MEMO

TO: CVRD LWMP TACPAC Committee

COPY: Kris LaRose, P.Eng.; Zoe Berkey, EIT; Paul Nash; Al Gibb, P.Eng.

FROM: Negin Tousi, EIT; Carol Campbell, P.Eng.

SUBJECT: **CVRD LWMP Stage 2 – Conveyance Options Assessment - Final**

DATE: **September 21, 2020**

FILE: **18P-00276-00**

1.0 SUMMARY OF STAGE 1 CONVEYANCE ASSESSMENT

Three installation options from the LWMP Stage 1 Conveyance Options Assessment were advanced to Stage 2. They are: 1) Option 1: Cut & Cover Forcemain Installation; and 2) Option 2: Trenchless Forcemain Installation; and 3) Option 3: Phased Trenchless Forcemain Installation.

At the March 22, 2019 TACPAC meeting, the following options were advanced to Stage 2 for further assessment:

- Option 2A: Overland Forcemain (Cut and Cover installation);
- Option 3: Optimal Tunnelling, which included:
  - Option 3A: Tunnel through Comox Road Hill and Lazo Road Hill;
  - Option 3B: Tunnel through Lazo Road Hill; and
  - Option 3C: Gravity Tunnel from Comox to CVWPCC;

These options were subsequently modified as follows:

- Option 1: Cut & Cover Forcemain Installation

  This is the "Overland Forcemain" option from the Stage 1 Assessment, which has been re-named to more appropriately describe the installation method.
- Option 2: Trenchless Forcemain Installation

  Trenchless (tunnel) options were combined into one option, called Trenchless Forcemain Installation. The trenchless conveyance concept utilizes trenchless methods to install the forcemain through Lazo Road Hill and Comox Road Hill, which will reduce the pumping requirements of the upgraded pump stations. Horizontal Directional Drilling (HDD) is the trenchless method being proposed.
- Option 3: Phased Trenchless Forcemain Installation

  This is the same as Option 2 but the forcemain would be installed in 2 phases. Phase 1, from Jane Place Pump Station to the CVWPCC, would be installed initially, and Phase 2, from Courtenay Pump Station to Jane Place Pump Station would be installed in a future phase. This would allow deferring significant capital spending to a later date.

Option 3C and other gravity trenchless options were reviewed separately (WSP Memo; October 11, 2019) and it was found that none of the gravity trenchless options were clearly preferred compared to the trenchless forcemain options for the following reasons:

- The capital cost of the gravity options were higher than the forcemain options.
- The operational cost savings for the gravity options are reduced pumping energy costs due to gravity interception; the payback period for these savings ranged between 60 years to over 100 years.
- Although the gravity options eliminated some of the surface disturbance in Comox compared to the forcemain options, a significant amount of disturbance is still to be expected for the gravity options.
- For the gravity option, the alignment must maintain slope and be close to surface at gravity interception points and tunnel section connection points, and, therefore the alignment is still dependent on ground topography.
- For the gravity option, the HGL will be similar to that of the forcemain HDD option, and, therefore, will provide no additional benefit over the forcemain option in terms of hydraulic requirements and pumping costs.

Therefore, the gravity option (Option 3C) was eliminated and only the Trenchless Forcemain Options 3A and 3B under the "Optimal Tunnelling" option were advanced to the Stage 2 assessment, along with Option 2A (cut & cover installation).

2.0 STAGE 2 CONVEYANCE ASSESSMENT OVERVIEW

The Stage 2 conveyance assessment further evaluates the preferred options advanced from the Stage 1 shortlisted options. Additional technical assessments were completed to further develop the shortlisted options and the criteria re-evaluation.

A LWMP process is a long-term planning process to allow communities to develop local wastewater management solutions. This part of the process is to develop and select a preferred conveyance option for the forcemain replacement along Willemar Bluffs together with a long-term solution for conveying wastewater to the Comox Valley Water Pollution Control Centre (CVWPCC).

Each conveyance option considers future growth, impacts on pumping head requirements, associated energy costs, required flow capacity upgrades, required pump station upgrades or replacements, archaeological and environmental considerations, climate change resilience, and geotechnical risks.

2.1 OPTIONS BOUNDARIES

The focus of this conveyance assessment is analysis of alternate conveyance concepts for the existing foreshore forcemain system. The scope of the conveyance assessments is limited to the existing sanitary conveyance systems between Courtenay, Comox, the Comox Valley Water Pollution Control Centre (CVWPCC) and to the current boundaries of the Comox Valley Sewer Service Area (CVSSA). Potential future sewage contributions from the South Region sewer project underway in Electoral Area 'A', which is currently un-serviced, have also been included in this assessment, however, this work is still pending approvals from its various partners, and a decision on a grant application made to acquire partial funding for the project is not expected until spring of 2021. Depending on the outcome of these efforts, it's possible the sizing may need to be adjusted prior to detailed design if the likelihood of south flows coming into system is decreased.

The flows conveyed through the Hudson Trunk, Greenwood Trunk, and the CFB Pump Station and associated forcemain are not included in this assessment. This conveyance network has been recently upgraded, and does not contribute to the foreshore forcemain system. Some of the flows to the foreshore forcemain system were diverted to this gravity system as a result of the upgrade. Details of the diversions are discussed in Section 3.1.

2.2 ADDITIONAL ASSESSMENTS COMPLETED

Additional desktop level assessments were completed for Stage 2, including:

1. Review of previous assessments of condition and capacity of existing infrastructure, including the forcemain, the three pumps stations, Courtenay Pump Station (CPS), Jane Place Pump Station (JPS), and K'ómox First Nation Pump Station (KFNPS);
2. Review of existing data related to anticipated sea level rise and assesment of potential impacts on conveyance infrastructure.
3. Assessment of the potential to upgrade, rather than replace the exising pump stations; construction of a new replacement station would be needed if the pump size needed can not be accommodated in the existing wet well/dry well structure at CPS and in the existing wet well structure at JPS; it may be preferred to upgrade existing stations, by installing newer, higher capacity pumps in the existing structures, and replacing aging equipment, for the following reasons:
   - Lack of available land in the vicinity of JPS to construct a replacement station;
   - Lower capital costs to upgrade rather than replace; and
   - Potential to use remaining life of structures which may be in good condition.
4. Assessment of the ability to phase upgrades; with a large amount of infrastructure to potentially be replaced or upgraded (3 pumps stations and 8,800 m of forcemain); the ability to phase upgrades will allow the CVRD to spread costs over a number of years.

The following specialist assessments were also completed:

5. Environmental: *CVRD Sanitary Forcemain – Marine and Inland Options Study*, Current Environmental, August 12, 2019.
6. Archaeological: *AOA of Comox Road from 17th St. to KFN IRI*, Baseline Archaeological Services Ltd., August 9, 2019; *Archaeological Site Summary: Comox Sewer Line, K'ómoks IR 1 to Curtis Road*, Baseline Archaeological Services Ltd., August 12, 2019.
7. Hydrogeological: *CVRD Liquid Waste Management Plan – Preliminary Hydrogeological Assessment of Tunnel Options*, GW Solutions, July 29, 2019.
8. Trenchless Installations (tunneling): *Conceptual Trenchless Design*, McMillen Jacobs Associates, October 4, 2019.

9 Geotechnical: Geotechnical Ground Investigations were completed to explore the viability of trenchless installations of sections of the proposed forcemain, including through Lazo Road Hill, Comox Road Hill and the Lazo Marsh, WSP, final reports pending.

10 Trenchless Installations: Horizontal Directional Drilling Design and Construction Assessment, WSP, final report pending.

2.3 ASSESSMENT CRITERIA

The Stage 2 conveyance options were assessed based on the additional information from the investigations completed, and an expanded list of critical factors initially identified in the Stage 1 options assessment. The expanded list of evaluation criteria is as follows:

- Hydraulics considerations;
- Condition of existing infrastructure, including remaining life and Post Disaster earthquake resilience considerations;
- Opportunity for upgrading versus replacing the pump stations;
- Opportunity for phasing;
- Flooding and climate change resilience for existing and proposed infrastructure;
- Construction risks;
- Operations and maintenance considerations including ability to isolate the system and shut down operations to undertake repairs, flexibility, and redundancy;
- K'ómoks First Nation impacts;
- Archaeological considerations such as proximity to known sites;
- Environmental considerations such as habitat impact, ecosystem impacts, and proximity to known sensitive habitat;
- Geotechnical and hydrogeological considerations;
- Public impacts such as construction disturbance and visibility of constructed works;
- Permitting requirements;
- Land and ROW acquisition requirements and considerations, property availability; and
- High-level capital and operational and maintenance costs (primarily consist of pumping energy costs).

3.0 INPUTS TO STAGE 2 CONVEYANCE ASSESSMENTS

The following sections summarize the background information for the Stage 2 assessment.

3.1 DESIGN FLOWRATES

Population projections were previously determined for the Stage 1 Assessment for the CVWPCC service area, and include the City of Courtenay, the Town of Comox, CFB, and K'ómoks First Nation (KFN) plus potential flows from the South Region.

The CVRD, with support from the City of Courtenay and Town of Comox, recently completed the construction of the Greenwood and Hudson Trunk Sewers. These new sewers will collect portions of the future sewage flows generated in the two communities. As well, approximately 20% of the current sewage flows from Courtenay have been diverted away from the CPS to the Hudson and Greenwood Trunk Sewers. Therefore, the following population projections for the Courtenay Pump Station service area are reduced by 20% of existing population.

Table 1: Projected Population for the Regional Collection System

Year	Courtenay PS Service Population[1]	Jane Place PS Service Population	Total Projected Population
2016	21,389	14,652	36,041
2020	23,366	15,580	38,946
2030	27,706	17,901	45,607
2040	32,412	20,449	52,861
2050	37,788	23,361	61,149
2060	43,930	26,687	70,617
2105[2]	84,350	45,578	132,928

[1] Accounting for 20% Diversion from Existing Population
[2] Used for sizing forcemain (80-year design life)

Based on the above population estimates, flow projections were estimated for both Courtenay Pump Station and Jane Place Pump Station.

To account for the diversion of approximately 20% of existing sewage flows from Courtenay with respect to I&I, the calculated geographical area was reduced from 1,950 ha to 1,560 ha.

Further, also due to the construction of Hudson and Greenwood Trunk Sewers, not all flows from future growth will be directed to Courtenay Pump Station and Jane Pump Station. Based on direction provided by the CVRD, it is assumed that 50% of additional future flows will be diverted to the Greenwood/Hudson system. Table 2 shows the total estimated flows to be conveyed through the foreshore forcemain system based on the above diversion assumptions.

Table 2: Projected Future Flow for the Foreshore Forcemain System, Accounting for Diversions to the Greenwood and Hudson Trunk Sewers and Contributions from the South Region

Year	Courtenay PS			Jane Place PS			Total		
	ADWF	PDWF	PWWF	ADWF	PDWF	PWWF	ADWF	PDWF	PWWF
	L/s	L/s	L/s	L/s	L/s	L/s	L/s	L/s	L/s
2016	59	138	350	41	98	209	100	236	559
2020	70	161	469	42	101	212	112	262	680
2030	79	181	488	45	108	218	124	289	707
2040	91	203	511	49	115	226	139	318	737
2050	103	228	534	53	124	234	156	351	769
2060	116	253	559	57	133	244	173	386	803
2105	193	392	700	88	193	303	281	585	1003

3.2 EXISTING FORCEMAIN REVIEW

DESCRIPTION

Currently, sewage is conveyed from CPS in a 750 mm diameter reinforced concrete cylinder pipe (Hyprescon) eastward along Comox Road and Bayside Road before routing into the foreshore. Sewage from JPS pumps directly into the common forcemain, at which point the diameter increases to 860 mm. A short section of forcemain is routed out of the foreshore in Marina Park, near the Jane Place Pump Station. The forcemain turns northward at Goose Spit by crossing Hawkins Road and continues in the foreshore along Willemar Bluffs to the CVWPCC.

CONDITION

In 2002, the Comox Valley Regional District (CVRD) discovered sections of the forcemain in the foreshore were exposed without the protective cover material due to changes in soil deposition patterns and erosion. This was confirmed by Northwest Hydraulic Consultants Ltd. (NHC) in 2003, which was again reaffirmed in a 2016 study, *Risk Analysis of CVRD Forcemain on Balmoral Beach*, NHC, 2016. The risk analysis of the forcemain along the Willemar Bluffs prepared by NHC in 2016 concluded that risk of forcemain failure exists along the beach, and estimated a minimum 24-hour response time is required to fix any major failures to the forcemain.

