would recommend pigging/swabbing to help clean the forcemain.

In addition, high flow velocities (> 2.5 m/s) are predicted in six (6) forcemains: Scott; Valleycliffe; Judd & Cotton; Enterprise; Queens Way; and, Centennial. The velocities in Scott, Valleycliffe, and Queens Way are marginally over the criteria at not more than 3.0 m/s and do not justify a pipe upsize. For Centennial, a velocity of 3.2 m/s is predicted for the sections downstream of the bridge, which are expected to experience higher velocities. Finally, for the Judd & Cottonwood and Enterprise forcemains, large velocities are only predicted for the very short sections at the beginning of the forcemains. In the long-term, these considerations are taken into account with additional factors (e.g. increased pumping rates, forcemain replacement year, constructability) when developing the District's forcemain renewal plan, which is embedded in the Capital Investment Plan in Section 10. The forcemain renewal plan must also be linked to lift station pumping improvements to provide a holistic view of system renewal. Therefore, in most cases in the short term where minimal lift station upgrades are proposed, these forcemains are recommended to be operated as per status quo.

7.4 Buildout (2050) $PWWF_5$ Analysis

This section describes our assessment of the District's current sanitary system in its ability to accommodate future buildout (2050) peak flows in Squamish. Figure 7-2 illustrates of our assessment results, showing the locations of deficient lift stations and gravity sewers under the buildout scenario. Figure 7-2 also shows the locations of all the developments slated to occur between 2015 and 2050.

7.4.1 Lift Station & Forcemain

A total of six (6) lift stations are considered deficient by capacity under the future buildout condition: the Easter Seal, North Yards, Centennial, Queens Way, Buckley, and Mamquam lift stations. These deficiencies also cause upstream gravity sewers to surcharge and manholes to overflow, especially upstream of the North Yards and Centennial lift stations. To mitigate these deficiencies, improvement options, including installing larger and/or more pumps in the lift stations, building new lift stations, forcemain upsizing/twinning, and other alternative servicing strategies, are evaluated and recommended for each of these deficient lift stations in Section 8.

In addition to those forcemains noted in the 2015 analysis (Section 7.3), one (1) other forcemain, Easter Seal, is predicted to have high velocities (> 2.5 m/s) under the buildout scenario. The marginal velocity deficiency does not justify a pipe upsize, and plus, the Easter Seal lift station and forcemain have been recommended by this SMP for decommissioning (see Section 8).

7.4.2 Gravity Sewer

If the current system were to remain unchanged until 2050, a total of 7.1 km of gravity sewers are predicted to surcharge and 16 manholes are likely to overflow in the 2050 buildout scenario. A large portion of these sewer deficiencies are due to insufficient hydraulic capacities in the pipe, such is the case for those located in the Tantalus Road and East Brackendale areas. The other main cause of sewer surcharging is the lack of pumping capacity in the downstream lift station, causing sewer back ups upstream. In more severe cases, these cause manholes to overflow.

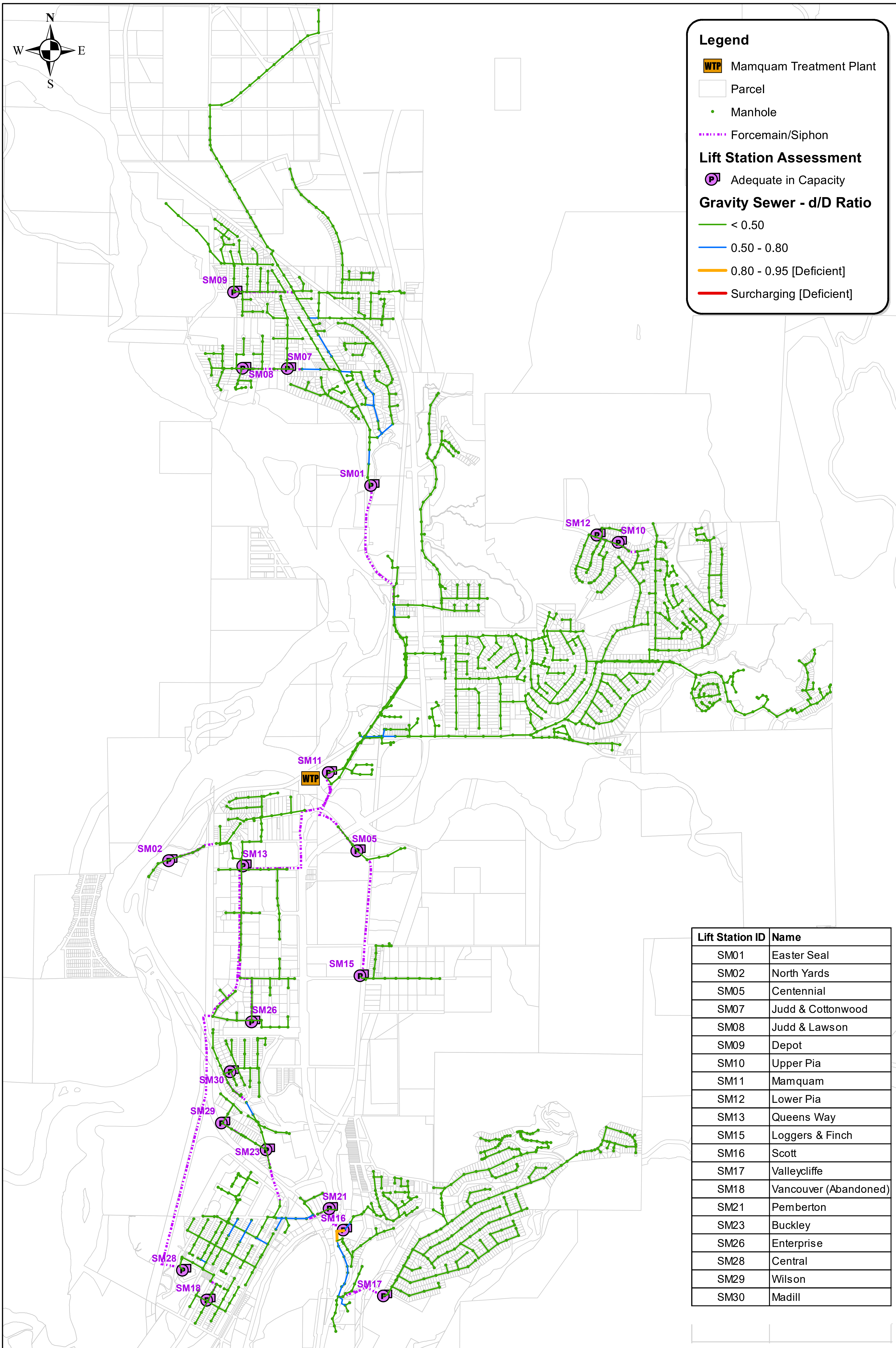
7.5 Capacity Assessment Summary

Table 7-1 summarizes our capacity assessment results (i.e. system deficiencies) of the District's existing sanitary sewer system under the existing and 2050 buildout scenarios.

Appendix D provides tabulated summary of model predicted results for the District's gravity sewers, forcemains, and lift stations.

Table 7-1: Assessment Summary – Deficient Sanitary Assets

<table>
<tr><th>Sanitary Assets</th><th>Existing (2015) Scenario</th><th>Buildout (2050) Scenario</th></tr>
<tr><td>Gravity Sewer</td><td>• 130 m of gravity sewers upstream of Scott lift station are deficient.</td><td>• 7.1 km of gravity sewers are deficient. They are mainly located in the Tantalus Road and East Brackendale areas.
• A total of 16 manholes are expected to overflow. They are caused by the insufficient capacities in the downstream lift stations and/or gravity sewers.</td></tr>
<tr><td>Lift Station</td><td>• No lift stations are deficient under the existing scenario.
• Pigging/swabbing of the Central lift station forcemain is recommended.</td><td>• List of deficient stations:
o North Yards
o Centennial
o Easter Seal
o Buckley
o Queens Way
o Mamquam</td></tr>
<tr><td>Forcemain</td><td>• High velocities (> 2.5 m/s) are predicted in the following forcemains:
o Scott – 200 mm @ 3.0 m/s
o Valleycliffe – 200 mm @ 3.0 m/s
o Judd & Cottonwood – short 100 mm section @ 5.9 m/s
o Enterprise – short 100 mm section @ 7.3 m/s
o Queens Way – 300 mm @ 2.7 m/s
o Centennial – 150 mm @ 3.2 m/s
• The Scott, Valleycliffe, and Queens Way forcemains are marginally deficient and do not justify a pipe upsize.
• Only the section of Centennial forcemain downstream of the bridge has high velocities, as expected.
• The deficient Judd & Cottonwood and Enterprise forcemains are very short sections in relation to the overall length of the forcemains and do not justify a pipe upsize.</td><td>• In addition to those noted under the 2015 analysis, the following forcemains have high velocities (> 2.5 m/s):
o Easter Seal – 250 mm @ 2.9 m/s
• All the above forcemains are marginally deficient and do not justify a pipe upsize.</td></tr>
<tr><td>Siphon</td><td colspan="2">• The 150 mm low-pressure siphon at Maple Drive does not reach the minimum cleansing velocity of 0.75 m/s (at least once per day). Regular flushing on the siphon is recommended for the short term.</td></tr>
</table>



Lift Station ID	Name
SM01	Easter Seal
SM02	North Yards
SM05	Centennial
SM07	Judd & Cottonwood
SM08	Judd & Lawson
SM09	Depot
SM10	Upper Pia
SM11	Mamquam
SM12	Lower Pia
SM13	Queens Way
SM15	Loggers & Finch
SM16	Scott
SM17	Valleycliffe
SM18	Vancouver (Abandoned)
SM21	Pemberton
SM23	Buckley
SM26	Enterprise
SM28	Central
SM29	Wilson
SM30	Madill

OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: District of Squamish

SQUAMISH

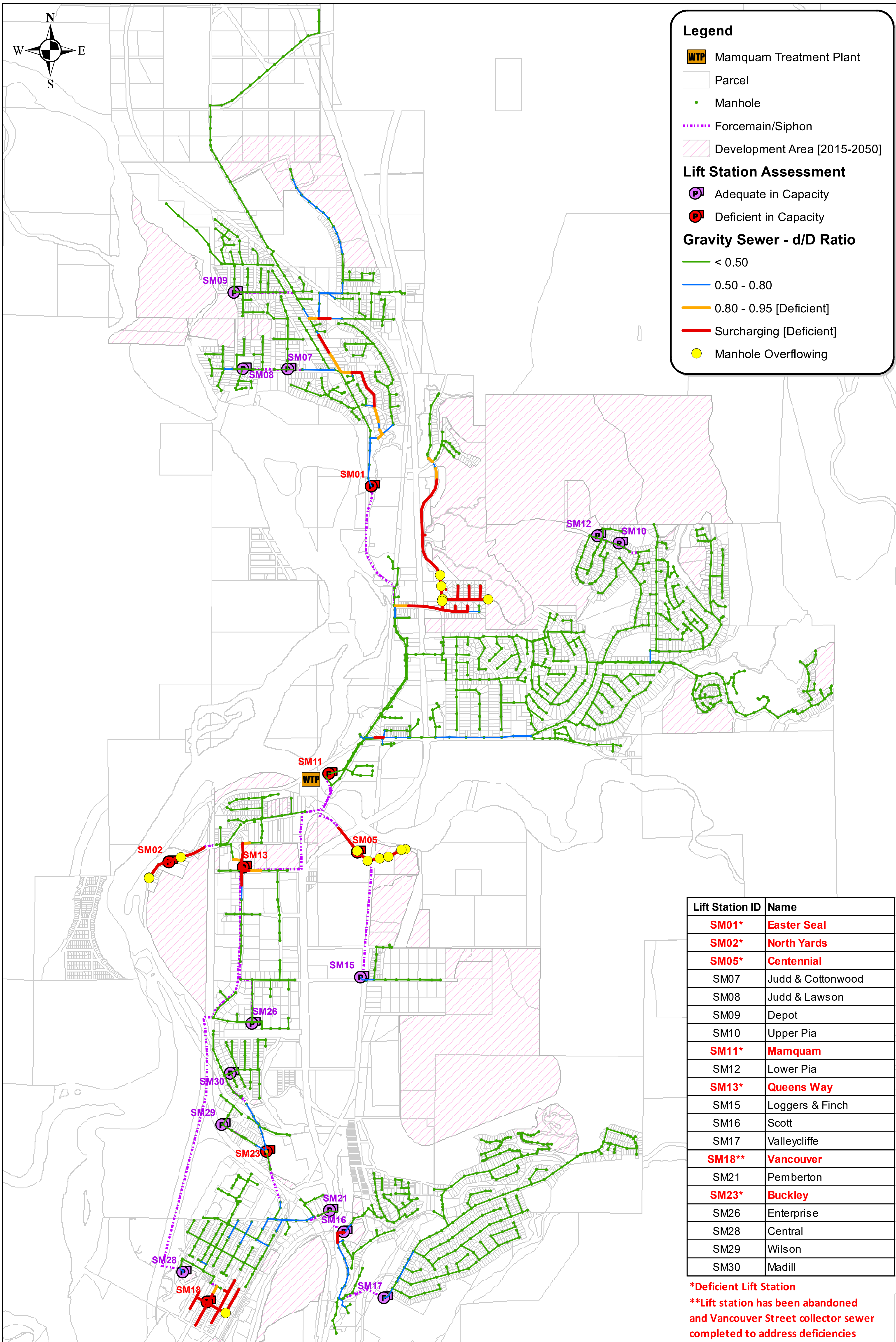
Figure 7-1
Sanitary System Capacity Assessment under 2015 PWWF$_5$ Condition

