McElhanney

February 7, 2014

Our File: 2211-47277-0

Ms. Shelley Ashfield, P.Eng.
Town of Comox
1809 Beaufort Avenue
Comox, BC V9M 1R9

Dear Ms. Ashfield,

TOWN OF COMOX 2013 SANITARY MODEL UPDATE

Further to your e-mail correspondence of 19 December 1013, attached are three hard copies of the final version of the Town's 2013 sanitary sewer master plan update document. We have incorporated changes as requested therein and as further discussed. We wish to thank the Town for the opportunity to have been of assistance in this project and for your assistance in strategic direction and review of draft report content.

Yours truly,

MCELHANNEY CONSULTING SERVICES LTD.

Ian S. Whitehead, P.Eng.
Regional Manager

QMS Reviewed by:

Bob Hudson, P.Eng.

ISW/njg

Enclosure

cc: Town of Comox, Glenn Westendorp, AScT

495 Sixth St
Courtenay BC
Canada V9N 6V4

Tel 250 338 5495
Fax 250 338 7700
www.mcelhanney.com/mcsl

TOWN OF COMOX

2013 SANITARY MODEL UPDATE

MCSL FILE # 2211-47277-0

January 3, 2014

FINAL

TABLE OF CONTENTS

LIST OF ACONYMS:

SFE	SFE Global (flow monitoring company)
FTRE	Full Time Residential Equivalent
IRR	Integrated Resource Recovery
IRM	Integrated Resource Management
DCC	Development Cost Charges
LGA	Local Government Act
OCP	Official Community Plan
PWWF	Peak Wet Weather Flow
SWMM	Storm Water Management Model
SANSYS	not an acronym
LTF	Long Term Future
STF	Short Term future
SFD	Single Family Dwelling
RM	Multi-Family Residential Zone
MF	Multi-Family
SMP	Sewer Master Plan
RGS	Regional Growth Strategy
HGL	Hydraulic Grade Line
SMH	Sanitary Manhole
PCSWMM	variant of SWMM as per above

FIGURES

TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Purpose

The Town of Comox owns and operates municipal infrastructure, including sanitary sewer collection, on behalf of the taxpayers within its boundaries. The Town requires an up-to-date understanding of the operational shortfalls (existing and longer term), within its sewerage system. This information will determine the need for on-going system maintenance and for planning of capital improvements. These include:

- The differing age and condition of system components. The reasonably expected remaining lifespan of each system component.
- The likelihood of population growth within the Town and the expected areas within which this growth is expected to occur, including infill densification.
- Forecasting of any variations in demand for each utility, on a unit area or per capita basis.
- Forecast changes in externally controlled variables, such as the cost per unit of service offered by the CVRD for bulk water supply and sewer pumping/treatment service, or the extent to which storm rainfall rates and resulting surface runoff flows will increase over time.
- Identification of realistic options for upgrading of system components and the relative/comparative costs for each.
- Pressures to expand the geographic boundaries of the Town and, if so, what capital upgrading or extensions would be required.
- Market constraints and the Town's presumed intent to remain competitive in attracting investment, and the impact this might have on capital cost recovery mechanisms and formulae.

The purpose of this Town sanitary sewerage system capital plan update study is to:

- Provide the Town with a review of the Town's existing sanitary sewer system function.
- Assess the need for improvements to suit expectations in future demand on this system. Future increase in demand is expected to result from geographic expansion of the service area and

from "infill" redevelopment. Infill densification has been accounted for by application of a 0.5% fixed rate population growth percentage. This is only an approximation, i.e: an estimate was needed; greater than zero and less than the total Town growth percentage.

- Consider options in the provision of service upgrading.
- Estimate costs for these options.
- Recommend a planning/implementation strategy which the Town can use in developing and updating a five year capital plan for this sewer utility.

1.2 Scope

The scope of work undertaken is essentially as agreed per MCSL proposal dated November 20, 2012. This proposal reflects a reduced scope from that formerly presented to the Town, based on our understanding of the Town's resource limitations and more specific areas of focus needing attention. Briefly, the scope of work includes the following elements:

- Conversion of sewer system software models to a new platform and updating the Town's system model geometry, reflecting upgrades/extensions having occurred since the last system report update in 2010.
- Model calibration based on past in-stream data, past models and information provided by the CVRD pertaining to its Jane Place pumping station [to which the majority of the Comox system drains].
- Development of 5 year model and 20 year future system models, based on population and spatially specific land use assumptions, agreed to with senior Town staff as part of this study effort.
- System upgrading options analysis, including review of two diversion options specifically suggested by Town staff.
- Consideration of regionally planned system upgrades; how these might be expected to affect the Town's longer term [20 year horizon] planning.
- 5 year capital plan cost estimates, intentionally differentiated from service life related upgrading needs.

- Recommended sequential capital plan priorities, and rationalization criteria for same.
- Although not a scope of work requirement, we have included a brief discussion regarding DCC bylaw issues and suggested bylaw update tables.
- Final report production, c/w accompanying explanatory maps and supporting figures.

Agreed assumptions and limitations:

- No full build out model, just an indication of expected full build out population, per past CVRD SMP effort. (Where build out is defined as the expected most probable long term total development within the confines of the Town's OCP and zoning bylaws. This may require more than 20 years to materialize.)
- Modeling of areas tributary to the Jane Place pumping station only.
- No further in-stream monitoring data collection was undertaken in support of this update study. Rather, in the interests of budget and scope constraints, new models were calibrated based on previous monitoring data, having been conducted in winter months of 2008/2009 and 2009/2010.
- 20 year future capital cost estimates are not provided.
- Preliminary DCC update discussion is limited to areas tributary to the CVRD's Jane Place station, as the Colby station catchment, Butchers Road area and Knight Road area catchment are assumed already accommodated with trunk infrastructure.

1.3 Expected Outcomes – Specific Issues

The 2013 Town of Comox sanitary sewerage update study will:

- Provide the Town with an understanding of capital upgrading priorities, for purposes of updating the Town's five year capital plan.
- Provide updated sewer modeling platform, more easily integrated into the Town's ongoing strategic mapping and GIS initiatives.
- Provide recommendations as to longer term impacts and system component routing, to suit a longer term, 20 year horizon. This includes conceptual trunk sewer routing to suit agreed longer

term municipal boundary extension expectations – again, limited to areas tributary to the Jane Place station only.

- Provide specific consideration to the issue of inflow and infiltration [I&I] of stormwater and groundwater entering the Town's sanitary sewer system, present a discussion regarding the relevant impacts this has and the opportuneness/costs of attending to reducing this component of overall sewer flows.

2.0 BACKGROUND REFERENCES

2.1 Past Town Of Comox Capital Planning Reports/Studies

Previous Town of Comox flow monitoring, sanitary computer models and reporting include:

- 2006 Sanitary Sewer Study - MCSL
- 2007 Flow Monitoring - SFE
- 2008 and 2009 Flow Monitoring - MCSL
- 2010 Sanitary Sewer Inflow and Infiltration Monitoring and Analysis - MCSL

2.2 Other Relevant Past Work, Studies And Policies

The following documents have been referenced in the 2013 update study:

- CVRD Regional Growth Strategy (2010)
- CVRD Sewerage Master Plan (2011)
- Town of Comox Official Community Plan (2011)
- Town of Comox Zoning Bylaw & Map (2012)

3.0 COMPUTER MODEL CONVERSION (To SWMM)

Attached as Appendix A, is a detailed description of the software conversion process having been undertaken, updating 2006 SANSYS models to the PCSWMM platform.

4.0 CONVEYANCE NETWORK UPDATE TO PRESENT DAY (2013)

4.1 System Description

Figure 1, located in the rear pocket, is a map at 1:7,500 scale, indicating the Town's existing sanitary sewer collection system. The system was originally constructed predominantly of asbestos cement pipe material.

Figure 1 indicates the numbering convention used to define pipes and manholes in the system computer models, along with colored shading of sub-catchment areas tributary to existing sewage pumping stations.

The majority of development within the Town's geographic boundary drains to the CVRD's Jane Place pumping station, also indicated on Figure 1. This station discharges to the CVRD's trunk foreshore pressure sewer which, in turn, drains to the Comox Valley Pollution Control Centre, at Brent Road.

Portions of the Town drain to the CVRD operated Colby Pumping Station, located at the intersection of Colby Road and Lazo Road, as well as the Kye Bay pumping station, serving the Kye Bay and foreshore area, and the Simon Crescent pumping station which discharges into the Kye Bay station pressure sewer.

Table #1 below indicates the tributary areas and capacities of the pumping stations of relevance to this study.

Table 1 - Pump Station Summary

Pump Station	Operator	Statistics	
Jane Pl	CVRD	Tributary Area	590.1 ha
		Tributary Population	14,220 EFTR
		PWWF in (Present Day)	373.5 lps
		Year of Construction	1983
		Pumps	3 x Flygt CP3201MT 77HP
		Storage Well	5.0m x 7.5m Wet Well
		Standby Power	Yes
		Forcemain	450mm Steel

Pump Station	Operator	Statistics	
Lancaster (tributary to Jane St. pump station)	Town	Ultimate Tributary Area	13.1 ha
		Ultimate Tributary Pop.	182 EFTR
		PWWF in (Present Day)	6.3 lps
		Year of Construction	2007/2008
		Pumps	2 x Flygt NP3102SH 6.5HP
		Storage Well	2.4m x 2.4m Wet Well
		Standby Power	Yes
		Forcemain	100mm PVC
Colby*	CVRD	Ultimate Tributary Area	94.9 ha
		Ultimate Tributary Pop.	2,095 EFTR
		PWWF in (Present Day)	23.5 lps
		Year of Construction	1996
		Pumps	2 x Flygt C3127MT 7.5HP
		Storage Well	2.4m x 2.4m Wet Well
		Standby Power	Yes
		Forcemain	200mm PVC
Kye Bay*	Town	Not available	Not available
Simon Crescent*	Town	Not available	Not available

*The Lancaster station serves a sub-catchment of the area tributary to the Jane Place station. As agreed with the Town, investigation and commentary regarding areas outside of the Jane Place pumping station catchment, are not included in this report.

4.2 Model Calibration Discussion

Based on the design criteria and modeling parameters defined in Section 5 below, the existing system SWMM model was calibrated to reflect outcomes as simulated in the former 2006 'SANSYS' models. Other than variation in peaking factors (as described in later sections of this document), the SWMM model and former SANSYS model generate very similar results. The means of attending to peaking factors in the SWMM platform is described in Section 5 below.

4.3 Updates since 2006 Model Compilation

The 2013 conveyance network model includes representation of infrastructure and development projects added since 2006, including major areas as follows:

- Anderton Road Sanitary Upgrades – Comox Avenue to Bolt Avenue.
- Lancaster subdivisions Phases 1 through 6, including the Lancaster Pump Station.
- Comox Avenue: Anderton Road to Ellis Street Upgrades.
- Highland Village off-site upgrades on Guthrie Road along with on-site sanitary lift station.
- Aspen/Guthrie sanitary diversion.

5.0 MODELING & DESIGN CRITERIA

5.1 Average Day - Dry Weather Flow Sewage Loads

During past work for the Town of Comox and other municipal governments in BC, it has been observed that, based on in-stream flow monitoring results, a realistic Full Time Equivalent (FTE) residential daily sewage load of 240 litres per person is reflective of actual loading conditions. This value has been verified through past sewerage studies prepared on behalf of the Town.

In Table 2 below, we have indicated assumed loading and occupancies as adopted for the Town's sewer models.

Table 2 – Dry Weather Sewage Loading

$$ADWF\ Sewerage\ Load = \sum Contributing\ Area\ x\ Zoning\ Density\ x\ Per\ Capita\ Flow$$

Zone	Description	Density (ppl/ha)	Sewerage (l/c/day)	Sewerage by Area (l/ha/day)
PA1.1	PA1.1 Public Assembly			8000
C	Commercial	30	240	7200
CD	Comp. Dev.	25	240	6000
I	Industrial			11000
R1.1	Single-family	22	240	5280
R1.2	Mobile Home	40	240	9600
R1.3	Single-family (1,100 sq.m.)	19	240	4560
R2.1	Single/Two Family	30	240	7200
R2.2	Two-Family	25	240	6000
R3.1	SF w/Sec Suite	30	240	7200
R3.2	SF w/Sec Suite (450 sq.m.)	34	240	8160
R3.3	SF w/Sec Suite (Large Lot)	10	240	2400
R3.5	SF w/Sec Suite (1,300 sq.m.)	17	240	4080
R3.6	SF w/Sec Suite (1,100 sq.m.)	19	240	4560
RM1.1	Patio Dwelling - 4.6m Max Ht	40	240	9600
RM1.2	Patio Dwelling - 6.3m Max Ht	40	240	9600
RM2.1	Patio Dwelling / Townhouse	26	240	6240
RM2.2	Townhouse	40	240	9600
RM2.3	Street Oriented Townhouse	40	240	9600
RM3.1	Apartment / Townhouse - Low Density	28	240	6720
RM3.2	Apartment / Townhouse - High Density	32	240	7680
RM4.1	Congregate / Intermediate Care	25	240	6000
RM5.1	Marine Plaza	32	240	7680
RM5.2	Marine Plaza	32	240	7680
Add_Pop	Additional Population @ 1/ppl ha	1	240	240

In cases where development does not conform to the above table, sewerage flows were converted to FTRE population and multiplied by 240 l/cap/day.

Dry weather, average day loading at each applicable manhole [junction] were assigned via a contributing area and specific population density unique to the property's zoning, per Table 2.

5.2 Peaking Factor

The Town's 2006 SANSYS models used a proportion of the Harmon peaking factor, in the absence of more sophisticated analytical means of determining actual peaking rates/patterns. This methodology, though simplistic in approach, offers the benefit of providing conservatively high estimates of peak sewerage flow.

By contrast, SWMM-based modeling uses a 'time-of-day' multiplier to convert average dry weather flows to peak instantaneous flows. Past in-stream flow data was re-processed, utilizing an algorithm within the SWMM software, in order to produce diurnal flow curves, specific to the Comox system. Analysis of this data has indicated a Peak to Average Day ratio of slightly less than 2.0. This value is significantly lower than the peaking factors generated utilizing traditional design formulae, including Harmon, MMCD, BCBC, etc. These formulae are intentionally very conservative, allowing for unforeseen influent or statistically anomalous flows with no conveyance routing effect. By contrast, the Town's model indicates actual observed flow rates, with no factor of safety applied.

As illustrated in Figure 2, below, the typical peaking factor experienced in Comox is something less than 2.0, within trunk sewers in lower reaches of the system.

A dry weather flow peaking factor of 3.0 has been applied, as agreed with the Town, in interests of conservatism and noting the small total change in peak wet weather flow(s) this increase to a 3.0 multiplier represents, at least until such time as I&I component of flow is reduced, as discussed in the following section.