With much of the alignment located in the foreshore, replacing and relocating the entire forcemain is being planned for.

The CVRD engaged Pure Technologies to complete a condition assessment of the forcemain in 2017. The study concluded the following regarding the condition of the pipe:

- “Of the 1,258 pipes inspected in the CPS Force Main, no pipes had electromagnetic anomalies consistent with broken prestressing wire wraps or broken bar wraps.
- A transient pressure monitor …installed on the header of the force main at the Courtenay Pump Station… recorded an average pressure of 31.8 psi, with a maximum pressure of 68.2 psi.
- Based on the results of the AWWA C301 analysis, the pipe design for 750-mm LCP satisfied the criteria for the current design pressure and earth cover. However, the pipe design at 2- and 4-feet of earth cover and a design working pressure of 108 psi did not satisfy the AWWA C304 design criteria. The pipes created using this design are not expected to fail; rather, the pipes should be considered under-designed by the current standard… the values are within 5 percent of passing.
- Based on the results of the AWWA C303 analysis, the pipe design for the 820-mm BWP, Class 100 satisfied the criteria for the current design pressure and earth cover.
- No pipes on the CPS Force Main were identified to exceed any of the Micro Cracking, Visible Cracking, Yield, or Strength Limits based on the finite element analysis.
- … it is recommended that CVRD implement procedures to proactively manage the transmission main system via acoustic monitoring…. This information … combined with the electromagnetic inspection data …is the best available and most economical option to minimize the risk of future pipeline failure when combined with proactive rehabilitations.

- AWWA failure statistic…from the same era (1979 – 1991) as the CPS Force main, indicate that approximately 0.55% of pipe sticks are anticipated to display significant deterioration or structural weakness…"

The assessment found the pipes to be in good condition and no significant issues were found. These conclusions are based on current measured pumping pressures including transients.

Moving the forcemain to a higher elevation out of the foreshore will increase working pressures in the forcemain. With respect to the pipe's ability to operate at higher pressure ranges:

- The reinforced concrete pressure pipes in the CPS forcemain were manufactured in 1982 and rated as Class 100 (100 psi working pressure).
- The 108 psi referred to in the above conclusions is based on 68.2 psi (maximum observed pressure as stated above) plus 40 psi transient, which is normal minimum transient allowance in the AWWA C304 standard; this is a conservative assumption, as Section 21 of AWWA C304 defines working pressure as static plus hydraulic gradient; using this definition, the current working pressure of the forcemain would be 47 psi for two pumps running.
- Measured maximum pressure of 68 psi includes at least 20 psi transient allowance already.
- Pipes are rated at working pressure of 100 psi (static + pumping) and includes 40 psi surge allowance above 100 psi.

The forcemain is rated to operate up to a working pressure of 100 psi (70 m) and allows for 40 psi transients over and above 100 psi. This working pressure limitation will be a consideration with any proposed pump upgrades that will discharge into the existing forcemain.

No significant anomalies were noted in the 1,258 pipe sections inspected in the Pure Technologies condition assessment report. Continued monitoring of the pipeline condition as recommended by Pure Technologies is recommended. As an additional precaution, the variable frequency drives of the existing pumps at Courtenay Pump Station can be reviewed to see if transients can be reduced.

CAPACITY

The forcemain flow capacity is estimated to be as follows, based on a maximum velocity of 2 m/s:

- For the section from CPS to JPS, 750 mm diameter: 885 L/s
- For the section from JPS to the CVWPCC, 860 mm diameter: 1,160 L/s

These capacities are well above the projected 2060 flows in the forcemain of 559 L/s from CPS to JPS, and 803 L/s from JPS to CVWPCC.

3.3 EXISTING PUMP STATIONS REVIEW

DESCRIPTION

The Courtenay Pump Station (CPS), Jane Place Pump Station (JPS), and K'ómoks First Nation Pump Station (KFNPS) were constructed in 1982.

CPS has a wet well and dry well configuration with two service and one standby 170 HP pumps. The pump station had a significant upgrade in 1995 where the pumps, electrical and control equipment, and structure were upgraded. The pumps at this station now run on variable frequency drives (VFDs) which allows for automated control of pump speed. The elevation of the sewage in the wet well after the pumps turn off is -3.95 m.

JPS has a wet well configuration with two service and one standby 70 HP pumps. The wet well has space allocated for the installation of a fourth pump. The elevation of the sewage in the wet well after the pumps turn off is -3.4 m. The station has not undergone any major upgrades. A biobed odour control system was recently installed and the relay controls for the pump station were replaced by a programmable logic controller (PLC) to control the station's operation. Pumps are operated using across the line starters, meaning the pumps do not have variable speed controls.

The KFNPS has a wet well configuration with one duty and one standby 10 HP pumps. The elevation of the sewage in the wet well after the pumps turn off is -2.28 m.

Currently, sewage is generally conveyed at 0 m elevation with the forcemain generally located in the foreshore. The CVWPCC has an inlet invert elevation at 8 m and a high-water elevation at 12 m. The current discharge pumping head of CPS and JPS pump stations are presented in Table 3[1].

Table 3: Discharge Head for Existing Pump Stations

Operation Condition	Courtenay PS	Jane Place Ps	K'ómoks First Nation PS
One pump running, station operating alone	26 m	16 m	15 m
Two pumps running, station operating alone	33 m	18 m	21 m

CAPACITY

Both CPS and JPS are loaded beyond capacity in peak wet weather events when pumping simultaneously, as reported by operators and shown in Table 4. The table compares current and 2060 projected flows for both stations to current capacity when operating individually and simultaneously.

Table 4: Pump Stations' Capacity

	Courtenay PS	Jane Place PS
2016 PWWF, L/s	504	209
2060 Projected PWWF (assumes diversions to Greenwood/Hudson), L/s	559	244
Pumping Capacity, 2 pumps running, PS operating alone, L/s	510	340

[1] Courtenay Pump Station Upgrade Sewerage Systems Upgrading and Staging Plan, AECOM, February 2013

	Courtenay PS	Jane Place PS
Pumping Capacity, 2 pumps running, PS operating together, L/s	360	150 (increases to 201 L/s if CPS pumps are operated at low speed.)

CONDITION

In 2016, CVRD commissioned an asset renewal study for the pump stations[2], and reported the following, which applies to both CPS and JPS:

"Overall, the structural components of the CVRD pump stations assets are in a sound condition with limited signs of deterioration. However, some of the electrical and mechanical assets show significant deterioration ad/or are about to reach the end of its expected service life or in some cases far beyond its expected service life."

Immediate pump replacements were recommended based on asset life at both CPS and JPS.

In an earlier report by AECOM[3], a condition assessment reported that CPS was in good condition, consistent with its age. The pump station wet well has experienced some corrosion due to H_2S in the airspace; however, there was minimal corrosion of structural elements. JPS was reported to be in good condition consistent with its age.

The pump stations were constructed in 1982, and at that time Post Disaster seismic standards for earthquake resilience were typically not applied to wastewater pump station structures. The Post Disaster standard is required by current building codes for critical water and wastewater infrastructure, which includes sanitary pump stations. It is unlikely that the structures meet these criteria, but this will be assessed through a review of the designs by a structural engineer.

RESILIENCE TO CLIMATE CHANGE

Both stations are located near sea level, with the CPS wet well bottom at elevation -5.0 m and the top of floor slab at elevation 3.8 m. The JPS wet well bottom is at elevation -4.25 m and top of building floor slab elevation at 3.05 m. To date, flooding related to storm surges has not been reported to have occurred.

In the Comox Valley, local sea levels are projected to rise approximately one meter over the next century along its 77 km coastline[4].

The data shown in Table 5 are from the City of Courtenay's Integrated Flood Management Study[5]. The location is close to the CPS. Currently, the slab elevation at CPS is above the 200-year return flood period level but is at less than the recommended flood elevation level. JPS is below both these levels, and both stations are below the 2100 Climate Planning Flood Level. This indicates

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2 CVRD Pump Stations Asset Renewal Study, AECOM, March 2016

3 Sewerage System Upgrading Plan, AECOM, 2013

4 https://www.comoxvalleyrd.ca/services/environment/climate-change-cvrd/sea-level-rise

5 https://www.courtenay.ca/assets/Departments/Engineering/IFMS2013-Courtenay-p1-69Study.pdf

that the effects of sea level rise should be planned for and addressed through flood protection measures, or by eventually rebuilding the stations on higher ground.

Table 5: Comparison of Current Flood Construction Levels and Future Planning Flood Levels due to Sea Level Rise and Climate Change

Levels at Courtenay River at Comox Bay

CPS Slab Elevation (m-GSC)	3.80
JPS Slab Elevation (m-GSC)	3.05
Current 200-Year Return Period Flood Level (m-GSC)	3.45
Current Flood Construction Level (m-GSC)	4.05
1990 Flood Plain Level (m-GSC)	3.7
Existing Climate Flood Construction Level (m-GSC)	4.05
2100 Climate Planning Flood Level (m-GSC)	4.49
2200 Climate Planning Flood Level (m-GSC)	5.72

3.4 PUMP STATION UPGRADES VERSUS REPLACEMENT

Construction of a new replacement station will be needed if the required pump size, for additional flow capacity and increased pump head requirements, cannot be physically accommodated in the existing pump station wet well structure. Upgrading, as opposed to complete replacement, would include retaining the wet well (and dry well for CPS) physical structure and installing larger pumps, and replacing piping and valves, electrical equipment, HVAC equipment, backup power and ancillary items.

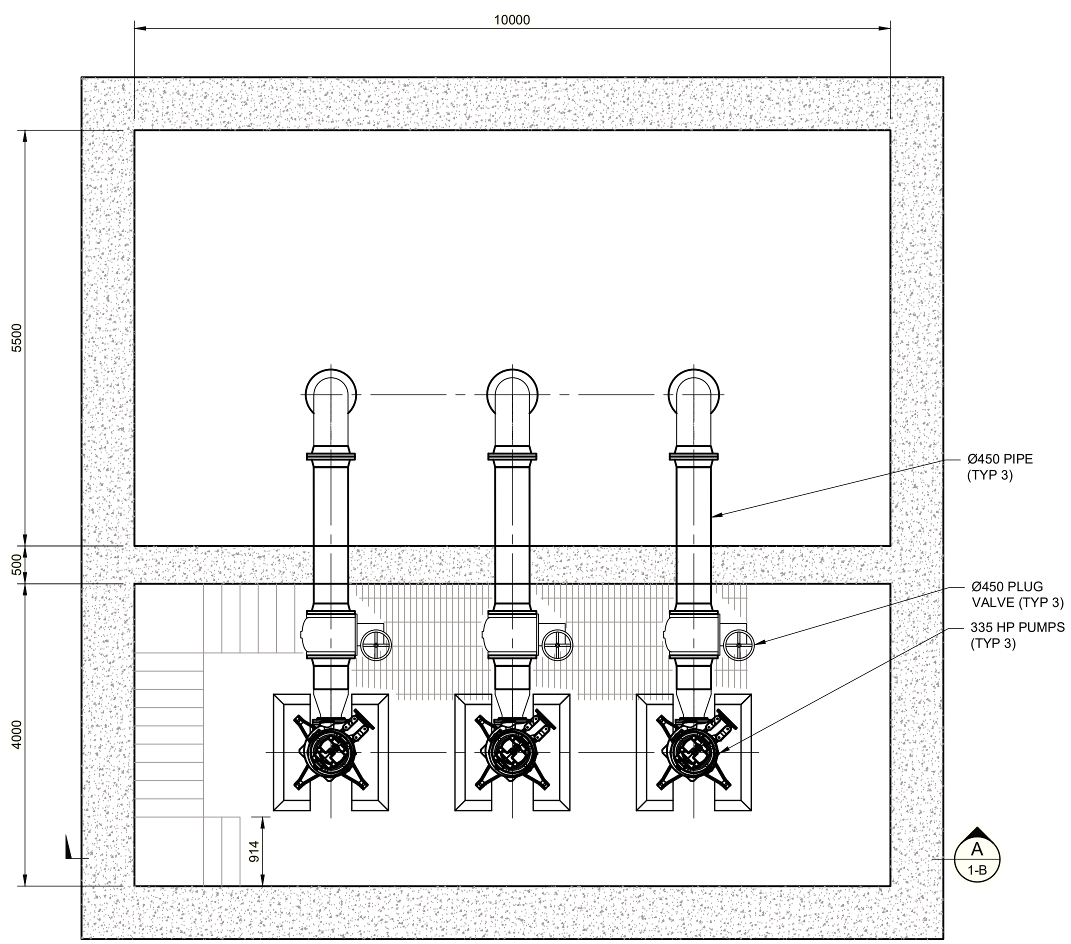
For CPS, for Option 1: Cut & Cover Forcemain (which has the highest head requirement), the following pumping requirements were assumed:

- 559 L/s (2060 projected flows with diversions to the Hudson/Greenwood system)
- 63 m TDH
- 3 pumps in a 2 + 1 standby configuration, with both duty pumps pumping at 280 L/s.

