Comox Valley REGIONAL DISTRICT

Staff report

DATE: May 9, 2018

FILE: 5330-20/CVWTP

TO: Chair and Directors
Comox Valley Water Committee

Supported by Russell Dyson
Chief Administrative Officer

R. Dyson

FROM: Russell Dyson
Chief Administrative Officer

RE: **Value Planning Study Final Report – Comox Valley Water Treatment Project**

Purpose

To present the findings and recommendations of the recently completed value planning process for the Comox Valley Water Treatment Project (CVWTP) and to provide the rationale and discussion for the recommended updated scope and cost estimate for the CVWTP.

Recommendation from the Chief Administrative Officer:

THAT the revised scope and cost estimate for the Comox Valley Water Treatment Project as presented in the Value Propositions Implementation Response Technical Memo prepared by WSP Engineering and attached as Appendix A to the staff report dated May 9, 2018 be approved, including selection of direct filtration as the filtration technology, and reducing the depth and length of the lake intake.

Executive Summary

The value planning process commenced in January 2018 to review the scope and implementation strategy of the CVWTP with the aim of finding cost efficiencies. This process is a vital step for eligibility for large provincial grants, and the process was attended by a representative of the Ministry of Municipal Affairs and Housing, which administers the grant program.

The value planning process involves a group of subject matter experts analysing the project and trying to find "value alternatives" which may improve the project, primarily focussed on cost, risk and schedule. These experts are a fresh set of eyes on the project, allowing out-of-the-box ideas without being constrained by the greater project context. The project proponent (Comox Valley Regional District (CVRD)) are then tasked with responding to the value planning report, justifying which value alternatives will be incorporated to provide the best value project, and thus the most efficient use of grant funds.

The Value Planning Final Report is attached as Appendix B and includes many value alternatives which have been reviewed and analysed in detail by the project team to determine feasibility. The project team have selected the value alternatives which we plan to implement, and produced a technical memo attached as Appendix A justifying the incorporation or exclusion of each of the options presented in the report. This technical memo will become an addendum to the indicative design of the project and will officially modify the project scope.

The following list highlights the main value alternatives and summarizes the more detailed responses included in Appendix A:

1. To select the filtration technology prior to procurement of the design-build team (PD-29). Allowing flexibility in filtration technology increases procurement risk significantly, as an "apples-to-apples" comparison of design-build proposal becomes more subjective, and is

thus more susceptible to legal challenges. CVRD plan to implement this recommendation.

2. To significantly reduce the length of the in-lake pipeline, reducing the depth of the deep water intake (IR-10/14/61). The water quality and security at a shallower intake (EL120 vs. EL105) is still maintained. CVRD propose to implement this recommendation.

3. To change the project to a river intake, adjacent the water treatment plant just upstream of the penstock diversion dam, and add a floating pump station in the lake to be used in dry years to provide water security (IR-59). This idea poses significant water quality and contamination issues in drought years, with the pump station only able to send down five per cent of the water usually flowing in the summer months and then trying to recover it above the penstock. CVRD propose to reject this recommendation based on water quality, water security, permitting and schedule risk.

4. To build a smaller diameter treated water pipeline for the first phase, and twin this pipeline on a different route (down Lake Trail for example) in the future. This will save capital costs in the short term, approximated at $2 million, and provide redundancy when the second pipeline is built, increasing the resiliency of our system in the future. However, this option has a significantly higher lifecycle cost, approximated between $9 million and $13 million, due to the construction of the second pipeline. Additionally, the Morrison Wetland provides a significant environmental risk to the second pipeline. CVRD propose to reject this recommendation.

5. To install a small diameter sewer forcemain down Lake Trail to connect into the City of Courtenay's collection system, rather than installing dewatering equipment at the treatment plant and trucking filtered material to the nearby landfill. WSP analysed the lifecycle cost of the two options and they were equivalent: no savings would be realised by this option. However, the additional environmental risk of going through Morrison Wetland (as per #4 above) is seen as unacceptable, therefore CVRD propose to reject this recommendation.

In addition, and in light of the above, direct filtration technology from a lake intake is identified as the best value project. All value alternatives relating to membrane filtration are therefore not applicable, as detailed in the technical memo.

Overall, the value planning process confirms the pre-existing major scope items and cost estimate, while increasing contingency, optimizing the in-lake works, and reducing procurement risk. The process has shown itself to be very worthwhile: building confidence in the indicative design and providing a huge boost to grant prospects.

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Stakeholder Distribution (Upon Agenda Publication)

None	

Attachments: Appendix A – "Value Propositions – Implementation Response"
Appendix B – "Value Planning Study – Final Report"

Appendix A

Value Propositions Implementation Response

Comox Valley Regional District
Value Engineering Study

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Contents

1. Introduction

1.1. Project Background

The Comox Valley Regional District (CVRD) water system services a population of 45,000 in the Comox valley. This project is a new water supply system to achieve the requirements of the Vancouver Island Health Authority (VIHA). The system will treat water using filtration and ultraviolet disinfection. Proposed facilities include a Comox Lake intake, raw water pump station (RWPS), water treatment plant (WTP), conveyance pipelines to the existing system and ancillary systems. The project will use a design-build delivery approach.

1.2. Value Planning Study

CVRD retained SVS Solutions to conduct a Value Planning Study. A value study team met in Courtenay with CVRD staff and WSP staff the week of January 15-19, 2018 and reviewed project documentation which included presentation of the material by WSP and visits to the proposed facility locations. Final report was issued by SVS solutions on March 22, 2018.

The Value Planning study generated twelve alternatives and sixteen design suggestions. Capital savings estimates were produced for each of the value alternatives and documented in the Value Planning Report. The value planning team was comprised of a multidisciplinary team listed in Table 1 below.

Table 1 - Value Team Members

Name	Strategic Value Solutions, Inc.	Role
John L. Robinson, PE, CVS-Life, FSAVE	Strategic Value Solutions, Inc.	Value Team Leader
Patrick Carlson, PE	Carollo Engineers, Inc.	Filtration
Allen de Steiguer, PE	Independent Consultant	Civil Engineer
Denis O’Malley, PE, PMP, QSD	Independent Consultant	Constructability
Don Stafford, PE, CVS-Life, FSAVE, CTM	Strategic Value Solutions, Inc.	System Planner
Cecil Stegman, CET, CCE, AVS	Strategic Value Solutions, Inc.	Cost Estimator
Jim Vickers, PE	Separation Processes, Inc.	Membranes
Breanna Kinzel	Strategic Value Solutions, Inc.	Workshop Assistant

1.3. Purpose and Scope

This report reviews the assumptions of each value proposition and responds to each alternative/suggestion from the perspective of additional project knowledge. For valid alternatives or suggestions which are recommended to be accepted, this report discusses how it may be implemented into the proposed design. It also discusses any changes to the proposed alternatives required due to unforeseen issues.

2. Responses to Alternatives

2.1. Project Direction

Two alternatives proposed significantly affect the direction of the project and the way that the other alternatives were reviewed: IR-59 and PD-29. IR-59 proposed a significant change in design of the raw water supply to the treatment plant, using a river intake instead of drawing from the lake. The method to maintain water security with this option, was to deploy an additional floating pump station on Comox Lake during severe drought scenarios to pump just enough water down the Puntledge River to feed the river intake. This alternative introduced water quality, water security and contamination risks to the project. IR-59 is rejected based on this significant increase in risk to the project.

PD-29 identified that allowing flexibility in the DB specification to choose the filtration technology increases procurement and legal risk significantly and complicates the evaluation and comparison of design-build proposals. Therefore, PD-29 is accepted – wherein membrane filtration is dropped and the lower total lifecycle cost of direct filtration technology carried forward. As such, all suggested value alternatives specific to membranes will not be have a response as they are no longer applicable for this project.

2.2. Summary of Alternatives and Design Suggestions

Tables 2.1 and 2.2 provide a summary of each value alternative and design suggestion, respectively, and the corresponding decision by CVRD. A more detailed response to each alternative are in the following sections.

Table 2.1.Summary of Alternatives

Alt No.	Description	Decision
IR-10	Move the intake structure to the end of the tunneled pipe section from the pump station and eliminate the HDPE marine pipeline section.	Partial Accept
IR-14	Move the raw water pump station (RWPS) to a location adjacent to the spit and raise the intake screen location to EL 120 in the lake. Raise PS wet well from EL 125 to EL 129.	Partial Accept
IR-23	Install the pump station near shore with an approach channel.	Reject
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system.	Reject
IR-51	Design the raw water pump station (RWPS) for a capacity of 40 ML/d below lake EL 130.7.	Partial Accept
IR-59	Move the raw water intake to the diversion area on the river near the penstock and provide a floating pump station to withdraw from the lake below EL 130.7.	Reject
IR-61	Set the intake screen base at EL120.	Accept
SC-01	Eliminate the flocculation basins and rapid mix for membranes.	N/A
SC-02	Replace Actiflo® with settling basin and solids removal.	Reject
SC-13	Replace second stage membranes with plate settler or similar.	N/A
SC-23	Optimize the direct filtration design.	Partial Accept
SC-28	Install a sewer without using the penstock corridor and redesign the backwash handing system.	Reject

Table 2.2. Summary of Design Suggestions

Alt No.	Description	Decision
IR-07	Use finite element analysis (FEA) to design the connection with the HDPE marine pipeline and the fixed elements to better understand thermal movement.	Accept
IR-09	Suspend the marine pipeline above the bottom.	Reject
IR-47	Provide a berm around the RWPS for sound attenuation and aesthetics.	Accept
IR-49	Use single, cylindrical screen instead of a “T” screen, mounted on a sled, rather than fixed to the bottom	Reject
IR-60	Revise water system design delivery pressures relative to pressure zones.	Reject
SC-03	Replace centrifuge with belt press or screw press.	Partial Accept
SC-16	Limit membrane suppliers to those who have previously completed 50 ML/d facilities.	N/A
SC-17	Procure only open-platform pressure membranes.	N/A
SC-34	Eliminate all polymer from membrane options.	N/A
PD-02	Break the procurement into three packages: WTP, intake, and pipeline.	Reject
PD-05	Pre-qualify and pre-select the membrane supplier.	N/A
PD-18	Develop an enhanced risk response plan to better clarify and articulate what needs to be done.	Already implemented
PD-26	Retain an independent consultant to provide a third-party review of the procurement documents.	Already implemented
PD-27	Include a disputes resolution board in the design build delivery process	Further Study
PD-29	Reduce or streamline the number of variables in the RFQ/RFP process to reduce complexity in the selection process.	Accept
PD-34	Require a pilot demonstration to prove out the membrane design by the contractor.	N/A

2.3. Increase Reliability

2.3.1. IR-07 – Allow Movement in Marine Pipeline - Accept

It is agreed that the proposed 850 m length HDPE pipe will expand and contract. The indicative design report and drawings accounted for this expansion and it will be a requirement of the DB team. The extent of thermal expansion and contraction will be less based on IR-14 and IR-61 being accepted (reduction in length of the HDPE pipe).

The proposed raw water intake design does include a sliding mechanism. This capability will be maintained in the design and a minimum sliding distance for design build purpose will be added. Whether a full FEA is necessary, or another type of analysis, will be left to the discretion of the DB team.

2.3.2. IR-09 – Suspended Marine Pipeline - Reject

A suspended marine pipeline is not recommended for the following reasons:

- The intake pipeline will be shortened as per IR-61, therefore thermal expansion is less of a risk.
- The shorter intake pipeline is now located on a relatively flat area of lake bed and obstacles will be less likely to affect the pipeline due to the shorter length.
- The proposed raw water intake already includes a sliding mechanism to accommodate thermal expansion.
- The lake bed is relatively level.
- This installation technique is likely to be more expensive and take longer to install.

2.3.3. IR-10 – Delete Marine Pipeline – Partial Accept

This alternative moves the intake structure to the end of the tunnel section where the proposed transition joint is located. This will remove the HDPE marine pipeline and reduce project capital costs.

At this location, the lake bottom is between elevation 122 and 125 metres, and the intake structure is about 3.5 metres tall. Therefore, this may not be acceptable: the minimum clearance at the design minimum lake level must be verified based on the final DB intake design.

If turbidity levels do not vary by lake depth, which has been the case in the last turbidity events, shortening of the marine pipe section can be considered as to not increase the risk to treatment. One drawback of this option is that access to lower water temperatures in the summer will be lost. Colder water is more desirable for chlorine residual performance and lower reaction rates with respect to DBP formation. However, it is recognized that construction time and risk is reduced in addition to cost.

2.3.4. IR-14 – Raw Water PS at Spit – Partial Accept

This concept locates the RWPS on the north side of the spit and south edge of the lagoon. The south edge of the lagoon is filled in to accommodate access. It also proposes the shortening of the HDPE marine pipe to an elevation of EL 120. This concept has already been considered in terms of additional geotechnical investigations required.

Provided agreement with the Fish and Game Association is obtained, this alternative will be accepted but with the following alterations and considerations

- The shortening of the marine pipeline will reduce pipe losses and therefore the diameter could be reduced as stated in the Value Planning Report. However, reducing the raw water intake pipe to a 1000 mm pipe (42' HDPE SDR 26) will not provide significant cost savings as most of the costs are for set-up and installation. Also, because the marine pipe has been reduced in length, the cost savings will be even less.
- A section of the lagoon will be filled in to locate the pump station. The access road will not go along the lagoon but instead connect to the existing Colake Rd, and then be extended to Comox Logging Rd. The raw water pipe will follow the same alignment as this road and not cross the lagoon. A bridge/culvert will be required over the stream.
- The lagoon infill will be built up to an elevation of 138.5 m around the RWPS. All electrical gear must be above the probable flood elevation of EL 140, therefore, the generator and transformers will be located at a higher location.
- It was also proposed to raise the lake intake structure to EL 120. However, the location showed in the value planning report is at EL 121. The shortening of the marine pipe and raising the intake has been accepted but the ground elevations will need to be confirmed before it can be finalized.
- As part of this project, a hatchery is proposed for the Fish and Game Association. The hatchery will likely require cold water which was going to be provided from the deeper intake. This requires review by the Association.
- The value planning team also proposed to raise the RWPS invert level from elevation 125 metres to 129 metres. Elevation 125 metres was selected to ensure adequate submergence of the raw water pump impellers for the design minimum lake elevation of 128.93 metres (the sill elevation of the BC Hydro sluice gates) with allowance for 1.5 metres headloss from the intake structure to the RWPS wetwell (intake and frictional losses). With the reduction in length of the marine pipeline and subsequent decrease in friction losses, the invert elevation of the RWPS can be increased dependent on verification of the pump station hydraulics. Changing the design elevation of the minimum lake level is not accepted..

Cost table in Appendix A shows an updated comparison between the original, value planning and proposed alternative costings.

The estimated savings are less that originally predicted by the value planning team. A shorter length of micro-tunneling was added back into the estimate for the short length of suction pipe between the pump station and when the pipe penetrates the lake bed – further that the unit rate is higher. The road was aligned to run along the existing access road to reduce the amount of fill required and its effect on the adjacent lagoon. An allowance for a bridge and environmental assessments was included as this option will require access across the stream. Also, a blow-off and air valve chamber have been allowed for as this new raw water main route may create additional high and low points in the system.

2.3.5. IR-23 – Shore PS with Approach Channel - Reject

This alternative concept moves the pump station location to within the lake edge at a short distance from shore and with a dredged intake channel instead of the HDPE marine raw water suction pipe. This alternative is not recommended due to the following reasons:

- Increases the chances of a turbidity spike due to near shore activities around the inlet.
- The pump station will be more visible from the public boating area.
- Limited ability to block noise from pumps, VSD, etc with the pump station located in the lake area.
- Increased construction required inside the lake area which will result in an increased requirement for environmental safety measures.
- An onshore location for the generator and transformers is still required as having these located in the lake boundary is not recommended.

2.3.6. IR-46 – Phased Treated Water Pipeline - Reject

This alternative suggests replacing the single 1200 mm treated water transmission pipeline with a 900 mm pipeline on the original alignment and, when required, construct a second 750 mm pipeline on a new alignment. This essentially defers the capital cost, and provides redundancy in the future. This will save capital costs between $2 million (WSP estimate) to $5 million (VP report) in the short term and provide redundancy when the second pipeline is built. However, this option will have a higher present value cost to the project of between $9 million (VP report) and $13 million (WSP estimate) due to the construction of the second pipeline.

The savings for the treated water pipeline size reduction is less than what was indicated in the value planning report since the material costs normally accounts for only about 1/3 of the overall installed cost. This staging alternative is rejected.

2.3.7. IR-47 – Sound Berm - Accept

Berms or sound attenuation structures will be implemented where possible to reduces the noise pollution to the adjacent camping grounding and Game and Fishing Protective Association property. It will also help to improve the aesthetics of the RWPS.

2.3.8. IR-49 – Revised Inlet Screen - Reject

The Value Planning team has proposed to use a single larger intake screen instead of the “T” shaped intake to decrease the overall height and improve constructability. The “T” screen proposed in the current design will give a more linear distribution of flow through the screen area. A single long screen will lead to most of the flow being pulled though the initial part of the screen and then decreases as it gets closer to the end. Also, the height above the lake floor should be maintained, meaning a single larger 1830 mm ID screen will actually mean a larger overall height of the structure.

It was also proposed to use a sled style mounting system for the intake screen. The current design already incorporates a sliding surface to enable the pipe to thermally expand. Because the HDPE marine pipe will likely be shortened, the intake structure will not need to accommodate as much liner movement and a sled is not considered necessary.

2.3.9. IR-51 – Change Raw Water Pump Design Criteria – Partial Accept

The alternative pumps proposed by the value planning team assumes a higher minimum level in the lake of 130.3 and incorporate fixed speed pumps. The fixed speed pumps cause supply gaps at the initial minimum flows and compared to the original design and would necessitate flow control at the WTP (e.g. a modulating control valve).

When Stage 3 restrictions are imposed at EL 130.7, a flow restriction of 40 ML/day is assumed – which may not be valid if fire flows were to take place. However, the system curve will be updated to show that at minimum lake levels the normal flow will (in practice) be lower – creating a zone in the system curve where pump efficiency requirements could be relaxed thus achieving some potential for cost savings. The use of fixed speed pumps is rejected.

2.3.10. IR-59 – River Intake - Reject

This alternative proposes to locate the pump station in the river near the penstock diversion dam. Under normal operation, the water passes through the dam and into the river for withdrawal by the pump station on the river. Upon Stage 3 (or 4) restrictions, a floating pump station in the lake would transfer 80 ML/d into the river to supply to the RWPS allowed during the restriction.

This alternative is a new project as it relates to fish flows, a new intake location, with new environmental reviews. River intakes were considered during Project Definition and removed. As discussed in Section 2.1, this alternative is rejected.

2.3.11. IR-60 – Delivery Pressure - Reject

Maintaining system delivery design pressures will allow the Dingwall and Ryan Road pump station to be decommissioned and reduce O&M costs. The 130 metre HGL is equivalent to the existing system conditions when the penstock flow is low to zero (i.e. existing diversion dam elevation of 131 metres).

2.3.12. IR-61 – Elevate Intake Screen Level - Accept

It is accepted that due to the relatively small turbidity differences found deeper in the lake, an intake at EL 105 is expensive for the value it provides of consistently colder water. Therefore, IR-61 is accepted and its proposed alternative intake pipe alignment will be evaluated.

From the information available, the indicated intake screen elevation is at 121 metres not 120 metres, which will put the top of the screen at approximately EL 125. The final lake bed levels and pipe alignment will be confirmed. Regarding water temperature, the raw water temperature will increase 5 ^{o}C or more in the summer. This was originally viewed as less desirable from the perspective of disinfection by-product (DBP) formation in the distribution system. But since DBP’s are currently not an issue, and since piloting showed that direct filtration was effective at DBP precursor removal, this risk is limited in light of the cost savings.

2.4. Satisfy Criteria

2.4.1. SC-01 – Delete Flocculation Tanks from Membranes – N/A

Removed from design as per PD-29.

2.4.2. SC-02 – Convert BW Equalization - Reject

This approach converts the BW Equalization basins to sequencing clarifiers. Technically this option could work if spent filter backwash waste was the only waste stream, and if the backwash volume was fixed, and if sludge collection were assured, and if there were no upset conditions that required flexibility with the operation of the sequencing clarifiers.

However, this is a limitation to the operation of the filtration process. Currently, maturation water and flocculation tanks drains are also planned for the BW Equalization making it a multiple purpose tank system likely not appreciated by the VE team.

Further, this approach has been used at other facilities and it does not function well (Toronto Island WTP, Summerland WTP). It will result in lower quality water being sent to head of the plant and thickener supernatant is not considered in this proposal. Therefore, for multiple reasons this alternative is rejected.

2.4.3. *SC-03 – Dewatering Technology – Partially Accept*

A belt press will be included as alternative dewatering technologies to the centrifuge in the technical specifications of the design-build package.

2.4.4. *SC-13 – Delete 2nd stage membranes – N/A*

Removed from design as per PD-29.

2.4.5. *SC-16 – Qualify Membrane Suppliers – N/A*

Removed from design as per PD-29.

2.4.6. *SC-17 – Open Platform Membranes – N/A*

Removed from design as per PD-29.

2.4.7. *SC-23 – Adjust Direct Filtration Layout – Partially Accept*

This alternative looks at the optimization of the direct filtration design and has multiple points which will each be discussed below:

- The reorientation of the flocculation basins will be implemented to allow for extension of future flocculation tanks and addition of future sedimentation basins if required with less additional construction costs. The layout will be configured as required to suit the new basin alignment.
- The proposed centrifuge for residuals handling will be kept as the base design but belt press will be allowed. The final selection of technology will be left to the proponent.
- Additional flocculators will be evaluated and final selection left up to the proponent.
- Sewer connection is discussed in more detail in SC-28.

Because only the realignment of the flocculation basins was accepted, this alternative will not provide any substantial cost savings. However, it may potentially provide cost savings if upgrades are required in the future.

2.4.8. *SC-28 – Install Sewer – Rejected*

A sanitary sewer connection was most beneficial under the membrane treatment technology since it would be the most reliable approach to discharging and dealing with the CIP waste stream. This was echoed in the SVS report. Now that only direct filtration remains, this alternative would be a neutral total lifecycle cost saving measure – where increased capital cost is offset by lower operating cost. Therefore, this alternative was revisited in more detail to eliminate thickening, dewatering, and sanitary holding tank with drain field and replace with a sanitary sewer discharging to City of Courtenay. Some important remarks to the SVS report are as follows:

- The proposed corridor is within Lake Trail Road which traverses Morrison Creek wetlands and Highway 19. Therefore, trenchless technology would be required - 300 metres was assumed in the estimate. However, it would also involve new environmental permits in a highly sensitive habitat area whose costs are not accounted for. This is a departure from the information given to the public and stakeholders. While technically feasible, this would be a new risk to the project.

- The option as written by SVS has increased costs for modifying the equalization tanks and assumes eliminating the entire backwash treatment system – which increases the quantity of water released to the sewer to a design rate of 130 m^3/hour (Table 7-21 of IDR). As a substitute to backwash treatment, the report suggests changing the design of the backwash equalization tanks – essentially combining SC-02 with this option. WSP does not support this approach for the reasons described in SC-02. For this review, it was assumed that the backwash treatment would remain. Backwash treatment would reduce the flow to less than 5 m^3/hour consisting of the underflow sludge from the backwash treatment train. As a result of not deleting the backwash treatment, the adjusted savings would therefore be $1.6 million and not $4.55 million (i.e. deleted costs before markup).
- The crossing at the Highway 19 is a low point. Therefore, the proposed sewer pipeline would either operate as a siphon or a lift station would be required. The cost for a lift station is not accounted for in the estimate but would increase construction by approximately $0.3 million. A sewer siphon is not recommended from the risk of plugging and maintenance that would take place in the center of a sensitive environmental habitat.
- The sizing of the sewer at 6-inch in the SVS report is valid for the 130 m^3/hour. The report's estimate for the 150mm diameter sewer of $3.9 million (before markup) is higher than PDR's estimate of $2.2 million but appears to be a valid cost as it accounts for trenchless construction and upgrades to the City of Courtney system. Based on only 5 to 6 m^3/hour, amended capital costs for this conveyance approach would be approximately $1.9 million plus $0.3 million (i.e. added costs before markup).
- According to the Indicative Design Report, the average production of solids is 150 kg/day as dry solids, or 600 kg/day at 25% solids, or about 220 total tonnes per year removed from site via trucks. At $50/tonne tipping fee (PDR section 7.3) plus trucking costs of $40,000 (50 trucks per year) – the disposal costs are $50,000 per year or $1.0 million in present value. Including maintenance of dewatering ($0.54 million in SVS report) and sanitary holding tank solids removal – present worth operating cost deleted is $1.6 million.
- SVS present worth operating cost for the sanitary sewer – present worth cost added of $1.0 million.
- Table below shows the costs with mark-up from SVS report applied to the values above, and shows a net project savings of zero as total lifecycle costs, not $1.0 million per the SVS report.

Description	Deletions	Additions
Capital - Delete thickeners, dewatering, and reduce size of residual building.	$1.6	
Capital - Add sewer line with lift station and forcemain for 6 m^3/hour.		$2.2
Present Worth – Delete thickener and dewatering.	$1.6	
Present Worth – Add sewer discharge fees and PS costs.		$1.0
Total Alternative Savings (Increase)	$0.0	

- This option creates multiple issues in terms of environmental reviews through Morrison Creek watershed, MOTI Highway crossing, City of Courtenay costs, and operational implications. Within the accuracy of the estimate, the costs are considered equal but the environmentally risks suggest this alternative should be rejected.

2.4.9. *SC-34 – Eliminate Polymer for Membrane Systems – N/A*

Removed from design as per PD-29.

2.5. Project Delivery

2.5.1. *PD-02 – Change Procurement Strategy*

The procurement will not be broken into separate packages. Breaking the procurement into separate packages significantly changes the design-build procurement strategy. The VP team acknowledged that this would not necessarily provide value and was a matter of subjective opinion. This option would require significant change in implementation methodology, a significant increase in size of the project team, and delay to the project with no measurable benefit to the project.

2.5.2. *PD-05 – Pre-Qualify Membranes – N/A*

Removed from design as per PD-29.

2.5.3. *PD-18 – Risk Register – Already Implemented*

We believe the current risk register is adequate and it will continue to be reviewed by commercial and legal advisors. In principle, this is being implemented.

2.5.4. *PD-26 – 3rd Party Review of Procurement – Already implemented*

This option has already been implemented. CVRD have brought on board Deloitte as their commercial advisor on the project.

2.5.5. *PD-27 – Dispute Resolution Board – Further Study*

This will be brought to the attention of the commercial and legal advisors. Recommendation is generally supported.

2.5.6. *PD-29 – Reduce Procurement Complexity - Accept*

As discussed in section 2.1 this recommendation is accepted.

2.5.7. *PD-34 – Membrane Pilot – N/A*

Removed from design as per PD-29.

2.6. Operation & Maintenance Analysis

The below table summarizes the Operation & Maintenance alternatives outlined in the VP report and the response from Opus. The alternatives which apply to the membrane option will not be responded to as this option will not be taken forward any further.

2.6.1. *Labour*

The VP team has recommended to increase the staffing for the treatment plant from 3 to 5 FTE's. The original labour calculation used one head operator and operator full time and 3 part time personnel. This works out to approximately 3.5 people full time and is summarized in the table below:

Table 2.3: Original Labour Estimate

Type	Hourly Rate	Hours/yr	Cost
Operator (1)	$52	2000	$104,000

Head Operator	$65	2000	$130,000
Mechanic (1/2 time)	$52	1000	$52,000
Electrician (1/2 time)	$52	1000	$52,000
Instrumentation (1/2 time)	$52	1000	$52,000
Total			**$390,000**

The annual cost difference of having 3.5, 4 and 5 full time staff is outlined in Table 2.4 below. Further discussions will be had with CVRD to confirm final labour cost allowance.

Table 2.4: Labour Estimates

Labour	Annual Labour Costs
1 Head Operator + 2.5 Full time (3.5 Total)	$390,000
1 Head Operator + 3 Full time (4 Total)	$442,000
1 Head Operator + 4 Full time (5 Total)	$546,000

3. Conclusion

Of the 28 value alternatives and design suggestions put forward from the Value Planning team, 9 were either accepted or partial accepted. Due to the decision to select direct filtration as the only filtration technology, all of the membrane alternatives (7) are now not applicable.

One major change to the procurement strategy for this project is the preselection of a filtration technology. Direct filtration has been selected as the filtration technology prior to procurement of the design-build team (PD-29). This will decrease flexibility of the design-build proposals and the evaluation will be less subjective. As a result, the procurement risk is decreased and therefore is not as susceptible to legal challenges.

Another change in the design is the decreased depth of the water in-take from EL105 to EL120 and the relocation of the RWPS adjacent to the spit. (IR-10,14,61). This reduces the length of the in-lake pipeline from 1100 m to approximately 160 m and decreases construction complexity. An investigation into the turbidity change of the lake with respect water depth found little change in the turbidity levels and the water quality can be maintained at this shallower depth.

Another major value alternative from the VP report was to build a smaller diameter treated water pipeline for the first phase, and twin this pipeline on a different route in the future. This would save capital costs in the short term and provide redundancy when the second pipeline is built. But this option will have a higher lifecycle cost due to the construction of the second pipeline. Routing, sizing, and timing of future conveyance has been considered in the design; opportunities for optimizing the treated water design remains opportunities for innovation under the design-build procurement method.

Costs for all those accepted or partially accepted alternatives were reviewed and updates were made to the project cost summary which is presented in Table 4 below. The first two columns are as per the original cost estimate in Table 18 of the Indicative Design Report. The next column ‘Direct Filtration: VP Changes’ incorporates all of the accepted value alternatives but does not include the changes to the indirect cost, contingency and escalation. This was included to illustrate how the changes to contingency and escalation has effected the final budget. This final column incorporates all changes including indirect updates, changing escalation to a direct cost and increasing the contingency from 20% to 25%.

Table 3.1: Opinion of Probable Construction Costs

Item Description	2016 PDR	2017 IDR Direct Filtration	VP Changes – Direct Filtration	
			Former Application of Indirect Cost	Revised Application of Indirect Cost
Raw Water				
Intake and Marine Pipeline	$4.94	$5.32	$3.01	$3.01
Pump Station	$4.68	$5.47	$6.70	$6.70
Water Treatment				
Site Works	$1.80	$4.14	$4.14	$4.14
Buildings (Operations)	$10.51[c]	$4.73	$4.73	$4.73
Pre-Treatment/Coagulation	$0.63	$1.19	$1.19	$1.19
Flocculation	$0.79	$1.12	$1.12	$1.12
Filtration	$7.81	$12.10	$12.10	$12.10
Backwash Equalization	$0.62[a]	$1.48	$1.48	$1.48
Backwash Treatment	$0.62[a]	$1.57	$3.01	$3.01
Residuals	$0.00	$2.96	$1.51	$1.51
Primary Disinfection (UV)	$1.57	$1.84	$1.84	$1.84
Residual Disinfection (Chlorine)	$1.55	$0.26	$0.26	$0.26
Clearwell	$4.77	$6.52	$6.52	$6.52
Pipelines				
Raw Water Pipeline	$5.53	$5.46	$6.05	$6.05
Treated Water Pipeline	$11.93[b]	$14.93	$13.96	$13.96
Tie-In	$0.70	$0.45	$0.45	$0.45
Sewer / CIP Waste	$2.44	$0.03	$0.03	$0.03
Subtotal – Direct Cost before Escalation	**$60.92**	**$69.56**	**$68.10**	**$68.10**
Escalation to Midpoint - as direct cost (8%)	-			$5.45
Subtotal – Direct Cost to Midpoint	**$60.92**	**$69.56**	**$68.10**	**$73.55**
Contractor Indirect Cost (10%)	$6.09	$6.96	$6.81	$7.36
DB Engineering (6%)	-	$4.17	$4.09	$4.41
Contingency [d]	$18.28	$13.91	$13.62	$18.39
Subtotal - Construction Cost	**$85.29**	**$94.61**	**$92.62**	**$103.71**
Indirect Costs				
Land Cost - PS	$0.40	$0.70	$0.70	$0.70
Land Cost - WTP	$0.50	$0.60	$0.60	$0.35
Environmental Assessment & Water License	$0.20	$0.11	$0.11	$0.20
BC Hydro Service Extension	$1.50	$1.75	$1.75	$0.15 [f]
CVRD Indirect Costs	$3.41	$2.04	$2.04	$2.04
Engineering and CM (15%)	$12.79	-	-	-
OE Engineering and CM	-	$3.22	$3.22	$3.22
Escalation to mid-point – as indirect cost (8%)	$1.71 [e]	$7.57	$7.41	-
Subtotal - Indirect Cost	**$20.51**	**$15.99**	**$15.83**	**$6.66**
Total Project Cost	**$105.8**	**$110.6**	**$108.5**	**$110.4**

Notes:

a) 2016 PDR carried one line item for “Backwash Systems” which has been split 50/50 between equalization and treatment.
b) Treated water pipeline costs in the PDR were $1.6 million low when compared to TM-4 of the PDR which was $13.50 million.
c) PDR carried filtration superstructure as “building” and is now categorized correctly.
d) Contingency rates were as follows: 30% at PDR; 20% at IDR; 25% following Value Planning.
e) Escalation at PDR was 2% based on construction schedule at that time.
f) Based on actual estimates from BC Hydro using most recent connected load design.

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Value Planning Study

Final Report

Comox Valley
REGIONAL DISTRICT

Comox Lake Water Treatment Project

Comox Valley, BC

March 2018

Strategic Value Solutions, Inc.

Value Improvement Specialists

Final

Value Planning Study Report

for

Comox Lake Water Treatment Project

Comox Valley, BC

March 2018

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Acknowledgements

Strategic Value Solutions, Inc. would like to express our appreciation to the Comox Valley Regional District staff members who assisted us in the review of this project. Particular thanks to Charlie Gore for providing valuable insights into project issues and for assisting in the coordination and management of this study.

In addition, we would like to thank Tim Phelan and other members of the Opus design team for sharing their knowledge about the project and for their responsiveness to our questions and requests throughout this Value Planning study.

This project has an outstanding team and we are pleased to have had the opportunity to play a small role and hopefully make a contribution to the ultimate success of the project.

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

This report presents the results of a Value Planning (VP) Study conducted by Strategic Value Solutions, Inc. (SVS) on the Indicative Design for the Comox Lake Water Treatment Project for the Comox Valley Regional District (CVRD).

Design/Construction Strategy:	Design-Build
Level of Project Development:	Indicative Design
Owner's Engineer:	Opus International Consultants Ltd (Opus)

The VP Study included a 5-day (40-hour) value methodology workshop that was conducted with a multidisciplinary team in Courtenay, BC on January 15-19, 2018.

The purpose of the VP Study was to identify viable alternatives to the proposed indicative design for consideration as value improvements. The Value Alternatives and Design Suggestions provided in this report are only conceptual and advisory in nature. The VP Team makes no project decisions and has performed no detailed engineering analysis beyond that shown within this report.

Project Description Summary

The CVRD water treatment system had been operating under a filtration deferral from the regulatory authority, Vancouver Island Health Authority (VIHA), based on an upgrade to the existing treatment system to include ultraviolet (UV) disinfection. However, after two extended boil water notices issued in 2014 and 2015 during elevated turbidity events, VIHA revoked the filtration deferral and has now direct CVRD to include filtration in their water treatment system.

In response to VIHA's requirements, CVRD commissioned this project which consists of a new water supply with an initial capacity of 80 ML/day expandable to 120 ML/day. The project includes a new intake on the Comox Lake, a new raw water pump station, a new water treatment plant, conveyance pipelines with connections to the existing system, and ancillary systems and facilities.

The project will be administered by the CVRD under a design-build (DB) delivery approach with a single point of responsibility to reduce risks and project costs.

Value Study Team

The Value Planning Team members that comprised this multidisciplinary team are listed on the introductory pages of this report. All other participants of the study are identified in Appendix A.

The VP Team members were independent of the project development team to ensure maximum objectivity towards identifying alternative solutions.

Value Methodology

This VP Study followed the international standard Value Methodology established by SAVE International®, the professional society for value engineering. The Value Methodology (VM) is a six-phase process executed in a workshop format with a multidisciplinary team led by a Certified Value Specialist® (CVS®). Value is expressed as the relationship between functions and resources where functions are measured by the performance requirements of the customer and resources are measured in materials, labor, price, time, etc. required to accomplish those functions. VM focuses on improving Value by identifying the most resource efficient way to reliably accomplish a function that meets the performance expectations of the customer.

With this process, the VP Team identifies the essential project functions and alternative ways to achieve those functions, and then selects the best alternatives to develop into workable solutions for value improvements.

Additional information about the VP Study processes used in the generation of the results presented is provided in Section 2 of this report.

Study Considerations

This section describes some of the key considerations identified during the VP Study.

Action Items

The following were identified as action items for the VP Team. These are aspects of the project or specific issues that the District and/or Opus asked the VP Team to review for concurrence with the current concept or to offer alternative solutions.

- Constructability of the intake, marine pipeline, and raw water pump station specifically regarding micro-tunneling
- Provide any options that would optimize the filtration strategies

Agreements

There are typically a number of agreements, formal and informal, which affect the decision-making throughout the planning and design process. The following were identified as key agreements for the VP Team to consider when identifying alternative solutions.

- The project will use a design-build acquisition strategy
- The BC Hydro penstock corridor can be used for the treated water transmission pipeline alignment but cannot be used for a sewer pipeline
- Land acquisition for the water treatment plant site is close to being finalized

Assumptions

Through the planning and design process, many assumptions have to be made in order to advance the project. The following were identified as some of the key assumptions that have affected the decision-making on this project.

- The highest quality water in Comox Lake is nominally at EL 105 which is below the thermocline
- The existing water delivery system will accept a higher delivery pressure to allow the elimination of existing pump stations in the distribution system
- The project will receive a cost benefit by giving contractors the option to design either a direct filtration or membrane filtration plant

Management Strategy Risks

From the VP Team's understanding of the procurement strategy, there is a substantial risk associated with the planned design-build (DB) request for qualifications (RFQ) and request for proposal (RFP) solicitation process as it was presented to the team. The multiple filtration process variations being contemplated will significantly complicate the proposal selection process and will likely result in procurement delays and an increased potential for litigation by an unsuccessful proposer. With the number of process variables being considered, it will be difficult to write a solicitation package that sufficiently articulates CVRD's requirements and priorities while also providing the contractor sufficient latitude in the design and construction process to benefit CVRD from the DB process. Further, evaluation of proposals will be very complicated, and the final decision-making and selection of a winning proposal will be very challenging.

In the opinion of the Value Team, this one issue has the greatest likelihood to cause project delays.

To mitigate the risks associated with the planned DB approach, the CVRD is encouraged to streamline and reduce the number of variables in the filtration process by making a decision now and selecting a single filtration process based on the technical and operational considerations that are in the best interest of the CVRD. With this decision, the entire DB RFQ/RFP solicitation can be tailored to the specific requirements and priorities of CVRD. Design-build is certainly a proven project delivery strategy and with this revised approach, the Value Team would not be concerned about the Project Team's ability to successfully execute the construction contract. Of course, this approach does not eliminate procurement risks but it does, in the opinion of the Value Team, mitigate the risks by reducing the likelihood of occurrence and making them more easily managed.

Water Quality Objectives

This project is driven by the CVRD's mandate to meet the VIHA requirements to provide a water filtration system that complies with the 4-3-2-1-0 minimum water treatment objectives of the Drinking Water Protection Act which stipulates:

4 - Virus reduction to 4-log (99.99%)

3 - Protozoa reduction to 3-log (99.9%) for both *Giardia* and *Cryptosporidium*

2 - Minimum number of treatment barriers

1 - Maximum allowable turbidity of 1 NTU turbidity (or less if filtered)

0 – (Bacteria) Zero detectable E. coli (fecal) coliforms and zero total coliforms

While the water treatment system needs to address all of these criteria, it is primarily the <1 NTU turbidity criteria that is driving the need for a water filtration plant.

Project Cost Analysis

The Value Team was provided a construction cost estimate as part of the project documentation. This estimate included an anticipated project cost of $110.6 million for direct filtration, $116.9 million for the submerged membrane option, $117.1 million for the pressure membrane based on prices escalated to the mid-point of construction. Currently the CVRD is using $110.6 million as the project budget.

The CVRD is pursuing Provincial grant funding for a portion of the project cost. Because of a mandate that VIHA gave the CVRD to implement filtration by September 2019, the CVRD is discussing the possibility of obtaining early funding from the Ministry of Municipal Affairs and Housing to allow an early construction start to allow project completion prior to the winter of 2020/2021. Based on this potential for early funding, the construction start is scheduled for January 2018 with a 20-month construction duration. If the early funding is not available, then the construction start would be September 2019 with plant operation June 2021.

As a part of this workshop, the team reviewed the engineer's construction cost estimate to verify the estimated costs and ensure that the Value Team had reliable data to use as the basis for cost comparisons of alternative concepts. This review also served as a second opinion on the overall project cost. The review concluded that:

- The direct cost was reasonable for this level of project development
- The order of application of the various indirect markups should be reviewed.
- The markups on direct cost should be applied in a compounding manner instead of additive

The Value Team made the adjustments to the markups and have included the revised cost summary in the Appendix C to this report. These changes were discussed with the CVRD project manager but were not reconciled with the Opus cost estimator.

In addition, the Value Team was asked to provide a second opinion on the long-term owning and operating costs of the new water treatment system considering the three filtration options. In general, the Value Team agrees with the order of magnitude costs identified by Opus and while the Value Team recommends some revisions to Opus's analysis, the recommended changes do not change the original conclusions that the direct filtration system is the lower cost system to operate over the 30-year analysis period.

The following table shows a direct comparison of capital cost and O&M costs for the three filtration options by both Opus and the Value Planning (VP) Team.

	Source	Construction Cost	Project Cost	Present Worth O&M Costs	Total
Direct Filtration	Opus	$94,600,000	$108,600,000	$31,000,000	$139,600,000
	VP	$109,500,000	$116,000,000	$32,200,000	$148,200,000
Submerged Membranes	Opus	$99,000,000	$113,400,000	$38,400,000	$151,800,000
	VP	$114,600,000	$121,000,000	$39,100,000	$160,100,000
Pressure Membranes	Opus	$99,200,000	$113,600,000	$41,900,000	$155,500,000
	VP	$114,800,000	$121,000,000	$41,700,000	$162,700,000

A more detailed analysis of the construction costs and O&M costs are included in Appendix C – Cost Information.

Cost Models

Further analysis of the project cost was conducted using a construction cost model. This model gave the VP Team a better perspective on how the costs are distributed through the project. In particular, the VP Team was looking for those aspects of the project which account for the largest shares of the total cost. This analysis indicated that:

- The new water treatment plant (WTP) accounts for 45%/48% (direct filtration/membrane filtration) of the construction costs
- The new raw water pump station, marine pipeline, and intake structure accounts for 14%-15% of the construction costs
- The raw water and treated water transmission pipelines account for 28%-29% of the total construction cost
- The clearwell storage accounts for about 10% of the total construction costs

Therefore, 42%-45% of the project cost is related to moving water, 45%-48% to filtering and treating water, and 10% related to storing treated water.

The relevance of this analysis is that helps the team better understand the “resource” component of the value expression.

Workshop Results

Using function analysis and Function Analysis System Technique (FAST) diagramming, the VP Team analyzed the functional requirements of this project and concluded that the mission of this project is to *Reduce Interruptions* to service which can be caused by flow restrictions or by water quality restrictions. Specifically, the team defined the basic functions of this project as *Satisfy 43210 Criteria* and *Increase Source Water Reliability*. Key secondary functions that supported these basic functions included *Limit Pathogens, Reduce Turbidity, and Access Lake*. There are two critical dimensions to the function of accessing the lake. One is to access it directly, to avoid using the BC Hydro penstock, and the other is to allow withdrawal when the lake level is below EL 130.7. Analysis of the functions intended to be performed by the project, helped the VP Team focus on the mission of the project and, consequently, to identify alternative concepts that would still meet the mission while exploring opportunities for value enhancement.

Analyzing the functions of this project gave the team the following key insights:

- The lake intake at EL 105 was established based on accessing the highest quality water with an objective to continue operating under a deferred filtration exemption by the VIHA. However, the turbidity excursions have been shown to still effect the lake at this intake level which nullifies the argument for filtration deferral. Even though the initial design assumption is not valid, the intake elevation has not been reevaluated.
- A primary driver for moving the source water intake from the penstock to the lake was to allow CVRD to continue withdrawal, even if the lake level drops below the sill of the sluice gate on the BC Hydro diversion dam at EL 130.7.
- VIHA requires the water quality to meet the "43210" criteria. The filtration plant is needed to address two specific functions; one is to provide two barriers to pathogens and the other is to reduce turbidity below 1 NTU.

Value Alternatives

Table 1-1, at the end of this section, includes a complete list of all the Value Alternatives developed. This table shows the number and title of each alternative as well as a summary of the cost savings. These savings include the capital or first cost savings as well as the present worth value of the savings associated with the long term owning and operating costs over the economic life of the project. The first cost savings and the present worth savings on operations and maintenance (O&M) sum to give the overall life cycle cost savings for each Value Alternative.

After completing the development of the Value Alternatives, the VP Team reviewed the composite list of alternatives to identify what they believed to be the optimum combination of alternatives. This combination represents the best value solution for the project in the opinion of the VP Team. This review concluded that if both direct filtration and membrane filtration are retained as options, then there are four scenarios resulting from the two filtration options and another water source option proposed by the Value Team. These four combinations are detailed in Tables 1-2 through 1-5 - Optimum

Combinations. In summary, these combinations result in the following potential cost savings:

Optimum Combinations - Summary

Optimum Combination	First Cost Savings	O&M Savings	O&M Savings	LCC Savings
Direct Filtration (Lake Intake)	$10,177,000	($8,156,000)	($8,156,000)	$2,021,000
Direct Filtration (River Intake)	$17,640,000	($7,816,000)	($7,816,000)	$9,824,000
Membrane Filtration (Lake Intake)	$14,861,000	($7,214,000)	($7,214,000)	$7,647,000
Membrane Filtration (River Intake)	$22,324,000	($6,874,000)	($6,874,000)	$15,450,000

Revised Life Cycle Cost of Project with Value Planning Savings

	Water Source	Total LCC	LCC Savings	Revised LCC
Direct Filtration	Lake	$148,200,000	$2,021,000	$146,200,000
	River	N/A	$9,824,000	$138,400,000
Submerged Membranes	Lake	$160,100,000	$7,647,000	$152,500,000
	River	N/A	$15,450,000	$144,600,000
Pressure Membranes	Lake	$162,700,000	$7,647,000	$155,100,000
	River	N/A	$15,450,000	$147,200,000

In addition to the cost savings potential of these scenarios, the Value Team also considered a few key qualitative factors and how each scenario responded to these factors. As a disclaimer, this analysis was performed very quickly (about 30 minutes) and was strictly based on the team members' judgment.