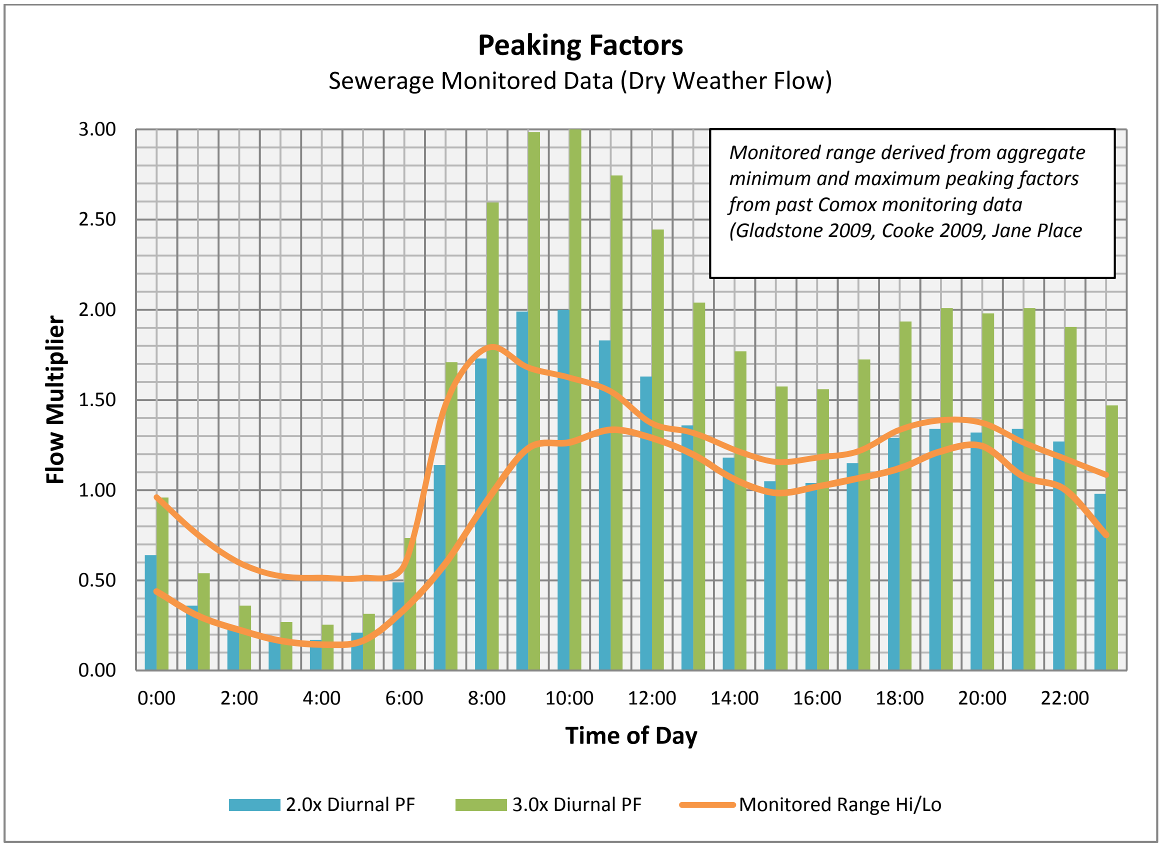


Figure 2 – Diurnal Flow (peaking factor derivation)

5.3 Inflow and Infiltration [I&I]

Flow monitoring during 2009 and 2010 revealed high Inflow and Infiltration (I & I) rates within the Town's network. These I & I rates have been carried forward for this model, without update or refinement. Each applicable manhole has been assigned an area and I&I rate applicable to one of the five Town system sub-catchment areas. For simplicity and in recognition of the lack of data that might compel us toward a more sophisticated approach, the contributing area at each manhole, or node, was assigned an I&I allowance as a constant flow value. It is intended that this I&I component of flow reflects actual measured values, during the admittedly limited duration of in-stream I&I monitoring.

Catchment	I&I Rates
1	15% 0.07 L/s/ha
1	85% 0.356 L/s/ha
2	0.70 L/s/ha
3	0.356 L/s/ha
4	0.356 L/s/ha
5	0.356 L/s/ha

Given the known high I&I within the Town's system *and*:

1. The Town's desire to minimize risks associated with sewerage overflows, *while*
2. Maximizing return on investment related to I&I reduction (system "tightening"),

We recommend the following:

- A statistical analysis/determination of the rainfall return period that gave rise to the I&I rates documented in 2009/2010 should be undertaken. The current model is based on the greatest flows documented to date, however, I&I rates modeled may not correspond to a worst case/design rainfall event. Analysis may show that documented I&I rates are too low, when extrapolated to 5 or 10 year return periods.
- The PCSWMM platform allows for very detailed modeling and analysis of I&I monitoring data. This analysis can include a comparison of I&I volumes expected to be reduced over time, based on specific system improvements. I.e, the reduced costs of pumping and treating effluent can be determined based on specific improvement projects being undertaken, and thereafter used to justify capital expenditures for same.
- Continued flow monitoring and documentation of observed capacity constraints within the system, for model refinement.
- The next model update should include a more sophisticated I&I modeling process, wherein base infiltration rates (wet and dry weather) are modeled independent of inflow. This approach will

allow for a number of rainfall hyetographs to be modeled, to predict system response to varying rainfall events.

Figure 1, located in the rear pocket, identifies the five differing sub-catchments, having been established to date for purposes of I&I analysis.

5.4 Hydraulic Modeling Parameters [SWMM]

Physical modeling parameters have remained consistent with those used in previous model versions, particularly:

1. Minimum allowable flow velocity = 0.6 m/s
2. Manning's 'n' friction coefficients:

   - PVC pipe 0.011
   - Concrete/asbestos cement 0.013

5.5 Component Replacement Criteria

Given the relatively small data set utilized to establish the flow rates in the model, (continuous, year round monitoring was not practical), it is prudent to establish reasonable thresholds for considering existing pipes "full", particularly in areas where future growth is anticipated. Based on the above, we recommend the following "pipe full" thresholds be used:

80% full	250mm diameter and greater
75% full	100 to 200mm diameter

A higher probability of peak to average day flows exists in smaller, shorter or terminal sections of pipe due to the increased likelihood of anomalously high flows not being buffered or routed. This is generally acceptable, given the decreased risk associated with capacity exceedence in these pipes, and the relatively low percent full that these pipe typically operate at.

For comparison, both MMCD and current Town new pipe design standards are presented in the table below.

Table 3 – Pipe Replacement Criteria

New Sewer Design/Maximum Flow Depth by Pipe Diameter			
	100mm to 200mm	250mm	300mm and larger
MMCD Design Guidelines Section 3.6	50%	60%	70%
Town Engineering Design Standards	50%	70%	80%

Periodic, temporary surcharging ought to be considered by the Town as potentially acceptable, provided sufficient freeboard exists to the closest or worst case adjoining service connection[s]. The current PCSWMM sewer models do not include adjacent property freeboard analysis within the pipe network. This feature is supported in advanced versions of the software. At the Town's discretion, future models could be expanded with appropriate manhole depth data and service/building slab information to provide such analysis.

Attached as Appendix B is a listing of all pipes within the Jane Place pumping station catchment which are modeled as exceeding the thresholds noted as recommended values from Table 3.

5.6 Capital Plan Prioritization Criteria

In recognition of scarce or at least finite capital funding, a series of capital upgrading prioritization criteria need to be established which are rational and defensible. We have developed the following series of criteria, during effort for the CVRD SMP process, and we believe the same are equally applicable to the Town's capital planning prioritization:

Factors which could influence the prioritization of component replacement (as a function of both growth/demand and service life), include the following:

- Existing infrastructure at end of useful service life, i.e. is known to require replacement. Review of the Town's PSAB listing and existing system component replacement planning due to age, rather than capacity.

- Other related planned capital infrastructure projects, such as parallel water or storm projects within the same corridor or planned road surface upgrading project within the same corridor – presumption of economy of scale.
- System extensions or capacity increases, brought about through community need [Institutional – schools or hospitals, emergency services development, etc.].
- Health and safety issues requiring remedy [re: community as a whole as compared to workers at the treatment plant].
- Service interruption – system failure [that portion of cost attributable to new service population]. Known sections of sewer where high ongoing maintenance costs are being incurred, i.e. frequent degreasing, root cutting, anti-fouling efforts.
- Legislated requirements [legally mandated] for change – e.g. the Municipal Wastewater Regulation – MWR. This could include pumping redundancy requirements, green initiatives, etc.
- System efficiency enhancements, e.g. reduction in operating costs, IRR and IRM initiatives. Sustainability initiatives, etc.
- Land developer need – new commercial and residential development, typically. Economic development benefits to the community.
- Takes advantage of outside funding.

6.0 GROWTH ASSUMPTIONS - TOTAL EQUIVALENT POPULATION & SPATIAL DISTRIBUTION

6.1 Existing Conditions

The Town's Official Community Plan, recently updated in 2011, predicts future annual population growth between 1.2% and 1.6%. Figure 3, overleaf, illustrates the total population change, over time, based on these OCP percentage predictions, and indicates a comparison from this band of population projections to that indicated in the CVRD's 2009 sewer master plan assumptions. Also indicated is the equivalent full time residential population change resulting from the development of specific areas as agreed probable with Town staff, for purposes of this sanitary sewer update report, coupled with a modest continuous background infill growth rate expected due to land re-development, over the same time period. Attached as Appendix C, is a table of population projections used in the development of Figure 3.

6.2 Short Term Future [5 Year] Growth Scenario

The short term future (STF) horizon has been set as a 5 year period, to late 2018. Five years is a sufficiently short planning horizon as to allow reasonable assuredness of development growth. Estimating population growth over this short-term horizon ties to the Town's capital budget planning cycle. By contrast, the Town's DCC bylaw was set to a 10 year horizon, expected at the time of writing, to be applicable to year 2019.

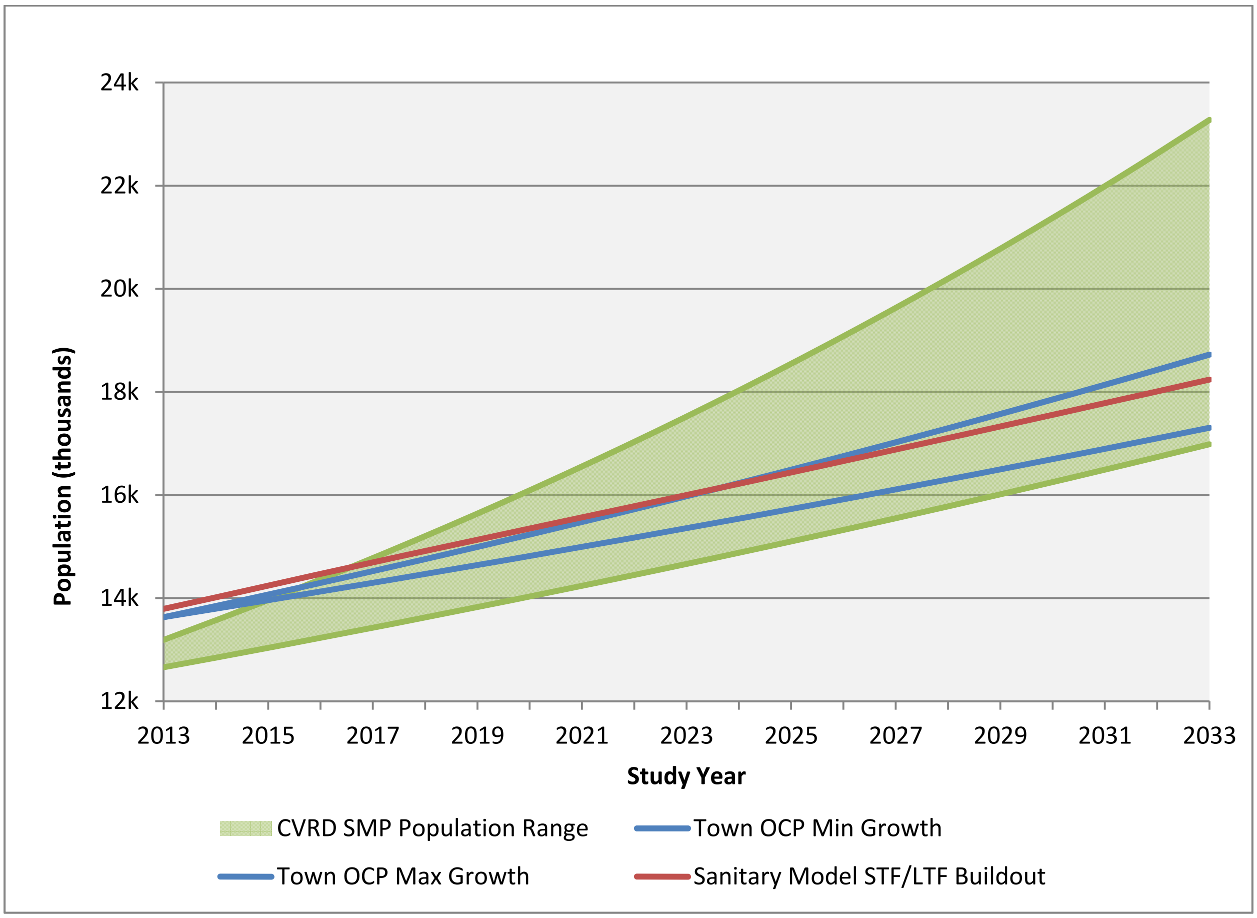


Figure 3 – Comox FTE Population Projections (2013 to 2033)

Based on agreement with senior Town staff, specific areas [or nodes] of development, expected over the coming five years, were identified. These specific sites are mapped, per Figure 4, located in the rear pocket.

In addition to the specific nodes of new development, it has been assumed that infill and small lot densification such as duplexes or secondary suites will also occur with reasonable regularity, over time. An allowance for this general infill and densification, being 0.5% of the Town's net growth, has been included as a component of the expected total sewerage loading growth rate. The combined result is a total population prediction, shown in the red line Figure 3 above.

Details as to agreed specific development areas are included in Table 4 below.

