Comox Valley REGIONAL DISTRICT

Staff Report

DATE: February 19, 2021

FILE: 5330-20/CVSS LWMP

TO: Chair and Members
Sewage Commission

FROM: Russell Dyson
Chief Administrative Officer

Supported by Russell Dyson
Chief Administrative Officer

R. Dyson

RE: Sewer System Conveyance Project – Implementation Decisions

Purpose

To confirm the preferred Liquid Waste Management Plan (LWMP) conveyance option and public assent process to be used to authorize long term debt for the Sewage System Conveyance Project.

Recommendations from the Chief Administrative Officer:

1. THAT the preferred conveyance option for the Comox Valley Sewer System, as developed through the Liquid Waste Management Plan (LWMP), be determined as the tunnel forcemain (Option 2), which includes a combination of trenching and tunneling from the Courtenay and Jane Place Pump Stations to the treatment plant and related equipment;

   AND FURTHER THAT the conveyance component of the LWMP be advanced separate from the LWMP to more quickly mitigate the environmental risk of the current conveyance line that is located along Willemar Bluffs;

   AND FURTHER THAT the public approval required for funding the conveyance project be obtained through an Alternative Approval Process;

   AND FINALLY THAT staff report back with a proposed Sewage System Conveyance Project implementation strategy, including project delivery method, project schedule and Alternative Approval Process logistics to the March 9, 2021 sewage commission meeting.

2. THAT the Sewage System Conveyance Project funding strategy include $21 million of reserve funds and $52 million of debt financing over a 30 year repayment term;

   AND FURTHER THAT this funding model is endorsed and incorporated into the Comox Valley Sewerage Service, functions 335-338 financial plan, to be brought forward for review and approval to the March 9, 2021 sewage commission meeting.

3. THAT the Comox Valley Sewage Commission pursue all opportunities available to receive funding from any and all infrastructure grants, including authority for commission members and staff to meet with ministers and Treasury Board members to deliver the conveyance project.

Executive Summary

- The Comox Valley Regional District (CVRD) began conducting a LWMP process in June 2018 to:
    - Resolve an at-risk portion of the conveyance currently located along Balmoral Beach below the Willemar Bluffs and find the optimal long-term solution for managing sewer flows from Courtenay, Comox, the K'ómoks First Nation and CFB Comox to the Comox Valley Water Pollution Control Center (CVWPCC);
    - Select the desired level of treatment at the CVWPCC; and
    - Explore further opportunities for resource recovery from Comox Valley Sewerage Service (CVSS) operations.
- Following extensive technical assessment and public engagement and guided by the Technical and Public Advisory Committees (TACPAC), staff recommend selection of Option 2 (tunnel forcemain), as the preferred conveyance option.
- Appendix B shows the approximate alignment of the new conveyance line. The final alignment will be confirmed through detailed design, – with any changes driven to minimize impacts on residents and businesses, archeologically and environmentally sensitive areas and financial efficiency.
- The updated total estimated capital cost for conveyance Option 2 is $73 million, of which approximately $21 million will be funded by reserves, and $52 million in long term debt. The debt repayment term is proposed at 30 years in recognition that a mix of reserves and debt funding ensures that both current and future ratepayers fund this significant investment that is integral to the Comox Valley regional sewer system and will provide service for an estimated 80 years.
- Requisition fees are expected to increase an average 5.5 per cent annually over the five year financial plan as previously communicated to the member municipalities. The majority of this service's revenues and any requisition increase to the City of Courtenay and Town of Comox is passed onto the ratepayers through municipal user fee bylaws. A moderate requisition increase ensures funding availability for other core upgrades in the sewerage system and local municipality systems.
- The total cost implications to the average sewer service property owner has been determined in partnership with the member municipalities and is anticipated to be $150 per household. This is compared to the fall 2020 LWMP public consultation process of $210 per household which included a $58 million cost funded solely by borrowing, and over a 20 year debt repayment term.
- Given the urgency to resolve the environmental risk along Willemar Bluffs, staff are recommending that borrowing for the conveyance project be authorized by an Alternative Approval Process (AAP) rather than waiting for the authorization provided by the approved LWMP, which is not expected for approximately two years.
- Should the recommended conveyance option be supported, staff will bring forward an implementation strategy to the March 9, 2021 Comox Valley Sewage Commission meeting for review and approval, addressing the following:
    - Funding model for the preferred conveyance option;
    - Project delivery method and project schedule; and
    - AAP logistics.

Due to the large amount of information necessary to support the recommendations presented above, some topics have an accompanying appendix with additional schedules to further support the topic. Please reference the attachments section at the end of this document for a full summary of appendices and schedules.

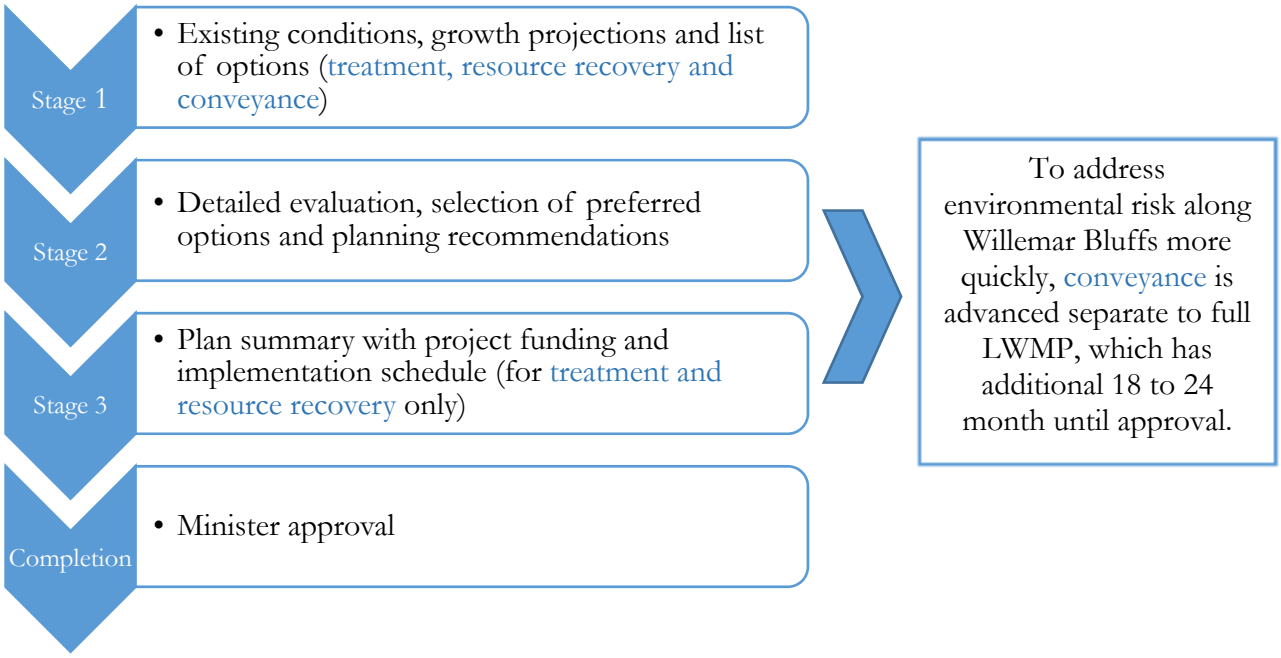
Prepared by:	Concurrence:	Concurrence:
K. La Rose	***J. Warren***	***M. Rutten***
Kris La Rose, P. Eng Senior Manager of Water/Wastewater Services	James Warren Deputy Chief Administrative Officer	Marc Rutten, P. Eng General Manager of Engineering Services

Government Partners and Stakeholder Distribution (Upon Agenda Publication)

City of Courtenay	✔
Town of Comox	✔
K'ómoks First Nation	✔
Ministry of Environment	✔

Background and Current Status

- The CVRD initiated an LWMP process in June 2018 to investigate and develop solutions for sewer conveyance (the pumps and sewer lines that move sewage to the treatment plant), treatment (specific to upgrades and/or changes at the CVWPCC on Brent Road) and resource recovery (innovative solutions appropriate to the CVSS).
- One of the primary objectives for the LWMP is to address the environmental risk of the current conveyance line in the intertidal zone along the Willemar Bluffs.
- The CVRD and the K'ómoks First Nation (KFN), a valued partner of the regional district, have recently approved a sewer Community Benefits Agreement (CBA) that addresses the impact of past and future sewer infrastructure crossing Indian Reserve No. 1. The agreement also commits the Comox Valley Sewage Commission to receiving wastewater from KFN lands south of Royston to help support the nation in building capacity towards independent government and future economic stability, resolve the longstanding issues of failing septic systems in Royston and Union Bay and protect the aquaculture industry.
- Services to the south will provide a long term benefit to the CV sewage service as the system has the capacity to accept waste without compromise to the current participants and new connections will help service the debt and pay for this work.
- The LWMP process includes establishment of the TACPAC to help guide the planning process as well as assessing in detail the various components of treatment, resource recovery and conveyance.
- Following the recommendations from the TACPAC, in December 2020 the Comox Valley Sewage Commission resolved to include in the LWMP secondary treatment with disinfection of all wastewater flows at the CVWPCC, incorporating into the design the ability for future implementation of filtration if and when required. No further opportunities for resource recovery were identified, with the exception of increased reclaimed water use at the CVWPCC which will be further studied through a subsequent master planning process for that facility.