A 250 kW (335 HP) Flygt pump was identified that can meet these requirements, in a 2 duty + 1 standby configuration, and can physically fit into the existing wet well/dry well. Drawings showing the installation of the larger pumps can be found in Figures 1A and 1B. Installation of the pumps will be somewhat challenging to accommodate the larger pump size in the wet well and dry well arrangement.

For JPS, for Option 1: Cut & Cover Forcemain (which has the highest head requirement), the following pumping requirements were assumed:

- 244 L/s (2060 projected flows)
- 56 m TDH
- 4 pumps in a 3 + 1 standby configuration, with all three pumps pumping at 83 L/s.



PLAN @ SUCTION PIPING
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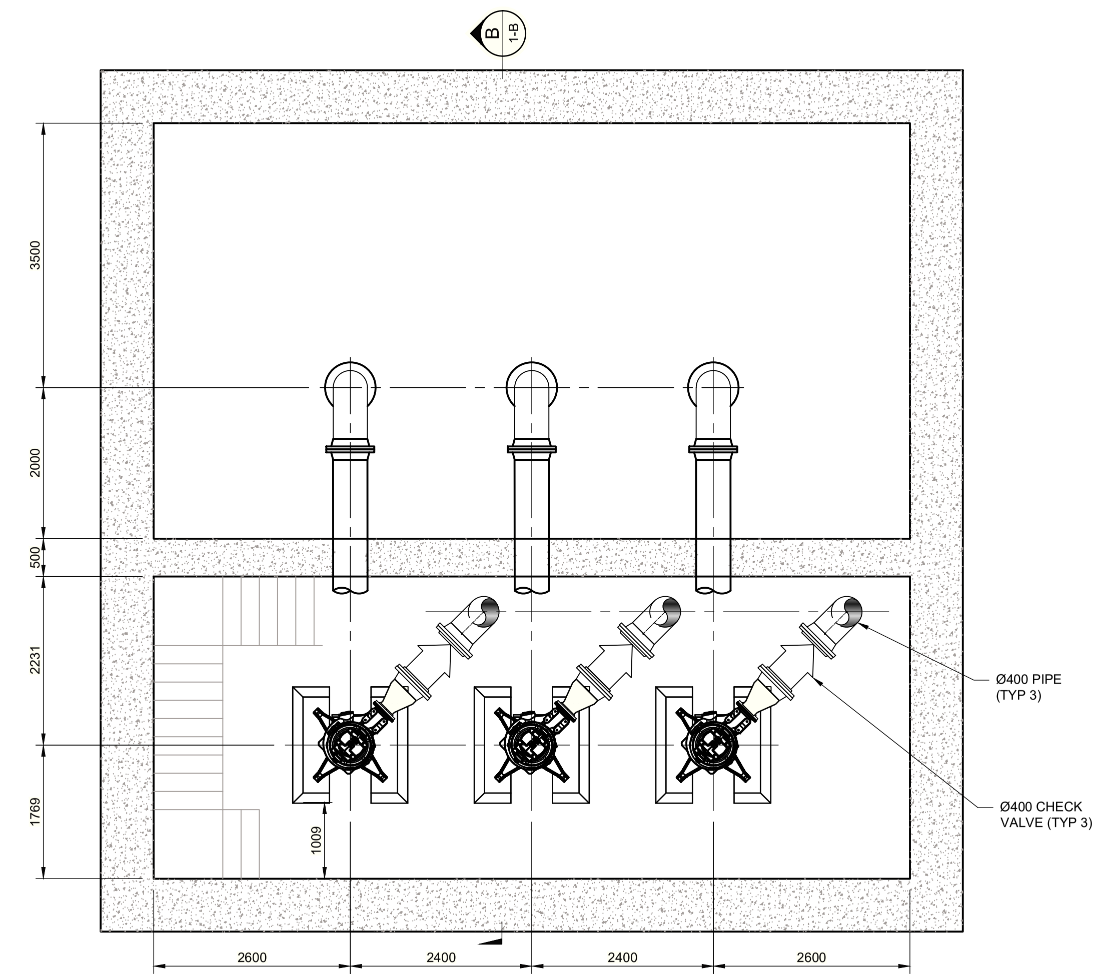

PLAN @ DISCHARGE PIPING
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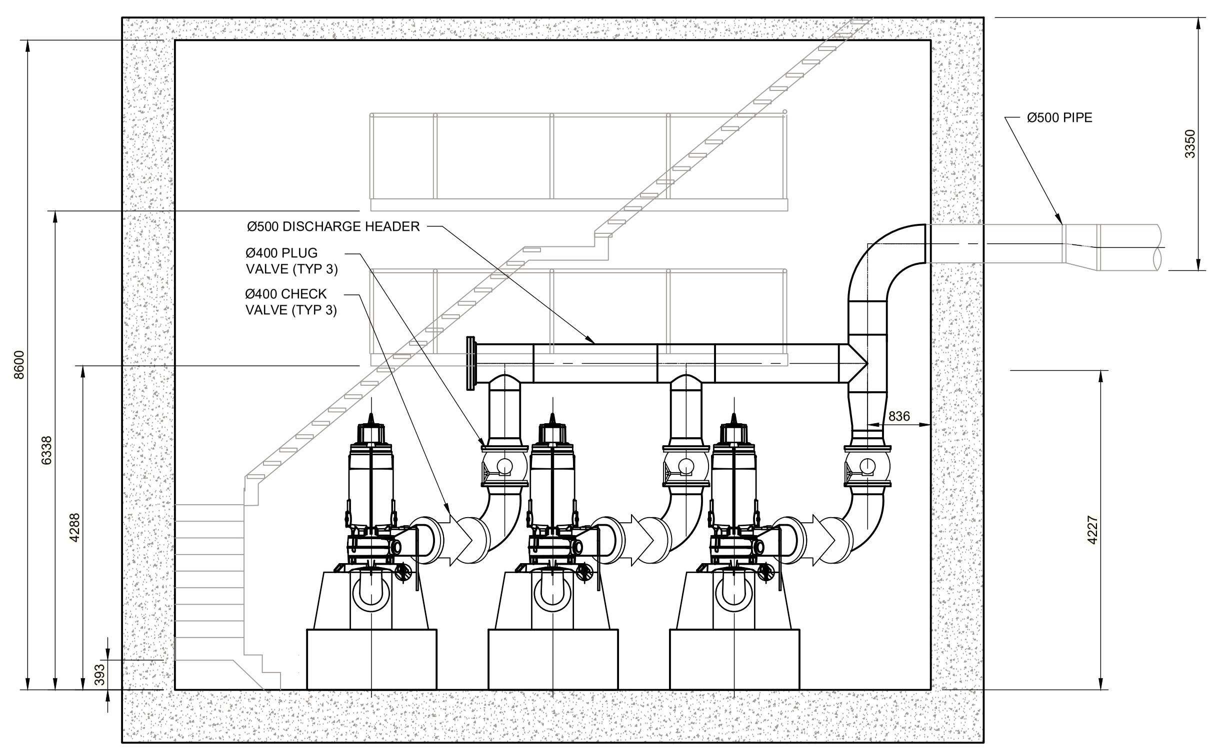
FIGURE 1-A: COURTENAY PUMP STATION
UPGRADE FOR OPTION 1 - CUT AND COVER
FORCEMAIN INSTALLATION - PLANS



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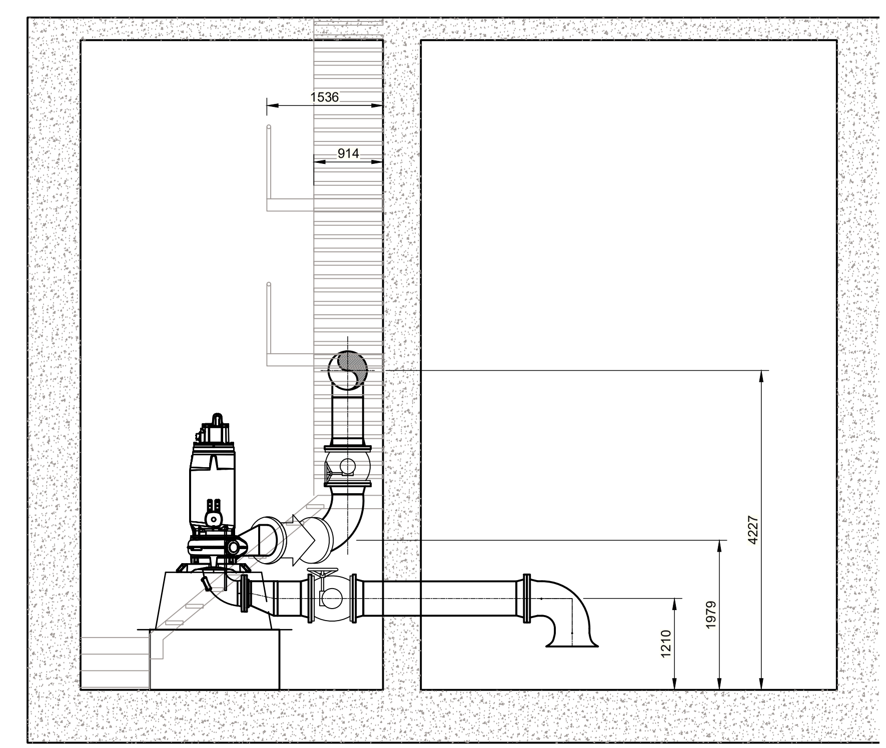

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FIGURE 1-B: COURTENAY PUMP STATION UPGRADE FOR OPTION 1 - CUT AND COVER FORCEMAIN INSTALLATION - SECTIONS

A 97 kW (130 HP) Flygt pump, was identified that can meet these requirements, in a 3 duty + 1 standby configuration, and can be retrofitted into the existing wet well. Variable frequency drive (VFD) control for the pumps is recommended. It is proposed that the larger space needed for the VFDs could be met by relocating the generator in an outdoor enclosure next to the pump station and using the space for the additional MCC length. A drawing of the new pump installation and pump station layout can be found in Figure 2.

For the trenchless forcemain options (Options 2 and 3), the pumping head requirements for both stations would be reduced, so the required pumps can also be accommodated in the existing structures.

These assessments show that the pump stations can physically accommodate larger pumps that can provide greater flows and higher heads, even the high heads needed for Option 1: Cut & Cover Forcemain. Therefore, upgrading each station is possible as opposed to constructing a replacement station.

3.5 PHASING (Option 3)

The entire forcemain is to be eventually replaced and relocated out of the foreshore, due to potential exposure and damage, long response times to repair leaks, and potential environmental damage resulting from a forcemain break in the foreshore. Replacement and relocation to a higher elevation requires both CPS and JPS to be upgraded to be able meet the higher pumping head requirements. Both CPS and JPS are aging and are at capacity during peak weather flows (although this has been mitigated by the diversion of some flows to the Greenwood/Hudson Trunk Sewers), so require upgrading or replacement in any case.

If the project is to be phased, the following factors are to be considered:

- Replacement of forcemain along Willemar Bluffs is urgent due to risk of exposure and failure due to erosion;
- CPS and JPS are at capacity now during peak weather flows;
- Both stations will need new higher head pumps when the new forcemain (or a portion of it) is constructed and relocated out of foreshore;
- Both stations can be upgraded for both conveyance installation options (cut & cover, or trenchless), and do not need to be re-built (structure in good condition, pumps can physically fit inside); however, upgrading CPS for the high discharge pressures needed for the cut & cover conveyance option will require more extensive modifications than JPS because the lift station is constructed in a dry well/wet well configuration;
- There is currently no land available in the vicinity of JPS to re-construct JPS;
- Both stations may not meet current Post Disaster seismic standards;
- CPS and JPS are now located 0.25 m and 1 m below the recommended climate construction level, which will increase to 0.69 m and 1.44 m by Year 2100 at CPS and JPS respectively; and
- The pressure rating of the existing forcemain from CPS to JPS is 100 psi. Estimates of discharge pressures at CPS for the cut & cover conveyance option approaches this value.

