REGIONAL DISTRICT OF CENTRAL KOOTENAY

ARROW CREEK WATER TREATMENT & SUPPLY COMMISSION OPEN MEETING AGENDA

Time:	**10:00am PST**
Date:	**July 31, 2025**
Locations:	(1) Sunshine Room at the Creston Rec Centre 312 19th Avenue N, Creston, BC
	(2) RDCK Board Room, 202 Lakeside Drive, Nelson, BC

To promote openness, transparency and provide accessibility to the public we provide the ability to attend all RDCK meetings in-person or remote (hybrid model).

Join Zoom Meeting
https://rdck-bc-ca.zoom.us/j/97342265352?pwd=mRb16mr8ryKhAd16DoqeRv6YLsKYoa.1

Meeting ID: 973 4226 5352
Passcode: 644191

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COMMISSION/COMMITTEE MEMBERS

Commissioner D. Dumas	Councillor, Town of Creston (Chair)
Commissioner R. Tierney	Director Electoral Area B
Commissioner K. Vandenbergh	Director Electoral Area C

ALTERNATE COMMISSION MEMBERS

Megan Holland	Councillor, Town of Creston
Kala Hooker	Alternate Director

RDCK STAFF

U. Wolf	General Manager of Environmental Services
C. Gainham	Utility Services Manager
A. Divlakovski	Water Operations Manager
A. Richardson	Water Operations Supervisor, East
N. Metz	Meeting Coordinator

TOWN OF CRESTON STAFF

C. Farynowski	Manager of Engineering
B. Ziefflie	Director of Infrastructure Services

1. CALL TO ORDER

The Chair to call the meeting to order at 10:00 a.m. PST.

1.1 TRADITIONAL LANDS ACKNOWLEDGEMENT STATEMENT

We acknowledge and respect the indigenous peoples within whose traditional lands we are meeting today.

1.2 ADOPTION OF AGENDA

The Agenda for the July 31, 2025 Arrow Creek Water Treatment & Supply Commission meeting, be adopted as circulated.

1.3 RECEIPT OF MINUTES

RECOMMENDATION:
The February 10, 2025 Arrow Creek Water Treatment & Supply Commission minutes, have been received.

2 STAFF REPORTS

2.1 Filtration Feasibility Study – Report

The Commission Report dated July 31, 2025 from Alexandra Divlakovski, Water Operations Manager, providing a summary of filtration replacement options, including pressurized ceramic membranes, upgraded polymeric membranes, and conventional treatment for the Arrow Creek Water Treatment Plant, and recommending that staff proceed with the design of raw water pre-treatment upgrades in 2025, funded through a reallocation of existing capital reserves. Included with the written report is a supplemental presentation that provides a media filtration options summary has been received.

RECOMMENDATION:
That the Arrow Creek Commission direct staff to proceed with proposed measures to improve raw water quality through pre-treatment upgrades for the Arrow Creek water treatment facility; AND FURTHER, that the design of pre-treatment upgrades be completed in 2025 and be financed through the reallocation of funds in the Arrow Creek Water Service – S251 Capital Expenses Account for the Pilot Filtration Study to a maximum amount of $120,000.

2.2 O&M and Capital Update

Abbreviations:
DCVA – Double Check Valve Assembly
HMI – Human Machine Interface
MIT – Membrane Integrity Testing
PLC – Programmable Logic Controllers
HVAC – Heating, Ventilation, Air Conditioning
SCADA – Supervisory Control And Data Acquisition
SRoW – Statutory Right-of-Way

WTP – Water Treatment Plant
RFP – Request for Proposal
UVT – Ultraviolet Transmittance
BoD – Board of Directors

WATER EAST

Arrow Creek

Operations and Maintenance:

- Membrane Filter Train 1 is passing MITs Trains 2, 3 & 4 are currently not passing MITs, fibre repairs have been suspended as overhead crane cannot be operated due to scaffold set-up for HVAC System upgrade project.
- Overhead WTP crane and intake jib have been completed.
- Recovery Cleans on the membrane Filters will be performed.
- Installed a new online UVT monitoring system, currently in communication with manufacturers tech support to resolve issues with it not reading at a constant flow.
- Chlorination Disinfection By-Products Treated water is tested for the formation of chlorination disinfection by-products Trihalomethane and Haloacetic Acid on a bi-annual basis. Sampling was completed April 15, 2025 and demonstrated unacceptable results. Results were just above Maximum Acceptable Concentration, and re-testing was initiated. Trihalomethanes and Haloacetic Acids in drinking water are assessed based on locational running annual averages of quarterly sampling results. For bi-annual sampling with two samples per year per location, the LRAA is calculated from the most recent four quarters of available data.

Capital:

- HVAC system upgrade project has begun, 95% ducting work completed, currently working on the controls system, delivery and set-up of the new MUA unit pending (est. late August).
- Final back pulse tank overflow connections have been completed and actuator on the valve has been installed.

Ongoing Considerations:

The Arrow Creek water treatment plant has historically reached maximum emergency rated capacity in high demand months (July-August).

Erickson

Operations and Maintenance:

- Continuing to locate service valves for properties, meter pit installs for Phase 1 Project.

Capital:

- Replaced 6 old meter pits with new 2” x 48” tandem meter/DCVA pits as part of the Phase 1 Universal Metering.
- Erickson Road (from train tracks west to Morris Flowers) watermain and PRV Upgrade Project has been awarded, and work will commence in August 2025.
- Phase 2 Universal Metering procurement awarded for meter supply, RFP for meter pit supply and installation to be issued late 2025.
- Phase 1 Universal Metering installation for all new meter/pits to proceed in summer 2025.

3 FINANCIAL STATEMENT

The June 2025 Service Statement for S251 Water Utility - Area B (Arrow Creek), has been received.

4 PUBLIC TIME

The Chair will call for questions from the public at _______ a.m./p.m.

5 NEXT MEETING

The next Arrow Creek Water Treatment & Supply Commission Meeting will be at the call of the Chair.

6 ADJOURNMENT

RECOMMENDATION:

The Arrow Creek Water Treatment & Supply Commission meeting adjourn at _____ p.m.

REGIONAL DISTRICT OF CENTRAL KOOTENAY

ARROW CREEK WATER TREATMENT & SUPPLY COMMISSION
OPEN MEETING MINUTES

A meeting of the Arrow Creek Water Treatment & Supply Commission was held at 1:00 pm PST / 2:00 pm MST on Monday, February 10, 2025, through a hybrid model.

Join by Meeting Link:
https://rdck-bc-ca.zoom.us/j/94172814570?pwd=nYRgABAKNcLnJjp1TKosIvS1aAV1GA.1&from=addon

Meeting ID: 941 7281 4570
Passcode: 939667

Dial by your location
• 833 955 1088 Canada Toll-free

Locations: (1) Council Chambers, Town of Creston, 238 – 10th Ave N., Creston, BC
(2) RDCK Board Room, 202 Lakeside Drive, Nelson, BC

COMMISSION MEMBERS

Commissioner D. Dumas	Councillor, Town of Creston (Chair)	[2]In-person
Commissioner K. Vandenberghe	Director Electoral Area C	[2]In-person
Commissioner R. Tierney	Director Electoral Area B	[2]In-person

RDCK STAFF

U. Wolf	General Manager of Environmental Services	[1]In-person
C. Gainham	Utility Services Manager	[1]In-person
A. Divlakovski	Water Operations Manager	[1]In-person
A. Richardson	Water Operations Supervisor, East	
E. Clark	Meeting Coordinator	[1]In-person

TOWN OF CRESTON STAFF

S. Klassen	Director of Finance & Corporate Services	[2]In-person

1. CALL TO ORDER & WELCOME
General Manager Wolf assumed the chair and called the meeting to order at 1:00 p.m. PST / 2:00 p.m. MST.

2. ELECTION OF COMMISSION CHAIR

2.1 Call for Nominations (3 Times)
General Manager Wolf called for nominations a first time.

Commissioner Vandenberghe nominated Commissioner Dumas.

Commissioner Dumas accepted the nomination.

General Manager Wolf called for nominations a second and third time.

2.2 Opportunity for Candidates to Address the Commission
No address.

2.3 Vote by Secret Ballot
No vote.

2.4 Declaration of Elected or Acclaimed Chair
General Manager Wolf declared Commissioner Dumas as the acclaimed Chair of the Arrow Creek Water Treatment & Supply Commission.

2.5 Destroy Ballots
No ballots.

3. CHAIR'S ADDRESS
Commissioner Dumas thanked the Commission.

4. COMMENCEMENT OF REGULAR COMMISSION MEETING
The Arrow Creek Water Treatment & Supply Commission Chair assumed the chair.

5. CALL TO ORDER & WELCOME

5.1 Traditional Lands Acknowledgement Statement
We acknowledge and respect the indigenous peoples within whose traditional lands we are meeting today.

5.2 Adoption of Agenda

Moved and seconded,
And Resolved:

The Agenda for the February 10, 2025 Arrow Creek Water Treatment & Supply Commission meeting, be adopted as circulated.

Carried

5.3 Receipt of Minutes

The July 30, 2024 Arrow Creek Water Treatment & Supply Commission minutes, have been received.

6. STAFF REPORTS

6.1 Arrow Creek Water Treatment Plant Operation and Maintenance Update

Operations and Maintenance

- Membrane Filter Trains 1, 3 & 4 are currently not passing Membrane Integrity Tests (MITs). Train 2 is passing MITs and fibre repairs on Train 1 are almost complete.
- Train 1 suction pump had the flow starting to surge up and down when it was in production. The Variable Frequency Drive (VFD) was tested and was not an issue; the pump section has been removed and sent out to be inspected and tested, and has come back with no issues or repairs needed; the next step will be to replace the pump motor with a new spare we have in stock and that should resolve the problem.
- Annual overhead Water Treatment Plant (WTP) crane and intake Jib Inspection
- Preventative maintenance on all WTP motors.
- Large furnace that heats the WTP process room had to be shut down due to a faulty gas valve and a hole in the heat exchanger. HVAC contractor retrofitted a smaller decommissioned furnace used previously to heat the control room and redirected the ducting to blow heat down into the process room. The same will be done for a second smaller furnace previously used for heating chemicals rooms once the parts are in.
- Replacement of a 12” valve (leaking from the stem) on Train 1 and 3 old actuators.

Capital

- The Request for Proposal (RFP) for the WTP Mechanical Upgrades has been issued and posted to BC Bid, closes February 20, 2025.
- The final report for the filtration feasibility study was submitted by Associated Engineering on Thursday February 6th,2025.
- An emergency replacement of the failing back pulse line, valve and tank will proceed and be awarded to the various suppliers and contractors.

6.2 Receipt of Associated Engineering Final Report for Filter Feasibility Study

Staff provided a verbal report on the final report for the Filter Feasibility Study.

6.3 Creston Valley Alternative Water Supply Study Update

Staff provided a verbal update on the Creston Valley Alternative Water Supply Study.

7. DRAFT 2025-2029 FINANCIAL PLAN

A copy of the DRAFT 2025-2029 Financial Plan for S251 Water Utility-Area B (Arrow Creek) has been received.

8. PUBLIC TIME

The Chair celled for questions from the public at 2:24 p.m. PST / 3:24 p.m. MST.

9. NEXT MEETING

The next Arrow Creek Water Treatment & Supply Commission Meeting will be at the call of the Chair.

10. ADJOURNMENT

Moved and seconded,
And Resolved:

The Arrow Creek Water Treatment & Supply Commission meeting adjourn at 2:26 p.m. PST / 3:26 p.m. MST.