Conveyance Option Selection and Next Steps for LWMP Process (Appendix A)

- After a multi-year process including setting goals, development of a long list of possible conveyance solutions, using the goals to evaluate first the long list and then subsequent shortlist of conveyance options, and considering public feedback from surveys and open houses, at their October 20, 2020 meeting the TACPAC eliminated Option 1 (overland forcemain), and concluded that Option 2 (tunnel forcemain) and 3 (phased tunnel forcemain) were tied.
- Attached as Appendix A is a detailed summary of the TACPAC evaluation process and commentary the TACPAC has provided for the Comox Valley Sewage Commission to consider when making their decision. Additional information, background reports and technical documentation is available on the project website at www.comoxvalleyrd.ca/lwmp.
- Following completion of the TACPAC evaluation, and as directed by the Comox Valley Sewage Commission at their November 17, 2020 meeting, in early December staff undertook a value engineering workshop with an external panel of engineering experts from across North America for the complex conveyance project. Assessment of the outcome of that process is ongoing, but one strong conclusion to date is that continued use of the section of forcemain between the Courtenay Pump Station and Comox required for Option 3, phased tunnel forcemain, is no longer considered viable:
    - This type of pipe is prone to corrosion and not recommended for use in sewer conveyance, and is known to fail catastrophically rather than through small leaks.
    - Continued use through implementation of Option 3 would double the working pressure of the pipe, compounding the risk of failure.
    - As there is no redundancy in our conveyance system, a failure of this section of pipe would leave 90 per cent of the City of Courtenay and possibly the Town of Comox without sewer service until repaired, and cause significant environmental impact to the estuary.
- Given the outcome of the TACPAC evaluation, and the new understanding of the risks inherent to continued use of the foreshore forcemain, CVRD and municipal staff are recommending implementation of Option 2 (tunnel forcemain). Undertaking a full replacement of the forcemain will ensure sustainable services for this service over the short and long term, and mitigate the risk of catastrophic failures in the system.

- It is recommended that the Comox Valley Sewage Commission separate the conveyance project from the LWMP at this stage to expedite resolution of the environmental risk along Willemar Bluffs.
- Next steps for the LWMP include finalizing the Stage 2 document and submitting to the Minister for approval following the elector approval outcome this summer. The document will include the decisions on treatment and resource recovery and incorporate the conveyance project.

Project Cost and Funding Details

- The $58 million cost estimate for LWMP Option 2 communicated in the public engagement period in September and October 2020 was based entirely on work performed by our engineering consultants up to that point. Since then significant further analysis has been performed, including seismic and flood risk assessment of the Courtenay Pump Station, and the value engineering exercise referred to above.
- Also as discussed above, in the interim we have finalized a CBA with the KFN, and progressed discussions with the Town of Comox regarding their requirements for restoration of Town roads after the new conveyance pipe has been installed.
- As is appropriate for a cost estimate based on the available level of design and analysis, the project is currently carrying a 35 per cent contingency which is in between a Class C and D with standard contingency levels as some preliminary design has been undertaken to some components of this project through value engineering and geotechnical works undertaken in 2020. Staff have carefully reviewed the WSP cost estimates, and those generated by the value engineering firm SVS, and developed a synthesized CVRD conveyance project cost estimate that projects a total project cost of $73 million.
- As the project progresses through design, that contingency will be reduced, eventually ending up at approximately five per cent to be carried through construction. Until the design is complete it's not possible to predict how much, if at all, the cost estimate will come down.
- In their analysis staff have worked to ensure the cost estimate is conservative, to avoid future cost escalation, and will be working hard to deliver the project as cost effectively as possible.
- The conveyance project is not happening in isolation, and there are other significant capital expenditures on the horizon. The system has aging sewer conveyance, treatment centre, and outfall infrastructure with required replacements and upgrades over the next ten to fifteen years. This has been considered in building a solid financing strategy for both the conveyance project and overall funding strategy for the regional sewer system capital plan to ensure funding is available to complete necessary upgrades to maintain service levels, but also ensuring the impact to the ratepayers is palatable and stable. With this analysis it is expected requisition fees for this service will increase an average of 5.5 per cent annually for the next five years and then stabilize to a more inflationary increase over the longer term as major infrastructure upgrades are completed. Debt financing allows the smoothing out of requisition increases and as with a household mortgage, provides affordability for major infrastructure investments with long service lives.

- The following table summarizes the estimated impacts on the requisition over the next five years for the recommended funding strategy as determined in partnership with key partners:

Conveyance Funding Strategy: $21M reserves, $52M debt (30 year term)	2021	2022	2023	2024	2025
Requisition	$6,800,000	$7,200,000	$7,600,000	$8,000,000	$8,400,000
Requisition % increase	6.3%	5.9%	5.6%	5.3%	5.0%

- Total borrowing - $52,000,000
- Annual debt servicing costs - $2,892,747
- Net debt interest over term - $34,782,418
- Estimated impact per house: $152

Conveyance Project Design and Schedule

- To satisfy CVRD due diligence and support the process to date significant analysis and assessment has been completed. However, given the size and complexity of the project this amounts to concept level design – with the exception of preliminary design work completed for some of the pipe alignment through the Town of Comox.
- Should the Comox Valley Sewage Commission support the recommendation to implement Option 2 (tunneled forcemain), staff will report back to the next Comox Valley Sewage Commission meeting with the recommended project delivery method, which will determine the type of engineering support role required for the project moving forward.
- Regardless of project delivery method selected for the project, a strong focus will be placed on groundwater monitoring and protection, and mitigating any environmental and cultural heritage impacts from the project. The following high level schedule is likely to apply:
    - Second quarter 2021 – conveyance borrowing assent process
    - Second quarter 2021 – conveyance detailed design
    - First quarter 2022 – start conveyance procurement
    - Third quarter 2022 – start conveyance construction
    - Second quarter 2024 – complete conveyance construction

Public Assent (Appendix C)

- The LWMP process is a robust community consultative approach regulated by the province to consider social, technical, economic and environmental factors and identify solutions for sewer servicing. The robust consultative process inherent to a Ministry approved LWMP enables local government to implement the solutions, which can be very costly and impactful, without obtaining specific additional electoral assent; however, obtaining Ministry approval for an LWMP will take an additional 18 to 24 months.
- Due to the length of time involved before an LWMP is approved and the ongoing environmental risk associated with the conveyance line along the Willemar Bluffs, staff are recommending that the Comox Valley Sewage Commission advance the conveyance project separate from the LWMP and achieve elector approval for borrowing through an alternate approval process.
- Advancing the conveyance project separate from the LWMP means that elector approval is required before the CVRD can adopt a loan authorization bylaw. Options include:
    1) AAP: follows the extensive public engagement efforts for the LWMP process to date, building on information shared through fall 2020 consultation events, an AAP is the most cost effective process; suitable for infrastructure projects that have a high degree of social, health or environmental benefit and to resolve significant environmental risks. Additionally, moving forward on the conveyance portion of the

sewerage system upgrades ensures the project team can transition to the next phases of the necessary upgrades over the next few years including treatment plant and outfall upgrades to ensure sustainable service delivery of core infrastructure to the region.

2) Referendum: typically connected to an election because of costs and extensive requirements to conduct a referendum; often used for contentious projects with high community impacts and on more discretionary projects such as recreation centres.
3) Although an approved LWMP enables borrowing and service delivery; the urgent need to resolve the environmental risk suggests that waiting for an approved LWMP is undesirable.

- As noted above in the design section of this report, work to refine the project costs is required before establishing a final amount. A report will be presented at the March 9, 2021 Comox Valley Sewage Commission meeting that confirms the budget and schedule and initiates the AAP. The conveyance AAP would be conducted in conjunction through May and June, aligned with other CVRD approval processes.

Public Engagement – Consultation and Communications (Appendix D)

- Phase 4 of a five-phase public engagement program for the LWMP concluded in November 2020 and incorporates feedback from residents and business owners regarding conveyance options (summary report is included in Appendix D).
- The results of this outreach phase included a survey completed by 320 people, and approximately 250 comments and questions submitted. Digital ads resulted in 1,018 clicks and reached over 44,000 people, primarily through mobile devices.
- The survey results reveal that the lower risks and lower costs were seen as the top benefits for Options 1 (overland forcemain) and Option 2 (tunnel forcemain). The need to address the urgent environmental risk at Willemar Bluffs was considered a top benefit of Option 3 (phased tunnel forcemain) which was viewed as likely to be implemented more quickly. Groundwater protection was ranked as the top concern or challenge for all three options.
- The extensive engagement undertaken throughout the LWMP is a strong basis for proceeding with elector approval in spring 2021 as community awareness about the project is high.