Project No: D-03692
Designed: DF
Approved:

Scale:
Meters
0 125 250 500

Date: Mar 2018
Revision:
Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 7-1 PWWF5 Issues-2015.mxd



Lift Station ID	Name
SM01*	Easter Seal
SM02*	North Yards
SM05*	Centennial
SM07	Judd & Cottonwood
SM08	Judd & Lawson
SM09	Depot
SM10	Upper Pia
SM11*	Mamquam
SM12	Lower Pia
SM13*	Queens Way
SM15	Loggers & Finch
SM16	Scott
SM17	Valleycliffe
SM18**	Vancouver
SM21	Pemberton
SM23*	Buckley
SM26	Enterprise
SM28	Central
SM29	Wilson
SM30	Madill

*Deficient Lift Station

**Lift station has been abandoned and Vancouver Street collector sewer completed to address deficiencies

OPUS
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: District of Squamish

SQUAMISH

Figure 7-2
Sanitary System Capacity Assessment under 2050 PWWF$_5$ Condition

Project No: D-03692
Designed: DF
Approved:

Scale: Meters 0 125250 500

Date: Mar 2018
Revision:
Revision Date:

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 7-2 PWWF5 Issues-2050.mxd

8 Capital Projects List

This section provides a prioritized list of capital projects for the District to undertake over the next 33 years. They are being recommended, primarily, to address deficiencies identified in our system capacity assessment. In addition, several O&M projects have also been identified at the end of the section for the District's consideration. The renewal of sewer mains – gravity sewer and forcemains, is discussed in Section 9, which also includes a description of our costing methodology for gravity sewers and forcemains.

When recommending the capital projects, Opus reviewed various recommendations from previous studies including the most current Development Cost Charge (DCC) Bylaw, the 2011 Asset Management Plan, the Downtown Squamish Servicing Strategies, and the M1 LS Assessment and I&I Reduction Study (2016). Opus has considered and incorporated the relevant recommended projects from these past studies into this list.

The recommended capital projects are split into three categories: Gravity Sewer (ID prefix "GS-"), Lift Station (ID prefix "LS-"), and Operational and Maintenance (ID prefix "OM-") projects. These projects are prioritized into three implementation schedules: ***[2017-2021]***, ***[2022-2031]***, and ***[2032-2050]***. The timing of these projects is estimated after the Sewer Utility Financing assessment (i.e. affordability) and is presented in the Capital Investment Plan in Section 10 along with the sewer main renewal plan, and their general locations.

The reader should note that some of the projects in this list may service a single development or a small number of developments. In those cases, costs for the upgrade project would be borne by the developer(s). In cases where several developments trigger and benefit from upsizing a piece of critical infrastructure, the District may choose to incorporate the project into the DCC Bylaw. In either case, the projects would be funded by developers directly or by DCC funds. In addition, assumptions have been made on the timing of some capital projects, it should be refined based on the actual timing of development(s), when known.

8.1 Gravity Sewer Projects

A total of ten (10) gravity sewer capital projects are recommended with a total length of approximately 3.6 km. A description of each project, including the suggested implementation schedule, is detailed below for each sewer catchment.

8.1.1 Tantalus Road

There are four (4) gravity sewer capital projects in the Tantalus Road area:

GS-01 – Tantalus Road Sewer Upgrade [2017-2021]

The existing 200 mm gravity sewers on Tantalus Road (from Tantalus Place to Starview Place) act as a severe bottleneck to the system. It is recommended to upsize these sewers to 450 mm immediately to avoid sewer back up and surcharging.

GS-02 – New Chief View Road Highway Crossing [2017-2021]

The current highway crossing (200 mm gravity sewers) at Harris Road will become under capacity when developments upstream commence (e.g. Garibaldi Springs). Two improvement options have been considered: pipe bursting the current 200 mm sewers to 525 mm; or, constructing a new 525 mm sewer across the highway at Chief View Road via tunnelling. There are limitations to pipe bursting in terms of sewer size increase – pipe bursting is inappropriate in this case due to the 5-size increase from 200 mm to 525 mm and as such, Opus recommends the tunneling option.

A new 450 mm sewer will need to be constructed to connect the existing system at Starview Place to the new 525 mm crossing. It is recommended to install a 450 mm stub facing south at the crossing to accommodate the flow diversion from Garibaldi Way at a later stage (see Project "GS-09").

GS-03 – Harris Road Highway Crossing Abandonment [2017-2021]

Upon completion of the Chief View Road Highway Crossing ("GS-02"), the Harris Road crossing may be abandoned. The existing 200 mm gravity sewers on Harris Road upstream of the existing crossing (east of the highway) should be replaced and graded to flow east (instead of west) to the sewer system on Tantalus Road.

GS-12 – Newport Ridge Drive Sewer Upgrade [2032-2050]

The trigger for capacity upgrades to the existing 200 mm gravity sewer on Newport Ridge Drive is very likely to be the Cheema (DL 509/510) and/or Holborn Group (DL 510/511) developments, a portion of which has been assumed to discharge to this 200 mm gravity sewer. At the time of writing this report, layouts for DL 509/510/511 have not been planned/proposed and as such, this "GS-12" capital project is subject to refinement in the future when more details about the developments become available.

8.1.2 Downtown

No gravity sewer capital project is proposed for the Downtown area.

8.1.3 Brackendale

There are two (2) gravity sewer capital projects in the Brackendale area:

GS-05 – Government Road Sewer Upgrade and Flow Diversion [2022-2031]

The Brackendale area is mainly serviced by the gravity system along Government Road, which is split at Judd Road. Sewage from north of Judd Road is conveyed east on Judd Road and south on Meadow Avenue (the "Meadow alignment") before connecting back to the 450 mm Government Road trunk sewer.

This Meadow alignment currently consists of 350 mm gravity sewers and is inadequate to service the proposed Cheekeye River Development, which could add approximately 3,900 Population Equivalent (subject to change) to the Brackendale area.

Two improvement options have been considered: 1) Upsize the entire alignment (on Government Road and Meadow Avenue) from 350 mm to 450 mm, and 2) Upsize only the sewers on Government Road and divert some sewage away from Judd Road and Meadow Avenue by connecting the north and south sewers at the Government Road and Judd Road intersection.

The second option is certainly the least costly and recommended option – upsizing of sewers on Judd Road and Meadow Avenue is not required as it utilizes the capacity available in the 450 mm Government Road trunk sewers south of Judd Road. The Judd Road and Meadow Avenue sewers are still subject to relining or replacing according to our proposed Sewer Main Renewal Plan (Section 9). The flow split will provide a redundancy to the network as the Judd Road and Meadow Avenue gravity sewers are no longer the only sewers servicing areas north of Judd Road.

Lastly, a short section of 200 mm gravity sewer, located immediately east of Government Road on the easement south of Depot Road, needs to be upsized to 300 mm to accommodate 2050 buildout flows.

Note that the exact timing of this project is going to be based on the timing of the development.

GS-11 – Easter Seal Gravity Bypass [2022-2031]

Our capacity assessment identifies the Easter Seal lift station as deficient under the 2050 buildout scenario, mainly as a result of the proposed Cheekeye River Development. The District has completed a desktop study in 2016 – *"M1 LS Assessment and I&I Reduction Study",* which looked at two (2) servicing options for the Brackendale area: 1) upgrade the lift station's capacity to accommodate future flows, and, 2) constructing a gravity bypass from the lift station to the Government Road trunk sewer. The study included lifecycle cost analyses which suggest that both the options have similar net present values (NPV). The study concluded with the Gravity Bypass option being the more favourable option, mainly due to the reduced maintenance efforts and improved aesthetics of the area, which is adjacent to a tourist attraction point.

Based on the available desktop-level information, Opus would recommend the Gravity Bypass option as well. The implementation of this option is not required in the short-term as the current Easter Seal lift station is operating adequately (condition- and capacity-wise) and has 10-15 years of remaining service life, as per the abovementioned 2016 study.

The reader should note that Opus' cost estimate for this Gravity Bypass option is significantly higher than that estimated in the 2016 study and as a result, could impact/change the NPV analysis conducted. It is advisable for the District to complete further preliminary engineering in the future to confirm the cost estimate and NPV analysis results before embarking on this Gravity Bypass option.

8.1.4 Scott Crescent

There is one (1) gravity sewer capital project in the Scott Crescent area:

GS-06 – Scott Crescent Sewer Upgrade [2022-2031]

The 250 mm gravity sewers immediately upstream (~133 m) of Scott lift station are deficient under the existing scenario but because the sewers are deep and there a very few service connections, we would recommend using them as system storage (i.e. allowing the sewers to surcharge) to defer, until 2021, the immediate need of upsizing them to 375 mm.

District staff have indicated that these sewers are deep and that any construction work in this area will be impacted by the high groundwater level, especially in areas near Scott lift station. The District may consider pipe-bursting to avoid a deep trench (~5 m).

8.1.5 Loggers Lane

There is one (1) gravity sewer capital project in the Loggers Lane area:

GS-08 – Centennial Way Sewer Upgrade [2022-2031]

The current 200 mm gravity sewer on Centennial Way, from the east end all the way to the Centennial lift station, will become deficient under the 2050 buildout scenario. They are recommended to be upgraded to 300 mm to service future developments (e.g. Anthem Development). This project would be 100% funded by the developer(s).

8.1.6 Garibaldi

There is one (1) gravity sewer capital project in the Garibaldi area:

GS-13 – Mamquam Road Sewer Upgrade [2032-2050]

The existing 300 mm gravity sewer along Mamquam Road from Willow Court to Government Road needs to be upsized to 375 mm to accommodate 2050 buildout flows. The current sewer discharges into the 450 mm trunk sewer on Government Road. We recommend the new and upsized 375 mm Mamquam Road sewer to discharge into the larger 1,050 mm Government Road trunk sewer instead.

8.2 Lift Station & Forcemain Projects

A total of eight (8) lift station and forcemain capital projects, including decommissioning of two stations, are recommended. A description of each project, including the suggested implementation schedule, is detailed below. It should be noted that these recommendations are made based on available data of the existing infrastructure, the District has mentioned that some forcemains have been upgraded without record and that for each of the recommended forcemain project, a preliminary investigation at the earliest stage of design should be conducted.

LS-01 – Central Lift Station Pumping Upgrades [2017-2021]

Based on our understanding, there are currently three (3) pumps in the Central lift station: 2 x 60hp and 1 x 30hp. We would recommend the District replace the remaining 30hp unit with the same 60hp unit as the other pumps in the station, and operate the station under a “2 Duty + 1 Standby” configuration. This work is currently underway and is nearly complete.

In addition, the District has expressed concerns about the flow discrepancies between the observed and model predicted flows. We suspect there could be significant grease and sediment/silt buildup along the forcemain, especially at various low points along the alignment and would recommend pigging/swabbing to recover some hydraulic capacity in the forcemain and subsequently delay costly improvements to the lift station. There could also be air-locking issues.

With a “clean” forcemain, the lift station should be able achieve flow rates of 200 L/s and 222 L/s when the two and three 60hp pumps, respectively, turn on. It has adequate capacity to service the peak inflow of 205 L/s under the 2050 buildout scenario. The 5 L/s shortfall is marginal and does not warrant a pump upsize at present, but perhaps in the future when these pumps are being replaced due to condition or end of service life, larger pumps can be put in place instead.

LS-02 – New Buckley Lift Station [2017-2021]

The existing Buckley lift station was built in 1972 (45 years old) and consists of two 7.5hp pumps with a flow rate of 46.4 L/s when only one pump is operating – it is more than adequate (hydraulically) to service the current (2015) peak inflow of 18.5 L/s, and is only marginally deficient (hydraulically) under the 2050 buildout scenario with peak inflow of 50 L/s. The urgent need to replace this station, however, is driven by the poor condition and old age of the wet well.

In 2016, Opus completed a Buckley Lift Station Replacement scoping study which included developing a design brief for a new Buckley lift station near its current location. The new station has a design flow of 60 L/s and a total dynamic head of 12.9 m. For the purpose of this SMP, we are recommending the same design as that described in the 2016 design brief. Pumps should be selected during detailed design with due consideration given to achieving optimal efficiency (phasing) and accommodating future growth. The existing 200 mm forcemain will be replaced with the same size as per the forcemain renewal plan discussed in Section 9 of this SMP report.