Table 4 – Short Term Growth Expectation – Specific Development Lands

Area ID	Civic Address	Description	Future Zoning	Area (ha)	Pop Density (ppl/ha)	Additional Pop	ADWF LPS (240 l/c/d)	I & I LPS (Default 0.35 l/s/ha)	Point of Entry
1	221 Glacier View Dr.	Townhouse/MF	RM 2.2	0.38	40	15.2	0.04	**0.27**	2-014
3	1651 McDonald Rd	Single Family	R 1.1	2.52	22	55.4	0.15	0.18	1-1113
4	2200 Murrelet	GF Commercial	C	0.40	30	12.0	0.03	0.14	1-1291
5	2200 Murrelet	65 Apartments	CD	0.41	300	123.0	0.34	0.14	1-1291 ‡
7	2310 Guthrie	Commercial	C	0.86	30	25.8	0.07	0.30	1-046*
8	2310 Guthrie	Single Family	RM 2.2	0.30	40	12.0	0.03	0.11	1-046
10	2123 Hector	Townhouse/MF	RM 2.2	2.71	40	108.4	0.30	0.95	1-041
11	1966 Guthrie - HV Ph3	Mixed Use	I	1.18	46	54.3	0.15	0.41	PLS-2 *
12	700 Anderton	Commercial	C	0.50	30	15.0	0.04	0.18	1-808
13	618 Anderton	GF Commercial	C	0.28	30	8.4	0.02	0.10	1-805
14	618 Anderton	2 story Res	RM 3.2	0.28	36	10.1	0.03	**0.20**	1-805
18	335 Anderton	Townhouse/MF	RM 2.2	1.07	40	42.8	0.12	**0.75**	2-420
25	1805 Wilcox	3 story Res	RM 3.2	0.46	300	138.0	0.38	0.16	3-003 ‡
27	1770 Comox	GF Commercial	C	0.13	30	3.9	0.01	0.05	4-202
28	1770 Comox	3 story Res	RM 3.2	0.13	100	13.0	0.04	0.05	4-202 ‡
31	1375 Noel	10 Lot SFD c/w secondary suites	RM 2.2	1.50	40	60.0	0.17	0.53	5-706
38	202 Hawkins	Townhouse/MF	RM 2.2	1.85	40	74.0	0.21	0.65	5-020
			Total STF Additional Pop			771.3	2.14	5.14	
39	2240 Comox Ave	Townhouse	***74 units proposed***						

6.3 Long Term Future [20 Year] Growth Scenario

The 20 year Long Term Future (LTF) population assumptions provided herein are, by definition, only a rough approximation. This acknowledged, LTF projections are useful to highlight general trends in growth and to verify expected impact on proposed 5 year horizon capital upgrade projects. Long term growth areas, again as agreed to with senior Town staff, are indicated in Table 5 below and reflected on Figure 3.

Table 5 – Longer Term Growth Expectation – Specific Development Lands

Area ID	Civic Address	Description	Future Zoning	Area (ha)	Pop Density (ppl/ha)	Additional Pop	ADWF LPS (240 l/c/d)	I & I LPS (Default 0.35 l/s/ha)	Point of Entry
2	Redwood/Chestnut/Walnut	Townhouse/MF	RM 2.2	7.41	40	296.4	0.82	2.59	2-604
6	695 Aspen	5 story Institution	I	1.28	46	58.9	0.16	0.45	1-1401
9	2123 Hector	Apartments	RM 3.2	2.24	32	71.7	0.20	*0.16*	1-043
15	528 Anderton	Townhouse/MF	RM 2.2	0.83	40	33.2	0.09	0.29	1-801
16	368/382 Anderton	Townhouse/MF	RM 2.2	0.81	40	32.4	0.09	0.28	2-320
17	1984 Buena Vista	Townhouse/MF	RM 2.2	0.74	40	29.6	0.08	*0.52*	2-301
19	2026 Comox Ave	Townhouse/MF	RM 2.2	0.54	40	21.6	0.06	*0.38*	2-007
20	2085 Wallace	Townhouse/MF	RM 2.2	1.02	40	40.8	0.11	*0.71*	2-410
21	2085 Wallace	Commercial	C	0.50	30	15.0	0.04	*0.35*	2-402
22	Hospital Re-development	4 story Apartment	RM 3.2	2.77	36	99.7	0.28	0.97	3-015
23	1825 Comox Ave	GF Commercial	C	0.20	30	6.0	0.02	0.07	1-008
24	1825 Comox Ave	3 story Res	RM 3.2	0.20	150	30.0	0.08	0.07	1-008 ‡
26	1823 Beaufort	4 story Hotel	I	0.31	400	124.0	0.34	0.11	3-003 ‡
29	1700 Balmoral	40 Apartments	CD	0.28	300	84.0	0.23	0.10	4-301 ‡
30*	1475 Noel	Townhouse/MF	RM 2.2	4.50	40	180.0	0.50	1.58	5-038
33	King / Casey	Single Family w/sec	R 2.1	11.41	30	342.3	0.95	3.99	5-020
34	King / Lazo	Townhouse/MF	RM 2.2	15.44	40	617.6	1.72	5.40	5-020
		Total LTF Additional Pop				2083.2	5.8	18.0	

*May remain a school site; we are told the land was recently purchased by a Christian school group.

A comparison between previous [2006] Town sewer model population estimates with those now indicated in the 2013 SWMM models is summarized in Figure 5 below. We conclude there to be good uniformity in the conversion process.

The large difference indicated in Figure 5, between the longer term estimates from 2006 SANSYS models and the long term future model now adopted herein, stems from the approximately 2,000 equivalent residents formerly expected within Catchment 5. This difference in growth assumption is explained, in part, due to the area bounded by Pritchard, Knight and Cambridge Roads, [North East Comox], sewage from which having formerly been expected to be pumped back toward the CVRD's Jane Place pumping station. This is now less likely, as portions of the CVRD's 'Greenwood Trunk' and 'Hudson Trunk' gravity sewers have since been constructed, as it transpires, by the Town and it is explicitly assumed that development in NE Comox will be serviced via this trunk gravity system.

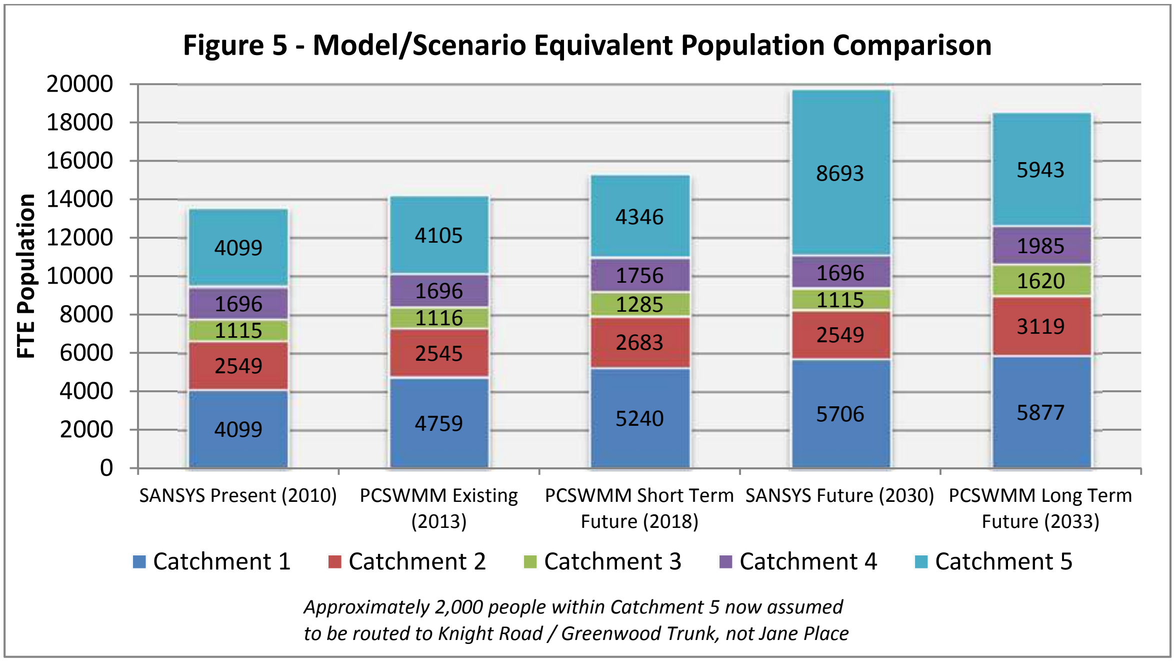


Figure 5 – Model/Scenario Equivalent Population Comparison

6.4 'Full Build Out' Expectation for Comox – per CVRD SMP & RGS [Including Areas Tributary to the Proposed Docliddle Pump Station and CFB Comox Trunk].

Reference is made to the CVRD sewer master plan document, dated May, 2011. While completion of the CVRD SMP preceded the regional growth strategy adoption, we believe the assumptions as to long term full build-out development and the service population this represents remain valid for purposes of longer term sewer system planning.

Figure S8-A from the 2011 SMP and the discussion on pages 26 and 27 of that document pertaining to Figure S8-A, suggest a total long term Comox (full time) equivalent population of 20,000 by year 2033. This is based on a 3% growth rate, as provided by the Town of Comox planners at that time.

The CVRD SMP core area plan, preferred system layout option 6 includes a new pumping station, the Docliddle station, to be situated as indicated on Figure 6, located in the rear pocket. Figure 6 also identifies the CVRD RGS mapping intended to reflect the limits of future Town boundary extensions.

7.0 OPERATIONAL DEFICIENCIES, UPGRADING OPTIONS AND PREFERRED SOLUTIONS

7.1 General

The Town's existing conveyance system, tributary to Jane Place includes a total of approximately 875 manholes and a similar number of pipes connecting these, along with one municipally operated pump station within the Lancaster subdivision. As agreed with the Town, it has been assumed the existing Jane Place pumping station service area boundary will remain unchanged, for the 5 year and 20 year future models. One minor exception to this is the area modeled, at the Town's request, north of Guthrie Road, fronting Anderton Road.

7.2 Existing Conditions (2013)

7.2.1 Operational Deficiencies

Figure 7, located in the rear pocket, identifies system capacity shortfalls, based on 2013 loading conditions and the 'pipe full' parameters outlined in Table 3 above. The Comox collection system is, generally speaking, functioning very well at present, with only four isolated sections of gravity sewer modeled as under the required capacity. Of these four, two sections are located along the foreshore and modest surcharge is likely inconsequential, as discussed below. The four areas of capacity shortfall are described as follows:

7.2.1.1 Central Foreshore – Pt. Augusta to Jane Pl. [1-003 to 1-001]

All of the flow emanating from western Comox routes through the Central Foreshore to the CVRD's Jane Place pump station. Originally, a 300mm diameter was constructed to service all of west Comox. The Town's continued growth warranted installation of, and parallel to the original sewer, a 375mm diameter trunk sewer in the late 1980s.

The 2013 Sewer Model assumes the 375mm diameter sewer intercepted the original 300mm sewer at the Beaufort Avenue / Ellis Street intersection and continues to carry sewer flow east on Beaufort

Avenue until Port Augusta, then across the foreshore to Jane Place pump station. Properties upstream of the interception point are generally located north of Comox Avenue and west of Church Street. As-built drawings provided by the Town indicate neighboring properties most likely remained connected to the original 300mm diameter sewer. Thus, surcharging within the 375mm sewer is not likely to cause localized operational issues. Rather, replacement of this section of sewer will likely be triggered by service life expiration, and the threat of raw sewage discharge, or leakage to the abutting marine environment.

Hydraulic Grade Line (HGL) profiles, depicting modeled 2013 peak wet weather operating condition for this section, are shown overleaf. Surcharge in the order of 1.44 metres is predicted at worst case manhole SMH 1-003, at a peak wet weather flow rate of 196 l/s.

Section 7.5 below, outlines the potential for the CVRD Docliddle pumping station to allow for diversion of a portion of the existing service area tributary to the Jane Place pumping station.

7.2.1.2 Comox Avenue – Rodello to Anderton [2-009 to 2-005]

Tributary to this sewer along Comox Avenue includes properties north of Comox Avenue to Downey St/McKenzie Avenue and east of Gladstone Street to the Town's western boundary. This area is largely developed and includes a mix of residential single-family and duplex homes along with commercial developments fronting Comox Avenue. This area was subject to flow monitoring in 2008 and 2009, where high I&I rates were observed.

Potential re-development of note includes the former Comox Elementary School site and Harbour Wood properties (former PMQs) on Redwood & Walnut Avenue and Chestnut Street. This section of sewer is predicted to be subject to surcharge between 1.03m to 1.18m, under present day peak wet weather flow.

7.2.1.3 Western Foreshore [3-601 to 3-007]

This section of gravity main services an area bounded by Comox Avenue, Beach Drive, Beaufort Avenue, Bay Court and the Western Foreshore of Comox Harbour. The eastern portion of this service area is predominately single family homes while the western portion includes St. Joseph's Hospital and several apartment buildings.

The area is essentially completely built out, with the exception of the Hospital property. Development of a new hospital in Courtenay, expected to be commissioned in 2017, may cause re-purposing of the St. Joseph's facility, or eventual reconstruction within this site. Speculatively, changes in land use may include expanding the existing long-term care capacity and perhaps the addition of a residential apartment complex.

Flow from this sub-catchment is routed towards the Comox Harbour foreshore within a relatively flat run of 200mm A/C pipe. Significant flow enters the foreshore sewer at SMH 3-009, resulting in surcharge downstream to 3-007 under 2013 peak wet weather conditions. This surcharge is also modeled to extend further west from 3-009 to 3-601, within the lateral to the lowest portion of Beach Drive.

7.2.1.4 Stewart Street / Comox Avenue [4-007 to 4-004]

Development upstream of this section is predominantly single family residential. The service area is bounded roughly bounded by Church St, Noel Avenue, Pritchard Road and Comox Avenue. While the performance analysis indicates this section exceeds the "full pipe" criteria, the HGL remains within the pipe. Therefore, conveyance capacity is not considered to be an issue requiring immediate attention.

7.2.2 Upgrade Options

7.2.2.1 Stewart Street Diversion – SMH 4-007 to 4-003

The Town wishes to pursue an upgrade plan, to divert flow away from the surcharged Comox Avenue portion of this section, from SMH 4-006 to 4-004. The intended principal benefit of this plan is the expected economy of scale involved with the coincident surface work upgrading along Beaufort Avenue, planned for construction in 2014.

The Stewart diversion will involve installation of a 250mm diameter pipe from Stewart Street and Alder Avenue to the corner of Beaufort, then westward, upgrading the existing 200mm sanitary to terminate at existing manhole 4-002 at Jane Pl. This is as depicted in Figure 8, overleaf.