Carried

APPROVED

APPROVED VIA EMAIL

____

Councillor D. Dumas
Chair, Arrow Creek Water Treatment & Supply Commission
February 11, 2025

Commission Report

July 31, 2025

Filtration Feasibility Study – Report

Author: Alex Divlakovski, Water Operations Manager
File Reference: 11-5700-ACK
Electoral Area/Municipality: Area B/C
Services Impacted Water Utility – Arrow Creek S251/ Water Utility – Erickson S250

1.0 STAFF RECOMMENDATION

That the Arrow Creek Commission direct staff to proceed with proposed measures to improve raw water quality through pre-treatment upgrades for the Arrow Creek water treatment facility; AND FURTHER, that the design of pre-treatment upgrades be completed in 2025 and be financed through the reallocation of funds in the Arrow Creek Water Service – S251 Capital Expenses Account for the Pilot Filtration Study to a maximum amount of $120,000.

2.0 BACKGROUND/HISTORY

The Arrow Creek water treatment plant (WTP) was commissioned in 2005 and cost $9.3 million (approximately $11.8 million in today's costs) to construct. The current filtration system consists of four ZeeWeed 1000 ultrafiltration membrane (ZW1000-450) trains. Over time, these membranes have experienced frequent membrane fiber breakage, leading to increased operation and maintenance needs. Membrane cassettes have been replaced periodically at a high cost, with plumbing retrofits required for manufacturers' modifications to accommodate next versions. All membrane cassettes have now reached the end of their expected lifespan, with most trains unable to successfully pass the Membrane Integrity Tests (MIT's). They are currently able to maintain turbidity levels at the target 0.1 NTU for membrane filtration, and certainly below the 0.3 - 1 NTU for systems that either employ filtration exemption or alternate accredited filtration systems. The downstream UV units and chlorination disinfection ensure that sufficient log-reduction credits are achieved to meet treatment objectives for surface water supplies.

A study completed in 2020 by WSP Canada Group Limited *Arrow Creek Water Utility - Capacity, Filtration and Potential Improvements* identified that converting the existing ultrafiltration polymeric membranes to ceramic membranes may provide a more cost-effective method of achieving the same 4-log accredited filtration for *Giardia* and *Cryptosporidium*. The reported advantages of ceramic membranes (porous ceramic coatings on the ultrafiltration layers) are increased mechanical strength and a greater resistance to chemical cleans. This equates to a longer warrantied service life.

The RDCK issued a Request for Proposal in August 2023 for consulting services to evaluate and recommend options to replace the current membrane system at Arrow Creek WTP. The contract was awarded to Associated Engineering Ltd., with an expanded scope that included investigating non-membrane alternatives (approved in

August 2024). The final report presented by Associated Engineering Ltd. includes analyses of polymeric/polymer membranes, ceramic membranes, and media-based filtration options. The three final filtration options that include capital and 20-year life-cycle costs are: pressurized ceramic membranes, submerged polymeric membranes (like-for-like), and conventional treatment with adsorption clarifier (CTAC).

3.0 PROBLEM OR OPPORTUNITY DESCRIPTION

The Arrow Creek water treatment plant ultrafiltration polymeric membranes have now reached the end of their expected lifespan. This presents the opportunity to change filtration technology over replacing existing polymeric membranes should the projected capital and 20-year lifecycle costs demonstrate a benefit to implementing a new type of filtration.

Associated Engineering Ltd. (AE) explored 4 membrane options that would provide the same level of log-reduction credits for *Giardia* and *Cryptosporidium*: ZeeWeed 500 (ZW500) Reinforced Polymeric Membranes, MetaWater Pressurized Ceramic Membranes (MetaWater), Cerafiltec Submerged Ceramic Membranes (Cerafiltec), and ZeeWeed 1000 Polymeric Membranes (ZW1000-550). It should be noted that the existing membrane model has been discontinued by the manufacturer and the closest like-for-like replacement (ZW1000-550) still requires retrofits to the tanks and a possible WTP expansion.

As part of the filtration review, AE also completed a high-level review of potential media filtration systems that would provide sufficient log-reduction credits at the level of turbidity that can occur in the source water: Conventional Treatment, Conventional Treatment with Adsorption Clarifier (CTAC), Direct Media, Slow Sand, Dissolved Air Filtration (DAF), and Ballasted Clarification.

The three shortlisted filtration options to compare for capital costs, operations costs, and 20-year lifecycle costs include: MetaWater, ZW1000-550, and CTAC.

3.1 Alignment to Board Strategic Plan

Manage our assets and service delivery in a fiscally responsible manner (be forward thinking in asset replacement in order to take advantage of developments in technology with the goal of longer-term cost reduction). Organizational Excellence in the efficient and effective delivery of a core service – water.

3.2 Legislative Considerations

An Interior Health Construction Permit will need to be secured for any option selected.

3.3 What Are the Risks

The existing membrane filters are at end of life and failures in the cassette frame headers will eventually allow unfiltered water into the treatment system and likely increase turbidity in the permeate water beyond the allowable 1 NTU. When this occurs, the system would be in contravention of the Interior Health Operating permit and likely placed on a Boil Water Notice.

4.0 PROPOSED SOLUTION

The AE report recommends that the existing ZW1000-450 membrane system be upgraded with either the ZW1000-550 submerged polymeric membranes or the MetaWater pressurized ceramic membranes.

Prior to selecting a filtration replacement, piloting for a period of one year is recommended to determine the effectiveness of the selected treatment equipment, and any operational challenges/benefits that would result from the new technology.

For the MetaWater ceramic membranes, the manufacturer would provide a pre-built skid of treatment and monitoring equipment for the pilot.

Should the ZW1000-550 polymeric membranes be selected, AE has recommended:

- a single existing tank and frames be modified to accommodate the new membranes,
- an upstream non-wedge wire strainer and booster pump be installed, and,
- tank controls be modified to drain from the bottom of the tank.

AE has also recommended that the settling ponds be optimized to reduce the magnitude of turbidity spikes and sediment loading on the treatment equipment. RDCK staff agree that improving raw water quality through settling pond and intake upgrades is an integral part of overall treatment system upgrades and may even produce raw water quality that meets filtration deferral criteria.

4.1 Financial Considerations of the Proposed Solution

The following table summarizes Capital, Annual, and 20-year Life Cycle costs of three filtration options shortlisted in the AE report:

Table 7-2 Opinions of Probable Cost Summary

Option	MetaWater Pressurized Ceramic Membranes	ZW1000-550 Submerged Polymeric Membranes	CTAC
Capital Cost	$11.6 m	$7.4 m	$13.4 m
Annual Costs (at 100 L/s average)	$181,000 / year	$167,000 / year	$344,000 /year
20-year Lifecycle Cost	$16.8 m	$13.5 m	$19.8 m

The 5-year Financial Plan for the Arrow Creek service includes $120,000 for a filtration pilot study in 2025. The Arrow Creek membrane reserves are projected to total $1,425,569 by the end of 2025 when accounting for the pilot study costs. The following 4 years (2026-2029) have $2.2M withdrawn from the reserves for membrane replacement, with a total of $509,196 remaining at the end 2029. Replacement of the membranes with any of the options presented will require borrowing.

4.2 Risks with the Proposed Solution

Implementing a new filtration technology may not result in operational or cost advantages. Replacing the membranes (like-for-like) has historically resulted in retrofitting components to meet the manufacturers requirement for new versions, and this will likely continue.

4.3 Resource Allocation and Workplan Impact

Piloting of the selected filtration system is recommended to be completed over a year to capture seasonal weather events. Both filtration system options are proposed to be implemented in stages to maintain WTP capacity and will be completed over 2 years. Should settling pond and intake upgrades also be implemented, it is recommended that these be completed prior to piloting for a more accurate representation of raw water quality.

4.4 Public Benefit and Stakeholder Engagement of Proposed Solution

Not applicable.

4.5 Leveraging Technology

Pressurized ceramic membranes are more robust than the existing polymeric membranes and offer a 20-year warranty on components. This would reduce operator time for repairs while providing the same treatment credit for Giardia and Cryptosporidium.

4.5 Measuring Success

Success will be measured by improvements to operations and reduced annual costs for the treatment system selected.

5.0 ALTERNATIVE SOLUTION(S)

The existing UF membranes are at end-of-life and currently only provide turbidity reduction as part of the overall treatment system. Historical poor water quality during freshet and heavy rain events results in raw water quality that doesn't meet the criteria for filtration deferral. A focused effort on improving raw water quality through pre-treatment structural upgrades and process improvements may provide an opportunity to revisit an application for filtration deferral. At a minimum, improving raw water quality will reduce loading on future filtration equipment, in turn extending serviceable life and lowering associated operating costs (i.e. chemicals, spare parts, electricity). Piloting of future filtration equipment would occur after pre-treatment upgrades as existing raw water would no longer be representative of source water quality for the pilot.

The pre-treatment upgrades that would most improve raw water quality are as follows:

<u>Automate Intake</u> – the two existing sluice gates are currently manually operated to provide flow control into the upper settling pond. Automation of these gates based on level in the lower settling pond would prevent overflow and inefficient use of water.

<u>Replace Baffles</u> – the existing baffles are either non-operational or minimally effective. Replacing and/or repairing baffles along with installing an energy dissipater on the inlet would increase settling capability.

<u>Reconfigure Piping Between Ponds</u> – The existing configuration of piping between ponds does not permit isolation of either pond and directs potentially unscreened water to the WTP. Constructing a bypass chamber with an additional 0.5mm vertical screen would ensure that screened water is being provided to the WTP, and would allow either pond to be taken off-line.

<u>Replace Strainer</u> – The existing Johnson screen is constructed of 0.5mm wedge wire, which is both insufficient for UF membrane warranty and is subject to frazzle ice formation. Replacing the Johnson screen with a 500-micron non-wedge wire strainer would satisfy UF membrane requirements. Installing heated air compressor system or backwash system (would require booster pumps) would mitigate frazzle ice formation

Implementing these moderate changes would improve raw water quality to either support an application for filtration deferral or significantly reduce sediment loading on a new filtration system.

5.1 Financial Considerations of the Alternative Solution(s)

Initial estimates for the pre-treatment upgrades are as follows:

- Automate intake - $150K
- Replace/repair baffles - $80K
- Reconfigure piping between ponds - $500K
- Replace strainer - $150K

The total projected costs for the upgrades plus Project Management fees are $970K (not including the $80,000 cost for design). There are sufficient funds in the Arrow Creek service membrane reserves to finance these upgrades.

Design for the proposed upgrades would be completed in 2025, with construction beginning early 2026. The projected design costs of ~$80K can be financed through the relocation of funds for the filtration pilot capital project ($120K) detailed in the 2025 financial plan. The filtration pilot project, should filtration deferral criteria not be achieved, would be deferred until intake upgrades are completed (2027).

5.2 Risks with the Alternative Solution(s)

Not applicable – improvements will benefit the overall treatment system.

5.3 Resource Allocation and Workplan Impact

Improvements can be completed during low demand to minimize potential disruptions to the WTP.

5.4 Public Benefit and Stakeholder Engagement of Proposed Solution

Not applicable.

5.5 Measuring Success

Success will be measured by overall reduction in raw water turbidity and reduced magnitude of seasonal spikes.

6.0 OPTIONS CONSIDERED BUT NOT PRESENTED

Not applicable.