Attachments: Appendix A – LWMP TACPAC conveyance evaluation process
Appendix B – Preferred conveyance option map
Appendix C – Elector Approval Process for Funding the Conveyance Project
Appendix D – Public Engagement (Consultation and Communication) for LWMP and Conveyance Project

Developing the Evaluation Process

The first three meetings of the joint Technical Advisory Committee and Public Advisory Committee (TACPAC) were focused on developing a multi criteria evaluation system that would be used for ranking and selection of long and short list options. This was a series of collaborative goal setting sessions and public engagement and feedback, to arrive at set of weighted evaluation criteria for each of the three Liquid Waste Management Plan (LWMP) components (conveyance, treatment and resource recovery), as summarized in Table No. 1.

Table No. 1: Summary of Evaluation Weightings for Goal Categories

Category	Conveyance	Treatment	Resource Recovery
Technical	45%	30%	25%
Affordability	18%	30%	50%
Local Economic Benefit	2%	0%	5%
Environmental Benefit	18%	25%	15%
Social Benefit	17%	15%	5%
Total	**100%**	**100%**	**100%**

The different category weightings for the different components reflects the TACPAC's views and the results of the public consultation. For conveyance, the emphasis was clearly on a robust technical solution. The evaluation system was approved by the Comox Valley Sewage Commission (CVSC) at the February 25, 2019 meeting.

Developing the Long List

The long list of conveyance options was initially developed through a series of workshop meetings between Comox Valley Regional District (CVRD) staff and CVRD's technical consultant, WSP, and then presented to the TACPAC at the January 24, 2019 meeting. The initial list had six different options, and some sub-variants were developed to create a list of ten options that were taken to the public for feedback.

The public feedback was considered at the February 8, 2019 meeting and a decision was made to drop one of the options, as WSP deemed it to be not technically feasible. This left a long list of nine options that the TACPAC recommended to the CVSC for consideration:

- 1A Estuary pipe, new inline pump station with tunnel through Lazo Hill
- 1B Estuary pipe, new inline pump station with forcemain over Lazo Hill
- 1C Estuary with high pressure Courtenay and Comox Pump Stations
- 2A Overland forcemain with high pressure Courtenay and Comox Pump Stations
- 2B Overland forcemain with new inline pump station
- 3A Overland forcemain with forcemain tunnel through Comox and Lazo Hills
- 3B Overland forcemain with forcemain tunnel through Lazo Hill
- 3C Overland forcemain with gravity tunnel through Lazo Hill
- 4A Northside overland forcemain option (Noel ave)
- 4B Northside via Greenwood and Hudson trunk mains and CFB Pump Stations
- 5 Decentralised Treatment (second wastewater treatment plant)

At the March 12, 2019 meeting the CVSC approved the long lists of conveyance options for conceptual study.

Selection of the Short List

Following approval of the long list, WSP completed a conceptual study of the long list conveyance options for evaluation by the TACPAC to determine the short list of options for further study. The WSP analysis was circulated to the TACPAC and:

- Technical criteria were evaluated at the March 21, 2019 TAC meeting.
- Financial criteria were evaluated by the CVRD staff, and presented at the March 22, 2019 TACPAC meeting.
- Environmental and social criteria were evaluated by the TACPAC at their March 22, 2019 meeting.

The evaluation resulted in the three tunneling concepts (3A, B, C) scoring the highest, and very close to each other. In discussion at the TACPAC it was felt that to advance only the tunneling options and no other was effectively a decision on a preferred option, since the three tunnelling concepts are so similar to each other. On further discussion at the March 22, 2019 TACPAC, it was decided to group the tunneling options as one optimal tunneling option. This would then be compared to the next two highest ranked non-tunneling options.

Thus, the final shortlist of options recommended by the TACPAC for detailed study were:

- 2A – Overland Forcemain;
- 3 – Optimal Tunneling Concept; and
- 4A – North side Forcemain Concept.

Throughout the remainder of 2019 and early 2020 there were extensive discussions with the K'ómoks First Nation (KFN) about these options, as each would require crossing of Indian Reserve No. 1 (IR1) along the ministry road right of way.

In parallel with consultation with the KFN was further technical development of the three options. This further analysis confirmed that Option 4A, the north side forcemain concept, was significantly inferior to the other options on both technical and economic grounds, because of the very high pumping pressures and longer distances involved. After confirming the viability of crossing IR1 with KFN, Option 4A was dropped from further study.

Simultaneously, a phased implementation variant of Option 3 (optimal tunneling concept) was developed.

The final short list approved by the CVSC on March 10, 2020, to be studied in detail by WSP were:

- Option 1: conventional overland forcemain (previously Option 2A);
- Option 2: optimal tunnelling concept (previously Option 3); and
- Option 3: optimal tunneling concept (Option 2) implemented in two phases.

Detailed Study of the Short List

After confirmation of the short list by the CVSC at the March 10, 2020 meeting, WSP proceeded with the detailed study of the short list of options. A copy of this study is provided as Schedule A.1.

The optimal tunneling concept was to be the best of the three tunnelling variants from the long list:

- 3A forcemain with two tunneled sections through Comox Hill and Lazo Hill;
- 3B forcemain with one tunneled section through Lazo Hill;
- 3C forcemain from Courtenay Pump Station to central Comox then a gravity tunnel through Lazo Hill.

Further study of the tunneling techniques confirmed that the gravity tunnel option would require precise but expensive micro-tunneling, whereas the forcemain tunnels could be accomplished with the more economical horizontal directional drilling (HDD) method. While the gravity tunnel concept offered lower pumping head and the ability to intercept part of the Jane Place catchment area, it could not overcome the significant cost disadvantage compared to the forcemain/HDD options.

Comparing the two forcemain options, it was determined that the benefits of the lower pumping head achieved by the two-tunnel option more than offset the additional cost of the second HDD section (through Comox hill). Thus the optimal tunneling option became the forcemain with two HDD sections. HDD is not a true "tunnelling" method, and is more accurately called a "trenchless" method, and so Options 2 and 3 are renamed to optimal trenchless concept.

The final iteration of the study of the trenchless options revealed that the best way for the forcemain to cross Lazo Marsh to the CVWPCC is by a third, short HDD section, to go under the marsh. This finding also applied to Option 1, the cut and cover forcemain, so ultimately, all three options incorporate some amount of trenchless (HDD) installation.

Consultation was planned for April and May 2020, with selection of the preferred conveyance option by the CVSC intended for June 2020. Given that public engagement is a cornerstone of the LWMP process and in March 2020 traditional engagement was not possible due to the COVID-19 pandemic, the consultation process and subsequent selection of the preferred conveyance solution was delayed until fall 2020.

With the additional time provided by the COVID-19 related delay, WSP completed further due diligence for the proposed short list of conveyance options, including hydraulic, structural, geotechnical and hydrogeological assessments.

The additional work completed by WSP helped eliminate possible red flags associated with the shortlisted conveyance options and will inform subsequent development of the detailed design for the conveyance solution. The stage two conveyance report was finalized and circulated to the TACPAC members as part of the agenda for TACPAC Meeting No. 10 and 11 and are attached as Schedules A.2, A.3 and A.4 to this report.

For each of the conveyance options presented in the short list, the study considered:

- The design flow rates for the service, considering growth and potential flow rates from the South Region;
- System hydraulics, alignment and elevation profiles;
- Existing pump station and forcemain condition and capacity, including resilience to climate change;
- Construction impacts for the various options; and
- Archaeological, environmental, geotechnical and hydrogeological considerations.

For all options, upgrades at Courtenay, Jane Place and the KFN Pump Stations are required to accommodate the increased discharge heads resultant from increasing the maximum elevation of the forcemain. Phasing for Option 1 is not feasible as the discharge pressures are nearing the design working pressure of the existing forcemain, so retaining a portion of the existing forcemain is not recommended due to increased risk of pipe failure at higher pressures.

The capital costs were presented for each option, along with the 30 and 50 year life cycle costs for each option. Costs include a 40 per cent contingency and a 60 per cent contingency for HDD, along with a 15 per cent contingency for engineering.

The major technical and financial attributes of the options are summarized below in Table No. 2.

Table No. 2: Summary of Comparison of Evaluation and Scoring for Options 2 and 3.