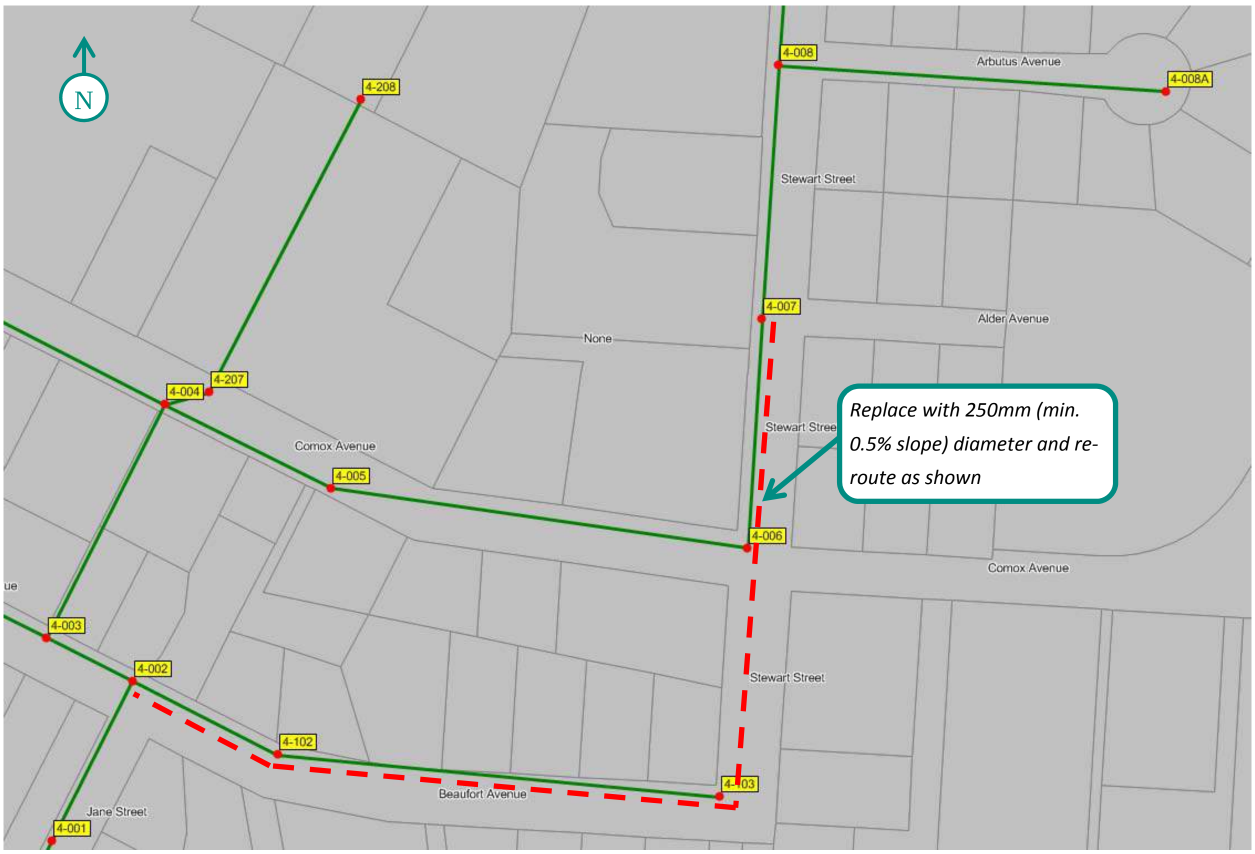


Figure 8 – Proposed Stewart Street Diversion

7.2.2.2 Central Foreshore Diversion – SMH 1-003 to 1-001

The Town has asked that the benefit of a diversion across the Comox Golf Course be investigated, with the aim being a reduction in pipe surcharge along the foreshore, thus avoiding the need for construction in the foreshore area until such time as existing system design life expiration occurs.

The concept would involve intercepting flow from Church Street near Buena Vista Ave, routing across the Comox Golf Course to Port Augusta Street. The topographic feasibility of the route was not confirmed with certainty. However, preliminary review from Google Earth elevation models show this route could be constructed as a gravity diversion. Figure 9, below, indicates the proposed diversion routing.

Figure 9 – Golf Course Diversion Option

Modeling of this diversion across the golf course reveals some benefit, in terms of reduction in surcharge along the Central Foreshore, noting the peak wet weather diversion of roughly 28 l/s (assumed LTF sewage loading) represents approximately 15% of the total flow conveyed. Net surcharge at SMH 1-003 would be reduced by 0.57m, from 1.76m to 1.19m, which may be significant. However, monitoring of this section is recommended in the short term. Field surveys of abutting services, confirmation of remaining pipe service life and better I&I understand may confirm the golf course diversion as a suitable capital project. This should be pursued. In the interests of conservatism, the five year plan includes a recommendation that the Central Foreshore sewer section be replaced or twinned, eliminating its surcharge entirely.

7.2.2.3 Western Foreshore

The recommendation, based on 2013 flows, is to monitor this section and to confirm modeled surcharge during wet weather, peak flow events. This said, eventual replacement, per the agreed replacement criteria, is required, and has been carried in the 5 year cost estimates below. It is recommended that localized abutting service connection inverts and MHFEs be checked, to ensure expected surcharge is tolerable with a sufficient safety factor.

7.2.2.4 Comox Avenue - Rodello to Anderton

Again, the recommendation, based on 2013 flows, is to monitor this section and to confirm modeled surcharge during wet weather, peak flow events. The 5 year capital plan should include replacement of this section, as surcharge exceeds allowable, per the agreed criterion. It is recommended that abutting service connection inverts and MHFEs be checked, to ensure expected peak surcharge is tolerable in the short term, allowing a reasonable safety factor.

7.2.3 I&I Reduction Opportunities

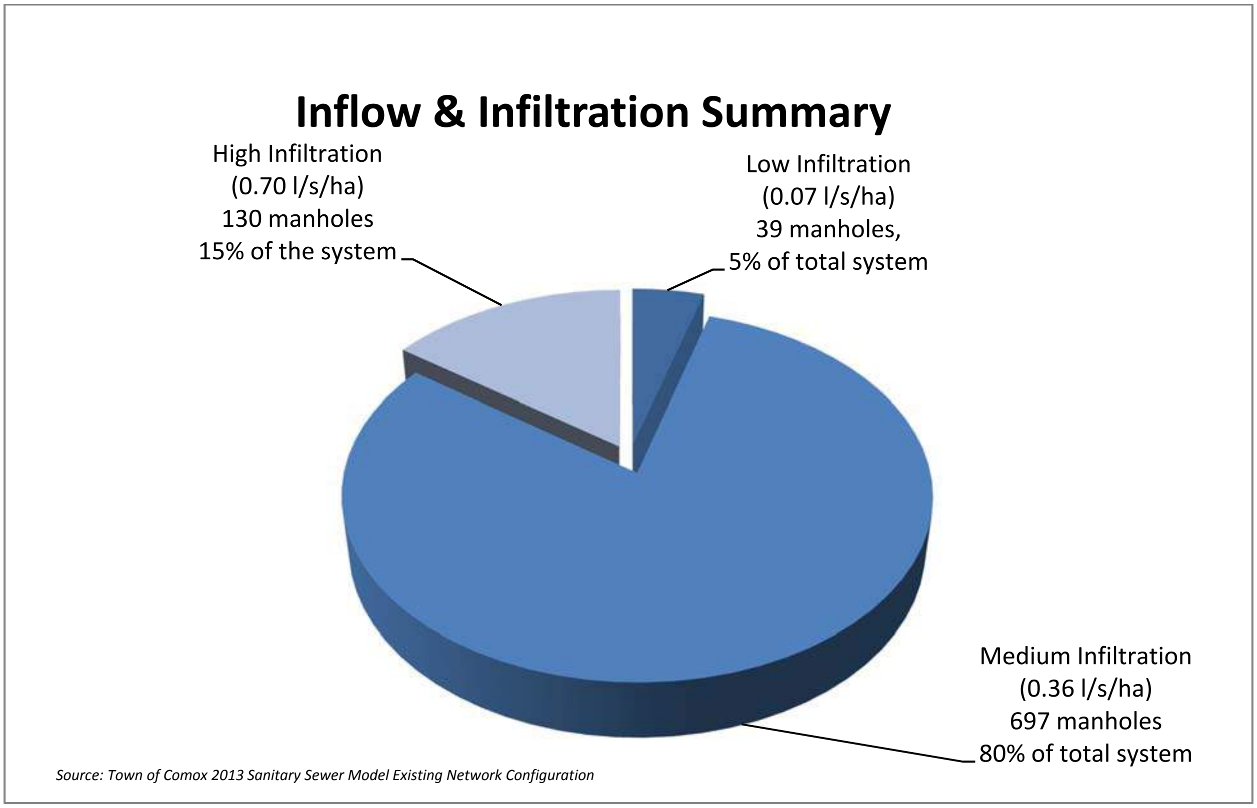
It is assumed herein, for purposes of brevity, that the reader is familiar with the concept of infiltration and inflow and the different causes of both. Past work has concluded the Town's sewer conveyance system experiences significantly higher flows during the wet weather months than in dry weather, and conveys much higher flows during significant rainfall events than not.

I&I reduction is important consideration for two fundamental reasons:

- Deferring or eliminating the need for Town owned conveyance infrastructure upgrading.
- Reducing the pumping, treatment and disposal costs incurred by the CVRD and recovered from the Town. [During past CVRD SMP effort, it was determined that roughly 50% of total annual sewage flow was attributable to I&I].

The Town of Comox faces the cost of replacement of four or five sections of trunk sewer, to be constructed over the next five years. Before definitively concluding the absolute need for these capital projects, a better understanding is needed, of the causes, extent and differential magnitude of I&I within the system.

In the past, it was determined that peak I&I rates differ substantially by sub-catchment within overall the Jane Place Pumping station catchment. Figure 10 below, graphically represents the understanding of I&I rates by sub-catchment, based on in-stream work completed late in the last decade.



By comparison:

- Town design criteria for green field development = 0.06 l/s/ha
- CVRD SMP criterion = 0.17 l/s/ha

Figure 10 – I&I Summary

It is understood that the Town has been making efforts toward I&I reduction, but that a systematic cataloguing of efforts made and improvements resulting, has not been possible thus far. The basis of the Town's I&I reduction strategy needs to include the following sequential components, moving forward:

- Through in-stream monitoring, isolate gradually smaller sub-catchment areas, assessing the relative I&I rates in each. Catalogue the results of in-stream monitoring.

- Determine the cost of allowing I&I to continue unabated.
- Assess cost effective means of reducing I&I, focusing first on sub-catchment areas exhibiting highest I&I rates:
    - Further isolate issues via dry winter weather camera inspections, toward assessment of infiltration component of winter flow, and instream monitoring of pipes exhibiting large flows during wet weather (inflow) component.
    - Assessment, through flow monitoring, of total magnitude and differences in base infiltration rates during summer vs. winter conditions.
    - Assess probable causes of suspected inflow by smoke and dye testing methods.
- Undertake a cost/benefit analysis in reference to each identifiable I&I source, with agreed acceptable degree of certainty as to flow reduction outcome.
- Breakout planned actions into capital plan elements and efforts better undertaken by Town operations staff. Include cross-referencing of system component age and pipe material, etc.
- Prepare both capital works and operations maintenance plans to reduce I&I, attending to areas and issues of highest financial return first.
- Ensure an on-going annual effort is maintained, as budgets allow and financial benefit is demonstrated. Update the plan annually.

To demonstrate the magnitude of the Town's I&I issue, and to differentiate between infiltration and inflow components, Figure 11, overleaf, was prepared. This graphic depicts seasonal variations in approximate flow rates entering the Jane Place pumping station. Values indicated are averages of five data points for each day [date], over the period from 2008 to 2013. Two issues are clearly identifiable. Firstly, that average winter weather flow rates are roughly 1,000 cubic metres per day higher than during the drier months of the year. Secondly, that short duration spikes in winter weather flow at Jane Place are quite pronounced, even when muted through averaging of these daily values over a five year period.

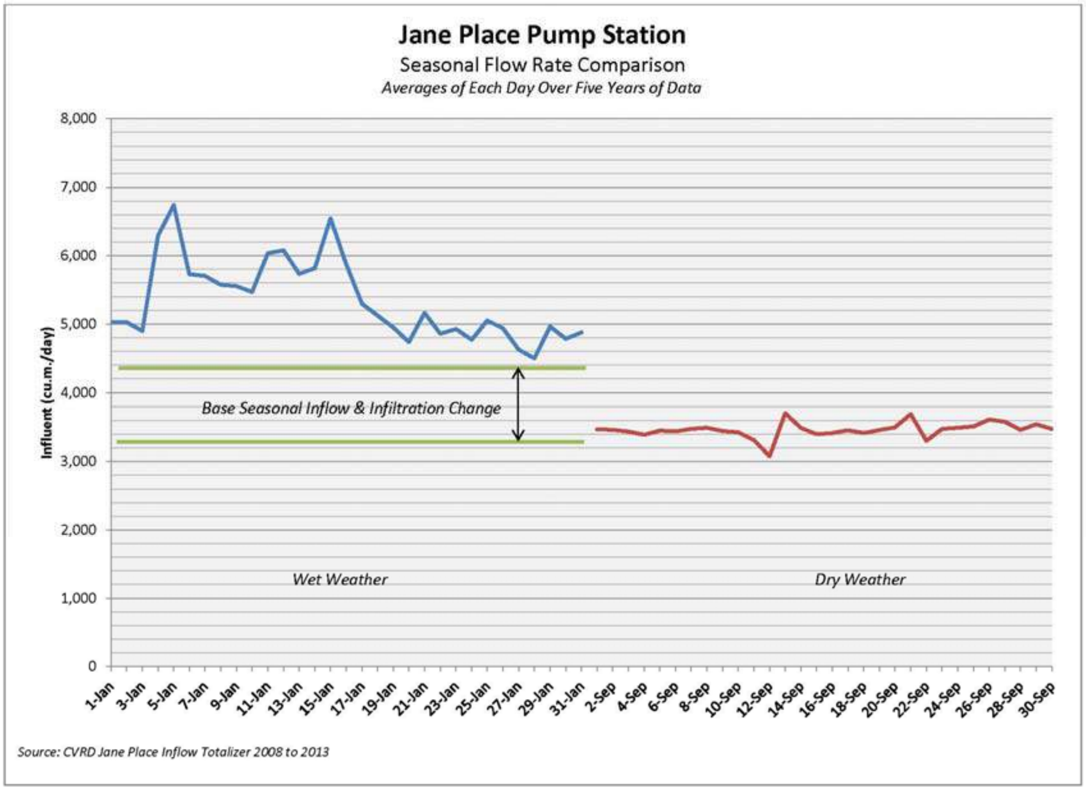


Figure 11 – Jane Place PS Seasonal Flow Rate Comparison

By way of illustrative example, but by no means intended as an intended target for I&I reduction, we note the CVRD rate charged to the Town of Comox, is roughly $1.40 per cubic metre of sewage entering the Jane Place pump station. If the Town were successful in reducing winter base infiltration rates by only 200 cubic metres per day, over the wet season of say four months, this equates to something in the order of $50,000 in direct savings per year. The Town should investigate this target more rigorously and implement a plan to achieve infiltration rate reductions of a magnitude deemed financially advantageous.

During work undertaken as part of the CVRD SMP process, it was concluded that, as expected, a diminishing returns curve exists in efforts toward reducing I&I. This said, flow records indicate periodic spikes in average daily flow from Comox with reasonably regular frequency, together with more anomalous, less frequent, much higher rates. Although the record data set is relatively short, we do conclude the Town does have an opportunity to achieve real, measureable benefit, through the implementation of a rigorous I&I reduction strategy.