7.0 OPTIONS SUMMARY

Option 1:

Recommendation:

That the Arrow Creek Commission direct staff to proceed with piloting MetaWater pressurized ceramic membrane filtration equipment for a period of one year and schedule a phased replacement of the existing ZeeWeed 1000-450 polymeric membranes for the Arrow Creek water treatment facility.

Option 2:

Recommendation:

That the Arrow Creek Commission direct staff to proceed with piloting ZeeWeed 1000-550 polymeric membrane filtration equipment for a period of one year and schedule a phased replacement of the existing ZeeWeed 1000-450 polymeric membranes for the Arrow Creek water treatment facility.

Option 3:

Recommendation:

That the Arrow Creek Commission direct staff to proceed with proposed measures to improve raw water quality through pre-treatment upgrades for the Arrow Creek water treatment facility; AND FURTHER, that the design of pre-treatment upgrades to be completed in 2025 be financed through the reallocation of funds in the Arrow Creek Water Service – S251 Capital Expenses Account for the Pilot Filtration Study to a maximum amount of $120,000.

8.0 RECOMMENDATION

That the Arrow Creek Commission direct staff to proceed with proposed measures to improve raw water quality through pre-treatment upgrades for the Arrow Creek water treatment facility; AND FURTHER, that the design of pre-treatment upgrades be completed in 2025 and be financed through the reallocation of funds in the Arrow Creek Water Service – S251 Capital Expenses Account for the Pilot Filtration Study to a maximum amount of $120,000.

Respectfully submitted,
Alex Divlakovski

CONCURRENCE

Utility Services Manager – Chris Gainham
General Manager of Environmental Services – Uli Wolf
Acting CAO, General Manager of Finance, IT and Economic Development - Yev Malloff

ATTACHMENTS:
Attachment A – Arrow Creek Ceramic Filter Feasibility Study Final Report
Attachment B – Presentation: Filtration Feasibility Study

Arrow Creek Commission Report - Supplemental

Filtration Feasibility Study

Presented by: Alex Divlakovski

Date: [Date of presentation]

Outline/Meeting Agenda

1. Background/Desired Outcomes
2. Report Approach and Overview
3. Membrane Options Summary
4. Media Filtration Option Summary
5. All Options Summary
6. Recommendation for Next Steps

Outline/Meeting Agenda

1	Background/Desired Outcomes

Arrow Creek WTP Commissioned in 2005 - $9.3M (~ $11M 2025)

Treatment Components Include:

- Four ZeeWeed Ultrafiltration Membrane Trains
- Two Ultraviolet Reactors
- Chlorine Disinfection System

Legislated Treatment Requirements

Interior Health requires that treatment meet Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia

Table 3-1 Provincial Drinking Water Treatment Objectives for Various Source Waters (modified)

Provincial Drinking Water Treatment Objectives	Surface Water and GARP	Arrow Creek WTP Actual Treatment
4-log virus inactivation	✓	✓
4-log protozoa inactivation	✓	✓
3-log protozoa inactivation		✓
2 Forms of treatment	✓	✓
1 Less than or equal to 1 NTU	✓	✓
0 E.coli, Fecal Coliforms and Total Coliforms	✓	✓

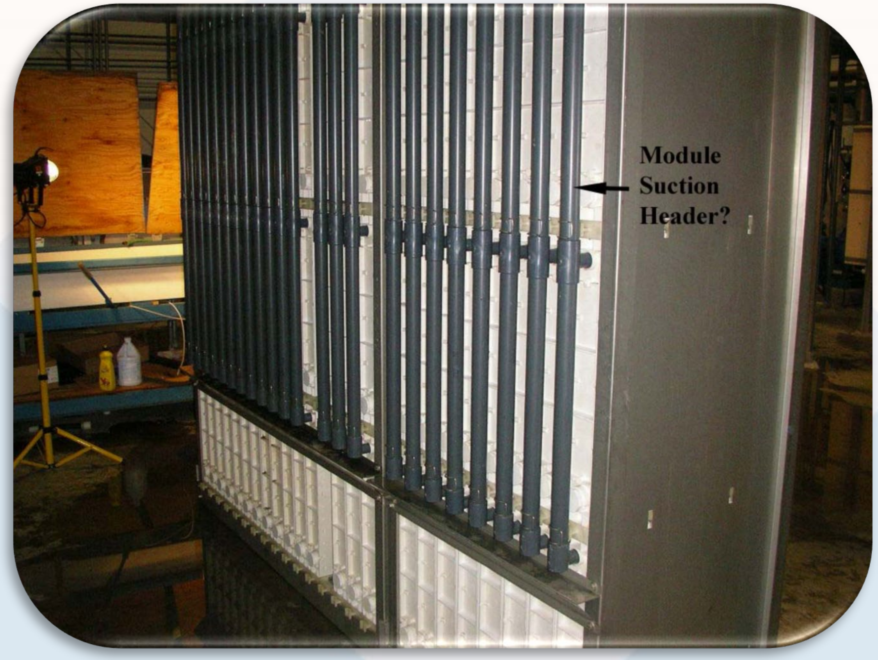
Source: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/how-drinking-water-is-protected-in-bc/dwog_part_b_-_17_design_guidelines_for_drinking_water.pdf

The Arrow Creek WTP exceeds treatment objectives for surface water by providing 4-log (99.99%) protozoa inactivation/removal credits through the ultrafiltration membrane system, in addition to the 3-log (99.9%) inactivation/removal credits assigned to UV disinfection.

For surface water, 2 forms of treatment MUST include accredited filtration, though the log-credit value is not defined.

Challenges with UF Filtration System

- High cost of replacement membranes
- Increased operator time for maintenance and repairs
- Plumbing retrofits to accommodate manufacturers process changes with each new version



Membrane Replacement Schedule/Cost

Train 3	• 2013 (189 new modules) • $266,025	$1,308 per module (100%)
Train 2	• 2016 (189 new modules) • $453,600	$2,400 per module (171%)
Train 4	• 2018 (138 new modules) • $354,191	$2,567 per module (182%)
Train 1	• 2019 (189 new modules) • $523,040	$2,767 per module (197%)

2020 Study by WSP Canada Group Limited

Arrow Creek Water Utility - Capacity, Filtration and Potential Improvements

Section 6 Filtration Review – *"evaluates the current treatment process operation and compares with alternate membrane technologies to determine the preferred long-term filtration approach for the WTP"*

A high-level analysis of five alternate membrane filtration systems were evaluated to upgrade the exiting WTP to meet the future Arrow Creek Water Utility demands to 2045. **The converting to ceramic membrane filtration is the lowest life cycle cost alternative to meet the future demands**.

The membrane replacement costs represent a significant portion of the existing treatment upgrade option totalling approximately $7.0M of the total $10M on a 25-year NPV analysis.

The raw water quality of the Arrow Creek Water Utility does not satisfy the filtration exemption criteria, as the turbidity of water is consistently higher than 1 NTU and higher than 5 NTU more than 2 days in any 12-month period.

Desired Outcomes

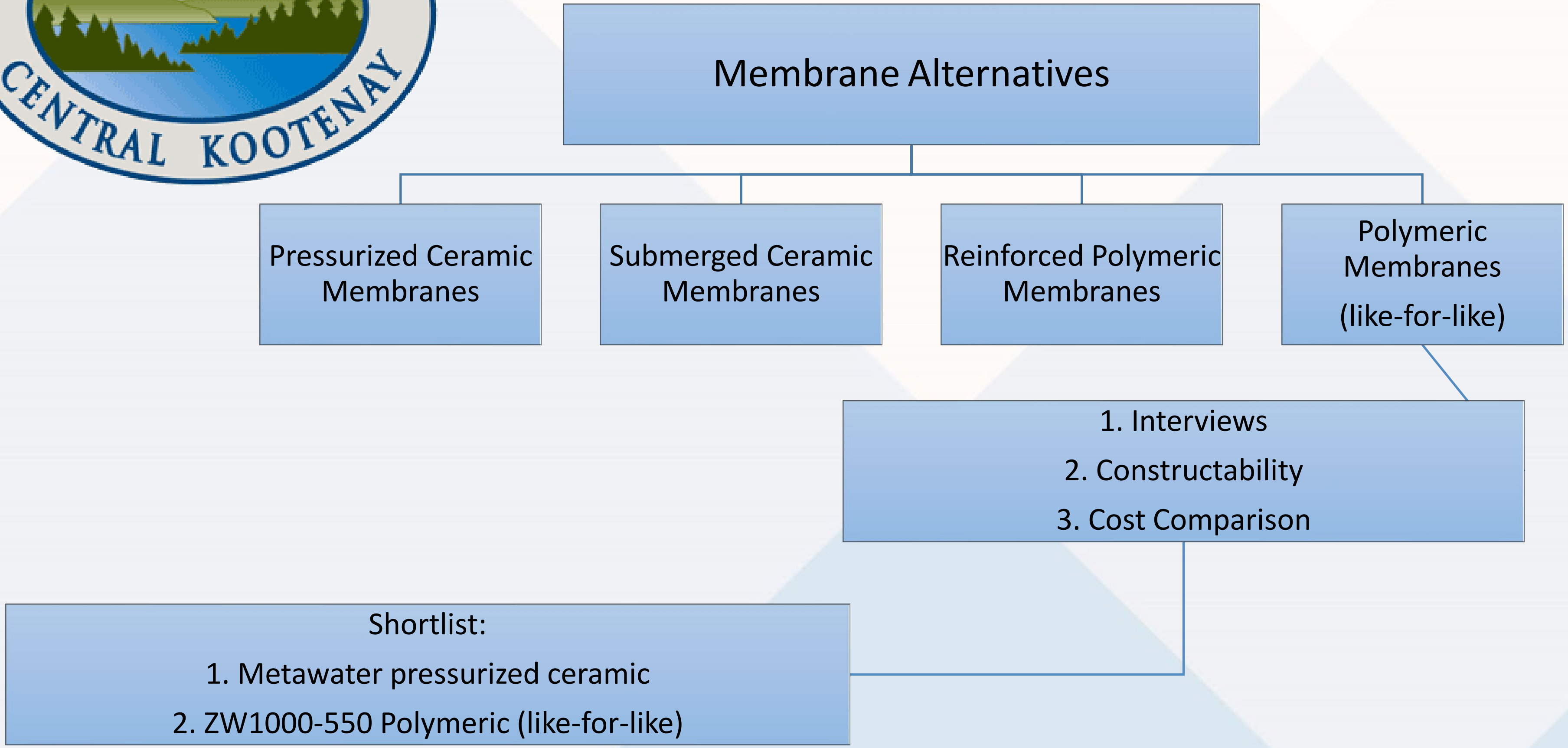
Replacing the existing ZW1000 - 450 membranes with an alternate filtration system to meet the following criteria:

- Meet B.C. Drinking Water Treatment Objectives for filtration and provide a reduction in turbidity from incoming water
- Improved filtration robustness that will lead to a significant drop in maintenance and repair requirements
- Can be incorporated into the existing water treatment plant for the least amount of effort and cost
- Staged replacement to maintain capacity during construction and fund project through multiple years
- Enables the treatment of the same water capacity as current