Qualitative Analysis of Optimum Combinations

	Direct Filtration (Lake Intake)	Direct Filtration (River Intake)	Membrane Filtration (Lake Intake)	Membrane Filtration (River Intake)
Water Security	→	↓	→	↓
Reliability	↑	↗	↑	↗
43210 Criteria	→	→	→	→
Schedule	↗	↓	↑	↓
DB Ease of Execution	↑	↑	↓	↓

Design Suggestions

In addition to the Value Alternatives, the team also identified 17 Design Suggestions. These are suggestions for changes or clarifications to the project documents that did not have an identifiable or quantifiable cost impact that could be determined within the scope of the workshop. The Design Suggestions from this study are included in Table 1-6 and Section 5 of this report.

Resolution of Value Alternatives

To finalize the Value Planning effort, it is essential that decisions are made on the resolution of each of the Value Alternatives and Design Suggestions presented in this report. This needs to be a collaborative effort between the CVRD and Opus. The ultimate disposition of the findings from this study will be documented separately from this report.

Conclusions

The VP team recommends that the CVRD make a decision on a single filtration technology as soon as possible and then tailor the entire request for qualifications and request for proposal (RFQ/RFP) documents and selection process around obtaining the best solution for that technology. If a decision is not made, the project is at significant risk of delays due to procurement challenges and protests. Further, if the technology options are not simplified, it will be very difficult to clearly communicate to the proponents in the RFQ/RFP what specifically is required in the chosen solution and it will be challenging for CVRD to discern between proposals. While life cycle cost is a valuable discriminator, it can also be easily manipulated. With a single technology, it will be much easier to focus the selection criteria and address all of the factors that are important to selecting the best value solution.

The CVRD is fortunate to have normally high-quality water for their supply. Unfortunately, the Comox Lake has many tributaries that carry sediment during and after major rain events causing turbidity in the normally crystal-clear water. Because of the generally high source water quality, the VP Team believes that either the membrane filtration or direct filtration (granular bed) plant can perform well. The membrane plant will produce a consistent water quality regardless of any anticipated fluctuations in source water quality. The direct filtration plant will require a little more operator interaction to adjust plant parameters as the source water quality changes, but these are very manageable.

Considering a number of factors, including the ease of executing a successful design/build strategy, the VP Team recommends focusing on the direct filtration technology. Further, the team recommends moving the pump station to the spit location and setting the intake elevation at EL 120 which would substantially reduce the length of marine pipe construction. However, if the river is considered a viable and sustainable source and a pump station could be employed to withdraw from the lake when the lake elevation is below EL 130.7 to supplement flow to a river intake, then a river intake could be a very viable solution as well.

If the decision by CVRD is to select membrane technology as the path forward through the RFQ/RFP process, then the VP Team recommends focusing the solution on pressure membranes instead of the submerged membranes. This would provide the simpler design and operations.

Further, regardless of the selected filtration technology, CVRD and Opus should simplify the system for handling filter backwash flows to reduce operating costs and to ensure that the backwash system does not become the limiting factor in the plant's ability to perform as designed.

Table 1-1
Summary of Alternatives

Alt. No.	Description	First Cost Savings	Present Worth O&M Savings	Present Worth Future CapEx	Life Cycle Cost Savings
IR- Increase Reliability					
IR-10	Move the intake structure to the end of the tunneled pipe section from the pump station and eliminate the HDPE marine pipeline section	$2,394,000	$0		$2,394,000
IR-14	Move the raw water pump station to a location adjacent to the spit and raise the intake screen location to EL 120 in the lake. Raise PS wet well from EL 125 to EL 129	$4,007,000	$0		$4,007,000
IR-23	Install the pump station near shore with an approach channel	$3,062,000	($324,000)		$2,738,000
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system	$5,364,000		($8,749,000)	($3,385,000)
IR-51	Design the raw water pump station (RWPS) for a capacity of 40 ML/d below lake EL 130.7	$656,000	$1,549,000		$2,205,000
IR-59A	Move the raw water intake to the diversion area on the river near the penstock and provide a floating pump station to withdraw from the lake below EL 130.7	$11,470,000	$340,000		$11,810,000

Alt. No.	Description	First Cost Savings	Present Worth O&M Savings	Present Worth Future CapEx	Life Cycle Cost Savings
IR-59B	Move the raw water intake to the diversion area on the river near the penstock and provide a larger floating pump station that can also support environmental flows to withdraw from the lake below EL130.7	($4,030,000)	($1,946,000)		($5,976,000)
IR-61	Set the intake screen base at EL120	$2,463,000	$0		$2,463,000
SC - Satisfy Criteria					
SC-01	Eliminate the flocculation basins and rapid mix for membranes	$3,630,000	$628,000		$4,258,000
SC-02	Replace Actiflo® with settling basin and solids removal	$2,269,000	$0		$2,269,000
SC-13	Replace second stage membranes with plate settler or similar	$882,000	$858,000		$1,740,000
SC-23	Optimize the direct filtration design	$806,000	$593,000		$1,399,000
SC-28	Install a sewer without using the penstock corridor and redesign the backwash handing system	$978,000	$49,000		$1,027,000

A = Accepted A/M = Accepted with Modifications P = Partially Accepted FS = Further Study Required R = Rejected

Table 1-2
Direct Filtration (Lake Intake)

Alt. No.	Description	First Cost Savings	Present Worth O&M Savings	Present Worth Future CapEx	Life Cycle Cost Savings
IR-14	Move the raw water pump station to a location adjacent to the spit and raise the intake screen location to EL 120 in the lake. Raise PS wet well from EL 125 to EL 129	$4,007,000	$0	$0	$4,007,000
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system	$5,364,000	$0	($8,749,000)	($3,385,000)
SC-23	Optimize the direct filtration design	$806,000	$593,000	$0	$1,399,000
	TOTAL:	**$10,177,000**	**593,000**	**($8,156,000)**	**$2,021,000**

Table 1-3
Direct Filtration (River Intakes)

Alt. No.	Description	First Cost Savings	Present Worth O&M Savings	Present Worth Future CapEx	Life Cycle Cost Savings
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system	$5,364,000	$0	($8,749,000)	($3,385,000)
IR-59A	Move the raw water intake to the diversion area on the river near the penstock and provide a floating pump station to withdraw from the lake below EL 130.7	$11,470,000	$340,000	$0	$11,810,000
SC-23	Optimize the direct filtration design	$806,000	$593,000	$0	$1,399,000
	TOTAL:	**$17,640,000**	**$933,000**	**($8,749,000)**	**$9,824,000**

Table 1-4
Membrane (Lake Intake)

Alt. No.	Description	First Cost Savings	Present Worth O&M Savings	Present Worth Future CapEx	Life Cycle Cost Savings
IR-14	Move the raw water pump station to a location adjacent to the spit and raise the intake screen location to EL 120 in the lake. Raise PS wet well from EL 125 to EL 129	$4,007,000	$0	$0	$4,007,000
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system	$5,364,000	$0	($8,749,000)	($3,385,000)
SC-01	Eliminate the flocculation basins and rapid mix for membranes	$3,630,000	$628,000	$0	$4,258,000
SC-13	Replace second stage membranes with plate settler or similar	$882,000	$858,000	$0	$1,740,000
SC-28	Install a sewer without using the penstock corridor and redesign the backwash handing system	$978,000	$49,000	$0	$1,027,000
	TOTAL:	**$14,861,000**	**$1,535,000**	**($8,759,000)**	**$7,647,000**

Table 1-5
Membrane (River Intake)

Alt. No.	Description	First Cost Savings	Present Worth O&M Savings	Present Worth Future CapEx	Life Cycle Cost Savings
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system	$5,364,000	$0	($8,749,000)	($3,385,000)
IR-59A	Move the raw water intake to the diversion area on the river near the penstock and provide a floating pump station to withdraw from the lake below EL 130.7	$11,470,000	$340,000	$0	$11,810,000
SC-01	Eliminate the flocculation basins and rapid mix for membranes	$3,630,000	$628,000	$0	$4,258,000
SC-13	Replace second stage membranes with plate settler or similar	$882,000	$858,000	$0	$1,740,000
SC-28	Install a sewer without using the penstock corridor and redesign the backwash handing system	$978,000	$49,000	$0	$1,027,000
	TOTAL:	**$22,324,000**	**$1,875,000**	**($8,759,000)**	**$15,450,000**

Table 1-6
Design Suggestions

ALT NO.	Description
IR-07	Use finite element analysis (FEA) to design the connection with the HDPE marine pipeline and the fixed elements to better understand thermal movement
IR-09	Suspend the marine pipeline above the bottom
IR-47	Provide a berm around the RWPS for sound attenuation and aesthetics
IR-49	Use single, cylindrical screen instead of a “T” screen, mounted on a sled, rather than fixed to the bottom
IR-60	Revise water system design delivery pressures relative to pressure zones
SC-03	Replace centrifuge with belt press or screw press
SC-16	Limit membrane suppliers to those who have previously completed 50 ML/d facilities
SC-17	Procure only open-platform pressure membranes
SC-34	Eliminate all polymer from membrane options
PD-02	Break the procurement into three packages: WTP, intake, and pipeline
PD-05	Pre-qualify and pre-select the membrane supplier
PD-18	Develop an enhanced risk response plan to better clarify and articulate what needs to be done
PD-26	Retain an independent consultant to provide a third-party review of the procurement documents
PD-27	Include a disputes resolution board in the design build delivery process
PD-29	Reduce or streamline the number of variables in the RFQ/RFP process to reduce complexity in the selection process
PD-34	Require a pilot demonstration to prove out the membrane design by the contractor

SECTION 2

VALUE STUDY PROCESS

SECTION 2
VALUE STUDY PROCESS

This section describes the process used to conduct this VP Study and the significant findings of the VP Team. This VP Study used the international standard Value Methodology established by SAVE International®. The standard establishes the specific 6-Phase, sequential process, and the objectives of each of those phases, but does not standardize the specific activities in each phase.

Value Methodology (VM) is the general term that describes the structure and process for executing the Value Workshop. This systematic process was used with a multidisciplinary team to improve the value of the project through the analysis of functions and the identification of targets of opportunity for value improvement.

The **VM Job Plan** provides the structure for the activities associated with the Value Study. These activities are further organized into three major stages:

1. Pre-Workshop preparation
2. VM Workshop
3. Post-Workshop documentation and implementation

Figure 2-2 at the end of this section shows a diagram of the VM Job Plan used for this Value Study.

Defining Value

Within the context of VM, Value is commonly represented by the following relationship:

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

In this expression, functions are measured by the performance requirements of the customer, such as mission objectives, risk reduction and quality improvements. Resources are measured in materials, labor, price, time, etc. required to accomplish the specific function. VM focuses on improving Value by identifying the most resource efficient way to reliably accomplish a function that meets the performance expectations of the customer.

It can be seen from this relationship that Value is improved or increased by:

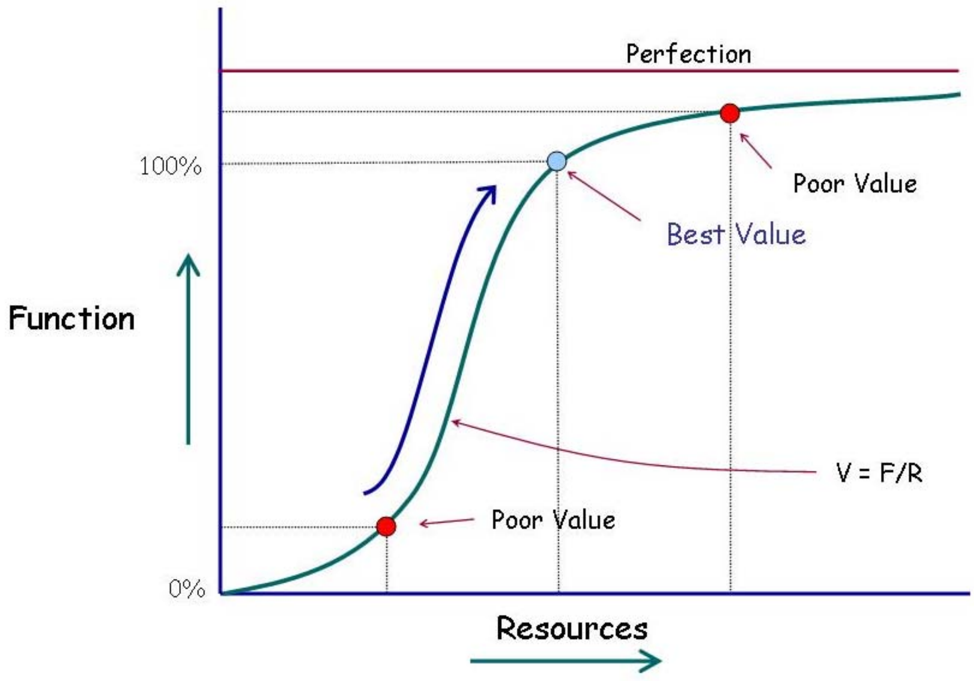
1. Increasing function without increasing resource consumption. Some increase in resources is acceptable as long as there is a greater increase in function performance.

2. Decreasing resources without decreasing function. Again, some decrease in function may be acceptable if the corresponding decrease in resources is significant enough.

Ideally, the VP Team looks for opportunities to increase function and concurrently decrease resource requirements. This will achieve the best value solution.

This Value concept is illustrated in the Figure 2-1, The Value Curve. This figure shows a hypothetical curve from plotting the value expression above. This curve will asymptotically approach perfection. The best value solution for a given project or project element will be found at the knee of the curve. At this point the required function or functions have been achieved to 100% of the required level with a corresponding minimum resource commitment. To attempt to increase the function performance beyond this level will result in a resource consumption that has a higher worth than the marginal increase in function. This results in a poor value solution. Conversely, a poor value solution can also be the result of not achieving the function to 100% of the requirement. In this case, an incremental increase in resources delivers significant increase in function performance. The Value Methodology is used to identify the poor value decisions in a project and then develop alternative solutions to better align the project along this curve to achieve a best value solution.

Figure 2-1
The Value Curve™



This understanding of how Value is affected by changes in function or resources provides the foundation for all SVS Value Studies. The following paragraphs describe the process we used to understand the functional requirements and how we identified value improvement alternatives.

Pre-Workshop

Prior to the start of the workshop, the VP Team was tasked with reviewing the most current documentation on the project development. This was done to familiarize them with the project design and to prepare them for asking questions of the project stakeholders during the project presentations at the beginning of the workshop. Much of the background information for this study was generated by Opus. Other pre-workshop activities included:

- Coordinating workshop logistics and communicating those to the various participants
- Providing guidance to the CVRD and Opus on presentation content for the project introduction
- Scheduling workshop participants and assigning tasks to ensure the team is prepared for the workshop
- Gathering necessary background information on the project and making sure project documentation is distributed to the team members

Materials furnished to the VP Team by the CVRD and Opus are listed in the Appendix.

VM Workshop

The VM workshop was an intensive session during which the project design was analyzed to optimize the balance between functional requirements and resource commitments (primarily capital and O&M costs).

The VM Job Plan used by SVS includes the execution of the following phases during the workshop:

1. Information Phase
2. Function Analysis Phase
3. Creative Phase
4. Evaluation Phase
5. Development Phase
6. Presentation Phase

Information Phase

At the beginning of the workshop, it was important to understand the background of the project from which the plan was developed. This background was provided in an oral overview by CVRD. The overview and subsequent project analysis provided information on the following topics:

- Rationale why this project is necessary
- Project objectives that have governed the proposed plan
- Rationale for the proposed plan configuration
- Explanation of plan features, criteria, and assumptions
- Value Study constraints
- Project cost

This was followed by OPUS's more detailed presentation on the project plan and an explanation of the rationale behind key plan level decisions. Further, this gave OPUS an opportunity to share their issues and concerns about the project from their perspective.

Site Visit

After the project presentations, representatives from the VP Team, CVRD, Opus, and the Ministry of Municipal Affairs and Housing visited the project site. The purpose of the site visit was to give the VP Team members a first-hand opportunity to see the physical features of the project site that influenced the plan development.

From this site visit, the VP Team made the following observations:

- The spit location for the pump station proposed by the project team appears to be a good option
- It was stated that sound really carries across the lake
- Construction access and laydown area should be reasonably good at the lake site
- The plant site will require some significant clearing of trees and brush
- The proposed alignment for the treated water transmission pipeline will require significant tree clearing

Project Cost Analysis

The VP Team's review of the estimate verified the reasonableness of the:

- Estimated quantities
- Estimated unit costs
- Estimated contingencies
- Mark-ups for overhead, profit, bonds, etc.

- Overall project cost

This was done to ensure that the VP Team had reliable data to use as the basis for cost comparisons of alternatives.

The review of the project cost estimate resulted in a recommended increase of the estimated project costs from $110.6 Million to $122 Million. This is approximately a 10% increase over the cost estimate dated July 2017, prepared by Opus.

Significant Cost Issues

The following items represent some of the more significant cost variations identified during the review.

- Increase contingency from 20% to 25%
- Move escalation to mid-point from indirect cost to direct cost
- Change hard cost from hard dollar numbers to percentages
    - o CVRD Indirect Cost (4%)
    - o Engineering and CM (15%)

Economic Data for Life Cycle Cost Analysis

To express life cycle costs, the Value Alternatives have been presented based on discounted present worth cost. The economic criteria used by the team were as follows:

Year of Analysis:	2018
Analysis Period:	30 years
Net Discount Rate:	2.5% per year
Power Cost:	$0.15/kWh
Labor:	
Operations (fully burdened):	$65/hr
Maintenance (fully burdened):	$65/hr
Generalized O&M:	
Civil Infrastructure:	1%/year of capital cost
Overall O&M of Buildings:	2.5%/year of capital cost
Mechanical and Electrical Equipment	5%/year of capital cost

Much of the data used for assessing operations and maintenance costs were taken from Table 18-2 of the Indicative Design Report dated October 10, 2017.

Function Analysis Phase

Function Analysis is the heart of the VM process and is the key activity that differentiates the VM process from other problem solving or improvement practices. During the Function Analysis Phase of the VM Job Plan, functions are identified that describe the expected outcomes of the project under study. Function Analysis also defines how those outcomes are expected to be accomplished by the project plan. These functions are described using a two-word, active verb and measurable noun pairing.

This identification and naming convention of project functions enables a more precise understanding by limiting the description of a function to an *active verb* that operates on a *measurable noun* to communicate what work an item or activity performs. This naming convention also helps multidisciplinary teams to build a shared understanding of the functional requirements of the project.

Function Determination

Defining functional requirements for the project allowed the CVRD to be sure that the project, with the current plan, would fulfill the needed purposes. The entire project was analyzed to determine what functions are being accomplished by the current level. Required functions were retained. Some functions were not necessary to accomplish the mission of the project and thus became candidates for deletion.

During the Function Analysis Phase, the VP Team used various function analysis techniques to analyze the project. This analysis helped the VP Team confirm its understanding of the overall project objectives and analyzed the functions of key project elements. The VP Team Leader led the team through an in-depth discussion of the possible functions of each key project element to clearly and precisely identify the purposes of each.

FAST Diagram

Function analysis was enhanced by using a graphical mapping tool known as the *Function Analysis System Technique* (FAST), which allows team members to understand how the functions of a project relate to each other. The resulting FAST Diagram allowed quick visualization of the logical relationship between project functions and the project as a whole. The FAST diagram is in the Function Analysis section of the Appendix.

The FAST Diagram is structured such that moving to the right of any function answers the question, “How are we accomplishing this function?” Moving to the left of any function answers the question, “Why are we accomplishing this function?” Elements that are vertically connected occur “When” or as a consequence of the function it is connected to on the horizontal path.

The diagram shows on the far left that the ultimate function or the mission that must be accomplished by this project is to *Reduce Service Interruptions*. This is accomplished by satisfying two basic functions: Increasing source water reliability and satisfying VIHA’s 43210 criteria. To increase source water reliability the project is increasing availability of water from the lake by accessing the lake below the sill elevation on BC Hydro’s diversion dam at EL 130.7. To accomplish this, the withdrawal point from the source water is being moved from the BC Hydro penstock to a direct lake withdrawal. By doing this, the CVRD can secure a water source in the lake when they have to initiate Stage 4 water restrictions. This approach also transfers the control of the community's water from BC Hydro to CVRD.

To satisfy the 43210 water quality criteria, the project must limit pathogens in the water and reduce turbidity. While there are other functions to meeting the criteria, these are the primary VIHA criteria that are not being met today which is resulting in boil water notices. To limit pathogens, the project will inactivate and remove pathogens through disinfection and filtration. In the accomplishing the function of reducing pathogens, the project provides redundant barriers to these pathogens getting into the treated water. When the pathogens are inactivated, provisions have to be provided to prevent regrowth in the treated water.

The functions between the two dashed lines, called Scope Lines, represent the functional elements of the project which are within the scope of the VE Study. The first column of functions (basic functions) within the left Scope Line represents the functions that must occur for this project to successfully accomplish its mission. The remaining functions (secondary or support functions) represent how the current plan has chosen to accomplish those basic functions.

Creative Phase

This step in the VM process involved generating ideas using creativity techniques. The team recorded all ideas regardless of their feasibility. In order to maximize the VP Team's creativity, evaluation of the ideas was not allowed during the creative phase. The VP Team's effort was directed toward a large quantity of ideas. These ideas were later screened in the Evaluation Phase of the workshop.

The creative ideas generated by the VP Team are included in the Appendix. The list also includes ratings for each idea based on the Evaluation Phase of the workshop. These lists should be carefully reviewed, as there may be other good ideas not developed by the VP Team because of time constraints. These should be further evaluated or modified to gain the maximum benefit for the project.

Evaluation Phase

In this phase of the workshop, the VP Team selected the ideas with the most merit for further development.

After an initial vote, the VP Team Leader assessed how many ideas could be developed into Value Alternatives within the remaining duration of the workshop. From this assessment, all ideas with a certain number of votes were selected for development. However, prior to the final selection, the results were revisited collectively by the VP Team to ensure that those selected by the voting process truly represented the best ideas for development. This gave the VP Team the opportunity to down-rate some ideas and to up-rate other ideas based upon team discussion of the ideas.

The criteria used for selection were:

1. The inherent value, benefit and technical appropriateness of the idea

2. The expected magnitude of the potential cost savings, both capital and life cycle

3. The potential for CVRD and Opus acceptance of the idea

Ideas were selected for development as Value Alternatives based on all three criteria.

Not all ideas were developed. This evaluation process is designed to identify those ideas with the greatest potential for value improvement that can be developed into Value Alternatives within the time constraints of the workshop and the production capacity of the VP Team. The remaining ideas were eliminated from further consideration by the VP Team; however, the ideas not developed should also be reviewed, as there may still be other good ideas not developed by the VP Team because of time constraints or other factors. These could be further evaluated or modified to gain the maximum benefit for the project.

To further ensure the VP Team is focused on developing the best ideas, a mid-point review meeting is conducted with the VP Team, the CVRD, the Ministry, and Opus representatives. This mid-point review allowed the CVRD and Opus to provide their input prior to the development of the ideas.

Development Phase

During the Development Phase of the workshop, each idea was expanded into a workable alternative to the original project concept. Development consisted of preparing a description of the value alternative, evaluating advantages and disadvantages, and making cost comparisons.

Each alternative is presented with a brief narrative to compare the original concept and the alternative concept. Sketches and brief calculations were also developed, if needed, to clarify and support the alternative. The Value Alternatives developed during the workshop are presented in Section 3 – Value Improvement Alternatives.

The VP Team Leader and, to the extent possible, other VP Team members reviewed each alternative to improve completeness and accuracy.

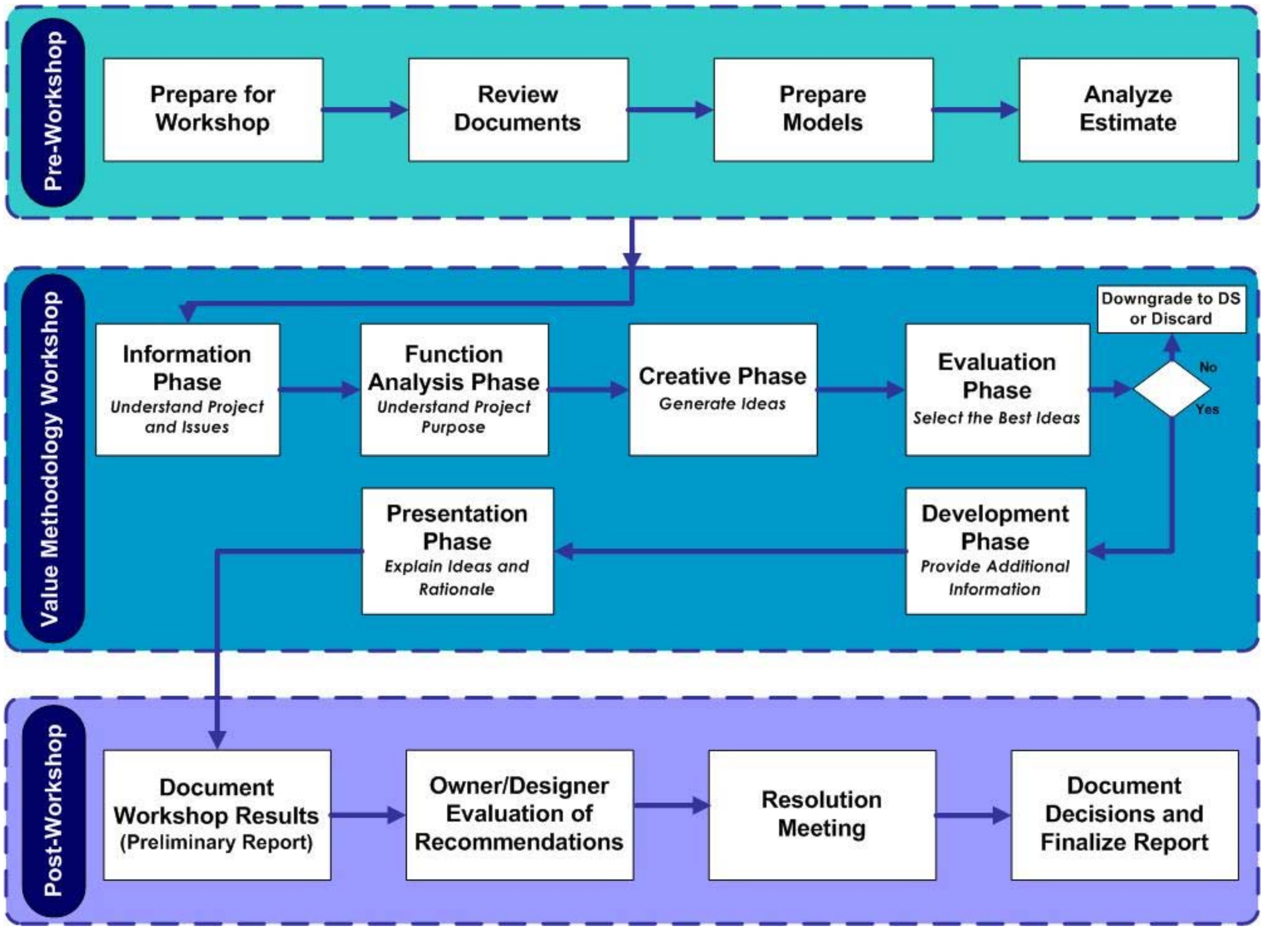
Redesign costs are not included in the cost comparison of alternatives. The responsibility for determining these costs is between the CVRD and Opus. Redesign costs, if any, should be addressed by Opus in their response to the CVRD on the alternatives.

Presentation Phase

The last phase of this workshop was the presentation of the Value Alternatives. The presentation was made by the VP Team on February 19, 2018 to representatives of

CVRD's and Opus's project team as well as the Ministry of Municipal Affairs and Housing. The VP Team described each Value Alternative and the rationale that went into the development. This was followed by answering the audience's questions. The acceptability of the Value Alternatives was deferred pending CVRD's and Opus's review of the Draft Report.

Figure 2-2
Value Planning Process Diagram



SECTION 3

VALUE ALTERNATIVES

SECTION 3
VALUE ALTERNATIVES

The results of this VP Study represent the value improvement opportunities that can be realized on this project. They are presented as individual alternatives for specific changes to the current design.

Each alternative includes:

- A summary of the original concept
- A description of the alternative concept
- A brief narrative comparing the original design and the recommended change
- Sketches, where appropriate, to further explain the alternative
- Calculations, where appropriate, to support the technical adequacy of the alternative
- A capital cost comparison
- And a life cycle cost analysis, if appropriate

Cost was the primary resource that was compared to the functions being accomplished in the project. To ensure that costs were compatible within the Value Alternatives proposed by the VP Team, the project cost estimate was used as the basis of cost. However, the VP Team recommended some changes to the design contingency and the order in which the markups are applied. These changes resulted in a 57.41% markup to the engineer's estimate of direct cost to determine the construction contract cost. See Appendix C – Cost Information for more detailed explanation.

Evaluating the Value Alternatives

Each part of a Value Alternative should be evaluated on its own merit, rather than discarding an entire Value Alternative because of concern over an aspect of the proposed change. Furthermore, the CVRD and Opus are encouraged to review all the ideas shown in the creative idea listing in the Appendix. Since the VP Team was constrained by a finite duration for the workshop and the production capacity of the VP Team, not all ideas were developed. Therefore, there may be other ideas in that list that would provide additional value improvement opportunities for the project.

Organization of Alternatives

The alternatives presented on the following pages are organized by functional categories, and then numerically within each of those categories. The divisions used to organize the alternatives are as follows:

Increase Reliability (IR) – These are generally ideas related to accessing the lake and delivering the water

Satisfy Criteria (SC) – These are generally ideas related to the filtering and treating of the raw water

General – These are ideas that did not fit into the other categories or composite ideas that spanned the two other categories

These designations have been used throughout the VP process to organize the ideas.

INCREASE RELIABILITY

Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-10
Move the intake structure to the end of the tunneled pipe section from the pump station and eliminate the HDPE marine pipeline section	
Description of Original Concept:	
In the original concept, the raw water intake screens will be constructed in Comox Lake and located approximately 1,100 meters south of the raw water pump station at EL105. The intake structure will be interconnected with the pump station wet well via a marine (submerged) pipeline, about 850 meters of which will be placed directly on the lakebed and approximately 266 meters which will be buried under the lagoon at the north end of the lake. The marine pipe will be HDPE assembled using thermal butt fusion or flanged connections at specific points. Flanged connections will be used to connect the pipeline to the screen assembly. As HDPE pipe is less dense than water, ballast weighting will be required to ensure that the pipeline remains at lake bottom once installed. Weighting of ballasts will be a minimum of 20% of the empty buoyant force of the pipe.	
Description of Alternative Concept:	
Eliminate the exposed HDPE pipe and ballast weights to be placed on the lakebed between STA 0+000 and STA 0+835±. Move the intake structure (screen assembly) to the end of the tunneled portion at EL129 or lower. There are no changes proposed to the pump station or screen. However, the alignment (vertical and horizontal) can change if necessary or desirable.	

Value Improvement

Value ≈ Function / Resources

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$2,394,000
O&M Savings:	$0
Life Cycle Cost Savings:	$2,394,000

Advantages/Disadvantages

Alternative No.: IR-10

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Reduces complex marine construction • Reduces amount of work within silt curtains • Shortens the raw water intake line • Reduces head loss in the raw water intake line • Shortens construction schedule for this project element • Moves intake structure closer to shore which may facilitate maintenance • The warmer water at the higher intake elevation will enhance the treatment process • Reduces construction activities in the lake which will reduce risks to the water quality that could result in boil water notices • Reduces the depth of the intake structure which may simplify construction and future maintenance	• Raises the intake level above the design elevation that has been evaluated the most

Discussion

Alternative No.: IR-10

In the Indicative Design, the intake elevation in the lake is set at EL105 which require a 1,100 meter long HDPE submerged pipeline extending from a micro-tunneled section of pipe connecting the intake pipeline to the wet well of the raw water pump station.

The intake elevation was initially established to obtain a filtration deferral from the VIHA. Since then water quality sampling has been performed for an extended period. That sampling did not show a notable difference in water quality throughout the water column in the lake.

Therefore, this alternative is to raise that intake elevation to approximate EL129 which would allow the intake to be moved closer to the shoreline and connected directly to the micro-tunneled section of pipe extending from the wet well of the raw water pump station.

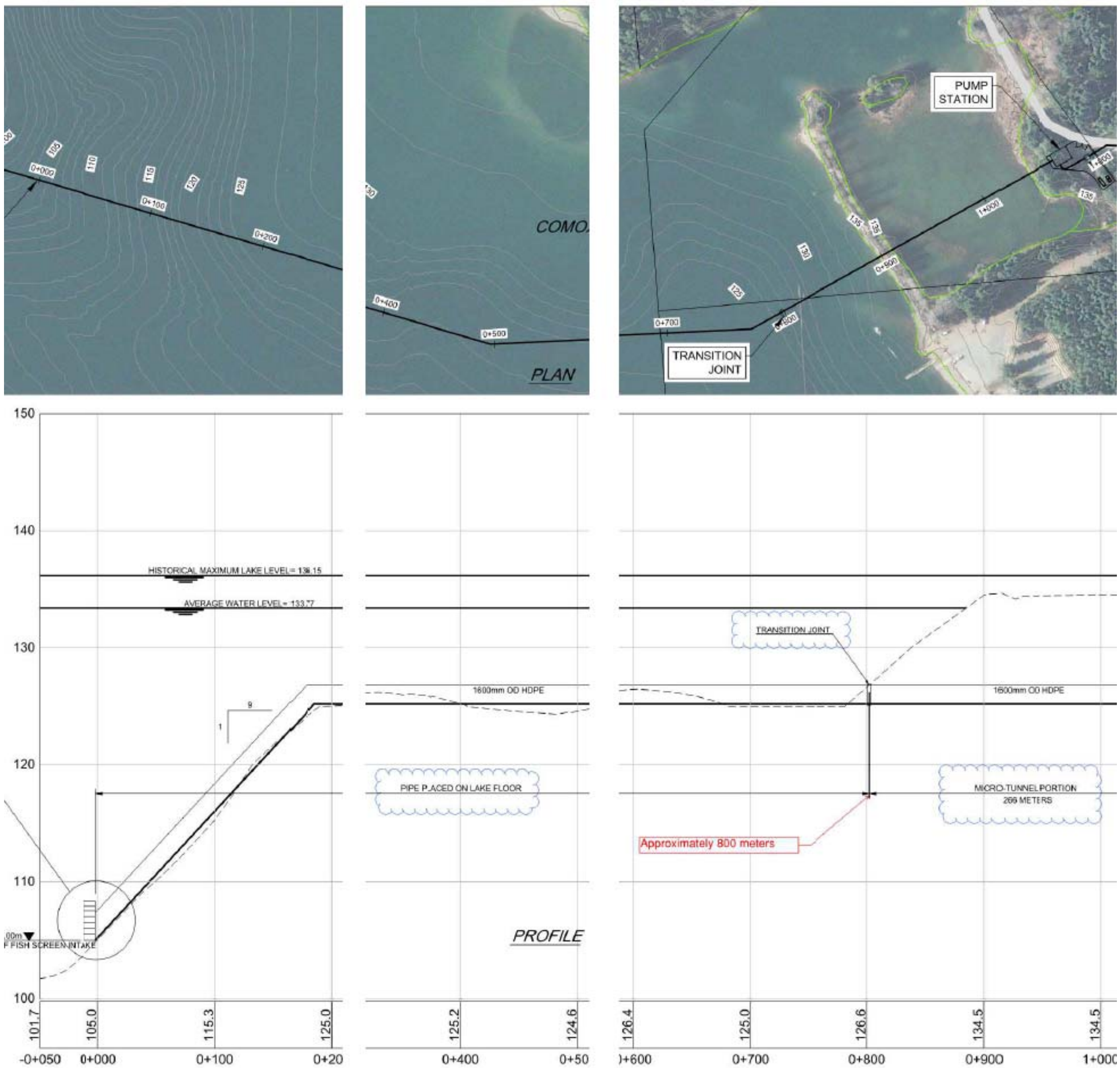
This will eliminate the need for the HDPE marine pipeline and ballast construction. Not constructing this pipeline and concrete ballasting sections will reduce the risk of creating turbidity plume in the lake that would result in another boil water notice.

Based on the water quality data and the fact that the raw water must be filtered, there does not appear to be justification for keeping the intake at EL105. Significant cost savings can be realized by raising the intake without appreciably affecting the plant operations or the treated water quality.

Sketch

Alternative No.: IR-10

☑ Original ☐ Alternative



Raw Water Intake Line STA 0+000 to STA 0+835±

Construction Cost Estimate

Alternative No.: IR-10

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
In-Lake Environmental - Hanging Silt Curtains	LS	50,000.00	1	$50,000	0.5	$25,000
In-Lake Divers Allowance	LS	100,000.00	1	$100,000	0.5	$50,000
In-Lake Pipe - 63-inch dia. (1600mm) SDR 26 HDPE Intake Pipe - supply only	LM	790.00	1,175	$928,250	340	$268,600
In-Lake Pipe installation	LS	150,000.00	1	$150,000		
On Shore Pipe Fusing	LS	20,000.00	1	$20,000	0.49	$9,800
Pipe Ballasts Weights 3.25m spacing supply only (3.0 - 3.5 spacing)	EA	2,000.00	313	$626,000	0	
Total Markup	57.41%			$1,076,007		$202,887
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$2,950,000		$556,000
NET SAVINGS						$2,394,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-14
Move the raw water pump station to a location adjacent to the spit and raise the intake screen location to EL 120 in the lake. Raise PS wet well from EL 125 to EL 129	
Description of Original Concept:	
The original concept sites the raw water pump station (RWPS) on the north shore of the lake, north of the lagoon. An inlet conduit of 277 m is constructed at EL125 on a flat grade from the pump station to the point that it meets the lake bottom. The intake line at this location would be installed using micro-tunneling techniques. The lake intake structure is set at EL105.	
Description of Alternative Concept:	
The alternative concept, is to locate the RWPS on the north side of the spit and south edge of the lagoon. The alternative location includes a pump station with a raised wet well at EL129. The top elevation of the pump station above grade would remain the same as the original. The lake intake structure would be raised to EL120. The raw water pipeline leaving the new pump station location would be routed in one of two locations, as proposed by CVRD.	

Value Improvement

Value ≈ Function / Resources

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$ 4,007,000
O&M Savings:	$0
Life Cycle Cost Savings:	$4,007,000

Advantages/Disadvantages

Alternative No.: IR-14

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Shortens the raw water intake pipeline • Reduces the intake pipe depth, and eliminates the need for a micro-tunnel section • The RWPS substructure is not as deep which will reduce the construction effort • Reduces risk by eliminating the need to micro-tunnel	• RWPS located closer to active land uses (Game and Fish Association) • RWPS electrical house superstructure is taller • Fill is required in the lagoon to support the RWPS and the raw water pipeline • Aesthetic issues and community pushback could occur for any tall/above grade pump station on the spit • Noise from the VFD driven motors could cause an issue with any exposed pump station on the lake

Discussion

Alternative No.: IR-14

The original concept is to construct the RWPS on the north shore of the lake, north of the lagoon. This requires an inlet pipeline of 277 m to be constructed at EL125 on a flat grade from the pump station to the point that it intersects the lake bottom. The raw water intake pipeline at this location would be installed using micro-tunneling techniques. The raw water intake pipeline continues from the end of the micro-tunneled section another 821 m as an HDPE pipeline with an internal diameter of 1,500 mm for a total length of 1,098 m. The intake structure is set at EL105 based on an early decision to access colder water with less turbidity.

The raw water pipeline exits the RWPS at its north side and proceeds up the hill in the direction of the water treatment plant.

The alternative concept, is to locate the RWPS on the north side of the spit and south edge of the lagoon. This alternative location was suggested by CVRD and Opus as an alternative site location at the beginning of this VP study. The VP Team expanded on the concept. The alternative location would include a pump station with a raised invert at EL129. The top elevation of the pump station above grade would remain the same as the original. The intake structure would be raised to EL120. The raw water pipeline leaving the new pump station location would be routed in one of two locations, as proposed by CVRD.

The alternative site location has the following significant impacts on the project. They are discussed from intake to raw water pipeline.

Raw Water Intake and Pipeline. Moving the intake elevation up from EL105 to EL120 in the lake is facilitated by taking advantage of relatively the same lake water turbidity history as the proposed deep-water intake. Moving the intake point to EL 120 shortens the intake pipeline to 160 m, or about 840 m less length. The raised intake elevation and the new pump station location requires less excavation at a shallower depth. allows a dredge-based installation of pipeline, and elimination of the need for a micro-tunnel.

Raising the intake screen elevation to EL120, reduces intake friction losses. The result is that the pipe diameter may be reduced from 1,600 mm to 900-1,000 mm, for a total intake loss of <1 m, and the elevation of the invert in the pump station may be raised from EL125 to EL129, taking into account that water supply levels in the lake below EL130.7 reduce allowable consumption to 40 ML/D (reference CVRD, Jan.16, 2017.)

Raw Water Pump Station. Relocating the RWPS from the original location to the alternate location primarily reduces the length of the intake pipeline, and it reduces the depth of excavation of the pump station structure by about 5 m (20%). It also adds about 150 m to the length of the raw water pipeline. There are more significant construction activities involved with bringing the RWPS site up to an elevation equal to that of the original location that include the placement of fill in the lagoon. The environmental impacts of this fill are currently unclear to the VP Team. Additionally, routing the extended raw water pipeline from the new site to the original RWPS site involves additional fill.

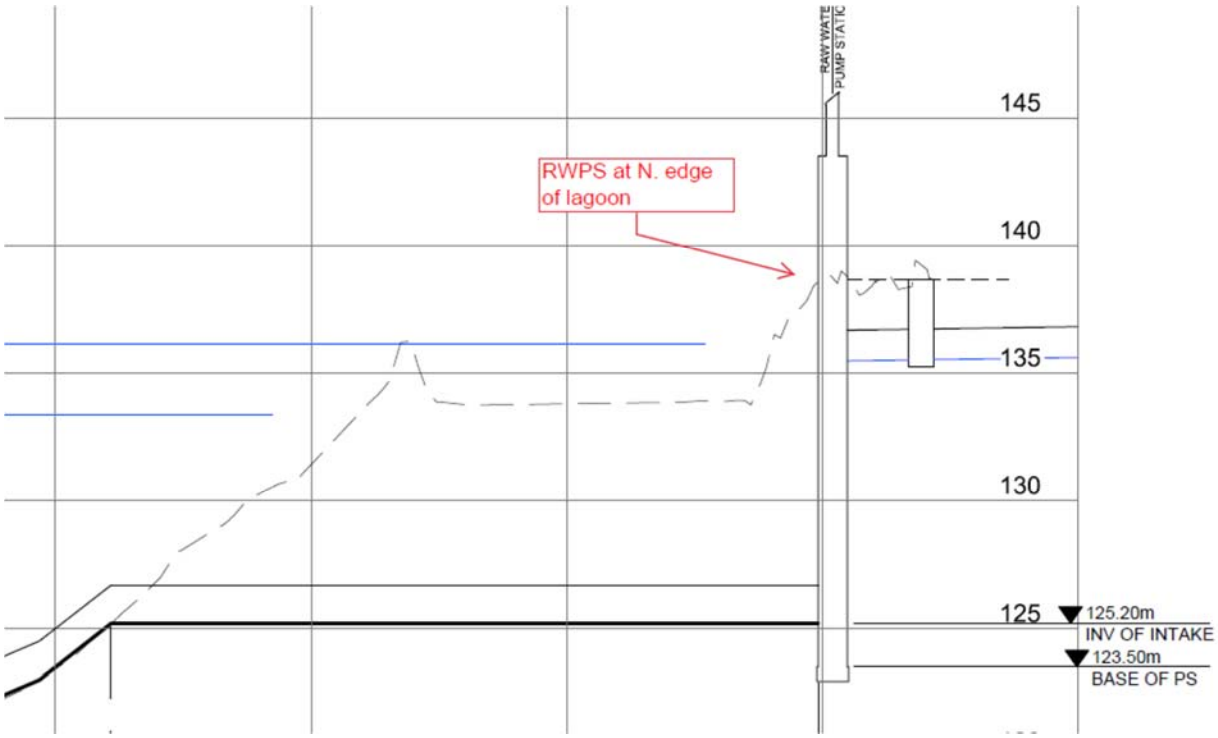
Raw Water Pipeline. The raw water pipeline is extended by about 150 m across the lagoon or very close to it, to reach the alternate RWPS site. The most direct route from the alternate site to the original is along the edge of the lagoon; this would require fill along the lagoon to accommodate the pipeline. Once the fill is in place, the access road for the pump station could be along this same alignment. The anticipated elevation of the roadway would be about EL138, or approximately 4.5 m of fill. Material excavated from the RWPS could be used for part or all of this fill.

Operations and Maintenance. O&M and therefore lifecycle cost does not change for the project.