LS-03 – Centennial Lift Station Pumping Upgrades [2032-2050]

The existing Centennial lift station consists of two 9.4hp pumps with a flow rate of 22.4 L/s when only one pump is operating – it is inadequate to service the 2050 peak inflow of 49 L/s to the wet well. Opus recommends replacing the pumps with two new 70hp pumps, each with a design point of 50 L/s of flow at 42.5 m of head.

The timing for this project will be triggered when the peak inflow into the wet well exceeds 22.4 L/s. The existing (2015) peak inflow is 5.0 L/s.

LS-05 – Queens Way Forcemain Twinning [2032-2050]

The Queens Way lift station is currently equipped with four 47hp pumps, and has a capacity of 176 L/s with 3 pumps operating (i.e. one redundant pump), and 193 L/s when all 4 pumps operate – 2015 peak inflow is predicted to be 159.2 L/s. The station however, is inadequate to service the 2050 peak inflow of 235 L/s, which occurs when 2 pumps are operating at the Central lift station. Two options have been considered: 1) upgrade all the pumps in the Queens Way lift station; and, 2) increase the Queens Way forcemain capacity by twinning.

The current 300 mm forcemain is already operating at a peak velocity of 2.5 m/s when 3 pumps are operating at 176 L/s. Any increase in the pumping capacity (i.e. Option 1) will result in velocities exceeding the design criteria of 2.5 m/s, which will trigger the need to increase forcemain capacity. In addition, the fourth pump was only recently installed, and there is no room in the existing station to install another pump.

Opus recommends the forcemain twinning option as it helps increase the flow capacity of the existing Queens Way lift station to 255 L/s when 3 pumps are operating with a peak velocity of 1.8 m/s in each forcemain. This will delay the need to build a new lift station until beyond 2050.

LS-06 – North Yards Lift Station Pumping & Forcemain Upgrades [2032-2050]

The existing North Yards lift station consists of two 10hp pumps with a flow rate of 7.6 L/s when only one pump is operating – it is inadequate to service the 2050 peak inflow of 16.6 L/s to the wet well. Opus recommends upsizing the existing 75 mm forcemain to 100 mm to avoid large velocities and headlosses in the forcemain. Then, a recommendation is made to replace the pumps with two new 11hp pumps, each with a design point of 16.6 L/s of flow and 22.0 m of head. The timing for this project will be triggered when the peak inflow into the wet well exceeds 7.6 L/s. The existing (2015) peak inflow is 2.2 L/s.

This project has been recommended based on available information at the time of writing. It is possible that the CN Rail Yards development would opt to cross the railway to the east and tie-in to the gravity sewer on Queens Way, by-passing the North Yards lift station and negating the need for this project. A detailed sanitary sewer servicing review should be conducted as part of the area's re-development prior to commissioning this project, which is to be 100% funded by the developer.

LS-07 – Easter Seal Lift Station & Forcemain Decommission [2032-2050]

For the purpose of this SMP, it is assumed that the "*GS-11 – Easter Seal Gravity Bypass"* project will go ahead with the Gravity Bypass option. In this case, the Easter Seal lift station and forcemain can be decommissioned upon completion.

LS-08 – Mamquam Lift Station [2022-2031]

The existing Mamquam lift station (SM11) is a quadraplex station with three 25-hp pumps (NP3171LT3) currently installed. When two of the three pumps are operating, District staff measured a combined flow rate of 143 L/s – it is inadequate to service the 2050 peak inflow of 270 L/s to the wet well.

Opus recommends replacing all three pumps with 35-hp pumps (e.g. NP 3202 MT 3 Model – 643 Impeller). This allows Mamquam to pump 281 L/s of flow at 10.5 m of head when two of the three 35-hp pumps are operating. Additionally, there is the flexibility of adding one more pump unit into the station if future peak inflows are higher than projected.

The exact timing of Mamquam upgrade is dependent on the timing of some of the major developments (e.g. Cheekeye, Cheema, Holborn Group) upstream of the station. Based on current knowledge, we estimated the timing of this Mamquam upgrade to be in the early 2020s.

8.3 Operational & Maintenance Projects

In addition to the above proposed capital projects, we have identified the following O&M projects to enhance operations of the District's sewer utility.

OM-01 – Feasibility Study to Abandon Pia Lift Stations [2032-2050]

The small pocket of residential areas along Pia Road, Jay Crescent, and Condor Place in the Garibaldi Highlands are serviced by two lift stations (Upper and Lower Pia). Upon commencement of the planning stages for the Cheema and/or Holborn Group developments, there are opportunities to include these two Pia catchments into their respective development servicing strategy reviews. It is envisioned that all sewage from these Pia catchments will be routed to a potential trunk sewer designed to service, mainly, the Cheema and Holborn Group developments, leading to the abandonment of the two Pia lift stations.

OM-02 – Feasibility Study to Abandon Judd & Cottonwood Lift Station [2017-2021]

The current Judd & Cottonwood (J&C) lift station services a small sewer catchment that consists mainly of houses along Cottonwood Road. It pumps into Judd & Lawson (J&L) lift station's forcemain, which, according to District staff, has experienced pipe breaks in recent years.

In terms of capacity, both of these lift stations are adequate to service 2050 buildout flows. However, in terms of operations, we would recommend the District consider routing sewage westward from Cottonwood Road to J&L's wet well via a new gravity sewer. This will allow for the decommissioning of J&C lift station. The District may then consider replacing the pumps and forcemains at J&L as they are more than 45 years old. The feasibility study should prepare a business case with NPV analysis to support optimal solution.

OM-03 – Implement Sanitary Flow Monitoring Program [Recurring starting in 2022]

The District is to implement the flow monitoring program as recommended in Section 5 to primarily assist in providing data for future sanitary model and master plan updates every 5 years. Secondly, it should provide a measure of effectiveness of the District's I&I reduction efforts over the coming years.

OM-04 –Yearly Model Update [Recurring starting in 2018]

Opus recommends updating the District's sanitary sewer model every year with the latest development and sewer capital works information. One limitation of the current hydraulic model is that it assumes all sanitary sewer mains to be "clean" and with full hydraulic capacity. This is not the case as is evident from some of the CCTV footage which show significant Fat, Oil, and Grease (FOG) buildup in some areas of the District's sanitary system. In light of this, the District may wish to incorporate this key piece of information from the CCTV inspections into the model during the next model update. Opus has completed a few projects where the inclusion of operational conditions of sanitary sewers has significantly impacted the proposed/recommended capital projects.

OM-05 – Develop a Groundwater Monitoring Strategy [2017-2021]

We recommend the District, in Section 5, to develop a groundwater monitoring strategy to compliment its on-going I&I reduction efforts.

OM-06 – Recurring CCTV Inspections, Manhole Inspections, and Vapour Testing [Recurring starting in 2018]

The District is to implement the various inspections and testing annually to asses 10% of its gravity sewer network. The intent is to provide the District with up-to-date sewer condition data to update the District's sewer rehabilitation program and/or sewer main renewal plan.

OM-07 – Recurring SMP Update [Recurring starting in 2023]

We recommend updating the District's SMP in 2023, and then every 5 years after to keep it as "live" as possible. In future updates, it may be worth considering correlating river elevation and water table elevation with I&I as well as determining the effect of development and creation of more impervious surface has on I&I.

OM-08 – Queens Way Lift Station Condition Assessment [2017-2021]

District staff has expressed concerns over the condition of the Queens Way wet well. Hydrogen sulphide produced in the Central to Queens Way forcemain has been degrading concrete and steel in the Queens Way lift station for years. The station has sufficient capacity past the 2050 horizon but the wet well's deteriorating condition and recommendations out of this condition assessment could trigger renewals or upgrades earlier.

OM-09 – Assessment of Landfill Expansion Impacts to the Sanitary System [2017-2021]

The District's landfill expansion project is scheduled for completion in 2019. As the landfill facility discharges to the District's sanitary system in Brackendale, the impacts of the increased leachate flow to the sanitary system should be better understood. The scope of this assessment could include reviewing the leachate flow monitoring data that the District has been collecting for many years and determining if the landfill expansion could cause capacity issues in the downstream sanitary sewer system.

8.4 Capital Projects Summary

The total cost of the capital projects is estimated to be approximately $15.6 million (2017 dollars).

Table 8-1 provides a cost breakdown of the capital projects for each suggested implementation period. Refer to Section 10 for further details.

Table 8-1: Capital Projects – Cost Breakdown (2017 Dollars)

Project Type	2017-2021	2022-2031	2032-2050	*Sub-Total*
O&M	$160,000	$1,330,000	$2,770,000	*$4,260,000*
New Gravity Sewer	$1,260,000	$3,670,000	$0	*$4,930,000*
Gravity Sewer Upsize	$397,000	$1,520,000	$1,100,000	*$3,017,000*
New Forcemain	$0	$0	$2,250,000	*$2,250,000*
New Lift Station	$655,000	$0	$0	*$655,000*
Pumping Capacity Upgrade	$100,000	$147,000	$152,000	*$399,000*
Decommission	$14,000	$100,000	$0	*$114,000*
Sub-Total	*$2,586,000*	*$6,767,000*	*$6,272,000*	**$15,625,000**

9 Sewer Main Renewal

This section details the development of the District of Squamish's Sanitary Sewer Main Renewal Plan to the year 2050 and beyond. In the process, Opus has refined an in-house Sewer Main Renewal Tool to identify the most cost-effective method to renew a sewer main, and when to renew it, for every sewer main in the District's GIS database. The following sections aim to illustrate the framework of this renewal process, and more importantly, to provide an indicative cost/budget required to meet the District's sewer main renewal needs until 2050.

Together with the Capital Projects identified in the previous section, they form the basis of a comprehensive Capital Investment Plan (Section 10) for the District to upgrade and renew its sewer mains to the year 2050 and beyond. Maps illustrating the sewer main renewal methods, locations, and implementation schedules, are also shown in Section 10.

9.1 Renewal Framework

The original scope of the SMP project has called for the development of a sewer main renewal/rehabilitation plan, which was to be based on theoretical design life (age-based) and, for gravity sewers, the physical conditions recorded via CCTV inspections. Opus has incorporated all of the above, and many more factors and criteria to develop a robust, comprehensive, and easily updateable sewer main renewal framework.

For forcemains, due to the lack of pipe condition data, an age-based only, same-size replacement approach (open-cut assumed for costing purposes) was adopted as agreed upon with the District. For gravity sewers, the renewal framework is illustrated in Figure 9-1. As shown, there are two main parts to the approach: the first step is to determine the year that a renewal is required ("Year_Renew"); and, in the second step, the tool determines the most cost-effective renewal method to be conducted at the renewal year. In the context of this report, the term "renewal" refers to the renewal methods considered in the framework including repairs ("TPR" trenchless point repairs and "EPR" external point repairs), relining, and replacement of sewer mains.

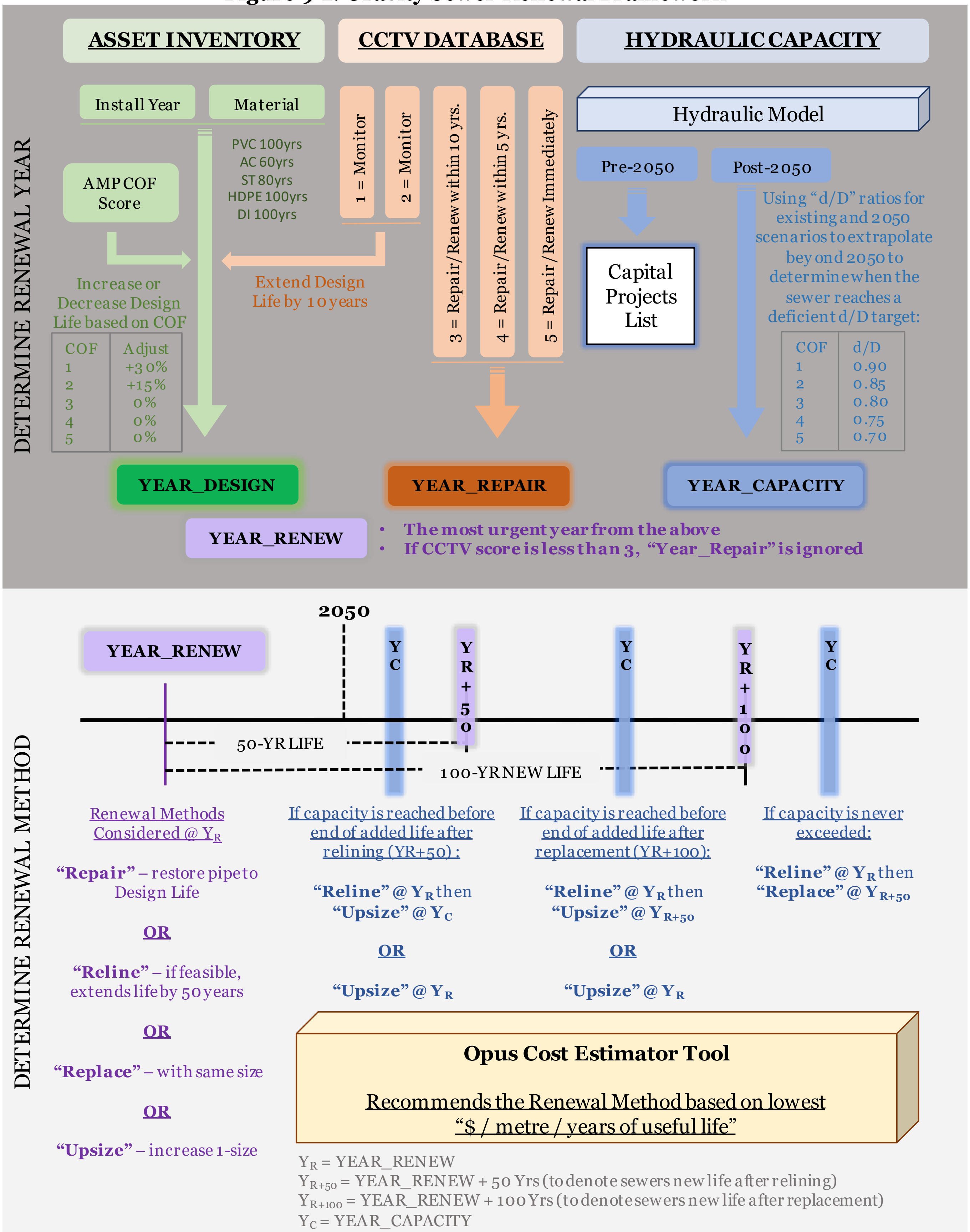
9.1.1 Renewal Year

The year at which a renewal is required is dependent on three factors: 1) gravity sewer's design life (i.e. Remaining Useful Life); 2) recommendations from the CCTV program; and, 3) its hydraulic capacity.