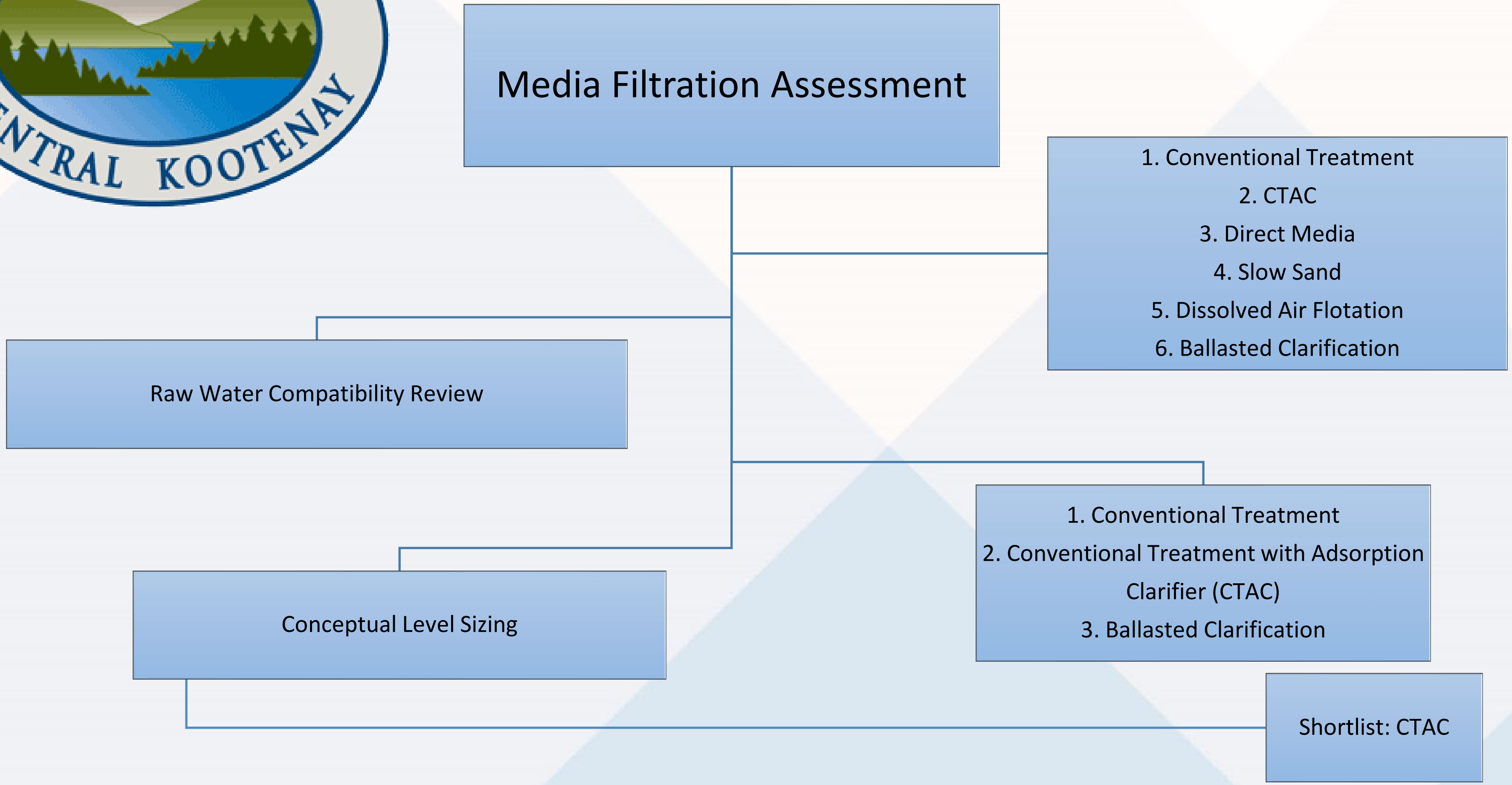
Outline/Meeting Agenda

2	Report Approach and Overview

Feasibility Study Report - Membranes



Feasibility Study Report - Media



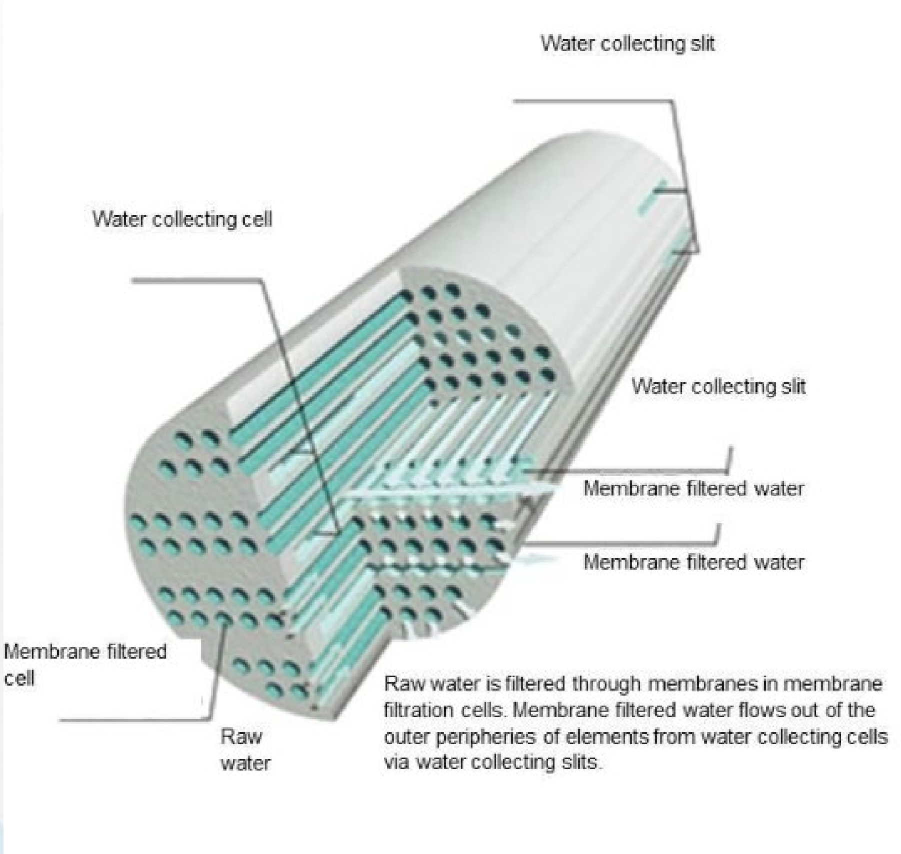
Outline/Meeting Agenda

3	Membrane Options Summary

Metawater Pressurized Ceramic - Interviews

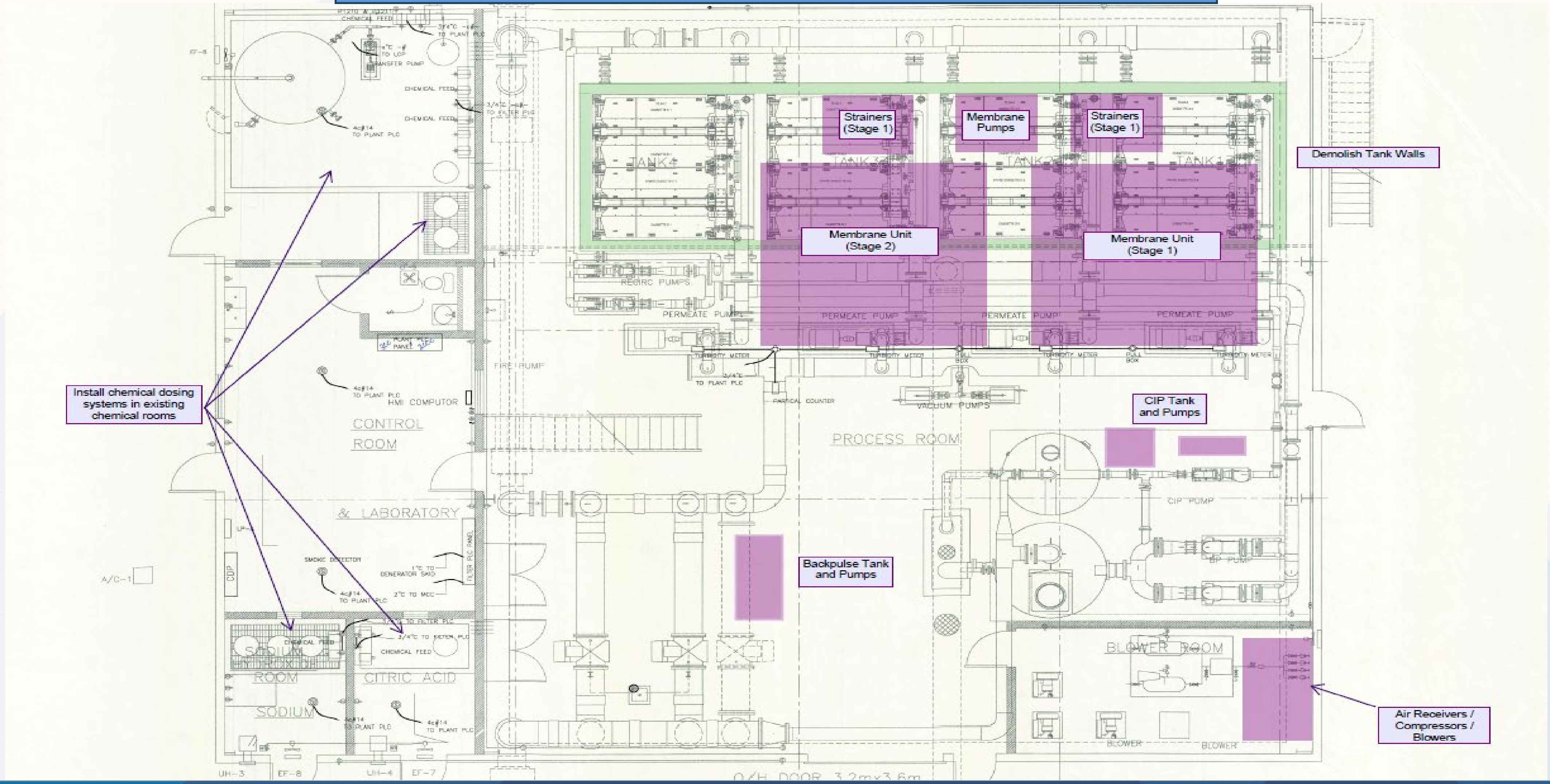
Only one drinking water facility in North America currently in operation, and a second is currently being built

- Membrane assembly done on-site and installation took 4-5 months
- Membranes were shipped dry, no glycerine disposal required
- Actuators are biggest maintenance issue
- No rapidly wearing parts, air driven process
- Performance is as expected, no seasonal changes, no issues with flow
- No information on system clean frequency
- Good customer support
- SCADA system works well
- 20-year warranty



Source: https://www.metawater.co.jp/eng/news/2016/11/post-96.html

Metawater Pressurized Ceramic - Constructability



Metawater Pressurized Ceramic - Constructability

No. of Membrane units	Plant Capacity During Construction	Pre-Filtration Needed?	Membrane Tank Modifications	Major Infrastructure Changes
2	50%	Yes – Wedge wire fine	Demolish	N/A