	Option 1	Option 2	Option 3, Ph 1	Option 3, Ph 2	Option 3, Total
Max Pumping Head @Courtenay PS (m)	63m	45m	45m	45m	45m
Largest Pipe Diameter	48"	34"	34"	34"	34"
Length of Cut and Cover (m)	8800m	6700m	2300m	4400m	6700m
Trenchless Section 1 - Lazo Marsh	300m	300m	300m	-	300m
Trenchless section 2 – Lazo Hill	-	1200m	1200m	-	1200m
Trenchless section 3 – Comox Hill	-	700m		700m	700m
Km of Existing Pipeline Remaining in Service	0	0	4600m	0	0
Capital Cost	$54.7	$51	$35.9	$17.5	$53.4
Annual Operating Cost	$457k	$358k	$361k	$358k	$358k
30 year NPV	$77.5M	$67.6M			$68.6M
50 Year NPV	$97.2M	$81.6M			$82.7M

Evaluation of the Short List of Options

The study also provided the technical consultants assessments of the benefits and risks for each option, providing considerations on the technical, environmental, economic and social benefits of each option. This information helped to inform the discussion and subsequent evaluation by the TACPAC. The final scoring for each option is summarized in Table No. 3 below.

Table No. 3: Summary of the Evaluation of the Short Listed Options

Category	Goal	Weight %	1. Cut & Cover	2. Trenchless	3. Phased Trenchless
Technical	Resilience to External Factors	15%	9.0	9.0	7.5
	Resilience to Internal Factors	15%	3.0	9.0	6.0
	Long Term Solution	10%	6.0	6.0	6.5
	Flexibility to accommodate future changes	5%	3.0	3.0	4.0
Technical Total		***45%***	***21.0***	***27.0***	***24.0***
Affordability	Minimize Lifecycle Cost	14%	7.0	9.5	12.9
	Long term Value	4%	2.4	2.4	2.7
Affordability Total		***18%***	***9.4***	***11.9***	***15.5***
Economic Benefits	Benefits to local economy	2%	1.4	1.0	0.9
Local Economic Benefit Total		***2%***	***1.4***	***1.0***	***0.9***

Environment Benefits	Minimize risk of impacts to sensitive environment	12%	6.5	6.7	5.5
	Mitigate climate change impacts (Energy and GHG's)	6%	3.6	3.5	3.6
Environmental Benefit Total	-	***18%***	***10.1***	***10.2***	***9.1***
Social Benefit	Minimize noise, odour and visual impacts in operation	10%	6.7	6.7	6.7
	Minimize community disruption during construction	3%	1.3	0.4	0.9
	Maximize community and recreational amenity value	4%	0.7	0.5	0.4
Social Benefit Total	-	***17%***	***8.7***	***7.7***	***8.1***
Grand Total	-	**100%**	**50.6**	**57.8**	**57.6**

Discussion of the Results

There were some consistent themes that emerged from the scoring. The main ones being:

- The higher pumping pressures for Option 1 are a significant operational concern, and so it is less resilient to internal factors (operational failure).
- There is significant flexibility associated with Option 3, as when the time comes to do the second phase, an alternate trenchless method and/or alignment is possible.
- The total costs for Options 2 and 3 are similar, but there is a significant near term tax burden advantage for Option 3, and the second phase cost is not only deferred, but also spread over an enlarged tax base.
- Option 1 creates more work for local contractors, as they can participate in cut and cover, but trenchless components are for specialized contractors.
- Consideration was given on the environmental considerations associated with the various options, in particular concerns surrounding the estuary and groundwater in the Lazo Hill Area/Electoral Area B. Option 3 retains the estuary pipeline to Comox for 20 years, and increases the operating pressure, which reduces the resiliency to both internal and external factors. For Options 2 and 3, the tunnel through Lazo hill was of concern relating to local groundwater. While the risk of leakage from the tunnel is low, correcting it is harder than for a cut and cover pipeline. There is also the potential risk associated with the drilling operation and drilling fluids
- The community disruption caused by the horizontal directional drilling could actually be greater than that of the cut and cover option. While the tunneled sections are not disturbed, there is significant disturbance at each end. This led to the counter intuitive result of Option 1 being the least disruptive overall.
- The only potential recreational amenity associated with any of the options is the possibility of putting cycle/recreational paths over the pipeline, and then only for the cut and cover sections. This led to all options scoring relatively low in this category, and Option 1 being the highest of them.

Selecting the Preferred Solution

In seeing the final results, there was general consensus that the results reflected the TACPAC's discussion of the options.

It was agreed by majority vote that Option 1 be removed from further consideration. This option scored lowest overall and lowest in the technical and affordability criteria and was the least desirable option.

The final evaluation results of Options 2 and 3 resulted in the options being essentially tied. There was significant discussion around the table on the merits of each option, with Option 2 providing improved technical and environmental benefits and Option 3 providing affordability benefits. In discussion, the TACPAC considered that the weightings of the criteria were completed by the TACPAC and approved by the CVSC two years ago, when the current global pandemic was not a consideration, and that higher emphasis may have been placed on economic considerations if being done at the current time. Notwithstanding, it was decided by the TACPAC that no changes to the weighting of the criteria should be made, but that it is a decision of the CVSC to consider the current economic situation in light of COVID-19 when evaluating the pros and cons of Options 2 and 3.

After significant discussion around the table, there was consensus from the group that no recommendation of a preferred conveyance solution should be made and that the merits of both Options 2 and 3 be presented to the CVSC for their decision and selection of the preferred solution. Below are the key points made by the TACPAC to help inform the CVSC decision:

- Weightings created prior to COVID-19 and consideration of cost impacts should be made by CVSC in light of the unexpected current COVID-19 situation.
- Option 3 utilizes the full lifecycle of existing assets and reflects policies within the Regional Growth Strategy.
- Phased approach allows for more flexibility in future, e.g. updating growth projections and potential for new technology consideration.
- No input from KFN at this time on Options 2 and 3; input from KFN is an important consideration in decision of preferred solution.
- Priority for decommissioning Willemar Bluffs and importance of doing so quickly.
- There are unknown costs associated with delaying part of construction, and escalation of project costs should be considered.
- Concern with challenges associated with pipe running under private property as part of HDD installation.
- The CVSC may wish to have further study on the technical and environmental aspects of the phased approach. There is some environmental risk associated with the phased approach for both the Marina Park tie-in, and keeping the existing estuary pipeline in operation, at higher pressure, for another to decades. While the TACPAC made best efforts at meaningful scoring on these two issues, further technical study will refine the decision making on these questions.

Analysis/Options

The selection of preferred conveyance solution as outlined in this report is the result of the intentional process of first setting the goals, then developing the options and using the goals to evaluate the options. Through the course of this process a global pandemic has occurred, resulting in discussion and consideration on the appropriateness of the weighting of the goals and criteria that were originally conceived of for evaluation of the options. With this in mind, the TACPAC has determined that both Options 2 and 3 provide unique advantages but that the ultimate decision of the preferred implementation strategy be determined by the CVSC.

Given that most of the technical aspects of Options 2 and 3 are very similar, the only further work that could be done to refine the decision making would be further study of the phase specific components – operating the remaining section of estuary pipeline at a slightly higher pressure, and the Marina Park tie-in.

If the CVSC prefers Option 1, then this suggests that something has been either missed in the evaluation process, or that the CVSC is making the change based on other factors. If this is the case then the CVSC is requested to clearly identify any areas for reconsideration, and the reasons for doing so, for communication back to the TACPAC.

Financial Factors

The importance of minimizing the financial burden of additional sewer infrastructure on the community has been a priority during the LWMP process and was a topic of great discussion and weighed heavily on the decision by the TACPAC.

An analysis into the cost per connection impacts for users was completed, the main assumptions used to develop the cost per connection estimate are summarized below:

1. All capital costs will be recovered from existing users; growth was not considered in developing the cost per connection analysis. If the valley continues to grow the number of connections will grow and will help to lessen the cost per connection impacts, but the analysis below represents the cost impacts for users for year one.
2. The entire project will be funded by borrowing, no reserve or development cost charge contributions are assumed.
3. Operating costs will borne by the existing connected users in any given year.

Presented in Table No. 2 below is the estimated cost per connection for each option.

Table No. 2: Estimated Cost Impact for Single Family Residential Dwelling

Component	Option 1	Option 2	Option 3*
Capital Cost	$65M	$58M	$43M
Cost to Run and Maintain (30-year)	$17M	$13M	$13
Cost Per Connection Increase	**$240**	**$210**	**$160**

* Phase 2 capital cost to be implemented in 15-20 years is anticipated to be $18M

Regional Growth Strategy Implications

Throughout the process the idea was to have the options achieve as many of the goals within the Regional Growth Strategy (RGS) and Sustainability Strategy as possible, including affordability. Both Options 2 and 3 represent the implementation of the goals and evaluation system as related to conveyance, however for some of the below listed goals one of the two contemplated options better meets the intent of the goal.

RGS Goals

Goal 2. Ecosystems, natural areas and parks: Protect, steward and enhance the natural environment and ecological connections and systems.

Goal 5. Infrastructure: Provide affordable, effective and efficient services and infrastructure that conserves land, water and energy resources.

Goal 8. Climate change: Minimize regional greenhouse gas emissions and plan for adaptation.

RGS Objectives

5-D. Encourage sewage management approaches and technologies that respond to public health needs and maximize existing infrastructure.

5D-2. New development will replace and/or upgrade aging sewer infrastructure or provide cash-in-lieu contributions for such upgrades through Development Cost Charges or similar financial contributions.