Sketch

Alternative No.: IR-14

☑ Original ☐ Alternative

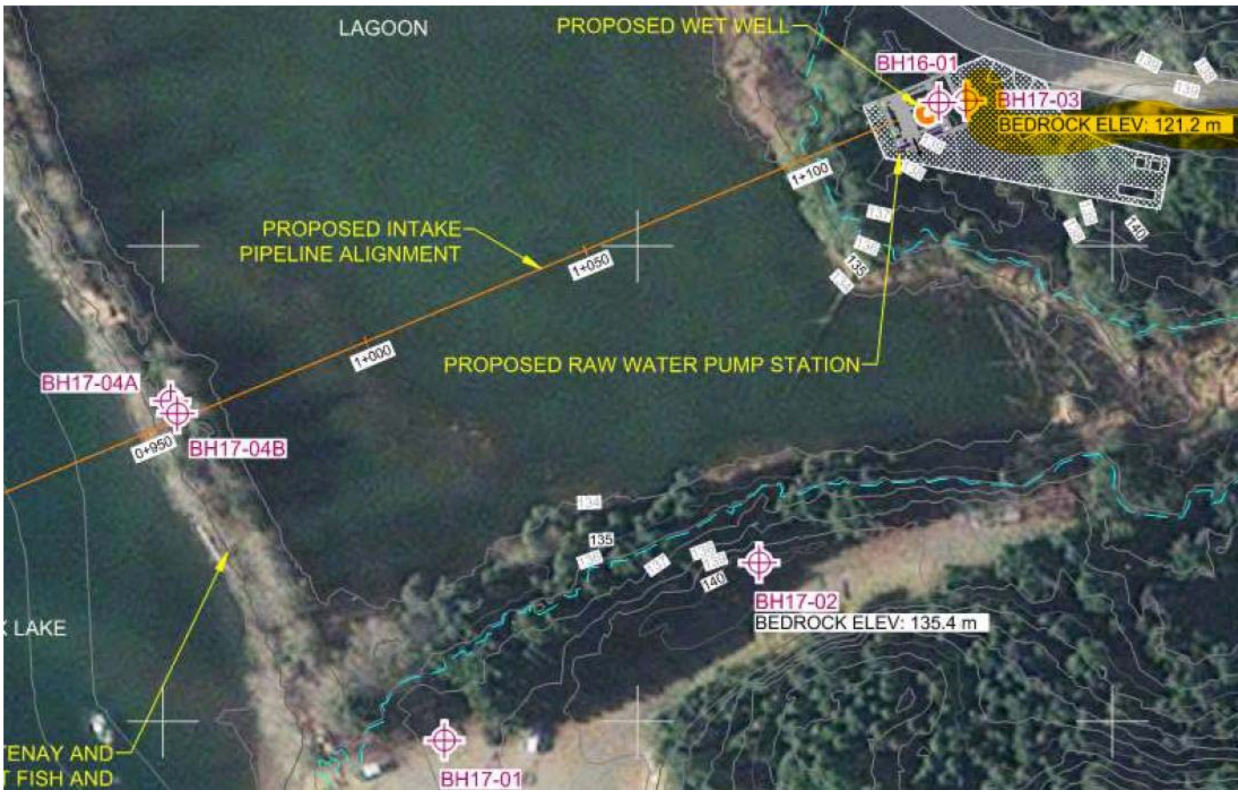


Proposed Raw Water Pump Station Section

Sketch

Alternative No.: IR-14

☑ Original ☐ Alternative

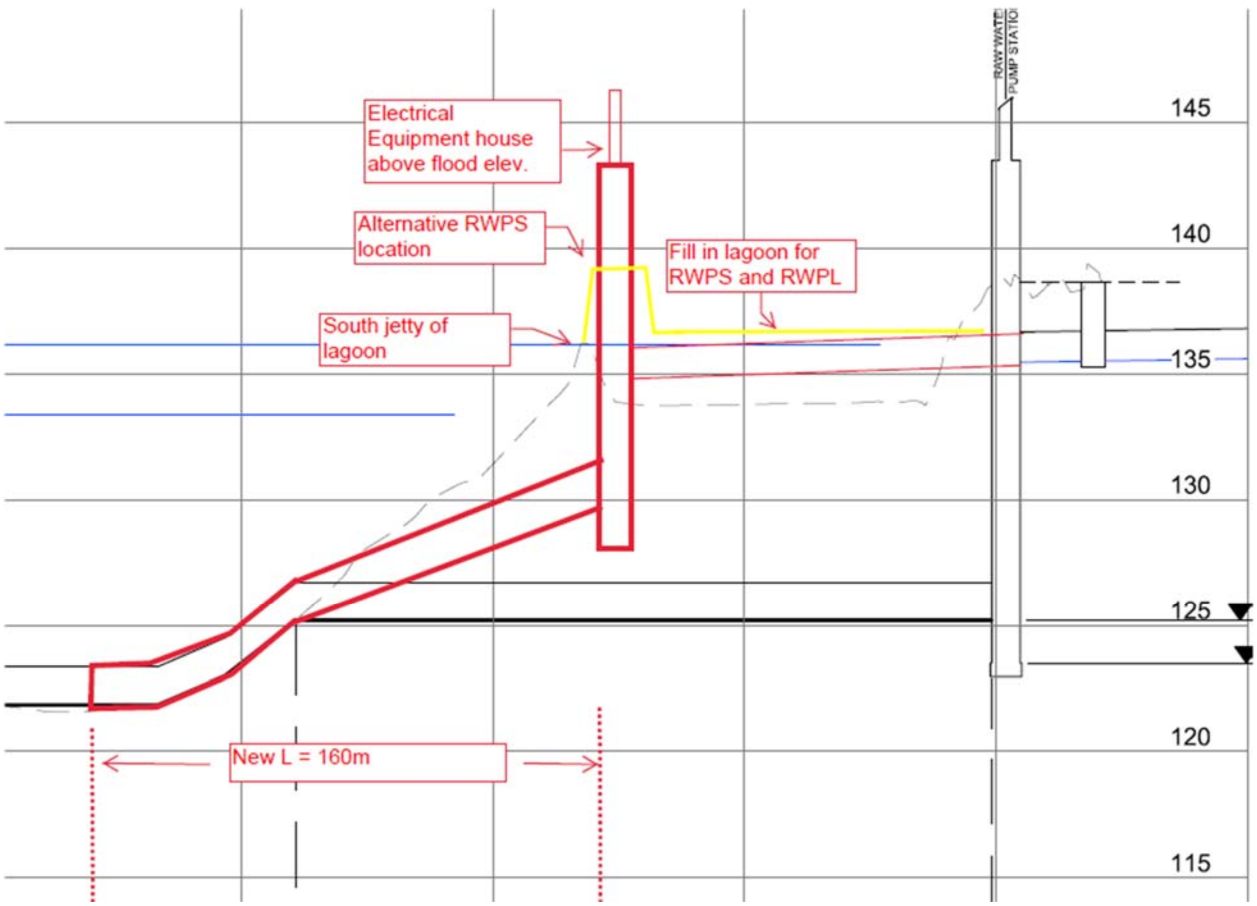


Raw Water Pump Station Site Plan

Sketch

Alternative No.: IR-14

☐ Original ☑ Alternative



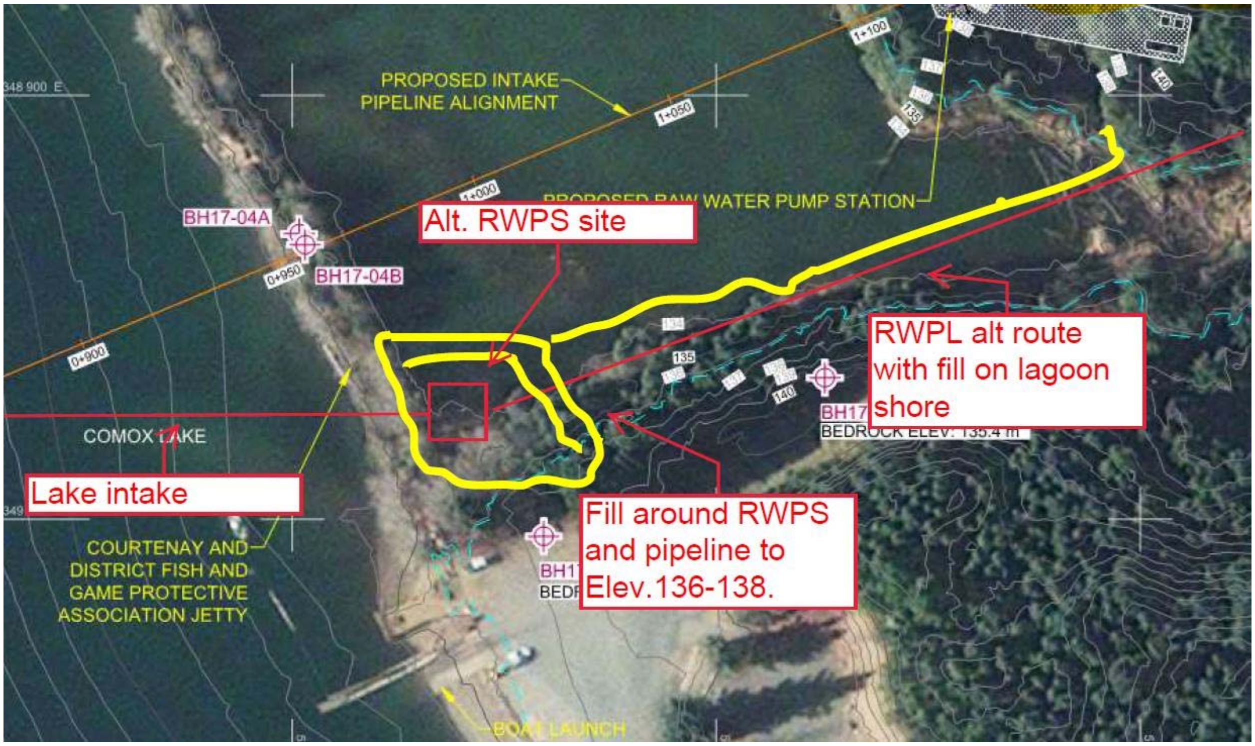
Alternative Raw Water Pump Station and Intake

Note: There are differences between the site plan topography and the profile topographic elevations. The new intake profile is based on the profile topography shown. Profile length may change as a result.

Sketch

Alternative No.: IR-14

☐ Original ☑ Alternative

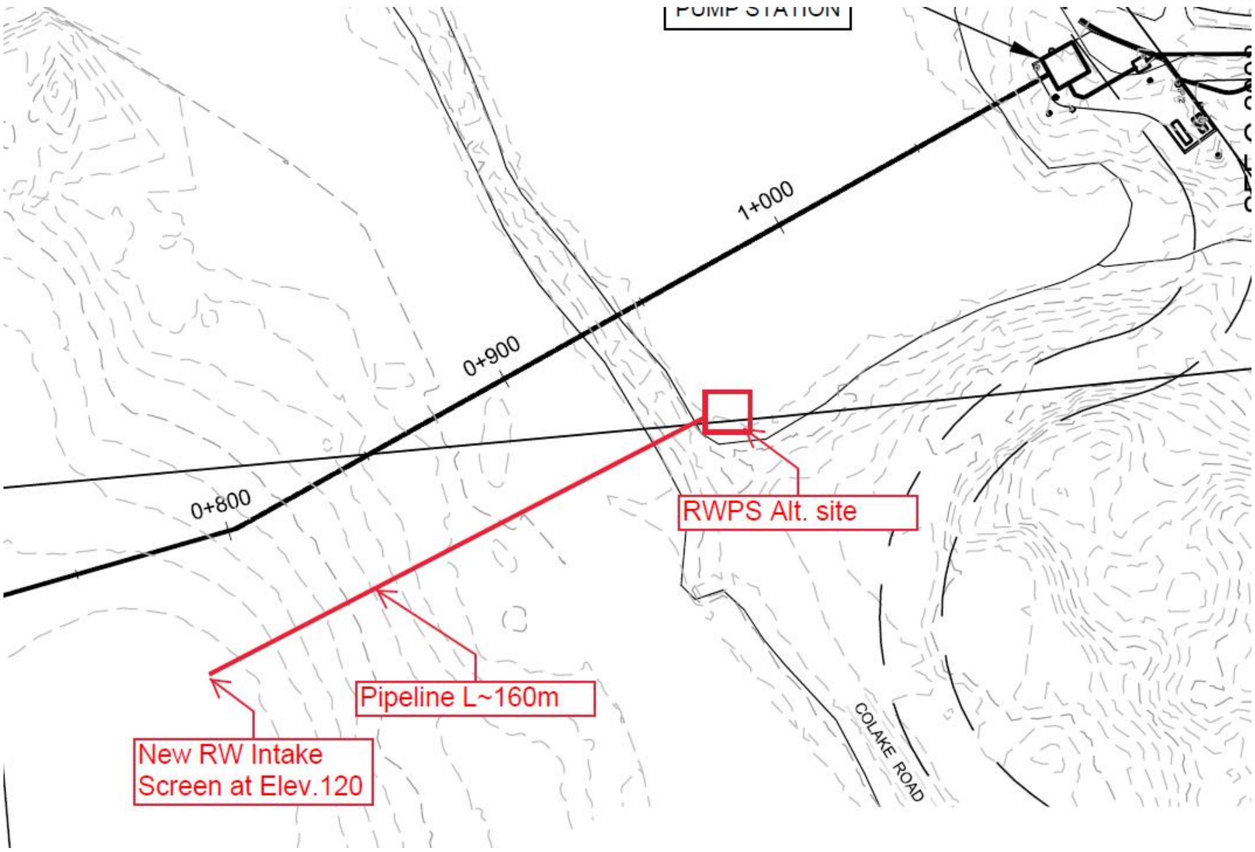


Raw Water Pump Station Site Plan

Sketch

Alternative No.: IR-14

☐ Original ☑ Alternative



Raw Water Intake Pipeline

Calculations

Alternative No.: IR-14

☐ Original ☑ Alternative

Bulk Excavation

Pump Station volume equal 0.75 of original (5 m shallower)

Wall volume: 75% of Original. All other quantities same.

Roadway fill, extended roadway:

150 m length.

15 m width

Average depth 6 m

Volume = 13,500 m^3

Paving, sitework, bollards, lighting, landscaping: 10% additional for extended roadway.

Pump station fill:

Area: 14 m x 12 m excavation area including shoring clearance of 1.5 m around.

Fill area: Pump Station footprint plus 3 m around, 20 m x 16 m area

Depth: (EL138) 6 m

Volume: 20 x 16 x 6 – 14 x 12 x 6 = 920 m^3

Construction Cost Estimate

Alternative No.: IR-14

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
In-Lake - Micro-tunneling (Station 0+820 to 1+115)	LM	$6,500	295	$1,917,500		
Tunneling mobilization	LS	$200,000	1	$200,000		
In-Lake - Micro-tunneling slurry treatment & mtl export	LS	$300,000	1	$300,000		
On-Shore - Site Access Works	LS	$72,720	1	$72,720		
On-Shore Site Clean-Up	LS	$103,880	1	$103,880		
On-Shore Site Clearing/Grubbing, Site Grading, Site Security	LS	$30,000	1	$30,000		
Pipe Ballasts Weights 3.25m spacing supply only (3.0 - 3.5 spacing)	ea	$2,000	313	$626,000	49	$98,462
In-Lake Pipe - 63-inch dia. (1600mm) SDR 26 HDPE Intake Pipe - supply only	LM	$790	1,175	$928,250	160	$188,000
In-Lake Pipe installation	LS	$150,000	1	$150,000	0.3	$37,500
On Shore Pipe Fusing	LS	$20,000	1	$20,000	0.8	$15,000
Environmental Measure	LS	$65,000	1	$65,000	2	$130,000
Backfill and Site Grading	LS	$32,000	1	$32,000		
Bulk Excavation (11350 x 10800) + 5 m	CM	$50	3,536	$176,800	2,652	$132,600
Rock Excavation (11350 x 10800) + 5 m	CM	$260	816	$212,160	816	$212,160
Shoring - Provision	LS	$156,000	1	$156,000	0.8	$124,800
Dewatering - Provision	LS	$50,000	1	$50,000	0.8	$40,000
Select Fill	CM	$100	50	$5,000	14,420	$1,442,000
Site works - Bollards, paving, landscaping, lighting - Provision	LS	$150,000	1	$150,000	1.1	$165,000
Stormwater Management - Provision	LS	$20,000	1	$20,000	1	$20,000
Cast-In-Place Concrete – Walls	CM	$1,870	528	$987,360	396	$740,520
Raw water transmission main 1050 mm (ST) STA 0+965 to 2+675	LM	$2,070	1,710	$3,539,700	1,860	$3,850,200
Total Markup	57.41%			$5,593,095		$4,131,363
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$15,335,000		$11,328,000
NET SAVINGS						$4,007,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-23
Install the pump station near shore with an approach channel	
Description of Original Concept:	
The original concept is a pump station located to the northeast of the lagoon on Comox Lake, with an approximately 1.1 km intake pipe.	
Description of Alternative Concept:	
The alternative concept is a pump station located within the lake a short distance from shore, with a dredged intake channel.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$3,062,000
O&M Savings:	($324,000)
Life Cycle Cost Savings:	$2,738,000

Advantages/Disadvantages

Alternative No.: IR-23

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Eliminates marine pipeline • Eliminates micro-tunneling • Avoids crossing lagoon • Eliminates noise issues that an above grade pump station could cause with long distance sound trade across the lake	• Requires new access road • Requires causeway construction in lake • Requires boat access at lake flood levels • Like the other pump station locations at the spit, this alternative will be highly visible from all locations and residents on the south end of the lake

Discussion

Alternative No.: IR-23

The existing design constructs a new raw water pump station on land at approximate EL138.5, using multiple vertical turbine pumps. A standby generator is provided in an adjacent building. Access is from a logging road. A 1,175 m submerged 1,600 mm intake pipeline will be constructed, terminating in a fish screen. Approximately 295 m of the intake pipeline will be constructed using a micro-tunneling approach.

The proposed alternative constructs a new raw water pump station in the lake, using the same pump capacities, but using submersible pumps. An approach channel will be dredged to the pump station intake. Fish screens will be mounted on the pump station wall.

The pump station will be of similar footprint size to the existing. The generator and variable frequency drives (VFDs) would be installed on the upper floor of the pump station above the probable maximum flood (PMF). The operating floor of the pump station would be at EL137, one foot above the highest lake water level over the last 23 years. Access to the vertical slide rail-mounted submersible pumps would be through hatches in the operating floor. A crane would be required to pull the pumps. The roof elevation of the pump station's upper floor would be at approximate EL145. If other VP alternatives are accepted that affect pump number and sizing, it may be possible to reduce the footprint of the station. A single-entry port has been assumed for costing, but multiple entry ports and fish screens would likely ultimately be installed.

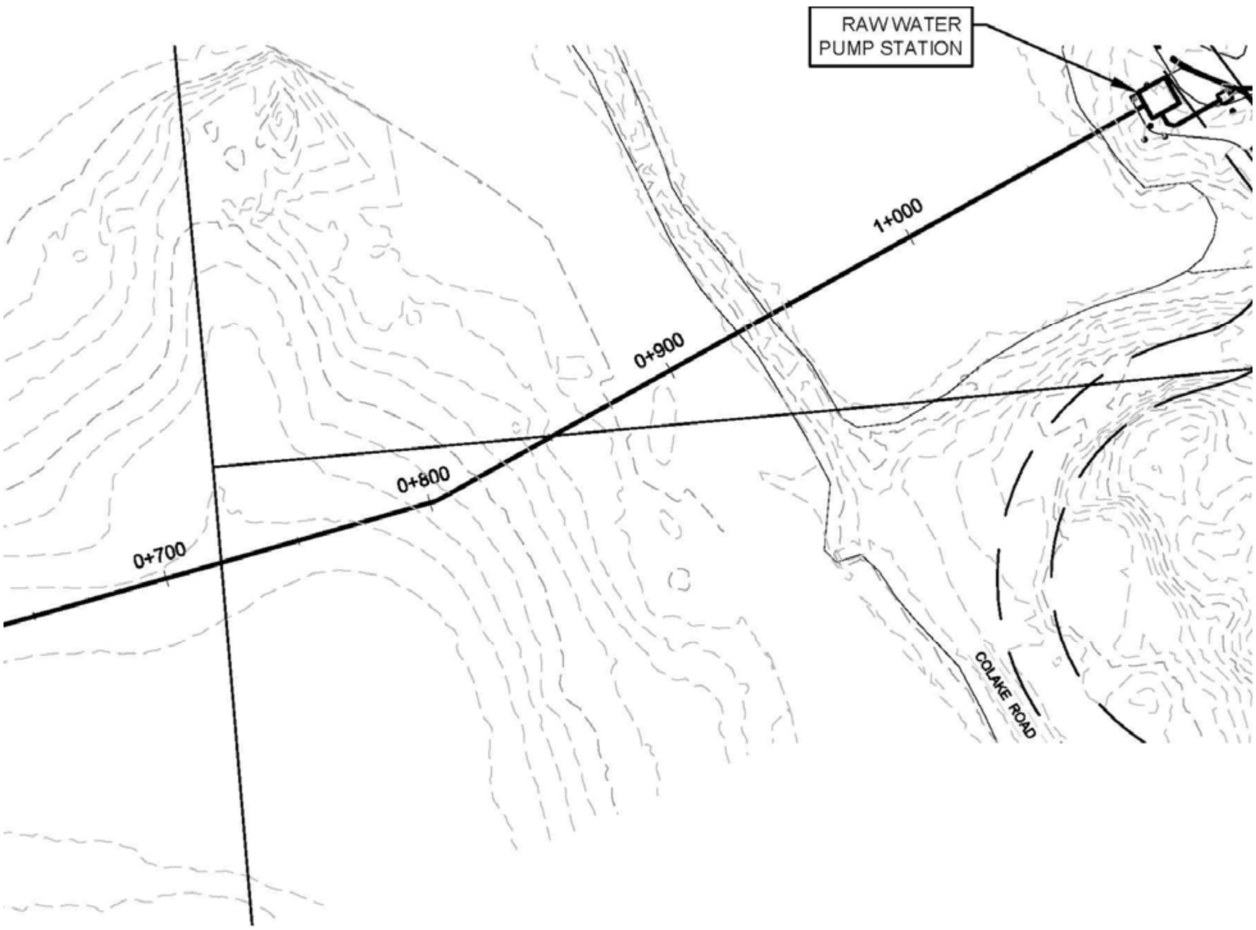
Access to the station would be via an approximately 65 m long earthen causeway, with an asphalt-paved eight-meter roadway. The causeway would use rip rap to minimize erosion. A new roadway would be required across current Rod and Gun Club land adjacent to the lagoon. For this alternative, it has been assumed to be at approximately the current ground elevation. With further review, it may be necessary to raise this roadway, if not above normal lake operating levels.

An entrance channel would be dredged to the lakeside face of the pump station. For this analysis, the bottom elevation of the channel has been assumed to be at EL126.

Sketch

Alternative No.: IR-23

☑ Original ☐ Alternative

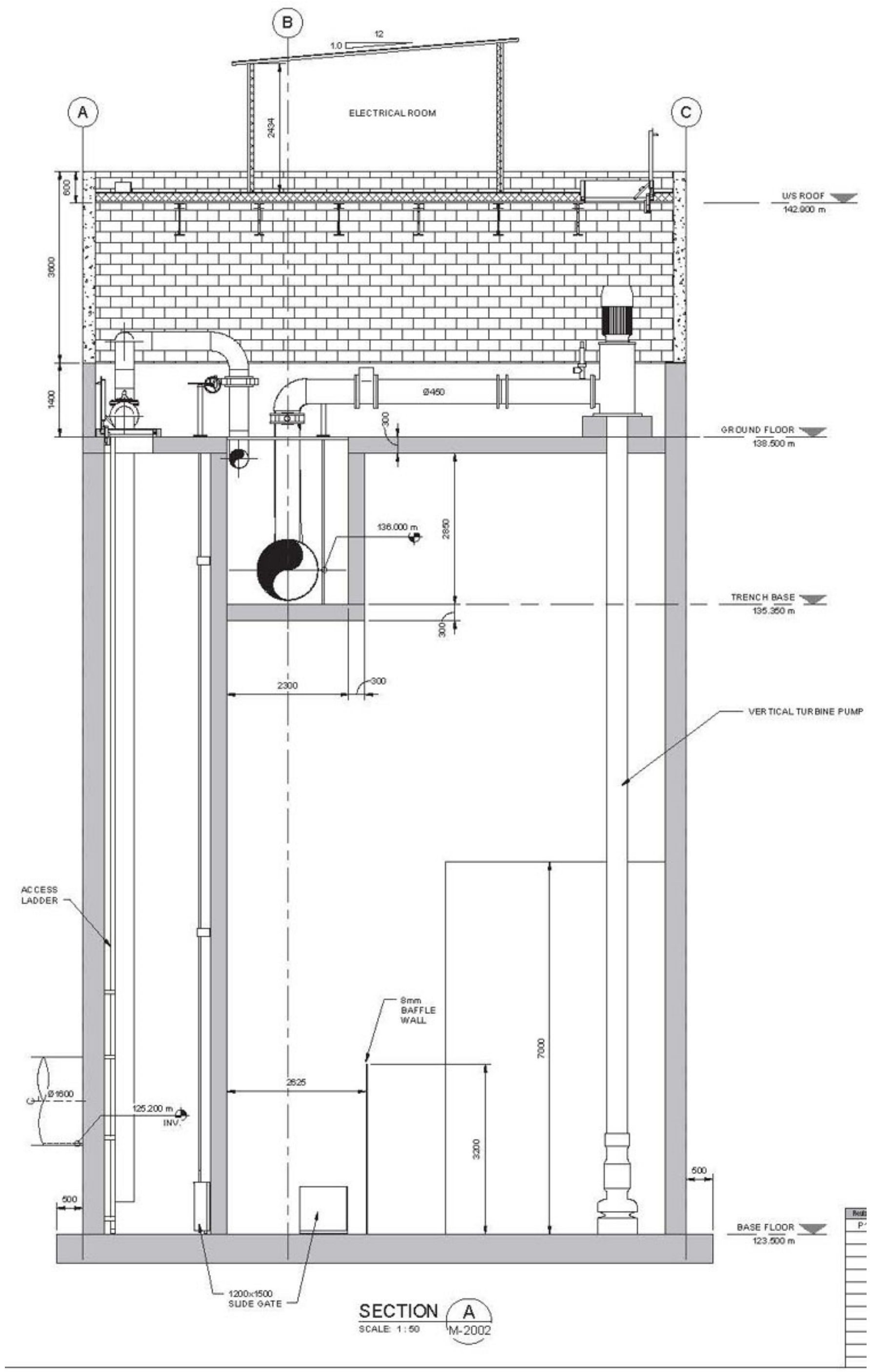


Original Design Pump Station and Intake Pipeline

Sketch

Alternative No.: IR-23

☑ Original ☐ Alternative

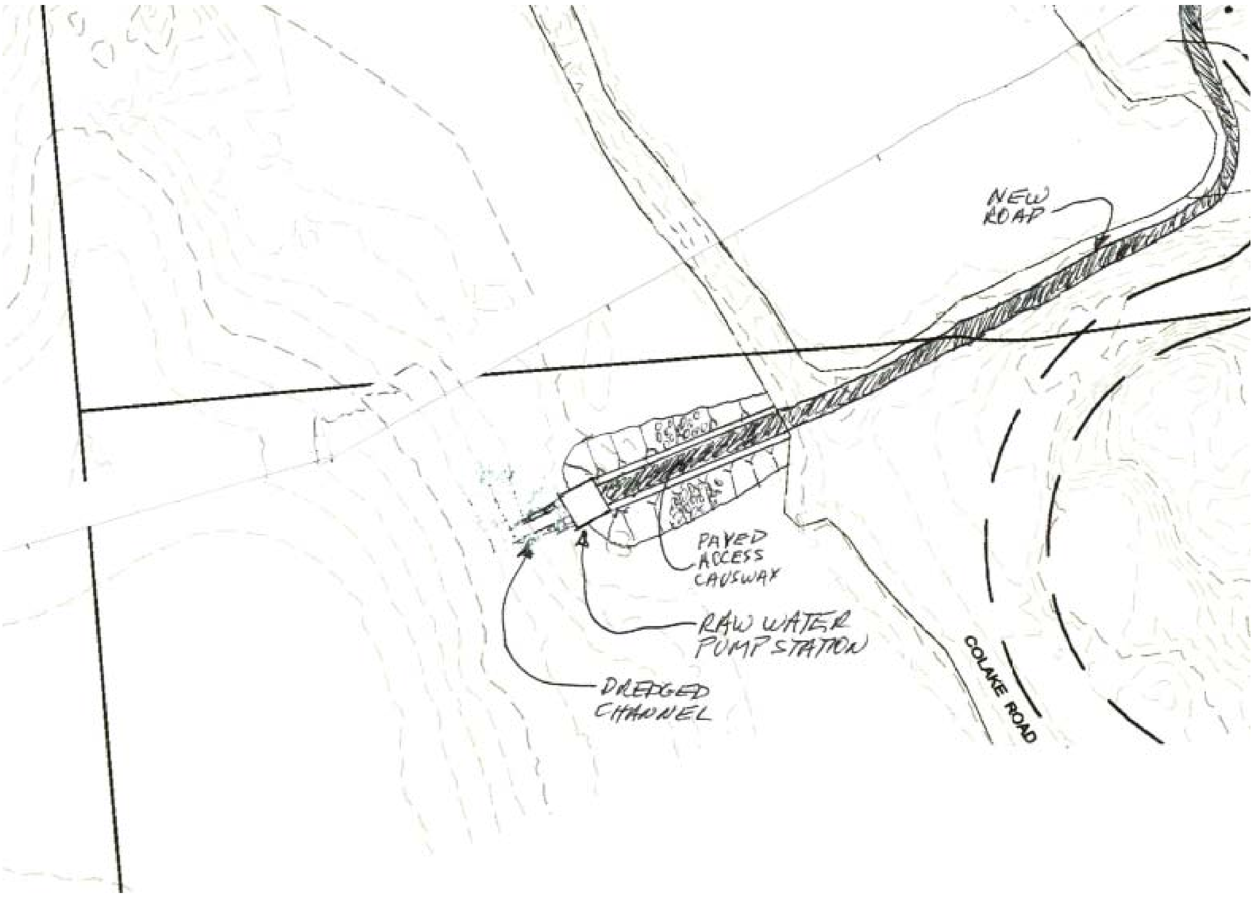


Original Pump Station Section

Sketch

Alternative No.: IR-23

☐ Original ☑ Alternative

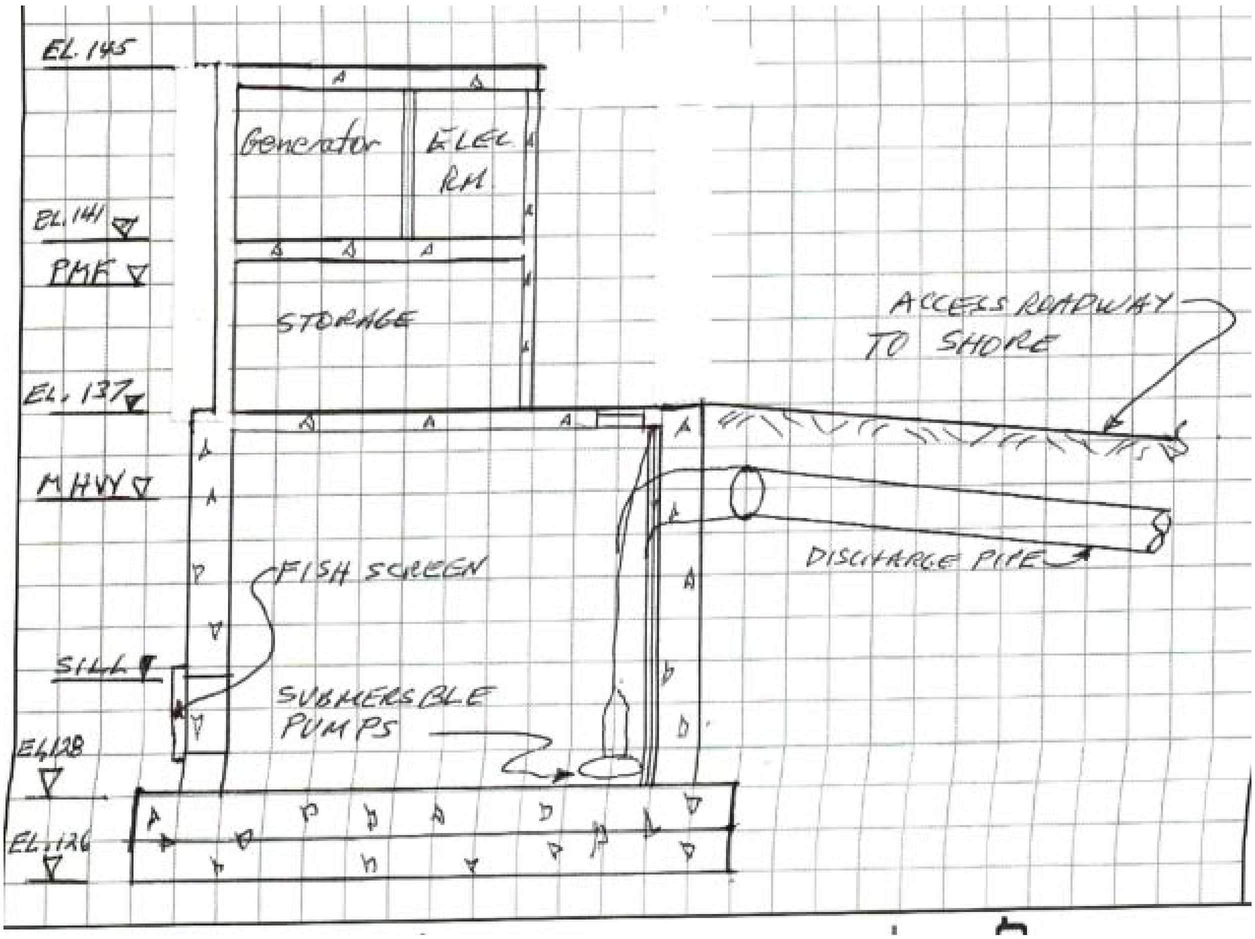


Alternative Pump Station Location with Approach Channel

Sketch

Alternative No.: IR-23

☐ Original ☑ Alternative



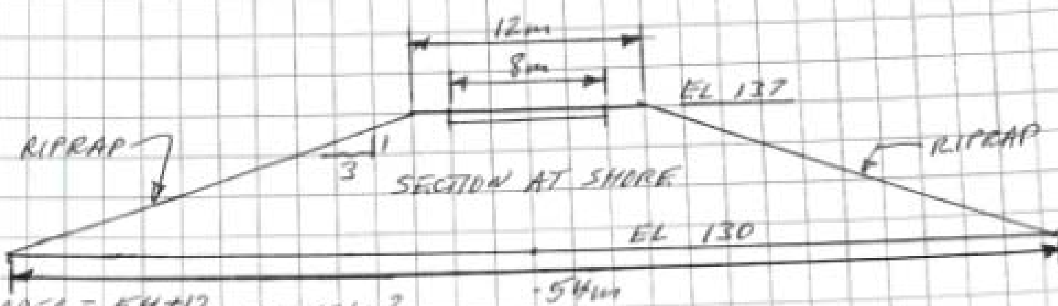
Alternative Pump Station Section

Calculations

Alternative No.: IR-23

☐ Original ☑ Alternative

CAUSEWAY

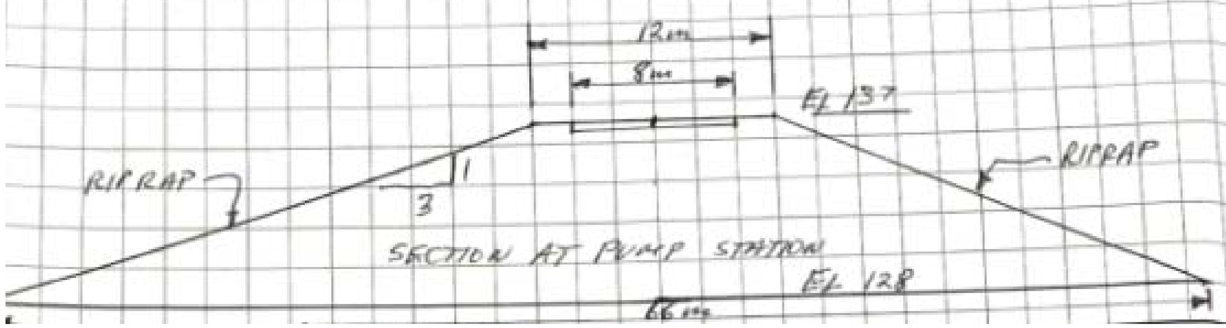


ORE: AREA = $\frac{54+12}{2} \times 7 = 231\ m^2$

p Station = $\frac{66+12}{2} \times 9 = 351\ m^2$

UME LENGTH = 70 m to allow for slope around sides of pump station

ume = $\frac{231+351}{2} \times 70 = 20{,}370\ m^3$



Construction Cost Estimate

Alternative No.: IR-23

			Original Concept		Alternative Concept	
			(Deletions)		(Additions)	
Item	**Unit of Meas**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Intake and marine pipeline (from estimate)	Ea	5,155,100.00	1	$5,155,100		
Pump Station sitework	Ea	866,950.00	1	$866,950		
Pump Station	Ea	4,503,385.00	1	$4,503,385		
Raw water pipeline (trenched)	LM	2,070.00			330	$683,100
Silt screen	LS	50,000.00			1	$50,000
Fill	m3	30.00			20,370	$611,100
Riprap	m2	175.00			3,640	$637,000
sheet pile cofferdam	m2	450.00			3,888	$1,749,600
cofferdam dewatering	Mo	66,000.00			6	$396,000
flow meter and chamber	LS	150,000.00			1	$150,000
Bottom slab	m3	1,250.00			392	$490,000
walls	m3	1,870.00			520	$972,400
suspended slabs	m3	2,080.00			103	$214,240
Paving	m2	48.00			2,640	$126,720
stormwater mgmt	LS	20,000.00			1	$20,000
Stairs	LS	6,000.00			1	$6,000
Doors	Ea	2,080.00			3	$6,240
Artistic concrete finishes	LS	20,000.00			1	$20,000
Painting	LS	8,000.00			1	$8,000
Floor hatches	Ea	8,470.00			3	$25,410
submersible pump 31.5 ML/d-200 hp	Ea	225,000.00			1	$225,000
submersible pump 42 ML/d-250 hp	Ea	325,000.00			2	$650,000
Sluice Gates (1200x1500)	Ea	3,750.00			2	$7,500
Air release valve (100mm)	Ea	9,000.00			3	$27,000
check valve (500mm)	Ea	6,000.00			3	$18,000
Actuated Butterfly isolation valve 500	Ea	43,200.00			3	$129,600
Surge relief valve	Ea	14,400.00			2	$28,800
Piping	LS	221,500.00			1	$221,500
500 kW generator	Ea	175,000.00			2	$350,000
Misc Instrumentation	LS	99,800.00			1	$99,800
Output filters for drives	Ea	2,500.00			3	$7,500

			Original Concept		Alternative Concept	
			(Deletions)		(Additions)	
Item	Unit of Meas	Unit Cost	Qty	Total	Qty	Total
200 HP drive	Ea	24,000.00			1	$24,000
250 HP drives	Ea	26,400.00			2	$52,800
Lighting and general electrical (80%)	LS	20,776.00			1	$20,776
Electrical MCC	LS	350,000.00			1	$350,000
Hatchery cost	LS	192,000.00			1	$192,000
Dredge approach channel	m3	20.00			500	$10,000
Total Markup	57.41%			$6,042,652		$4,925,827
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$16,568,000		$13,506,000
NET SAVINGS						$3,062,000

Life Cycle Cost Analysis

Alternative No.: IR-23

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST	ORIGINAL CONCEPT	ALTERNATIVE CONCEPT
	$16,568,000	$13,506,000
Capital Cost Savings		$3,062,000

ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Raw Water Pump Station power		20.9303		93,000	1,947,000		108,500	2,271,000
Generalized O&M (% of Capital Cost)								
		SUB-TOTAL			$1,947,000			$2,271,000

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
		SUB-TOTAL		$0		$0
		TOTAL PRESENT WORTH		$1,947,000		$2,271,000

PRESENT WORTH SAVINGS ON O&M	($324,000)
LIFE CYCLE COST SAVINGS	$2,738,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-46

Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system

Description of Original Concept:

The original concept is to construct a single 1,200 mm finished water transmission pipeline from the new filtration plant approximately 4.8 km to connect to the distribution system at the existing chlorination facility location.

Description of Alternative Concept:

The alternative concept is to construct an initial 900 mm finished water transmission pipeline on the original alignment, and, when needed, construct a second 750 mm pipeline from the new filtration plant to a connection point in the system near the intersection of Lake Train Road and Inland Island Highway.

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☑ Increased	☑ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☐ Decreased

Cost Savings Summary

First Cost Savings:	$5,364,000
Present Worth of Future CapEx:	($8,749,000)
Life Cycle Cost Savings:	($3,385,000)

Advantages/Disadvantages

Alternative No.: IR-46

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Provides some transmission redundancy in the future • Increases water security in the future	• Requires crossing sensitive wetlands; however, this can effectively be avoided with directional drilling • Requires obtaining easement from timber company

Discussion

Alternative No.: IR-46

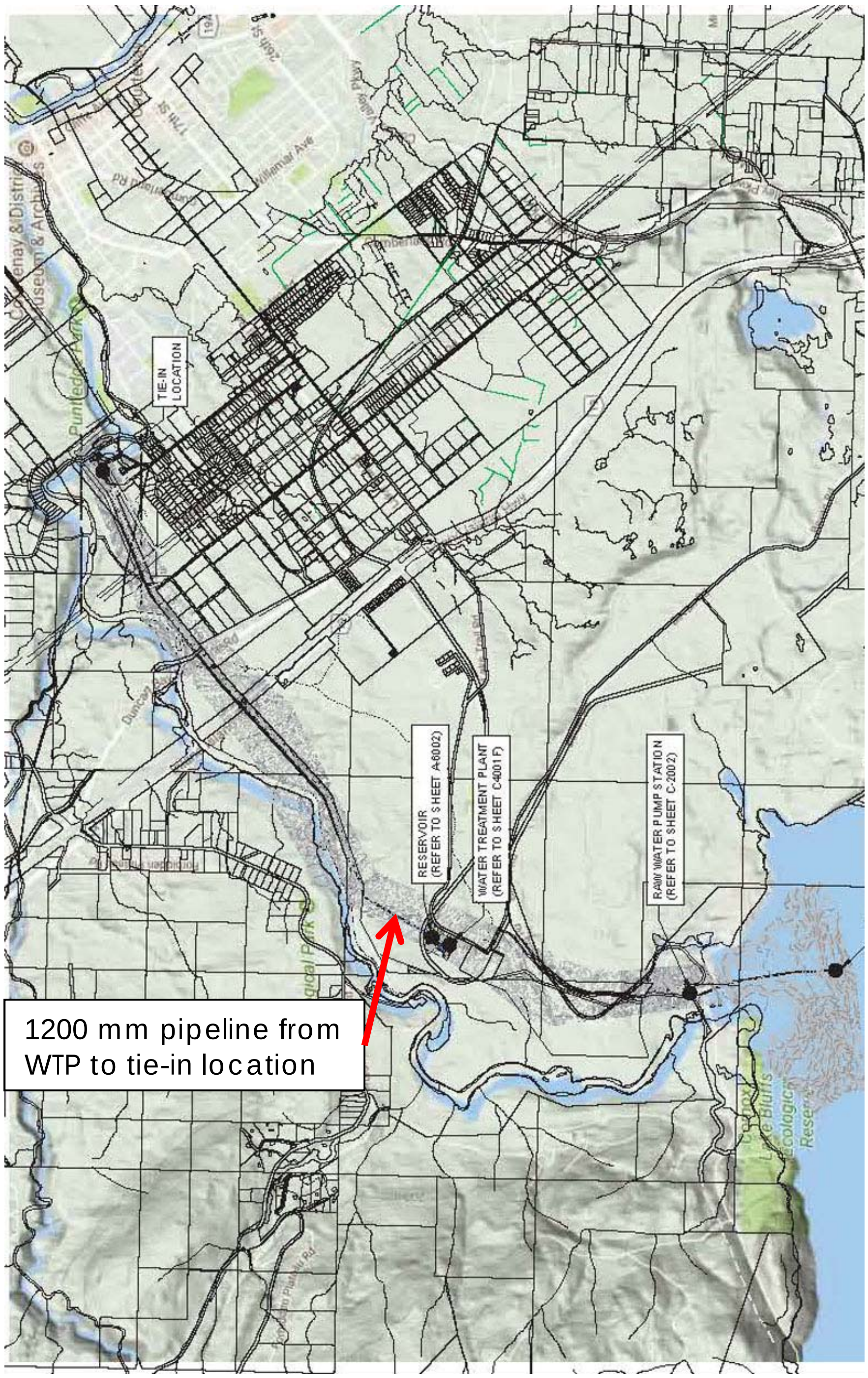
The original design installs the 100-year required transmission capacity in the current project and delivers all of the flow to the distribution system and the current delivery point.

The alternative installs approximately 67 ML/d of transmission capacity along the currently planned alignment initially and defers installation of the additional transmission capacity until later, deferring the cost of added transmission capacity to the future, when additional customers are available to share the cost. The second transmission pipeline would add approximately 47 ML/d capacity (assuming the same allowable headloss per meter) in the future and deliver that water to a different location in the distribution system. This approach limits transmission capacity in the initial years but provides substantial transmission security once the second pipeline is built. For the purpose of this analysis, we have assumed that the pipeline could be installed adjacent to the existing roadways (some of which are timber company roads) by conventional trenching but would be installed with a directional drill through the Morrison Wetlands area. For costing, both pipelines have been assumed to be steel, but it may be possible to construct the second using HDPE, provided pressures are not excessive along the second route.