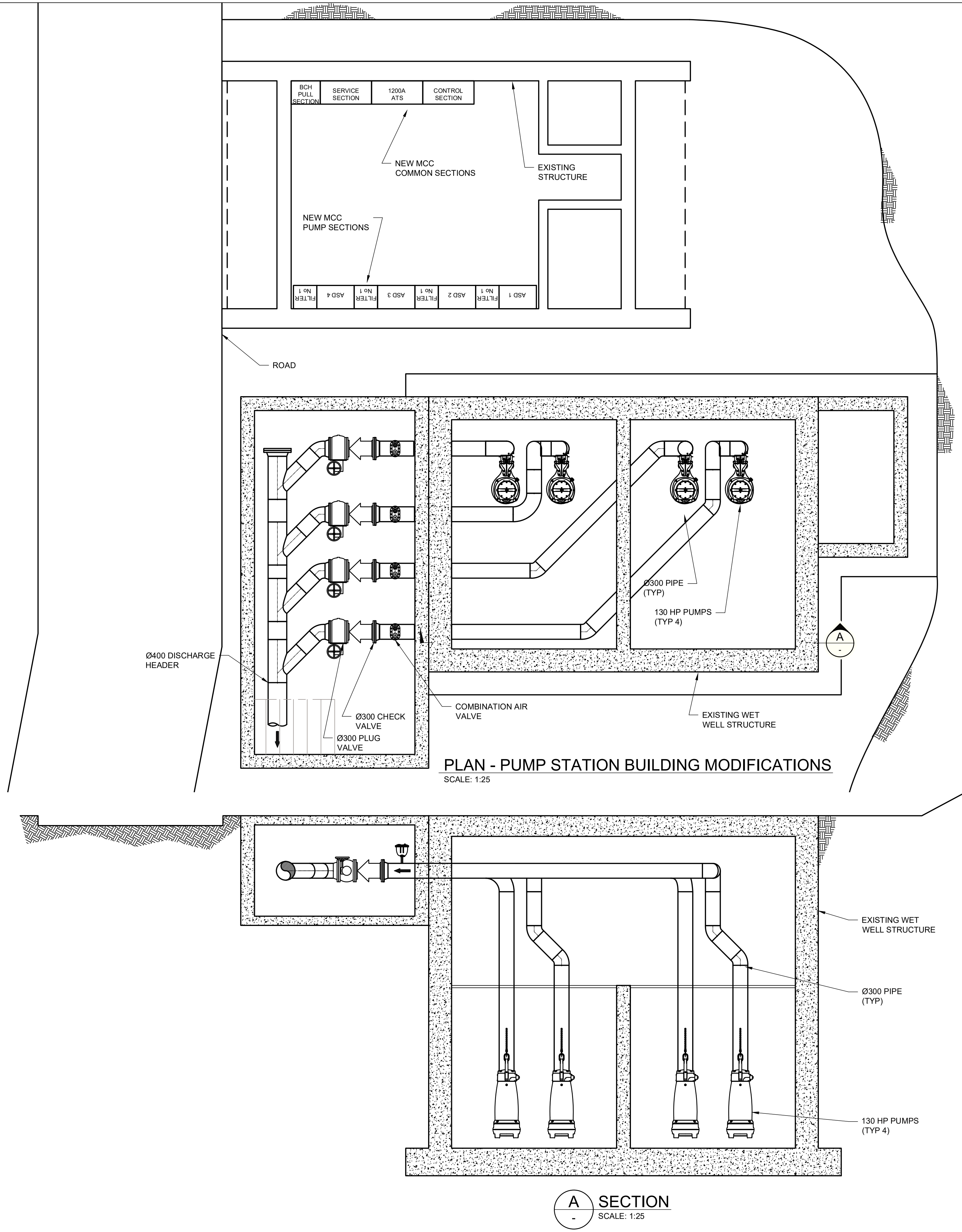


FIGURE 2: JANE PLACE PUMP STATION UPGRADE FOR OPTION 1 - CUT AND COVER FORCEMAIN INSTALLATION

Considering the above, the following is a possible phasing strategy that was developed as Option 3, which is described in detail later in this Memorandum:

- Phase 1:
  - Construct new forcemain from JPS to CVWPCC;
  - Upgrade JPS;
  - Upgrade CPS;
  - Replace pumps at KFNPS.
- Phase 2:
  - Replace forcemain from CPS to JPS.

The tie-in of the new Phase 1 forcemain is proposed to be done in Marina Park near Jane Place Pump Station, where the forcemain is routed onto land out of the foreshore.

We note that this phasing strategy is likely only viable for the Trenchless Forcemain options (Options 2 and 3), as the pump discharge pressures for Option 1 (Cut & Cover Forcemain) are approaching the working pressure of the existing pipe.

3.6 ARCHAEOLOGICAL ASSESSMENT

Two studies were prepared to determine the potential for archaeological sites along the proposed forcemain routes and were undertaken as defined in the *British Columbia Archaeological Impact Assessment Guidelines* (1998). One study covers the proposed forcemain route from CPS to K'ómoks First Nation IR1 and the second covers the remaining length to Curtis Rd.

The first study, covering the area from CPS to IR1, states that the eastern study area, located between 17th Street (location of CPS) and the Rotary Wildlife Viewing Park is largely characterized by deposits of native sterile material and fill and is considered to have a low archaeological potential based on its location within the Courtenay River flood plain. The western portion located between the Rotary Park and the boundary of IR1 was assessed as having a high archaeological potential based on the presence of previously recorded archaeological sites and its location on higher terrain above the Courtenay River and Comox Harbour. The second study covers IR1 to Curtis Road. Ten known archaeological sites are located within, or partially within, this study area. However, all are close to or in foreshore area and away from the proposed relocated forcemain. The complete archeological reports are included in Appendix A.

Archaeological monitoring will be undertaken during construction of the entire alignment, and where there are areas of particular sensitivity, such as from Rotary Park though IR1, a pre-dig will be conducted in advance of construction.

3.7 ENVIRONMENTAL ASSESSMENT

Current Environmental Ltd. completed a preliminary environmental constraints assessment for the proposed inland sanitary forcemain alignment. This assessment included the following:

- Identify environmental features with the potential to be impacted by the proposed alignment;

– Highlight significant environmental risks;
– Identify permitting requirements and respective durations/timelines associated with each;
– Comment on crossing of any environmental features or waterbodies.

The following table from their report is copied below and lists the environmental features and potential risks for the conveyance project.

Table 6: Summary of Environmental Features and Potential Risks (Current Environmental)

Chainage (approximate)	Feature(s)	Potential Risks
0 km @ Courtenay PS	• Courtenay River estuary • Comox Bay Farm (controlled by Ducks Unlimited Canada and other conservation partners)	• Release of deleterious substances to adjacent sensitive habitat • Impacts to nesting avians during typical breeding period (Mar 1 – Aug 31) • Impacts to seasonal occurring avian species associated with K'omoks (BC272) IBA, including Comox Bay Farm
0 – 2 km	• Courtenay River estuary • Glen Urquhart Cr • wet sites at east end of #1 IR • K'omoks (BC272) IBA • Comox Bay Farm	• Release of deleterious substances to adjacent sensitive habitat • Impacts to nesting avians during typical breeding period (Mar 1 – Aug 31) • Impacts to migrating and rearing salmonids Impacts to seasonal occurring avian species associated with K'omoks (BC272) IBA, including Comox Bay Farm
2 – 6 km	• Port Augusta Cr (~km 3.8) • Golf Cr (~km 4.6) • Brooklyn Cr (~km 5.6)	• Release of deleterious substances to adjacent sensitive habitat • Impacts to nesting avians (Mar. 1 – Aug. 31) and raptors (Jan. 1 – Aug. 31) during typical breeding periods. • Impacts to migrating and rearing salmonids
6 – 8 km	• Lazo Marsh-Northeast Comox Wildlife Management Area (127 ha) • other existing forest and thicket stands	• Release of deleterious substances to adjacent sensitive habitat • Impacts to nesting avians (Mar. 1 – Aug. 31) and raptors (Jan. 1 – Aug. 31) during typical breeding periods. Impacts to at-risk amphibians • Impacts to wildlife species associated with Lazo Marsh-Northeast Comox Wildlife Management Area
8 km @ CVWPCC	Existing forest and thicket stands	Impacts to nesting avians (Mar. 1 – Aug. 31) and raptors (Jan. 1 – Aug. 31) during typical breeding periods.

Their report concludes:

"Based on this preliminary environmental assessment, the construction and operation of the CVRD Sanitary Forcemain …… is expected to be completed without significant environmental effects. Any potential adverse effects can be mitigated to result in no, or negligible impacts. Measures should be in place to respond to accidents and malfunctions that have the potential to affect the environment. Provided that this project follows the mtigation hierarchy described in Section 4, temporary encroachment and permanent alterations of the sensitive habitats identified in this technical memorandum are not expected to have an adverse effect on the environment."

The complete environmental report is included in Appendix B.

3.8 TRENCHLESS CONSIDERATIONS

TRENCHLESS OPTIONS

McMillen Jacobs Associates were engaged to complete a high-level overview of trenchless options and costing. Three trenchless installation methods were considered as viable for this project: 1) shield tunnelling; 2) slurry micro-tunnelling; and, 3) horizontal directional drilling (HDD), each having advantages and disadvantages. Their report is attached in Appendix C.

GW Solutions undertook a desktop investigation into the subsurface geology and groundwater conditions around the proposed trenchless alignments. However, only the proposed Lazo Road Hill trenchless section had sufficient well water data to enable a desktop investigation.   Further geotechnical investigations and studies have since been have been undertaken to further assess the viability of trenchless installation through both Lazo Road Hill and Comox Road Hill (presented in next section).

Based on the work completed for the hydrogeological study for the Lazo Road Hill trenchless section, GW Solutions found that groundwater in wells drilled above (northeast of) Hawkins Road in the Quadra Sand Aquifer (#408) is greater than 40 m and as much as 60 m below ground level, putting the top of groundwater in this zone at below elevation 20 m. Their report is attached in Appendix D.

Table 7 summarizes the characteristics and constraints for each trenchless option considered.

Table 7: Summary of Constraints for Trenchless Options

Category	Shield tunnelling	Micro-tunnelling	Horizontal Direction Drilling
Groundwater / Face Control	Not designed to work below the water table	Can operate above and below the water table.	Can operate above and below the water table.
Typical Diameter Installed	2.2 m or larger	0.5 m to 2.7 m	0.1 m to 1.5 m
Typical Length Installed	No limitations	Installed lengths are typically in the range of 600 m, however 1,100 m has been installed before	Up to 1,500 m
Relative Cost	x2.3	x2	x1

From a cost perspective, horizontal directional drilling offers significant cost advantages over the other methods provided borehole stability can be maintained. The primary drawback to horizontal directional drilling is the laydown room needed to fuse a pipe string long enough for one continuous pullback or to fuse two or three sections that are welded together during pullback.

Horizontal directional drilling has the lowest cost and was deemed likely to be a viable option. The micro-tunnel option and the shield tunneling option do not offer any advantages for this application.

Following this initial work, the followingadditional assessments were undertaken to further confirm the feasibility of an HDD installation:

- Geotechnical and groundwater investigations to confirm feasibility of HDD through Comox Road Hill and Lazo Road Hill;
- Confirm the availability of land for staging areas and portal construction to assess the feasibility of HDD construction (because a laydown the length of the fully strung out product pipe is highly desirable, or a laydown area of half or one-third of the alignment length to build up two or three pipe sections for welding during pullback).

A summary of these investigations is presented below; preparation of detailed reports is underway.

GEOTECHNICAL INVESTIGATIONS

The geotechnical investigations for Lazo Road Hill found that the HDD alignment would encounter dense to very dense sand for most of its length, which is favorable for horizontal directional drilling. However, in some boreholes, the drilling and pressure measurement operations encountered difficulties which were attributed to potential formation squeezing and swelling. These conditions are, however, considered to be manageable.

The difficulties reported by the driller during the geotechnical drilling program for Lazo Road Hill highlighted the potential for squeezing ground. Squeezing ground is represented by time dependant ground movements towards underground openings. When an underground space is created and ground movements are restricted by the supporting structure (e.g., tunnel lining or pipe) of the opening, squeezing pressures are generated at the interface between the ground and the structure.