Sustainability Strategy Implications

As part of the development of the goals for the three components, comparisons were made to the Comox Valley Sustainability Strategy, which contains numerous goals directly related to wastewater and many others indirectly related (e.g. resource recovery).

Sustainability Strategy 2050 Targets

Climate	80 per cent reduction in greenhouse gases from 2007 levels.
Energy	50 per cent decrease in per capita energy use and/or will not increase energy use from current levels.

Sustainability Strategy Goals & Objectives

2.2.2.	Existing local government buildings and facilities are retrofitted to achieve a 25-30 per cent improvement in energy and water efficiency.
3.5.	Liquid waste is handled to minimize negative impacts and to turn wastes into resources.
3.5.1(a).	Consider amending approach to Sewer Master Plan to make it a comprehensive LWMP that addresses all aspects of sustainable wastewater management. Ensure any update to sewer/liquid waste management plans are aligned with sustainability objectives and targets.

As with the overall intent of the strategy, these targets are to be achieved by 2050, which is at the end of the design horizon for this LWMP. However, by being aware of these aspirational targets and goals at the start of the LWMP process, appropriate emphasis can and has been placed on them.

For all attachments, please refer to the LWMP project webpage:

http://www.comoxvalleyrd.ca/lwmp

Schedule A.1 – Stage 2 Conveyance Assessment Report (WSP) Pages 8 – 126 of PDF

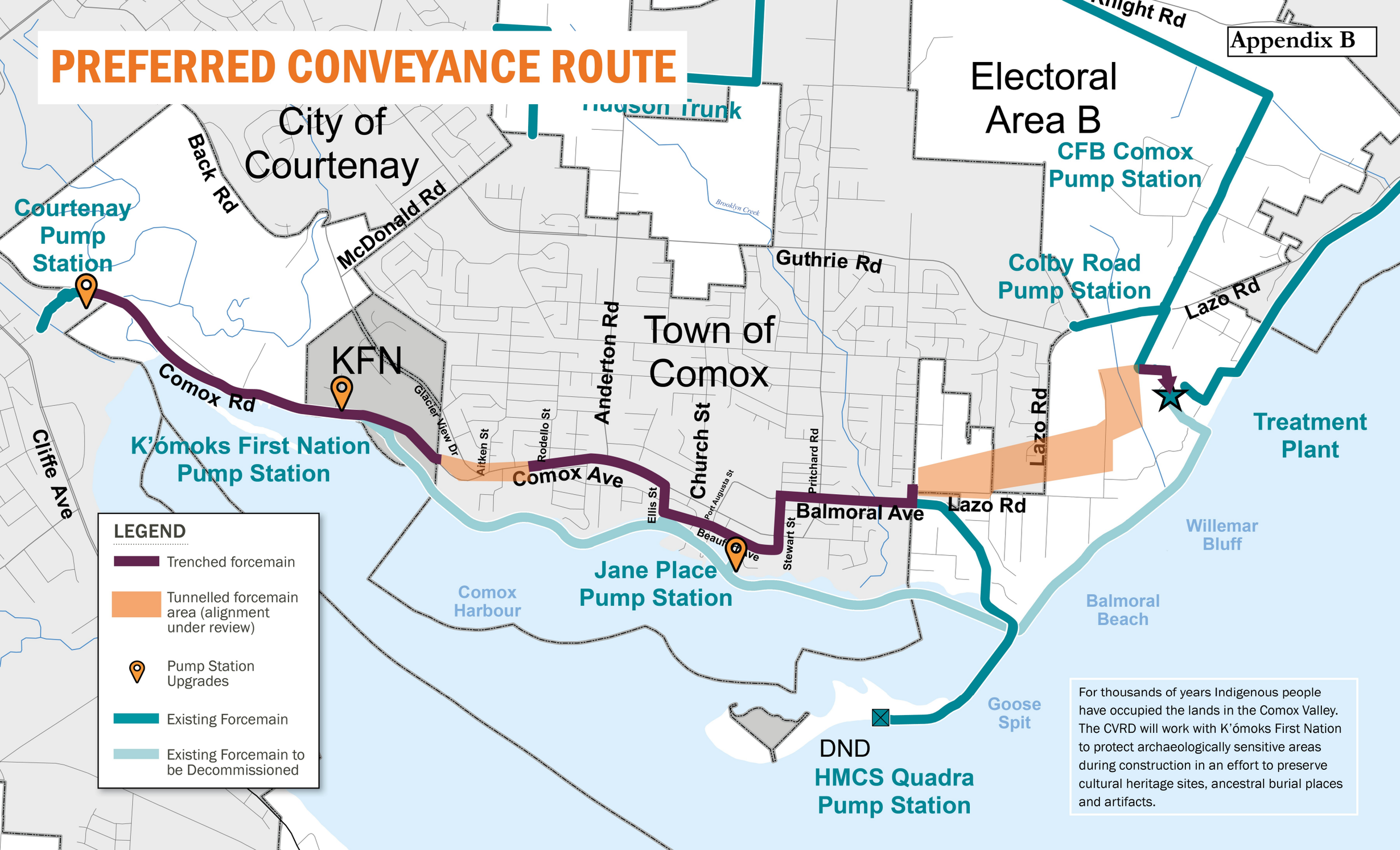
Schedule A.2 – TACPAC 10 Meeting Minutes (September 28, 2020)

Schedule A.3 – TAC 10A Meeting Minutes (October 20, 2020)

Schedule A.4 – TACPAC 11 Meeting Minutes (October 27, 2020)

Appendix B

PREFERRED CONVEYANCE ROUTE



For thousands of years Indigenous people have occupied the lands in the Comox Valley. The CVRD will work with K'ómoks First Nation to protect archaeologically sensitive areas during construction in an effort to preserve cultural heritage sites, ancestral burial places and artifacts.

Appendix C – Elector Approval Process for Funding the Conveyance Project

Elector approval is required for certain regional district projects, such as establishing new services and borrowing funds. The Comox Valley Sewage Commission and Comox Valley Regional District (CVRD) Board may choose to use assent voting (referendum) or the alternative approval process (AAP) in the case of funding a portion of the conveyance project. A comparison of the two approaches concerning process, timing and other considerations is shown in Table No. 1 below.

Table No. 1

	Referendum	**Alternative Approval Process (AAP)**
Administration	A Chief Election Officer administers the process as a vote as set out in the *Local Government Act*.	The Corporate Legislative Officer administers a petition process as set out in the *Local Government Act*.
Cost	The CVRD estimates the cost of a referendum at between $20,000 and $30,000.	The CVRD estimates the costs of an AAP at $3,000 to $4,000
Elector Eligibility	Resident electors and non-resident property owners living within the area for which the vote or the AAP is being held in accordance with the *Local Government Act*.	
Method	• Special and advance voting days; • General voting day at voting stations; • Mail-in ballot.	• Electors have at least 30 days after the second advertised public notice to sign and submit and elector response form
Notice	• Notice must be published in a locally circulated newspaper once a week for two consecutive weeks. • Additional advertising requirements.	• Notice must be published in a locally circulated newspaper once a week for two consecutive weeks.
Timing	Approximately 16 weeks (four months) from the introduction of the bylaw to receipt of the results	Approximately 12 weeks (three months) from the introduction of the bylaw to receipt of the results
Threshold	Majority rules (50 per cent plus one).	Ten per cent of voters in the area must submit elector response forms in opposition.

Staff have spent considerable time reflecting on the importance of this project to the Comox Valley, the importance of obtaining elector approval for borrowing and elected official and public concerns relating to the AAP. Staff have also considered the substantial public education and consultation undertaken in fall 2020 to provide information about costs and construction impacts for the project and environment impacts should the current conveyance line fail.

Given all of these considerations, staff recommend that an AAP be used to obtain elector approval for the following reasons:

1. The conveyance project is critically important to the Comox Valley and relates to public health and environmental protection.
2. Treated wastewater and a protected environment are mandated by the provincial government and the public expects its wastewater to be managed appropriately; implications of not acting could bring catastrophic damage to the land, marine and coastal ecosystems including severe impacts to the economic fortunes associated with the Baynes Sound aquaculture industry and tourism in general.
3. Referendums are notoriously difficult in obtaining a high enough voter turnout to gauge the broad public opinion.
4. AAPs are a legitimate and democratic process while allowing for a full referendum should the board choose (and if ten per cent of the voters submit forms).
5. This process will be open to all eligible voters within the City of Courtenay and the Town of Comox.

Appendix D

COMOX VALLEY SEWER SERVICE
LIQUID WASTE MANAGEMENT PLANNING

Phase 4 Consultation – Summary Report

SEPTEMBER/OCTOBER 2020

Comox Valley
REGIONAL DISTRICT

comoxvalleyrd.ca

Table of Contents

Executive Summary

In March 2020, after a year of technical assessment and consultation with community partners, the Comox Valley Regional District (CVRD) launched Phase 4 of a five-phase public engagement program for the Comox Valley Sewer Service Liquid Waste Management Plan (LWMP). However, a state of emergency was issued for the province soon after and the consultation was put on hold to comply with COVID-19 public health guidelines.