Sketch

Alternative No.: IR-46

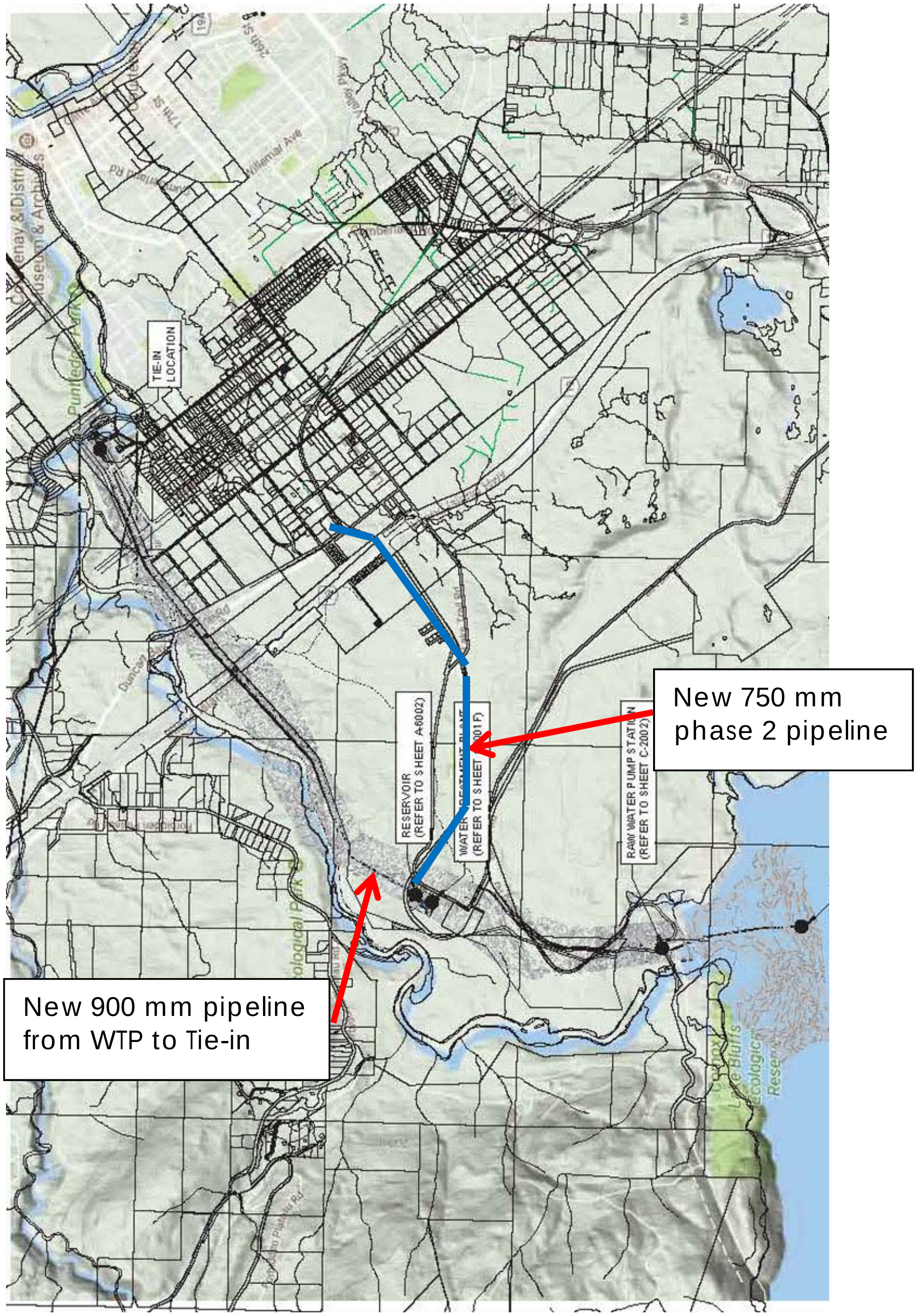
☑ Original ☐ Alternative



Sketch

Alternative No.: IR-46

☐ Original ☑ Alternative



Calculations

Alternative No.: IR-46

☑ Original ☐ Alternative

Existing pipeline size – 1,200 mm

Max flow rate = 120 ML/d = 120,000 m^3/d

Area of pipe =3.1416 x ($1.2m^2$)/4 = 1.13 m^2

Velocity = 120,000/1.13/86,400 = 1.23 m/s

Construction Cost Estimate

Alternative No.: IR-46

Initial Construction

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
1200 mm Duncan Road Crossing	LS	300,000.00	1	$300,000		
1200 mm Highway 19 crossing	LS	500,000.00	1	$500,000		
1200 mm Creek crossing - Bevan Creek	Ea	200,000.00	2	$400,000		
Transmission main (1200mm)	LM	2,380.00	4,820	$11,471,600		
1200 mm line Air Release Valves	Ea	250,000.00	2	$500,000		
1200 mm Line Valve / Blowdown Station	Ea	250,000.00	4	$1,000,000		
1200 mm Tie-ins-Clearwell and Distribution	Ea	40,000.00	2	$80,000		
900 mm Duncan Road Crossing	LS	225,000.00			1	$225,000
900 mm Highway 19 crossing	LS	375,000.00			1	$375,000
900 mm Creek crossing - Bevan Creek	Ea	150,000.00			2	$300,000
Transmission main (900mm)	LM	1,785.00			4,820	$8,603,700
900 mm line Air Release Valves	Ea	190,000.00			2	$380,000
900 mm Line Valve / Blowdown Station	Ea	225,000.00			4	$900,000
900 mm Tie-ins-Clearwell and Distribution	Ea	30,000.00			2	$60,000
Total Markup	57.41%			$8,181,844		$6,225,368
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$22,433,000		$17,069,000
NET SAVINGS						$5,364,000

Construction Cost Estimate

Alternative No.: IR-46

Future Second Pipeline

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
750 mm Road Crossings (assume 2)	Ea	170,000.00			2	$340,000
750 mm Pavement restoration	LM	365.00			3,800	$1,387,000
750 mm Highway 19 crossing	LS	284,000.00			1	$284,000
750 mm Creek crossings (assume 2)	Ea	110,000.00			2	$220,000
Steel Transmission main (750 mm)	LM	1,488.00			3,800	$5,654,400
Air Release Valves (assume 1)	Ea	140,000.00			1	$140,000
750 mm Line Valve / Blowdown Station (3)	Ea	170,000.00			3	$510,000
750 mm Tie-ins at Clear well & Distribution	Ea	20,000.00			2	$40,000
750 HDD bore under Morrison Wetlands	LM	1,065.00			500	$532,500
Total Markup	57.41%					$5,228,845
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix					$14,337,000
NET SAVINGS						($14,337,000)

Life Cycle Cost Analysis

Alternative No.: IR-46

LIFE CYCLE PERIOD 30 YEARS   ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST			ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
					$22,433,000			$17,069,000
Capital Cost Savings								$5,364,000
ANNUAL EXPENDITURE	**%**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**			**ALTERNATIVE CONCEPT**		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Generalized O&M (% of Capital Cost)								
SUB-TOTAL					$0			$0

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
750 mm second pipeline	20	0.6103		0	14,337,000	8,749,000
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$8,749,000
TOTAL PRESENT WORTH				$0		$8,749,000
				PRESENT WORTH SAVINGS ON O&M		($8,749,000)
				LIFE CYCLE COST SAVINGS		($3,385,000)

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-51
Design the raw water pump station (RWPS) for a capacity of 40 ML/d below lake EL 130.7	
Description of Original Concept:	
The original concept, as depicted in the IDR, Section 6 and as shown in the sketch below, uses lake levels from EL137 to EL125 to determine pump sizing. All sizing is based on delivering the ultimate peak day flow of 147ML/d and a minimum flow of 15ML/d. See pump head conditions in the Discussion.	
Description of Alternative Concept:	
The alternative concept comprises a pump selection based on alternative conditions of service as described by CVRD.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$656,000
O&M Savings:	$1,549,000
Life Cycle Cost Savings:	$2,205,000

Advantages/Disadvantages

Alternative No.: IR-51

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Reduces pump horsepower • Reduces capital costs • Reduces O&M cost • May allow reducing wet well size	• Fixed speed pumps used for Stage 4 restriction may cause supply gap at initial minimum day.

Discussion

Alternative No.: IR-51

The alternative concept is based on the following conditions of service, as presented by CVRD.

Normal Service. Normal service ranges from 15 ML/d minimum to 143 ML/d peak day demand, at lake levels above EL130.7, the sill elevation of the overflow dam at the lake.

Flow Restriction. At Stage 4 flow restrictions, when the lake level falls below EL130.7 and the Puntledge River may not have water, the maximum allowable demand is 40 ML/d.

Lake Level. CVRD has indicated that when Stage 4 flow restrictions are invoked, it is assumed the condition could have a duration of up to 180 days. At a maximum demand of 40 ML/d, the lake drawdown is estimated to be 2.4 mm/day (based on a lake surface area of 16.2 km^2) Therefore, the maximum lake drawdown is expected to be limited to EL130.3 (for a total drawdown of 0.4 M over 180 days.)

Given this new information, there is no benefit in assuming lower lake levels. Therefore, pump selection would be based on 40 ML/d at the lowest lake levels, while normal service would be provided above EL130.7 up to EL137. These new head conditions result in lower total dynamic head (TDH) at all operating conditions.

These lake level calculations do not include the effects of evaporation or seepage from the lake bottom.

Pump Selection. For the alternative concept, the pump selection is changed, as follows.

1. Stage 4 Flow Restrictions. Static head changes due to lake level, from EL125 as presented to EL130.3 as calculated for a 180-day flow restriction. At this head, a demand of 40 ML/d will have a static head of 14.7 m and a dynamic head loss of approximately (assuming a "C" value of 140) of 0.6 m. This yields a total dynamic head (TDH) of 15.3 m. It is possible to use fixed speed pumps, but the CVRD must decide if that can be accommodated in this service scenario.
2. Normal Demand. An assumed low lake level of EL125 shown in the IDR, would be raised to EL130.3 for the latest conditions, described herein. Normal demand could vary from 15 ML/d to 143 ML/d as shown, for lake levels between EL130.3 and EL137. A peak dynamic loss is then 8 m at Q=140 ML/d. Total Dynamic Head (TDH) is then 22.3 m.
3. Therefore, the pump station would have two pumps at 40ML/d for Stage 4 service and a portion of the minimum day service of 15 ML/d, and it would have three 47 ML/d pumps for the flow range from 40 ML/d to 143 ML/d.

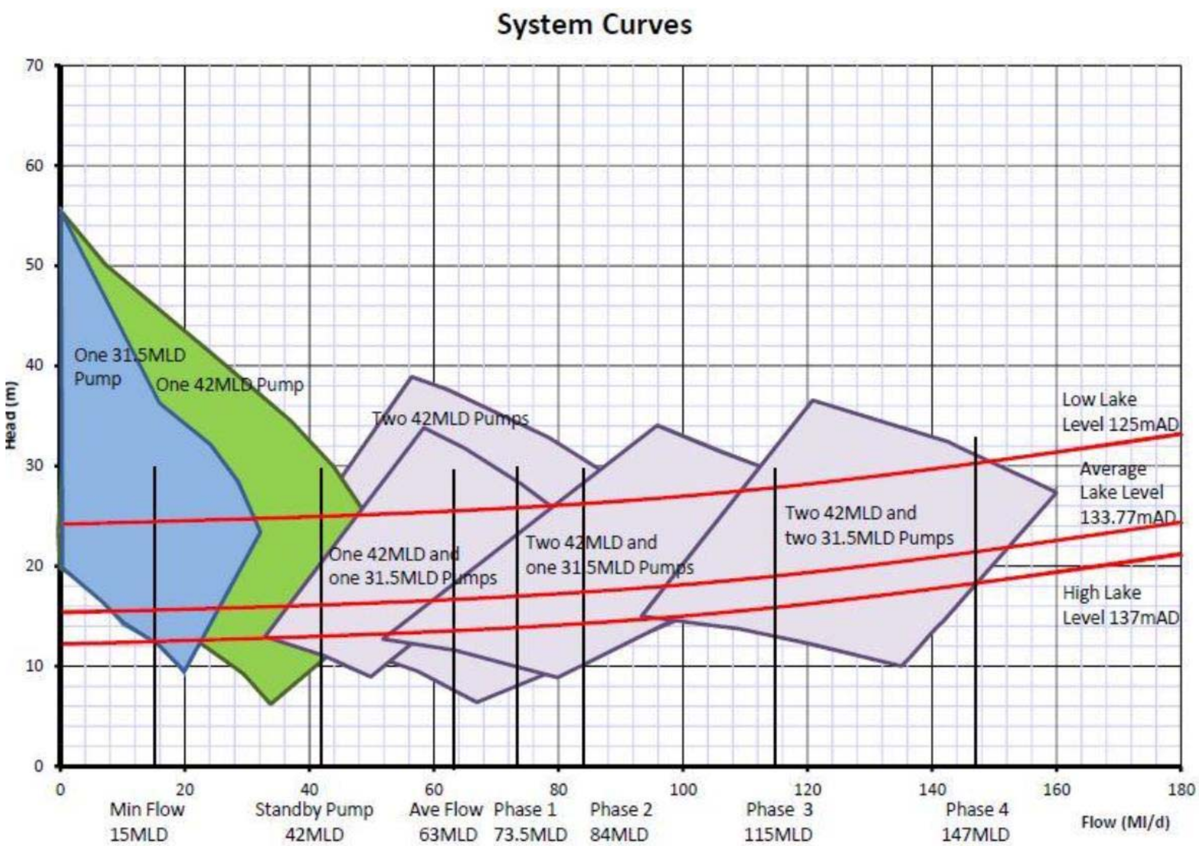
Pump Horsepower. Pump horsepower changes from those assumed in the documents for the following conditions.

1. Stage 4 Flow Restrictions. Two pumps (one standby) of 40 ML/d at a head of 15.3 m yields two pumps at 120 hp (125 hp nominal.) These could be fixed speed pumps.
2. Normal flow conditions. Three pumps at 47 ML/d are required for ultimate flow of 143 ML/d, with three pumps at 200 hp. One additional pump would be installed for standby. These should be variable speed pumps.
3. Total installed horsepower would be 850 hp.

Sketch

Alternative No.: IR-51

☑ Original ☐ Alternative

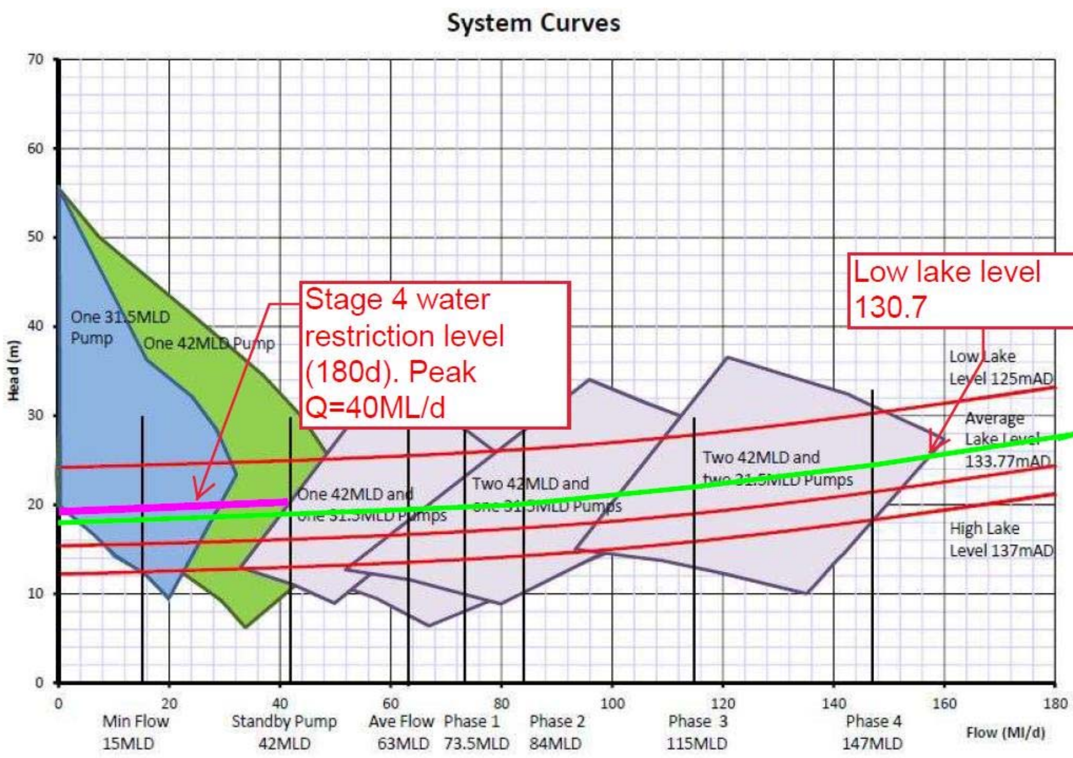


Pump Staging and Selection

Sketch

Alternative No.: IR-51

☐ Original ☑ Alternative



Alternative Pump Staging and Selection

Calculations

Alternative No.: IR-51

☐ Original ☑ Alternative

Q	gpm	ML/d			
	7338.12	40	1ML/d = 183.453 gpm		
H	ft	m			
	50.19685	15.3	1m = 3.28084 ft		

Q=gpm x ft/ 3960 x eff.

Q, ML/d	H, m	WHP	eff	KW
40	15.3	120.8023	77%	89.39374
47	22	204.1007	77%	151.0345

Annual Costs:

Average flow for the first 30 years is approximately 35 ML/d on the average day.

Power consumption for original concept pumping is therefore an average of:

158 kW x 24 hr x 365 = 1,385,000 kW/h = $208,000 per year.

Power consumption for alternative concept pumping is therefore an average of:

102 kW x 24 hr x 365 = 893,000 kW/h = $134,000 per year.

Construction Cost Estimate

Alternative No.: IR-51

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
Pump - 31.5 ML/D & 200hp motor - 315P200M1	EA	292,500	1	$292,500		
Pump - 42 ML/D & 250hp motor - 42P250M2	EA	325,000	1	$325,000		
Pump - 42 ML/D & 250hp motor - 42P250M3	EA	325,000	1	$325,000		
Pump - 40 ML/D & 125hp motor	EA	200,000			2	$400,000
Pump - 47 ML/D & 200hp motor	EA	292,500			1	$292,500
Drive - 200hp VS - 200VSD1	EA	24,000	1	$24,000		
Drive - 250hp VS - 250VSD2A	EA	26,400	1	$26,400		
Drive - 250hp VS - 250VSD3	EA	26,400	1	$26,400		
Drive - 125hp VS - 200VSD1	EA	15,000			2	$30,000
Drive - 200hp VS - 200VSD1	EA	20,000			1	$20,000
Electrical MCC (switchgear, ATS, power monitoring, bus)	LS	350,000	1	$350,000	0.6	$210,000
Total Markup	57.41%			$786,115		$546,830
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$2,155,000		$1,499,000
NET SAVINGS						$656,000

Life Cycle Cost Analysis

Alternative No.: IR-51

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST	ORIGINAL CONCEPT	ALTERNATIVE CONCEPT
	$2,155,000	$1,499,000
Capital Cost Savings		$656,000

ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Power		20.9303		208,000	4,354,000		134,000	2,805,000
Generalized O&M (% of Capital Cost)								
SUB-TOTAL					$4,354,000			$2,805,000

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$4,354,000		$2,805,000
PRESENT WORTH SAVINGS ON O&M						$1,549,000
LIFE CYCLE COST SAVINGS						$2,205,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-59A
Move the raw water intake to the diversion area on the river near the penstock and provide a floating pump station to withdraw from the lake below EL130.7	
Description of Original Concept:	
The original concept includes a lake intake and pump station, with a 2.6 km raw water pipeline to convey water to the WTP.	
Description of Alternative Concept:	
The alternative concept includes a floating pump station to withdraw up to 80 ML/d at Stage 4 water restrictions plus an amount to reduce riverbed losses, into the river through a 600 m, 600 mm pipeline. During normal lake levels, the water passing over the dam sill is withdrawn from the river at an intake and pump station near the penstock diversion dam. Water is then conveyed to the WTP. There is a short 500 m of 700 mm pipeline from the river to the WTP.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$11,202,000
O&M Savings:	$340,000
Life Cycle Cost Savings:	$11,542,000

Advantages/Disadvantages

Alternative No.: IR-59A

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Reduces the length of raw water pipeline from 2.5 km to 0.5 km which reduces future maintenance • Replaces the marine pipeline with a short pipeline in the lake which reduces construction risks	• Adds a second pump station and a 200 m discharge pipeline that must be maintained

Discussion

Alternative No.: IR-59A

This alternative is directed toward reducing operating head and shortening the raw water pipeline by putting the inlet for the WTP on the Puntledge River at the diversion dam for the BCH penstock. A pump station at that location would pump raw water to the WTP site through a 700 mm pressure pipeline, from about EL132 to EL145 (HGL.) A floating or non-floating pump station is needed in the lake to convey water over the dam when lake levels are below 130.7. It is assumed that more than 40 ML/d would be needed to insure at least that amount would be delivered in the riverbed, in absence of other flows above the river diversion dam; 80 ML/d is assumed.

The river diversion would include a concrete inlet channel with a vertical fish screen and an open inlet to the raw water delivery pumps. There would be five pumps in the pump station, sized to provide flow up to 140 ML/d in the future. The pump station structure would have a footprint like that of the original concept, but much shorter in vertical dimension. The RWPS would be a structure with its bottom elevation at about EL 125 and a top elevation at about EL136. It would have a footprint like that of the original concept. With a TDH of about 20 m, the pumps would be about 175 hp. The discharge pipeline would be 700 mm ID.

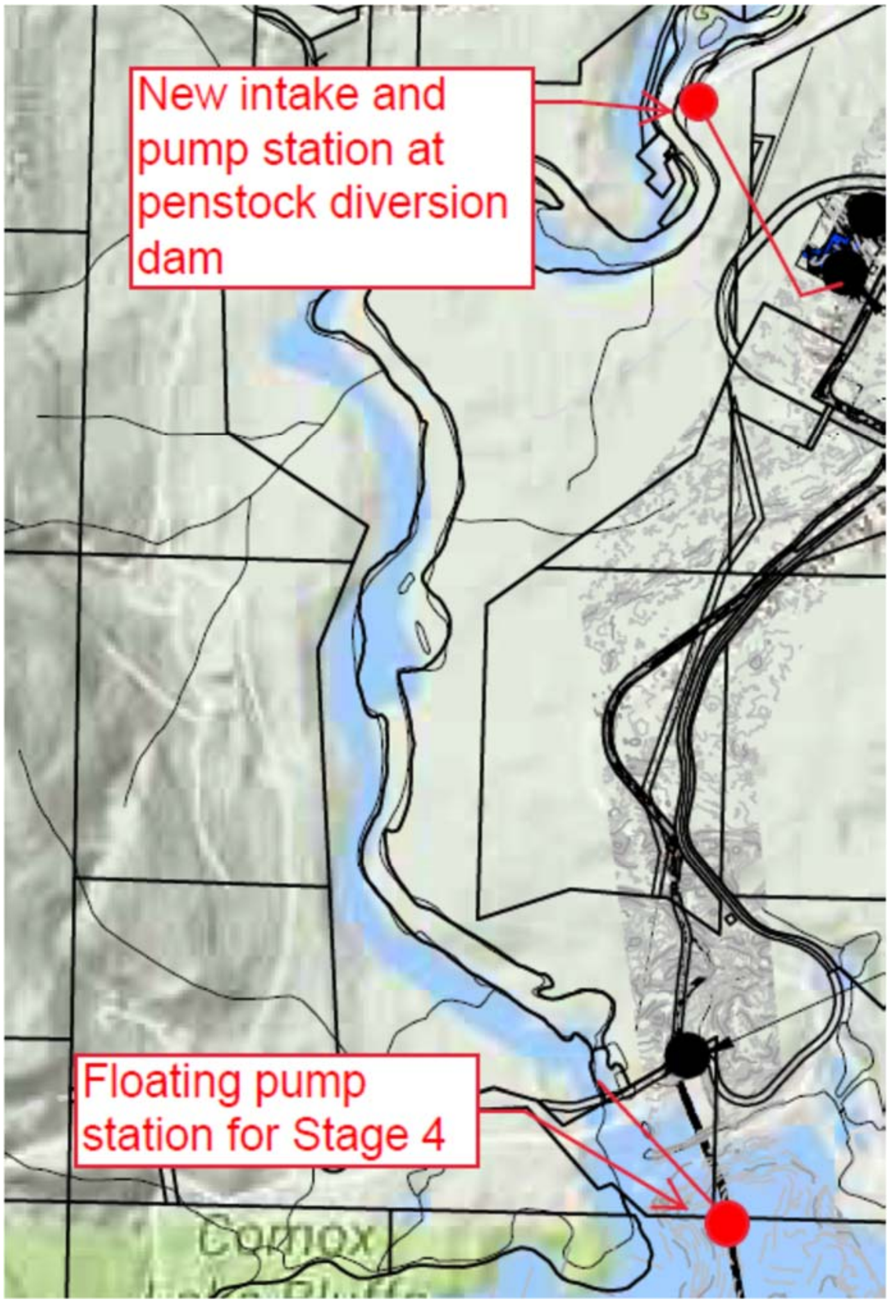
The floating pump station could be barge mounted with an underwater cable to a shore power connection point. At a TDH of about 5 m, the pump station could be comprised of two, 80 ML/d mixed flow submersible pumps each with a 75Hp motor. Total station load would be about 60 kW.

The support platform for the pumps might include a steel barge with a size of about 5x10m to include a single fish screen. The pumps would be horizontal, submersible, mixed flow pumps, with integrated and connected fish screens. The barge would be located offshore at a point where the bottom location is EL125 or less, probably about 400m from the dam. The discharge pipeline would be a 600 mm pipeline. The pipeline would be laid on the lake bottom or floated below the surface of the lake, at about a 4m depth. For purposes of this alternative a 600m pipeline on the bottom is assumed to get over the spillway.

Sketch

Alternative No.: IR-59A

☐ Original ☑ Alternative

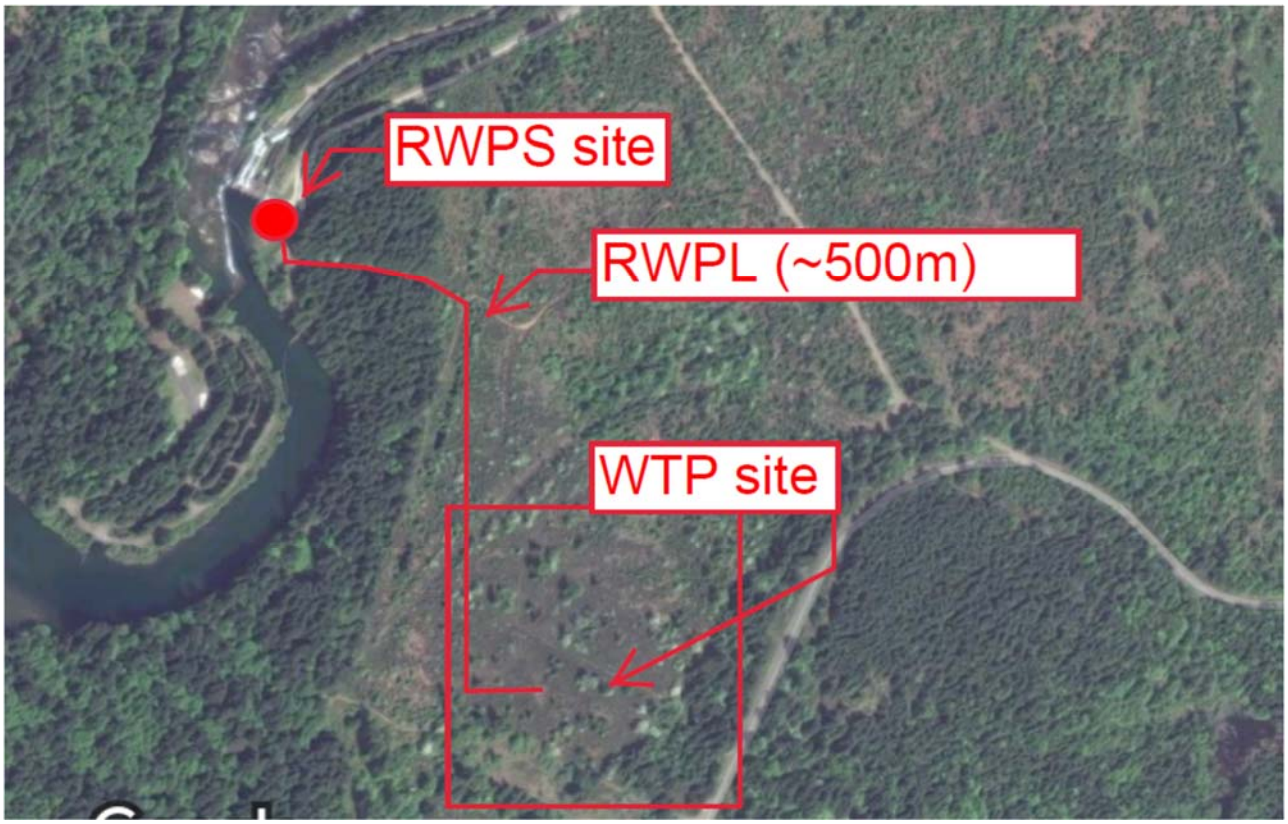


Alternative Intake/RWPS location

Sketch

Alternative No.: IR-59A

☐ Original ☑ Alternative

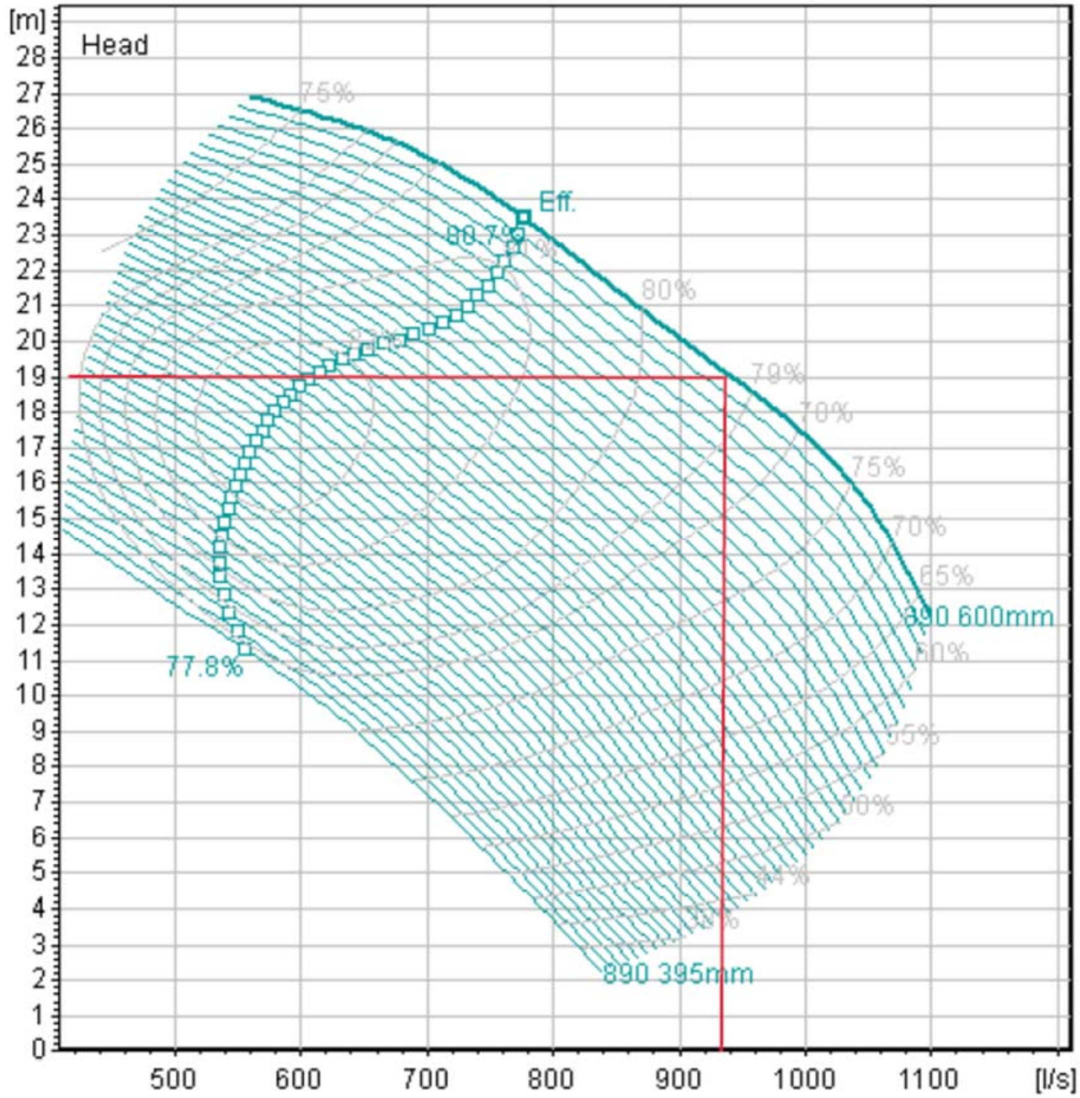


Intake and WTP site

Sketch

Alternative No.: IR-59A

☐ Original ☑ Alternative



Pump Selection Lake Pump station

Note: Flygt L 3400 3 phase 8p 890 60hz

Sketch

Alternative No.: IR-59A

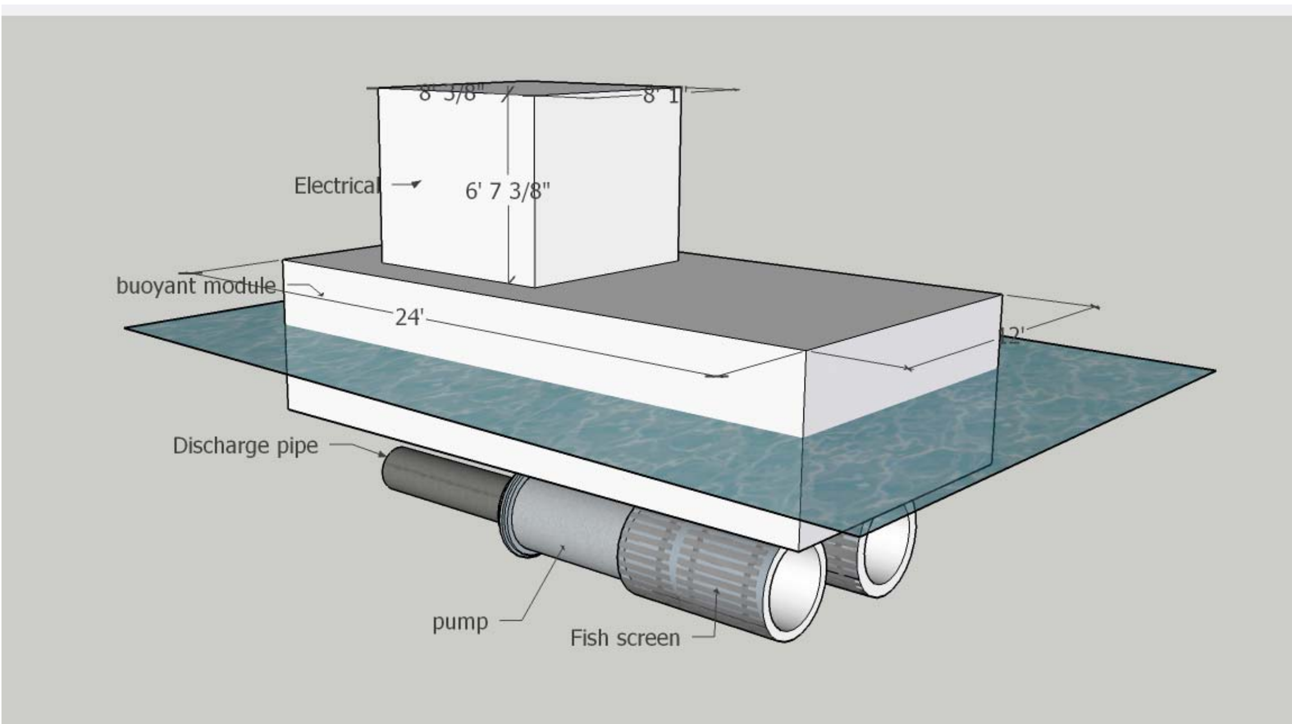
☐ Original ☑ Alternative

Typical submersible pump for lake pump station.

Sketch

Alternative No.: IR-59A

☐ Original ☑ Alternative



Lake Pump Station

Calculations

Alternative No.: IR-59A

☐ Original ☑ Alternative

Annual Costs:

Average flow for the first 30 years is approximately 35 ML/d on the average day.

Power consumption for original concept pumping is therefore an average of:

158 kW x 24 hr x 365 = 1,385,000 kW/h = $208,000 per year.

Power consumption for alternative concept pumping is an average of:

River Intake PS: 140 kW x 24 hr x365 = 1,227,000 kW/h = $184,000 per year.

Lake PS: average once per 5 years for 180 days. Over 30 years, total days = 1,080 days.

60 kw x 24 hr x 1080 = 1,555,200 kW/h = $233,300. Over 30 years this is an average of $7,776 per year.

Construction Cost Estimate

Alternative No.: IR-59A

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Pump - 31.5 ML/D & 200hp motor - 315P200M1	EA	292,500	1	$292,500		
Pump - 42 ML/D & 250hp motor - 42P250M2	EA	325,000	1	$325,000		
Pump - 42 ML/D & 250hp motor - 42P250M3	EA	325,000	1	$325,000		
Pump floating- 80 ML/D & 75hp motor	EA	150,000			2	$300,000
Pump - 47 ML/D & 200hp motor	EA	292,500			3	$877,500
Drive - 200hp VS - 200VSD1	EA	24,000	1	$24,000		
Drive - 250hp VS - 250VSD2A	EA	26,400	1	$26,400		
Drive - 250hp VS - 250VSD3	EA	26,400	1	$26,400		
Drive - 175hp VS - 200VSD1	EA	15,000			3	$45,000
Electrical MCC (switchgear, ATS, power monitoring, bus)	LS	350,000	1	$350,000	0.6	$210,000
Cast-In-Place Concrete – Walls	CM	1,870	528	$987,360	348	$650,760
Raw water transmission main 1050 mm (ST) STA 0+965 to 2+675	LM	2,070	1,710	$3,539,700		
Raw water transmission main 900 mm (ST)	LM	1,790	675	$1,208,250		
Raw water transmission main, 700mm	LM	1,100			500	$550,000
Raw water transmission main (floating) 600mm	LM	600			600	$360,000
Intake and marine pipeline	LS	5,155,100	1	$5,155,100		
River intake	LS	1,000,000			1	$1,000,000
Floating platform, lake pump station	LS	500,000			1	$500,000
Electrical service, lake pump station	LS	300,000			1	$300,000
Generator, lake pump station, 350kw	LS	150,000			1	$150,000
site work, lake pump station, allow	LS	200,000			1	$200,000
						2855149
Total Markup	57.41%			$7,038,300		$2,952,746
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$19,298,000		$8,096,000
NET SAVINGS						$11,202,000

Life Cycle Cost Analysis

Alternative No.: IR-59A

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST			ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
					$19,298,000			$8,096,000
Capital Cost Savings								$11,202,000
ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Power		20.9303		208,000	4,354,000		184,000	3,851,000
Power		20.9303					7,776	163,000
Generalized O&M (% of Capital Cost)								
SUB-TOTAL					$4,354,000			$4,014,000

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$4,354,000		$4,014,000
PRESENT WORTH SAVINGS ON O&M						$340,000
LIFE CYCLE COST SAVINGS						$11,542,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-59B

Move the raw water intake to the diversion area on the river near the penstock and provide a larger floating pump station that can also support environmental flows to withdraw from the lake below EL130.7

Description of Original Concept:

The original concept includes a lake intake and pump station, with a 2.6 km raw water pipeline to convey water to the WTP.

Description of Alternative Concept:

The alternative concept includes a floating pump station to withdraw up to 140 mgd (6 m^3/s), into the river through a 600 m, 600 mm pipeline. During normal lake levels, the water passing over the dam sill is withdrawn from the river at an intake and pump station near the penstock diversion dam. Water is then conveyed to the WTP. There is a short 500 m of 700 mm pipeline from the river to the WTP. When lake levels are below the dam sill, the pump station would continue to deliver water in the river for environmental flows and to supply the WTP.

Value Improvement

Value ≈ Function / Resources

Function	Resources
☑ Increased	☑ Increased
☐ Maintained	☐ Maintained
☐ Decreased	☐ Decreased

Cost Savings Summary

First Cost Savings:	($4,030,000)
O&M Savings:	($1,946,000)
Life Cycle Cost Savings:	($5,976,000)

Advantages/Disadvantages

Alternative No.: IR-59B

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Reduces the length of raw water pipeline from 2.5 km to 0.5 km which reduces future maintenance • Replaces the marine pipeline with a short pipeline in the lake which reduces construction risks • Adds the ability to maintain environmental flows in the river even at low lake levels	• Adds a second pump station and a discharge pipeline that must be maintained

Discussion

Alternative No.: IR-59B

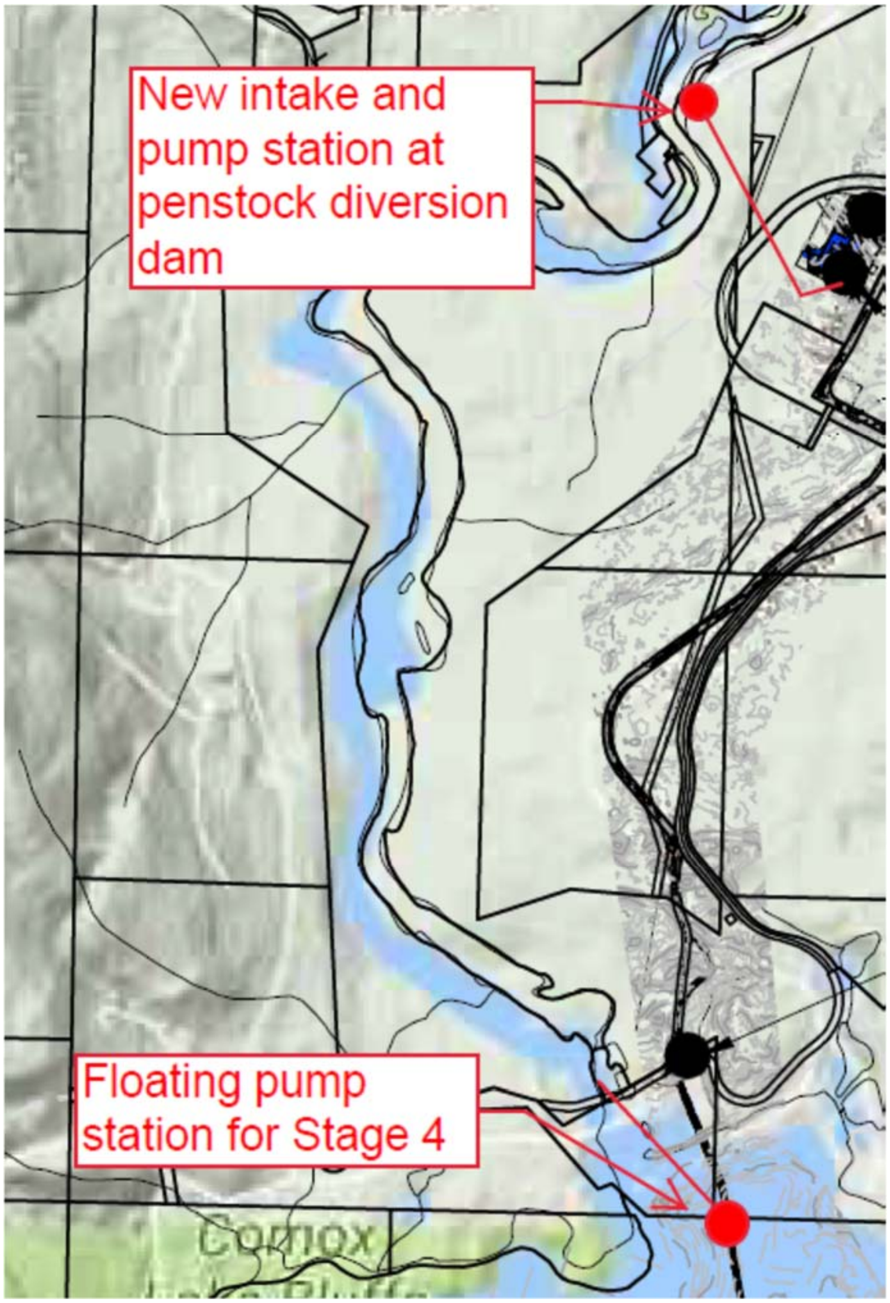
During the presentation at the end of the Value Planning workshop, a concept was discussed as part of IR-59A that if the proposed floating pump station were larger it could actually provide environmental flows (fish flows) in the river in addition to the water needed by the WTP. Following the workshop, members of the VP Team and CVRD continued to develop this concept to determine the cost implications to the project for a 140 mgd (6 m^3/s) floating pump station.

The concept is the same as IR-59A except with a larger pump station capacity.