The risk for pulling the pipeline in sections is the potential ground movement and/or collapse towards the previous reamed hole and the section of pipeline that has already been pulled while the following pipeline section is maneuvered into position and welded to the previous section. Such a scenario could lead to operation failure if the increase in ground/pipeline frictional forces exceeds the HDD rig pulling capacity or the yielding stress of the pipes. This risk could be mitigated by using drilling fluid of high viscosity to maintain the reamed hole stability and ensuring that the size of the reamed hole is sufficiently larger than that of the pipes to allow ground movement.

The observation of potential for squeezing ground by the drillers must be provided to the HDD contractors during tendering, so they can plan their drilling methods and program accordingly, (for example, to allow for additional reaming), and a contract developed which includes provision for additional operations that may be required.

As well, it is recommended that a strategy to allow for installing the forcemain pipe in a single pull be utilized, so that there is no break in the pulling operation to weld together sections of pipe.

In general, the geotechnical investigations for Comox Road Hill found the soils to consist of dense to very dense coarse grained materials (generally sand), with varying amounts of fines and cobbles. These conditions are also, in general, acceptable for horizontal directional drilling, although there remains a risk of larger cobbles being encountered during the HDD operations. Unexpected large cobbles could cause delay, and the HDD contractor would need to ensure that the ramming tools are of capable of breaking up large cobbles and maintaining the integrity of the bore path.

PIPE LAYDOWN AND PULLING CONSIDERATIONS FOR HORIZONTAL DIRECTIONAL DRILLING

As stated above, the primary drawback to horizontal directional drilling is the laydown room needed to fuse a pipe string long enough for one continuous pullback, or to fuse two or three sections that are welded together during pullback. For HDD, pulling the pipeline in sections is feasible, although it is preferable to pull the whole length of pipeline in one continuous operation.

The potential for squeezing ground at Lazo Hill amplifies the risk of the pipes being constricted by the ground, particularly if the pipe pulling operation is undertaken in sections. Therefore, a strategy to pull the pipe in one continuous pull was developed for Lazo Road Hill to mitigate the potential squeezing ground risk.

Figure 3 shows the proposed HDD alignment and laydown area that will be part of the squeezing ground risk mitigation by allowing the pipeline to be pulled in one continuous operation. The laydown area extends from the west end of Balmoral Avenue to the southern area of the Comox Golf Club to provide the required pipe laydown area. The length of the HDD section of forcemain for Lazo Road Hill is 1,270 m at an elevation of 26 m, and the laydown area is approximately 1,320 m. A detailed step by step construction sequence, which outlines impacts to properties and traffic, and proposes alternative accesses, for the jointing of the pipe string and pulling it through the drilled alignment is attached in Appendix E. The operations are anticipated to take 8 weeks, optimised to ensure the pulling operations to follow the completion of drilling phase immediately.

Figure 3 – Lazo Road Hill HDD Forcemain Section and Laydown Area

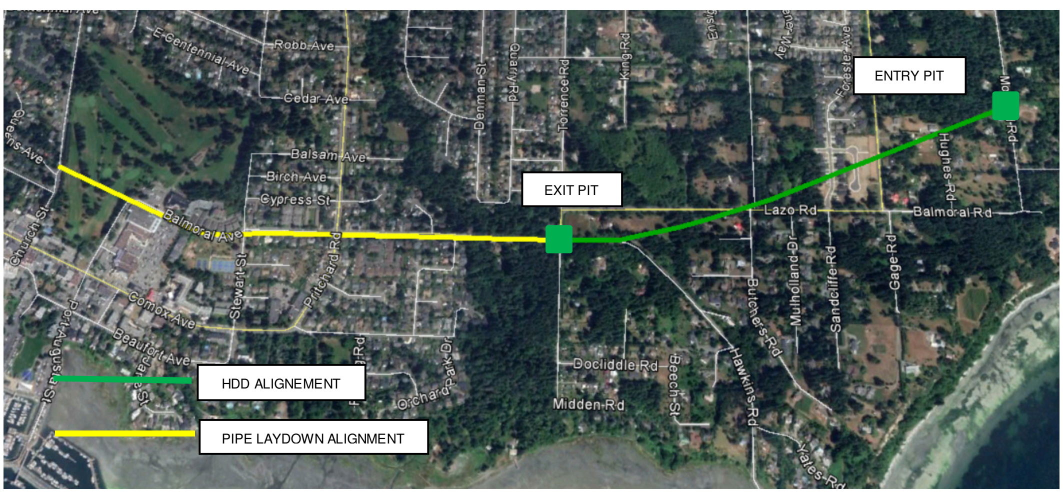


Figure 4 shows the proposed HDD alignment and laydown area for Comox Road Hill, allowing the pipeline to be pulled in one continuous operation. The laydown area extends along Comox Road from near KFN IR1 and the Town of Comox. The length of the HDD section of forcemain for Comox Road Hill is 740 m at an elevation of 30 m at the entry pit, sloping to 20 m at the exit pit. The laydown area is approximately 750 m. A detailed step by step construction sequence, which outlines impacts to traffic, for the jointing of the pipe string and pulling it through the drilled alignment is attached in Appendix E. The operations are anticipated to take 7 weeks, optimised to ensure the pulling operations to follow the completion of drilling phase immediately.

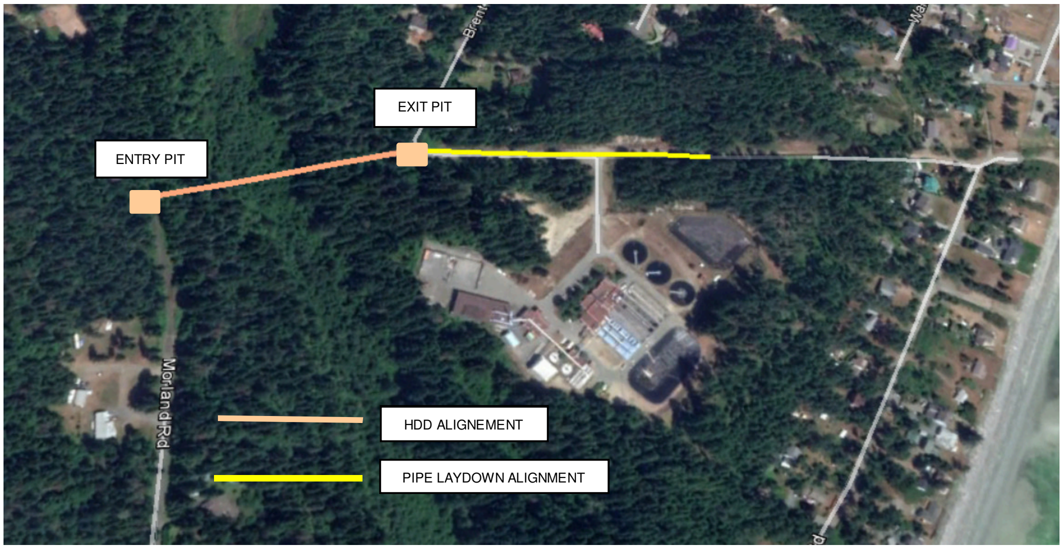
Figure 4 – Comox Road Hill HDD Forcemain Section and Laydown Area

It is also proposed to install the forcemain across Lazo March using horizontal directional drilling to avoid environmental impacts to the marsh. Figure 5 shows the proposed HDD alignment and laydown area for Lazo Marsh. The laydown area will extend along the road to CVWPCC from Brent Road.

Two exploratory boreholes were drilled, one at the entry pit and the other at the exit pit. The drillhole at the entry pit towards the northern end of Morland Road encountered gravels and cobbles, while the drillhole at the exit pit suggested that the ground is dominated by sands. There is a risk that large cobbles, and potential boulders, may be encountered during HDD operations. As described previously, the HDD contractor would need to ensure that the ramming tools are of capable of breaking up large cobbles and boulders and maintaining the integrity of the bore path.

The length of the HDD section of forcemain for Lazo Marsh is 250 m. The steel pipe installed for the Lazo Hill HDD section will terminate at Morland Road at about 5 m below ground level. This will be picked up by a cut and cover section and be continued to the northern end of Morland Road where the entry pit for the Lazo Marsh HDD is located. At this location, the pipe invert can be raised to approximately 2 m below ground level. The laydown area is approximately 260 m. A detailed step by step construction sequence is also included in Appendix E. The operations are anticipated to take 3 weeks, following the completion of the drilling phase.

Figure 5 – Lazo Marsh HDD Forcemain Section and Laydown Area



TRENCHLESS CONSTRUCTION RISKS

Trenchless installations, and horizontal directional drilling in particular, have a number of risks associated with design and construction, mostly associated with subsurface conditions, but also related to permitting, community impacts, and property factors.

Subsurface conditions, as revealed by the ground investigations to date, include potential squeezing ground at Lazo Hill, and cobbles at Comox Hill and Lazo Marsh where there is a potential for large cobbles being present, although boulders were not encountered. The locations and nature of underground utilities will be confirmed such that design of the route and depth of the installation and the location of HDD pits could be refined.

The unintentional return of drilling fluids to the surface, referred to as a frac-out, is a risk during HDD installation and can result in the release of drilling fluids at the ground surface. This risk is mostly mitigated by lining the entry/exit pits using starter casing and locating the horizontal alignment at a suitable depth. However, a spill contingency plan would also be developed for each HDD site to ensure that should such an event occur, a proper management protocol is in place to mitigate its impact.

The following summarizes risks associated with trenchless installation for this project:

Geotechnical Risks

- Squeezing ground;
- Obstructions including large cobbles;
- Geotechnical conditions different from those assumed;
- Soils which may contain archaeological or fill material that may be problematic (e.g., wood waste), particularly for the Comox Hill HDD entry and exit pits where previous construction activities had taken place.

Right of Way Risks

Any risks pertaining to obtaining a Statutory Right of Way would apply for the trenchless option, including but not limited to:

- Availability of land, including land owners not interested in allowing the pipe to cross under their property.

Environmental Risks

- Permitting which involves multiple jurisdictions/agencies;
- Unidentified contamination;
- Restrictions on construction timing imposed by environmental considerations such as bird nesting or fish spawning windows;
- Restrictions on construction methods such as fluid returns for HDD installations.

Construction Risks

- Market considerations limiting the number of qualified firms;
- Longer trenchless sections have higher risks;
- Community impacts, such as traffic and access impacts, noise and working hours.

The ground investigation programs have revealed the ground risks and allow the development of mitigations. Risks during construction will need to be addressed through a contract that appropriately allocates the identified risks between the parties.

4.0 STAGE 2 CONVEYANCE OPTIONS ASSESSMENT

The following assesses each of the shortlisted options, listed below, against the criteria listed in Section 2.3

Option 1: Cut & Cover Forcemain Installation - The new forcemain is installed using conventional cut & cover installation methods.

Option 2: Trenchless Forcemain Installation - Trenchless methods are utilized to install the forcemain through Lazo Road Hill and Comox Road Hill. Horizontal Directional Drilling (HDD) is the trenchless method being proposed.

Option 3: Phased Trenchless Forcemain Installation - This is the same as Option 2 but the forcemain will be installed in 2 phases. Phase 1, from Jane Place Pump Station to the CVWPCC, will be installed initially, and Phase 2, from Courtenay Pump Station to Jane Place Pump Station will be installed in a future phase.

It is assumed that regardless of which option is selected, the forcemain will be installed using trenchless methods across Lazo Marsh to avoid environmental impacts.

4.1 OPTION 1: CUT & COVER FORCEMAIN INSTALLATION

DESCRIPTION

Option 1 would operate similarly to the existing system, where a single forcemain conveys sewage directly to the CVWPCC; however, the forcemain would be moved out of the foreshore and located beneath existing streets. The three pump stations (Courtenay Pump Station, K'ómoks First Nation Pump Station and Jane Place Pump Station) would operate independently of each other and pump into the common forcemain, as they do now. The forcemain would follow the natural topography of the land, rather than run along the foreshore, and, therefore, the pump stations must provide significantly higher discharge pressures to overcome the topography of the new overland forcemain alignment.

The forcemain would be installed using traditional cut and cover trenching methods and would generally follow existing road rights-of-way and contours to minimize low points and high points in the system. This approach is very common and well established. Complexities would involve relocating existing utilities and restoring surface roadways, sidewalks, and landscaping. Due to the nature of sanitary systems, the installed depth excavation would be set to be below the existing water distribution system. As well, it is prudent to install relatively large mains deeper leaving space above for other smaller utilities.