1) The pipe's Remaining Useful Life (RUL) is first estimated by considering the pipe's installation year and material. It is then refined by considering the pipe's physical condition (i.e. CCTV inspection results). The intent is to extend a pipe's RUL if it is still in good physical condition (CCTV score of "1" or "2") by 10 years, which is a typical period before the next CCTV inspection is scheduled to occur. The framework also adjusts the pipe's RUL based on its Consequence of Failure (COF) score determined in the District's 2011 AMP. The intent is to capture the pipe's criticality into the decision-making process of how urgent the renewal should happen. The above analyses refine the year at which the pipe reaches the end of life ("Year_Design").

2) For pipes with CCTV score higher than "2", the pipe renewal (likely repairs) will need to happen within 10 years from now. If a pipe was observed to experience infiltration in the CCTV inspection, the CCTV score for the pipe is set to "3" or higher, depending on the severity (i.e. dripper, gusher etc.). The CCTV score allows us to determine when the pipe needs to be renewed based on its deteriorating physical condition ("Year_Repair").

Figure 9-1: Gravity Sewer Renewal Framework



3) In terms of hydraulic capacity, the renewal/upsizing of gravity sewers that are deficient prior to 2050 have already been identified in the Capital Projects List. It is those that are deficient post-2050 that are of interest in this renewal framework. The year at which a pipe reaches hydraulic capacity post-2050 coincides with the year its d/D ratio reaches 0.8 for a pipe with a COF score of "3". For more critical pipes with COF scores of "4" or "5", the deficient d/D ratio criteria switches to 0.75 and 0.70, respectively. The d/D ratio is assumed by extrapolation using the pipe's existing and 2050 after-upgrades d/D ratios. This assumes a uniform growth in the District post-2050. The above analyses help estimate the year at which a pipe reaches hydraulic capacity post-2050 ("Year_Capacity"). The value of this is that it helps the District make better pipe sizing decisions now (i.e. whether to replace pipe with same size or one size up) to minimize the risk of having to upsize the pipe shortly after replacing it. This in-built forecasting ability in the renewal framework makes it an indispensable planning tool for the District.

Upon determining the above "Years", the year closest to 2017 will be the year that the pipe renewal needs to happen ("Year_Renew"). In the next section, we detail how the framework then determines what is the most cost-effective renewal method to perform.

9.1.2 Renewal Method

The renewal methods considered in the renewal framework includes point repairs (TPR), relining, and replacement (same size or one size up). The framework recommends the most cost-effective method by way of comparing the per linear metre cost of each method per years of useful "life" added to the pipe after completion of each method. Estimation of the per linear metre cost is detailed in the Costing Methodology section of this report (Section 9.2) along with descriptions of all the factors considered. In this section, we determine, for each renewal method, how much "life" is added to a pipe, which is then fed into the cost-benefit analysis:

- "Repair" – TPR and/or EPR returns the pipe to its design life (to "Year_Design"), as defined in the previous section;
- "Reline" – adds up to 50 years of life to the pipe; and,
- "Replace" – adds up to 100 years of life to the pipe.

However, depending on when the pipe reaches hydraulic capacity, the full useful life may not be realized. For example, if a pipe is to become deficient before reaching the 50 years of added life due to relining, we may want to upsize the pipe at renewal year instead of relining. However, it could potentially be more cost-effective to reline the pipe first at renewal year and then upsize it later when it reaches capacity. This is where the cost-benefit analysis, which is programmed into the renewal framework, becomes invaluable.

The framework also considers the feasibility of relining a gravity sewer. Factors considered include:

- A pipe cannot be relined if diameter is less than 150 mm;
- A pipe cannot be relined if there are service connections and the diameter is less than 200mm;
- A pipe cannot be relined if CCTV records noted pipe sags and alignment changes; and,
- A pipe is not typically relined if the downstream and/or upstream structure is a cleanout mainline or a lift station.

There are other factors that affect the feasibility of relining a pipe but only the above factors were considered as data was readily available and in the format that allows for system-wide assessment.

9.1.3 Renewal Recommendation

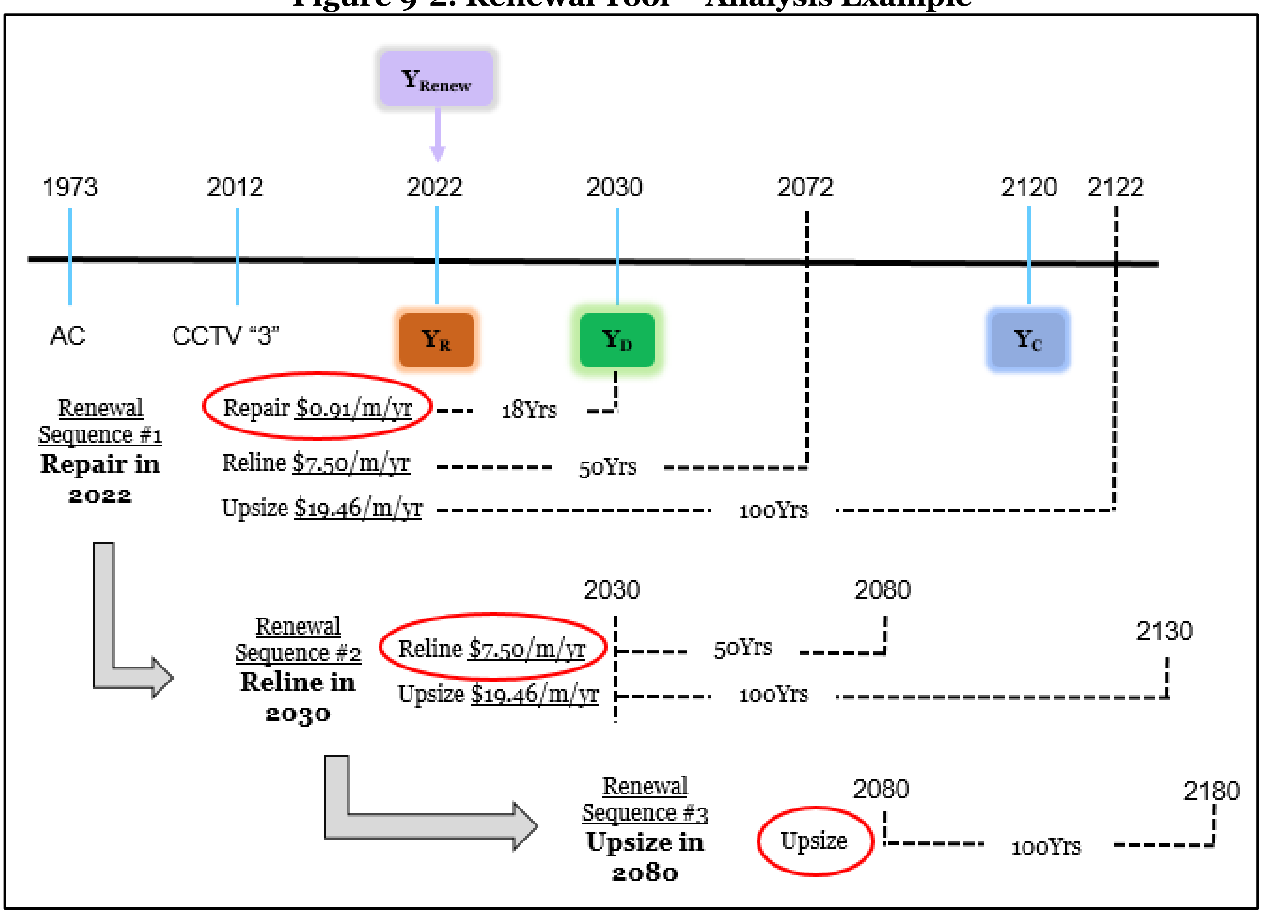
The framework can recommend up to a maximum of three sequential renewal years and methods for each pipe (e.g. repair first in 2018, then reline in 2030, and then finally upsize in 2080). For each pipe, the renewal sequence ends if a "Replace" has been recommended.

In addition to Figure 9-1, Figure 9-2 illustrates an example that shows how the renewal tool processes the available inputs, and recommends the sequence of renewal year(s) and method(s) for a pipe.

In this example, an AC pipe was installed in 1973 and had been CCTV inspected in 2012 with a score of "3". This indicates that some form of renewal work needs to be implemented within 10 years following the CCTV inspection – 2022 is identified as the "Year_Repair". Based on the theoretical design life of an AC pipe and the COF score of this specific pipe, the "Year_Design" is determined to be 2030. Based on d/D ratio extrapolation, the pipe is predicted to reach hydraulic capacity in the year 2120 – the "Year_Capacity". Since 2022 comes first, it is identified as the renewal year for the pipe ("Year_Renew").

The next question is then, which renewal method is the most cost-effective? The "Repair" method is estimated to have the lowest cost per metre per useful life by our in-house cost estimator tool and was selected as the preferred method for 2022. The tool then assumes the repair would extend the pipe's life to 2030 – the "Year_Design", where it then determines that relining is the cheaper option to extend the pipe's life to 2080. Finally, the tool recommends the pipe's ultimate replacement (upsize) in 2080.

Figure 9-2: Renewal Tool – Analysis Example



9.1.4 Renewal Tool Limitations

One of the key inputs of the renewal tool is the District's GIS database for the sanitary sewer main (i.e. shapefiles). The reliability of the renewal plan is highly dependent on the data completeness and quality of the District's shapefiles. The shapefile used in this study was provided by the District in August 2017 and as such, any sewer main renewals since then, or before then, not captured in the shapefile will not have been accounted for in the tool and our renewal planning. Another key input to the renewal tool is the District's CCTV inspection database. To ensure consistency in our renewal recommendations, the approach used to determine the CCTV scores should be consistent. Ideally, any future CCTV inspections will be conducted by one consultant and/or contractor, intimately familiar with the scoring system and the consequences of the recommendations provided.

Finally, the reader should note that, while the renewal tool is able to provide the District with renewal projects required for all gravity and forcemain sewer renewals for one asset lifetime up to and beyond the 2050 horizon, the level of detail for the post-2050 period is only indicative. The intent is to help us recommend the required reserve balance in 2050 to mitigate financial shortfalls post-2050 in relation to the replacement of the District's entire sewer main network. Refer to Section 10 for more details on the financial analysis completed for the District's sewer utility.

9.2 Costing Methodology

In-built into the renewal framework is Opus' Cost Estimator Tool for repairing, relining and replacing sewer mains. In the efforts to ensure the accuracy of the estimated costs and their applicability to the District of Squamish, we have validated the outputs of the tool against the actual costs for two recent gravity sewer replacement projects in the District – *Government Road Trunk Sewer Phase 2* and *Garibaldi Estates Diamond Road* – to within 10%. This provided us with the confidence in the applicability of the tool to the District of Squamish and, in the suitability of the tool to provide a planning-level cost estimate (Class 'D').

Despite our best efforts to develop accurate cost estimates, the reader should note that the cost estimates presented in this report are not based on detailed field assessment and that they should be refined during the design stages based on detailed site conditions (i.e. environmental issues, ground conditions, creek/highway/rail crossings, etc.).

9.2.1 Repair Cost

The repair cost for a gravity sewer is as per the cost estimates from the District's CCTV inspection database.

9.2.2 Relining Cost

The relining cost for a gravity sewer is dependent on several factors. In our cost tool, we have considered the factors shown in Table 9-1.