Perhaps less consequentially, then, if the Town can achieve reductions in peak wet weather discharges by 1,000 cubic metres per day, through the reduction of direct inflow sources, this equates to a peak flow rate reduction of roughly 12 l/s. This is not a sufficient quantity to render any of the trunk system replacement projects identified above as unnecessary, but we would not recommend the impact of inflow reduction be discarded until a better understanding of site specific sources of inflow is in hand.

Figure 12, overleaf, illustrates daily total flows entering the Jane Place station, between January 2008 and September, 2013, inclusive. Notable is the large [4,000 cubic metres per day] anomalous spike, occurring once in the data available. This is, we presume, a function of heavy inflow of rainfall to the system. A reduction in the order of 4,000 cubic metres per peak wet weather day, if achieved, would be of consequence in reducing pipe replacements otherwise needed. A better understanding of catchment specific I&I rates is needed, to allow for future model calibration and better assessments of specific system component upgrading urgency.

In summary, to reiterate to some degree, we recommend the Town work to frame this issue through investigating the costs and benefits of I&I reduction strategies:

- Via sewer system response to discrete storm events [i.e., in the order of hours or days]. Short duration 'Inflow' peaks, giving rise to conveyance system capacity issues [trunk sewer pipe replacement requirements] but not very large total sewage volume increases. Typically problematic in terms of pumping and treatment components function also.
- Via system function during the wet weather season [I.e.: November through February]. Elevated baseline infiltration levels and, potentially, large volumes of total sewage to the pumping and treatment systems downstream.
- As a function of total average annual sewage volumes and variation in same, on a month by month basis. To what extent can this average flow rate be reduced, seasonally and annually, at what cost and with what benefits.

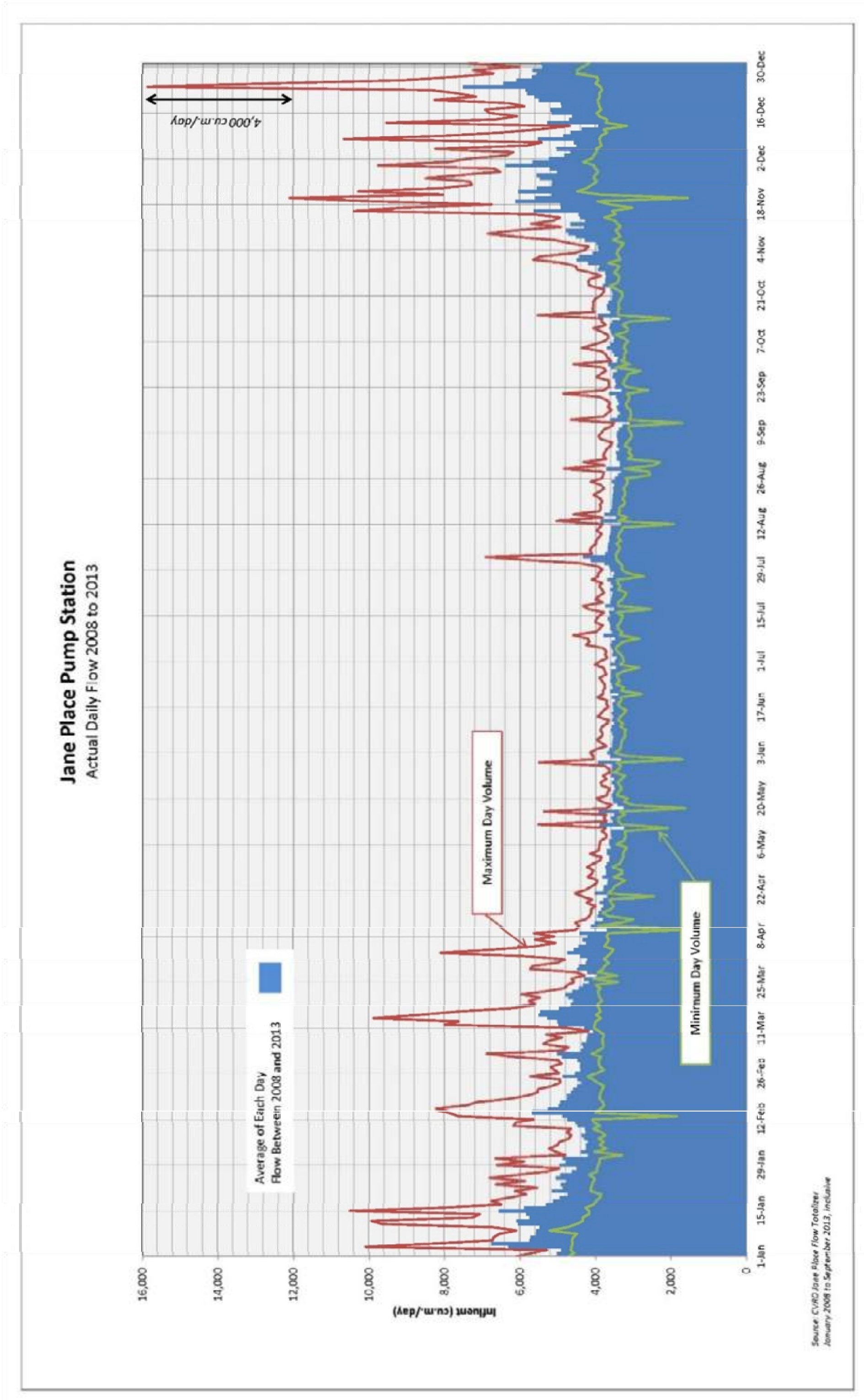


Figure 12 – Jane Place PS Daily Flow 2008 to 2013

Lastly, we would note that I&I reduction strategies can be considered as one of [likely the largest of, by a wide margin] a series of flow and volume reduction measures. These might also include efforts to reduce average dry weather flows via lower per capita total sewage loading. However, efforts during the preparation of the CVRD SMP suggest that total average annual dry weather sewage load reduction potential is quite limited; amounting to at most roughly a 10% reduction in ADWF, if aggressively pursued.

7.3 5 Year Future (STF) (2018±)

7.3.1 Operational Deficiencies

Figure 13 (rear Pocket) indicates surcharge resulting from the expected increases in peak wet weather flow rates at each of the four locations identified as under-capacity for the existing conditions, 2013, model. Interestingly, no additional capacity issues are indicated, based on loads imposed through the modeled five year horizon.

Replacement of the gravity sewer along Anderton from Bolt to Guthrie is included, carried forward from the Town's existing sanitary DCC bylaw. This project may be required, depending on final land use decisions forthcoming, pertaining to the remainder of the "Shoppers Drug" development lands. If constructed, this upgrade would also permit further development beyond the Town's current municipal boundary northwards along Anderton Road, to service the conceptual 'Brooklyn' pump station.

It is expected that pressure to provide sewer service to areas currently beyond the Town's northerly boundary will occur at some point over the next five years. Specifically, we anticipate the area indicated in the hatched area noted on Figure 6 will become the subject of short term development pressure. As discussed with Town engineering staff, this area, while not presently in the Town, could be serviced via a pumping station, likely located along Anderton Road, at or near the crossing of Brooklyn Creek. Short term, the Town might expect flow from this new service area to be directed, via a pressure sewer, to the intersection of Anderton at Guthrie.

For purposes of completeness, we made a preliminary assessment of the impacts which servicing this additional area, beyond the Town's existing northerly boundary, would have on the Town's existing gravity collection network. If, assuming typical R-1 density, development of this ±45 ha area would result in a peak, wet weather flow rate tributary to the proposed 'Brooklyn' pumping station of ± 10l/s, therefore a pumped flow out of this station in the order of ±15 l/s. Modeled as such, pipe 1-006 to 1-005 is expected to experience roughly 0.3m of surcharge, and therefore should be checked for adjoining service connection MHFEs, and this pipe section "monitored" for performance issues, subsequent to commissioning the possible Brooklyn pump station. Replacement of the trunk sewer on Anderton, from Guthrie to Bolt, would also be required, per the existing Town DCC project.

Surcharge along the central foreshore would likely exceed manhole depth (floods), in advance of upgrading along the foreshore, given this loading regime, inclusive of the proposed Brooklyn pump station.

Longer term, sewage from this area would be best directed, via a pressure sewer flowing northward, to the Hudson Road CVRD trunk sewer, the probable route of which is as indicated on Figure 6, [rear pocket]. The CVRD timing for the Hudson Road trunk sewer extension is indicated in the CVRD's 10 year capital plan as circa 2016-17, and therefore, it remains to be seen if a short term, interim, direction of sewage toward the existing Town conveyance system will materialize.

It is assumed here this Brooklyn pumping station and pressure sewer will be funded directly, and entirely, by developers of the land to which it will provide benefit, potentially, inclusive of latecomer agreement(s).

7.4 20 Year (LTF) (2023±)

Models indicate no additional system capacity shortfalls, over that indicated in the existing conditions and 5 year future models.

This implicitly assumes I&I rates will be held at existing levels and infill development rates will occur at or below the rate of growth agreed to with the Town.

7.4.1 Operational Deficiencies

No change from five year models are noted, other than modest increase in surcharge predicted, per Figure 13. However, assuming the 5 year plan projects are completed as recommended, surcharge conditions in the 20 year horizon will be eliminated.

7.5 'Full Build Out' System Planning

The CVRD sewer master plan, dated May, 2011, provides strategic direction in regard to longer term trunk conveyance and treatment planning. This includes the following, of relevance to Comox:

- Diversion of flow from the Jane Place pumping station to the proposed Docliddle station, thereby providing some capacity for future infilling/densification within the Jane Place station catchment.
- Diversion of the existing Willemar bluffs foreshore sewer, routing from the proposed Docliddle station, overland to the CVPCC at Brent Road.
- Extension of the Hudson trunk sewer, providing a longer term option for the Town to discharge from areas not tributary by gravity to Jane Place or Colby Road stations.

These elements are included in the CVRD's current 10 year capital plan. Figure 6, located in the rear pocket, identifies the proposed long term Town boundary limits, per the CVRD RGS, and includes an indication of areas potentially to be diverted from the Jane Place station to the Docliddle station.

8.0 FIVE YEAR CAPITAL PLAN AND COST ESTIMATES

8.1 5 Year Proposed Sequential Capital Upgrading Plan

The following five year implementation plan balances project priorities based on forecasted conveyance shortfalls and fiscal benefit to the Town. We recommend attention be focused initially on reducing I&I as there are no current known operational issues related to the forecasted surcharge that require immediate attention. Benefit to the Town may be realized in reducing ongoing CVRD pumping and treatment charges and possibly deferring or negating the need for gravity pipe upgrades, as alluded to previously. Figure 14 (in rear pocket), highlights each of the projects listed in Table 6 below:

Table 6 provides a summary of expected capital costs for each major project in the recommended 5 year capital plan along with year of implementation.

Table 6 – Town 2013 Sanitary Sewer Model Cost Estimate Summary

Town of Comox
2013 Sanitary Sewer Model Update
Cost Estimate Summary

Project No	Project Description	Fiscal Year	Qty	Unit	Unit Cost	Project Cost
S-4	Stewart / Comox / Beaufort Upgrade	2014	350	l.m.	$ 759	$ 266,000
S-5	Inflow & Infiltration Reduction	2014-2018	5	yr	$ 75,000 *	$ 375,000
S-6	Western Foreshore Upgrade	2015	460	l.m.	$ 905	$ 416,000
S-7	Comox Ave Upgrade - Rodello to Anderton*	2016	355	l.m.	$ 1,050	$ 373,000
R-1	Anderton - Bolt to Guthrie	2017	430	l.m.	$ 899	$ 387,000
S-8	Central Foreshore Upgrade	2018	200	l.m.	$ 1,205	$ 241,000
					Grand Total	**$ 2,058,000**

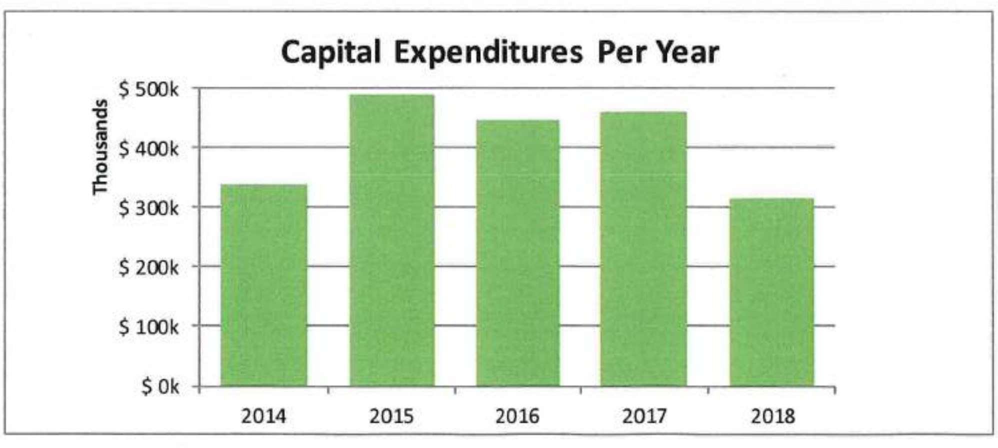
Notes:

**Consideration is needed as to the benefit of completing this sewer capacity upgrade in association with the planned introduction of a traffic circle at the Rodello/Comox Avenue intersection.*

***Include diameters in Appendix D, which include further cost estimate breakdowns and derivations.*

Assumptions:

- Prices are based on 2013 construction values for similar Comox Valley based projects.
- Replacement sewer mains are assumed to be aligned adjacent (twinned) to original sewers. Existing sanitary services are to be reconnected at the main line only and no allowance has been included for rebuilding or installing new services to property line.
- Bypass pumping of effluent is limited to facilitate tie-ins only.
- No allowance has been made for off-site disposal of asbestos concrete materials, if present, rather, assumed in-place disposal.
- Restoration is limited to trench limits only, returning surfaces to original condition such as road paving and/or boulevard hydroseeding.
- No allowance has yet been made to account for environmental studies or potential compensation works mandated by provincial and/or federal authorities.



Note:

** Year 1 is expected to cover development of a systematic I&I reduction plan, field work and reporting, cost estimates, cost/benefit analysis and breakout of capital vs. Town operations project. Years 2 through 5 are expected to include specific I&I related capital work, potentially rolled into a lesser number of more costly projects.*

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

- The Town's existing collection network is, for the most part, functioning quite effectively, with little operational difficulty being experienced.

- The results of 2013 computer model updating correlate well to output from past SANSYS models.

- Population and development growth in the Comox Valley is predicted to occur at a lesser rate than past studies had assumed.

- A dry weather peaking factor of 3.0, universally applied to the collection network as a whole, renders reasonably conservative results, while not unduly indicating system deficiencies unlikely to manifest as operational issues over the design life of the system.