Sketch

Alternative No.: IR-59B

☐ Original ☑ Alternative

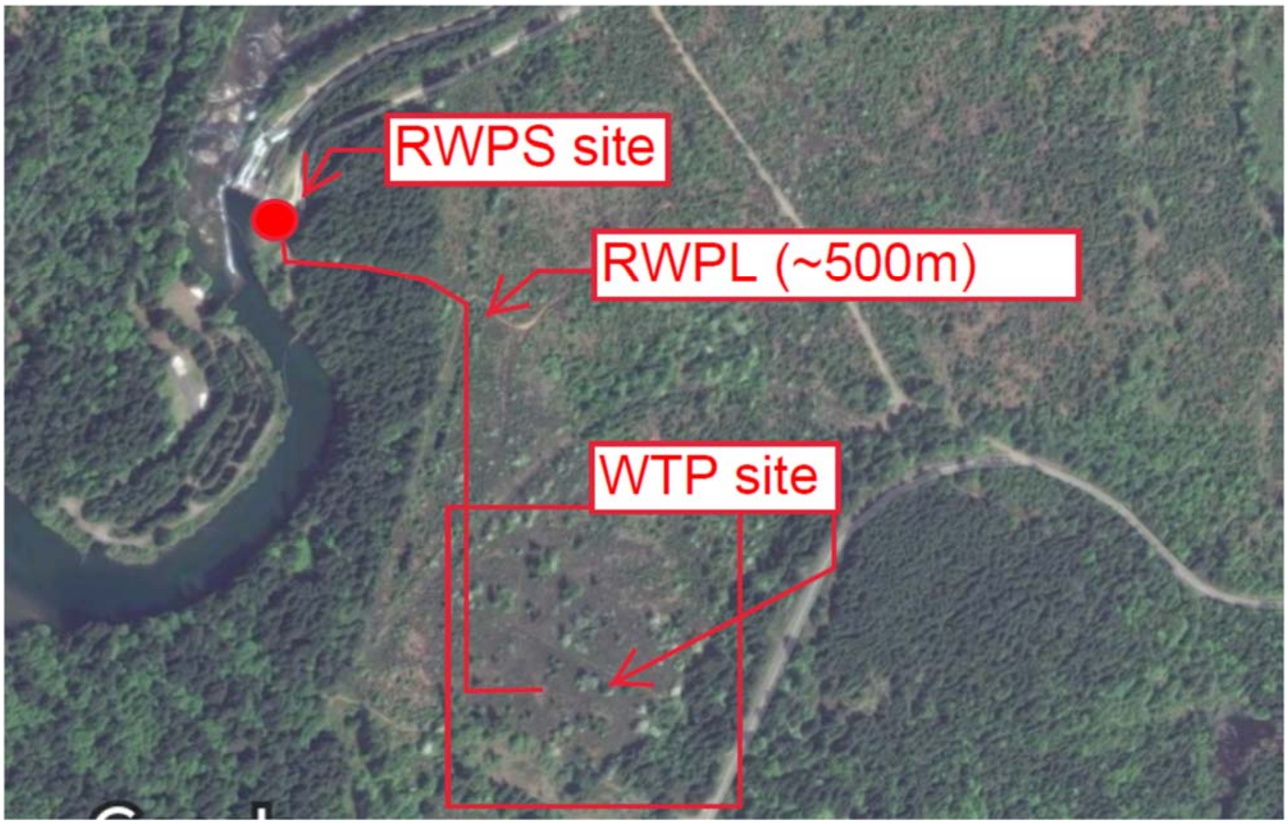


Alternative Intake/RWPS location

Sketch

Alternative No.: IR-59B

☐ Original ☑ Alternative

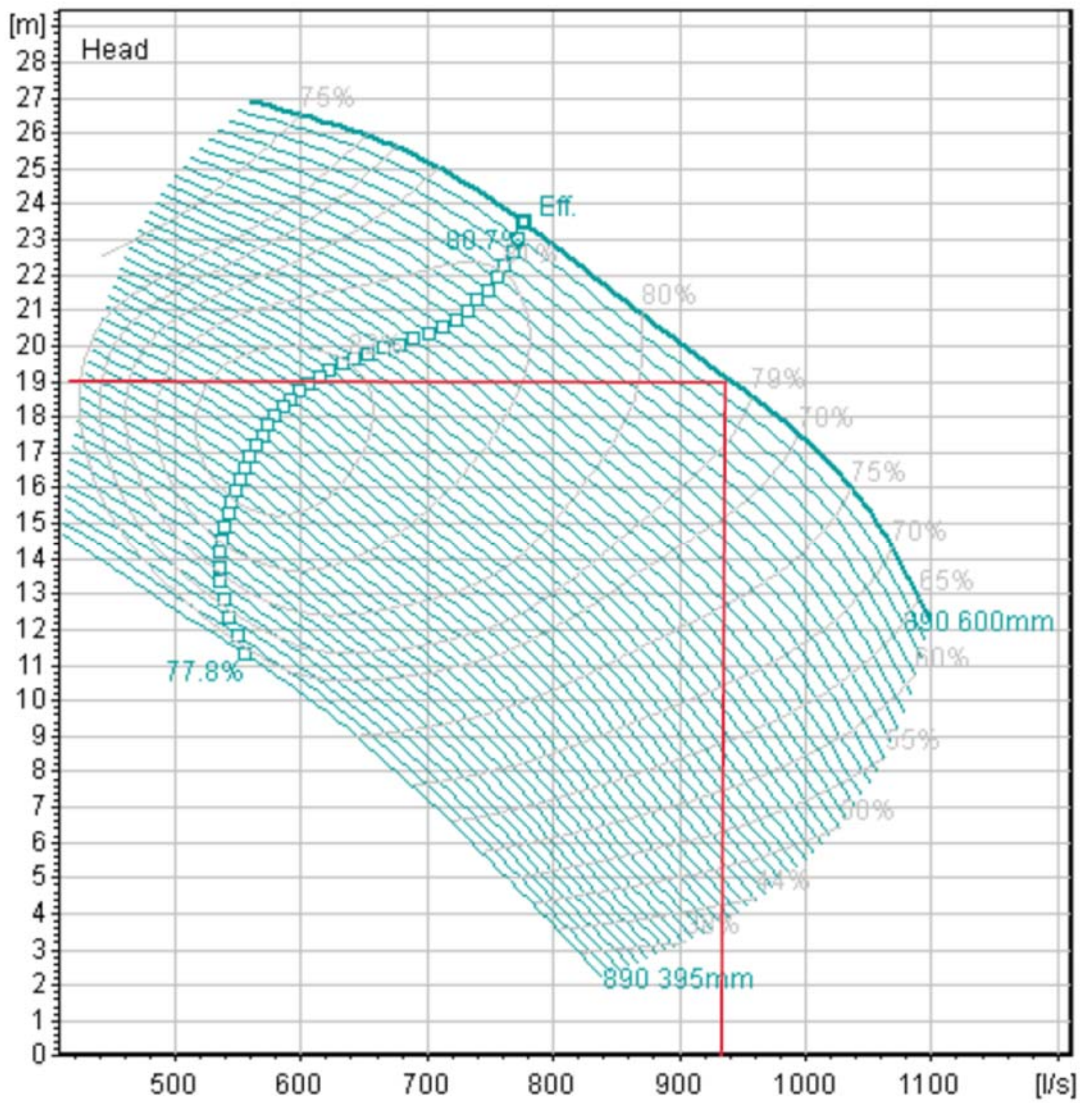


Intake and WTP site

Sketch

Alternative No.: IR-59B

☐ Original ☑ Alternative



Pump Selection Lake Pump station

Note: Flygt L 3400 3 phase 8p 890 60hz

Sketch

Alternative No.: IR-59B

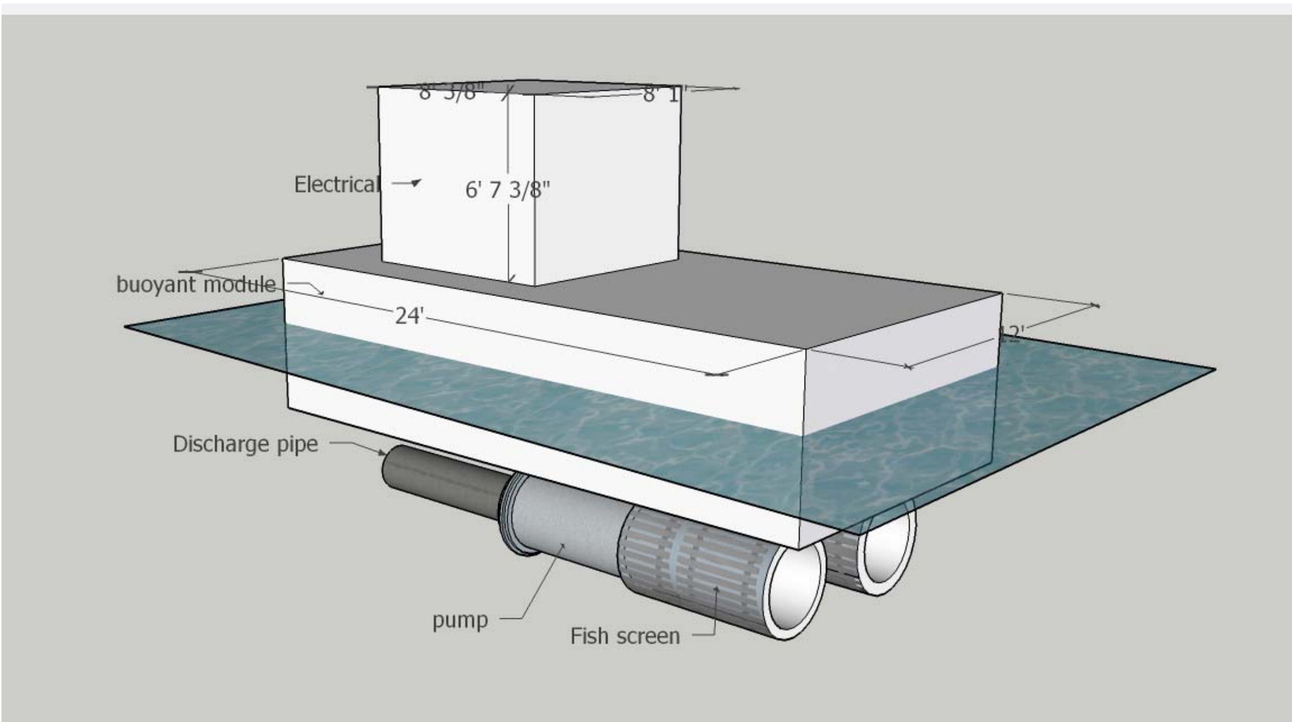
☐ Original ☑ Alternative

Typical submersible pump for lake pump station.

Sketch

Alternative No.: IR-59B

☐ Original ☑ Alternative



Lake Pump Station

Calculations

Alternative No.: IR-59B

☐ Original ☑ Alternative

Annual Costs:

Average flow for the first 30 years is approximately 35 ML/d on the average day.

Power consumption for original concept pumping is therefore an average of:

158 kW x 24 hr x 365 = 1,385,000 kW/h = $208,000 per year.

Power consumption for alternative concept pumping is an average of:

River Intake PS: 140 kW x 24 hr x365 = 1,227,000 kW/h = $184,000 per year.

Lake PS: average once per 5 years for 180 days. Over 30 years, total days = 1,080 days.

900 kw x 24 hr x 1080 = 23,328,000 kW/h = $3,500,000. Over 30 years this is an average of $117,000 per year.

Construction Cost Estimate

Alternative No.: IR-59B

			Original Concept		Alternative Concept	
			(Deletions)		(Additions)	
Item	Unit of Meas	Unit Cost	Qty	Total	Qty	Total
Pump - 31.5 ML/D & 200hp motor - 315P200M1	EA	292,500	1	$292,500		
Pump - 42 ML/D & 250hp motor - 42P250M2	EA	325,000	1	$325,000		
Pump - 42 ML/D & 250hp motor - 42P250M3	EA	325,000	1	$325,000		
Pump floating- 80 ML/D & 75hp motor	EA	150,000			2	$300,000
Pump - 47 ML/D & 200hp motor	EA	292,500			3	$877,500
Drive - 200hp VS - 200VSD1	EA	24,000	1	$24,000		
Drive - 250hp VS - 250VSD2A	EA	26,400	1	$26,400		
Drive - 250hp VS - 250VSD3	EA	26,400	1	$26,400		
Drive - 175hp VS - 200VSD1	EA	15,000			3	$45,000
Electrical MCC (switchgear, ATS, power monitoring, bus)	LS	350,000	1	$350,000	0.6	$210,000
Cast-In-Place Concrete – Walls	CM	1,870	528	$987,360	348	$650,760
Raw water transmission main 1050 mm (ST) STA 0+965 to 2+675	LM	2,070	1,710	$3,539,700		
Raw water transmission main 900 mm (ST)	LM	1,790	675	$1,208,250		
Raw water transmission main, 700mm	LM	1,100			500	$550,000
Raw water transmission main (floating) 600mm	LM	600			600	$360,000
Intake and marine pipeline	LS	5,155,100	1	$5,155,100		
River intake	LS	1,000,000			1	$1,000,000
Floating platform, lake pump station	LS	500,000			1	$500,000
Electrical service, lake pump station	LS	300,000			1	$300,000
Generator, lake pump station, 350kw	LS	150,000			1	$150,000
site work, lake pump station, allow	LS	200,000			1	$200,000
						2855149
Total Markup	57.41%			$7,038,300		$8,508,162
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$19,298,000		$23,328,000
NET SAVINGS						($4,030,000)

Life Cycle Cost Analysis

Alternative No.: IR-59B

LIFE CYCLE PERIOD 30 YEARS   ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST			ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
					$19,298,000			$23,328,000
Capital Cost Savings								($4,030,000
ANNUAL EXPENDITURE	**%**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**			**ALTERNATIVE CONCEPT**		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Power		20.9303		208,000	4,354,000		184,000	3,851,000
Power		20.9303					117,000	
Generalized O&M (% of Capital Cost)								
SUB-TOTAL					$4,354,000			$6,300,000

SINGLE EXPENDITURE (REPLACEMENT)	**YEAR**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**		**ALTERNATIVE CONCEPT**	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$4,354,000		$6,300,000
PRESENT WORTH SAVINGS ON O&M						($1,946,000)
LIFE CYCLE COST SAVINGS						($5,976,000)

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	IR-61
Set the intake screen base at EL120	
Description of Original Concept:	
The original concept constructs an 1,175 m long 1,600 mm diameter HDPE submarine intake pipeline to EL105 in the lake. Approximately 295 m of the installation will use micro-tunneling.	
Description of Alternative Concept:	
The alternative concept constructs a 340 m long 1,600 mm diameter HDPE submarine intake pipeline to EL120 in the lake. Approximately 310 m of the installation will use micro-tunneling.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$2,463,000
O&M Savings:	$0
Life Cycle Cost Savings:	$2,463,000

Advantages/Disadvantages

Alternative No.: IR-61

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Faster construction • Less construction impact on the lake biota • Less silt generation during construction • Shallower water access to the fish screens for installation and maintenance • Warmer water may improve water treatability • Less space required to string pipe for installation • Slightly lower pump suction head loss • Reduces construction time and activities in the lake which will reduce risks to the water supply during construction	• May be slightly greater variation in intake water quality • Slightly longer micro-tunnel

Discussion

Alternative No.: IR-61

The original concept for installation of the intake at the proposed EL105 was as a component of justifying filtration avoidance. Based on data provided to the VP Team, the water quality in most of the lake and in the river below the lake is well within the capability of the proposed alternative filtration technologies. Accordingly, there appears to no longer be justification for extending the intake pipeline to the depth originally proposed.

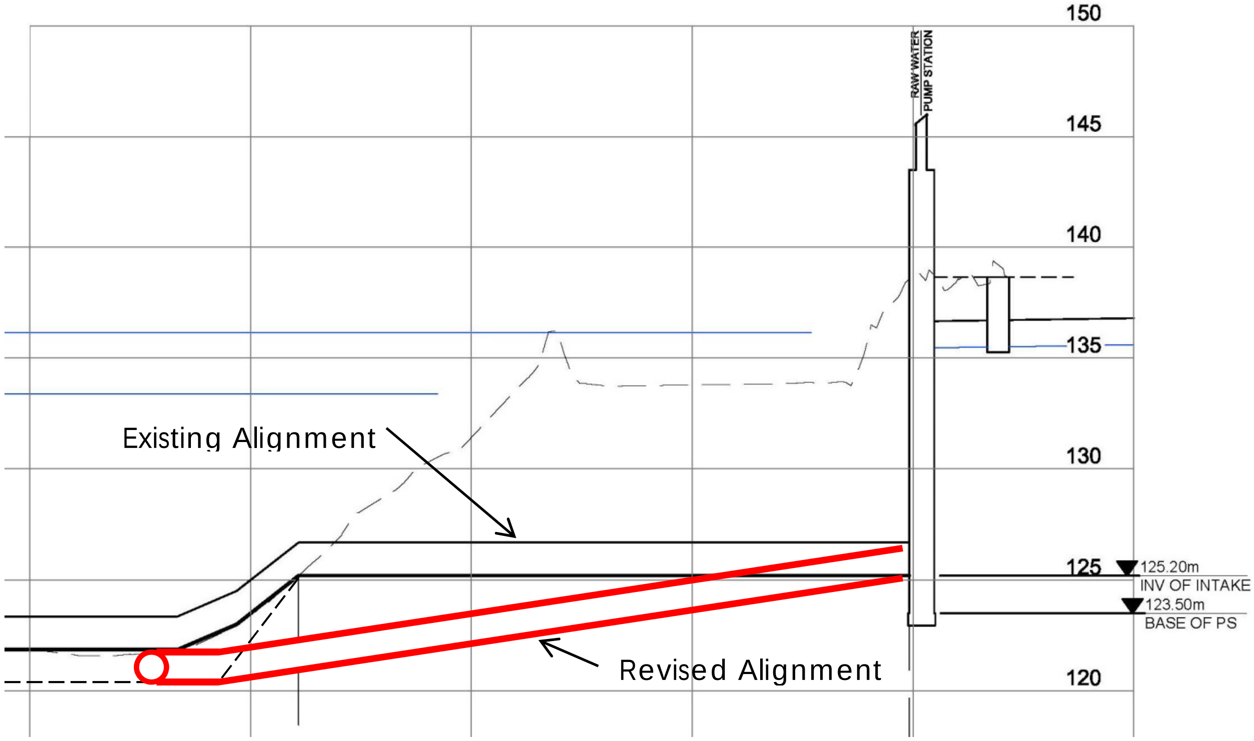
The VP Team is therefore proposing installation of the intake on a shelf in the lake at EL120. This will shorten the intake pipeline by approximately 835 meters and raise the intake elevation by 15 meters. This would place the top of the fish screen at about EL124, providing more than adequate navigational clearance even if the lake level is at the dam sill level. This change will reduce first cost and provide both construction and operation and maintenance benefits, as follows:

- Reducing the length will:
  - materially reduce construction time
  - reduce sediment generation during construction, reducing potential raw water turbidity impacts during construction
  - reduce construction impacts on lake biota
  - reduce construction impacts to the fish and game property
  - slightly reduce the suction head loss
- Locating the intake at the shallower depth will afford the following benefits:
  - The water will likely be warmer, affording improved flocculation for direct filtration and measurably reduced head requirements for membrane treatment
  - The shallower fish screen installation will simplify installation, improve diver efficiency, and simplify maintenance
  - The membrane system can be designed for a higher flex at the warmer temperature

Sketch

Alternative No.: IR-61

☑ Original ☑ Alternative

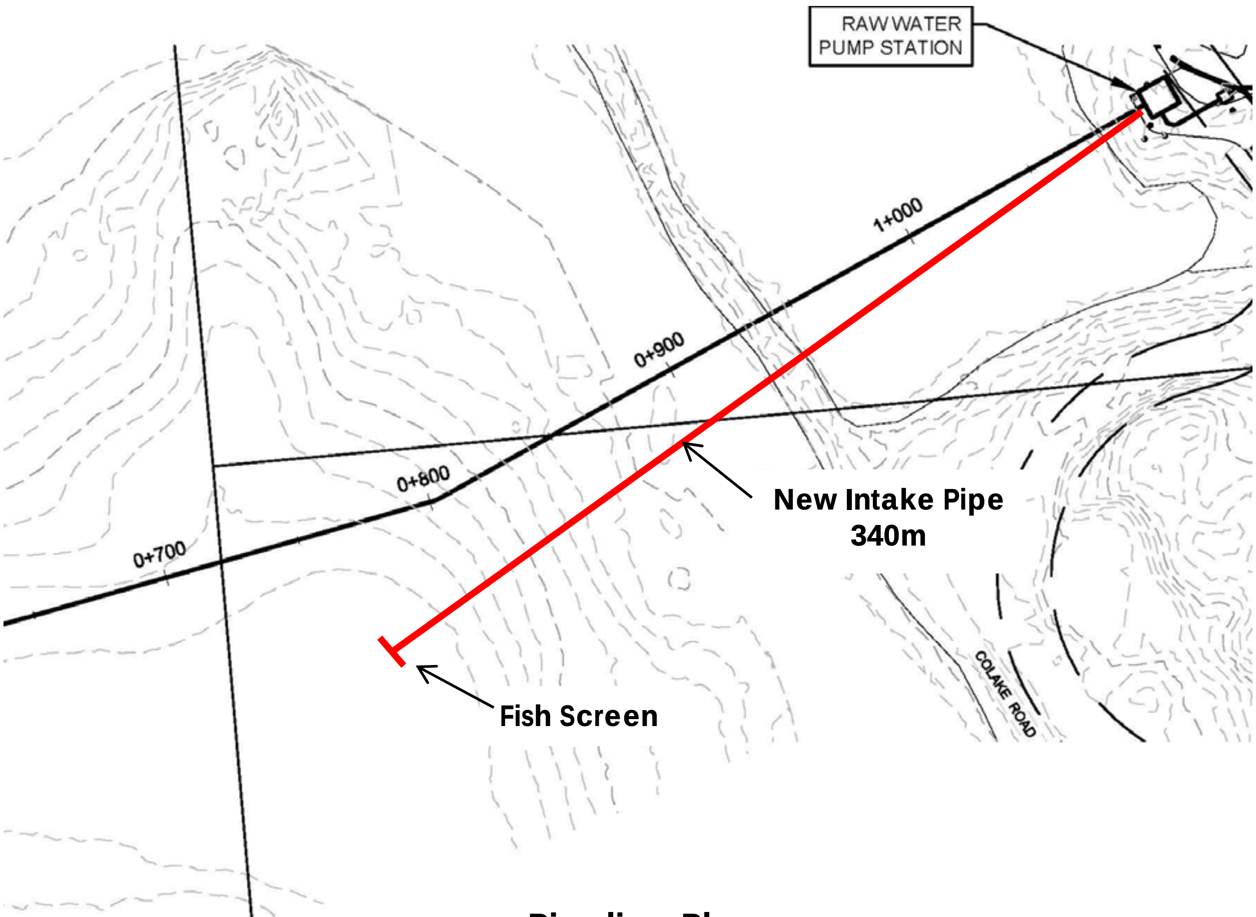


Pipeline Profile

Sketch

Alternative No.: IR-61

☑ Original ☑ Alternative



Pipeline Plan

Construction Cost Estimate

Alternative No.: IR-61

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Tunnel slurry treatment & matl export	LS	300,000.00	1	$300,000	1.03	$309,000
Silt Curtains	LS	50,000.00	1	$50,000	0.66	$33,000
foundation, manifold and screens	LS	120,000.00	1	$120,000	0.92	$110,400
Divers allowance	LS	100,000.00	1	$100,000	0.66	$66,000
Pipe ballast weights	EA	2,000.00	313	$626,000	11.00	$22,000
Micro-tunnel	LM	6,500.00	295	$1,917,500	310.00	$2,015,000
In-lake tremmy concrete	CM	10,000.00	5	$50,000		
In-lake tremmy concrete (Reduce Depth)	CM	6,600.00			5.00	$33,000
In-lake pipe	LM	790.00	1,175	$928,250	34.00	$26,860
In-lake pipe installation	LS	150,000.00	1	$150,000	0.48	$72,000
On-shore pipe fusing	LS	20,000.00	1	$20,000	0.49	$9,800
Total Markup	57.41%			$2,446,671		$1,548,382
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$6,708,000		$4,245,000
NET SAVINGS						$2,463,000

SATISFY CRITERIA

Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	SC-01
Eliminate the flocculation basins and rapid mix for membranes	
Description of Original Concept:	
The original concept includes rapid mix and flocculation basins prior to the membrane treatment. This applies to both pressure and submerged alternatives.	
Description of Alternative Concept:	
The alternative concept is to remove the flocculation basins and rapid mix functions for the membrane alternatives.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$3,630,000
O&M Savings:	$628,000
Life Cycle Cost Savings:	$4,258,000

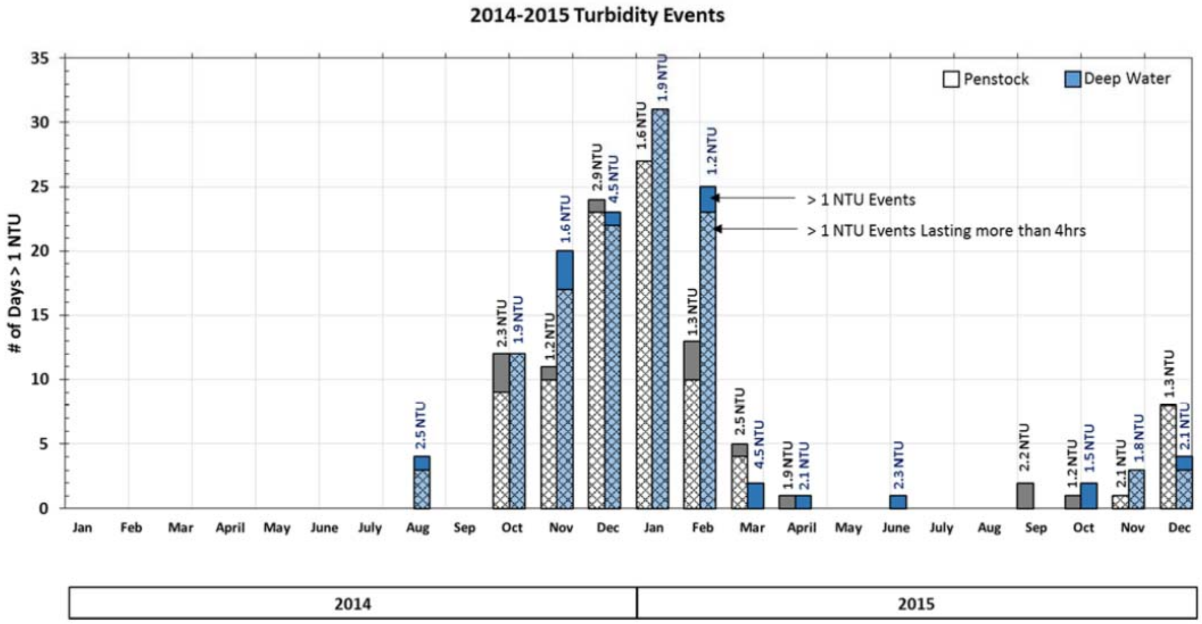
Advantages/Disadvantages

Alternative No.: SC-01

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Rapid mix and flocculation are necessary for a direct filtration WTP and is not required for membranes • Potentially adds cost to pressure membrane system as flocculated water would have to be re-pumped as head is broken at the plant • If coagulation was needed, provisions for direct inline coagulation in a pressure pipe would accomplish the same objective • Would save concrete construction for a submerged membrane system	• Potentially higher fouling could occur at elevated turbidity conditions; however, these are uncommon events that occur during lower demand periods associated with rain events

Discussion

Alternative No.: SC-01



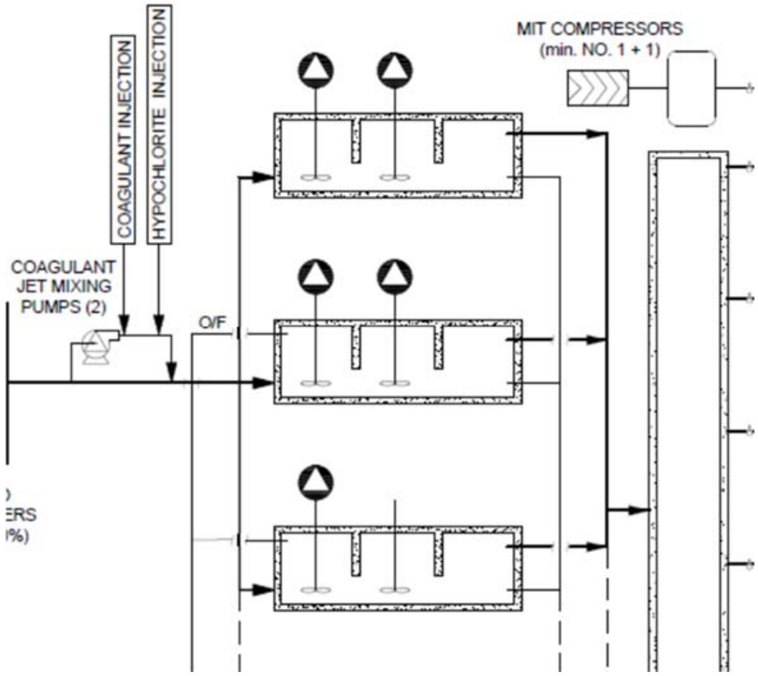
This is the profile for the turbidity during 2014-15. The penstock is representative of the water that would be used as feed to the membrane system. The turbidity is sufficiently low enough to not include rapid mix and flocculation for the membrane process.

It would be prudent to install a direct inline coagulant injection point into the supply line to provide an opportunity to add coagulant at some point in the future.

Sketch

Alternative No.: SC-01

☑ Original ☐ Alternative

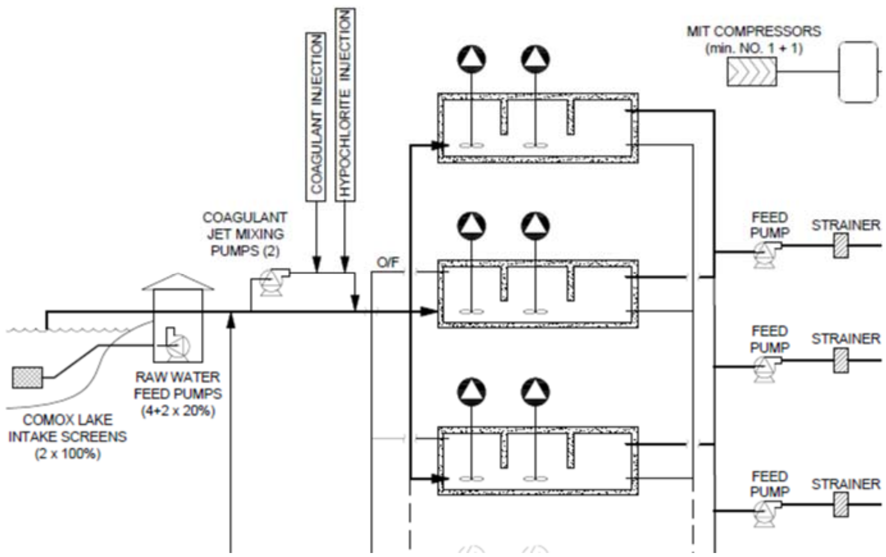


Original concept for submerged membranes

Sketch

Alternative No.: SC-01

☑ Original ☐ Alternative

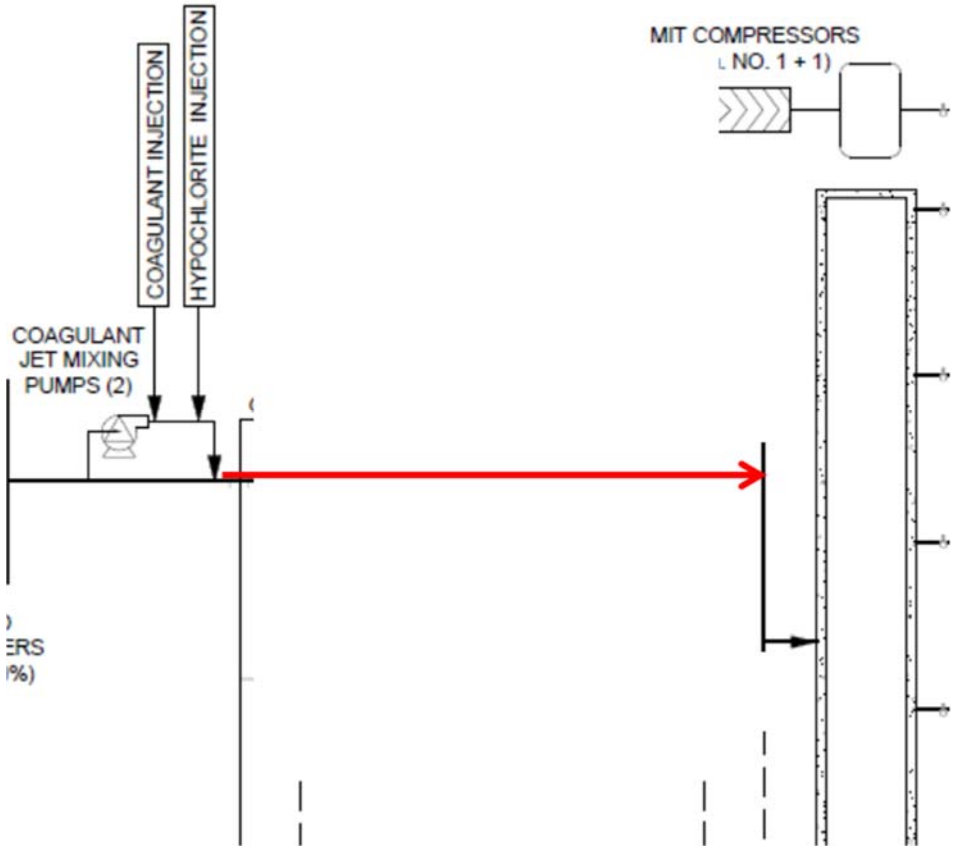


Original concept for pressure membranes

Sketch

Alternative No.: SC-01

☐ Original ☑ Alternative



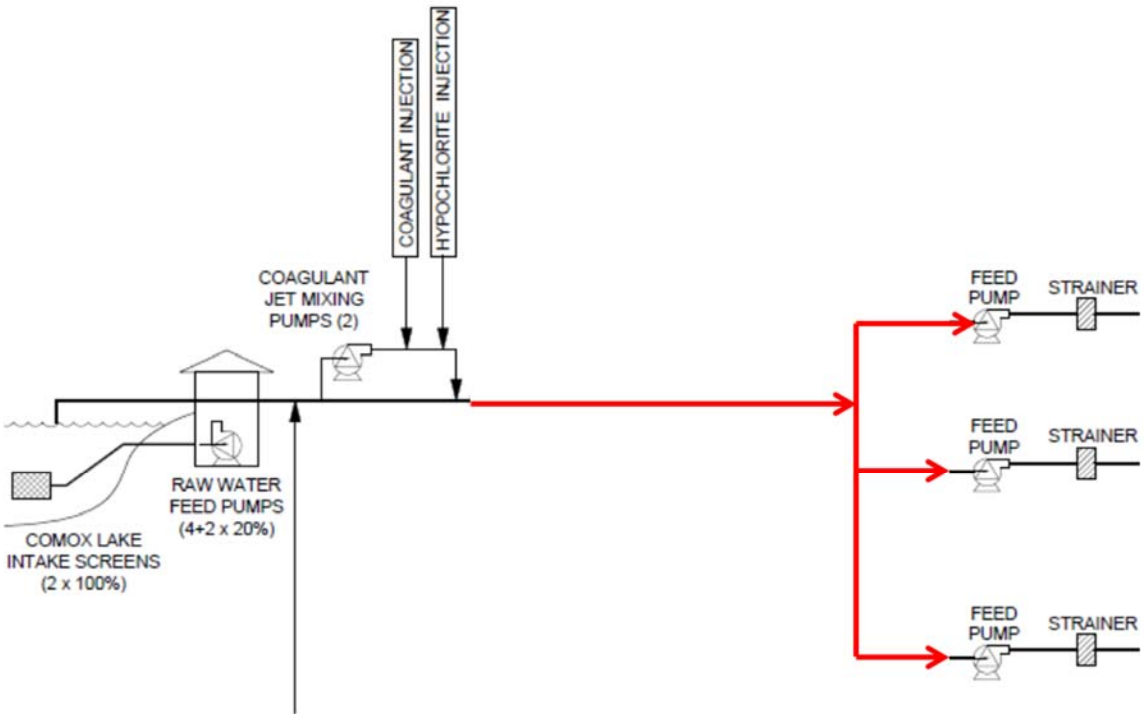
Eliminate the rapid mix and flocculation chambers for both the submerged and pressure membrane options.

Note to designer, the use of sodium hypochlorite as a feed to submerged membrane systems raises concern regarding corrosion of conduits and other metal structures and requires special consideration if carried through as a project requirement. PVC or PVC coated conduit will be required, and fiberglass structures are preferred over galvanized.

Sketch

Alternative No.: SC-01

☐ Original ☑ Alternative



For pressure membrane, the alternative looks similar, however the fact that the system is now not breaking head means that raw water feed pumps could be potentially used to provide pressure through the membranes, which would eliminate the second feed pump located at the membrane unit. If the transmission line is of extended length, a hydropneumatic tank would be necessary to stabilize the feed pressure to the membrane system.

Calculations

Alternative No.: SC-01

☐ Original ☑ Alternative

The operational cost estimate has $30,000/year for coagulant.

Construction Cost Estimate

Alternative No.: SC-01

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Pre-Treatment Coagulation	1	ea	1	$1,186,000		
Flocculation	1	ea	1	$1,120,000		
Total Markup	57.41%			$1,323,875		
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$3,630,000		
NET SAVINGS						$3,630,000

Life Cycle Cost Analysis

Alternative No.: SC-01

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST			ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
					$3,630,000			$0
Capital Cost Savings								$3,630,000
ANNUAL EXPENDITURE	**%**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**			**ALTERNATIVE CONCEPT**		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Coagulant		20.9303		30,000	628,000		0	0
Generalized O&M (% of Capital Cost)								
		SUB-TOTAL			$628,000			$0

SINGLE EXPENDITURE (REPLACEMENT)	**YEAR**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**		**ALTERNATIVE CONCEPT**	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
		SUB-TOTAL		$0		$0
		TOTAL PRESENT WORTH		$628,000		$0
				PRESENT WORTH SAVINGS ON O&M		$628,000
				LIFE CYCLE COST SAVINGS		$4,258,000

Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	SC-02
Replace Actiflo® with settling basin and solids removal	
Description of Original Concept:	
The original concept includes Actiflo® for backwash solids concentration prior to gravity thickening.	
Description of Alternative Concept:	
The alternative concept is to use the backwash capture basin to decant the solids and return them to the plant headworks. Settled solids would go to the gravity thickener and dewatering process.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$2,269,000
O&M Savings:	$0
Life Cycle Cost Savings:	$2,269,000

Advantages/Disadvantages

Alternative No.: SC-02

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Eliminates Actiflo® from the backwash system • Removes mechanical equipment • Pumps can be located external of system for ease of maintenance • Eliminates air mix blowers • Backwash recirculation pumps are deleted. (price not adjusted as additional pumps would be used for pumping decant to headworks) • Accomplishes the same function at a lower cost • Simplifies operations • May save additional building space • Accomplishes the same function at a lower cost	• Requires backwash basin to settle and decant the backwash from gravity filters • May require automation of valves to operate in fill, settle and drain modes of operation

7.12.1 Direct Filtration Residuals Handling

Wastewater from the direct filtration plant is primarily the filter backwashes and the filter-to-waste during filter ripening. Optimizing filter performance can reduce the frequency of backwashes and thereby the volume of residuals produced. The onsite filter backwash water treatment consists of a high rate clarification stage; a thickening stage; followed by a centrifuge. The filter backwash will first be equalized for pumping to the spent filter backwash treatment system.

7.12.2 Backwash Equalization

The backwash equalization tanks will consist of 2 cells sized to receive at least four backwashes. A wet-well will allow pumping from either using submersible pumps. The submersible pumps will operate by VFD and run continuously to transfer backwash waste flow to backwash treatment.

Table 7-22 describes the sizing of the equalization tank and waste transfer pumps.

Table 7-22: Equalization Tank Sizing

DESCRIPTION	CRITERIA
Equalization Tank	
Size of cell, m, m	10 x 40
Depth of cell, m	2.5
Volume of cell, m^3	1,000
No. of Backwashes	5.7
Number of Cells	2
SFBW Pumping	
No. and Type of Pumps, total (duty/standby)	3 (2/1) submersible VFD
Pump Flow Rate (ea), m^3/day (US gpm)	800 to 1,250 (230)
Pump TDH, metres	15
Pump Motor Size, hp (kW)	7.5 (5.6)

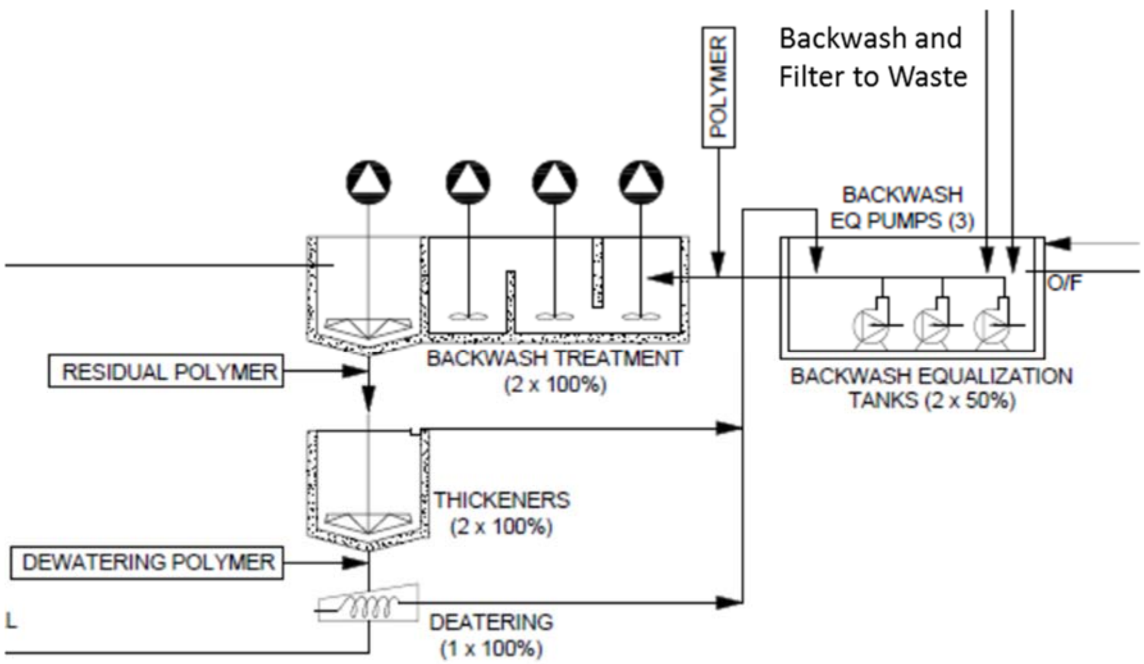
The proposed alternative would operate in fill, settle and drain mode. In the fill mode, backwash water would enter the basin, during the settling mode, the solids are allowed to separate. In the drain mode, the clarified water is returned to the rapid mix basin. Typically, the return rate from the backwash basin is no more than 10 percent of the feed rate to the filters in accordance with the filter backwash rule (USEPA) standard.

The more optimal configuration is a 3 x 50 percent configuration. The system is currently designed to accept 11.4 backwashes in total. With a total number of 8 filters, a backwash will occur every 32 hours based on the pilot study, thus the average backwash period is every 4 hours.

Sketch

Alternative No.: SC-02

☑ Original ☐ Alternative



Sketch

Alternative No.: SC-02

☑ Original ☐ Alternative

The following graphic was included in the pilot study report.

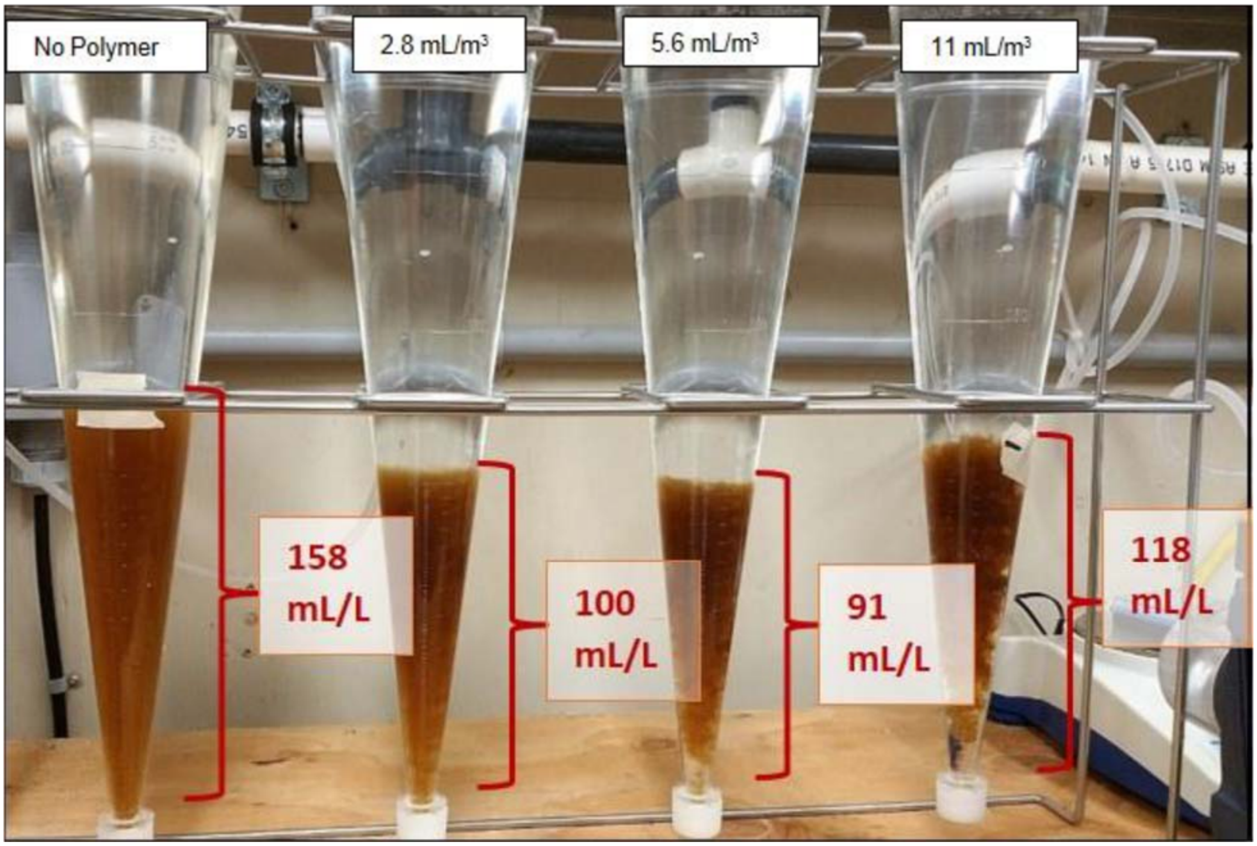


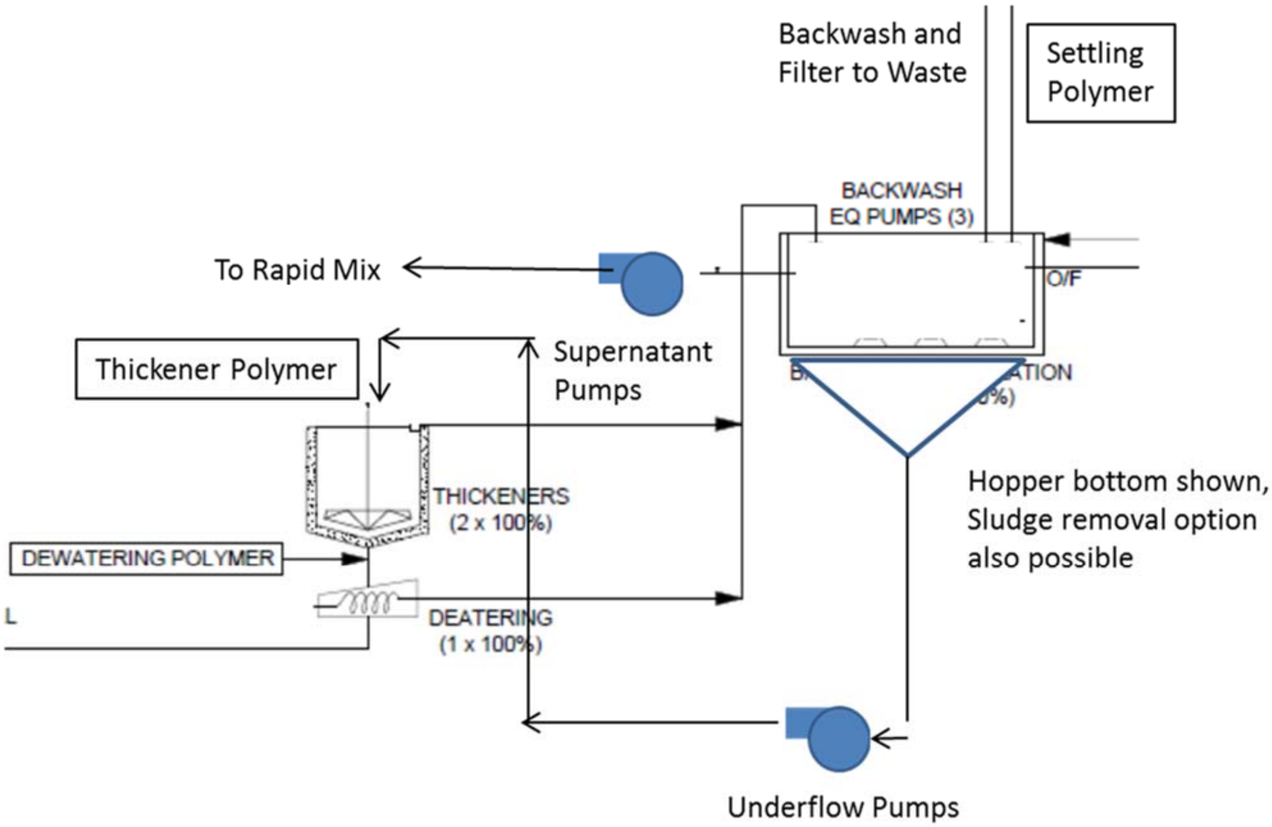
Figure 6-7 Settleable Solids in the Imhoff Cones using the Zetag 8816

The backwash settles nicely without the use of polymer, although polymer could be added to the backwash water. A simpler approach is to use the backwash basins to settle the backwash water, then decant the supernatant, to the head of the plant and the solids to disposal.