The general alignment and associated hydraulic grade line are shown in Figure 6 and Figure 7. The route would follow the existing forcemain alignment along Comox Road from the CPS for about 2.3 km through farmlands and K'ómoks First Nation lands, where it would be re-routed out of the foreshore and continue through Comox to the CVWPCC. The length of the overland route would be in the order of 8,800 m. The forcemain would pass over Comox Road Hill at roughly 40 m elevation and over the Lazo Road Hill at roughly 51 m elevation.

Due to the high static head posed by the two hills, the forcemain size will need to be larger than required based on flows alone in order to reduce the dynamic head (friction losses) so the pump discharge pressure is within the range that can be accommodated by available wastewater pumps. Therefore, the proposed pipe size for this option is 1067 mm (42") HDPE from CPS to JPS and 1219 mm (48") HDPE from JPS to CVWPCC. These larger pipe size selections, compared to those for the trenchless options (Options 2 and 3), are necessary to reduce dynamic head losses in the pipe such that the needed pump TDH is within values that can be achieved by available wastewater pumps.

HYDRAULICS

To cross over the Lazo Road Hill (51 m) elevation, the pump discharge pressures need to be increased significantly at all three stations, in addition to increasing flow capacities to meet future growth needs. CPS discharge pumping head would need to increase from roughly 29 m to about 62 m and at JPS, from roughly 22 m to 55 m.

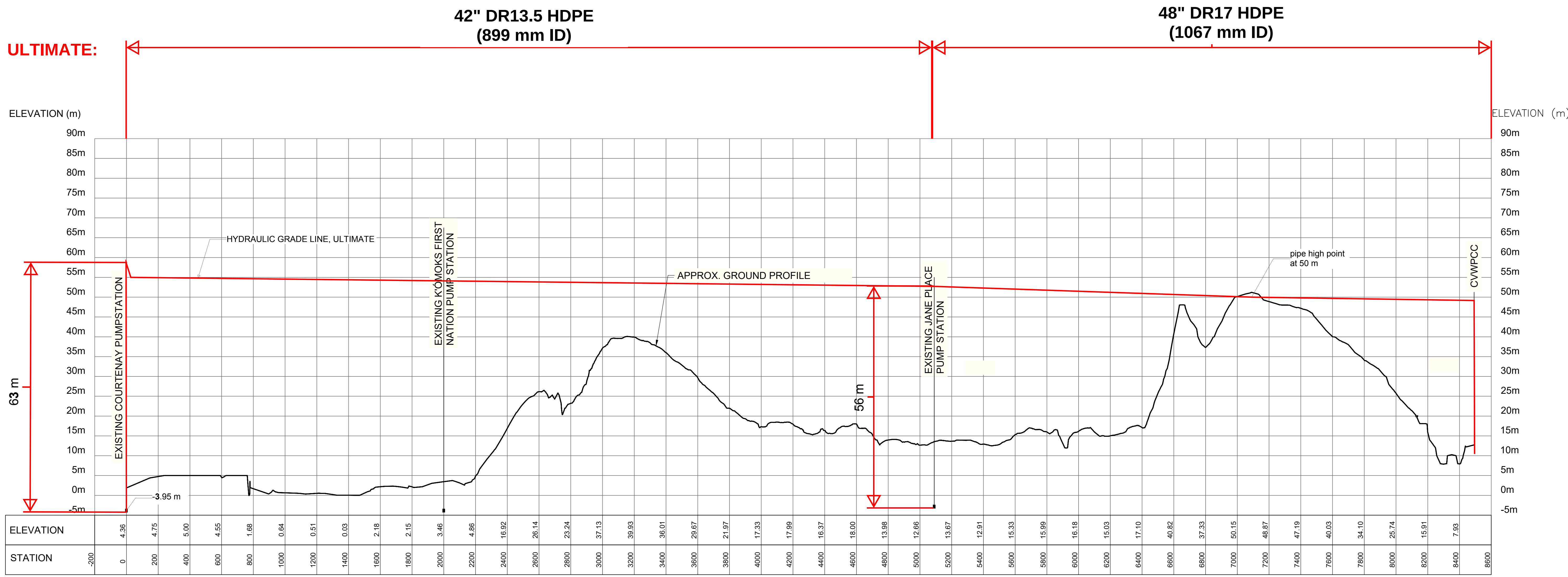
Figure 6 – Option 1: Cut and Cover Forcemain Alignment

When JPS and CPS are running together, the additional flow and resultant head losses in the forcemain will result in higher pump discharge heads and lower pumping rates, as is happening now. Pumps can be installed and run on variable frequency drives (VFDs), so that when more than one station is running, the pumps can be operated at higher speeds than for when the station is operating alone. Higher pump speeds will raise both flow and pumping discharge head – thus discharge pressures will be higher with both stations running. Discharge pressures with both pump stations running are estimated to be 63 m from CPS and 56 m from JPS.

For Option 1, the KFNPS would also require pump upgrades to increase the pumping discharge head from about 16 m to roughly 55 m. It is not possible to find pumps that can provide enough head to match the low flows at this station. However, oversized pumps operating at low efficiencies could likely be used to provide the needed head requirements. Another option would be to direct these flows to CPS via a dedicated forcemain, which can be installed in common trench with the new forcemain.

These discharge pressures (for both stations) are considered very high for sanitary pumping systems, and pumps can be expected to have higher maintenance challenges. A good deal of care must be exercised during pump selection to be satisfied that proposed equipment will perform for a given high head application and design attention to issues such as transients must be carefully addressed.

Energy costs for pumping will increase significantly compared to the current costs due to the high pumping discharge head requirements.



2060 DESIGN FLOWS (ULTIMATE):
COURTENAY PS: 547 L/s
JANE PLACE PS: 244 L/s

HGL FOR OPEN CUT INSTALLATION
LIQUID WASTE MANAGMENT PLAN - STAGE 2
CONCEPTUAL FORCEMAIN ALIGNMENT
HORIZ 1:12500 VERT 1:500

wsp
North Vancouver Office
604-990-4800
210-889 Harbourside Drive
North Vancouver BC
V7P 3S1, Canada

FIGURE 7

High discharge pressures for this option approach the working pressure limitations of the existing forcemain and increase the risk of failure of the forcemain if it is retained between CPS and JPS. Therefore, replacement of the entire forcemain pipe with pipe that has a higher pressure rating to accommodate the high pressure discharge is prudent for Option 1, to reduce the risk of pipe failure; this means that phasing of Option 1 is not recommended.

EVALUATION

Table 8 shows the assessment of Option 1 against the criteria outlined in Section 2.0, which is based on the evaluation matrix developed by the TAC/PAC at the initiation of the Project, expanded for the Stage 2 assessment:

Table 8: Evaluation of Option 1

Criteria	Comments
Hydraulics	– Significant hydraulic changes to the CPS, JPS, and KFNPS but can be accommodated with pumps with higher discharge heads. – Significantly higher discharge pressures will be needed at all stations; these are considered very high for sanitary pumping systems, and pumps will have higher maintenance challenges and requirements. – Pumping energy costs will rise significantly from current costs.
Condition of existing infrastructure, including remaining life, post disaster considerations	– Stations are 37 years old, but are in good condition, although they will require upgrading or replacement in the forseeable future due to their age. – Stations likely do not meet current Post Disaster seismic standards.
Opportunity for upgrading vs. replacing pump stations	– Upgrading is feasible at CPS and JPS stations by installing new pumps in the existing wet wells, however upgrading CPS will require significant modifications due to the wet well/dry well arrangement and will be more challenging. – Upgrading is especially favourable for JPS where land requirements for a replacement station is a concern; a replacement station at higher elevation would require a new lift station to serve the properties below the new JPS, and pump sewage up to JPS.
Opportunity for Phasing	– High discharge pressures from CPS approach the working pressure limitations of the existing forcemain, and increase the risk of failure of the forcemain if it is retained between CPS and JPS. – Phasing for Option 1 is, therefore, not recommended; therefore, all upgrades (forcemain and pump stations) would be constructed in single phase.
Flooding and climate change resilience for existing and proposed infrastructure	– Climate change will increase risk of flooding to pump stations now located at sea level. – Re-constructed pump stations can be constructed with appropriate flood protection. – Flood protection measures to mitigate existing stations can be constructed, although will be more challenging at JPS due to constrained site.

Table 8: Evaluation of Option 1

Criteria	Comments
Construction risks	– Construction of new conveyance system through an area with existing infrastructure and high traffic. – Working within roadways and near the public – Congested utilities in roadways may require relocation of existing utilities
Operations and maintenance considerations including ability to isolate the system and shut down operations to undertake repairs, flexibility, redundancy	– Maintenance and repair of the cut & cover forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur, standard methods of isolation and pumping off-site using a vacuum truck would be employed. – Maintenance of the higher head pumps will be greater than that of the existing facilities.
K'ómoks First Nation impacts	– Forcemain will cross IR1 Reserve on Comox Ave. – Construction disturbance.
Archaeological considerations such as proximity to known sites	– The intention would be to remain within existing areas of disturbance, so no unique archaeological impacts are likely – Area from Rotary Park through IRI has most potential for archeological finds and appropriate protocols will need to be put in place including conducting a pre-dig prior to construction. – Archaeological monitoring will be conducted throughout construction.
Environmental considerations such as habitat impact, ecosystem impacts and proximity to known sensitive habitat	– Crossing of Lazo Marsh is proposed to be done by horizontal directional drilling to avoid environmental impacts to this sensitive area. – Cut & cover portions routed along existing roadways would have limited environmental impacts. – Areas with significant adjacent trees could be potentially damaged due to root damage.
Geotechnical/hydrogeological considerations	– With forcemain in roadways, generally know that geotechnical conditions can be accommodated.
Public impacts such as construction disturbance and visibility of constructed works	– Potential for utility breaks and service disruptions. – Traffic disruptions. – Construction noise.
Permitting requirements	– MoTI permit will be required for MoTI ROW for Comox Road. – Various environmental permits.
Land and ROW acquisition requirements and considerations, property availability	– Large component will be constructed in existing ROWs. – ROW will be needed across forested area/wetlands to CVWPCC. – Crosses K'ómoks First Nation Reserve.

Table 8: Evaluation of Option 1

Criteria	Comments
	– No current land availability to construct a new JPS.
Life Cycle Costs	– This option has the highest 30-year and 50-year life cycle cost due to higher pumping costs at all stations to pump sewage over the heights of land at both Comox Road and Lazo Road hills, as well as higher asset replacement costs.

RISKS AND UNKNOWNS

- Pumps at CPS will have significantly higher discharge pressures (>60 m TDH); these pressures are considered very high for sanitary pumping systems, and pumps can be expected to have higher maintenance challenges and greater maintenance requirements;
- For CPS, although it is possible to retrofit the required large pumps into the existing station, modifications inside the wet well/drywell would be required, and installation of the pumps will be more challenging;
- It is likely that the CPS wet well/dry well structure and the JPS wet well structure do not meet current Post Disaster seismic standards; the structures will be assessed to determine how they compare to the current Post Disaster standard, and what upgrades would be needed to bring the structures up to the current Post Disaster standard; based on the assessments, the decision whether to retrofit each station will be made; for CPS, the need for a seismic upgrade will considered along with other factors, to determine if a rebuild is warranted compared to upgrading the station; due to site constraints, a retrofit is envisaged for JPS.
- Due to their location, both pump stations will require floodproofing against the impacts of climate change and sea level rise; because the JPS is constrained, flood proofing will be more challenging; and
- The discharge pressures for this option are approaching the design working pressures of the forcemain, so phasing of the system upgrades (by retaining a portion of it to be replaced in a future phase) is not recommended, due to increased risk of forcemain failure at higher pressures.

4.2 OPTION 2: TRENCHLESS FORCEMAIN INSTALLATION

DESCRIPTION

Option 2 is similar to the existing system where a single forcemain conveys sewage directly to the CVWPCC; however, the forcemain would be moved out of the foreshore and located beneath existing streets, with a portion installed through high point(s) in the route using trenchless methods. The three pump stations would operate independently of each other and pump into the common forcemain.

The new forcemain would be installed using both open cut trenching methods, as discussed in the preceding section, and trenchless methods. The two areas where trenchless methods could be used are through the Comox Road Hill, represented by the orange-shaded area in the center of Figure 8 below, and through the Lazo Road Hill, represented by the orange-shaded area to the east. Between the two hills, the forcemain will transition to an open cut installation through Comox.