Source: https://www.metawater.co.jp/eng/solution/product/water/membrane_clarify/

Metawater Pressurized Ceramic - Cost

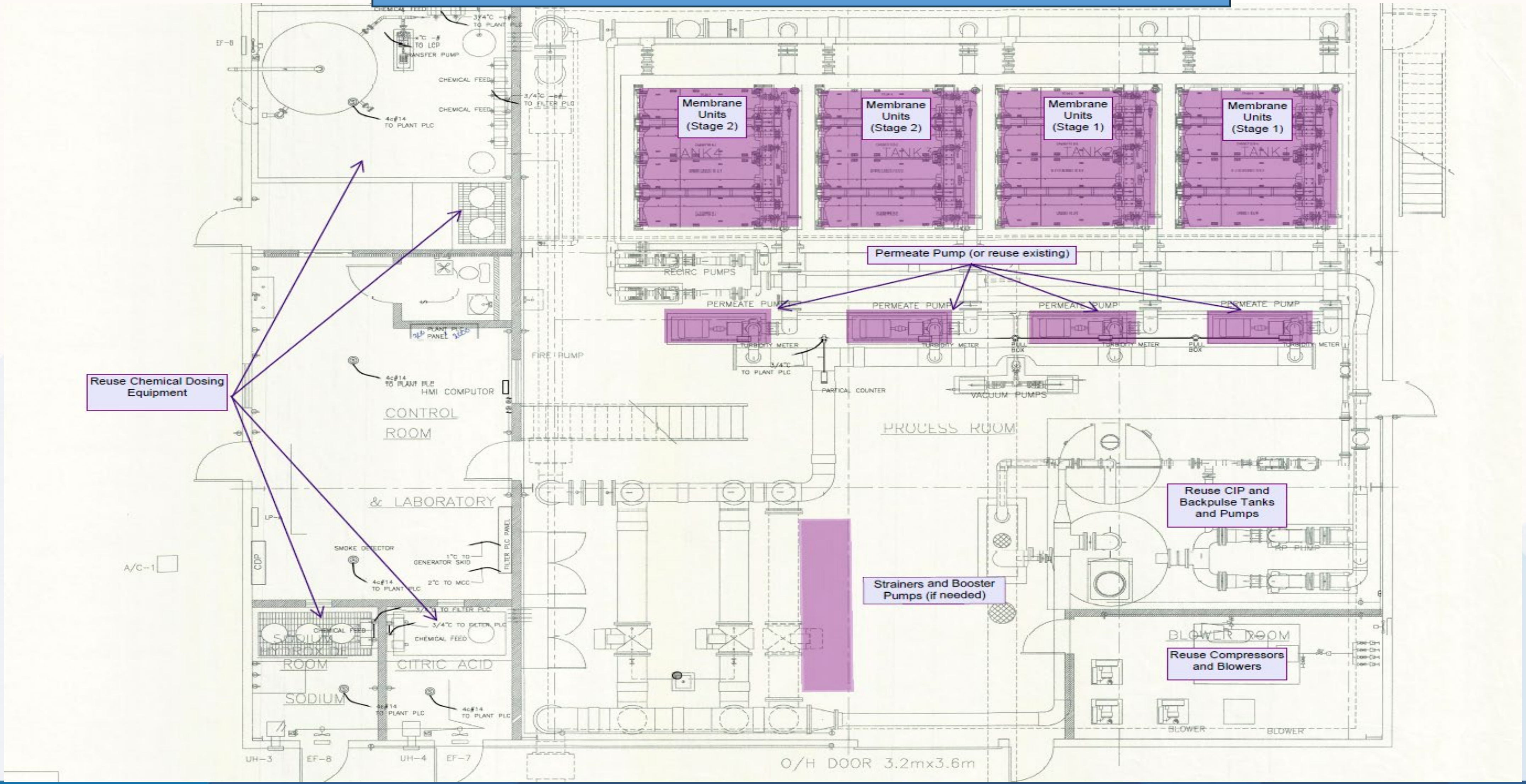
Capital Costs		Annual Costs	
Treatment Equipment Vendor Allowance Supporting Equipment Demolition Additional Housing Labour Costs	$5.5 m $0.6 m $0.7 m $0.1 m - $0.3 m	Annual Labour Costs Annual Chemical Costs Annual Power Costs Misc. Spare Parts	$78,000 $25,000 $13,000 $65,000
New Clearwell Expanded Lagoon Allowance BCH Allowance Contractor Mark-up and Overhead (20%)	- - $0.1 m $1.4 m	Total Annual	$181,000 /year
Subtotal	$8.6M	Lifecycle Costs (Present Value in 2024 Dollars)	$16.8M
Engineering and Contingency (35%)	$3.0M	• Assumed 20 hours of operator time on site each week at a rate of $75/hr for the membrane system. Does not include operator time for other equipment and duties on site. • Chemical consumption costs based on weekly hypochlorite cleanings and monthly acid/hypochlorite cleanings. • Replace membranes every 20 years. • Replace feed pumps, permeate pumps, compressors and blowers every 15 years. • Replace chemical pumps every ten years.	
Total	**$11.6M**		

ZW1000-550 Polymeric - Interviews

Veolia discontinued the Version 2 ZW1000 system that is currently installed in the Arrow Creek WTP.

Section 3.2.4 *– "Veolia could not provide examples of other sites where an older model of the ZW1000 system was replaced with newer ZW1000 system and resolved issues with premature fibre failure. Therefore, no interviews were conducted for ZW1000 sites."*

ZW1000-550 Polymeric –Constructability



ZW1000-550 Polymeric –Constructability

No. of Membrane units	Plant Capacity During Construction	Pre-Filtration Needed?	Membrane Tank Modifications	Major Infrastructure Changes
4	75%	Yes – Non-wedgewire 500um	Pipe connections[1]	Housing Expansion[2]

[1]Reuse of the existing tanks will require modifications to fill in unused space and/or to accommodate different pipe connections to the tank for inlets, outlets, drains, and cleaning lines. In later stage of design, the cost to upgrade the existing tanks should be compared to the cost of demolishing tanks and building new tanks in their place.

[2]Strainers and booster pumps may fit in the existing building or can be housed in a WTP expansion.

ZW1000-550 Polymeric – Cost

Capital Costs	
Treatment Equipment Vendor Allowance Supporting Equipment Demolition Additional Housing Labour Costs	$2.8 m $0.4 m $0.7 m $0.1 m $0.1m $0.3 m
New Clearwell Expanded Lagoon Allowance BCH Allowance Contractor Mark-up and Overhead (20%)	- - $0.1 m $0.9 m
Subtotal	$5.5M
Engineering and Contingency (35%)	$1.9M
Total	**$7.4M**

Annual Costs	
Annual Labour Costs Annual Chemical Costs Annual Power Costs Misc. Spare Parts	$78,000 $25,000 $26,000 $38,000
Total Annual	$167,000 /year
Lifecycle Costs (Present Value in 2024 Dollars)	$13.5M

- Assumed 20 hours of operator time on site each week at a rate of $75/hr for the membrane system. Does not include operator time for other equipment and duties on site.
- Assumed that the majority of existing equipment could be reused and does not include costs for new pumps, compressors, or tanks in the capital estimates.
- Chemical consumption costs based on weekly hypochlorite cleanings and monthly acid/hypochlorite cleanings.
- Includes costs for feed pumps and strainers upstream of membranes, in new housing.
- Replace membranes every 8 years.
- Replace feed pumps, permeate pumps, compressors and blowers every 15 years.
- Replace chemical pumps every ten years.

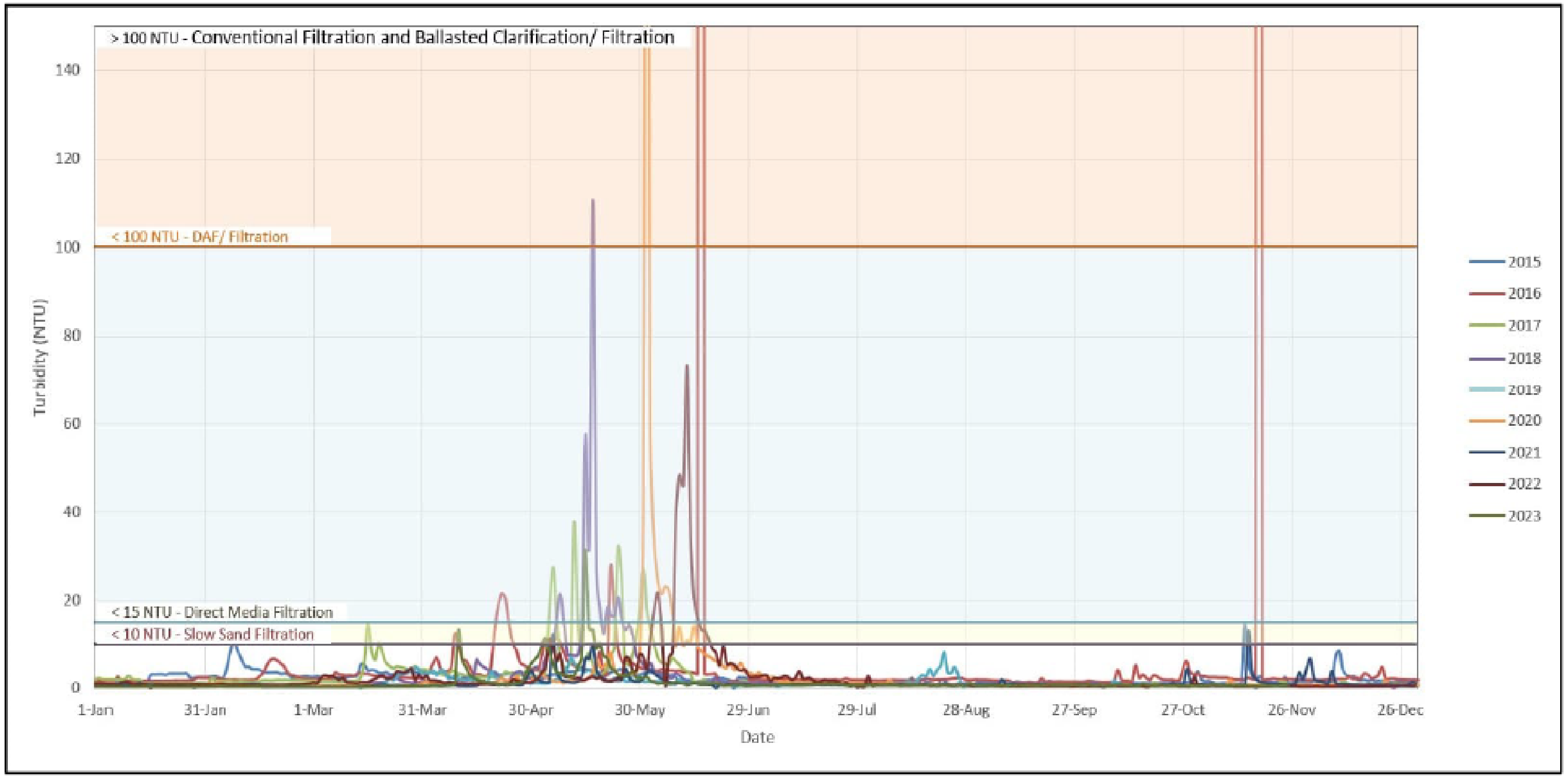
Outline/Meeting Agenda

4	Media Filtration Option Summary

Raw Water Quality – Media Filtration

- Based on recorded turbidity spikes at Arrow Creek WTP exceeding upper treatment limits for several days, slow sand and direct media filtration are not recommended.
- **Upper turbidity limits for CTAC recommended to be determined via piloting**
- 2 CTAC manufacturers claim a 50 NTU threshold

Figure 5-1 Raw Water Turbidity (2015-2023)