Sketch

Alternative No.: SC-02

☐ Original ☑ Alternative



Eliminate Actiflo®

Construction Cost Estimate

Alternative No.: SC-02

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Actiflo®	1	1,967,600.00	1	$1,967,600		
Backwash Equalization Tanks (Modifications)						
Add Pump for Third chamber	1	126,000.00			1	$126,000
Modify Equalization tanks for Hopper	EA	1,253,900.00			0.32	$400,000
Total Markup	57.41%			$1,129,599		$301,977
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$3,097,000		$828,000
NET SAVINGS						$2,269,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	SC-13
Replace second stage membranes with plate settler or similar	
Description of Original Concept:	
The original concept includes a second stage membrane system for backwash solids concentration prior to gravity thickening.	
Description of Alternative Concept:	
The alternative concept is to use a more conventional clarification approach (e.g. a plate settler) to process backwash water from the membrane process. A conventional clarification process is less subject to water quality events during high turbidity events. Backwash water can be more easily processed through a plate settler and does not require the operational effort associated with cleaning of the second stage.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$882,000
O&M Savings:	$858,000
Life Cycle Cost Savings:	$1,740,000

Advantages/Disadvantages

Alternative No.: SC-13

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Eliminates second stage membrane • Eliminates UV on the second stage filtrate, if membrane product is proposed for discharge to distribution • Coagulant can be used for feed enhancement • Alternative equipment such as dissolved air flotation can also be considered	• Space and height limitations may preclude the use of some types of conventional clarification equipment

Discussion

Alternative No.: SC-13

Although there are several two-stage membrane systems in operation, often these systems are challenged and become the bottleneck in the facility which can limit overall production.

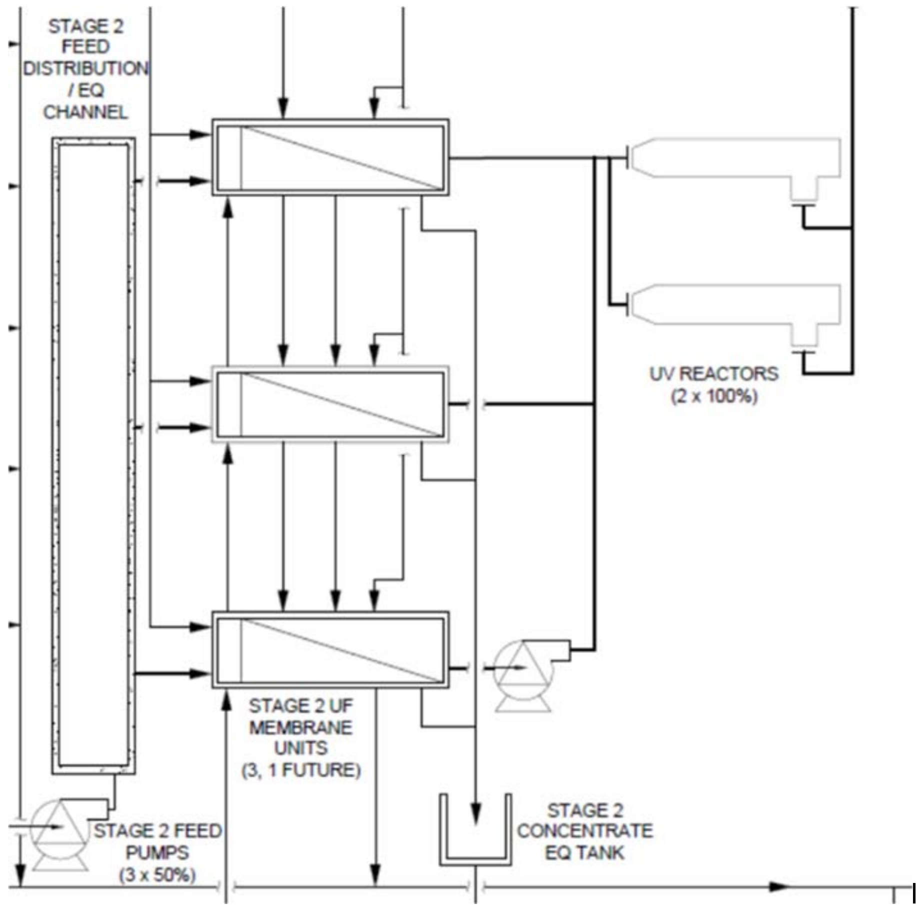
Instead of a two-stage system, a conventional plate settler or similar coagulation-based system is often a far more reliable and robust system. This type of system eliminates the challenges associated with the operation of a two-stage membrane system.

This option will also eliminate the need for second stage UV disinfection.

Sketch

Alternative No.: SC-13

☑ Original ☐ Alternative

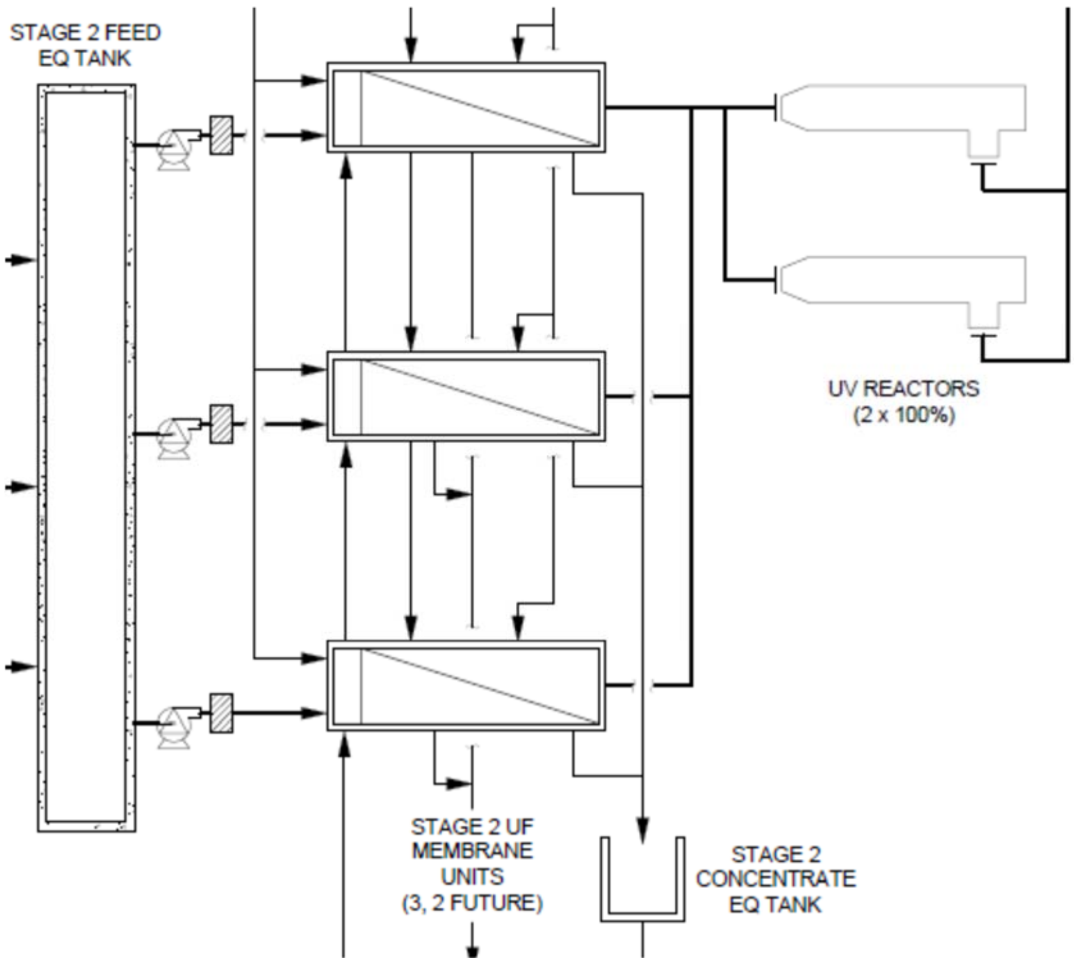


Submerged System Schematic

Sketch

Alternative No.: SC-13

☑ Original ☐ Alternative



Pressure System Arrangement

Sketch

Alternative No.: SC-13

☐ Original ☑ Alternative

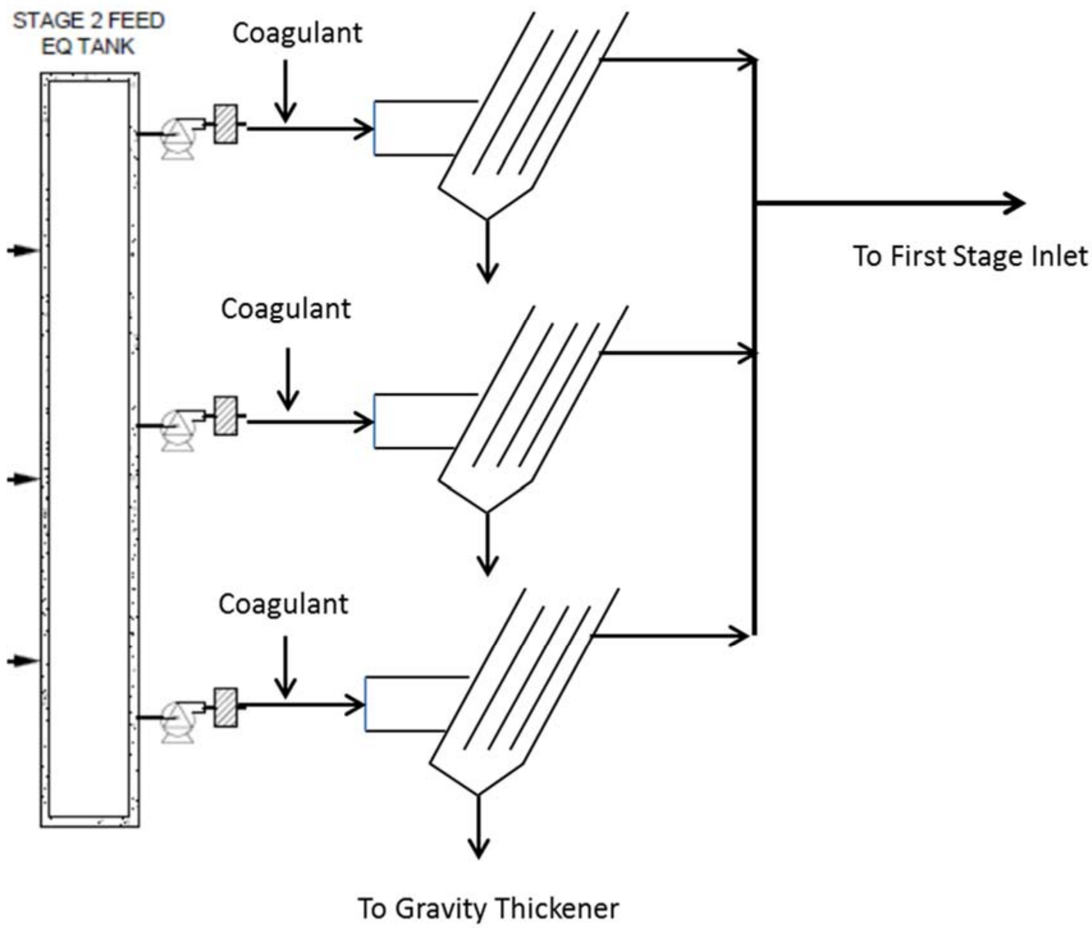


Plate settlers shown for second stage clarification

Alternative Arrangement (Pressure or Submerged)

Calculations

Alternative No.: SC-13

☐ Original ☑ Alternative

Basis of Assumptions

All items removed from cost estimate that contained the wording second stage.

Second stage system was estimated at 10 percent of the overall cost.

The UV system was removed from the second stage system.

Annual operating costs used in the LCCA were taken from the Indicative Design Report

Construction Cost Estimate

Alternative No.: SC-13

			Original Concept (Deletions)		Alternative Concept (Additions)	
Item	**Unit of Meas**	**Unit Cost**	**Qty**	**Total**	**Qty**	**Total**
UV UNIT -51-A	EA	$166,980.00	2	$333,960		
Pressurized Membrane Package	LS	8,832,000.00	1	$8,832,000	0.9	$7,948,800
UVT Indicator Transmitter	EA	18,113.00	1	$18,113		
Plate Settler 2ML/d	EA	225,000.00			3	$675,000
Total Markup	57.41%			$5,272,576		$4,950,924
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$14,457,000		$13,575,000
NET SAVINGS						$882,000

Life Cycle Cost Analysis

Alternative No.: SC-13

LIFE CYCLE PERIOD 30 YEARS   ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST	ORIGINAL CONCEPT	ALTERNATIVE CONCEPT
	$14,457,000	$13,575,000
Capital Cost Savings		$882,000

ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Coagulant		20.9303		0	0		30,000	628,000
Clean in Place		20.9303		40,000	837,000		0	0
Electrical		20.9303		31,000	649,000		15,000	314,000
UV Disinfection		20.9303		15,000	314,000		0	0
Generalized O&M (% of Capital Cost)								
SUB-TOTAL			$1,800,000			$942,000		

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL			$0		$0	
TOTAL PRESENT WORTH			$1,800,000		$942,000	

PRESENT WORTH SAVINGS ON O&M	$858,000
LIFE CYCLE COST SAVINGS	$1,740,000

Construction Cost Estimate

Alternative No.: SC-13

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
UV UNIT -51-A	EA	166,980.00	2	$333,960		
Submerged Membrane Package	LS	10,729,000.00	1	$10,729,000	0.9	$9,656,100
UVT Indicator Transmitter	EA	18,113.00	1	$18,113		
Plate Settler 2ML/d	EA	225,000.00			3	$675,000
Total Markup	57.41%			$6,361,644		$5,931,085
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$17,443,000		$16,262,000
NET SAVINGS						$1,181,000

Life Cycle Cost Analysis

Alternative No.: SC-13

LIFE CYCLE PERIOD 30 YEARS   ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST			ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
					$17,443,000			$16,262,000
Capital Cost Savings								$1,181,000
ANNUAL EXPENDITURE	**%**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**			**ALTERNATIVE CONCEPT**		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Coagulant		20.9303		0	0		30,000	628,000
Clean in Place		20.9303		40,000	837,000		0	0
Electrical		20.9303		17,600	368,000		15,000	314,000
UV-Disinfection		20.9303		15,000	314,000		0	0
Generalized O&M (% of Capital Cost)								
SUB-TOTAL					$1,519,000			$942,000

SINGLE EXPENDITURE (REPLACEMENT)	**YEAR**	**PRESENT WORTH FACTOR**	**ORIGINAL CONCEPT**		**ALTERNATIVE CONCEPT**	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$1,519,000		$942,000
PRESENT WORTH SAVINGS ON O&M						$577,000
LIFE CYCLE COST SAVINGS						$1,758,000

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Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	SC-23
Optimize the direct filtration design	
Description of Original Concept:	
The original concept is for a compact direct filtration plant design.	
Description of Alternative Concept:	
The alternative concept is to modify the layout of the direct filtration plant to provide flexibility to convert the plant to conventional filtration should raw water quality degradation necessitate such a change. The alternative also offers other modifications to simplify the waste wash water handling facilities.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$806,000
O&M Savings:	$593,000
Life Cycle Cost Savings:	$1,399,000

Advantages/Disadvantages

Alternative No.: SC-23

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Reconfiguring the plant layout now provides the future flexibility to be converted to a conventional filtration plant in the future should a decrease in raw water quality necessitate such a change • Replacement of Actiflo® and centrifuge with less mechanical intensive processes reduces the plant's reliance on high wear items, improving reliability and reducing operator time and maintenance • Adding mixers to the third flocculation chamber provides operators additional flexibility with respect to flocculation energy and treatment flexibility • Adding a sewer connection avoids the need for thickening and dewatering, further simplifying plant operations and improving reliability	• Filter waste wash water handling footprint will increase in size • Time will need to be spent to reconfigure the plant layout and incorporate design changes

Discussion

Alternative No.: SC-23

Reconfiguration of the Admin, Flocculation, Filter, chemical storage and UV facilities

The current plant layout is configured with a direct connection to the administration portion of the building. The tight integration between the process area and administration area will make it more challenging to reconfigure the plant to a conventional filtration plant should water quality degradation ever necessitate such a change. Planning additional flexibility into the facility now could prove helpful in some future decades.

Key features of a reconfigured flocculation, filtration, and UV facility would provide the following benefits:

1. If necessary in the future, the flocculation basins could be easily extended to provide additional flocculation time.
2. If necessary in the future, sedimentation basins could also easily be added without significant modifications to the existing facilities.

Replacement of residuals handling processes with less mechanically intensive processes

The proposed residuals handling, and centrifuge equipment are highly mechanized processes that will require operator attention and maintenance. When a centrifuge that is included in the design is taken offline for maintenance or shipped back to the factory for rebalancing, the plant will only be able to store solids in the thickener for a finite period. After that, the plant would have to shut down or other emergency solids removal activities would have to be taken.

Replacing these facilities with a simpler settling tank and sewer discharge of 0.25% solids would be preferred. If a sewer discharge cannot be provided, a thickener and belt press or screw press should be considered. Belt presses and screw presses have maintenance advantages over centrifuges for this application.

Adding flocculators to the last third portion of flocculation

The design currently incorporates three stages of flocculation tankage but only includes vertical shaft flocculators in the first two tanks. It is suggested that flocculator equipment be added to the third stage to provide operators more flexibility with respect to flocculation energy.

Add a 150 mm (6 inch) 1.2 ML/d (250 gpm) sewer connection

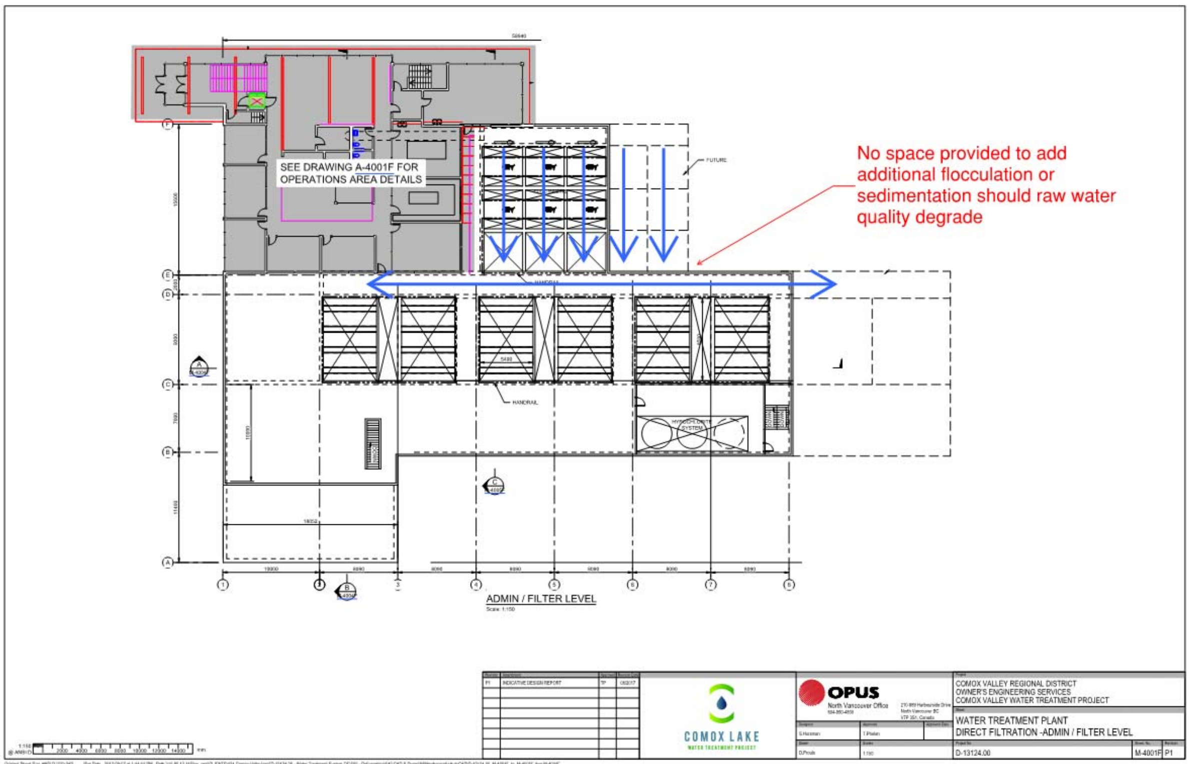
Adding a sewer connection to the plant will simplify operations at the plant by eliminating the need for thickening or dewatering. The table below presents a solids analysis for peak summer and winter flows under various turbidity and coagulant conditions. Based on the analysis the sewage discharge rate would be approximately 0.53 ML/D at a conservatively low assumed solids concentration of 0.25% solids.

Solids Production Scenarios

Season	Plant Flow ML/d	Turbidity NTU	Coag mg/L	Kg/day	Conc wt/wt	Sewer Discharge Flow L/day	L/min	gpm
Summer	120	1	7	398	0.25%	159,200	111	29.21
Summer	**120**	**4**	**9**	**1001**	0.25%	**400,400**	**278**	**73.46**
Summer	90	1	7	299	0.25%	119,400	83	21.91
Summer	90	4	9	751	0.25%	300,300	209	55.10
Summer	75	1	7	249	0.25%	99,500	69	18.26
Summer	75	4	9	626	0.25%	250,250	174	45.91
Winter	40	1	7	133	0.25%	53,200	37	9.76
Winter	**40**	**20**	**12**	**1325**	**0.25%**	**530,000**	**368**	**97.24**
Winter	30	1	7	100	0.25%	39,900	28	7.32
Winter	30	20	12	994	0.25%	397,500	276	72.93
Winter	25	1	7	83	0.25%	33,250	23	6.10
Winter	25	20	12	828	0.25%	331,250	230	60.78

Alternative No.: SC-23

☑ Original ☐ Alternative

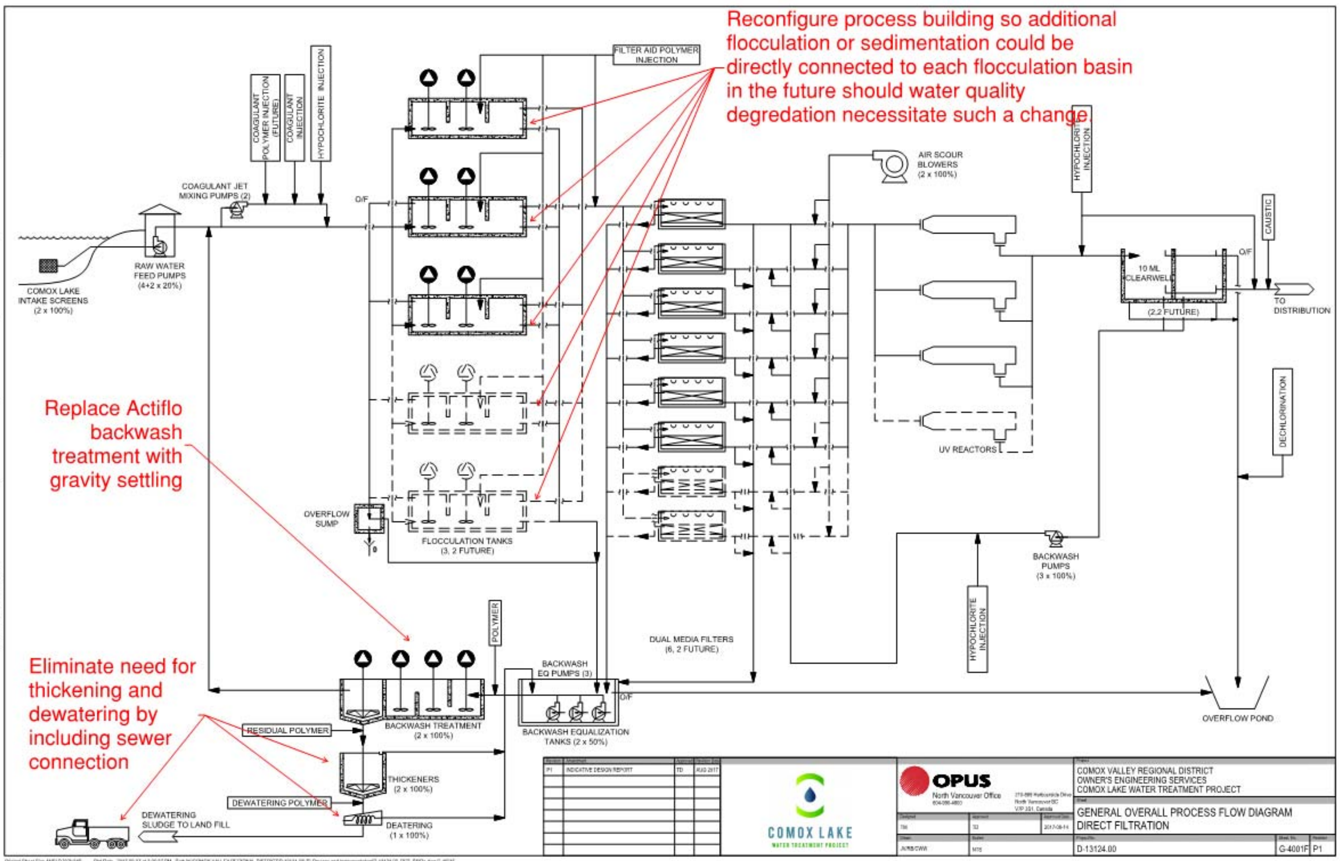


Original layout showing that extension of the flocculation basins or direct connection of sedimentation basins is not possible

Sketch

Alternative No.: SC-23

☐ Original ☑ Alternative

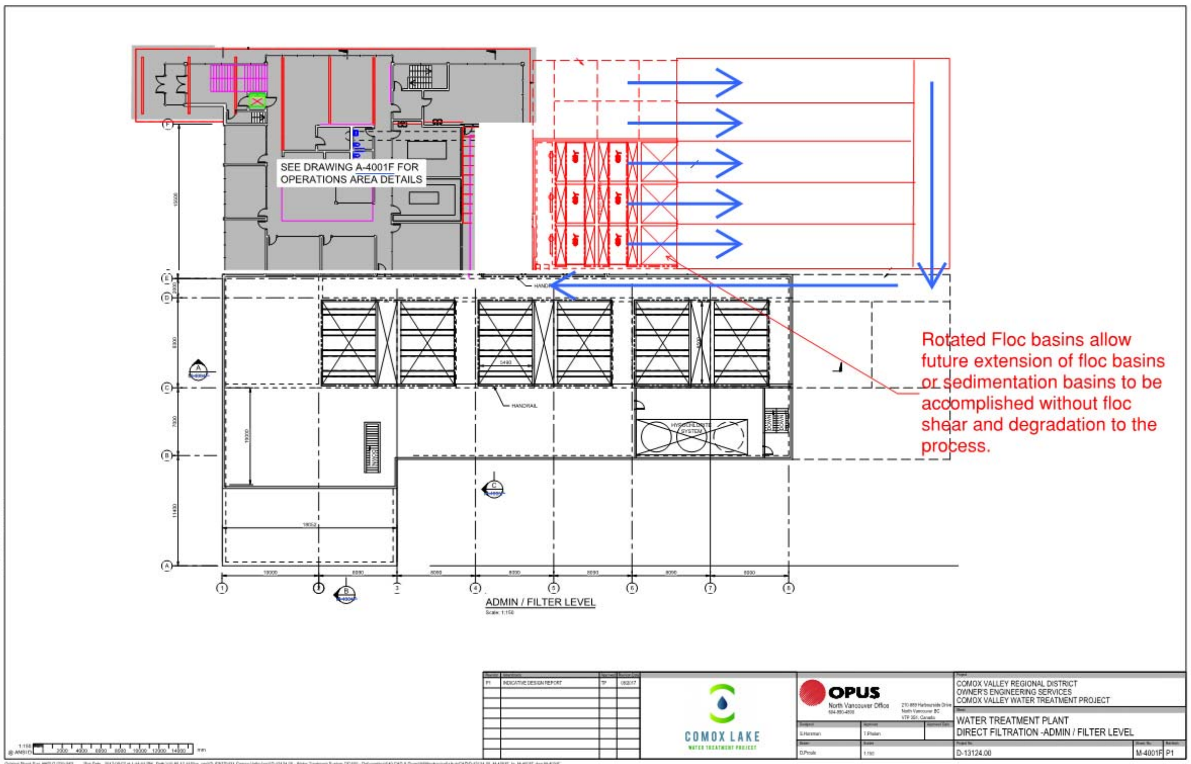


Modifications to the Direct Filtration Alternative

Sketch

Alternative No.: SC-23

☐ Original ☑ Alternative



Modified layout showing rotated flocculation basins to provide flexibility for future process changes

Calculations

Alternative No.: SC-23

☐ Original ☑ Alternative

Unit Sludge Production Rate Calculator

Capacity		**40**	**ML/day**	**10.6**	**mgd**
Overall plant recovery		100%	percent		
Turbidity		20	NTU		
Turbidity to TSS Ratio		1.5	NTU:TSS		
Suspended Solids		30	mg/L		
Feed (assume ZLD)		40	ML/day		
Mass of suspended solids		**1200**	**kg/day**		
Dose of Coagulant		12	mg/L		
Coagulant sludge production ratio		0.26	no		
Solids from Coag		3.12	mg/L		
Mass of Coagulant		125	Kg/day		
Total Solids	1,325		kg/day	2,914.56	lb/day
USPR		33.12	kg/ML	275.79	lb/MG

Construction Cost Estimate

Alternative No.: SC-23

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Actiflo®	1	1,967,600.00	1	$1,967,600		
Backwash Equalization Tanks (Modifications)						
Add Pump for Third chamber	1	126,000.00			1	$126,000
Modify Equalization tanks for Hopper	EA	1,253,900.00			0.75	$940,425
Residual Building	LS	2,575,930.00	1	$2,575,930		
12" Upgrade existing sewer mains in Lake Trail RD	LM	590.00			1,200	$708,000
6" Direction drill	LM	300.00			800	$240,000
6" Sewer Line	LM	200.00			4,800	$960,000
12" Upgrade existing sewer mains in Lake Trail RD	LM	590.00			1,200	$708,000
6" Direction drill	LM	300.00			800	$240,000
Floccoutor Stage 3	EA	36,360.00			3	$109,080
Total Markup	57.41%			$2,608,441		$2,314,487
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$7,152,000		$6,346,000
NET SAVINGS						$806,000

Life Cycle Cost Analysis

Alternative No.: SC-23

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST	ORIGINAL CONCEPT	ALTERNATIVE CONCEPT
	$7,152,000	$6,346,000
Capital Cost Savings		$806,000

ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Generalized O&M (% of Capital Cost)								
Actiflo® Operational Cost	1.0%	20.9303	3,345,000	33,000	691,000	214,200	2,100	44,000
Backwash Treatment	1.0%	20.9303	1,967,600	20,000	419,000	0	0	0
Residuals System	1.0%	20.9303	2,575,930	26,000	544,000	0	0	0
Sewer Connection	1.0%	20.9303	0	0	0	4,855,200	48,600	1,017,000
SUB-TOTAL					$1,654,000			$1,061,000

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$1,654,000		$1,061,000

PRESENT WORTH SAVINGS ON O&M	$593,000
LIFE CYCLE COST SAVINGS	$1,399,000

Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	SC-28
Install a sewer without using the penstock corridor and redesign the backwash handing system	
Description of Original Concept:	
The original concept is to build the treatment plant without a sewer connection. This was driven by BC Hydro's decision to deny use of the penstock corridor for a sanitary sewer line. BC Hydro's reasoning was because they did not want anything that is potentially deleterious in their right of way.	
Description of Alternative Concept:	
The alternative concept is to use an alternate sewer route to provide a 150 mm sewer connection for the plant. The sewer connection for the plant eliminates the need for onsite thickening and is essential for CIP waste discharge for the membrane options.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$978,000
O&M Savings:	$49,000
Life Cycle Cost Savings:	$1,027,000

Advantages/Disadvantages

Alternative No.: SC-28

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• A sewer line connection has the greatest benefit to the membrane options by eliminating regulatory concern with onsite discharge of neutralized CIP waste. • A sewer line connection benefits the membrane and direct filtration options by eliminating the need for thickening and dewatering. • The elimination of thickening and dewatering reduces plant failure points and reduces operational headaches and distractions.	• Environmental groups could provide opposition to the Lake Trail Road corridor or other routes

Discussion

Alternative No.: SC-28

Due to BC Hydro's denial of the sewer line routing from the plant, the current plan is to design the plant as a zero-liquid discharge plant. A true zero-liquid discharge plant is challenging, if not impossible, to implement in wet environments since year-round evaporation is not available. Therefore, zero liquid discharge plants in wet climates really become infiltration plants. Infiltration is problematic as it can suffer regulatory permitting issues now and in the future, especially for neutralized CIP waste. Most plants that have lagoons for neutralized CIP waste have lined lagoons and rely on solar evaporation to avoid land or groundwater discharge.

Because of concerns related to the permitting of a neutralized CIP waste system, a sanitary sewer connection is considered necessary for a membrane plant design. It not only eliminates the regulatory concern with the CIP waste, but it also eliminates the need for the thickener and dewatering processes.

As for a direct filtration plant, a sanitary sewer connection is not required to operate as a zero-liquid discharge plant. However, it is beneficial since it simplifies operation and eliminates the need for thickening and dewatering.

Overall, securing a sanitary sewer connection for the plant will be highly beneficial.

The sketch below shows one potential route for a sanitary sewer line within Lake Trail Road. The line is estimated to be a minimum required size of 150 mm (6 inch) and would have more than double the required capacity needed for plant waste discharge. The pipeline could gravity flow from the plant to the connection point near the school on lake trail road with and an inverted siphon used below the riparian crossing.

At this time, it is unknown what capacity improvements would be needed to the existing collection system downstream of the tie in point. A bottleneck is known to occur in the 150 mm pipeline near Willemar Avenue and Lake Trail Road.

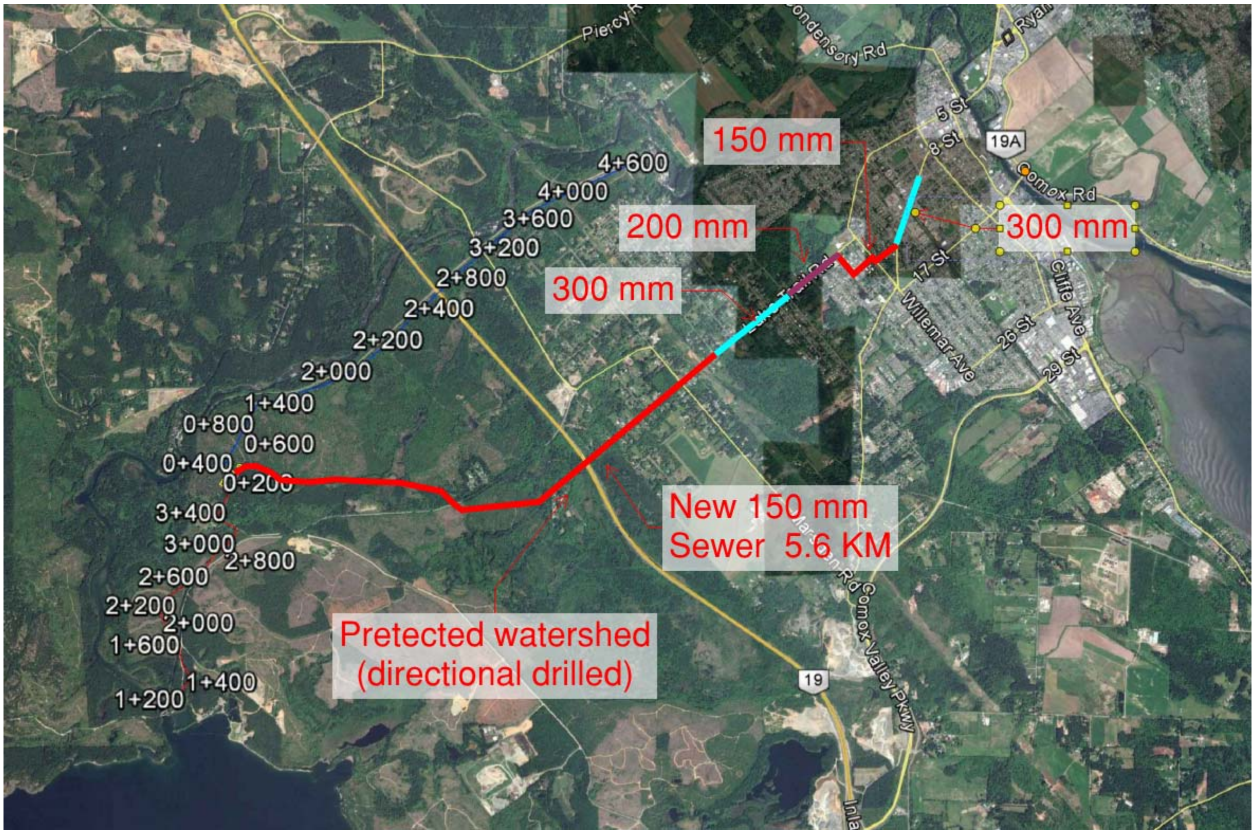
This is primarily a regulatory/permitting concern that may require undefined special design consideration that should be addressed at this time. The simpler course of action is to construct a sewer correction.

This is primarily a regulatory permitting concern that may require undefined special design considerations that should be addressed at this time. The simpler course of action is to construct a sewer connection.

Sketch

Alternative No.: SC-28

☐ Original ☑ Alternative



New 5.6 KM sewer pipeline from plant to Lake Trail Road

Construction Cost Estimate

Alternative No.: SC-28

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Actiflo®	1	1,967,600.00	1	$1,967,600		
Backwash Equalization Tanks (Modifications)						
Add Pump for Third chamber	1	126,000.00			1	$126,000
Modify Equalization tanks for Hopper	EA	1,253,900.00			0.75	$940,425
Residual Building and thickener	LS	2,575,930.00	1	$2,575,930		
12" Upgrade existing sewer mains in Lake Trail RD	LM	590.00			1,200	$708,000
6" Direction drill	LM	300.00			800	$240,000
6" Sewer Line	LM	200.00			4,800	$960,000
12" Upgrade existing sewer mains in Lake Trail RD	LM	590.00			1,200	$708,000
6" Direction drill	LM	300.00			800	$240,000
Total Markup	57.41%			$2,608,441		$2,251,864
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$7,152,000		$6,174,000
NET SAVINGS						$978,000

Life Cycle Cost Analysis

Alternative No.: SC-28

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST			ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
					$7,152,000			$6,174,000
Capital Cost Savings								$978,000

ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Generalized O&M (% of Capital Cost)								
Actiflo® Operational Cost	1.0%	20.9303	3,345,000	33,000	691,000	214,200	2,100	44,000
Backwash Treatment	1.0%	20.9303	1,967,600	20,000	419,000	0	0	0
Residuals System	1.0%	20.9303	2,575,930	26,000		0	0	
Sewer Connection	1.0%	20.9303	0	0		4,855,200	48,600	1,017,000
SUB-TOTAL					$1,110,000			$1,061,000

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$1,110,000		$1,061,000
PRESENT WORTH SAVINGS ON O&M						$49,000
LIFE CYCLE COST SAVINGS						$1,027,000

GENERAL

Value Alternative

Project: Comox Lake Water Treatment Project
Location: Comox Valley, BC

	Alternative No:
Title:	G-05
Provide a river intake with pressure membranes, backwash treatment with plate settler, with residuals and CIP waste to sewer	
Description of Original Concept:	
The original concept includes for a pressure membrane system includes a deep-water intake in the lake (120 ML/d) a raw water pump station at the lake, and a raw water pipeline to the membrane plant. The plant includes rapid mix and flocculation, two stage pressure membrane filters, gravity thickener with polymer, and on-site CIP disposal.	
Description of Alternative Concept:	
The alternative concept for a pressure membrane system includes a river Intake with a 120 ML/d pump station and raw water pipe line to convey water from the river to the plant. There would also be a raw water pump station at the lake to convey water down the river when the lake level is below EL 130.7. The plant includes single stage pressure membrane filters, plate settler with coagulant, and a new sewer line for CIP disposal.	

Value Improvement

$$\text{Value} \approx \frac{\text{Function}}{\text{Resources}}$$

Function	Resources
☐ Increased	☐ Increased
☑ Maintained	☐ Maintained
☐ Decreased	☑ Decreased

Cost Savings Summary

First Cost Savings:	$23,081,000
O&M Savings:	($2,994,000)
Life Cycle Cost Savings:	$20,087,000

Advantages/Disadvantages

Alternative No.: G-05

Advantages of Alternative Concept	Disadvantages of Alternative Concept
• Takes advantage of higher water temperature in summer that will increase production capacity • Eliminates cumbersome and problematic second stage membrane treatment system • Settled solids and CIP waste volume are sufficiently minimized to discharge to sewer • Removes fatal flaw of having polymer feed in a membrane treatment system • Reduces the size of the raw water transmission pipeline • Refer to Alternatives SC-01, SC-13 for additional information and qualification • Possible discharge of backwash water to Puntledge River could be investigated • Close intake allows single pump arrangement where river/reservoir pumps are used to provide operating pressure for operation of the membrane system.	• Pump station and pipeline required for supply of water under drought condition. • CVRD would have to negotiate land acquisition with BC Hydro for a river intake and MFLNRO. • Process is sensitive to backwash flow and concentration of solids from plate settler

Discussion

Alternative No.: G-05

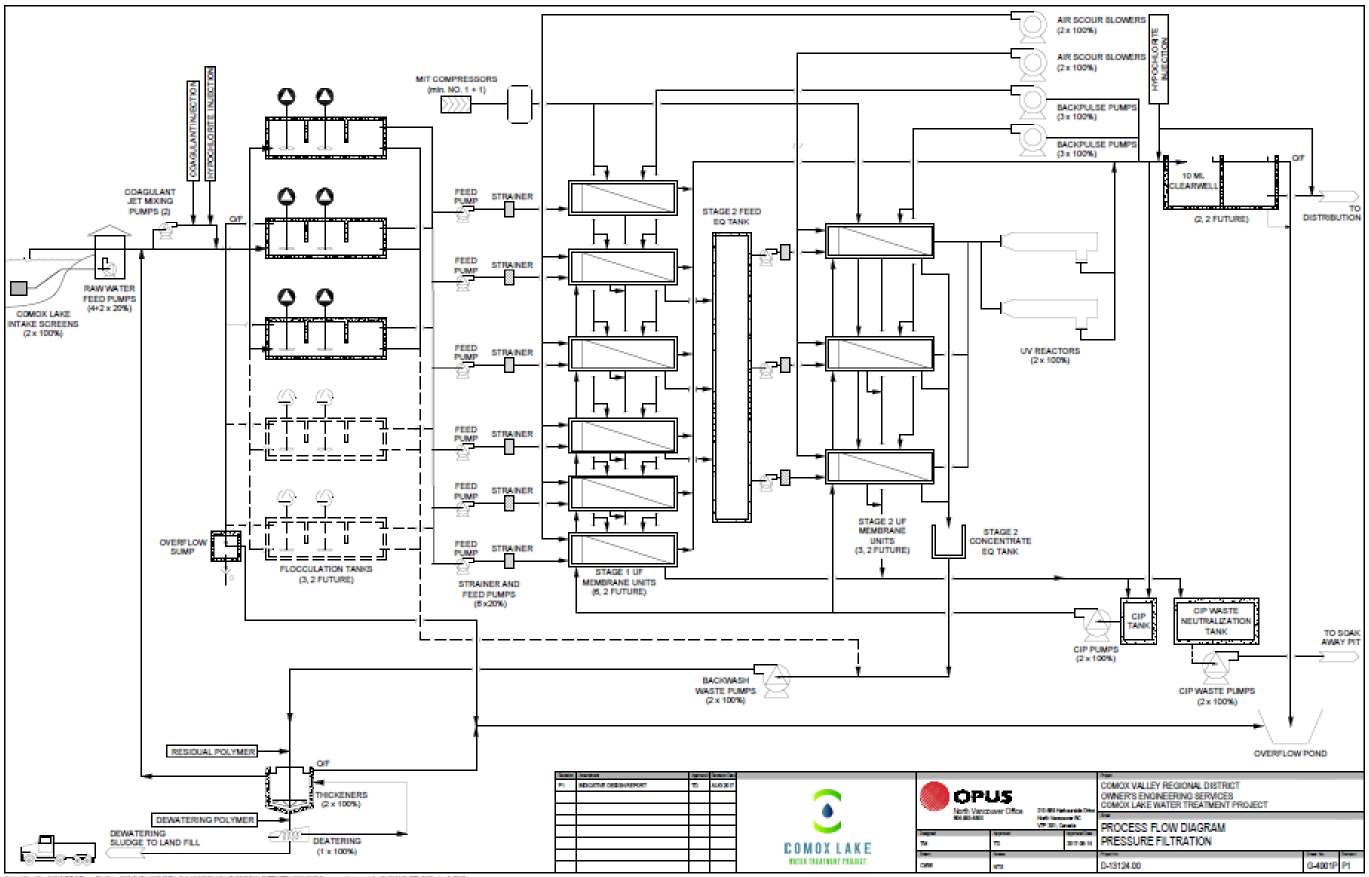
This option is a compilation of an alternative membrane system approach to optimize the total project cost for membranes. It is based upon the following.