On September 14, the Phase 4 consultation was again launched and continued through October 12, with follow up community consultation in the Lazo area happening in November.

The public health concerns during this period resulted in taking a slightly revised approach, which included using the following key outreach tools:

- **Online Survey and Information Hub:** ConnectCVRD was designated as the core consultation hub, with all feedback encouraged to be submitted through the online survey and feedback functions.

- **Information Sessions:** Three public open-house style events were created that allowed for reduced attendance to meet public safety protocols. Two were held in Comox and one was held in Courtenay.

- **Online Webinar:** To meet the needs of those who wanted additional information about the options and guided learning as well – but who did not feel comfortable attending an in-person event – an online webinar was created and delivered by CVRD staff with the support of technical and communications consultants.

The results of this outreach phase included a survey completed by 320 people, and approximately 250 comments and questions submitted. Digital ads resulted in 1,018 clicks and reached over 44,000 people, primarily through mobile devices.

The survey results reveal that lower risks and lower costs were seen as the top benefits for Options 1 (Overland Forcemain) and 2 (Tunnel Forcemain). The need to address the urgent environmental risk at Willemar Bluffs was considered a top benefit of Option 3 (Phased Tunnel Forcemain). Groundwater protection was ranked as the top concern or challenge for all three options.

Themes from the feedback included concerns about the potential for increased construction costs in the coming years, as well as community-specific comments from residents who had some personal apprehension about the project, including how it might impact their property or local traffic patterns. Other comments supported removing the forcemain pipe in the foreshore of the Comox estuary as quickly as possible.

While residents were not asked to 'vote' on a preferred option, they succeeded in providing valuable feedback that can be considered hand-in-hand with technical evaluations to inform the decisions about next steps.

Introduction

1.1 Project Background

The Comox Valley Sewer Service treats raw sewage (wastewater) from homes and businesses in Courtenay, Comox and K'ómoks First Nation. More than 14,000 cubic metres of wastewater from these communities flows daily through a pipe located along the Willemar Bluffs. This is an exposed section of beach that is vulnerable to damage by waves, rocks and logs and poses an environmental risk to beaches and waters throughout the Comox Estuary, Point Holmes and Goose Spit coastline, as well as Baynes Sound.

To find a solution, the Comox Valley Sewer Service decided to undertake a liquid waste management plan (LWMP) process that considers conveyance (pipes and pump stations), treatment and resource recovery. LWMPs are used by local governments in BC to develop strategies for managing sewer services. It includes the collection/review of existing information, development of options for future services, identification of a preferred option, completion of required studies and assessments and development of financial and implementation plans. The plan is ultimately submitted to the provincial government for review and consideration for approval.

1.2 LWMP Consultation Overview

The Comox Valley Sewer System LWMP process was kicked off in June 2018. The LWMP is critical to the long-term operational health of the sewer system and protection of the environment. The decisions made as part of the LWMP process will impact residents in Courtenay and Comox through increases to sewer fees and construction disruption. This impact requires continuous and dedicated engagement to allow community input about the options under consideration.

The International Association of Public Participation (IAP2) spectrum of public participation was used to define the engagement goals for this project.

Increasing level of public involvement in decision-making

INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
Provide balanced and objective information to residents.	Obtain feedback on analysis, alternatives and/or decisions from residents	Work directly with residents to address concerns	Partner with residents to develop a preferred solution	Place final decision making in the hands of residents

Engagement for the LWMP is currently in Phase 4 and includes the following objectives:

1. Provide information about the LWMP process.
2. Offer opportunities for active public involvement.

3. Clearly explain how feedback will be received and considered.
4. Create a record of engagement at the end of the process.
5. Demonstrate how engagement was considered and how input influenced final decisions.

The chart on the next page provides an outline of the consultation process, including engagement goals and tools for each of the five phases.

PHASE 1 EDUCATE/KICK-OFF (MAY-AUG. 2018)
✓COMPLETE

OBJECTIVES

INFORM: provide info about the sewer system and LWMP start

INVOLVE: connect with public to collect feedback on goals/ values in sewer planning

TOOLS

- **Project Webpage:** create dedicated pages on regional district + ConnectCVRD websites
- **Advertisements:** Promote online tool and sessions
- **Public Session #1**
- **Online Consultation Survey**

PHASE 2 KICK OFF & GOALS/OBJECTIVES (SEPT.-DEC. 2018)
✓COMPLETE

OBJECTIVES

INFORM: introduce LWMP process

COLLABORATE: work with the public advisory committee

CONSULT: collect feedback on goals and objectives

TOOLS

- **Open House #1:** including promotional and info materials
- **Public Session #2**
- **Online Consultation Survey**

PHASE 3 LONGLISTED OPTIONS (JAN-MAR. 2019)
✓COMPLETE

OBJECTIVES

COLLABORATE: PAC/TAC meetings, long list established

CONSULT: host an information session for public to review long list options, support with online consultation

TOOLS

- **Public Session #3**
- **Online Consultation Survey**

PHASE 4 SHORTLISTED OPTIONS
Sept/Oct. 2020

OBJECTIVES

COLLABORATE: PAC/TAC meetings, short list established

CONSULT: host virtual and in person opportunities for public to review short list options and rank benefits and challenges to each, using online survey

INFORM: Sewage Commission selection of shortlist of options and next steps

TOOLS

- **Public Session #4**
- **Webinar #1**
- **Online Consultation Survey**

PHASE 5 PREFERRED OPTION
Winter 2020/2021

OBJECTIVES

COLLABORATE: PAC/TAC meetings, consensus on preferred solution

INFORM: Sewage Commission signs off on preferred solution

INFORM: Present preferred solution to community and report on feedback obtained from public

TOOLS

- **Open House #2:** including promotional and info materials

Phase 4 (Conveyance Shortlist) Consultation Overview

1.3 Approach

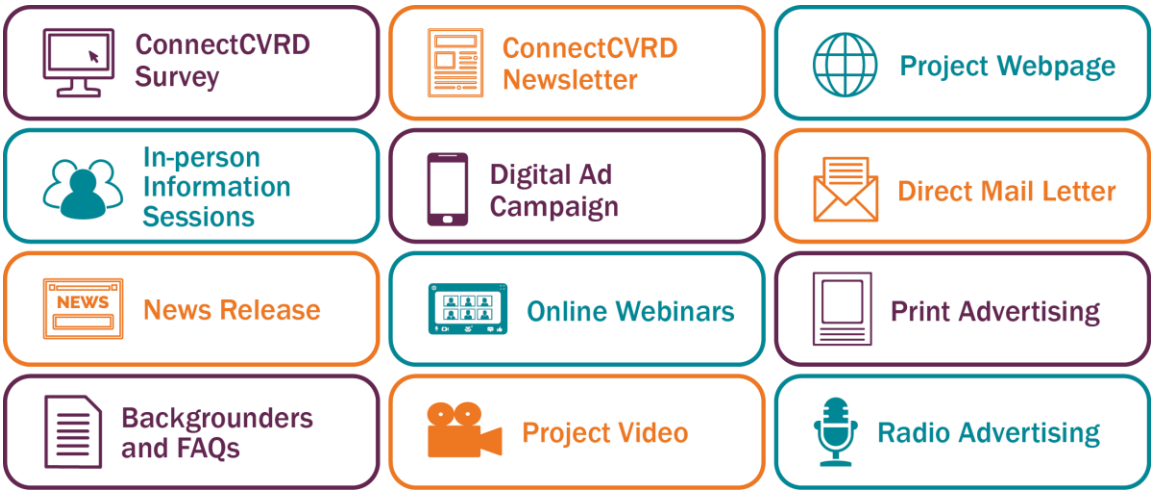
The current fourth stage of public engagement – review/assessment of the short-list conveyance options – was initially kicked off in early March 2020. It was postponed, however because of the COVID-19 public health emergency. Given the re-opening of business in British Columbia and the increasingly urgent environmental risk, the decision was made to relaunch the consultation in September 2020.

This pause allowed the consultation to incorporate subsequent assessment work by project engineers, resulting in more detailed information about traffic impacts and routing for each option, as well as revised cost estimates.

The primary objective of this consultation phase was to gauge community priorities when it came to assessing the three shortlisted options. Because of the technical nature of this assessment and the many-layered assessment that will be required to select a preferred option, participants were not asked to rank their preferred option. Instead, they were asked to provide feedback about the top benefits and risks to each option in order to inform directors, staff, the project team and public and technical advisory committees about what residents feel are the most important considerations in choosing a preferred conveyance option.

1.4 Engagement Tools

The overall success of the Phase 4 engagement was a result of the blend of tools used to promote, inform and encourage participation.



To prevent the spread of COVID-19, the consultation events were adapted to implement health and safety measures, including pre-registration for in-person events to ensure safe occupancy levels. A

Zoom webinar was offered for those uncomfortable with attending an open house in person. Both events were intended to provide more information on the options under consideration and encourage residents to submit their feedback via online surveys.