CTAC – Conceptual Sizing

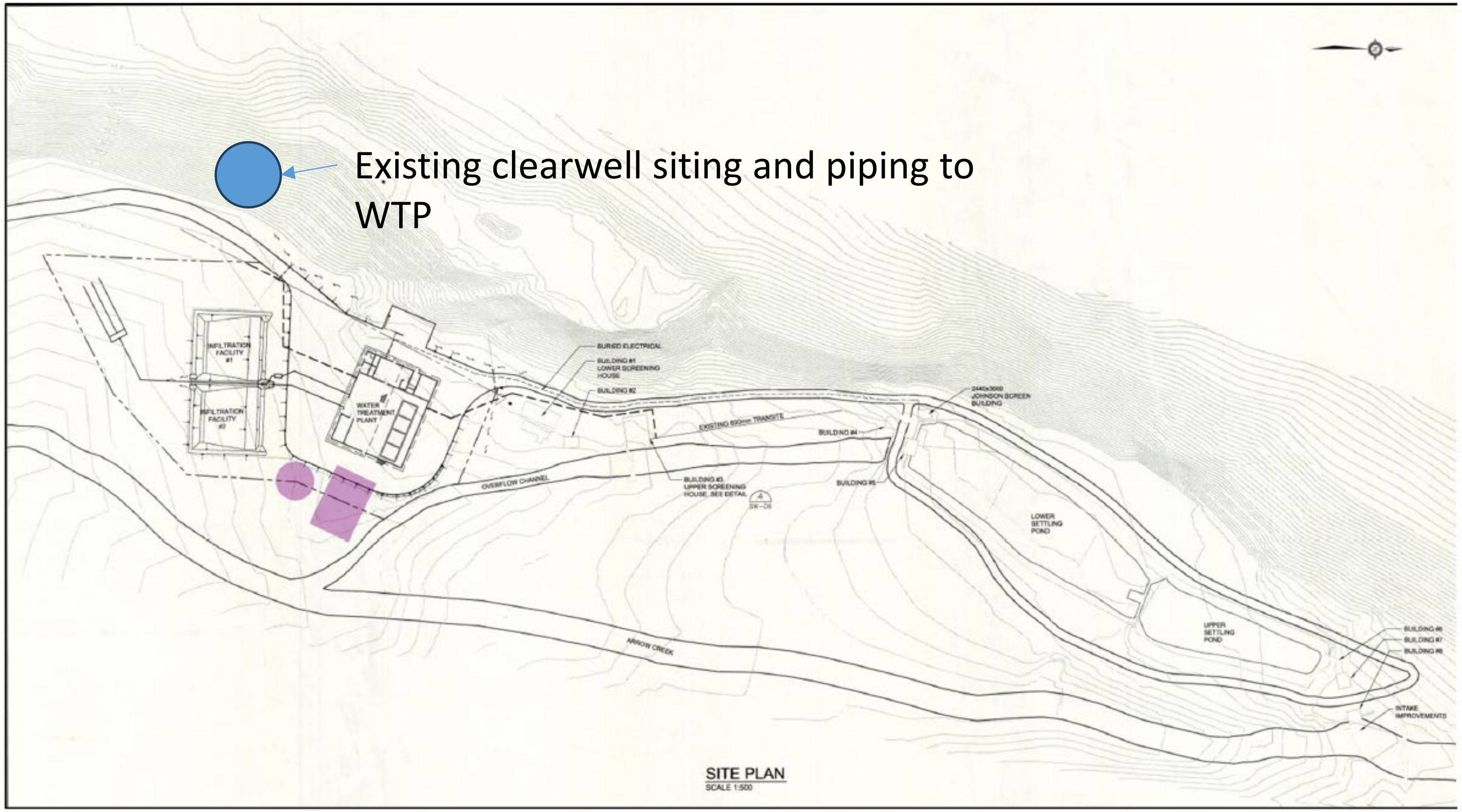


Figure above shows the relative footprint of CTAC as compared to the WTP

Conventional Filtration – Conceptual Sizing

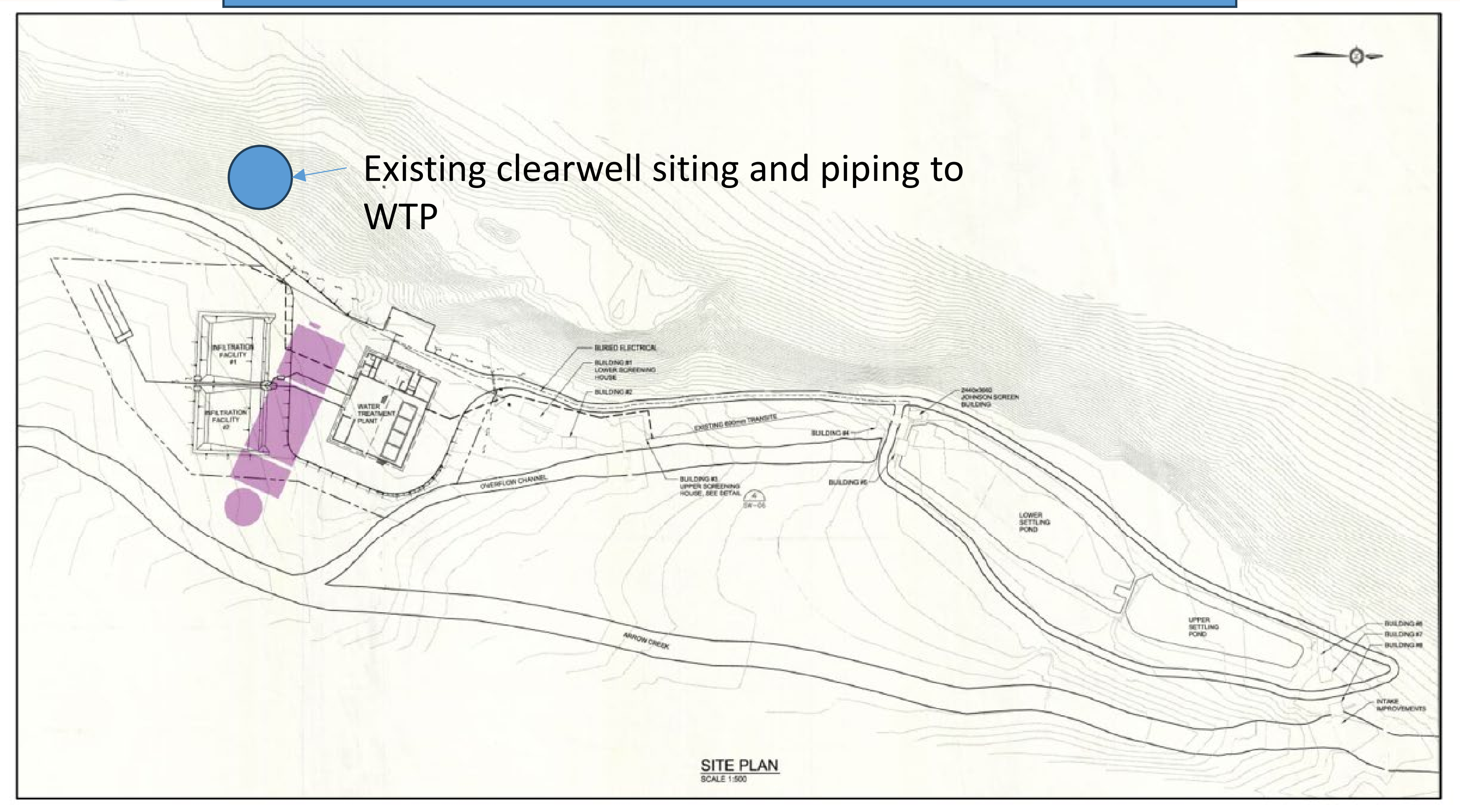


Figure above shows the relative footprint of Conventional Filtration as compared to the WTP

Ballasted Clarification/Filtration – Conceptual Sizing

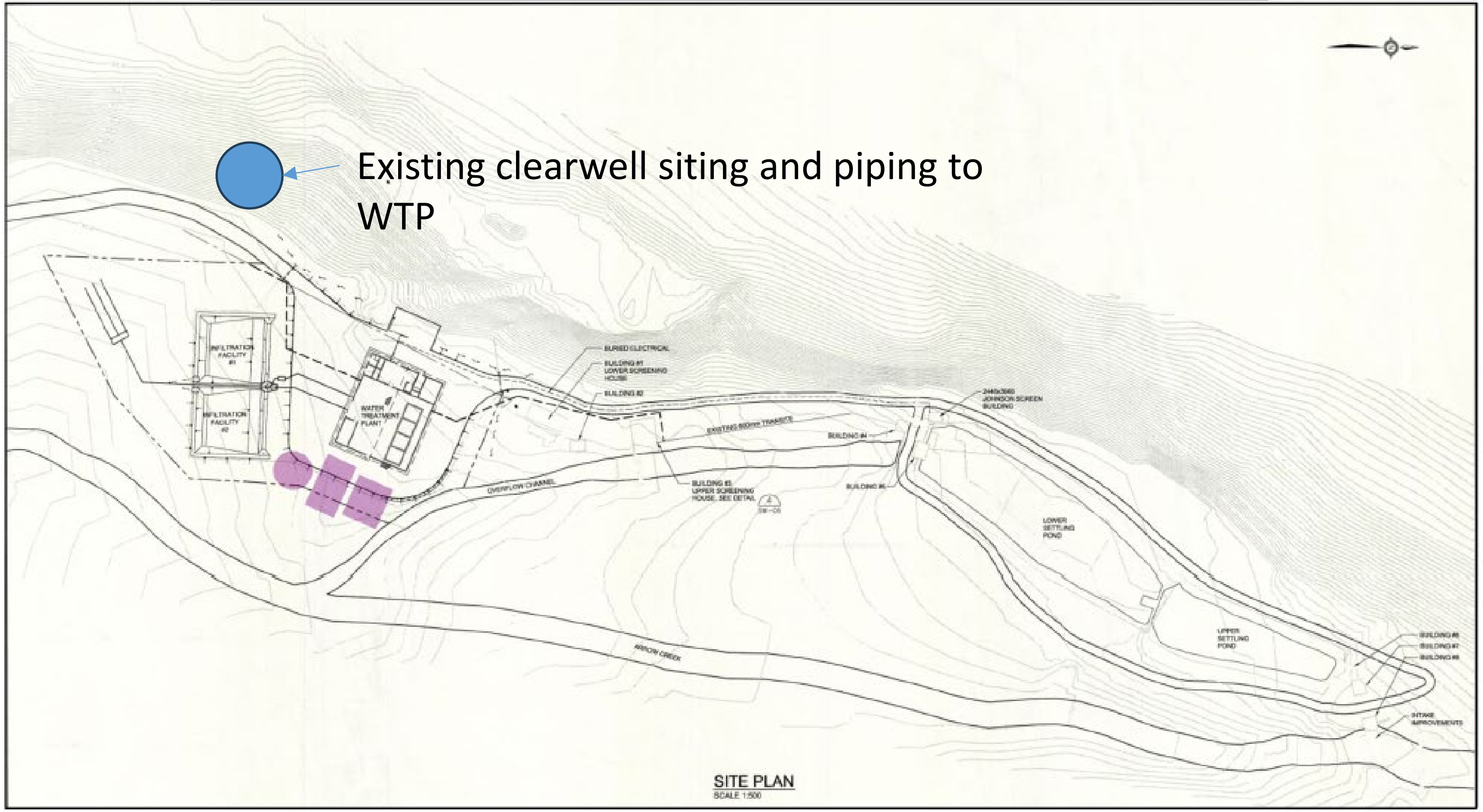


Figure above shows the relative footprint of Ballasted Clarification/Filtration as compared to the WTP