- It is well established that membrane capacity is a function of water temperature. The deep-water intake has a design temperature range of 5 to 11 degrees C. (Section 4.2.3 IDR). Maximum Surface Water Temperature is 20 degrees C. (Comox Lake and Puntledge River Water Temperature Study 2004) There will be about a 25 percent increase in capacity of the membrane system with a design temperature of 20 degrees C versus 11 degrees C. A more detailed analysis would be needed to determine the point at which maximum design conditions exist, but a nominal 15 percent increase in capacity will be used for the estimate.
- As discussed in SC-01, a membrane system does not require coagulation and flocculation prior to the system.
- As discussed in SC-13, a conventional solids separation system is less expensive and simpler to operate.
- Using solids from the plate settler at 1.0 percent solids sufficiently reduces the amount that can be discharged to a sewer. This eliminate the thickener and dewatering components of the design.
- Although not included as a component of this discussion, it may be possible to discharge the backwash water from the first stage membrane system to the Puntledge River, as only naturally occurring solids and no chemicals are contained in the backwash water. (MFLNRO)

Sketch

Alternative No.: G-05

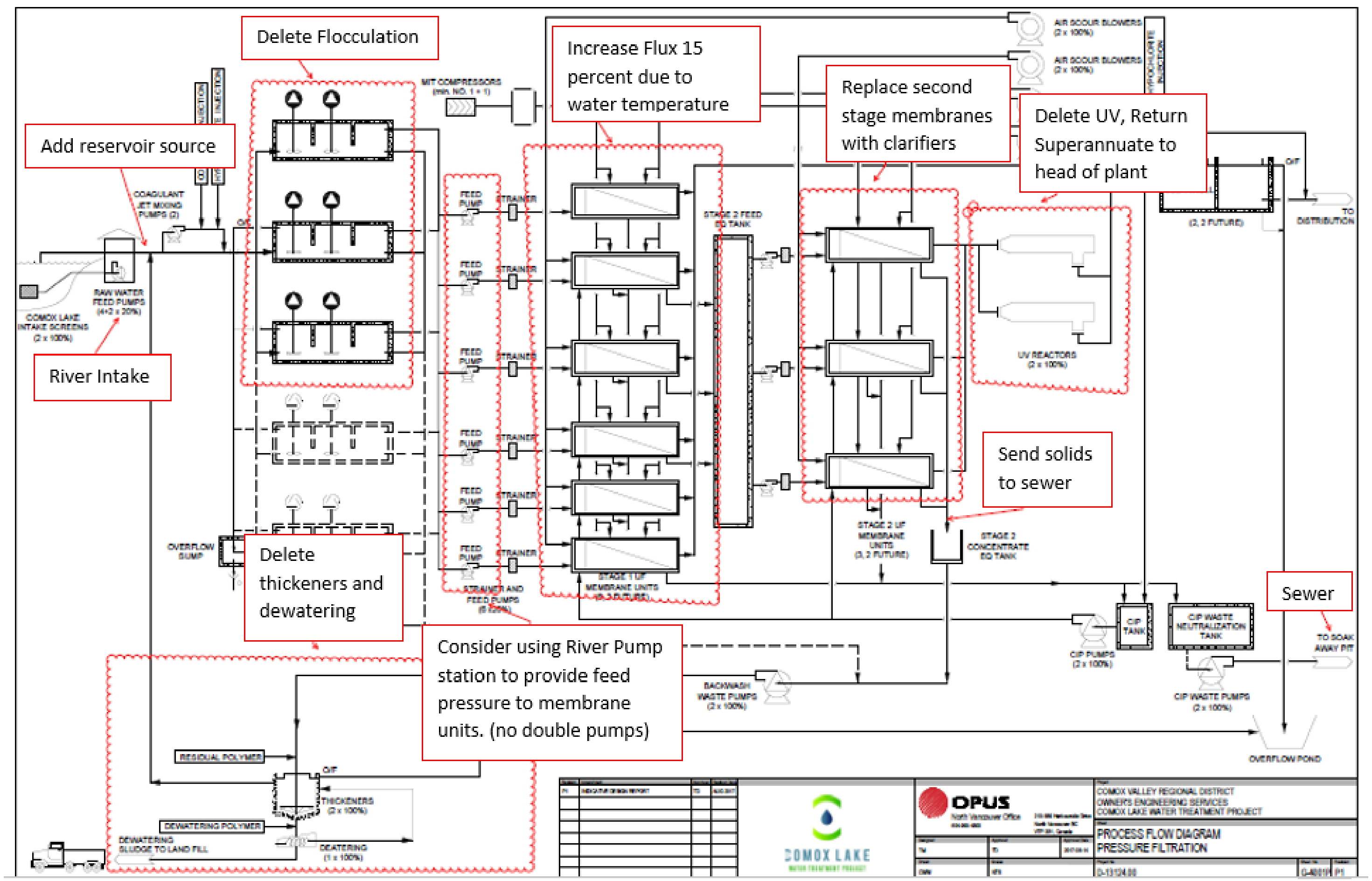
☑ Original ☐ Alternative



Sketch

Alternative No.: G-05

☐ Original ☑ Alternative



Construction Cost Estimate

Alternative No.: G-05

Item	Unit of Meas	Unit Cost	Original Concept (Deletions) Qty	Original Concept (Deletions) Total	Alternative Concept (Additions) Qty	Alternative Concept (Additions) Total
Pre-Treatment Coagulation	1	1,186,000	1	$1,186,000		
Flocculation	1	1,120,000	1	$1,120,000		
Actiflo®	1	1,967,600	1	$1,967,600		
Backwash Equalization Tanks	1	1,476,544	1	$1,476,544	1.25	$1,845,680
Add Pump for Third chamber	1	120,000			1	$120,000
UV UNIT -51-A	EA	166,980	2	$333,960		
Pressurized Membrane Package	LS	8,832,000	1	$8,832,000	0.9	$7,948,800
UVT Indicator Transmitter	EA	18,113	1	$18,113		
Plate Settler 2ML/d	EA	225,000.00			3	$675,000
Residual Building	EA	2,580,930	1	$2,580,930		
Raw Water Pipeline	EA	5,458,270	1	$5,458,270	0.1	$545,827
Raw Water Pump Station	EA	4,503,385	1	$4,503,385	0.9	$3,827,877
Intake Screen and Marine Pipeline	EA	5,155,100	1	$5,155,100		
Intake Screen/Installation to PS	EA	150,000.00			1	$150,000
Sewer Line Disposal					1	$2,856,000
Total Markup	57.41%			$18,733,975		$10,316,109
TOTALS - Construction Cost	Breakdown of Markup can be found in the Cost Appendix			$51,366,000		$28,285,000
NET SAVINGS						$23,081,000

Life Cycle Cost Analysis

Alternative No.: G-05

LIFE CYCLE PERIOD 30 YEARS ANNUAL PERCENTAGE RATE 2.500%

CAPITAL COST	ORIGINAL CONCEPT	ALTERNATIVE CONCEPT
	$51,366,000	$28,285,000
Capital Cost Savings		$23,081,000

ANNUAL EXPENDITURE	%	PRESENT WORTH FACTOR	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT		
			CAPITAL COST	ANNUAL COST	PRESENT WORTH	CAPITAL COST	ANNUAL COST	PRESENT WORTH
Coagulant		20.9303		30,000	628,000		0	0
Coagulant		20.9303		0	0		30,000	628,000
Clean In Place		20.9303		40,000	837,000		0	0
Electrical		20.9303		31,000	649,000		15,000	314,000
UV Disinfection		20.9303		15,000	314,000		0	0
Residual Polymer		20.9303		12,000	251,000		0	0
Sewer Disposal (BW)@75ML/d		20.9303					176,000	3,684,000
Sewer Disposal CIP		20.9303					50,000	1,047,000
Generalized O&M (% of Capital Cost)								
SUB-TOTAL					$2,679,000			$5,673,000

SINGLE EXPENDITURE (REPLACEMENT)	YEAR	PRESENT WORTH FACTOR	ORIGINAL CONCEPT		ALTERNATIVE CONCEPT	
			ESTIMATE	PRESENT WORTH	ESTIMATE	PRESENT WORTH
Salvage Value at End of Economic Life						
SUB-TOTAL				$0		$0
TOTAL PRESENT WORTH				$2,679,000		$5,673,000
PRESENT WORTH SAVINGS ON O&M						($2,994,000)
LIFE CYCLE COST SAVINGS						$20,087,000

SECTION 4

DESIGN SUGGESTIONS

SECTION 4
DESIGN SUGGESTIONS

In addition to the Value Alternatives in the previous section, the team generated several other ideas that we have termed design suggestions. These are presented to bring attention to areas of the design which, in the opinion of the team, should be changed. In general, these ideas were designated as design suggestions rather than Value Alternatives for one of two reasons:

1. The value improvement opportunity is relatively small
2. The concept could not be adequately evaluated or developed within the constraints of the workshop resources

Design suggestions typically are associated with issues such as:

- Improved operation
- Ease of maintenance
- Easier construction
- Reduced risk of construction claims
- Clarification of construction documents
- Or safer working conditions

Design Suggestion

	Alternative No:
Title:	IR-07

Use finite element analysis (FEA) to design the connection with the HDPE marine pipeline and the fixed elements to better understand thermal movement

Discussion:

The original concept presented in the IDR includes a fish screen structure, with the HDPE intake pipeline attached with a flanged connection.

The original concept presented includes some unknown but assumed to be fixed connection to the end of the micro-tunnel leading to the RWPS.

The Indicative Design Report indicates that the lake water temperatures at the 30m depth varies from 5 degrees C to 11 or 12 degrees C over the year.

HDPE has a thermal coefficient of expansion of 1.8 x10^{-4} m/m/degrees C.

Over the temperature range, the 850 m intake pipeline, as exposed on the lake bottom will expand or contract as much as 1 m.

If the HDPE pipe is fixed at both ends, thermal expansion/contraction forces will cause the pipe to bend. Additionally, when the pipe is installed, the end of the pipe attached to the fish screen is unlikely to be parallel to the flange on the end of the fish screen assembly.

It has been found, in working with other HDPE pipeline projects that are exposed to thermal changes without fixation (as in a water column without the restraint of soil), that finite element analysis has been helpful in examining approaches that are necessary to avoid excessive movement and the ability to reliably connect pipelines.

For instance, on a recent project comprising large diameter HDPE pipe to fixed objects, flexible connections were required to accommodate connecting pipe ends that are not parallel to each other, and to facilitate the movement of the pipe during thermal stresses.

It is suggested that the designer examine the details of installation to predict pipeline alignment and pipe stresses as a result of thermal stresses.

Design Suggestion

	Alternative No:
Title:	IR-09
Suspend the marine pipeline above the bottom	
Discussion:	

The marine pipeline, as proposed, would be placed on the bottom of the lake, using concrete weights. It is connected rigidly at both ends, to the fish screen at one end and to the micro-tunnel at the other.

Thermal stresses will force misalignment of the pipe during temperature variations in the lake, due to the fixed ends.

Suspending the pipeline in the water column will relieve stresses to some extent, allowing the pipeline to move as it relieves stresses.

The mechanical methods of suspending the pipeline can be achieved using the same concrete anchors as designed, but rather than fixing them to the pipe, they can sit on the lake bottom and be connected to the pipe using cable or chains and collars on the pipe. This method has been used to fix a gravity sewer line in a lake as a means of avoiding the construction and environmental impacts of laying the pipeline on the bottom. This method also avoids the undulations of the bottom topography, and it avoids potential settlement due to soft bottom conditions.

Potentially, this method, if combined with a movable fish screen assembly, would also allow some adjustment in horizontal and vertical position of the screen.

Design Suggestion

	Alternative No:
Title:	IR-47
Provide a berm around the RWPS for sound attenuation and aesthetics	
Discussion:	

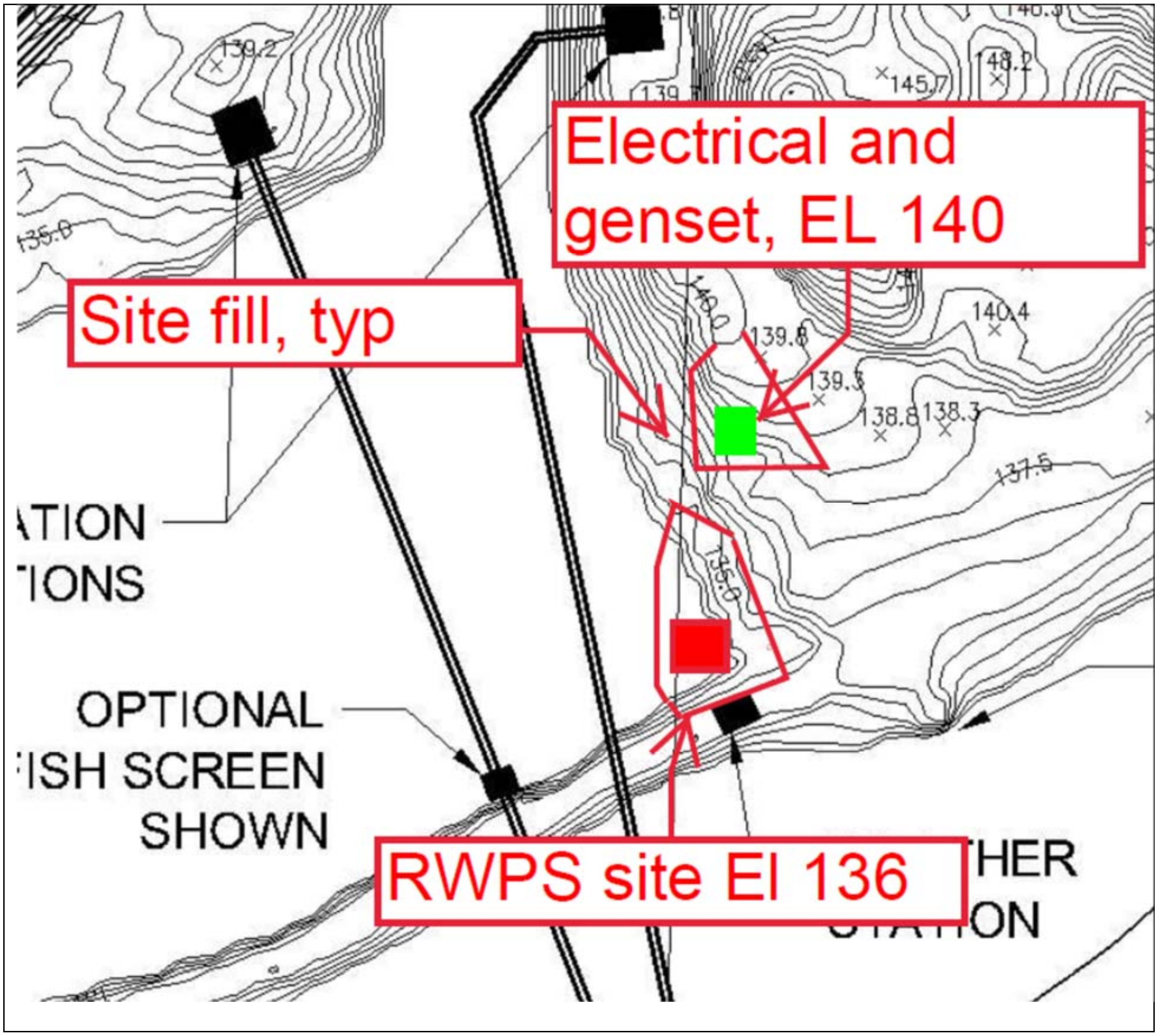
The alternative RWPS site being investigated by CVRD, which is located at the spit on the south side of the lagoon, near the Courtenay and District Fish and Game Protective Association (DCGPA) property is potentially sensitive due to noise associated with pump station equipment, particularly pump motors and variable speed drives. As well, when the emergency generator is tested and/or run for backup power, noise will be generated.

The RWPS and the emergency generators will likely be located adjacent to the pump station, at an elevation above the maximum probable flood of EL139. This will require at least 3 m of fill on land adjacent to the CDGPA boat launch and picnic area; as well, campsites are nearby.

This Design Suggestion comprises a recommendation to investigate adding additional berms and landscaping for sound attenuation and aesthetics. The illustration on the next page shows a conceptual layout.

RWPS site. The RWPS site would be at about EL136 to adequately screen the top of the pump station structure. Additional berming and planting on the east side of the structure would be high enough, about to EL 140 to screen the above grade utility structure. Security fencing could be incorporated into the screening.

Electrical Service Site. The electrical service, including switchgear, VFD's, and emergency generator might be located at EL140, above the maximum probable flood elevation. Berming here would reduce noise effects on the adjacent campground.


139.2
145.7
148.2
139.7
Electrical and genset, EL 140
135.0
Site fill, typ
140.0
139.8
140.4
139.3
138.8
138.3
137.5
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TIONS
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OPTIONAL
FISH SCREEN
SHOWN
RWPS site El 136
THER
STATION

Design Suggestion

	Alternative No:
Title:	IR-49

Use single, cylindrical screen instead of a "T" screen, mounted on a sled, rather than fixed to the bottom

Discussion:

The fish exclusion screen, as proposed includes a "T" screen, that is four screens, arranged in a "T" shape, and attached at their bottoms, to a solid steel pipe, and thence to a concrete foundation that is grouted into the lake bottom. Documents mention that, if necessary, the screen might be enlarged in the future. The "T" screen assembly projects about 3.8m above the lake bottom with a total screen area of about 28 m^2. The screen would be connected to the marine pipeline by either flanges or flexible connections.

Construction of the screen includes a prefabricated foundation and screen assembly that is grouted into concrete piers embedded in the lake bottom. As proposed, the foundation would be prepared by divers and underwater trenching equipment. It is expected that some soft conditions may be encountered at the proposed location, albeit, more firm than other locations proposed earlier.

It is not apparent, from the drawings that there is a convenient way to expand the screen in the future.

As an alternative, two design modifications might be considered.

Single Screen. A single fish screen, approximately 1830 mm ID (72 in) and 4.9 m long (16 ft) long, would provide the same screen area. This screen, if attached to the end of the pipe with its axis parallel to that of the pipeline, would reduce the overall height of the assembly by about 1 m. The screen needs clearance below it for adequate flow around the perimeter and it would need to be mounted on a platform with legs to achieve the required separation.

Sled. Further, if the screen assembly were mounted on a prefabricated sled, work associated with fixing the screen assembly to the lake bottom would not be necessary, obviating the need for underwater excavation and grouting. This sled would allow axial movement of the screen to accommodate changes in pipeline length due to thermal stresses. It would also avoid some problems that might occur trying to achieve level/plumb alignment of the screen during underwater construction. Lastly, if the sled weight was designed to minimize foundation pressure on the lake bottom, then adjustment up and down might be achievable to accommodate bottom siltation conditions.

Design Suggestion

	Alternative No:
Title:	IR-60
Revise water system design delivery pressures relative to pressure zones	
Discussion:	

This project will add about 20 m to the system delivery pressure at the delivery point on the Puntledge River site (HGL EL110 to HGL EL130.). Delivery pressure less than 130 m would require operation of the Dingwall and Ryan Road pump stations which are intended to be decommissioned under this project.

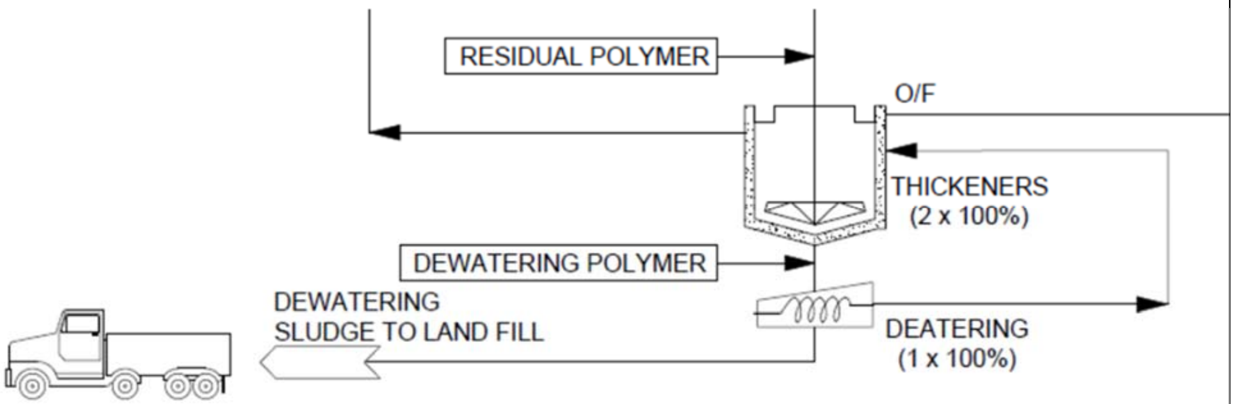
This Design Suggestion recommends a review of the delivery system pressures downstream of the connection point as a risk management measure. The purpose is to identify and evaluate system pressures to determine if the change in operating pressures could threaten the integrity of the existing delivery or distribution system. This could be accomplished with a hydraulic model and review of the physical attributes of the delivery system.

Design Suggestion

	Alternative No:
Title:	SC-03
Replace centrifuge with belt press or screw press	
Discussion:	

Only one is listed in the design. What happens when the centrifuge requires maintenance?

The diagram for the system is shown below.



Design criteria from the IDR is presented below.

Table 7-25: Centrifuge Design Criteria

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Centrifuge			
Number of units		1	
Hydraulic loading, m^3/hr		2 to 5	
Solids Recovery, %		95	
Dewatered Solids Content, %		20.0	
Solids Feed Concentration, %		2.0	
Polymer System			
Polymer Dose, kg per dry tonne		9	
Polymer Consumption, kg/d		4.5	

The choice of dewatering equipment is often an owner preference. The most common choices for selection are based upon operation and maintenance considerations as well as the water content of the solids discharged from the process.

We suggest that the owner investigate the local options as well as maintenance requirements that are associated with each type of dewatering equipment. A screw press is generally viewed as the simplest type of device, the belt press is more complex, and the centrifuge is the most mechanically complex device available(high speed rotating assembly).

The CVRD may have a preference based on local conditions at local wastewater facilities. It should be noted that the volume of solids generated from a water plant is typically significantly lower than from a wastewater facility.

Dewatering equipment generally requires a polymer to enhance operation. It is noted that for the membrane system design, polymers may not be compatible with the membrane fibers and the recycle stream may be a potential problem.

It is suggested that the CVRD develop an approach to address maintenance (e.g. trucking of underflow to WWTP, shelf spare, installed spare) that would be used when equipment was unavailable.

Design Suggestion

	Alternative No:
Title:	SC-16

Limit membrane suppliers to those who have previously completed 50 ML/d facilities

Discussion:

There are many potential membrane suppliers, the following table was provided in the IDR.

Table 7-11: Membrane Manufacturers and Characteristics

Flow Path	Material	Manufacturer	Pore Size (nm)	OD X ID (mm)
Pressurized				
Outside-In	PVDF	GE zw1500	20	1.1 x 0.66
		Pall aria	100	1.3 x 0.7
		Evoqua cp	40	1.03 x 0.54
		Hydranautics hydracap	80	1.2 x 0.6
		DOW integraflux	30	1.3 x 0.7
		Toray torayfil hfu	20	1.5 x 0.9
Inside-Out	PES	PENTAIRE NORRIT X-flow	20	1.2 x 0.8
		BASF inge DIZZER	20	4 x 0.9
		3m liqui-flux	10	1.2 x 0.8
Submerged				
Outside-In	PVDF	Ge zw1000	20	0.8 x 0.47
		Evoqua cs	40	1.03 x 0.54
		Toray torayfil hsu	20	1.5 x 0.9

There are other membrane suppliers not listed. Some suppliers are vertically integrated, that is they manufacture membranes and systems. Other membrane suppliers provide membranes through original equipment manufacturers (OEM's) who provide the associated equipment. Companies such as H2O Innovations, Wigen Water and Westech would likely be associated with the supply of membrane and offer "open platform" designs that can accept membrane modules from a variety of suppliers. They may or may not have prior experience with the specific membrane model being considered. A special circumstance exists with the Pall System which historically uses a the (Aria/Asahi) membrane can also accept membranes from GE or Scinor (not listed).

It is suggested that the CVRD pre-select and qualify the selected membrane supplier and OEM as part of the project. It should be noted that the pre-selection criteria should be specific to the exact membrane model being considered, as some suppliers have had numerous variations of product, with some products being used as replacement for more problematic membrane models.

In terms of operation, the following is suggested as considerations that are important in the selection of a membrane.

- Membrane fiber breakage history
- Time that a specific membrane model has been available
- Legal and warranty claims associated with specific membrane models
- Ease of cleaning
- Prior installed projects with (OEM/membrane manufacturer)
- Manufacturer service support

As a general trend, there are more options with pressure membranes. There may be future retrofits for vertically integrated membranes as well.

As a summary, the selection criteria should consider the specific membrane and specific supplier. It is advisable to limit the selection to those membranes and membrane suppliers that are well regarded.

Design Suggestion

	Alternative No:
Title:	SC-17
Procure only open-platform pressure membranes	
Discussion:	

There are a number of potential membrane pressure suppliers, the following table was provided in the IDR.

Table 7-11: Membrane Manufacturers and Characteristics

Flow Path	Material	Manufacturer	Pore Size (nm)	OD X ID (mm)
Pressurized				
Outside-In	PVDF	GE zw1500	20	1.1 x 0.66
		Pall aria	100	1.3 x 0.7
		Evoqua cp	40	1.03 x 0.54
		Hydranautics hydracap	80	1.2 x 0.6
		DOW integraflux	30	1.3 x 0.7
		Toray torayfil hfu	20	1.5 x 0.9
Inside-Out	PES	PENTAIRE NORRIT X-flow	20	1.2 x 0.8
		BASF inge DIZZER	20	4 x 0.9
		3m liqui-flux	10	1.2 x 0.8

There are other membrane suppliers not listed.

The most commercially successful membranes have the following characteristics.

- PVDF material
- TIPS (Thermally Induced Phase Separation)
- Outside-In-Flow
- Air assisted backwash
- Vertical orientation

It is suggested that the CVRD consider membranes of this type for the project. Membranes that satisfy the above criteria have historically low occurrences of fiber breakage and a generally superior reputation for installed capacity.

Although physical dimensions of the membrane modules may be different, some original equipment manufacturers are able to offer equipment designs that can accommodate membrane modules from different suppliers. This allows for competition within the market, and the ability to interchange membrane modules has lowered the cost of membrane modules over the past few years.

The membrane market is evolving, and membrane suppliers such as Scinor specialize in offering direct replacement membrane modules.

Other more established suppliers have replacement module offerings for systems other than their own. For example, Scinor, Dow and Suez (GE) offer membrane modules that will fit the Pall system.

The open platform design concept offers the owner greater ability to control membrane replacement options. There are essentially two types of platforms, the small module concept which is associated with Pall and a larger membrane module concept which is associated with Toray and Dow. It is possible to have a membrane that can accommodate more than one general size of membrane, although the platform requires additional spacing and has a larger footprint.

Fundamentally, PES membranes are not as commonly used for membrane treatment facilities. The underlying difference is that PES is not able to be backwashed, requires additional fibers to achieve the same capacity, and requires a high volume liquid backwash approach.

Some PES/PVDF suppliers design systems that use proprietary components and modules, and systems of this type should be avoided as it can significantly limit replacement options.

In some cases, it has been found to be more cost effective to replace a system in its entirety instead of replacing proprietary components of a system.

Design Suggestion

	Alternative No:
Title:	SC-34
Eliminate all polymer from membrane options	
Discussion:	

Polymeric membranes are generally not compatible with water treatment polymers, specifically cationic polymers, and this issue has been a problem for a number of membrane facilities.

The underlying problem with polymers is that they can permanently adhere to the membrane fiber and cannot be removed with the backwash or CIP process. Unless the specific polymer has been determined to be able to be cleaned, it should be avoided.

Many times, the underlying polymer chemistry is proprietary, and polymer suppliers are unwilling to disclose the underlying chemistry associated with the polymer. Some membrane suppliers have identified specific polymers that can be used with the membrane, and most of the polymers are of the non-ionic or anionic type.

Use of polymers is common in thickening and dewatering systems, and carryover of polymer to the membrane system can be problematic. The pilot study report evaluated a number of polymers; all of the cationic type and this is a concern.

The recommendation is to avoid if at all possible and confirm in writing or through demonstration prior to use. Once fouled membrane replacement is the only alternative.

Design Suggestion

Alternative No:	
Title:	PD-02

Break the procurement into three packages: WTP, intake, and pipeline

Discussion:

The project includes three areas requiring different construction techniques. Breaking the project into three separate packages offers several advantages:

- Each package would be bid by different contractors with differing specialties:
  - a structural-mechanical contractor for the WTP;
  - a marine contractor for the intake structure and pipeline on the lake bed;
  - a pipeline contractor for the transmission lines.
- It assures that the contractors will be bidding among technical peers.
- The owner will avoid the markups from a prime on specialty subcontractors.
- The project delivery method that is most appropriate for each style of work can be used.

This approach is common in the eastern and midwestern U.S. where projects are often bid along union craft divisions.

Design Suggestion

	Alternative No:
Title:	PD-05
Pre-qualify and pre-select the membrane supplier	
Discussion:	

The norm is that public agencies competitively bid construction projects and award the project to the lowest responsible and responsive bidder. A responsive bidder is readily determined by the bid submitted. However, a responsible bidder and the equipment it will provide is largely determined qualitatively. This presents inherent risk, generally "back-end" risk, i.e., risk that only becomes evident at the end of a project. For this project, in which the supplied membranes are approximately 20 percent of the project construction cost, prequalifying the membrane supplier is an excellent means for reducing risk.

Pre-qualification requires a Request for Information and Qualifications (RFIQ), which is a solicitation for a Statement of Interest and Qualifications (SOQ) from membrane suppliers followed by an evaluation of their qualifications and success in achieving project treatment requirements. This solicitation can be advertised before the contract documents are complete. After evaluation, acceptable membrane suppliers can be identified and selected for inclusion in the prime contract. This will allow sufficient time to refine the contract. In addition to the technical details identified by the owner's representative, interested membrane suppliers should provide information about their:

- Permanent employees;
- Financial status (current financial profile, bankruptcies, loans, and bonding);
- Proposed personnel and resources;
- Experience on projects of similar size, process type, and complexity, as well as timely supply of equipment and completion;
- References from banks, suppliers, contractors and clients.

Many states require that the pre-qualification process must include a mechanism to handle protests and inquiries. Protests from membrane suppliers who did not demonstrate acceptability constitutes front-end risk, i.e., a risk occurring at the beginning of a project. However, this front-end risk will be significantly less than the back-end risk from simply including a technical specification for membranes in the prime contract. Membrane suppliers are accustomed to the SOQ process and should be advised that this is a public process and assured that their submittals are confidential.

Design Suggestion

	Alternative No:
Title:	PD-18
Develop an enhanced risk response plan to better clarify and articulate what needs to be done	
Discussion:	

There is a Risk Register for the project. The following comments and question are based upon a cursory review of the register and suggest ways to enhance the utility of the Risk Register and Risk Response Plans.

1. Although it is titled Rev 008, it is not evident when the register was last updated and there are no entries for status or comments that might hint at that. Suggest adding review date within the spreadsheet. Ideally any change in risk should be identified along with the date of the update.
2. The register will become more useful if the "Mitigation Action/Strategy" is expanded to a risk response plan for each risk. Often these are separate documents and a summary and reference to the documents is sufficient.
3. "Risk Owner" is either Owner or Proponent. Consequently, unless there is another writing that accompanies the register, no individual is apparently responsible. At this point, it is appropriate to assign proponent risk generically. However, mitigation of proponent risks through the procurement documents should be identified as such. More importantly, assign an individual to ensure the mitigation is in effect.
   Assigning each risk to an individual is essential to the successful use of risk registers. In some instances, a group may be the owner; in that case name the individual who manages the group or is responsible for its input to the register.
4. Conventionally, risk falls into one of two categories – opportunities or threats. This register only characterizes threats. Suggest adding opportunities. For example, if funding arrives earlier than expected, the consequence might be an opportunity to accelerate other portions of the work.
5. Suggest adding a "Trigger" column. That helps identify the clues to the status of the risk. This is a conventional tool in risk management. The schedule may provide insight to dates for triggers.

These and other updates, refinements, and enhancements will add clarification and articulate the importance of individual responsibility for risk management.

Risk management in construction is critical to project success. PMI, in its Construction-Extension to the PMBOK Guide, discusses this. The following is excerpted from that document:

Special considerations should be taken regarding project communications and reporting, as project success relies heavily on communication throughout the project life cycle. Risk meetings should be held regularly to perform risk reviews; to update the status of risks in the risk register; and to repeat the process of identification, analysis, and response planning. Some risks may need to be escalated to program and portfolio level.

Communication with project stakeholders is important in order to periodically assess the acceptable level of risk on the project. Standard templates for risk status reports may be a helpful tool for project risk reporting.

Special considerations should be taken regarding project communications and reporting, as project success relies heavily on communication throughout the project life cycle. Risk meetings should be held regularly to perform risk reviews; to update the status of risks in the risk register; and to repeat the process of identification, analysis, and response planning. Some risks may need to be escalated to program and portfolio level.

Communication with project stakeholders is important in order to periodically assess the acceptable level of risk on the project. Standard templates for risk status reports may be a helpful tool for project risk reporting.

Design Suggestion

	Alternative No:
Title:	PD-26
Retain an independent consultant to provide a third-party review of the procurement documents	
Discussion:	
An additional set of eyes on the procurement documents will be quite helpful. One of the principal benefits can help in identifying the "unknown unknowns." This can be accomplished in several ways. Many agencies retain a consultant to assist the owner's representative in the development of the documents. CVRD is presently soliciting that assistance. Another option is to approach the Water Design-Build Council (WaterDesignBuild.com). Mark Alpert, the Executive Director, has helped many agencies. A third option is to convene a combination Value Engineering/Peer Review Team to review the documents. This has been successful for some agencies.	

Design Suggestion

	Alternative No:
Title:	PD-27
Include a disputes resolution board in the design build delivery process	
Discussion:	

Successful projects generally result from collaboration among the project participants, i.e., the owner, designer, contractor, and the stakeholders. Nevertheless, from time to time disputes will arise.

Most projects now have dispute resolution ladders established during project partnering. When a dispute arises between the two parties (the owner and the contractor), and the parties have not achieved resolution through the ladder, the parties may present the dispute to the Dispute Resolution Board (DRB) for the project. A DRB is a three-member board of impartial, experienced professionals formed at the beginning of the project to follow construction progress, encourage dispute prevention and avoidance, and assist in the resolution of disputes for the duration of the project. (Reference www.DRB.org) Both parties must select and approve the three members of the DRB. The DRB is formally convened by means of a signed three-party (Owner, Contractor, and DRB) agreement and the first meeting is held. The DRB then meets during site visits that occur at regular intervals.

The parties may present the dispute to the DRB. There are several ways in which this can be accomplished but the most common is that the DRB conducts a hearing at the site after receiving position papers from both parties. Once the hearing is concluded, the DRB prepares a recommendation to the parties commenting on the salient features of the dispute and presenting the DRBs findings and recommendations, principally on entitlement. If the parties accept the recommendations, the parties then proceed to negotiate an appropriate change order. If the parties do not accept the DRBs recommendations, the parties may pursue other Alternative Disputes Resolution processes (arbitration, mediation, and the like) and ultimately litigation. In all those processes, the DRBs recommendation may be submitted in evidence.

The DRBs record is impressive. Direct cost ranges from 0.06-0.30% of final construction contract amount, shared equally between the parties. Since 1970, more than 3,000 projects worldwide have been completed with DRBs for total projects' construction value more than $200 billion. Greater than 98% of matters going to the DRB do not go on to later arbitration or litigation! DRBs decrease the probability of events adverse to project objectives while increasing the probability and impact of positive events.

Design Suggestion

	Alternative No:
Title:	PD-29

Reduce or streamline the number of variables in the RFQ/RFP process to reduce complexity in the selection process

Discussion:

The current approach to design build for this project is significantly complicated by the number of variables that the contractor has to consider and the number of variable that the CVRD has to evaluate. The options include:

1. Direct filtration (granular bed)
2. Pressure membranes with inside-out flow
3. Pressure membranes with outside-in flow
4. Submerged membranes with inside-out flow
5. Submerged membranes with outside-in flow

While it is possible to write an RFQ/RFP to address all of the variables, there is really very little upside and considerable downsides. In the opinion of the Value Team, this approach the CVRD will very likely experience schedule delays due to bid protests and possible litigation. A project this size will attract a lot of attention and contractors will work every angle to win the job. The more room there is for interpretation of the selection process, the more likely one or more unsuccessful contractors will protest the selection.

The recommendation is to make a decision now based on the best technical and operational solution for the CVRD. Then tailor the RFQ/RFP and the selection criteria to this filtration strategy. Certainly, there could still be protests but the more straightforward the selection process is, the less likely it will result is substantial delays.

Examples of Necessary Prescriptiveness	
Membrane	**Direct Filtration**
Open Platform – allows definition of packages	Locate pump station
Secure river intake – reduces engineering complexity	Conventional waste washwater handling
Eliminate rapid mix flocculation	Number of filters
Use conventional settling	Specificity to avoid mistakes
Use conventional settling for backwash concentration	Planned expansion space for future, consider insertion of settling basin
Finalize sewer or dewatering options	
Separate packages for submerged vs pressure membranes	
Common Prescriptiveness	
Better define electrical and I&C	
Stainless steel piping for process units	
No mechanical single point of failure, determined by means of failure analysis	
HVAC criteria	
Avoid cross contamination of CIP, flush or gravity drain	
Mount transmitters at eye level	

Examples of Latitude for Innovation and Reduced Complexity
Optimize building design for process units
Reduce costly pipelines and other nontreatment components
Warmer water reduces cost

Design Suggestion

Alternative No:	
Title:	PD-34

Require a pilot demonstration to prove out the membrane design by the contractor

Discussion:

To ensure that CVRD receives the proper equipment and design flux, require the contractor and membrane supplier to demonstrate the membranes will perform as intended:

- Full-scale
- Identical module
- Skid-mounted
- 4-month demonstration period
- Flux should be temperature compensated

The contractor/membrane supplier should provide the results in the form and format required in the contract documents for the startup, commissioning, and testing documentation.

Opus's experience is that this would add to the bid cost by up to $30,000 per month for delivery and operation of a pilot. The manufacturers would build this cost into their bid. However, the benefit to the CVRD is reduced risk that the installed system will not perform as expected.

APPENDICES

A – AGENDA

B – PARTICIPANTS

Comox Lake Water Treatment Project
Comox Valley, BC
January 15-19, 2018

Name:	Organization:	Role on this Project	Phone:	Email:	Introduction	Site Visit	Mid - Point Review	VP Presentation
John Robinson	Strategic Value Solutions, Inc.	CVS Team Leader	816-877-8882	John@SVS-inc.com	X	X	X	X
Breanna Kinzel	Strategic Value Solutions, Inc.	Project Coordinator	816-877-8887	Breanna@SVS-inc.com	X	X	X	X
Cecil Stegman	Strategic Value Solutions, Inc.	Cost Estimator	816-877-8898	Cecil@SVS-inc.com	X	X	X	X
Don Stafford	Strategic Value Solutions, Inc.	System Planner	816-877-8897	Don@SVS-inc.com	X	X	X	X
Mike Herschmiller	Comox Valley Regional District	Water Manager	250-218-9699	Mherschmiller@comoxvalleyrd.com	X	X	X	X
Allen De Steiguer	Independent	Civil Engineer	202-391-3435	Adesteiguer@outlook.com	X	X	X	X
Marc Rutten	Comox Valley Regional District	General Manager	250-703-3166	Mrutten@comoxvalleyrd.com	X			
Patrick Carlson	Carollo Engineers, Inc.	Filtration	208-376-2288	Pcarlson@carollo.com	X	X	X	X
Stephen Horsman	Opus	Technical Team	250-215-7449	StephenHorsman@opus.com	X	X		X*
Timothy Phelan	Opus	PM - Technical Team	778-214-3499	Timothy.Phelan@opus.com	X	X	X*	X*
Trevor Dysktra	Opus	Assistant PM - Technical Team	604-202-7629	Trevor.Dysktra@opus.com	X	X	X*	X*
Jim Vickers	Separation Processes	WTP Membrane	760-400-3660	Jvickers@SPI-Engineering.com	X	X	X	X
Denis O'Maley	Denis O'Malley, PE, PMP	Constructability	925-250-8955	DenisOMalley@outlook.com	X	X	X	X
Catriona Weidman	Ministry of Municipal Affairs and Housing	Grant Funding	778-698-3255	Catriona.Weidman@gov.bc.ca	X	X	X	X*
Russell Dyson	CVRD	Client	250-334-6055	Rdyson@comoxvalleyrd.ca			X	
Kris La Rose	CVRD	Client	250-334-6083	KLaRose@Comoxvalleyrd.ca			X	X
Beth Dunlop	CVRD	Client	250-334-6004	Bdunlop@Comoxvalleyrd.ca			X	

Comox Lake Water Treatment Project
Comox Valley, BC
January 15-19, 2018

					Introduction	Site Visit	Mid - Point Review	VP Presentation
Ryan O'Grady	City of Courtenay	Stakeholder	250-815-5665	ROGrady@Courtenay.ca			X	
Zoe Beskey	CVRD	Client	250-334-6089	Zbeskey@comoxvalleyrd.ca			X	

* Attended via teleconference

C – COST INFORMATION

Cost Information

Current Estimate Information

The estimate provided to the Value Team:

- was prepared by Opus
- was dated July 2017
- indicated a construction cost of $94.61 M for Direct Filtration
- indicated a total project cost of $ 110.6 M for Direct Filtration

The overall project budget is $110.6 M.

During our review of the cost estimated provided, we identified a formula error in the Excel spreadsheet that resulted in the $110.6 M estimate to increase to $113.3 M.

Basis For Pricing

The following pricing information was provided to the Value Team for the current project cost estimate.

- Project costs are based on the work being performed by a contractor with prices prevailing during the last quarter of 2021.
- Project costs have been escalated to the mid-point of construction, which is October 2019.

The following adjustments have been made based on the:

- Information provided in the project documents

Mark-Ups

The table below shows the mark-ups used in the current construction cost estimate and the recommended mark-ups used by the Value Team. Where the percentages differ, an explanation is provided.

Mark-Up	Current	Recommended	Rationale for Change
CVRD Indirect Costs	4%	4%	Update cell formula
Engineering and CM	5%	5%	Update cell formula
Contingency	20%	25%	AACE Guidelines

In addition to correcting a formula error, the Value Team recommends that the order in which the mark-ups are applied be revised as shown in the following tables. Additionally, the mark-ups need to be applied in a compounding manner rather than an additive manner. These changes to how the mark-ups are handled results in about 8% increase in the estimated cost of the project.

Conclusions

After making the adjustments discussed above, the Value Team has revised the estimated project cost from:

- $113.3 M Direct Filtration to $116.0 M Direct Filtration
- $118.4 M Submerged Membrane to $121.0 M Submerged Membrane
- $118.6 M Pressure Membrane to $121.2 M Pressure Membrane

A revised project cost summary is attached.

Operation & Maintenance Cost Analysis

As part of the original design analysis, Opus prepared an operations and maintenance (O&M) analysis that included an annual O&M cost and the present worth of those O&M costs over a 30-year analysis period using a 2.5% discount rate (interest rate less inflation rate). Their analysis is summarized in Table 18-2 of the Indicative Design Report (IDR). Those costs are summarized in the table below.

As part of the Value Planning effort, the VP Team was asked to provide a second opinion on those O&M costs for the three water filtration options being considered in the IDR. The VP Team's analysis is also shown in the summary table below.

	Source	Present Worth O&M Costs
Direct Filtration	Opus	$31,000,000
	VP	$32,200,000
Submerged Membranes	Opus	$38,400,000
	VP	$39,100,000
Pressure Membranes	Opus	$41,900,000
	VP	$41,700,000

The VP Team generally agrees with the overall magnitude of the costs developed by Opus. That is, direct filtration (DF) is going to have a lower yearly O&M cost than the membrane filtration plants. This is primarily due to the added cost for power, membrane replacement, and CIP chemicals and disposal costs. While significant time could be spent trying to refine the numbers, it is not likely to change the overall trend.

Labor

From a staffing perspective, the VP Team agrees with Opus's estimate that the total number of staff for a membrane plant and DF plant is going to be equivalent. However, typically the responsibility of the staff changes between the two types of plants. For example, the staff of a membrane plant typically spends less time operating and more time on maintenance tasks (i.e., cleaning membranes, integrity testing, neutralizing chemicals, etc). Whereas, in a DF plant there is less time spent maintaining the system and more time dedicated to monitoring the process.