- Infiltration and inflow to the Town's sewer collection network is substantial and worthy of further scrutiny. This is concluded based on results of in-stream monitoring during past studies, and Jane Place Pumping station data acquired more recently. The Town has been working on this issue, as staff time and other resources permit.

- Cost to the Town for CVRD sewer pumping, treatment and disposal is expected to rise above the +/- $1.40 / cubic metre charged in the present day. Town capital upgrading may be deferrable, or even eliminated [at least until expected pipe material service life expiration], if sufficient I&I reductions can be achieved. By contrast, CVRD capital expansion plans, which will be recovered through increased DCCs, are not expected to be deferrable or avoidable via I&I reduction strategies.

- Surcharging of four sections of trunk sewer is expected, when subject to peak wet weather flows. Based on agreed replacement criteria, these sections of sewer require upgrading or diversion of flows away from them.

- Sections of surcharged trunk sewers along the foreshore may continue to be tolerable. Survey is required to confirm acceptable surcharge depths.

- In response to the 20 year future development scenario, no further upgrades to the collection network tributary to the Jane Place pumping station are expected, based on capacity shortfalls. This assumes I&I rates can be maintained not exceeding present day levels.

- Replacement of sewers should be prioritized based on a series of criteria, ordered to suit the priorities of Town staff and, potentially, elected officials. A suggested list is included in this report (Section 5.6).

9.2 Recommendations

- Assess tolerable surcharge in all portions of the system expected to have insufficient capacity, via field surveys and winter in-stream flow monitoring, followed by plotting of existing MHFEs against expected peak surcharge depths.

- The CVRD charges the Town roughly $1.40 per cubic metre for sewage pumping, treatment and ocean disposal. The Town has made efforts over the past several years. These should be catalogued and effects verified. I&I reductions that would cost effectively reduce total average annual and peak sewage flows should be pursued. Drafting and implementation of a more formal I&I reduction strategy is warranted.

- The Town should attend to updating of its DCC bylaw in the near future.

- Confirm pros and cons of the golf course diversion, via the criteria outlined in Section 7.2.2.2 and finalize capital plan for year 2017 (Central Foreshore replacement) as a result.

- Replace Trunk sewers, as required, per recommended updated capital plan and draft DCC Bylaw list.

- Town staff to review and agree on sequential capital upgrading criteria, based on operational needs, as listed in Section 5.6.

- Plan for pipe replacement if at end of pipe material service life or specific operational problems are confirmed/known to exist. The Town's capital plan should reflect <u>both</u> system capacity and service life replacement requirements.

- The current PCSWMM sewer models do not include the ability to undertake adjacent property freeboard analysis. This feature is supported in advanced versions of the software. At the Town's discretion, future models could be expanded with appropriate manhole depth data and service/building slab information.

- Population growth assumptions should be revisited at least on a five year recurrence basis.

APPENDICES

APPENDIX A – SWMM CONVERSION

APPENDIX B – LISTING OF ALL PIPES IN THE TOWN SYSTEM EXCEEDING TABLE 3 REPLACEMENT CRITERIA

APPENDIX C – 20 YEAR COMOX POPULATION CURVE DERIVATIONS TABLE

APPENDIX D – COST ESTIMATE BREAKDOWN DERIVATIONS & ASSUMPTIONS

APPENDIX A
SWMM CONVERSION

TOWN OF COMOX

2013 SANITARY MODEL UPDATE

PCSWMM

APPENDIX A

PCSWMM, developed by Computational Hydraulics International (CHI), uses the computational engine from US Environmental Protection Agency's Storm Water Management Model, widely held as an industry standard hydrologic and hydraulic simulation platform. PCSWMM enhances the base software with enhanced features and additional flexibility. While the software's primary purpose is simulating storm water runoff and conveyance, the hydraulic functionality is well suited for sanitary sewer applications.

This model update builds upon previous monitoring and modeling efforts while taking advantage of new functionality available with PCSWMM.

- Physical network objects defined with UTM coordinates and elevations
- GIS-based data storage
- Dynamic hydraulic modeling
- Google Earth data-sharing and presentation support
- Diurnal flow pattern analysis
-

Conveyance Network Conversion

Manhole locations, on local coordinates, were exported from AutoCAD then pseudo-referenced to the Town's GPS surveyed locations first using 'rubber-sheet' software routines. Then, with the Town's assistance, each manhole was reconciled manually on-screen, comparing the surveyed and translated locations. Lastly, each manhole, now with adjusted UTM real-world coordinates, was imported into PCSWMM.

The Town GPS manhole data contained rim elevations and surface UTM coordinates, but lacked rim-to-invert data. As PCSWMM requires manhole inverts for establishing pipe slope and HGL plotting, an interim workaround was devised. Using Excel, UTM coordinates for upstream and downstream manholes defined pipe length. SANSYS pipe slopes were used to calculate vertical elevation difference between the downstream and upstream manhole. This approach is cost-effective interim measure providing continuity between past models without re-surveying the entire network.

Exported SANSYS pipe data included upstream and downstream manhole connections, pipe size, material type (as indicated by Manning's n value) and pipe slope. This dataset was first compiled through Excel and then imported. PCSWMM automatically generated 'straight-line' connections between manholes which were then reviewed for pipe alignment and adjusted manually to better reflect real-world conditions (i.e. pipe curves).

Population and Sewerage Loads

PCSWMM was originally designed for storm water applications and, thus, utilization for sanitary sewer network simulation requires input assumptions to be made and conventions developed.

To this end, spreadsheet files were created, in parallel to PCSWMM, to calculate and track sewerage and inflow & infiltration loads.

Sewerage loads are calculated as a Full Time Residential Equivalent (FTRE) derived by the contributing area and zoning density. Inflow and Infiltration (I & I) flows use total contributing area with a catchment specific I & I rate, as determined in previous studies. Calculated values are imported into manhole attributes for peaked (sewerage) and non-peaked (I & I) flow inputs.

APPENDIX B

LISTING OF ALL PIPES IN THE TOWN SYSTEM EXCEEDING TABLE 3 REPLACEMENT CRITERIA

TOWN OF COMOX
2013 SANITARY MODEL UPDATE
APPENDIX B - Pipes Exceeding "Full" Criteria

NAME	INLETNODE	OUTLETNODE	LENGTH	ROUGHNESS	DIA (MM)	SLOPE (%)	EXISTING MODEL PWWF FLOW (LPS)	PERCENT FULL
P1-2	1-002	1-001	91.80	0.011	375	0.31	196.03	93%
P1-3	1-003	1-002	100.93	0.011	375	0.30	195.55	100%
P3-7	3-007	3-006	144.66	0.013	200	0.20	20.67	81%
P3-8	3-008	3-007	126.81	0.013	200	0.20	20.24	100%
P3-9	3-009	3-008	155.77	0.013	200	0.20	18.52	100%
P2-06	2-006	2-005	33.42	0.013	250	0.30	44.80	85%
P2-07	2-007	2-006	97.84	0.013	250	0.31	44.80	100%
P2-08	2-008	2-007	66.24	0.013	250	0.20	43.80	100%
P2-09	2-009	2-008	155.80	0.013	200	0.40	27.90	100%
P3-600	3-600	3-009	124.81	0.013	200	0.30	1.76	100%
P3-601	3-601	3-600	24.93	0.013	200	0.28	1.14	100%
P3-602	3-602	3-601	78.98	0.013	200	0.30	0.98	95%

based on Existing (2013) Model

APPENDIX C
20 YEAR COMOX POPULATION CURVE
DERIVATIONS TABLE

TOWN OF COMOX
2013 SANITARY SEWER MODEL UPDATE
APPENDIX C
20 YEAR COMOX POPULATIONS

			2011 Census			CVRD Sewer Master Plan [Table 3A - Comox - 46970 Tech Memo No1							
Study Year	Year	1.2% Growth	Average Pop	1.6%Growth	Delta 1.6-1.2	1.48% Growth CVRD Min. Growth	2.2% Growth	2.88% Growth CVRD Max Growth	MP Population Range	Sanitary Model RFTE @ 1.4%	Yr/Yr Add Pop	0.5% Background Infill	Sanitary Model STF/LTF Buildout
	2008									13571			13571
	2009									13761			
	2010									13954			
	2011	13,630	13,630	13,630	0	12,659	12,873	13,190	531	14149			
	2012	13,794	13,821	13,848	55	12,846	13,137	13,570	724	14347			13571
0	2013	13,959	14,014	14,070	111	13,036	13,407	13,961	924	14548	154	68	13793
1	2014	14,127	14,211	14,295	168	13,229	13,681	14,363	1,134	14752	154	69	14016
2	2015	14,296	14,410	14,523	227	13,425	13,962	14,776	1,351	14958	154	70	14241
3	2016	14,468	14,612	14,756	288	13,624	14,248	15,202	1,578	15168	154	71	14466
4	2017	14,641	14,817	14,992	351	13,825	14,540	15,640	1,814	15380	154	72	14693
5	2018	14,817	15,024	15,232	415	14,030	14,838	16,090	2,060	15595	154	73	14920
6	2019	14,995	15,235	15,476	481	14,238	15,142	16,554	2,316	15814	139	75	15134
7	2020	15,175	15,449	15,723	548	14,448	15,453	17,030	2,582	16035	139	76	15348
8	2021	15,357	15,666	15,975	618	14,662	15,770	17,521	2,859	16259	139	77	15564
9	2022	15,541	15,886	16,230	689	14,879	16,093	18,025	3,146	16487	139	78	15781
10	2023	15,728	16,109	16,490	762	15,099	16,423	18,545	3,445	16718	139	79	15999
11	2024	15,916	16,335	16,754	838	15,323	16,759	19,079	3,756	16952	139	80	16217
12	2025	16,107	16,565	17,022	915	15,550	17,103	19,628	4,078	17189	139	81	16437
13	2026	16,301	16,797	17,294	994	15,780	17,454	20,193	4,414	17430	139	82	16658
14	2027	16,496	17,034	17,571	1,075	16,013	17,811	20,775	4,762	17674	139	83	16881
15	2028	16,694	17,273	17,852	1,158	16,250	18,177	21,373	5,123	17921	139	84	17104
16	2029	16,894	17,516	18,138	1,243	16,491	18,549	21,989	5,498	18172	139	86	17328
17	2030	17,097	17,763	18,428	1,331	16,735	18,929	22,622	5,887	18427	139	87	17554
18	2031	17,302	18,013	18,723	1,420	16,983	19,318	23,274	6,291	18685	139	88	17781
19	2032	17,510	18,266	19,022	1,512	17,234	19,714	23,944	6,710	18946	139	89	18008
20	2033	17,720	18,523	19,327	1,607	17,489	20,118	24,633	7,145	19211	139	90	18237

APPENDIX D

COST ESTIMATE BREAKDOWN DERIVATIONS & ASSUMPTIONS

Town of Comox 03-Jan-14
MCSL 47277-0 Town Sanitary Model Update Rev 0
Construction Cost Estimate By: MS
Chk: CDE

PROJECT S-4 STEWART / COMOX / BEAUFORT UPGRADE
Class D - Concept Cost Estimate

Description	Unit	Quantity	Unit Price	Sub total	Total
REMOVALS / SITE PREPARATION					
Asphalt/Concrete Cut/Removal/Off-Site Disposal	sq.m.	600	$ 10	$ 6,000	
					$ 6,000
ROAD RESTORATION					
75mm Minus Granular Sub-base (230mm Thick)	sq.m.	600	$ 17	$ 10,200	
19mm Minus Crushed gravel base (130mm Thick)	sq.m.	600	$ 15	$ 9,000	
Hot-Mix Asphalt (75mm Thick)	sq.m.	600	$ 45	$ 27,000	
Line Painting	l.s.	1	$ 1,500	$ 1,500	
					$ 47,700
SANITARY SEWER					
250mm DR28 PVC Sewer Main (0.5% slope)	l.m.	350	$ 285	$ 99,750	
Reconnect existing sewers	ea	5	$ 250	$ 1,250	
1050mm dia Sanitary Manhole	ea	4	$ 4,500	$ 18,000	
Bypass Pumping	l.s.	1	$ 5,000	$ 5,000	
					$ 124,000
				Subtotal	**$ 177,700**
			Engineering (15%)	$26,655	
			Contingency (30%)	$61,307	
				Total (Rounded)	**$265,700**
				Total Project Length	**300**

Town of Comox 02-Dec-13

MCSL 47277-0 Town Sanitary Model Update Rev 0

Construction Cost Estimate By: MS

Chk: CDE

PROJECT S-6 WESTERN FORESHORE UPGRADE - SMH 3-006 TO 3-009

Class D - Concept Cost Estimate

Description	Unit	Quantity	Unit Price	Sub total	Total
REMOVALS / SITE PREPARATION					
Existing Manholes	ea	3	$ 1,750	$ 5,250	
					$ 5,300
RESTORATION					
Foreshore Restoration	l.m.	460	$ 70	$ 32,200	
					$ 32,200
SANITARY SEWER					
300mm DR28 PVC Sewer Main	l.m.	460	$ 375	$ 172,500	
1050mm dia Sanitary Manhole	ea	4	$ 5,000	$ 20,000	
Bypass Pumping	l.s.	1	$ 20,000	$ 20,000	
					$ 212,500
				Subtotal	**$ 250,000**
			Engineering (20%)	$50,000	
			Environmental Monitoring / Permiting	$20,000	
			Contingency (30%)	$96,000	
				Total (Rounded)	**$416,000**
				Total Project Length	**460**

Town of Comox 02-Dec-13

MCSL 47277-0 Town Sanitary Model Update Rev 0

Construction Cost Estimate By: MS

Chk: CDE

PROJECT R-1 ANDERTON AVE UPGRADE - BOLT TO GUTHRIE

Class D - Concept Cost Estimate

Description	Unit	Quantity	Unit Price	Sub total	Total
REMOVALS / SITE PREPARATION					
Asphalt/Concrete Cut/Removal/Off-Site Disposal	sq.m.	860	$ 15	$ 12,900	
					$ 12,900
ROAD RESTORATION					
75mm Minus Granular Sub-base (230mm Thick)	sq.m.	860	$ 18	$ 15,480	
19mm Minus Crushed gravel base (130mm Thick)	sq.m.	860	$ 15	$ 12,900	
Hot-Mix Asphalt (75mm Thick)	sq.m.	860	$ 50	$ 43,000	
					$ 71,400
SANITARY SEWER					
250mm DR28 PVC Sewer Main (min. 0.5% slope)	l.m.	430	$ 300	$ 129,000	
Reconnect existing sewers	ea	20	$ 500	$ 10,000	
1050mm dia Sanitary Manhole	ea	7	$ 4,000	$ 28,000	
Bypass Pumping	l.s.	1	$ 7,500	$ 7,500	
					$ 174,500
				Subtotal	**$ 258,800**
			Engineering (15%)	$38,820	
			Contingency (30%)	$89,286	
				Total (Rounded)	**$387,000**
				Total Project Length	**430**