1.5 By the Numbers

The numbers below highlight key data collected at the end of the consultation.

The graph below shows a further breakdown of survey respondents by area. Participants were invited to fill out the survey without requiring a registration to the site – reducing potential barriers to participation. It should be noted that a review of the survey submissions and user data was completed to ensure there was no evidence of abuse around multiple submissions.

While this phase of the LWMP consultation had the strongest engagement, interest in the project has been building over the life of the project with more than 4,700 visitors to the project page from project launch in May 2018 through October 2020.

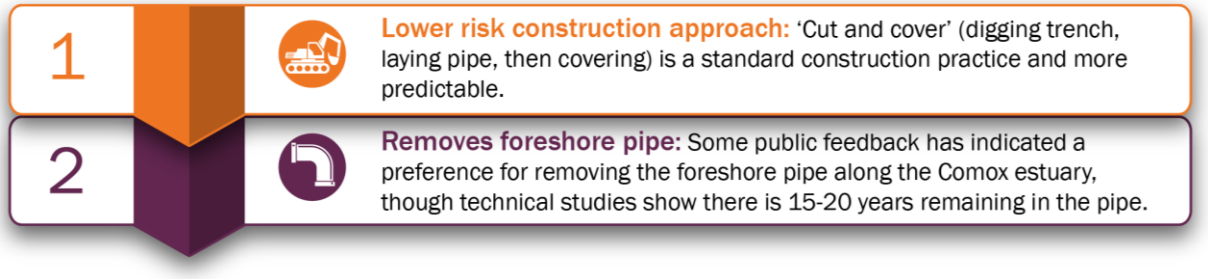
Phase 4 (Conveyance Shortlist) Consultation Results

1.6 Benefits Ranking

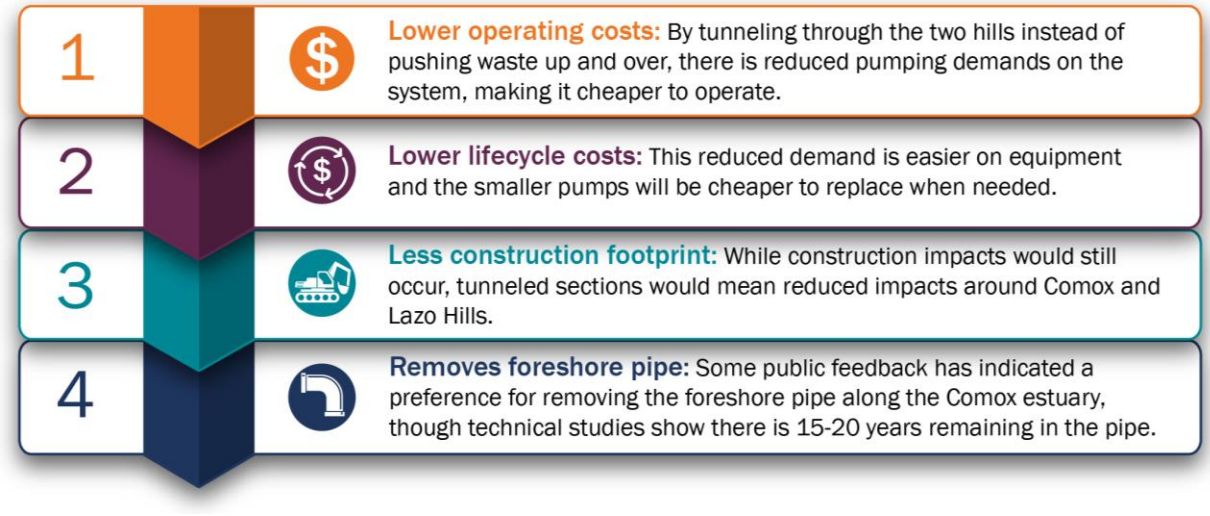
Participants in the survey were asked to rank the presented benefits for each option.

Between 264 - 272 people completed this exercise, resulting in the following rankings. Results were largely similar, regardless of the filtering applied based on where the respondent lives. Exceptions are identified below.

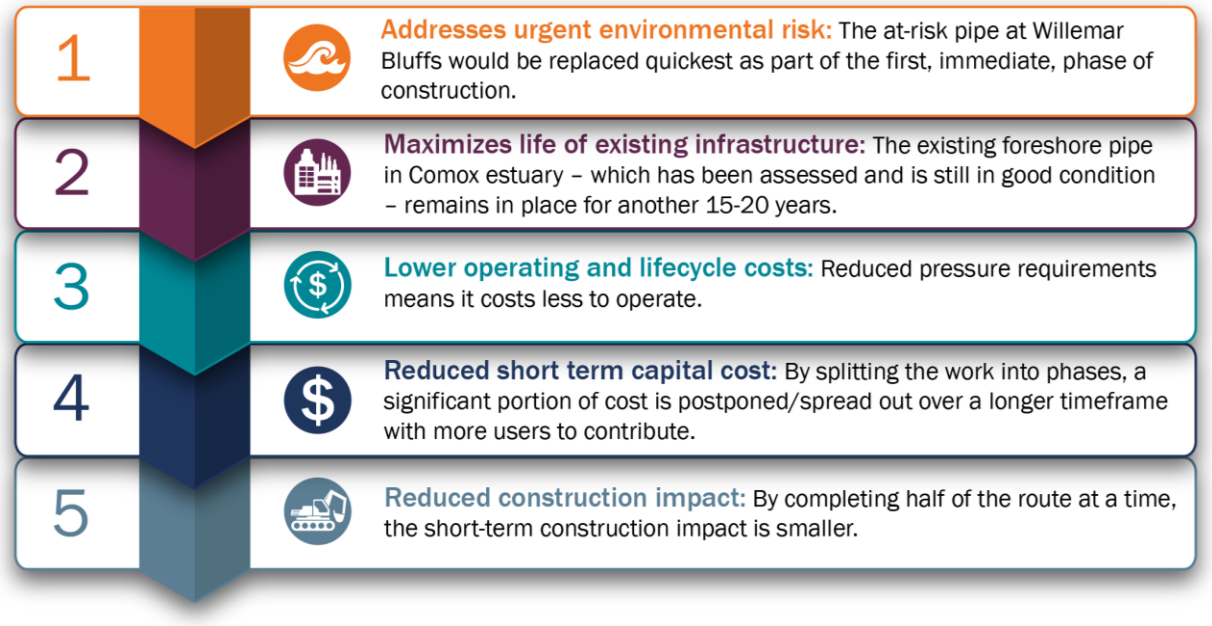
Option 1 – Benefits as Ranked by Survey Respondents



Option 2 – Benefits as Ranked by Survey Respondents



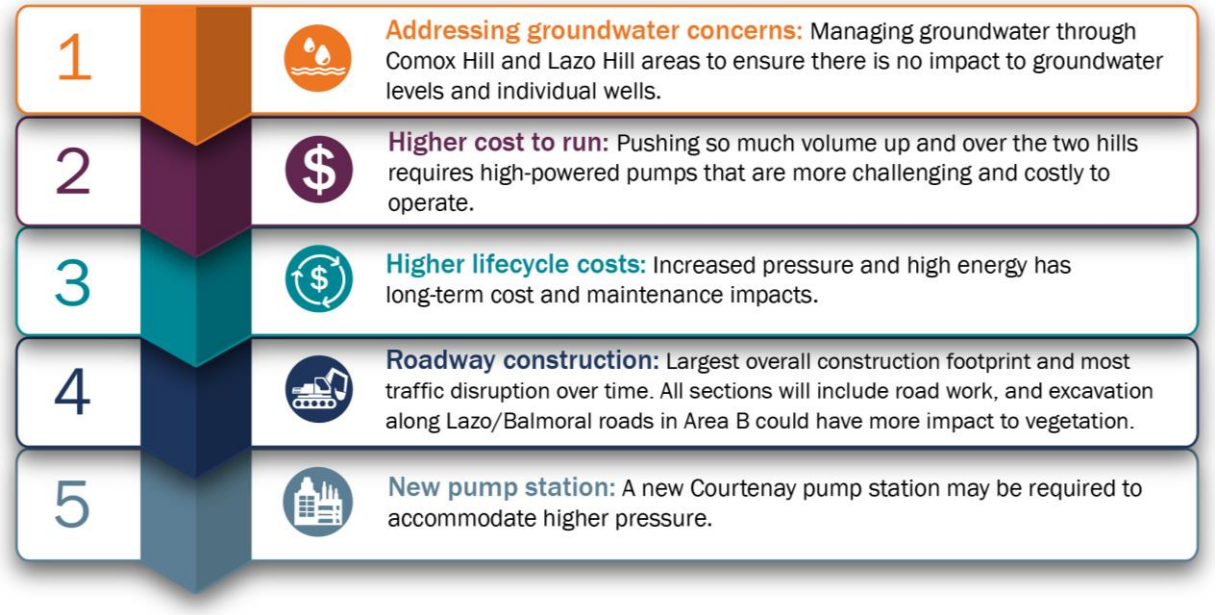
Option 3 – Benefits as Ranked by Survey Respondents