With that said, it would be prudent to increase the overall budget for staffing from 3 to 5 FTEs for all three options. Also, if there is a plan to conduct public tours and operate an outreach center as discussed, CVRD will probably need to add one additional person. Numerous small membrane and DF plants typically run with a minimum of 4-5 FTEs; CVRD should anticipate similar staffing levels.

Electrical Power

The VP Team would recommend reducing the energy costs for the DF option by approximately $10,000/yr. Opus's analysis included a 100 kW "lighting and misc." load included with the DF option that added 50% to the DF energy requirements, which is probably not appropriate.

The energy costs for the Submerged Membrane (SM) and Pressure Membrane (PM) are not fully documented. Opus's costs appear to be the correct order of magnitude; however, the VP Team was not able to arrive at the same numbers. For just the pumping costs, the numbers in Table 18-2 appear to be high; however, if 30% is added to the calculated loads for flash mix, backwash, blowers, compressors, etc., the costs are close to those in the Table 18-2.

Consumables - Chemicals

Filtration Polymer: For this supply, the 1 mg/L average cationic polymer dose is probably too high and can reasonably be assumed at 0.5 mg/L or lower.

CIP Waste Handling: O&M costs for both the SM and PM may go higher if the CIP waste must be shipped off site. The current approach of placing CIP waste in lagoons likely does not capture the true cost of CIP waste handling.

Dewatering Polymer: If the membrane plant options remain with a zero-liquid discharge criterion, dewatering polymers should not be used with the membrane options as they will likely void the membrane warranty. Therefore, it is highly recommended that the membrane options do not use any polymers in the main process or residual handling processes.

Other specific changes to the analysis includes the following:

1. For operating TMP, use 20 psi (15 meters) for pressure systems and 10 psi (7.5 meters) for vacuum. The PDR spreadsheet has 30 meters and 15 meters.

2. There would be about 1000 membranes for the pressure system, the PDR indicated 1020, therefore 220 is more appropriate for the pressure replacement cost. Most pressure and vacuum membranes are warrantied for 10 years, and the report has 7.

3. CIP systems are normally a bit larger for submerged, as you have to fill the tank, This should be 30,000, not 40,000 for the pressure.

4. We have always found higher maintenance requirements with vacuum, associated with membrane repairs. Pressure is pretty straight forward, vacuum more cumbersome. The numbers show a general allowance for operations and maintenance and that is fine for the purposes of the estimate.

DIRECT FILTRATION

VE TEAM MARK-UP APPROACH				**OPUS MARK-UP APPROACH**		
SUBTOTAL - All Direct Cost		**$ 69,565,000**		**SUBTOTAL - All Direct Costs**		**$ 69,565,000**
Contingency	25%	$ 17,391,250		Contractor Indirect Cost	10%	$ 6,956,500
Escalation to Mid-Point	8%	$ 6,956,500		DB Engineer	6%	$ 4,173,900
Contractor Indirect Cost	10%	$ 9,391,275.00		Contingency	20%	$ 13,913,000
DB Engineer	6%	$ 6,198,241.50		**SUBTOTAL - Construction Costs**		**$ 94,608,400**
SUBTOTAL - Construction Cost		**$ 109,502,267**		Land Cost - PS		$ 400,000
Land Cost - PS		$ 400,000		Land Cost - WTP		$ 500,000
Land Cost - WTP		$ 500,000		Environmental Assessment & Water License		$ 200,000
Environmental Assessment & Water License		$ 200,000		BC Hydro Service Extension		$ 100,000
BC Hydro Service Extension		$ 100,000		CVRD Indirect Costs		$ 2,040,000.00
CVRD Indirect Cost		$ 2,040,000.00		Engineering and CM		$ 3,220,000.00
Engineering and CM		$ 3,220,000.00		Escalation to mid-point	8%	$ 7,568,672.00
SUBTOTAL - Indirect Cost CAD		**$ 6,460,000**		**SUBTOTAL - Indirect Costs**		**$ 14,028,672**
TOTAL - Project Cost CAD		**$ 115,962,267**		**TOTAL PROJECT COST**		**$ 108,637,072**
		$ 7,325,195	**7%**			

MEMBRANE SUBMERGED

VE TEAM MARK-UP APPROACH				**OPUS MARK-UP APPROACH**		
SUBTOTAL - All Direct Cost		**$ 72,782,000**		**SUBTOTAL - All Direct Costs**		**$ 72,782,000**
Contingency	25%	$ 18,195,500		Contractor Indirect Cost	10%	$ 7,278,200
Escalation to Mid-Point	8%	$ 7,278,200		DB Engineer	6%	$ 4,366,920
Contractor Indirect Cost	10%	$ 9,825,570.00		Contingency	20%	$ 14,556,400
DB Engineer	6%	$ 6,484,876.20		**SUBTOTAL - Construction Costs**		**$ 98,983,520**
SUBTOTAL - Construction Cost		**$ 114,566,146**		Land Cost - PS		$ 400,000
Land Cost - PS		$ 400,000		Land Cost - WTP		$ 500,000
Land Cost - WTP		$ 500,000		Environmental Assessment & Water License		$ 200,000
Environmental Assessment & Water License		$ 200,000		BC Hydro Service Extension		$ 100,000
BC Hydro Service Extension		$ 100,000		CVRD Indirect Costs		$ 2,040,000.00
CVRD Indirect Cost		$ 2,040,000.00		Engineering and CM		$ 3,220,000.00
Engineering and CM		$ 3,220,000.00		Escalation to mid-point	8%	$ 7,918,681.60
SUBTOTAL - Indirect Cost CAD		**$ 6,460,000**		**SUBTOTAL - Indirect Costs**		**$ 14,378,682**
TOTAL - Project Cost CAD		**$ 121,026,146**		**TOTAL PROJECT COST**		**$ 113,362,202**
		$ 7,663,945	**7%**			

MEMBRANE PRESSURE

VE TEAM MARK-UP APPROACH						OPUS MARK-UP APPROACH			
SUBTOTAL - All Direct Cost		**$**	**72,918,000**			**SUBTOTAL - All Direct Costs**		**$**	**72,918,000**
Contingency	25%	$	18,229,500			Contractor Indirect Cost	10%	$	7,291,800
Escalation to Mid-Point	8%	$	7,291,800			DB Engineer	6%	$	4,375,080
Contractor Indirect Cost	10%	$	9,843,930.00			Contingency	20%	$	14,583,600
DB Engineer	6%	$	6,496,993.80			**SUBTOTAL - Construction Costs**		**$**	**99,168,480**
SUBTOTAL - Construction Cost		**$**	**114,780,224**			Land Cost - PS		$	400,000
Land Cost - PS		$	400,000			Land Cost - WTP		$	500,000
Land Cost - WTP		$	500,000			Environmental Assessment & Water License		$	200,000
Environmental Assessment & Water License		$	200,000			BC Hydro Service Extension		$	100,000
BC Hydro Service Extension		$	100,000			CVRD Indirect Costs		$	2,040,000.00
CVRD Indirect Cost		$	2,040,000.00			Engineering and CM		$	3,220,000.00
Engineering and CM		$	3,220,000.00			Escalation to mid-point	8%	$	7,933,478.40
SUBTOTAL - Indirect Cost CAD		**$**	**6,460,000**			**SUBTOTAL - Indirect Costs**		**$**	**14,393,478**
TOTAL - Project Cost CAD		**$**	**121,240,224**			**TOTAL PROJECT COST**		**$**	**113,561,958**
		$	**7,678,265**	**7%**					

Table 18-2: Annual Operating Cost Estimates (Revised)

Updated By SVS Value Planning Team

Item Description	Direct Filtration	Submerged Membrane Filtration	Pressurized Membrane Filtration	Direct Filtration - Check	Submerged Membrane Filtration - Check	Pressurized Membrane Filtration - Check
Consumables - Electrical Power						
Filtration	45,000	176,000	314,000	$ 10,000	$ 166,000	$ 300,000
Raw water pumping	93,000	93,000	93,000	$ 119,000	$ 119,000	$ 119,000
UV Disinfection	50,000	15,000	15,000	$ 21,000	$ 3,000	$ 3,000
Building Lighting and HVAC	127,000	127,000	127,000	$ 159,000	$ 159,000	$ 159,000
Consumables - Parts						
General Equipment Parts Replacement [a]	220,000	280,000	270,000	$ 360,000	$ 400,000	$ 400,000
Membrane Replacement	-	220,000	250,000		$ 150,000	$ 150,000
Consumables – Chemicals						
Coagulant	58,000	30,000	30,000	$ 61,000	$ 35,000	$ 35,000
Clean-in-Place	-	40,000	40,000	$ -	$ 40,000	$ 30,000
Filtration Polymers	5,000	-	-	$ 25,000		
Residuals Polymer	25,000	12,000	12,000	$ 23,000	$ -	$ -
Dewatering Polymer				$ 12,000	$ -	$ -
Sodium Hypochlorite	81,000	81,000	81,000	$ 82,000	$ 82,000	$ 82,000
Labour						
Operations - WTP and PS [b]	390,000	390,000	390,000	$ 494,000	$ 494,000	$ 494,000
Maintenance Staff [c]	75,000	75,000	75,000	$ 104,000	$ 104,000	$ 104,000
Solids Disposal	20,000	16,000	16,000	$ 20,000	$ 17,000	$ 17,000
Miscellaneous [d]	50,000	50,000	50,000	$ 50,000	$ 100,000	$ 100,000
Sum (6-24)	1,239,000	1,605,000	1,763,000	1,540,000	1,869,000	1,993,000
TOTAL PRESENT WORTH	**$ 25,932,633**	**$ 33,593,120**	**$ 36,900,106**	**$ 32,232,651**	**$ 39,118,717**	**$ 41,714,073**
		$ 7,660,487	$ 10,967,473		$ 6,886,066	$ 9,481,423

Notes:

a) Assumed as 1% of Division 11 to 16 capital cost.

b) Assumed salary and employment costs for 4 FTE's.

c) Assumed 2 service calls per w eek at $1,000 per call.

d) Miscellaneous includes variable costs for programming, outside laboratory testing, safety, training, communication, etc.

Period 30 years

Interest 2.50%

Table 18-2: Annual Operating Cost Estimates

Item Description	Direct Filtration	Submerged Membrane Filtration	Pressurized Membrane Filtration
Consumables - Electrical Power			
Filtration	45,000	176,000	314,000
Raw water pumping	93,000	93,000	93,000
UV Disinfection	50,000	15,000	15,000
Building Lighting and HVAC	127,000	127,000	127,000
Consumables - Parts			
General Equipment Parts Replacement [a]	220,000	280,000	270,000
Membrane Replacement	-	220,000	250,000
Consumables – Chemicals			
Coagulant	58,000	30,000	30,000
Clean-in-Place	-	40,000	40,000
Filtration Polymers	5,000	-	-
Residuals Polymers	25,000	12,000	12,000
Sodium Hypochlorite	81,000	81,000	81,000
Labour			
Operations - WTP and PS [b]	390,000	390,000	390,000
Maintenance Staff [c]	75,000	75,000	75,000
Solids Disposal	20,000	16,000	16,000
Miscellaneous [d]	50,000	50,000	50,000
SUBTOTAL - Annual Costs	1,070,000	1,442,000	1,600,000
TOTAL PRESENT WORTH	22,395,000	30,181,000	33,488,000

Notes:

a) Assumed as 1% of Division 11 to 16 capital cost.
b) Assumed salary and employment costs for 4 FTE's.
c) Assumed 2 service calls per week at $1,000 per call.
d) Miscellaneous includes variable costs for programming, outside laboratory testing, safety, training, communication, etc.

Flow (Average)	33	ML/day
	6,054	US gpm
TDH (per TM-3 system curve)	19.3	metres
	63	feet
Pump Efficiency	0.85	
Breakhorsepower	114	hp
Motor Efficiency	0.94	
Motor Power	90.4	kW
Energy Per year	791,494	kW-hours
Cost per kW-hour	0.15	
Cost per year	$ 118,724.09	

			Phase 1 (80 MLD)	**33**	**MLD (average flow)**	
	HP	KW	**Direct (KW)**	**Direct (KW)**		
PRCOCESS						
Flash Mix	8	5.9655992	6			
Flocculation			4			
Flocculators	2	1.4913998	0			
	1.5	1.11854985	2			
	1	0.7456999	1			
Backwash Pumps	125	93.2124875	93			
Blower	50	37.284995	37			
Sludge scraper	3	30	0			
Filter Control valves	0.5	0.37284995	3			
Misc Control valves	0.5	0.37284995	2			
Lighting and Misc (assumed)		0	0			
Filter drain pump	3	2.2370997	2			
Sed Channel agitation pump	7.5	5.59274925	0			
		Total	148			
		Total Ops KWh/day	346.3776036	142.8807615	kWh/d	
		Total Ops KWh/year	126427.8253	52151.47793	kWh/yr	
CHEMCIALS						
Coagulant feed pump		0.25	1			
Flocculant Aid feed pump		0.25	0			
Polymer blender	2	1.4913998	0			
Filter Aid feed pump		0.25	2			
		Total	3	1.03125		
		Total Ops KWh/day	60	24.75	kWh/d	
		Total Ops KWh/year	21900	9033.75	kWh/yr	
Disinfection						
12.5% SH feed pump		0.25	1	0.515625		
		Total Ops KWh/day	30	12.375	kWh/d	
		Total Ops KWh/year	10950	4516.875	kWh/yr	
UV		16	16			
		Total Ops KWh/day	384	384	kWh/d	
		Total Ops KWh/year	140160	140160	kWh/yr	21024

TOTALS		Total Ops KWh/day	820.3776036	180.0057615	kWh/d	
		Total Ops KWh/year	299437.8253	65702.10293	kWh/yr	
		$/KWH	$ 0.15			
		Yearly Cost	$ 16,394,220.93	$ 9,855.32	w.o uv	make this match 45000
				$ 21,024.00	UV	
OSGG			262			
0.8% SH feed		0.25	1	0.4125		
Generator		261.36	261.36	107.811		
Gas System						
Scrubber blower	40	29.827996	29.827996	12.30404835		
Monrail	5	3.7284995	7.456999	3.076012088		
Evaporator		18	36	14.85		

Estimated Chemical Costs - CVRD DF Option

Average Flow Rate 33 MLD

DF Chemical	Unit Cost	Bulk Strength	Average Concentration	Daily Usage	Cost per day	Annual Cost
	$/L	%	mg/L	L/day	$/day	$/year
PACL	$0.89	100%	7	186.3	$166	$60,516
Cationic polymer	$5.65	100%	0.5	11.8	$67	$24,305
Sodium hypochlorite	$0.45	12%	1.8	495.0	$223	$81,304
Total						$166,125

5.50/kg

Average Flow Rate 1.8 MLD

Residuals

Chemical	Unit Cost	Bulk Strength	Average Concentration	Daily Usage	Cost per day	Annual Cost
	$/L	%	mg/L	L/day	$/day	$/year
PACL	$0.89	17%	7	59.8	$53	$19,417
Cationic polymer	$5.65	100%	1	1.3	$7	$2,651
Total						$22,068

Average Flow Rate 33 MLD

Membrane Chemical	Unit Cost	Bulk Strength	Average Concentration	Daily Usage	Cost per day	Annual Cost
	$/L	%	mg/L	L/day	$/day	$/year
PACL	$0.89	100%	4	106.5	$95	$34,581
Cationic polymer	$5.65	100%	0	0.0	$0	$0
Sodium hypochlorite	$0.45	12%	1.8	495.0	$223	$81,304
Total						$115,885

Solids Disposal DF

	544	kg/d	Chapter 7 of the IDR
	198560	kg/yr	
	198.56	tons/yr	
	90	$/ton	
$	17,870.40	$/year (disposal)	
$	2,500.00	$/year (transpoert	
$	20,370.40	$/year total	

Solids Disposal DF

	441	kg/d	Chapter 7 of the IDR
	160965	kg/yr	
	160.965	tons/yr	
	90	$/ton	
$	14,486.85	$/year (disposal)	
$	2,500.00	$/year (transpoert	
$	16,986.85	$/year total	

Capital Cost Estimate

ITEM		COST	NOTE	
Process equipment		$6,000,000	GE quote (1 stage) (not incl. intake or distribution pumps)	
Process equipment (2nd stage)		$500,000	Guestimate	
Equipment installation		$6,500,000	100% of process equipment cost	
Building		$2,500,000	$300/sq.ft., 25m x 30m	
Exterior light, security, access		$200,000		
Below ground tanks		$400,000	$2/gal., 100m3 + 5 x 50m3 + 150m3 + 3 x 40m3 + 2 x 20m3 (NOT including clearwell)	
Floor slab (concrete)		$750,000	$1800/m2, 24mx40mx0.3m plus perimeter footings	
HVAC		$500,000	250 m2 office heat & AC, 500 m2 ventilation only	38%
Electrical		$2,500,000	MCC, ATS, Back-up Gen, plant power & lighting	
	Sub-Total	$19,850,000		
Design & Engineering		$3,400,000	17%	
Contingency		$5,000,000	25%	
	Total	$28,250,000		

Expansion to 140 MLD

ITEM		COST	NOTE
Process equipment		$4,100,000	GE quote (1 stage) (not incl. intake or distribution pumps)
Process equipment (2nd stage)		$200,000	Guestimate
Equipment installation		$4,300,000	100% of process equipment cost
Building		$1,800,000	$300/sq.ft., 25m x 30m
Exterior light, security, access		$100,000	
Below ground tanks		$120,000	$2/gal., 50m3 + 3 x 50m3 + 20m3 (NOT including clearwell)
Floor slab (concrete)		$530,000	$1800/m2, 23mx23mx0.3m plus perimeter footings
HVAC		$300,000	500 m2 ventilation only
Electrical		$1,800,000	MCC, ATS, Back-up Gen, plant power & lighting
	Sub-Total	$13,250,000	
Design & Engineering		$1,700,000	13%
Contingency		$3,300,000	25%
	Total	$18,250,000	

Operating Cost Estimate

ITEM		COST ($/yr)	NOTE
Design basis			80 MLD capacity, 35 MLD ADD
Pumps energy		$75,000	35,000,000/24/3600=400 kg/s, 15 m TMP ~ 120 kW, $0.07/kWhr
CIP heating		$5,000	300 kW x 5 hrs x 40 times/yr x $0.07/kWhr
Chemicals		$30,000	25 m3/yr 12.5% NaOCl x $400/m3, 6 m3/yr 50% Citric x $1500/m3, 3 m3/yr 50% NaOH x $300/m3, 3 m3/yr 93% H2SO4 x $600/m3
Membrane replacement		$150,000	$1000/membrane x 1500 membranes / ~~7~~ 10 yr membrane life
Equipment replacement		$250,000	$6M - $1.5M membranes / 20 yrs
Operator labour		$200,000	2 operators x $100k/yr
Tax, insurance, heat&light, misc		$100,000	a guess ??????
	Total	$810,000	

ITEM		COST ($/yr)	NOTE
Design basis			80 MLD capacity, 35 MLD ADD
Pumps energy		$160,714	35,000,000/24/3600=400 kg/s, 15 m TMP ~ 120 kW, $0.15/kWhr
CIP heating		$5,000	300 kW x 5 hrs x 40 times/yr x $0.07/kWhr
Chemicals		$40,000	25 m3/yr 12.5% NaOCl x $400/m3, 6 m3/yr 50% Citric x $1500/m3, 3 m3/yr 50% NaOH x $300/m3, 3 m3/yr 93% H2SO4 x $600/m3
Membrane replacement		$150,000	$1000/membrane x 1500 membranes / ~~7~~ 10 yr membrane life
Equipment replacement		$250,000	$6M - $1.5M membranes / 20 yrs
Operator labour		$200,000	2 operators x $100k/yr
Tax, insurance, heat&light, misc		$100,000	a guess ??????
	Total	$905,714	

Capital Cost Estimate for 80 MLD

ITEM		COST	NOTE
Process equipment		$7,500,000	GE and Pall quotes (1 stage) (not incl. intake or distribution pumps)
Process equipment (2nd stage)		$500,000	Guestimate
Equipment installation		$8,000,000	100% of process equipment cost
Building		$3,100,000	$300/sq.ft., 24m x 40m
Exterior light, security, access		$200,000	
Below ground tanks		$850,000	$2/gal., 4 x 300m3 + 150m3 + 60m3 + 100m3 (includes clearwell)
Floor slab (concrete)		$850,000	$1800/m2, 24mx40mx0.3m plus perimeter footings
HVAC		$600,000	250 m2 office heat & AC, 700 m2 ventilation only
Electrical		$3,800,000	MCC, ATS, Back-up Gen, plant power & lighting
	Sub-Total	$25,400,000	
Design & Engineering		$3,750,000	15%
Contingency		$6,250,000	25%
	Total	$35,400,000	

Expansion to 140 MLD

ITEM		COST	NOTE
Process equipment		$5,000,000	estimate from GE quote (1 stage)
Process equipment (2nd stage)		$200,000	Guestimate
Equipment installation		$5,200,000	100% of process equipment cost
Building		$1,600,000	$300/sq.ft., 24m x 40m
Exterior light, security, access		$100,000	
Below ground tanks		$320,000	$2/gal., 2 x 300m3 (includes clearwell)
Floor slab (concrete)		$400,000	$1800/m2, 14mx33mx0.3m plus perimeter footings
HVAC		$250,000	500 m2 ventilation only
Electrical		$2,500,000	MCC, ATS, Back-up Gen, plant power & lighting
	Sub-Total	$15,570,000	
Design & Engineering		$2,000,000	13%
Contingency		$3,900,000	25%
	Total	$21,470,000	

Operating Cost Estimate

ITEM		COST ($/yr)	NOTE
Design basis			80 MLD capacity, 35 MLD ADD
Pumps energy		$140,000	35,000,000/24/3600=400 kg/s, 30 m TMP ~ 220 kW, $0.07/kWhr
CIP heating		$3,000	200 kW x 5 hrs x 36 times/yr x $0.07/kWhr
Chemicals		$30,000	25 m3/yr 12.5% NaOCl x $400/m3, 6 m3/yr 50% Citric x $1500/m3, 3 m3/yr 50% NaOH x $300/m3, 3 m3/yr 93% H2SO4 x $600/m3
Membrane replacement		$150,000	$1500/membrane x 1200 membranes / ~~7~~ 10 yr membrane life
Equipment replacement		$300,000	$8M - $2M membranes / 20 yrs
Operator labour		$200,000	2 operators x $100k/yr
Tax, insurance, heat&light, misc		$100,000	a guess ??????
	Total	$923,000	

Design basis			80 MLD capacity, 35 MLD ADD
Pumps energy		$300,000	35,000,000/24/3600=400 kg/s, 30 m TMP ~ 220 kW, $0.15/kWhr
CIP heating		$6,429	200 kW x 5 hrs x 36 times/yr x $0.15/kWhr
Chemicals		$30,000	25 m3/yr 12.5% NaOCl x $400/m3, 6 m3/yr 50% Citric x $1500/m3, 3 m3/yr 50% NaOH x $300/m3, 3 m3/yr 93% H2SO4 x $600/m3
Membrane replacement		$150,000	~~$1500~~ $1250/membrane x 1200 membranes / ~~7~~ 10 yr membrane life
Equipment replacement		$300,000	$8M - $2M membranes / 20 yrs
Operator labour		$200,000	2 operators x $100k/yr
Tax, insurance, heat&light, misc		$100,000	a guess ??????
	Total	$1,086,429	

<u>Submerged Membrane</u>

Total Raw Water	80	MLD
	3333	m3/hr
	14667	USGPM

Stage 1 Membrane

# of Train	4	+1 standby
Flow per train	20	MLD
=	833	m3/hr
=	3667	USGPM
TMP	0.7	bar
=	10.15	psi
=	24	ft

<u>Permeate Pump</u>	<u>5@40hp</u>	
# of pump	5	
Bhp	30.9	hp
Nameplate hp	<u>40.0</u>	hp

<u>Backwash Pump</u>	<u>3@50hp</u>	
# of Pump	3	
Flow	24	MLD
=	1000	m3/hr
=	4400	USGPM
TDH	8	m
=	26.4	ft
Bhp	41.2	hp
Nameplate hp	<u>50.0</u>	hp

Backwash Waste Pump	3@10hp		
# of Pump	3		
Flow	4	MLD	
=	167	m3/hr	
=	733	USGPM	
TDH	10	m	5
=	33	ft	
Bhp	8.6	hp	4.058683
Nameplate hp	10.0	hp	5
Air Scour Blower	2@50hp		
# of blower	2		
Flow	650	m3/hr	
=	383	cfm	
Pressure	130	kPa	30
=	18.85	psi	
Bhp	39.4		
Nameplate hp	50.0	hp	20 From rotary lobe blower catalogue
Stage 2 Membrane			
# of Train	2	+1 standby	
Flow per train	4	MLD	
=	167	m3/hr	
=	733	USGPM	
TMP	0.7	bar	
=	10.15	psi	
=	24	ft	

Permeate Pump	3@10hp		
# of pump	3		
Bhp	6.2	hp	
Nameplate hp	**10.0**	**hp**	
UV Reactors	2@2.25kW		
# of reactors	2	Unit	
Power	2.25	kW	1.2 Ratio of direct filtration UV
Backwash Pump	3@20hp		
# of Pump	3		
Flow	6	MLD	
=	250	m3/hr	
=	1100	USGPM	
TDH	8	m	
=	26.4	ft	
Bhp	10.3	hp	
Nameplate hp	20.0	hp	10 flow and TDH are overstated, pump run-out (excess flow) not a concerr
Backwash Waste Pump	2@10hp		
# of Pump	2		
Flow	0.8	MLD	
=	33	m3/hr	
=	147	USGPM	
TDH	10	m	5
=	33	ft	
Bhp	1.7	hp	0.869718
Nameplate hp	10.0	hp	2
Air Scour Blower	2@10hp		

# of blower	2		
Flow	140	m3/hr	
=	82	cfm	
Pressure	130	kPa	30
=	18.85	psi	
Bhp	8.5		
Nameplate hp	10.0	hp	5 From rotary lobe blower catalogue

CIP	2@20hp		
# of Pump	2		
Flow	6.59	MLD	
=	275	m3/hr	
=	1208	USGPM	
TDH	10	m	5
=	33	ft	
Bhp	14.1	hp	7.164301
Nameplate hp	20.0	hp	10

MIT Blower

Pressurized Membrane

Total Raw Water	80	MLD	
	3333	m3/hr	
	14667	USGPM	
Stage 1 Membrane			
# of Train	4	+1 standby	
Flow per train	20	MLD	
=	833	m3/hr	
=	3667	USGPM	
TMP	1.4	bar	
=	20.3	psi	
=	48	ft	
Membrane Feed Pumps	5@80hp		
# of pump	5		
Bhp	61.9	hp	
Nameplate hp	80.0	hp	125
Backwash Pump	3@50hp		
# of Pump	3		
Flow	24	MLD	20
=	1000	m3/hr	
=	4400	USGPM	
TDH	8	m	
=	26.4	ft	
Bhp	41.2	hp	30.44013
Nameplate hp	50.0	hp	40
Backwash Waste Pump	3@10hp		
# of Pump	3		0 No BW waste pumps required
Flow	4	MLD	
=	167	m3/hr	
=	733	USGPM	
TDH	10	m	
=	33	ft	
Bhp	8.6	hp	
Nameplate hp	10.0	hp	0 No BW waste pumps required

Air Scour Blower	2@50hp		
# of blower	2		
Flow	650	m3/hr	550
=	383	cfm	
Pressure	130	kPa	30
=	18.85	psi	
Bhp	39.4		
Nameplate hp	50.0	hp	20 From rotary lobe blower catalogue
Stage 2 Membrane			
# of Train	2	+1 standby	
Flow per train	4	MLD	
=	167	m3/hr	
=	733	USGPM	
TMP	1.4	bar	
=	20.3	psi	
=	48	ft	
Membrane Feed Pumps	3@20hp		
# of pump	3		
Bhp	12.4	hp	11.77828
Nameplate hp	**20.0**	**hp**	
UV Reactors	2@2.25kW		
# of reactors	2	Unit	
Power	2.25	kW	1.2
Backwash Pump	3@20hp		
# of Pump	3		
Flow	6	MLD	4.2
=	250	m3/hr	
=	1100	USGPM	
TDH	8	m	
=	26.4	ft	
Bhp	10.3	hp	6.392426
Nameplate hp	20.0	hp	10
Backwash Waste Pump	2@10hp		
# of Pump	2		0 No BW waste pumps required
Flow	0.8	MLD	
=	33	m3/hr	
=	147	USGPM	

TDH	10	m	
=	33	ft	
Bhp	1.7	hp	
Nameplate hp	10.0	hp	0 No BW waste pumps required
Air Scour Blower	2@10hp		
# of blower	2		
Flow	140	m3/hr	
=	82	cfm	
Pressure	130	kPa	30
=	18.85	psi	
Bhp	8.5		
Nameplate hp	10.0	hp	5 From rotary lobe blower catalogue
CIP	2@20hp		
# of Pump	2		
Flow	6.59	MLD	
=	275	m3/hr	
=	1208	USGPM	
TDH	10	m	5
=	33	ft	
Bhp	14.1	hp	7.164301
Nameplate hp	20.0	hp	10
MIT Blower			

Labor Costs

Asssume same labor costs for all options

Type	Hourly Rate	Hours/yr	Cost
Operator (2)	$52	2000	$208,000
Head Operator	$65	2000	$130,000
Mechanic (1/2 time)	$52	1000	$52,000
Electrician (1/2 time)	$52	1000	$52,000
Instrumentation (1/2 time)	$52	1000	$52,000
Total			$494,000

D – PROJECT SCHEDULE

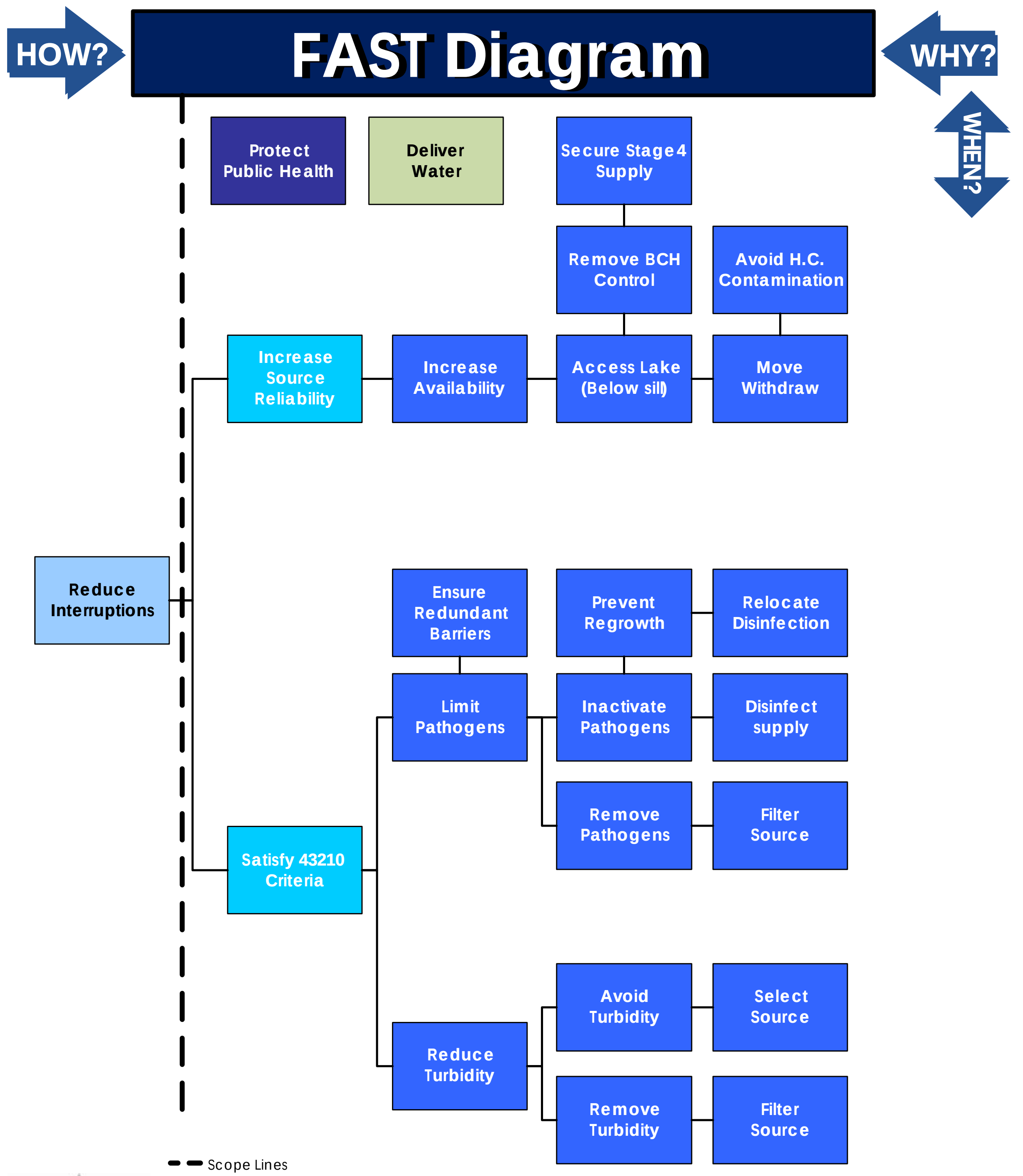
VALUE ENGINEERING WORKSHOP AGENDA

Comox Valley Water Treatment Project, Comox Valley, BC
Workshop Location: The Westerly Hotel,1590 Cliffe Avenue, Courtenay, BC V9N2K4
Workshop Dates: January 15-19, 2018

Time	Activity	Who Should Attend
Monday		
8:00 – 8:30	VE Team Orientation	VE Team Members
8:30 – 9:00	VE Study Introduction	Stakeholders & PDT
9:00 – 9:30	Owner Presentation	Stakeholders & PDT
9:30 – 12:00	Project Development Team (PDT) Presentation	Stakeholders & PDT
12:00 – 1:00	Lunch Break	
1:00 – 3:00	Site Visit	VE Team Members
3:00 – 5:00	Project Analysis/Function Analysis	VE Team Members
Tuesday		
8:00 – 12:00	Project Analysis/Function Analysis (Cont.)	VE Team Members
12:00 – 1:00	Lunch Break	
1:00 – 5:00	Creative Idea Generation	VE Team Members
Wednesday		
8:00 – 10:00	Creative Idea Generation (Cont.)	VE Team Members
10:00 – 12:00	Evaluation of Ideas	VE Team Members
12:00 – 1:00	Lunch Break	
1:00 – 3:00	Value Alternative Development	VE Team Members
3:00 – 4:00	Stakeholders/PDT Review of Ideas Selected for	Stakeholders & PDT
4:00 – 5:00	Value Alternative Development (Cont.)	VE Team Members
Thursday		
8:00 – 12:00	Value Alternative Development (Cont.)	VE Team Members
12:00 – 1:00	Lunch Break	
1:00 – 5:00	Value Alternative Development (Cont.)	VE Team Members
Friday		
8:00 – 11:00	Value Alternative Development (Cont.)	VE Team Members
11:00 – 12:00	Prepare for Value Team Presentation	VE Team Members
12:00 – 1:00	Lunch Break	
1:00 – 3:00	Value Team Presentation of Value Alternatives	Stakeholders & PDT

E – FUNCTION ANALYSIS

Function Analysis



- Scope Lines
- Higher Order Function (Mission)
- Basic Function
- Secondary Function
- Design Objective
- All the Time Functions

Comox Lake Water Treatment Project
Comox Valley, BC

F – CREATIVE IDEA LISTING

Creative Idea Listing

Idea No.	Description	Votes
IR- Increase Reliability		
IR-01	Use a siphon instead of a pump station	0
IR-02	Use a siphon to a level past the plant and pump back to the plant	0
IR-03	Put a fish screen on a neutrally buoyant platform instead of attaching to the bottom	0
IR-04	Raise the invert of the intake pipeline from EL 125 to EL 129.5	1
IR-05	Use historic low water elevation to size pumps	0
IR-06	Use fixed speed pumps in combination with equalization at the plant	1
IR-07	Use finite element analysis (FEA) to design the connection with the HDPE marine pipeline and the fixed elements to better understand thermal movement	DS
IR-08	Install the emergency generators for the pump station at the plant site	2
IR-09	Suspend the marine pipeline above the bottom	DS
IR-10	Move the intake structure to the end of the tunneled pipe section from the pump station and eliminate the HDPE marine pipeline section	4
IR-11	Install can pumps	0
IR-12	Use screw pumps	0
IR-13	Use fixed speed pumps with submersible motors	0
IR-14	Move the raw water pump station to a location adjacent to the spit and raise the intake screen location to EL 120 in the lake. Raise PS wet well from EL 125 to EL 129	3
IR-15	Move electrical components out of the flood plain	1
IR-16	Allow alternate pipe materials for raw and treated water pipelines	0
IR-17	Use horizontal wells and eliminate the intake	2
IR-18	Use a slant well intake	0
IR-19	Use a floating pump station	0
IR-20	Install a near shore intake tower with an excavated approach channel	2

Idea No.	Description	Votes
IR-21	Move to pump station location to the spit and use fixed speed submersible pumps	1
IR-22	Put pump station below grade to reduce noise	2
IR-23	Install the pump station near shore with an approach channel	3
IR-24	Use directional drilling to install the marine line segment	0
IR-25	Use conical screens instead of cylindrical screens	0
IR-26	Demonstrate that there are no fish at the intake depth and eliminate the screens	1
IR-27	Construct screens with "Z" metal to discourage zebra mussels	0
IR-28	Use a near shore intake tower with a screen around the bottom	0
IR-29	Use pressure grout on the intake structure foundation instead of tremie concrete	0
IR-30	Install submersible pumps in the lake at about EL 122 and put a silt screen around	1
IR-31	Pressure test the pipelines in short sections rather than in its entirety	0
IR-32	Install two smaller diameter treated water pipelines to facilitate maintenance	0
IR-33	Put energy recovery in the raw water pipeline	0
IR-34	Install a pig insertion station on the marine pipeline	0
IR-35	Use the raw water pump station to drive the pressure membrane system	2
IR-36	Tunnel through the high point of the raw water pipeline profile and eliminate the raw water pump station	2
IR-37	Provide a free water surface at the high point of the raw water pipeline	0
IR-38	Provide a free water surface at the plant site for the raw water pipeline	0
IR-39	Move clearwell capacity to the UV/Chlorination station and only provide backwash capacity at the plant site	0
IR-40	Put the treated water pipeline on the surface	1
IR-41	Put the raw water pipeline on the surface	2

Idea No.	Description	Votes
IR-42	Reduce the size of the treated water pipeline by adding storage in the distribution system	2
IR-43	Size all pipelines for average flow with fixed speed pumps and add storage where needed	0
IR-44	Use aquifer 480 to supplement or reduce lake source	0
IR-45	Connect the treated water pipeline to Lake Trail Road and the inland Island Highway location on the distribution system	1
IR-46	Build a treated water pipeline to the planned location based on 75 ML/d flow and build future pipeline to the Lake Trail Road and Inland Island Highway location in the distribution system	4
IR-47	Provide a berm around the RWPS for sound attenuation and aesthetics	DS
IR-48	Construct an infiltration gallery instead of the intake structure	0
IR-49	Use single, cylindrical screen instead of a "T" screen, mounted on a sled, rather than fixed to the bottom	DS
IR-50	Move the intake structure and pumps station toward the north shore where water is deeper	1
IR-51	Design the raw water pump station (RWPS) for a capacity of 40 ML/d below lake EL 130.7	4
IR-52	Design pumps based on range of operating conditions	0
IR-53	Use a circular caisson for the raw water pump station instead of square	1
IR-54	Do not require secant walls	1
IR-55	Use secant walls as the walls of the pump station	1
IR-56	Tunnel from the intake to the plant site with the pump station at the plant	0
IR-57	Reduce the headloss through the plant to reduce the raw water pump station	1
IR-58	Take the intake off the river near the diversional and move the plant closer (membrane)	1
IR-59A	Move the raw water intake to the diversion area on the river near the penstock and provide a floating pump station to withdraw from the lake below EL 130.7	3

Idea No.	Description	Votes
IR-59B	Move the raw water intake to the diversion area on the river near the penstock and provide a larger floating pump station that can also support environmental flows to withdraw from the lake below EL130.7	3
IR-60	Revise water system design delivery pressures relative to pressure zones	2
IR-61	Set the intake screen base at EL120	4
SC - Satisfy Criteria		
SC-01	Eliminate the flocculation basins and rapid mix for membranes	3
SC-02	Replace Actiflo® with settling basin and solids removal	4
SC-03	Replace centrifuge with belt press or screw press	DS
SC-04	Increase filtration rate to 20m^3/m^2- day for direct filtration	2
SC-05	Send thickener solids to sewer and eliminate dewatering	2
SC-06	Combine filter to waste lines	0
SC-07	Reduce the volume of stored backwash water to accommodate two backwashes	0
SC-08	Add a homogenizing tank to store solids	1
SC-09	Use internally backwashing filters	0
SC-10	Provide space for future floc basin for membrane	0
SC-11	Gravity flow into submerged membranes	0
SC-12	Collect all storm water and put into treatment	0
SC-13	Replace second stage membranes with plate settler or similar	3
SC-14	Use a "Nanaimo" system for handling CIP waste	0
SC-15	Put the backwash water back in to the lake	0
SC-16	Limit membrane suppliers to those who have previously completed 50 ML/d facilities	DS
SC-17	Procure only open-platform pressure membranes	DS
SC-18	Only allow submerged membranes to reduce required head	0
SC-19	Reduce storm water drainage criteria	0
SC-20	Use permeable pavement to reduce runoff	0
SC-21	Float design capacity of plant with water temperature	0
SC-22	Valid design flux for primary and secondary, if used	0
SC-23	Optimize the direct filtration design	3
SC-24	Refine the space allocation in the building and provide the design builder with an architectural space program	0

Idea No.	Description	Votes
SC-25	Separate the process building from the admin building	2
SC-26	Eliminate the community aspect of the design	0
SC-27	Design the plant for winter flows and use unfiltered water in the summer	0
SC-28	Install a sewer without using the penstock corridor and redesign the backwash handing system	4
SC-29	Use supplemental wells to continue filtration avoidance along with water restrictions	1
SC-30	Install wells and reduce the capacity of the filtration system	0
SC-31	Use a circular steel clearwell	0
SC-32	Discharge membrane backwash to the river	2
SC-33	Discharge membrane backwash to the lake	0
SC-34	Eliminate all polymer from membrane options	DS
G - General		
G-01	Provide substantial additional storage and reduce the treated water production capacity	2
G-02	Separate DB into three packages treatment, intake, and pipelines	1
G-03	Move the treatment plant to a location near the lake and keep the clearwell at the current site but sized for average flow	2
G-04	Use submersible pumps in the lake with direct filtration with additional storage and deliver using DBB with two treated water transmission mains	2
G-05	Provide a river intake with pressure membranes, backwash treatment with plate settler, with residuals and CIP waste to sewer	3
G-06	Do G-5 with a floating pump station in lake to draw water into the river with lake below the sill	2
G-07	Do G-6 and put treatment plane on the river	0
G-08	Reduce the plant size and use ground water banking for peak flow	1
G-09	Put the plant on the Cumberland side of the lake where it is deep and only conveys treated water	0

Idea No.	Description	Votes
G-10	Put a floating pump station I the lake for capturing water below the sill level and use the penstock to convey raw water to a new direct filtration plant at the existing chlorination plant	2
G-11	Do G-10 with a new raw water pipeline	0
G-12	Do G-10 but lower the sill with a bigger sluice gate	2
PD - Project Delivery		
PD-01	Select the design now and deliver using DBB	2
PD-02	Break the procurement into three packages: WTP, intake, and pipeline	DS
PD-03	Build pipelines and intake using DB while completing the design for the WTP and construct using DBB	2
PD-04	Break into two paces to accelerate work and increase competition	0
PD-05	Pre-qualify and pre-select the membrane supplier	DS
PD-06	Minimize the non-design/non-construction activities the DB construction has to perform	0
PD-07	Maximize CVRD activities to reduce uncertainties	0
PD-08	Use a best-value/open book DB approach	DS
PD-09	Use construction manager at risk	0
PD-10	Revisit the Deloitte analysis and conclusions	0
PD-11	Revise the weighting approach used by Deloitte	0
PD-12	Use pair-wise analysis	0
PD-13	Redo the Deloitte analysis with a revised approach and updated information	2
PD-14	Retain Opus through concept validation	0
PD-15	Minimize excessively prescriptive specifications	0
PD-16	Create a BC hydro, logging company, ad CVRD team to manage traffic on private roads	0
PD-17	Update and manage the risk register on a bi-weekly basis by those responsible for managing the risk	0
PD-18	Develop an enhanced risk response plan to better clarify and articulate what needs to be done	1
PD-19	Do the pipelines as DBB and the WTP as DB	2

Idea No.	Description	Votes
PD-20	Develop detailed specifications for the tie-in connections, including contingency plans	0
PD-21	Develop a preliminary schedule for design, procurement, construction and commissioning	0
PD-22	Prepare documents such that CVRD accepts risks of project unknowns	0
PD-23	Develop DB pre-qualifications to include experience on some number of other similar projects	0
PD-24	Convery Opus contract to CM at risk	0
PD-25	To achieve contract award objective develop a detailed schedule for preparing the RFQ/RFP with a three-week look ahead	0
PD-26	Retain an independent consultant to provide a third-party review of the procurement documents	2
PD-27	Include a disputes resolution board in the design build delivery process	DS
PD-28	Enhance the procurement strategy to be more comprehensive, robust, complete to include response plans to procurement challenges	2
PD-29	Reduce or streamline the number of variables in the RFQ/RFP process to reduce complexity in the selection process	3
PD-30	CVRD and Opus need to make key decisions early based on sound financial and technical analysis rather than leaving decisions to the market	0
PD-31	Define clear lines of communication and authorities between the contractor and the various stakeholders	0
PD-32	Recruit and retain operators and mechanics at 50% construction complete	0
PD-33	Develop an interactive C&M manual	0
PD-34	Require a pilot demonstration to prove out the membrane design by the contractor	DS

DS – Indicates the Idea was selected to be written as a Design Suggestion and is included in the Design Suggestion Section of this report

G – MATERIALS PROVIDED

Materials Provided

Document	Prepared by	Date
CVRD PDR with Appendices	Opus	August 11, 2016
CVRD IDR With Appendices	Opus	August 2017