Town of Comox — *02-Dec-13*
MCSL 47277-0 Town Sanitary Model Update — *Rev 0*
Construction Cost Estimate — *By:* *MS*
Chk: *CDE*

PROJECT S-4 COMOX AVE UPGRADE - RODELLO TO ANDERTON
Class D - Concept Cost Estimate

Description	Unit	Quantity	Unit Price	Sub total	Total
REMOVALS / SITE PREPARATION					
Asphalt/Concrete Cut/Removal/Off-Site Disposal	*sq.m.*	*800*	*$ 15*	*$ 12,000*	
					$ 12,000
ROAD RESTORATION					
75mm Minus Granular Sub-base (230mm Thick)	*sq.m.*	*800*	*$ 18*	*$ 14,400*	
19mm Minus Crushed gravel base (130mm Thick)	*sq.m.*	*800*	*$ 15*	*$ 12,000*	
Hot-Mix Asphalt (75mm Thick)	*sq.m.*	*800*	*$ 45*	*$ 36,000*	
Line Painting/Traffic Loops	*l.s.*	*1*	*$ 20,000*	*$ 20,000*	
					$ 82,400
SANITARY SEWER					
300mm DR28 PVC Sewer Main	*l.m.*	*355*	*$ 325*	*$ 115,375*	
Reconnect existing sewers	*ea*	*7*	*$ 500*	*$ 3,500*	
1050mm dia Sanitary Manhole	*ea*	*4*	*$ 4,000*	*$ 16,000*	
Bypass Pumping	*l.s.*	*1*	*$ 20,000*	*$ 20,000*	
					$ 154,900
				Subtotal	***$ 249,300***
			Engineering (15%)	*$37,395*	
			Contingency (30%)	*$86,009*	
				Total (Rounded)	***$372,800***
				Total Project Length	***355***

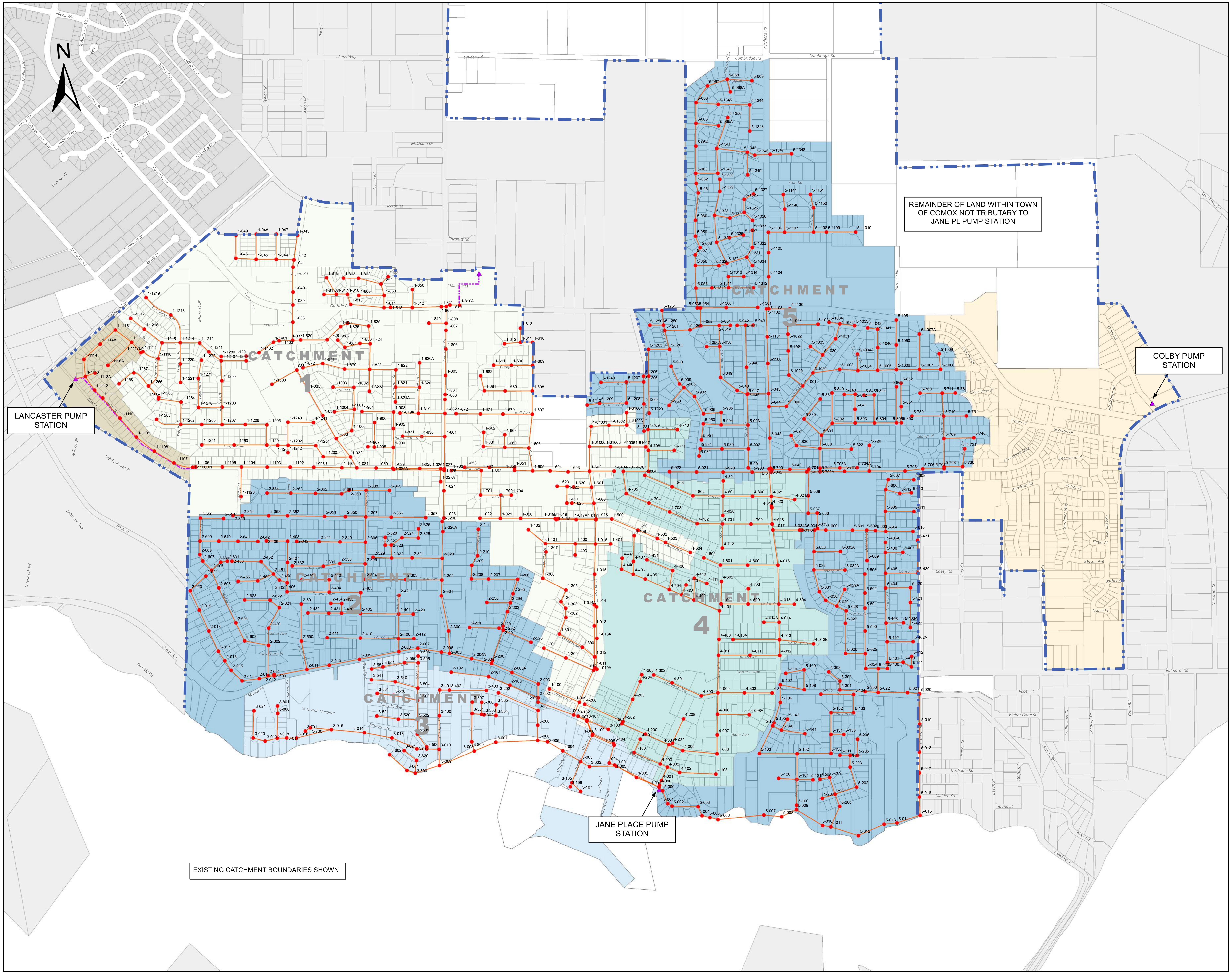
Town of Comox 02-Dec-13
MCSL 47277-0 Town Sanitary Model Update Rev 0
Construction Cost Estimate By: MS
Chk: CDE

PROJECT S-6 CENTRAL FORESHORE UPGRADE - SMH 1-003 TO 1-001
Class D - Concept Cost Estimate

Description	Unit	Quantity	Unit Price	Sub total	Total
REMOVALS / SITE PREPARATION					
Existing Manholes	ea	2	$ 2,500	$ 5,000	
					$ 5,000
RESTORATION					
Foreshore Restoration	l.m.	200	$ 70	$ 14,000	
					$ 14,000
SANITARY SEWER					
525mm DR28 PVC Sewer Main	l.m.	200	$ 400	$ 80,000	
1050mm dia Sanitary Manhole	ea	4	$ 4,500	$ 18,000	
Bypass Pumping	l.s.	1	$ 25,000	$ 25,000	
					$ 123,000
				Subtotal	**$ 142,000**
			Engineering (20%)	$28,400	
			Environmental Monitoring / Permiting	$15,000	
			Contingency (30%)	$55,620	
				Total (Rounded)	**$241,100**
				Total Project Length	**200**

FIGURES

Document Path: G:\2211 Engineering\47000 - 47999\47277\4.0 Engineering (in-house)\Modeling\GIS_Output\Draft Report Figures\47277-Fig#1-ExistingSystem-Rev1.mxd



0 150 300 600 900

Meters

1:7,500

Legend

- Municipal Boundary
- Manhole (Junction)
- Manhole (Junction)
- Sewer Pipe (Conduits)
- Pump Station
- Forcemain
- Colby PS Catchment
- Lancaster PS Catchment
- Town of Comox
- City of Courtenay
- CVRD

Catchment ID and I & I Rates

- 1 (85% 0.356 L/s/ha & 15% 0.07 L/s/ha)
- 2 (0.70 L/s/ha)
- 3 (0.356 L/s/ha)
- 4 (0.356 L/s/ha)
- 5 (0.356 L/s/ha)

Fig - 1
Town Existing Sanitary Collection System

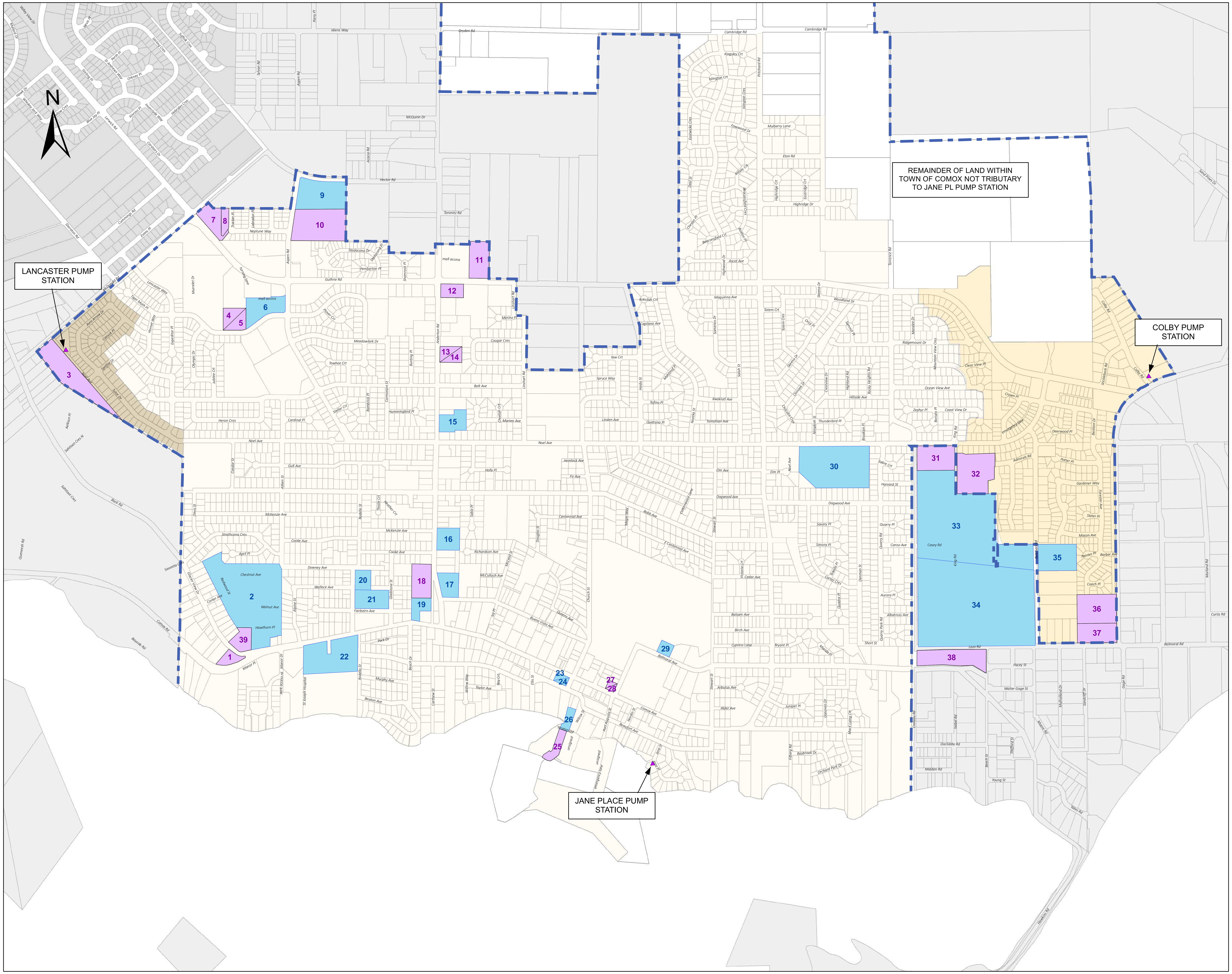
2013 Sanitary Sewer Model Update

November 15, 2013

Revision 0

McElhanney

TOWN OF COMOX



Legend

- Town Municipal Boundary
- STF (5yr) Growth Nodes
- LTF(20yr) Growth Nodes
- Existing Sewage Pump Stations
- Jane Place PS Catchment
- Colby PS Catchment
- Lancaster PS Catchment
- Town of Comox
- CVRD
- City of Courtenay

0 150 300 600 900
Meters
1:7,500

Fig - 4
STF (5YR) & LTF (20YR) GROWTH AREAS

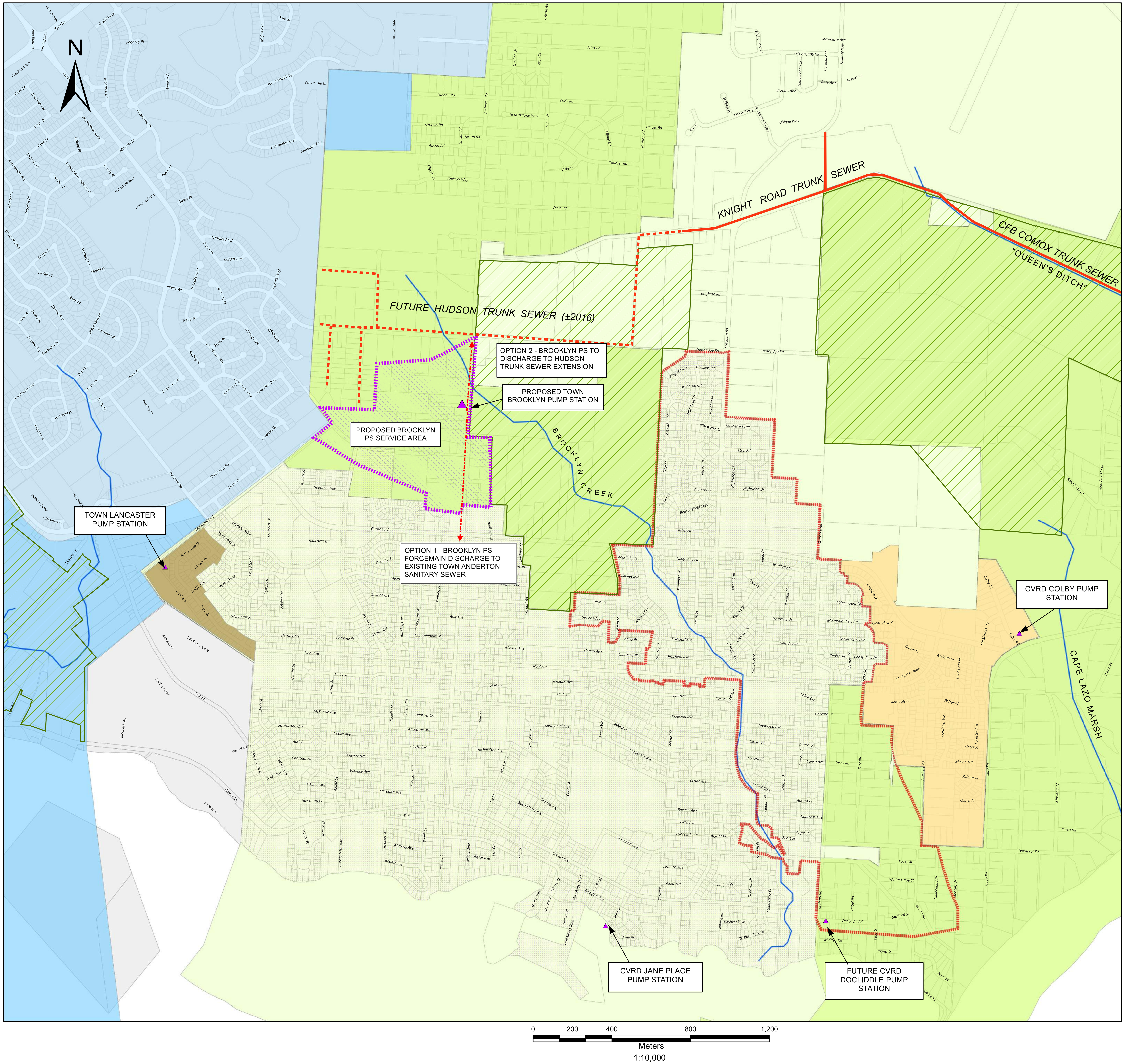
2013 Sanitary Sewer Model Update

November 15, 2013 Revision 0

McElhanney

TOWN OF COMOX

Document Path: G:\2211 Engineering\47000 - 47999\47277\4.0 Engineering (in-house)\Modeling\GIS_Output\Draft Report Figures\47277-Fig#4-STF-LTF-GROWTH-Rev1.mxd