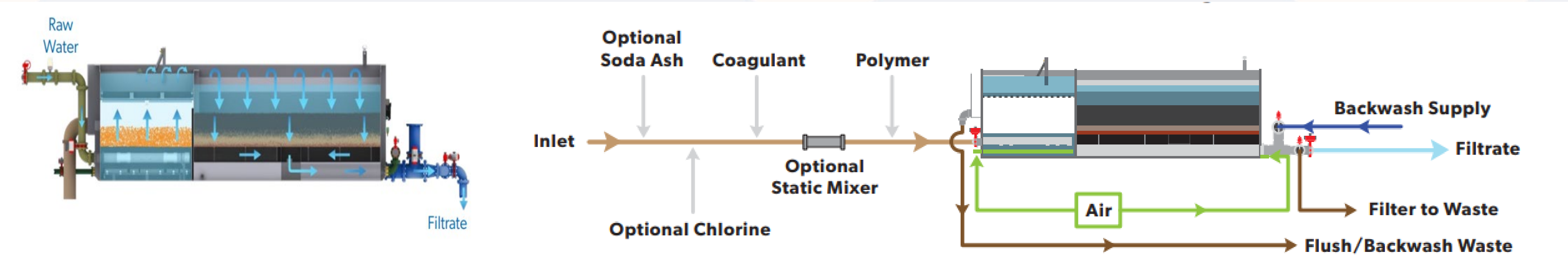
CTAC – Suitability

Based on footprint size where CTAC and Ballasted Clarification could potentially be retrofitted into the existing WTP, Conventional Filtration was discarded as a treatment option based on footprint size, given the alternatives

Of the remaining options (CTAC and Ballasted Clarification), the following concerns were expressed regarding Ballasted Clarification:

- ❑ Inefficiency of microsand system during the more common periods of low turbidity in raw water.
- ❑ Volume of waste residuals generated.
- ❑ Potential complexity of the treatment system, including the microsand recovery process.

Therefore, CTAC was selected as a potential media filtration option.



Source: https://f.hubspotusercontent10.net/hubfs/541513/content/brochure/Brochure-Trident.pdf

CTAC – Constructability

	No. of units	Plant Capacity During Construction	Pre-Filtration Needed?	Footprint (m2)	Major infrastructure Changes
Coagulation and Adsorption Clarifier Tanks	4	TBD	No[1]	72	Clearwell/ Upstream feed pumps
Media Filter Tanks	4	TBD	No[1]	102	Clearwell/ Upstream feed pumps

[1]The maximum turbidity that Adsorption Clarifiers can process is dependent on raw water quality and properties of the media used.

Outline/Meeting Agenda

5	All Options Summary

All Options Summary

MetaWater Pressurized Ceramic Membranes	ZW1000-550 Submerged Polymeric Membranes	Conventional Media Filtration Adsorbent Clarifier (CTAC)
Retrofit into existing WTP	Retrofit into existing WTP	Retrofit into existing WTP
Exceeds treatment req's	Exceeds treatment req's	Meets treatment req's
One example in North America	Used in multiple WTPs in North America	Used in multiple WTPs in North America
50% WTP capacity during construction	75% WTP capacity during construction	Unknown capacity during construction
173m^3/day residual amount	432m^3/day residual amount	780m^3/day residual amount
Capital Cost: $11.6M	Capital Cost: $7.4M	Capital Cost: $19.8M
Annual Costs: $181,000	Annual Costs: $167,000	Annual Costs: $344,000
*20-year Lifecycle: $16.8M	*20-year Lifecycle: $13.5M	*20-year Lifecycle: $19.8M
*40-year Lifecycle (RDCK):$18.2M	*40-year Lifecycle (RDCK): $16.3M	*40-year Lifecycle (RDCK): $22.1M

** Present value of future costs assuming 4% annual discount rate*

ZW1000-450 vs. ZW1000-550 Submerged Polymeric Membranes

Design Assumptions	ZW1000-450	ZW1000-550
Surface Area	450 ft^2	550 ft^2
No. of units	4 membrane units	4 membrane units retrofitted to existing cassettes/frames
Discharge	Discharges via tank overflows	Discharges via tank drains
Pre-treatment requirements	Wedge wire strainer	Punched hole/disc filter strainer
Permeate pumps	Use existing	Use existing
CIP system	Use existing	Use existing
Backpulse system	Use existing	Use existing
Air compressors and blowers	Use existing	Use existing
Dosing chemicals	Use existing	Use existing

Veolia claims that the increased surface area and new drain pattern increases the robustness of the new membrane version.

Outline/Meeting Agenda

6	Recommendation for Next Steps

Filtration System Selection

1. Improve raw water quality
2. Investigate potential for filtration exemption with improved raw water quality
3. Compare supplier options if maintaining UF membrane system
4. Pilot testing if selecting ceramic

Improving Raw Water Quality

Automate Intake

- Two existing sluice gates are currently manually operated to provide flow control into upper settling pond.
- Gates have provision for automation via electric motor
- Automated control of these gates based on level in the lower settling pond would prevent overflow and inefficient use of water

Replace Baffles

- Existing baffles are either non-operational or minimally effective
- Replacing and/or repairing baffles would increase settling capability of the ponds
- Installing an energy dissipater on inlet pipe would decrease velocity and enhance settling capability
- Provide baffle height adjustment for submergence level based on season

Reconfigure Piping Between Ponds

- Existing configuration of piping between ponds does not permit isolation of either pond and directs potentially unscreened water to the WTP
- Constructing a bypass chamber with an additional 0.5mm vertical screen would ensure that screened water is being provided to the WTP, and would allow either pond to be taken off-line

Replace Strainer

- The existing Johnson screen is constructed of 0.5mm wedge wire, which is both insufficient for UF membrane warranty and is subject to frazzle ice formation
- Replacing the Johnson screen with a 500-micron non-wedge wire strainer would satisfy UF membrane requirements
- Installing heated air compressor system or backwash system (would require booster pumps) would mitigate frazzle ice formation

Questions?

REPORT

Regional District of Central Kootenay

Arrow Creek Ceramic Filter Feasibility Study Final Report

MAY 2025

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EXECUTIVE SUMMARY

This report provides an evaluation of filtration options that could be used to replace the existing membrane filtration system at the Arrow Creek Water Treatment Plant (WTP).

In terms of membrane filtration, four options were considered:

- Submerged, reinforced polymer membranes (ZW500)
- Pressurized ceramic membranes (MetaWater)
- Submerged ceramic membranes (Cerafiltec)
- Submerged polymeric membranes (ZW1000-550)

The assessment of these options can be summarized as follows:

- ZW500 membranes have successfully been used at similar water treatment facilities across North America. Upgrading the Arrow Creek WTP with these membranes would require the construction of additional membrane tanks and housing, as well as several upgrades within the WTP.
- MetaWater had only one water treatment plant installation in North America, with other installations internationally. Upgrading the WTP with these membranes would require demolition of the existing tanks but the new equipment could all be installed within the existing WTP building.
- Cerafiltec had no water treatment plant installations in North America, but one wastewater treatment plant installation. Upgrading the WTP with these membranes would require an additional building to house the additional pumps and storage tanks, as well as several upgrades within the WTP.
- ZW1000-550 membranes have been used at similar water treatment facilities across North America. It is anticipated that these membranes could be installed inside the existing membrane tankage. An additional building may be required to house pre-membrane strainers.

A high-level assessment was also conducted of media-based filtration options, as follows:

- Conventional Treatment
- Conventional Treatment using Adsorption Clarifiers (CTAC)
- Direct Media Filtration
- Slow Sand Filtration
- Dissolved Air Flotation
- Ballasted Clarification / Filtration

Taking into consideration that Arrow Creek periodically experiences spikes in turbidity, and footprint requirements on site, CTAC was identified as the most suitable media filtration option to short-list for further consideration.

Opinions of Probable Cost were developed, hydraulic gradeline considerations and residual waste generation rates were developed for the following short-listed filtration options:

- Pressurized ceramic membranes (MetaWater)
- Submerged polymeric membranes (ZW1000-550)
- CTAC

The ZW1000-550 option had the lowest anticipated capital and 20-year lifecycle costs:

- $7.4 m capital and $13.5 m lifecycle cost

The MetaWater system had the next lowest capital and 20-year lifecycle costs:

- $11.6 m capital and $16.8 m lifecycle cost

The following actions are recommended as next steps:

- Meet with Interior Health to review the feasibility of getting approval for Filtration Exemption at the Arrow Creek site.
- Pilot one or both of the membrane options to verify their compatibility and resilience to Arrow Creek raw water conditions.
- Verify the engineering assumptions made as part of this assessment.
- Confirm the intent and details of executing the WTP upgrade in stages as opposed to all at once.

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1 INTRODUCTION

This report was prepared for the Regional District of Central Kootenay (RDCK) as part of a feasibility assessment for replacing the existing membrane system at the Arrow Creek Water Treatment Plant (WTP) with either ceramic membranes, new polymeric membranes, or a media filtration system.

2 BACKGROUND

2.1 Existing Water Treatment Plant

2.1.1 Process Overview

The Arrow Creek WTP is a surface water treatment facility with a 320 L/s (27.5 ML/d) design capacity. Community peak demands occur in the summer, in some cases exceeding 320 L/s, with winter demands averaging at 80 L/s. The community's agricultural industry creates a large water demand in the late spring, which often coincides with high turbidity events associated with freshet which, combined with the cold temperatures of the water at that time, apply additional strain to the membranes.

Treatment of Arrow Creek water currently consists of the following steps:

- Upper and lower settling ponds.
- Static Johnson intake screen using stainless steel wedge wire configuration with 500 micron spacing.
- Veolia Zeeweed 1000 (ZW1000) Version 2 / 450 submerged ultrafiltration membranes.
- Ultraviolet (UV) disinfection.
- Chlorination using 12% sodium hypochlorite.

Treated water then flows to the Town of Creston/Erickson reservoirs, then to the Erickson and Creston distribution systems. Wells located in Creston provide additional supply when demand exceeds the Arrow Creek WTP's capacity.

2.1.2 Membrane Equipment

The membrane system consists of four ZW1000 membrane units (3 of 4 available cassettes in use per unit, 64 modules per cassette), each submerged in concrete membrane tank and a permeate pump downstream of each membrane unit. The membrane system also consists of equipment for integrity testing, hydraulic cleanings, and chemical cleanings, as follows:

- For hydraulic cleanings:
  - 24,095 L backpulse supply holding tank.
  - Two backpulse pumps.
  - Three aeration blowers.

- For chemical cleanings:
  - One Clean-in-Place (CIP) holding tank (11,140 L) with tank heater.
  - One CIP pump.
  - Sodium hypochlorite dosing pump skid and bulk tank.
  - Citric acid dosing pump skid and day tank.

- For neutralization of chemical cleaning waste:
  - Sodium bisulphite dosing pump skid and day tank.
  - Sodium hydroxide dosing pump skid and day tank.

- For membrane integrity testing:
  - Two compressors.

- For lifting and moving the membrane units:
  - A bridge crane with a maximum 3.2 Tonne (3,200 kg) capacity, and a distance of 5.5 m from the highest elevation on the sloped floor in the membrane tanks to the underside of the crane.

The RDCK conducts CIP cleanings approximately three times a year, and maintenance cleans using less concentrated sodium hypochlorite on a weekly basis. Previously the RDCK had not found a significant improvement in transmembrane pressure after citric acid cleans, and stopped using citric acid during CIPs, though they continue to conduct chemical cleans using sodium hypochlorite.