Table 9-1: Relining Cost Factors

Item	Unit Cost	Unit	Item	Unit Cost	Unit
Linear (eg. 200mm)	$200	/m	Engineering and Contract Administration	10%	%
Service Connections	$850	ea	Municipal Overhead	1%	%
Install New Manhole	$10,000	ea	Design and Construction Contingency	10%	%
Pre/Post CCTV Inspection	$7	/m			

9.2.3 Replacement Cost

The replacement of a gravity sewer is dependent on several factors. In our costing tool, we have considered those factors shown in Table 9-2.

Table 9-2: Replacement Cost Factors

Item	Unit Cost	Unit	Item	Unit Cost	Unit
Base Pipe Cost	$140	/m	Dewatering Costs (0-2m=$0; $1,000/m of depth)	$1,000	/m/m
Pipe Diameter	$1.23	/mm/m	Engineering and Contract Administration	10%	%
Service Connections	$6,000	ea	Municipal Overhead	1%	%
Pre/Post CCTV Inspection	$7	/m	Design and Construction Contingency	10%	%
Pavement Restoration	~$94	/m^2	Creek/Hwy/Rail Crossings	+40%	%
Pipe Depth (Excavation and Import Materials)	~$20	/m			

The following describes the additional spatial analyses completed in GIS to better reflect the costs associated with the unique geographies of each pipe:

- The District has provided us with areas in Squamish where there are high groundwater levels to assist us in determining the dewatering costs associated with replacing pipes in these areas. The pipe's depth is also taken into consideration as it was agreed upon with the District that dewatering costs should not be applied to pipes shallower than 2 metres. It should be noted that the provided areas of high groundwater levels may not be complete.
- The percentage of pipe under a pavement or road is to better estimate the cost associated with pavement restoration. It is less costly to restore non-paved surfaces.

- Pipes crossing highways and railway tracks were also identified using GIS and a 40% premium to the replacement cost is applied.
- The costs associated with traffic control, utility congestion, and mobilization and demobilization have not been considered. They typically represent a small percentage of the total cost and can be excluded from the cost estimator tool whose intent is to provide a planning-level cost estimate (Class 'D').

9.3 Sewer Main Renewal Summary

The total cost of the sewer main renewals until 2050 is estimated to be approximately $40.8 million (2017 dollars), including approximately $36.6 million and $4.2 million of gravity sewer and forcemain renewals, respectively.

Table 9-3 provides a cost breakdown of the various renewal methods for each suggested implementation period. Refer to Section 10 for further details.

Table 9-3: Sewer Main Renewal – Cost Breakdown (2017 Dollars)

Renewal Type	2017-2021	2022-2031	2032-2050	*Sub-Total*
Repair (TPR and/or EPR)	$177,000	$413,000	$-	*$590,000*
Relining	$121,000	$678,000	$14,800,000	*$15,599,000*
Replacement (Same Size)	$1,600,000	$3,760,000	$11,900,000	*$17,260,000*
Replacement (Upsize)	$238,000	$178,000	$2,730,000	*$3,146,000*
Forcemain Replacement[1]	$4,205,000	$-	$-	*$4,205,000*
Sub-Total	*$6,341,000*	*$5,029,000*	*$29,430,000*	**$40,800,000**

[1] see Section 9.3.1 for more detail

9.3.1 Forcemain Renewal

Table 9-4 below shows the year in which each forcemain should be renewed/replaced according to a theoretical design life. The conditions of the forcemains were an unknown and as such, it was agreed upon with the District to plan for their renewal using only an age-based approach. The theoretical design life assumed for forcemain renewal is:

- PVC – 75 Years
- AC – 40 Years
- HDPE – 75 Years
- Ductile Iron – 75 Years
- Unknown Pipe Material – 40 Years

Table 9-4: Forcemain Renewal Schedule (Age-Based)

Forcemain	Pre-2050	Post-2050
Adventure Centre		2079
Buckley	2017/18	
Centennial		2070
Central		2080
Depot	2017 (2022)[3]	
Easter Seal	2017[1]	
Enterprise		2055
J&C	2017 (2020)[3]	
J&L	2017 (2020)[3]	
Loggers & Finch		2052
Lower Pia		2068
Madill	2017 (2021)[3]	
North Yards	2017[1]	
Pemberton	2017 (2019)[3]	
Queens Way		2072
RCMP		2078
Scott	2017[2] (2019)[3]	2084
Stawamus		2073
Upper Pia		2065
Valleycliffe	2017 (2019)[3]	
Wilson	2017 (2021)[3]	

[1] decommissioned or renewed as part of Capital Projects
[2] 200 mm sections of Scott FM upstream and downstream of the bridge
[3] a more realistic renewal year – prioritized based on peak velocities

As shown in Table 9-4, all the renewals pre-2050 are scheduled for 2017, despite most of them not having reached their theoretical design life yet. Their renewals were expedited for the following reasons: no condition assessment / data available; forcemains are critical assets; records of forcemain breaks (2 in the last 3 years according to feedback from Public Works); and, based on our conversations with the District over the years, we understand that the District have concerns about their forcemain conditions and would like to replace them sooner rather than later (another feedback from Public Works).

The 2017 renewals of all forcemains is unrealistic to achieve. We have spread their renewals over a 5-year period starting from 2018 to 2022. The exact year of their renewal was determined based on the severity of their peak velocities as well as opportunities to have construction work occur at the same time as a lift station upgrade, as is the case for the new Buckley lift station Capital Project.

The reader should note that the costs of replacing Easter Seal, Vancouver, and North Yards forcemains were excluded from the Sewer Main Renewal budget (Table 9-3) as they are either decommissioned or renewed as part of the Capital Projects.

10 Sewer Utility Capital Investment Plan 2017-2050

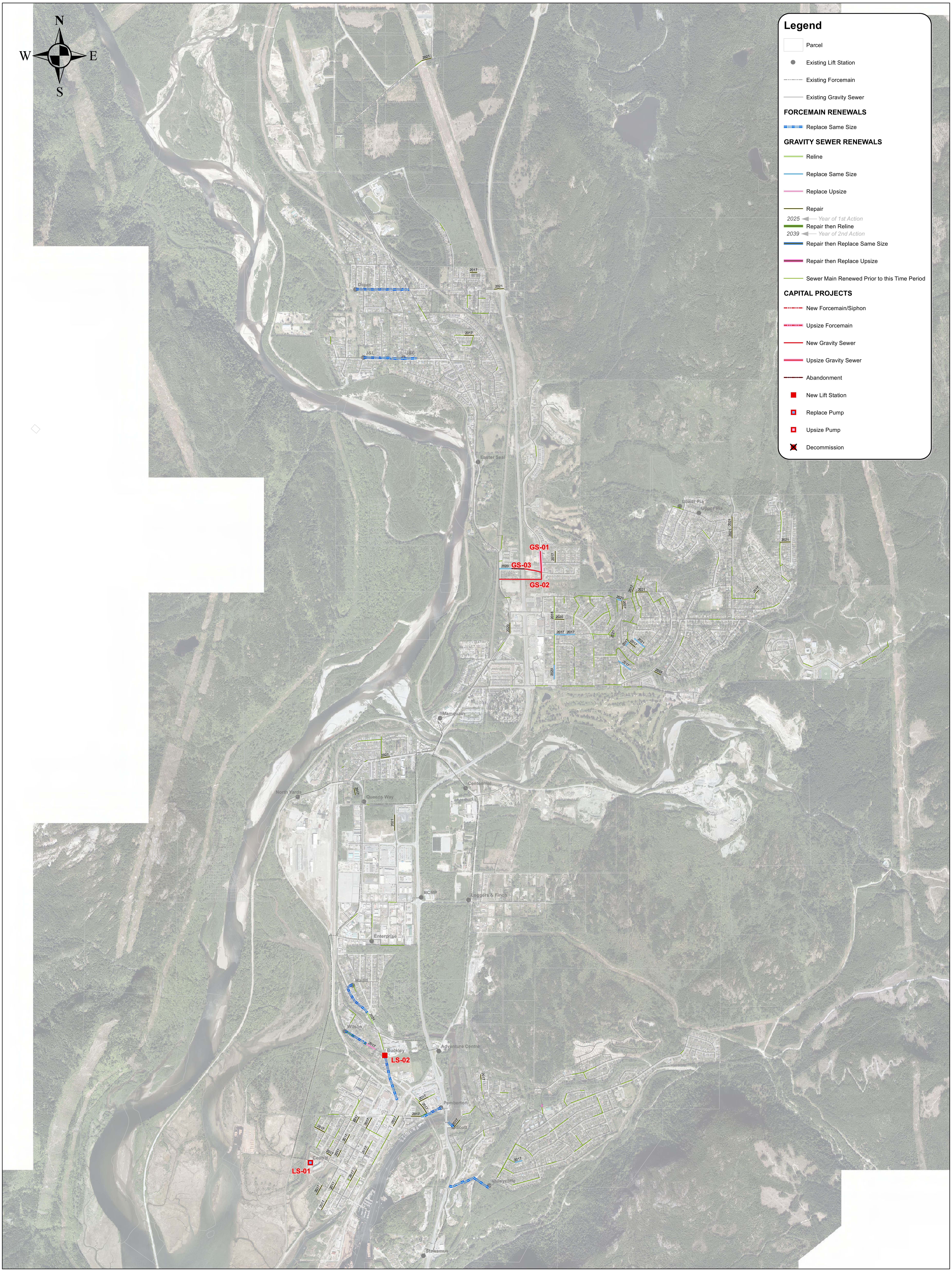
This section presents the District of Squamish's Sewer Utility Capital Investment Plan (CIP) for the period between 2017 and 2050. It lays out the implementation schedule for all capital and renewal projects for the next 33 years. In parallel to this planning process, Opus conducted a sanitary sewer utility financing review to ensure that the CIP is financially sustainable over the long-term while maintaining a reasonable increase in revenues. It was estimated that the District needs to maintain, until at least 2040, an annual revenue increase of 5% to fund the long-term operating, renewal, and new infrastructure costs of the sanitary sewer utility. This increase in revenues will need to occur through population growth and/or utility rate increases. Refer to Appendix E for further details.

Figures 10-1, 10-2, and 10-3 illustrate the locations of the Capital Projects and Sewer Main Renewal Projects for the periods of 2017-2021, 2022-2031, and 2032-2050, respectively. In addition to these figures, Opus will submit to the District a sewer main GIS shapefile containing information that are used to create these figures (i.e. renewal year, renewal method, renewal cost).

Table 10-1 presents the complete CIP and is organized into the following project categories:

- Capital Projects List – Gravity Sewer
- Capital Projects List – Lift Station & Forcemains
- Capital Projects List – O&M Projects
- Sewer Main Renewal – Forcemain Renewals
- Sewer Main Renewal – Gravity Sewer Renewals

The total estimated cost of implementing the CIP is $58.9 million (2017 Canadian Dollars). The vast majority ($46.9 million) of which is attributed to O&M costs, which include the Sewer Main Renewal Projects and the O&M projects. Of the remaining $12.0 million of Capital Projects, approximately 93% are development-driven upgrades, which can be considered for DCC funding.



OPUS

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

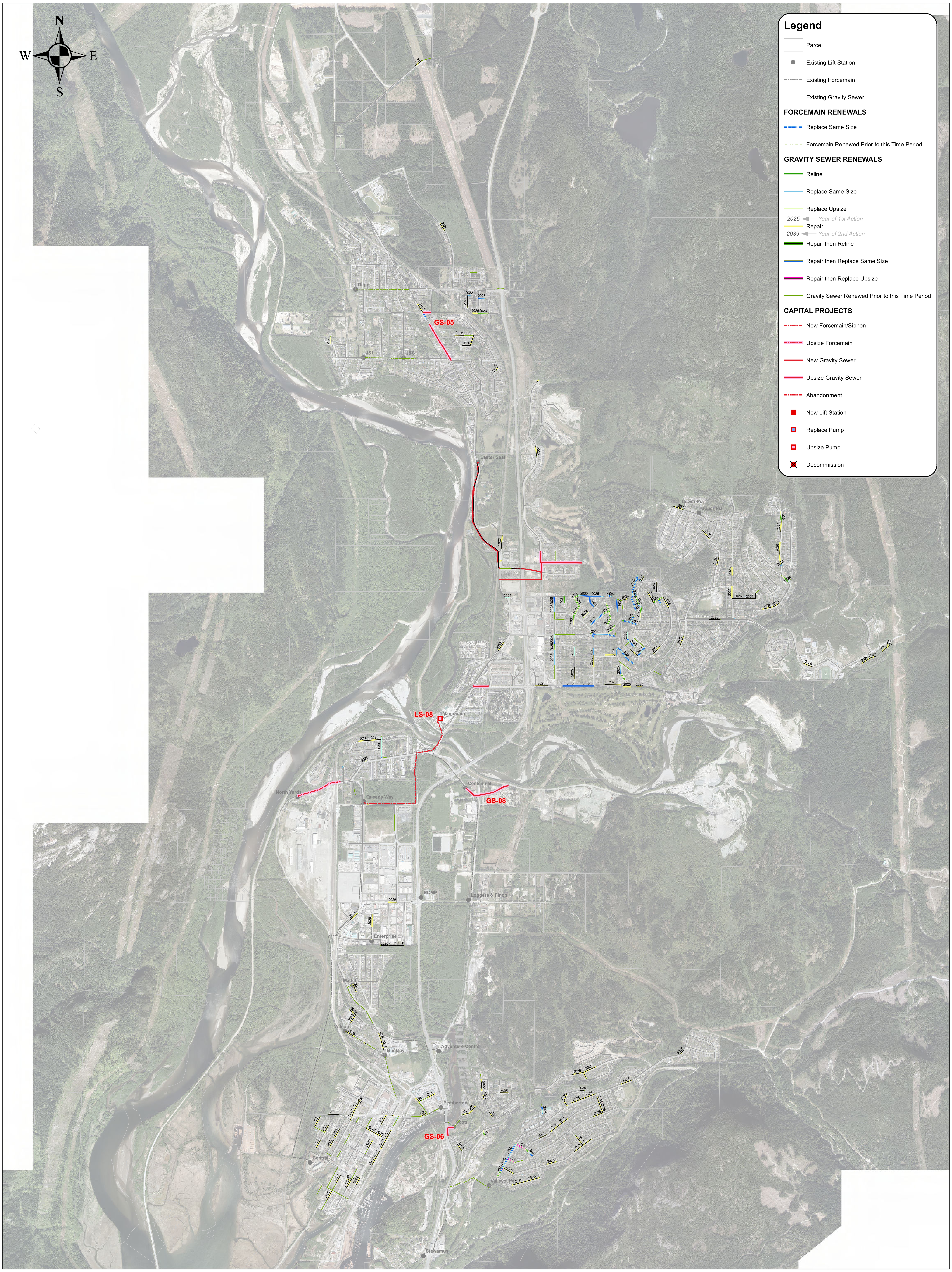
Client:

SQUAMISH

Figure 10-1
District of Squamish
Sanitary Sewer Utility Capital Investment Plan
[2017-2021]

Project No: D-03692.00	Scale: 0 250 500 m
Drawn: DF	
Note:	Date: Mar 2018

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 10-1 CIP - 2017-2021.mxd



OPUS

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: SQUAMISH

Figure 10-2
District of Squamish
Sanitary Sewer Utility Capital Investment Plan
[2022-2031]

Project No: D-03692.00

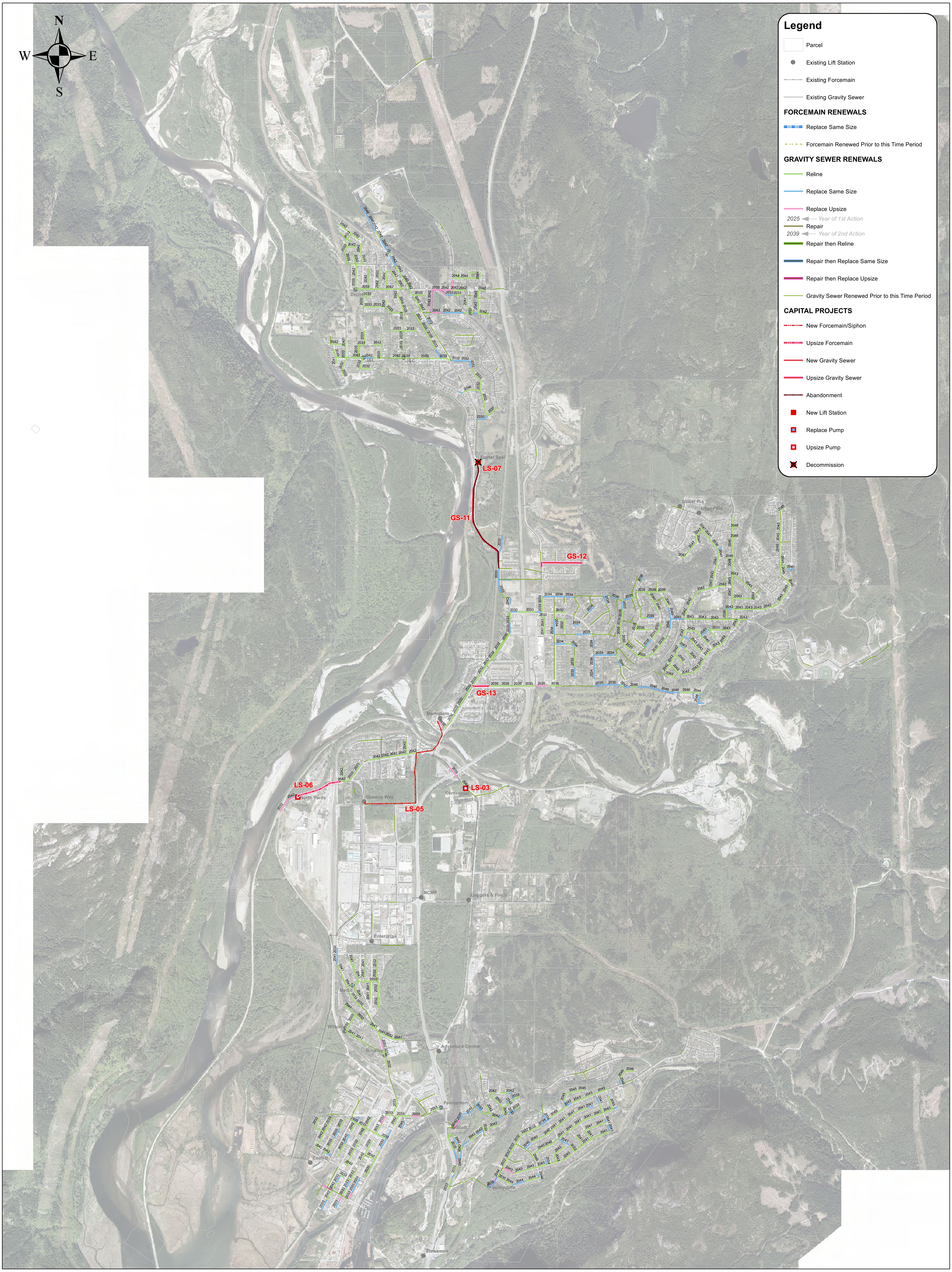
Drawn: DF

Note:

Scale: 0 250 500 m

Date: Mar 2018

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 10-2 CIP - 2022-2031.mxd



OPUS

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client:

SQUAMISH

Figure 10-3
District of Squamish
Sanitary Sewer Utility Capital Investment Plan
[2032-2050]

Project No:	Scale:
D-03692.00	0 250 500 m
Drawn: DF	
Note:	Date: Mar 2018

Path: G:\opus_dk\municipal\036 Squamish\GIS\D-03692.00 Squamish Sewer Master Plan\FINAL REPORT FIGURES\Figure 10-3 CIP - 2032-2050.mxd

District of Squamish
2017 Sewer Master Plan

Table 10-1 Capital Investment Plan (2017-2050)

2017 Dollars	Total	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Account 1	$ 721,000	$ -	$ 4,000	$ 11,400	$ 7,800	$ 1,300	$ -	$ 625,000	$ -	$ -	$ -	$ -	$ -
Account 2	$ 45,045,000	$ 950,100	$ 1,146,400	$ 696,000	$ 1,742,900	$ 1,174,400	$ 1,158,900	$ 771,000	$ 173,600	$ 2,522,400	$ 994,000	$ 175,000	$ 225,000
Account 3	$ 10,648,900	$ -	$ 393,000	$ 1,129,000	$ 760,000	$ 115,900	$ 542,800	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 56,414,900	$ 950,100	$ 1,543,400	$ 1,836,400	$ 2,510,700	$ 1,291,600	$ 1,701,700	$ 1,396,000	$ 173,600	$ 2,522,400	$ 994,000	$ 175,000	$ 225,000

	Year	Account 1 (New Capital) or Account 2 (O&M) or Account 3 (DCCs/Developer Contribution)	Estimated Developer Contri.	Sub-Total Cost (2017 Dollar)	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
From Capital Projects List - Gravity Sewer Projects																
GS-01 - Upsize the sewers along Tantalus Rd. from Tantalus Pl. to Starview Pl. from 200 mm to 450 mm.	2018	Account 1		$ 4,000		$ 4,000										
Estimated Developer's Contribution for the above		Account 3	99%	$ 393,000		$ 393,000										
GS-02a - New 525 mm Highway crossing at Chief View Rd. from Tantalus Rd. to Government Rd.	2019	Account 1		$ 10,400			$ 10,400									
Estimated Developer's Contribution for the above		Account 3	99%	$ 1,030,000			$ 1,030,000									
GS-02b - New 450 mm sewer along Tantalus Rd. from Starview Pl. to the new 525 mm Hwy. crossing.	2020	Account 1		$ 1,200				$ 1,200								
Estimated Developer's Contribution for the above		Account 3	99%	$ 112,000				$ 112,000								
GS-03a - Replace the current 200 mm sewers on Harris Rd. east of Highway with new 200 mm sewers to flow east to Tantalus Rd.	2021	Account 1		$ 1,100					$ 1,100							
Estimated Developer's Contribution for the above		Account 3	99%	$ 102,000					$ 102,000							
GS-03b - Decommission the current Harris Rd. Hwy. crossing.	2021	Account 1		$ 200					$ 200							
Estimated Developer's Contribution for the above		Account 3	99%	$ 13,900					$ 13,900							
GS-05a - Upsize the sewers along Government Rd. (from Dryden Rd. to Judd Rd.) from 350 mm to 450 mm.	2022	Account 1		$ -						$ -						
Estimated Developer's Contribution for the above		Account 3	100%	$ 424,000						$ 424,000						
GS-05b - New 450 mm sewer at the Government Rd. and Judd Rd. intersection to connect the 450 mm trunk sewers along Government Rd. together, north and south of Judd Rd.	2022	Account 1		$ -						$ -						
Estimated Developer's Contribution for the above		Account 3	100%	$ 33,100						$ 33,100						
GS-05c - Upsize a short section of sewer immediately east of Government Rd. along easement south of Depot Road from 200 mm to 300 mm.	2022	Account 1		$ -						$ -						
Estimated Developer's Contribution for the above		Account 3	100%	$ 85,700						$ 85,700						
GS-06 - Upsize the sewers upstream of the Scott lift station (west of the station) from 250 mm to 375 mm	2023	Account 1		$ 625,000							$ 625,000					
Estimated Developer's Contribution for the above		Account 3	0%	$ -							$ -					
GS-08 - Upsize the sewers along Centennial Way (east of the lift station) from 200 mm to 300 mm.	2031	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 378,000												
GS-11 - Gravity Bypass for Easter Seal lift station - 1 km of 525 mm gravity sewer + two (2) inverted siphon crossings at Dryden and Meighan Creeks)	2030	Account 1		$ 36,300												
Estimated Developer's Contribution for the above		Account 3	99%	$ 3,600,000												
GS-12 - Upsize the sewers along Newport Ridge Dr. from the east limit to Tantalus Rd. from 200 mm to 375 mm.	2048	Account 1		$ 7,900												
Estimated Developer's Contribution for the above		Account 3	99%	$ 775,000												
GS-13 - Upsize the sewers along Mamquam Rd. (from Willow Ct. to Government Rd.) from 300 mm to 375 mm.	2050	Account 1		$ 3,200												
Estimated Developer's Contribution for the above		Account 3	99%	$ 314,000												
Subtotal				$ 7,950,000	$ -	$ 397,000	$ 1,040,400	$ 113,200	$ 117,200	$ 542,800	$ 625,000	$ -	$ -	$ -	$ -	$ -
From Capital Projects List - Lift Station & Forcemain Projects																
LS-01a - Central lift station - Replace the remaining 30-hp pump with a new 60-hp pump (2 duty + 1 standby). Suggested pump start levels: 1.0 m and 1.25 m.	Done	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3		$ -												
LS-01b - Central lift station - Pigging/Swabbing of the forcemain, including 5 pig launching stations (1 at the start, 1 at each 90-degree bend)	2019	Account 1		$ 1,000			$ 1,000									
Estimated Developer's Contribution for the above		Account 3	99%	$ 99,000			$ 99,000									
LS-02 - A new Buckley Ave. lift station at the existing location - Two 20-hp pumps at 60 L/s flow and 12.9 m of head each (1 duty + 1 redundancy).	2020	Account 1		$ 6,600				$ 6,600								
Estimated Developer's Contribution for the above		Account 3	99%	$ 648,000				$ 648,000								
LS-03 - Centennial lift station - Replace existing pumps with Two 70-hp pumps at 50 L/s flow and 42.5 m of head each (1 duty + 1 redundancy).	2034	Account 1		$ 1,300												
Estimated Developer's Contribution for the above		Account 3	99%	$ 125,000												
LS-05 - 300 mm Queens Way lift station forcemain twinning.	2044	Account 1		$ 20,300												
Estimated Developer's Contribution for the above		Account 3	99%	$ 2,010,000												
LS-06a - North Yards lift station - Replace existing pumps with Two 11-hp pumps at 16.6 L/s flow and 22.0 m of head each (1 duty + 1 redundancy).	2047	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 25,200												
LS-06b - New forcemain for the North Yards lift station - 401 m of 100 mm forcemain	2047	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 221,000												
LS-07 - Easter Seal lift station and forcemain to decommission	2031	Account 1		$ 1,000												
Estimated Developer's Contribution for the above		Account 3	99%	$ 99,000												
LS-08 - Mamquam (SM11) lift station - Replace existing pumps with three 35-hp pumps to operate at 270 L/s flow and 10.5 m of head under a 2 duty + 1 redundancy configuration.	2031	Account 1		$ 1,500												
Estimated Developer's Contribution for the above		Account 3	99%	$ 146,000												
Subtotal				$ 3,404,900	$ -	$ -	$ 100,000	$ 654,600	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
From Capital Projects List - O&M Projects																
OM-01 - Feasibility Study to abandon Pia lift stations - to initiate when entering the planning stages for the "Cheema" development.	2032	Account 3	100.00%	$ 15,000												
OM-02 - Feasibility Study to abandon Judd & Cottonwood (J&C) lift station - to complete prior to the replacement of J&C forcemain	2019	Account 2		$ 15,000			$ 15,000									
OM-03 - Recurring Sanitary Flow Monitoring Program - starting in 2022, and then every 5 years after	5-Year	Account 2		$ 420,000						$ 70,000	$ -	$ -	$ -	$ -	$ 70,000	$ -
OM-04 - Yearly Model Update - starting in 2018	Yearly	Account 2		$ 165,000		$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
OM-05 - Develop a Groundwater Monitoring Strategy	2018	Account 2		$ 50,000		$ 50,000										
OM-06 - Recurring CCTV Inspections, Manhole Inspections, and Vapour Testing - starting in 2023	Yearly	Account 2		$ 2,800,000							$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
OM-07 - Recurring SMP Update - starting in 2023, and then every 5 years after	5-Year	Account 2		$ 720,000							$ 120,000	$ -	$ -	$ -	$ -	$ 120,000
OM-08 - Queens Way Lift Station Condition Assessment	2019	Account 2		$ 50,000			$ 50,000									
OM-09 - Assessment of Landfill Expansion Impacts to the Sanitary System	2019	Account 2		$ 25,000				$ 25,000								
Subtotal				$ 4,260,000	$ -	$ 55,000	$ 70,000	$ 30,000	$ 5,000	$ 75,000	$ 225,000	$ 105,000	$ 105,000	$ 105,000	$ 175,000	$ 225,000
From Sewer Main Renewal - Forcemain Renewals																
Buckley FM	2018	Account 2		$ 1,070,000		$ 1,070,000										
Scott FM	2019	Account 2		$ 297,000			$ 297,000									
Pemberton FM	2019	Account 2		$ 14,000			$ 14,000									
Valleycliffe FM	2019	Account 2		$ 315,000			$ 315,000									
Judd & Cottonwood FM	2020	Account 2		$ 207,000				$ 207,000								
Judd & Lawson FM	2020	Account 2		$ 602,000				$ 602,000								
Madill FM	2021	Account 2		$ 568,000					$ 568,000							
Wilson FM	2021	Account 2		$ 349,000					$ 349,000							
Depot FM	2022	Account 2		$ 783,000						$ 783,000						
Subtotal				$ 4,205,000	$ -	$ 1,070,000	$ 626,000	$ 809,000	$ 917,000	$ 783,000	$ -	$ -	$ -	$ -	$ -	$ -
From Sewer Main Renewal - Gravity Sewer Renewals																
Repair (TPRs and/or EPRs)	Yearly	Account 2		$ 590,000	$ 120,000	$ -	$ -	$ 10,000	$ 47,400	$ 33,800	$ -	$ -	$ 215,000	$ 164,000	$ -	$ -
Reline	Yearly	Account 2		$ 15,599,000	$ 8,100	$ 21,400	$ -	$ 17,900	$ 73,000	$ 62,100	$ 80,000	$ -	$ 74,400	$ 227,000	$ -	$ -
Replacement (same size)	Yearly	Account 2		$ 17,260,000	$ 584,000	$ -	$ -	$ 876,000	$ 132,000	$ 205,000	$ 466,000	$ 68,600	$ 1,950,000	$ 498,000	$ -	$ -
Replacement (up 1-size)	Yearly	Account 2		$ 3,146,000	$ 238,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 178,000	$ -	$ -	$ -
Subtotal				$ 36,595,000	$ 950,100	$ 21,400	$ -	$ 903,900	$ 252,400	$ 300,900	$ 546,000	$ 68,600	$ 2,417,400	$ 889,000	$ -	$ -
Total				**$ 56,414,900**	**$ 950,100**	**$ 1,543,400**	**$ 1,836,400**	**$ 2,510,700**	**$ 1,291,600**	**$ 1,701,700**	**$ 1,396,000**	**$ 173,600**	**$ 2,522,400**	**$ 994,000**	**$ 175,000**	**$ 225,000**