Using trenchless methods to install the forcemain will allow the forcemain elevation, and therefore hydraulic grade line, to be lowered by going through hills rather than over them reducing the associated pumping requirements from those for an over land route. The optimal trenchless conveyance concept optimizes the length and cost of a trenchless installation against the additional pumping costs associated with shorter trenchless sections at higher elevations. For the anticipated alignment, the Comox Road Hill is approximately at 40 m elevation and the Lazo Road Hill is approximately at 51 m.

Figure 8 - General Topography of the CVSSA

Similar to Option 1, the overland portion of the forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways.

The general alignment and associated hydraulic grade line are shown in Figure 9 and Figure 10. The forcemain would follow the same over land route as for Option 1, however, it would pass through Lazo Road and Comox Road Hill using trenchless methods. The length is shorter than for Option 1, at approximately 8,300 m, because the HDD sections do not need to follow roadways. The proposed pipe size for the is option is 860 mm (34") HDPE from CPS to CVWPCC with the HDD section through Lazo Hill being 762 mm (30") standard schedule steel. Pipe size selection is based on not exceeding recommended velocities in the pipe, however, pipe size was increased slightly to reducing dynamic losses and pump TDH requirements, to lower pump power requirements.

Figure 9 - Options 2 and 3: Trenchless Forcemain Alignment

HYDRAULICS

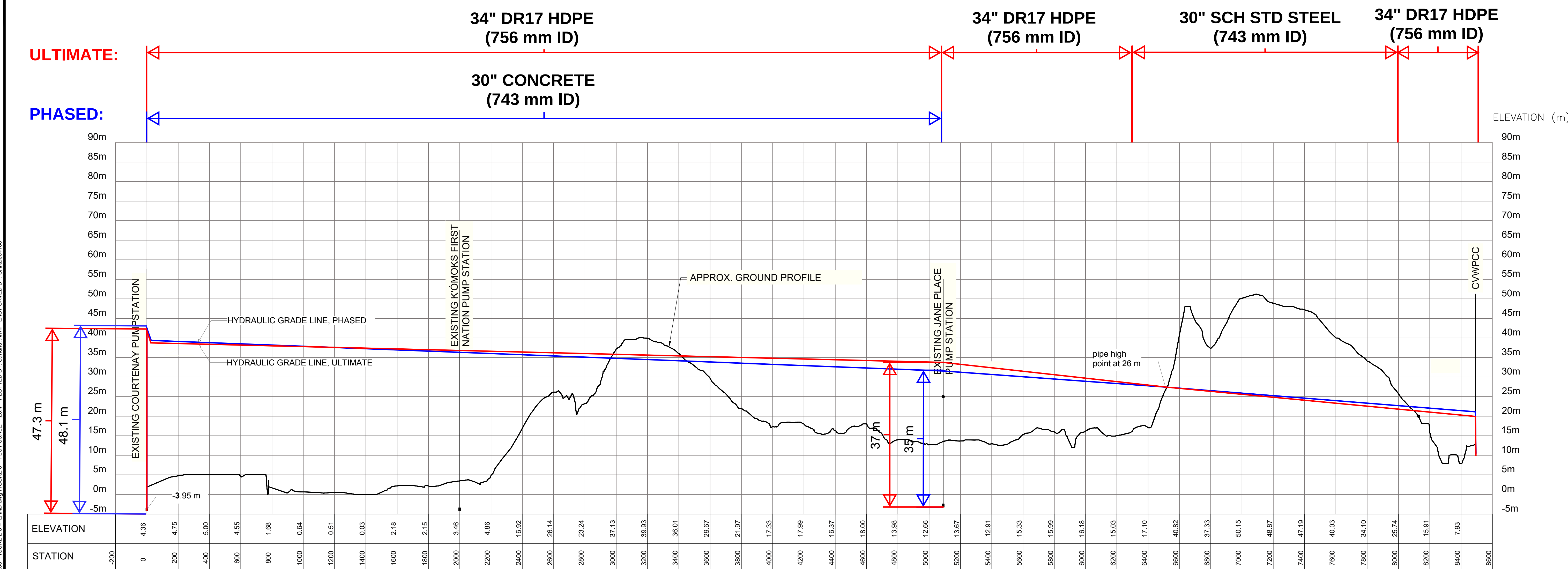
Assuming a horizontal direction drilling installation with the elevation of the forcemain through Lazo Road Hill set at 26 m, and a second trenchless section through Comox Road Hill, to maintain a low forcemain elevation, Table 9 summarizes the approximate length and elevations of the trenchless sections, and the corresponding required discharge head.

Table 9: Trenchless Design Criteria

Criteria

Trenchless installation length	– 1,270 m through Lazo Road Hill – 840 m through Comox Road Hill
Trenchless installation elevation	– 26 m through Lazo Road Hill – 20 - 30 m through Comox Road Hill
Required discharge head (TDH)[1] – CPS – JPS – KFNPS	 – 45 m – 32 m – 33 m

[1] Pump stations pumping alone.



HGL FOR TRENCHLESS FORCEMAIN INSTALLATION

LIQUID WASTE MANAGMENT PLAN - STAGE 2

CONCEPTUAL FORCEMAIN ALIGNMENT PROFILE

HORIZ 1:12500 VERT 1:500

2060 DESIGN FLOWS (ULTIMATE):
COURTENAY PS: 559 L/s
JANE PLACE PS: 244 L/s

2040 DESIGN FLOWS (INTERIM, PHASED):
COURTENAY PS: 511 L/s
JANE PLACE PS: 226 L/s

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V7P 3S1, Canada

As with Option 1, the above discharge heads are based on each station pumping into the forcemain alone, and when both stations are running, required discharge pressures are higher, at 47 m from CPS and at 37 m at JPS.

The discharge pressures for both JPS and CPS for this option are considered to be within acceptable ranges, as well as for KFNPS.

EVALUATION

Table 10 shows the assessment of Option 2 against the criteria outlined in Section 2.0. Where there are no unique risks, issues, or advantages that differentiate Options 1 and 2 with regards to each criterion, these are noted as such.

Table 10: Evaluation of Option 2

Criteria	Comment
Hydraulics	– Upgrades driven by hydraulic changes are required for the CPS, JPS, and KFNPS but are less than those for Option 1 and can be accommodated with pumps with higher discharge heads that would operate within typical ranges. – Pumping energy costs will increase from current costs but not as significantly as for Option 1
Condition of existing infrastructure, including remaining life, post disaster considerations	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regards to this criterion.
Opportunity for upgrading vs. replacing pump stations	– Upgrading is feasible at CPS and JPS stations by installing new pumps in the existing wet wells. – Upgrading is especially favourable for JPS where the land requirement for a replacement station is a concern, and where a replacement station at higher elevation will require a small lift station for the properties below.
Opportunity for Phasing	– This option allows for phasing as the discharge pressures from CPS are within the working pressure range of the existing forcemain – Option 3 has been identified as the phased option.
Flooding and climate change resilience for existing and proposed infrastructure	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regard to this criterion.
Construction risks	– Construction of new conveyance system through an area with significant existing infrastructure and high traffic. – Working within roadways and near the public. – Congested utilities in roadways may require relocation of existing utilities. – These risks will be reduced because a portion of the alignment will be installed using trenchless methods, however, construction risks are higher for a trenchless installation as compared to a cut and cover installation. If risks are realized, they potentially can be costly.
Operations and maintenance considerations including ability to isolate the system and	– Maintenance and repair for the cut & cover portions of the forcemain would be completed using well established repair methods based on

Table 10: Evaluation of Option 2

Criteria	Comment
shut down operations to undertake repairs, flexibility, redundancy	open excavation. Should a pipe failure occur, standard methods of isolation and pumping off-site using a vacuum truck would be employed. – Trenchless sections would be inaccessible for repair but would be well protected from damage due to the deep burial; also the trenchless sections will use a higher pressure class of pipe and in the case of Lazo Hill, steel pipe will be used. – Maintenance of the moderately higher head pump stations would be similar to that of the existing facilities.
K'ómoks First Nation impacts	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regards to this criterion.
Archaeological considerations such as proximity to known sites	– The intention would be to remain within existing areas of disturbance, so no unique archaeological impacts are likely. – Area from Rotary Park through IRI has most potential for archeological finds and appropriate protocols will need to be put in place including conducting a pre-dig prior to construction. – Archaeological monitoring will be conducted throughout construction. – Trenchless sections are not in areas where there is high potential for archaeological finds, so no significant benefit.
Environmental considerations such as habitat impact, ecosystem impacts and proximity to known sensitive habitat	– Crossing of Lazo Marsh is proposed to be done by horizontal directional drilling to avoid environmental impacts to this sensitive area. – Cut & cover portions routed along existing roadways would have limited environmental impacts. – Areas with significant adjacent trees could be potentially damaged due to root damage. – Trenchless sections would avoid environmental impacts, providing some environmental benefits; however, trenchless sections do not include any of the identified environmentally sensitive areas. – Potential risk with HDD of frac-out, but can typically be mitigated.
Geotechnical/hydrogeological considerations	– Known conditions are favourable for trenchless. – Investigations to confirm geotechnical/ hydrogeological conditions for trenchless sections have shown that subsurface conditions are suitable for an HDD installation, although there is a risk of different conditions being encountered, with potential additional associated costs. – Trenchless installations will be above groundwater elevation and will avoid installed groundwater wells.

Table 10: Evaluation of Option 2

Criteria	Comment
Public impacts such as construction disturbance and visibility of constructed works	– Potential for utility breaks and service disruptions. – Traffic disruptions. – Construction noise. – Less disruption through sections installed using trenchless methods, however, impacts increased at entry/exit pit locations. – Significant impacts of 7-8 weeks duration for each of Comox Road Hill and Lazo Road Hill installations to lay down, assemble and pull pipe into HDD hole, however, strategy to minimize impacts and minimize access restrictions to residents has been developed.
Permitting requirements	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regards to this criterion.
Land and ROW acquisition requirements and considerations, property availability	– Large component will be constructed in existing ROWs. – ROWs needed for trenchless sections which may cross several private properties. – ROW will be needed across forested area/wetlands to CVWPCC – Crosses K'ómoks First Nation Reserve. – No current land availability to construct a new JPS.
Life Cycle Costs	– This option has a lower 30-year and 50-year life cycle cost than Option 1 because pumping costs and asset renewal costs at all stations are lower than those for the cut and cover option. – This option has the lowest 30-year and 50-year life cycle cost.

RISKS AND UNKNOWNS

- ROWs will be needed for trenchless sections which may cross several properties, including private properties;
- Geotechnical and hydrogeological investigations indicate trenchless installations through Lazo Road Hill, Comox Road Hill and Lazo Marsh are feasible, trenchless installations have higher risks with costly consequences should the risk be realized, compared to a cut and cover installation;
- As with Option 1, it is likely that the CPS wet well/dry well structure and the JPS wet well structure do not meet current Post Disaster seismic standards; the structures will be assessed to determine how they compare to the current Post Disaster standard, and what upgrades would be needed to bring the structures up to the current Post Disaster standard; based on the assessments, the decision whether to retrofit each station will be made; for CPS, the need for a seismic upgrade will considered along with other factors, to determine if a rebuild is warranted compared to upgrading the station; due to site constraints, a retrofit is envisaged for JPS in the short term.
- Due to their location, both pump stations will require floodproofing against the impacts of climate change and sea level rise; because the JPS is constrained, flood proofing will be more challenging.

OPTION 3: PHASED TRENCHLESS FORCEMAIN INSTALLATION

DESCRIPTION

Option 3 is the same as Option 2, except that the forcemain replacement would be constructed in 2 phases. Phase 1 would replace the forcemain from JPS to CVWPCC, which includes the Willemar Bluffs section. Replacement of the remaining section from CPS to JPS would be deferred to Phase 2, assumed to occur in 2040. Pump station upgrades would be as for Option 2. The tie in point for Phase 1 would be in Marina Park, near JPS, where the forcemain is aligned out of the foreshore.

Since Option 3 is essentially the same as Option 2 (Option 3 is phased, and Option 2 is not), the assessment is not repeated here, except where there are differences.

EVALUATION

Table 11 shows the assessment of Option 3 against the criteria outlined in Section 2.0. Where there are no unique risks, issues, or advantages that differentiate Option 3 from Options 2 and with regards to each criterion, these are noted as such.