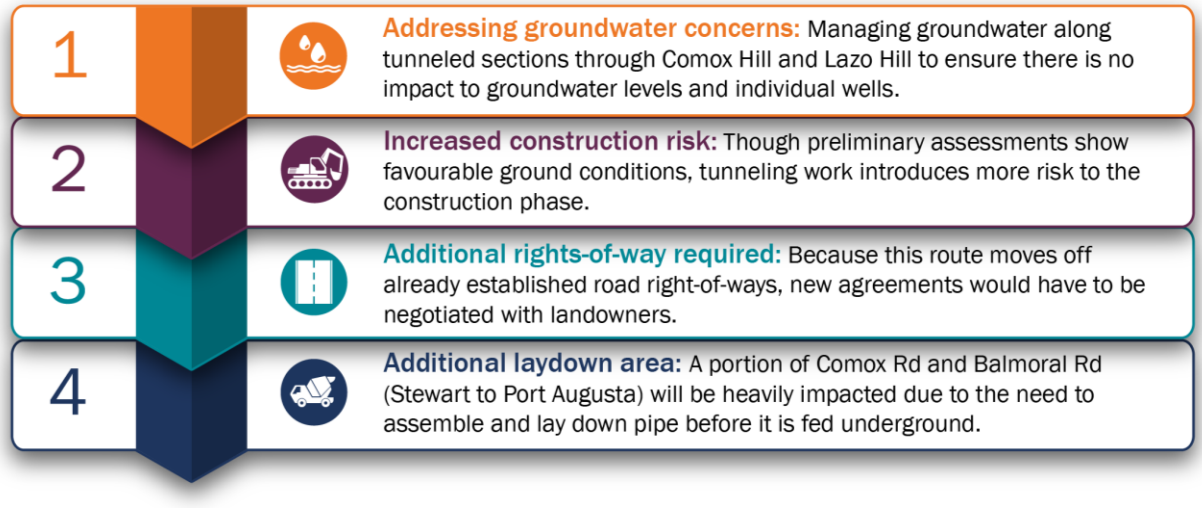
1.7 Challenges Ranking

Challenges and concerns for each option were also presented for ranking, resulting in the following prioritized list. For each of these, 272-273 people completed the ranking, and like the benefits, results were largely similar regardless of where the respondent lives. Exceptions are identified below.

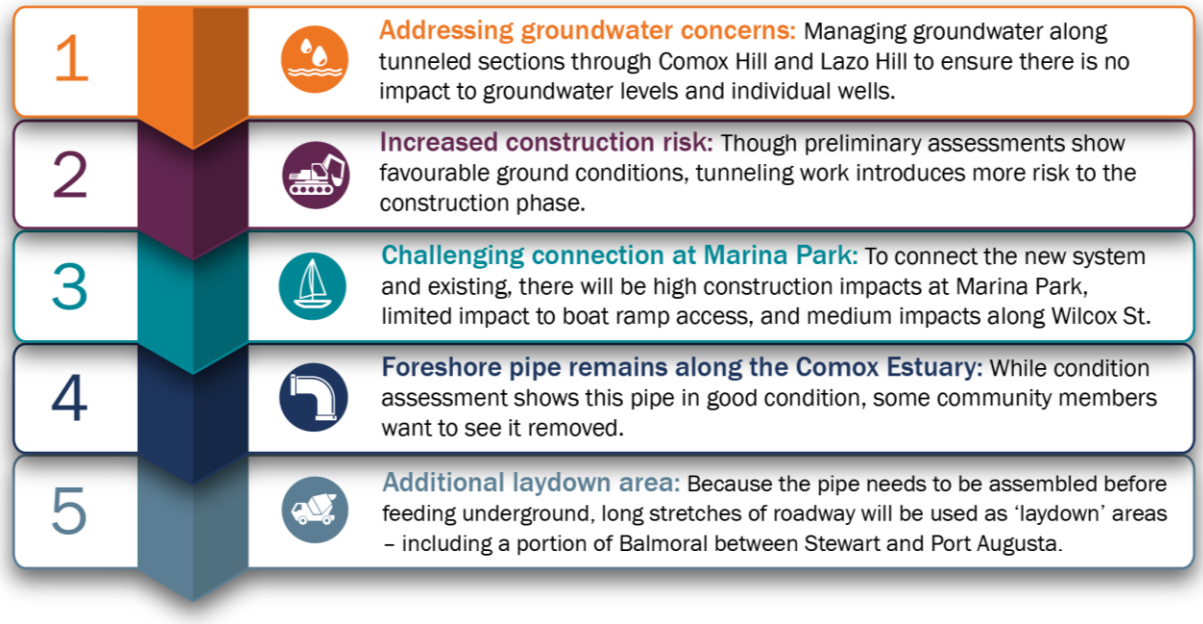
Option 1 – Challenges as Ranked by Survey Respondents



Option 2 – Challenges as Ranked by Survey Respondents



Option 3 – Challenges as Ranked by Survey Respondents



1.8 Themes of Comments

Along with the ranking, participants were asked to list further benefits, challenges or feedback that they would like the project team and sewage commission to consider as the options are assessed. On average, 44 comments were posted in each section, with 65, the most, in the first comment section. This equals about 16 per cent of those who completed the ranking questions.

These comments were wide-ranging, encompassing opinions, questions, and concerns about specific issues. The collection is valuable input for planners and decision-makers. While there were limited groupings of topics, a few clusters of comments did emerge:

Priority of foreshore pipe removal: The importance of removing both the environmental risk at the Willemar Bluffs, as well as proceeding with the removal of the estuary pipe, generated a cluster of supportive comments.

Concern about rising construction costs or unforeseen circumstances: Respondents felt the cost estimate for Option 3's Phase 2 would likely be higher and there was concern that there could be changes to regulations or priorities that prevent that phase from proceeding on time. There were some balancing comments about the value of having additional ratepayers in 20 years, and potential for new technologies then, but the concern outweighed the support when reviewing written comments.

Groundwater: The project team heard at open houses and via emails/letters that groundwater for residents in the Lazo area was a concern. This is especially important for those who rely on wells. To provide additional information, a webinar specifically on groundwater and tunneling was hosted on Nov. 5. Questions were focused on safeguards against possible breaks/leaks and methods of detection and repair. People living in the area had concerns about the impacts of right-of-ways through property in the long-term and sought additional information about alternatives that had been considered. Any questions that could not be addressed in the webinar were responded to online, with a notice going to attendees about the update.

Area-specific concerns and issues: Residents had a wide range of comments that were personal and specific to their circumstances, including the protection of important trees, protecting groundwater, preferring traffic on main roads rather than Balmoral, and Jane Place pump station construction concerns. Each of these clusters of comments were much smaller – between four and eight each – but represent good information and highlight the importance of follow up communication, particularly as the project approaches the construction phase.

Conclusion

Assessing the shortlist of options requires both critical technical evaluation as well as consideration of public input. The engagement plan was successful in drawing out the key concerns and benefits for each option so that they can be considered in relation to the technical analysis.

Environmental concerns, particularly around the protection of water (foreshore/ocean and groundwater) emerged as a top priority. Residents remain concerned about how the work will impact their specific areas – the water, trees, traffic etc. near them. Their varied comments will provide valuable considerations for the project team to consider as a preferred option is determined.

Participation in this stage was higher than any other phase of public consultation during the LWMP process, despite the COVID-19 pandemic. The direct community outreach in Comox drew a new audience and the online webinar offered a new and valuable tool that can support future engagement by the CVRD, across a wide range of regional projects and initiatives.

Next Steps

A commitment was made by the CVRD to follow up with the outcome of the consultation and decision regarding the preferred option.

- **Announce preferred option, share the consultation report and communicate next steps:** Direct outreach to residents who participated in open houses, webinars or signed up for more information about the project. The decision and the report will be posted online and a press release will be distributed to media and shared via social media for the general public.
- **Prepare for next phase of engagement**: Additional engagement is planned during the public assent period to obtain borrowing approval for the conveyance portion of the LWMP.
- **Present the plan to the public**: Open houses will be held later in 2021 to present the draft LWMP, including the proposed solution for conveyance, treatment and resource recovery to the public before it is submitted to the Ministry of Environment.

Appendices

Appendix 1 – Event Display Boards

Appendix 2 – Advertisement Samples

Appendix 3 – Digital Ad Campaign Report

Appendix 4 – Direct Mail

Appendix 5 – Groundwater Webinar – Letter, Map and Info Sheet

Appendix 6 – Online Survey

Appendix 7 – Online Survey Responses

For all appendices, please refer to the LWMP project webpage: https://www.comoxvalleyrd.ca/sites/default/files/docs/Services/sewer/20210119_lwmp_phase4_summary_appendix_final.pdf