District of Squamish
2017 Sewer Master Plan

Table 10-1 Capital Investment Plan (2017-2050)

			2017 Dollars		2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
			Account 1	$ 721,000	$ -	$ 36,300	$ 2,500	$ -	$ -	$ 1,300	$ -	$ -	$ -	$ -	$ -	$ -
			Account 2	$ 45,045,000	$ 211,000	$ 479,700	$ 444,000	$ 3,386,000	$ 9,849,000	$ 2,213,700	$ 2,060,000	$ 184,100	$ 383,000	$ 332,100	$ 202,100	$ 773,000
			Account 3	$ 10,648,900	$ -	$ 3,600,000	$ 623,000	$ 15,000	$ -	$ 125,000	$ -	$ -	$ -	$ -	$ -	$ -
			Total	$ 56,414,900	$ 211,000	$ 4,116,000	$ 1,069,500	$ 3,401,000	$ 9,849,000	$ 2,340,000	$ 2,060,000	$ 184,100	$ 383,000	$ 332,100	$ 202,100	$ 773,000
	Year	Account 1 (New Capital) or Account 2 (O&M) or Account 3 (DCCs/Developer Contribution)	Estimated Developer Contri.	Sub-Total Cost (2017 Dollar)	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
From Capital Projects List - Gravity Sewer Projects																
GS-01 - Upsize the sewers along Tantalus Rd. from Tantalus Pl. to Starview Pl. from 200 mm to 450 mm.	2018	Account 1		$ 4,000												
Estimated Developer's Contribution for the above		Account 3	99%	$ 393,000												
GS-02a - New 525 mm Highway crossing at Chief View Rd. from Tantalus Rd. to Government Rd.	2019	Account 1		$ 10,400												
Estimated Developer's Contribution for the above		Account 3	99%	$ 1,030,000												
GS-02b - New 450 mm sewer along Tantalus Rd. from Starview Pl. to the new 525 mm Hwy. crossing.	2020	Account 1		$ 1,200												
Estimated Developer's Contribution for the above		Account 3	99%	$ 112,000												
GS-03a - Replace the current 200 mm sewers on Harris Rd. east of Highway with new 200 mm sewers to flow east to Tantalus Rd.	2021	Account 1		$ 1,100												
Estimated Developer's Contribution for the above		Account 3	99%	$ 102,000												
GS-03b - Decommission the current Harris Rd. Hwy. crossing.	2021	Account 1		$ 200												
Estimated Developer's Contribution for the above		Account 3	99%	$ 13,900												
GS-05a - Upsize the sewers along Government Rd. (from Dryden Rd. to Judd Rd.) from 350 mm to 450 mm.	2022	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 424,000												
GS-05b - New 450 mm sewer at the Government Rd. and Judd Rd. intersection to connect the 450 mm trunk sewers along Government Rd. together, north and south of Judd Rd.	2022	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 33,100												
GS-05c - Upsize a short section of sewer immediately east of Government Rd. along easement south of Depot Road from 200 mm to 300 mm.	2022	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 85,700												
GS-06 - Upsize the sewers upstream of the Scott lift station (west of the station) from 250 mm to 375 mm	2023	Account 1		$ 625,000												
Estimated Developer's Contribution for the above		Account 3	0%	$ -												
GS-08 - Upsize the sewers along Centennial Way (east of the lift station) from 200 mm to 300 mm.	2031	Account 1		$ -			$ -									
Estimated Developer's Contribution for the above		Account 3	100%	$ 378,000			$ 378,000									
GS-11 - Gravity Bypass for Easter Seal lift station - 1 km of 525 mm gravity sewer + two (2) inverted siphon crossings at Dryden and Meighan Creeks)	2030	Account 1		$ 36,300		$ 36,300										
Estimated Developer's Contribution for the above		Account 3	99%	$ 3,600,000		$ 3,600,000										
GS-12 - Upsize the sewers along Newport Ridge Dr. from the east limit to Tantalus Rd. from 200 mm to 375 mm.	2048	Account 1		$ 7,900												
Estimated Developer's Contribution for the above		Account 3	99%	$ 775,000												
GS-13 - Upsize the sewers along Mamquam Rd. (from Willow Ct. to Government Rd.) from 300 mm to 375 mm.	2050	Account 1		$ 3,200												
Estimated Developer's Contribution for the above		Account 3	99%	$ 314,000												
Subtotal				$ 7,950,000	$ -	$ 3,636,300	$ 378,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
From Capital Projects List - Lift Station & Forcemain Projects																
LS-01a - Central lift station - Replace the remaining 30-hp pump with a new 60-hp pump (2 duty + 1 standby). Suggested pump start levels: 1.0 m and 1.25 m.	Done	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3		$ -												
LS-01b - Central lift station - Pigging/Swabbing of the forcemain, including 5 pig launching stations (1 at the start, 1 at each 90-degree bend)	2019	Account 1		$ 1,000												
Estimated Developer's Contribution for the above		Account 3	99%	$ 99,000												
LS-02 - A new Buckley Ave. lift station at the existing location - Two 20-hp pumps at 60 L/s flow and 12.9 m of head each (1 duty + 1 redundancy).	2020	Account 1		$ 6,600												
Estimated Developer's Contribution for the above		Account 3	99%	$ 648,000												
LS-03 - Centennial lift station - Replace existing pumps with Two 70-hp pumps at 50 L/s flow and 42.5 m of head each (1 duty + 1 redundancy).	2034	Account 1		$ 1,300						$ 1,300						
Estimated Developer's Contribution for the above		Account 3	99%	$ 125,000						$ 125,000						
LS-05 - 300 mm Queens Way lift station forcemain twinning.	2044	Account 1		$ 20,300												
Estimated Developer's Contribution for the above		Account 3	99%	$ 2,010,000												
LS-06a - North Yards lift station - Replace existing pumps with Two 11-hp pumps at 16.6 L/s flow and 22.0 m of head each (1 duty + 1 redundancy).	2047	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 25,200												
LS-06b - New forcemain for the North Yards lift station - 401 m of 100 mm forcemain	2047	Account 1		$ -												
Estimated Developer's Contribution for the above		Account 3	100%	$ 221,000												
LS-07 - Easter Seal lift station and forcemain to decommission	2031	Account 1		$ 1,000			$ 1,000									
Estimated Developer's Contribution for the above		Account 3	99%	$ 99,000			$ 99,000									
LS-08 - Mamquam (SM11) lift station - Replace existing pumps with three 35-hp pumps to operate at 270 L/s flow and 10.5 m of head under a 2 duty + 1 redundancy configuration.	2031	Account 1		$ 1,500			$ 1,500									
Estimated Developer's Contribution for the above		Account 3	99%	$ 146,000			$ 146,000									
Subtotal				$ 3,404,900	$ -	$ -	$ 247,500	$ -	$ -	$ 126,300	$ -	$ -	$ -	$ -	$ -	$ -
From Capital Projects List - O&M Projects																
OM-01 - Feasibility Study to abandon Pia lift stations - to initiate when entering the planning stages for the "Cheema" development.	2032	Account 3	100.00%	$ 15,000				$ 15,000								
OM-02 - Feasibility Study to abandon Judd & Cottonwood (J&C) lift station - to complete prior to the replacement of J&C forcemain	2019	Account 2		$ 15,000												
OM-03 - Recurring Sanitary Flow Monitoring Program - starting in 2022, and then every 5 years after	5-Year	Account 2		$ 420,000	$ -	$ -	$ -	$ 70,000	$ -	$ -	$ -	$ -	$ 70,000	$ -	$ -	$ -
OM-04 - Yearly Model Update - starting in 2018	Yearly	Account 2		$ 165,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
OM-05 - Develop a Groundwater Monitoring Strategy	2018	Account 2		$ 50,000												
OM-06 - Recurring CCTV Inspections, Manhole Inspections, and Vapour Testing - starting in 2023	Yearly	Account 2		$ 2,800,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
OM-07 - Recurring SMP Update - starting in 2023, and then every 5 years after	5-Year	Account 2		$ 720,000	$ -	$ -	$ -	$ -	$ 120,000	$ -	$ -	$ -	$ -	$ 120,000	$ -	$ -
OM-08 - Queens Way Lift Station Condition Assessment	2019	Account 2		$ 50,000												
OM-09 - Assessment of Landfill Expansion Impacts to the Sanitary System	2019	Account 2		$ 25,000												
Subtotal				$ 4,260,000	$ 105,000	$ 105,000	$ 105,000	$ 190,000	$ 225,000	$ 105,000	$ 105,000	$ 105,000	$ 175,000	$ 225,000	$ 105,000	$ 105,000
From Sewer Main Renewal - Forcemain Renewals																
Buckley FM	2018	Account 2		$ 1,070,000												
Scott FM	2019	Account 2		$ 297,000												
Pemberton FM	2019	Account 2		$ 14,000												
Valleycliffe FM	2019	Account 2		$ 315,000												
Judd & Cottonwood FM	2020	Account 2		$ 207,000												
Judd & Lawson FM	2020	Account 2		$ 602,000												
Madill FM	2021	Account 2		$ 568,000												
Wilson FM	2021	Account 2		$ 349,000												
Depot FM	2022	Account 2		$ 783,000												
Subtotal				$ 4,205,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
From Sewer Main Renewal - Gravity Sewer Renewals																
Repair (TPRs and/or EPRs)	Yearly	Account 2		$ 590,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Reline	Yearly	Account 2		$ 15,599,000	$ -	$ 8,700	$ 227,000	$ 2,360,000	$ 3,660,000	$ 78,700	$ 742,000	$ 36,500	$ 103,000	$ 84,300	$ 97,100	$ 317,000
Replacement (same size)	Yearly	Account 2		$ 17,260,000	$ 106,000	$ 366,000	$ 112,000	$ 375,000	$ 5,070,000	$ 2,030,000	$ 722,000	$ 42,600	$ 105,000	$ 22,800	$ -	$ 351,000
Replacement (up 1-size)	Yearly	Account 2		$ 3,146,000	$ -	$ -	$ -	$ 476,000	$ 894,000	$ -	$ 491,000	$ -	$ -	$ -	$ -	$ -
Subtotal				$ 36,595,000	$ 106,000	$ 374,700	$ 339,000	$ 3,211,000	$ 9,624,000	$ 2,108,700	$ 1,955,000	$ 79,100	$ 208,000	$ 107,100	$ 97,100	$ 668,000
Total				**$ 56,414,900**	**$ 211,000**	**$ 4,116,000**	**$ 1,069,500**	**$ 3,401,000**	**$ 9,849,000**	**$ 2,340,000**	**$ 2,060,000**	**$ 184,100**	**$ 383,000**	**$ 332,100**	**$ 202,100**	**$ 773,000**