Table 11: Evaluation of Option 3

Criteria	Comment
Hydraulics	– Same as for Option 2
Condition of existing infrastructure, including remaining life, post disaster considerations	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regards to this criterion.
Opportunity for upgrading vs. replacing pump stations	– Same as for Option 2
Opportunity for Phasing	– Same as for Option 2
Flooding and climate change resilience for existing and proposed infrastructure	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regards to this criterion.
Construction risks	– Same as for Option 2
Operations and maintenance considerations including ability to isolate the system and shut down operations to undertake repairs, flexibility, redundancy	– Same as for Option 2
K'ómoks First Nation impacts	– No unique risks, issues, or advantages are identified that will differentiate Options 1 and 2 with regards to this criterion.
Archaeological considerations such as proximity to known sites	– Same as for Option 2

Table 11: Evaluation of Option 3

Criteria	Comment
Environmental considerations such as habitat impact, ecosystem impacts and proximity to known sensitive habitat	– Same as for Option 2
Geotechnical/hydrogeological considerations	– Same as for Option 2
Public impacts such as construction disturbance and visibility of constructed works	– Same as for Option 2
Permitting requirements	– Same as for Option 2
Land and ROW acquisition requirements and considerations, property availability	– Same as for Option 2
Life Cycle Costs	– This option has a slightly higher 30-year and 50-year life cycle than Option 2, due to the additional costs incurred by phasing.

RISKS AND UNKNOWNS

- Same as for Option 2.

5.0 LIFE CYCLE COST ASSESSMENT

The life cycle cost for each option is the sum of the Present Value of each of the following components:

1. Capital costs, estimated based on the following:
   - Similar infrastructure installed in other communities, where available; and
   - Cost curves and unit rates.
2. Operating costs consisting of:
   - Estimated annual average power consumption for pumping;
   - Estimated labour effort; and
3. Asset renewal requirements, based on renewal freqency and renewal percent as shown in the table below.

The costs presented are in 2020 dollars and do not include GST. These costs are only for options comparison and discussion and are not suitable for budgeting. Costs include contingency (at 40%, 60% for HDD), and engineering (15%).

Table 12 and Table 13 show a summary of the infrastructure components that are applicable to each of the options, as well as the estimated capital cost associated with each item and the estimated annual operations and maintenance cost.

Table 12: Option 1 – Cut & Cover Forcemain Installation Option - Infrastructure Components' Capital Cost, Investment Year, and Renewal Assumptions, and Operations & Maintenance

Infrastructure	Capital Cost ($M)	Investment Year (yr)	Renewal Frequency (yrs)	Renewal (%)
Upgrade CPS (High Head)	$10,462,500	2020	25	40
Upgrade JPS (High Head)	$6,975,000	2020	25	40
Cut&Cover Forcemain - Courtenay to Jane Place PS	$18,831,500	2020	60	100
Cut&Cover Forcemain - JPS to CVWPCC	$16,588,500	2020	60	100
Cut&Cover Forcemain - JPS to Common Forcemain	$693,000	2020	60	100
Cut&Cover Forcemain - KFN PS to CPS[1]	$682,000	2020	60	100
Odour Control Upgrades for all Stations	$465,000	2020	25	40
Total	$54,697,500			
Initial Annual O&M Cost	$457,500			

[1]Proposed to install forcemain from KFNPS to CPS for this option

Table 13: Option 2 and Option 3 Trenchless Forcemain Installation - Infrastructure Components' Capital Cost, Investment Year, and Renewal Assumptions, and Operations & Maintenance

Infrastructure	Capital Cost ($M)	Investment Year (yr) Option 2 Unphased	Investment Year (yr) Option 3 Phased	Renewal Frequency (yrs)	Renewal (%)
Upgrade CPS (Medium Head)	$6,015,500	2020	2020	25	40
Upgrade JPS (Medium Head)	$4,068,750	2020	2020	25	40
CPS to JPS Including Trenchless Section – Option 2 Un-phased – Option 3 Phased	 $15,255,000 $17,543,250	2020	2040[1]	60	100
JPS to CVWPCC Including Trenchless Section	$23,960,500	2020	2020	60	100
Cut&Cover Forcemain - JPS to Common Forcemain	$693,000	2020	2020	60	100
KFN PS Upgrade (Medium Head)	$581,250	2020	2020	60	100
Odour Control Facility	$465,000	2020	2020	25	40
Total Option 2 (Unphased)	$51,039,000				
Total Option 3 - Phase 1 Total Option 3 – Phase 2 Total Option 3	$35,877,000 $17,543,250 $53,420,250				
Initial Annual O&M Cost – Option 2 Un-phased – Option 3 Phased	 $358,500 $360,500				

[1] assumed for life cycle cost estimate

The parameters used in calculating the Net Present Value (NPV) for future capital investments, asset renewal and operating costs are shown in Table 14.

Table 14: Net Present Value Calculation Assumptions Parameters

Parameter	Value	Unit
Assumed annual rate of return	3.5	%
15-yr Engineering News-Record (ENR) Construction Index rate of inflation	3.0	%
Demand Charge[1]	12.34	$/kW
Power Rate Increase	5.0	%
Operating hrs/day	10	hr

Parameter	Value	Unit
Energy Charge[2]	0.0606	$/kW-hr
Labour Rate	100,000	$/yr
Labour Inflation	3	%

[1] BC Hydro Demand Charge, current
[2] BC Hydro Power Rate, current

Table 15 shows the 30-year and 50-year Life Cycle Cost for each option.

Table 15: Options Life Cycle Costs

Option	Options Description	Initial Capital Cost	Future Capital costs	30-Year Net Present Value				50-Year Net Present Value			
				Capital	Asset Renewal	O&M	Total	Capital	Asset Renewal	O&M	Total
1	Cut&Cover	$ 54.7	$ -	$ 54.7	$ 6.3	$ 16.5	$ 77.5	$ 54.7	$ 12.0	$ 30.5	$ 97.2
2	Trenchless	$ 51.0	$ -	$ 51.0	$ 3.9	$ 12.6	$ 67.6	$ 51.0	$ 7.5	$ 23.1	$ 81.6
3	Trenchless - Phased	$ 35.9	$ 17.5	$ 51.9	$ 4.0	$ 12.7	$ 68.6	$ 51.9	$ 7.6	$ 23.3	$ 82.7

For ease of comparison, the following colour gradient has been used in Table 15. The highest cost in each column is shown in red (right of the color gradient), and the lowest cost in each column is shown in green (left of the colour gradient), with the in-between values shown in the respective colour along the gradient.

The higher capital cost of Option 1 Cut & Cover is primarily due to the larger pipe size needed for the forcemain to reduce the dynamic headlosses so the pump discharge pressure is within acceptable values. The length of the forcemain is also longer, and the pump station upgrades more extensive for the needed higher head pumps.

The 30-year and 50-year Present Value for Option 3 is higher than for Option 2 because of the additional costs that will be incurred due to phasing. This is offset somewhat because the assumed average annual rate of inflation over the next 50 years (represented by the ENR Construction Index, at 3.0%) is less than the assumed average annual rate of return (3.5%). As well, the benefits of the phased approach of Option 3 is that it defers some of the costs so that future users can bear some of the costs, and it allows the CVRD to accrue funding for the second phase over a number of years.

6.0 SUMMARY

Three options from the LWMP Stage 1 Conveyance Options Assessment were advanced to Stage 2 for more detailed assessment. They are: 1) Option 1: Cut & Cover Forcemain Installation; and 2) Option 2: Trenchless Forcemain Installation; and 3) Option 3: Phased Trenchless Forcemain Installation.

OPTION 1: CUT & COVER FORCEMAIN INSTALLATION

For Option 1, the new forcemain will be installed using conventional cut & cover installation methods. Because the forcemain traverses overland, it will cross two hills, Comox Road Hill and Lazo Road Hill before it discharges to the CVWPCC.

Significantly higher discharge pressures will be needed at pump stations to pump over these two hills. The discharge pressures are considered very high for sanitary pumping systems, and pumps will have higher maintenance challenges and requirements. Pumping energy costs will rise significantly from current costs.

The high pump discharge pressures that will be needed at both CPS and JPS to pump over the hills approach the working pressure limitations of the existing forcemain, with accompanying higher risk of pipe failure. Therefore, for Option 1, it was assumed that the entire forcemain would have to be replaced with pipe that has a higher pressure rating, and phasing of the forcemain replacement for Option 1 is not recommended.

Upgrading is feasible at CPS and JPS stations by installing new pumps in the existing wet wells, however upgrading CPS will require more significant modifications due to the dry well/wet well arrangement.

The following are the advantages of Option 1.

- Conventional installation with less risk than using trenchless methods;
- Most of the alignment will be within existing road right-of-ways; some new right-of-ways will be needed, but they can be selected within undeveloped areas.

The following are the disadvantages of Option 1:

- Upgrades of CPS and JPS will be more significant, and therefore, more expensive;
- Because of the high pump discharge pressures needed, it is recommended that for this option, a new forcemain be installed from the KFNPS to CPS to route wastewater to CPS;
- The required high head pumps at each station will have higher maintenance challenges and requirements, and higher operational risks;
- Higher pumping costs;
- Forcemain replacement can't be phased;
- Has the highest initial capital cost, and 30-year and 50-year life cycle cost.

The costs of Option 1 are estimated at:

- Initial capital cost: $54.7 million
- Initial annual O&M cost: $457,500
- 30-year Life Cycle Cost: $77.5 million
- 50-year Life Cycle Cost: $97.2 million

OPTION 2: TRENCHLESS FORCEMAIN INSTALLATION

In Option 2, trenchless methods will be utilized to install the forcemain through Lazo Road Hill and Comox Road Hill. Horizontal Directional Drilling (HDD) is the trenchless method being proposed.

Higher pump discharge pressures will be needed at the pump stations, but they will be substantially less than for Option 1, and the discharge pressures for this option are considered to be within acceptable ranges for all pump stations.

The lower discharge pressures can be accommodated within the existing forcemain, so replacement of the forcemain can be phased.

The following are the advantages of Option 2:

- Upgrades of CPS and JPS and KFNPS will be less significant and, therefore, less expensive than for Option 1;
- Lower pumping costs than for Option 1;

- Has a lower initial capital cost than Option 1 and has the lowest 30-year and 50-year life cycle cost;
- Forcemain replacement can be phased (Option 3).

The following are the disadvantages of Option 2:

- Trenchless methods carry additional risks, which can have large associated costs if the risk is realized;
- Trenchless alignments will cross private properties, and right-of-ways will be required through these properties.

The costs of Option 2 are estimated at:

- Initial capital cost: $51.0 million
- Initial annual O&M cost: $358,000
- 30-year Life Cycle Cost: $67.6 million
- 50-year Life Cycle Cost: $81.6 million

OPTION 3 TRENCHLESS FORCEMAIN INSTALLATION, PHASED

Option 3 is the same as Option 2 but the forecmain will be installed in 2 phases. Phase 1, from Jane Place Pump Station to the CVWPCC, will be installed initially, and Phase 2, from Courtenay Pump Station to Jane Place Pump Station will be installed in a future phase. This option:

- Has a lower initial capital cost than Option 1, but slightly higher 30-year and 50-year life cycle cost than Option 2.
- Allows replacement of the forcemain around Willemar Bluffs (Phase 1 - Jane St Pump Station to the CVWPCC), but defers the cost of replacing the rest of the forcemain (Phase 2 Comox Pump Station to Jane St Pump Station) until a future date, so that future users can also bear the costs, and the CVRD to accrue funding for the second phase over a number of years.

The costs of Option 3 are estimated at:

- Initial capital cost: $35.9 million
- Future capital cost: $17.5 million
- Initial annual O&M cost: $360,500
- 30-year Life Cycle Cost: $68.6 million
- 50-year Life Cycle Cost: 82.7 million

7.0 NEXT STEPS

To confirm the feasibility of the Stage 2 conveyance concepts, the following next steps are recommended (detailed scope of work currently being developed):

- Develop floodproofing concepts for CPS and JPS to protect against sea level rise;
- Assess CPS wet well/dry well and JPS wet well structures' seismic standard compared to the current Post Disaster seismic standards set out in the BC Building Code, to inform decision making on whether to undertake a seismic retrofit to each station; depending on findings, the need for a seismic upgrade will considered along with other factors, to determine if a rebuild of CPS is warranted compared to upgrading the station; due to site constraints, a retrofit is envisaged for JPS.