Document Path: G:\2211 Engineering\47000 - 47999\47277\4.0 Engineering (in-house)\Modeling\GIS_Output\Draft Report Figures\47277-Fig#6-CVRD-SMP.mxd

Legend

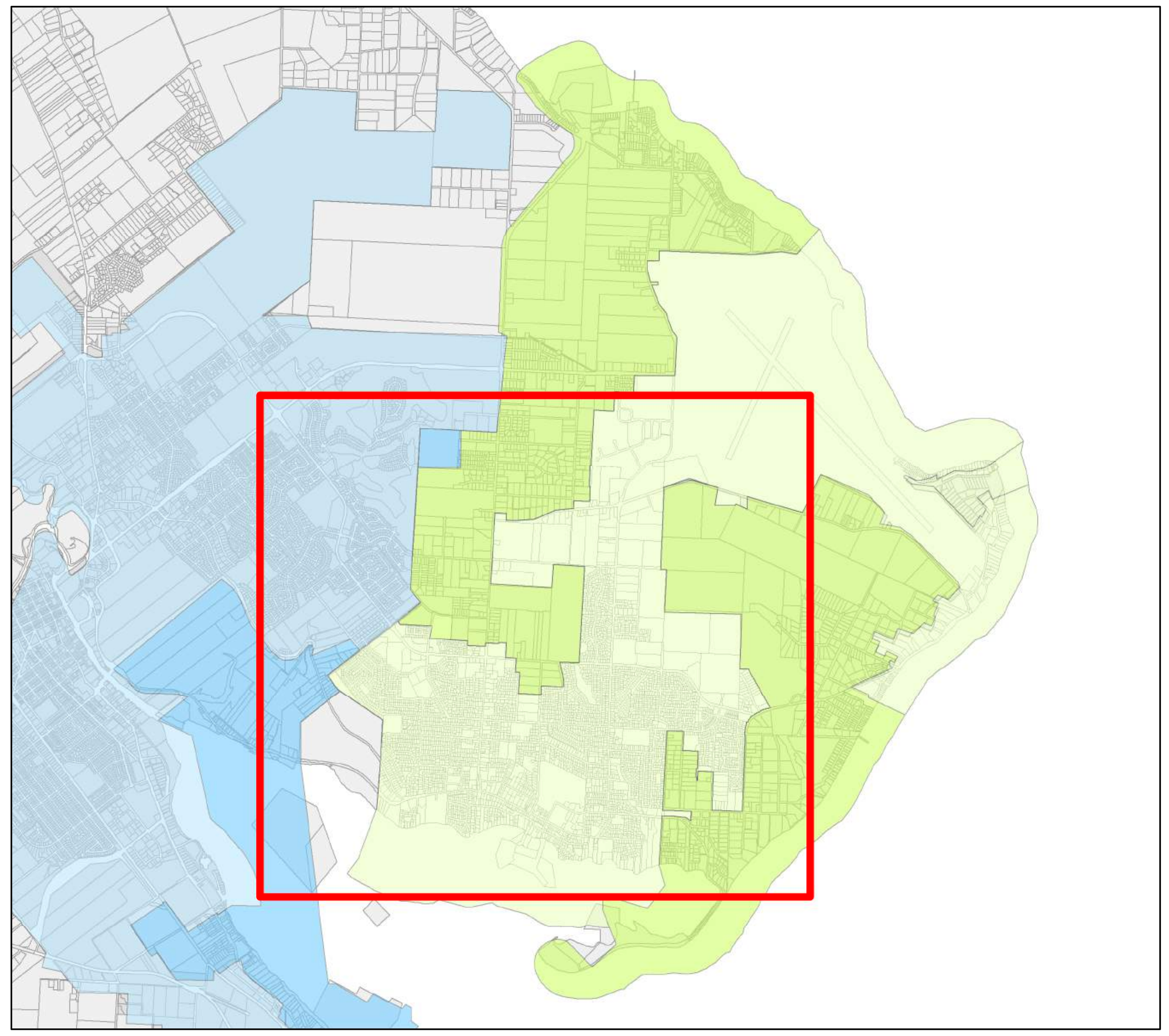
Agricultural Land Reserve

Lift Station Catchment Areas

- Future Docliddle PS Catchment
- Jane Pl PS Catchment
- Colby PS Catchment
- Lancaster PS Catchment

CVRD Sewer Master Plan Areas

- Comox, Existing Area
- Comox, Future Area
- Courtenay, Existing Area
- Courtenay, Future Area
- Town of Comox
- CVRD
- City of Courtenay



KEY MAP 1:50,000

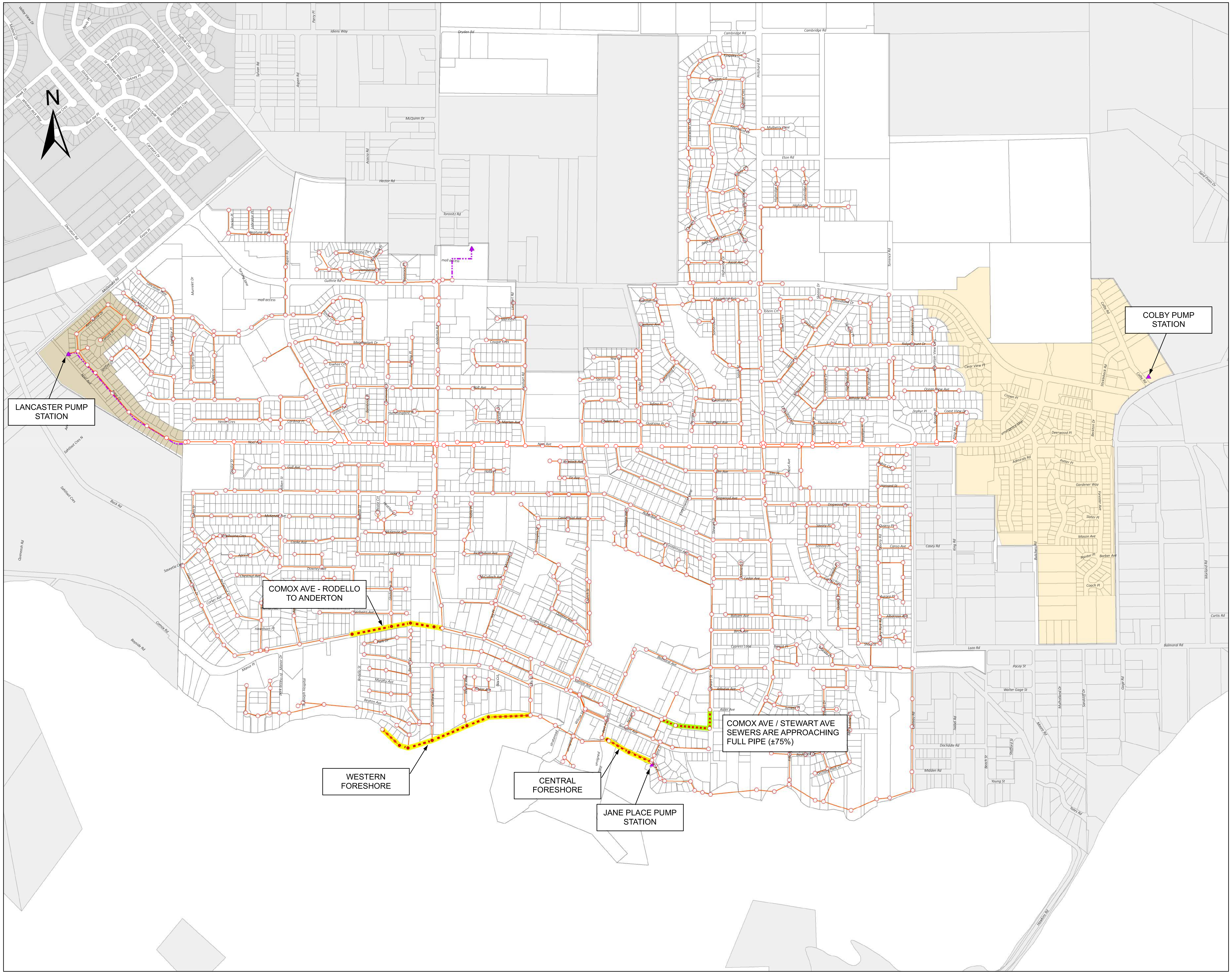
Fig - 6
CVRD Sewer Master Plan Annexation Areas

2013 Sanitary Sewer Model Update

November 15, 2013 Revision 0

McElhanney

TOWN OF COMOX



Legend

- Manholes (No Surcharge)
- Manholes (Surcharge)
- Pump Stations
- Existing Gravity Sewers
- Sewers Considered "Full"
- Forcemain
- Colby PS Catchment
- Lancaster PS Catchment
- Town of Comox
- CVRD
- City of Courtenay

0 240 480 960 1,440 1,920 Meters

1:7,500

Fig - 7
EXISTING SYSTEM (2013) CAPACITY ISSUES

2013 Sanitary Sewer Model Update

November 15, 2013 Revision 0

McElhanney

TOWN OF COMOX

Document Path: G:\2211 Engineering\47000 - 47999\47277\4.0 Engineering (in-house)\Modeling\GIS_Output\Draft Report Figures\47277-Fig#7-ExistingShortfalls-DraftReport.mxd

Document Path: G:\2211 Engineering\47000 - 47999\47277\4.0 Engineering (in-house)\Modeling\GIS_Output\Draft Report Figures\47277-Fig#13-STF-LTF-Shortfalls.mxd

Fig - 13
STF (5YR) & LTF (20YR) CAPACITY SHORTFALLS AND PROPOSED UPGRADES

2013 Sanitary Sewer Model Update

November 15, 2013 Revision 0

McElhanney

TOWN OF COMOX

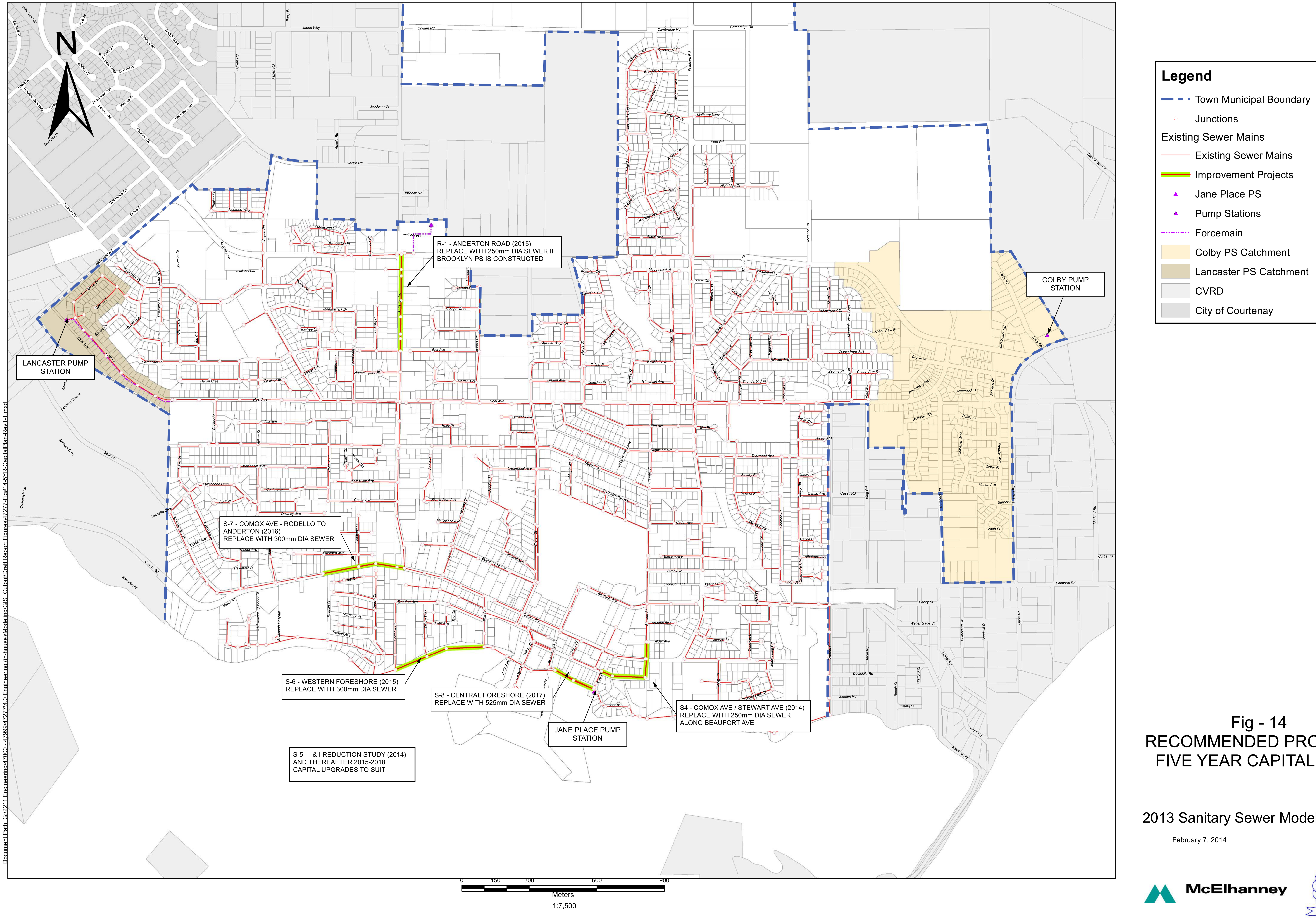


Fig - 14
RECOMMENDED PROJECTS FIVE YEAR CAPITAL PLAN

2013 Sanitary Sewer Model Update

February 7, 2014 Revision 1

McElhanney

TOWN OF COMOX