District of Squamish
2017 Sewer Master Plan

Table 10-1 Capital Investment Plan (2017-2050)

Description	Year	Account 1 (New Capital) or Account 2 (O&M) or Account 3 (DCCs/Developer Contribution)	Estimated Developer Contri.	Sub-Total Cost (2017 Dollar)	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
2017 Dollars			Account 1	$ 721,000	$ -	$ -	$ -	$ 20,300	$ -	$ -	$ -	$ 7,900	$ -	$ 3,200
			Account 2	$ 45,045,000	$ 1,995,900	$ 5,370,000	$ 2,352,000	$ 627,300	$ 661,000	$ 909,000	$ 395,900	$ 279,600	$ 105,000	$ 105,000
			Account 3	$ 10,648,900	$ -	$ -	$ -	$ 2,010,000	$ -	$ -	$ 246,200	$ 775,000	$ -	$ 314,000
			Total	$ 56,414,900	$ 1,995,900	$ 5,370,000	$ 2,352,000	$ 2,657,600	$ 661,000	$ 909,000	$ 642,100	$ 1,062,500	$ 105,000	$ 422,200
From Capital Projects List - Gravity Sewer Projects														
GS-01 - Upsize the sewers along Tantalus Rd. from Tantalus Pl. to Starview Pl. from 200 mm to 450 mm.	2018	Account 1		$ 4,000										
Estimated Developer's Contribution for the above		Account 3	99%	$ 393,000										
GS-02a - New 525 mm Highway crossing at Chief View Rd. from Tantalus Rd. to Government Rd.	2019	Account 1		$ 10,400										
Estimated Developer's Contribution for the above		Account 3	99%	$ 1,030,000										
GS-02b - New 450 mm sewer along Tantalus Rd. from Starview Pl. to the new 525 mm Hwy. crossing.	2020	Account 1		$ 1,200										
Estimated Developer's Contribution for the above		Account 3	99%	$ 112,000										
GS-03a - Replace the current 200 mm sewers on Harris Rd. east of Highway with new 200 mm sewers to flow east to Tantalus Rd.	2021	Account 1		$ 1,100										
Estimated Developer's Contribution for the above		Account 3	99%	$ 102,000										
GS-03b - Decommission the current Harris Rd. Hwy. crossing.	2021	Account 1		$ 200										
Estimated Developer's Contribution for the above		Account 3	99%	$ 13,900										
GS-05a - Upsize the sewers along Government Rd. (from Dryden Rd. to Judd Rd.) from 350 mm to 450 mm.	2022	Account 1		$ -										
Estimated Developer's Contribution for the above		Account 3	100%	$ 424,000										
GS-05b - New 450 mm sewer at the Government Rd. and Judd Rd. intersection to connect the 450 mm trunk sewers along Government Rd. together, north and south of Judd Rd.	2022	Account 1		$ -										
Estimated Developer's Contribution for the above		Account 3	100%	$ 33,100										
GS-05c - Upsize a short section of sewer immediately east of Government Rd. along easement south of Depot Road from 200 mm to 300 mm.	2022	Account 1		$ -										
Estimated Developer's Contribution for the above		Account 3	100%	$ 85,700										
GS-06 - Upsize the sewers upstream of the Scott lift station (west of the station) from 250 mm to 375 mm	2023	Account 1		$ 625,000										
Estimated Developer's Contribution for the above		Account 3	0%	$ -										
GS-08 - Upsize the sewers along Centennial Way (east of the lift station) from 200 mm to 300 mm.	2031	Account 1		$ -										
Estimated Developer's Contribution for the above		Account 3	100%	$ 378,000										
GS-11 - Gravity Bypass for Easter Seal lift station - 1 km of 525 mm gravity sewer + two (2) inverted siphon crossings at Dryden and Meighan Creeks)	2030	Account 1		$ 36,300										
Estimated Developer's Contribution for the above		Account 3	99%	$ 3,600,000										
GS-12 - Upsize the sewers along Newport Ridge Dr. from the east limit to Tantalus Rd. from 200 mm to 375 mm.	2048	Account 1		$ 7,900								$ 7,900		
Estimated Developer's Contribution for the above		Account 3	99%	$ 775,000								$ 775,000		
GS-13 - Upsize the sewers along Mamquam Rd. (from Willow Ct. to Government Rd.) from 300 mm to 375 mm.	2050	Account 1		$ 3,200										$ 3,200
Estimated Developer's Contribution for the above		Account 3	99%	$ 314,000										$ 314,000
Subtotal				$ 7,950,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 782,900	$ -	$ 317,200
From Capital Projects List - Lift Station & Forcemain Projects														
LS-01a - Central lift station - Replace the remaining 30-hp pump with a new 60-hp pump (2 duty + 1 standby). Suggested pump start levels: 1.0 m and 1.25 m.	Done	Account 1		$ -										
Estimated Developer's Contribution for the above		Account 3		$ -										
LS-01b - Central lift station - Pigging/Swabbing of the forcemain, including 5 pig launching stations (1 at the start, 1 at each 90-degree bend)	2019	Account 1		$ 1,000										
Estimated Developer's Contribution for the above		Account 3	99%	$ 99,000										
LS-02 - A new Buckley Ave. lift station at the existing location - Two 20-hp pumps at 60 L/s flow and 12.9 m of head each (1 duty + 1 redundancy).	2020	Account 1		$ 6,600										
Estimated Developer's Contribution for the above		Account 3	99%	$ 648,000										
LS-03 - Centennial lift station - Replace existing pumps with Two 70-hp pumps at 50 L/s flow and 42.5 m of head each (1 duty + 1 redundancy).	2034	Account 1		$ 1,300										
Estimated Developer's Contribution for the above		Account 3	99%	$ 125,000										
LS-05 - 300 mm Queens Way lift station forcemain twinning.	2044	Account 1		$ 20,300				$ 20,300						
Estimated Developer's Contribution for the above		Account 3	99%	$ 2,010,000				$ 2,010,000						
LS-06a - North Yards lift station - Replace existing pumps with Two 11-hp pumps at 16.6 L/s flow and 22.0 m of head each (1 duty + 1 redundancy).	2047	Account 1		$ -							$ -			
Estimated Developer's Contribution for the above		Account 3	100%	$ 25,200							$ 25,200			
LS-06b - New forcemain for the North Yards lift station - 401 m of 100 mm forcemain	2047	Account 1		$ -							$ -			
Estimated Developer's Contribution for the above		Account 3	100%	$ 221,000							$ 221,000			
LS-07 - Easter Seal lift station and forcemain to decommission	2031	Account 1		$ 1,000										
Estimated Developer's Contribution for the above		Account 3	99%	$ 99,000										
LS-08 - Mamquam (SM11) lift station - Replace existing pumps with three 35-hp pumps to operate at 270 L/s flow and 10.5 m of head under a 2 duty + 1 redundancy configuration.	2031	Account 1		$ 1,500										
Estimated Developer's Contribution for the above		Account 3	99%	$ 146,000										
Subtotal				$ 3,404,900	$ -	$ -	$ -	$ 2,030,300	$ -	$ -	$ 246,200	$ -	$ -	$ -
From Capital Projects List - O&M Projects														
OM-01 - Feasibility Study to abandon Pia lift stations - to initiate when entering the planning stages for the "Cheema" development.	2032	Account 3	100.00%	$ 15,000										
OM-02 - Feasibility Study to abandon Judd & Cottonwood (J&C) lift station - to complete prior to the replacement of J&C forcemain	2019	Account 2		$ 15,000										
OM-03 - Recurring Sanitary Flow Monitoring Program - starting in 2022, and then every 5 years after	5-Year	Account 2		$ 420,000	$ -	$ 70,000	$ -	$ -	$ -	$ -	$ 70,000	$ -	$ -	$ -
OM-04 - Yearly Model Update - starting in 2018	Yearly	Account 2		$ 165,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
OM-05 - Develop a Groundwater Monitoring Strategy	2018	Account 2		$ 50,000										
OM-06 - Recurring CCTV Inspections, Manhole Inspections, and Vapour Testing - starting in 2023	Yearly	Account 2		$ 2,800,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
OM-07 - Recurring SMP Update - starting in 2023, and then every 5 years after	5-Year	Account 2		$ 720,000	$ -	$ -	$ 120,000	$ -	$ -	$ -	$ -	$ 120,000	$ -	$ -
OM-08 - Queens Way Lift Station Condition Assessment	2019	Account 2		$ 50,000										
OM-09 - Assessment of Landfill Expansion Impacts to the Sanitary System	2019	Account 2		$ 25,000										
Subtotal				$ 4,260,000	$ 105,000	$ 175,000	$ 225,000	$ 105,000	$ 105,000	$ 105,000	$ 175,000	$ 225,000	$ 105,000	$ 105,000
From Sewer Main Renewal - Forcemain Renewals														
Buckley FM	2018	Account 2		$ 1,070,000										
Scott FM	2019	Account 2		$ 297,000										
Pemberton FM	2019	Account 2		$ 14,000										
Valleycliffe FM	2019	Account 2		$ 315,000										
Judd & Cottonwood FM	2020	Account 2		$ 207,000										
Judd & Lawson FM	2020	Account 2		$ 602,000										
Madill FM	2021	Account 2		$ 568,000										
Wilson FM	2021	Account 2		$ 349,000										
Depot FM	2022	Account 2		$ 783,000										
Subtotal				$ 4,205,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
From Sewer Main Renewal - Gravity Sewer Renewals														
Repair (TPRs and/or EPRs)	Yearly	Account 2		$ 590,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Reline	Yearly	Account 2		$ 15,599,000	$ 1,410,000	$ 2,840,000	$ 1,740,000	$ 303,000	$ 437,000	$ 420,000	$ 196,000	$ -	$ -	$ -
Replacement (same size)	Yearly	Account 2		$ 17,260,000	$ 461,000	$ 1,650,000	$ 283,000	$ 185,000	$ 119,000	$ 384,000	$ 24,900	$ 54,600	$ -	$ -
Replacement (up 1-size)	Yearly	Account 2		$ 3,146,000	$ 19,900	$ 705,000	$ 104,000	$ 34,300	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal				$ 36,595,000	$ 1,890,900	$ 5,195,000	$ 2,127,000	$ 522,300	$ 556,000	$ 804,000	$ 220,900	$ 54,600	$ -	$ -
Total				**$ 56,414,900**	**$ 1,995,900**	**$ 5,370,000**	**$ 2,352,000**	**$ 2,657,600**	**$ 661,000**	**$ 909,000**	**$ 642,100**	**$ 1,062,500**	**$ 105,000**	**$ 422,200**