2.1.3 Membrane Failure

The membranes experience frequent fibre breakage at the potting, that is, the point of connection between the membrane fibres and the cassette, in all of the membrane cassettes, resulting in a loss of membrane integrity and reduced *Cryptosporidium parvum* and *Giardia lamblia* removal efficiency in the form of decreased Log Removal Value. Failure frequency has reached a point where near-daily maintenance of the membranes has been required. The WTP does not have any redundant membrane units that would allow the facility to run at full capacity while one membrane unit is offline. Therefore, operators cannot do repairs during summer and are forced to wait until water demand has decreased before they can bring a membrane system offline for repairs. Membrane cassettes have been replaced as summarized in Table 2-1, but according to operations staff the previous rate of fibre breakage would resume after the cassettes had been running for approximately two years.

Table 2-1 Date of Membrane Replacements in Each Train

Train No.	1	2	3	4
Date of Last Membrane Replacement	2019 (189 new modules)	2016 (189 new modules)	2015 (189 new modules)	2018 (138 new modules)

A December 2020 assessment report (WSP, "Capacity, Filtration and Potential Improvements") was conducted for the drinking water system, which included recommendations to replace the existing ZW1000 membranes with submerged ceramic ultrafiltration membranes.

2.2 Ceramic Membranes

Ceramic membranes are membranes made of layers of refined porous ceramic coatings from the microporous support to the ultrafiltration layers. Ceramic membranes are reported to exhibit increased mechanical strength and tolerance to vigorous hydraulic cleaning compared with traditional polymeric membranes, as well as having a greater resistance to chemical cleans and greater tolerance to pH ranges. This should allow greater membrane backwash recovery and longer warrantied service life.

Ceramic membranes for treating municipal drinking water have predominantly been used in Japan, with the longest running ceramic membrane WTP in operation since 1996. To date, the application of ceramic membranes in Canada has been limited.

Some of the limiting factors that have hindered the mass adoption of ceramic membranes in BC include the following:

- High initial capital cost.
- Limited number of suppliers offering the product, thereby adding risk for long-term support for troubleshooting and spare parts.
- Inconsistent performance standards for ceramic membranes – For example, some ceramic membranes are advertised as being specifically designed for high organic-content waters, while other suppliers for similar models do not recommend their use in waters containing more than 4 mg/L TOC.

The appeal of ceramic membranes for Arrow Creek is their apparent greater resilience to physical wear and tear, and the potential to meet the WTP's current design capacity in a smaller footprint. An assessment of the membranes and the existing infrastructure that they will interact with is crucial for a successful upgrade.

2.3 Desired Outcomes

The RDCK is interested in replacing their existing ZW1000 membranes with an alternate filtration system that is able to meet the following criteria:

- Meet current BC drinking water standards for filtration processes and provide a reduction in turbidity and protozoa (when combined with the disinfection capabilities of the existing UV system) from incoming water.
- Improved membrane robustness that will lead to a significant drop in maintenance and repair requirements.
- Can be incorporated into the existing water treatment plant for the least amount of effort and cost.

In addition, the ability to stage replacement of the membranes is desired due to factors such as potential restraints on funding, the need to maintain at least partial capacity through the WTP during construction, and positioning the RDCK to replace the membranes in the future in a similar staged sequence.

2.4 Approach

2.4.1 Membrane Alternatives

Our evaluation of the different membrane options consisted of the following assessments:

- Interviews: Treatment facilities that use the different types of membrane being considered were interviewed to discuss the benefits and challenges they have been observed when running the systems.
- Constructability: Budgetary quotes were received for each of the membrane options to assess the ability to install new membranes into the existing WTP layout without reducing the WTP's treatment capacity by more than 50% during construction. Where space could not be found to feasibly place the new equipment in the existing building, the extent of additional housing that would be required was identified.
- Cost Comparison – Class "D" Opinion of Probable Costs (Cost Estimates; +/- 50%) to be developed for capital and lifecycle costs for the options.

The following alternatives to the existing ZW1000 system were evaluated:

- Pressurized Ceramic Membranes - The longest running ceramic membrane facilities are located in Japan, and predominantly use Metawater pressurized membrane system. Furthermore, the longest running WTP that uses ceramic membranes for drinking water, with 20 years of operating service, utilizes MetaWater pressurized membranes. Because of its historical use and proven track record at drinking water facilities, we used the Metawater membranes as the basis for evaluating the feasibility of pressurized ceramic membranes.
- Submerged Ceramic Membranes - Compared to pressurized membranes, immersed-style ceramic membranes have not been as widely used for full-scale WTPs, with none installed in BC. However, because of the potential that this type of membrane could fit into the existing membrane tankage at the WTP, submerged ceramic membrane were considered as an option for Arrow Creek. The evaluation of submerged ceramic membranes was based on the Cerafiltec brand, one of the few vendors of ceramic submerged membranes that are represented by a supplier in BC.
- Reinforced Submerged Polymeric Membranes – Veolia's Zeeweed 500D (ZW500) are reinforced, polymeric immersed membranes with significantly stronger integrity than the ZW1000. Associated Engineering has successfully implemented ZW500 membranes at drinking water facilities where hydraulic or particulate loading conditions are too onerous for ZW1000 units, and have successfully retrofitted ZW500 into numerous facilities where the existing polymeric membranes had experienced fiber breakages. While more robust, the key limitation of ZW500 membranes is that they have a lower surface area relative to ZW1000, meaning that a larger footprint is typically required for ZW500 to treat the same flowrate.

In addition, Veolia has stated that they have changed the design and module capacity of their ZW1000 systems since the version installed at Arrow Creek, including changing how the tanks drain and fill. At the time of this report it could not be verified whether membrane fibre failure would be reduced by the new ZW1000 design, however for the sake of comparison the feasibility of installing newer-model ZW1000 membranes into the existing WTP layout was considered as part of Section 4.

2.4.2 Media Filtration Alternatives

As part of providing a broader comparison of the filtration options available at Arrow Creek, a screening of the following media-based filtration processes was also conducted:

- Conventional Treatment:
  - With flocculator and sedimentation tanks.
  - With Adsorption Clarifiers or roughing filters.
- Direct Media Filtration
- Slow Sand Filtration
- Dissolved Air Flotation / Filtration
- Ballasted Clarification / Filtration

The screening of these non-membrane filtration options is detailed in Section 5.

3 CASE STUDIES FOR MEMBRANE OPTIONS

3.1 Overview

Interviews were conducted with the administrators and operators of treatment facilities that use the membrane options that were being considered. Where possible, the interviews focused on drinking water facilities located in North America, but when drinking water facilities were not available wastewater facilities were contacted. Ceramic membrane facilities outside of North America were contacted but turned down requests to participate in the interview process.

3.2 Interview Findings

A summary of the interview results is presented in Table 3-1, with greater detail provided in Appendix A.

3.2.1 Zeeweed 500D Reinforced Polymeric Membranes

ZW500 membranes are commonly used in water treatment facilities across North America and have been successfully used to treat water sources high in turbidity or otherwise physically stressful on membranes. Interviews were conducted with staff from three Canadian WTPs that use the ZW500. The key observations were as follows:

- The ZW500 were relatively straight-forward to install.
- Staff seemed satisfied with membrane operation, in that performance was as expected and maintenance requirements were relatively low.
- At their current observed rate of wear and tear, the ZW500 units at these sites were anticipated by the staff to have a 10 to 12 year useful life before requiring replacement.
- An issue noted at two sites was that the membrane tanks that hold the submerged membranes were undersized and did not account for sufficient clearance between the membrane and the tank walls. Without this clearance the membrane fibres along the perimeter of the membrane units would scrape against the tank walls during air scours and hydraulic cleans, causing premature abrasion damage and fibre breakage.
- The amount of glycerin requiring disposal was also noted as a challenge at two sites. Polymeric membranes are commonly shipped to site in glycerin to prevent them from drying out and cracking. However, at both sites the volume of glycerin was reportedly greater than anticipated. Because of its high biological oxygen demand (approximately in the order of 45,000 mg/L BOD) concentrated glycerin typically cannot be discharged to municipal wastewater facilities, but to industrial wastewater facilities instead.

3.2.2 MetaWater Pressurized Ceramic Membranes

To date only one drinking water treatment facility in operation in North America utilizes the MetaWater system. A second facility is currently under construction. From this interview with staff from this one site the key findings were as follows:

- To verify proof of concept the staff visited multiple sites and conducted a three-month membrane piloting program.
- The membranes were shipped “dry”, that is, not in glycerin, and assembled on site.
- It took approximately five months to assemble the membrane units on site.
- Staff seemed satisfied with membrane operation, in that performance was as expected and maintenance requirements were relatively low. CIPs are conducted two to three times a year, as opposed to 12 times a year that is typical for polymeric membranes.

- In terms of maintenance, it was flagged that there are a large number of actuated valves that are part of the MetaWater system. These valves are pneumatically actuated, and an air dryer is strongly recommended to ensure that moisture does not accumulate in the process air lines to these valves.
- The facility recycles some of the hydraulic cleaning waste that is dosed with polymer. Unlike polymeric membranes, the MetaWater system is able to treat water containing polymer without rapid fouling.
- The anticipated life of the membranes could not be predicted by staff at this time, as to their knowledge none of the ceramic membrane systems installed internationally in WTPs have reached the point where the membranes require replacement. MetaWater was providing a 20-year warranty on their membranes at this site.

3.2.3 Cerafiltec Submerged Ceramic Membranes

At the time of this assessment there are no drinking water treatment facilities in North America using the Cerafiltec membranes. Staff from a Cerafiltec wastewater treatment and reclamation facility were contacted instead. The staff from only one site were able to participate in an interview.

The key findings from this interview were as follows:

- The Cerafiltec system was relatively straightforward to install, with the exception that the membrane unit required Schedule 80 PVC pipe for the permeate lines, which the staff reported was difficult to install in the available space.
- Staff seemed satisfied with membrane operation, in that performance was as expected and maintenance requirements were relatively low. CIPs are conducted four to six times a year.

3.2.4 Zeeweed 1000 Polymeric Membranes

Veolia could not provide examples of other sites where an older model of the ZW1000 system was replaced with newer ZW1000 system and resolved issues with premature fibre failure. Therefore, no interviews were conducted for ZW1000 sites.

3.3 Summary

In terms of the extent that the different membrane options are in use in North America:

- The ZW500 membranes have been successfully used in multiple drinking water treatment facilities across North America for waters considered abrasive to ZW1000 membranes.
- At the time of this assessment, Metawater membranes are reportedly being used by only one drinking water treatment facility in North America, and Cerafiltec membranes are not being used in any North American drinking water treatment facilities.
- ZW1000 membranes are in use in many drinking water treatment facilities across North America, however Veolia could not provide examples of sites where older models of the ZW1000 were upgraded to newer models and saw a resulting improvement in membrane resilience and useful life.

In terms of installation:

- Clearance spaces around ZW500 units in their tanks should be closely examined to avoid membrane fibre contact with tank walls during cleaning operations that can result in abrasion damage.
- The ZW500 membranes are shipped in glycerin, and disposal of this glycerin must be accounted for during membrane installation or replacement.

- Installation of MetaWater systems must account for the membrane units being completely assembled on site.
- No significant issues were flagged during the installation of the Cerafiltec system.

In terms of operation:

- In general the contacted staff were satisfied with the performance of the ZW500, MetaWater and Cerafiltec membrane systems.
- The MetaWater system has a significant number of pneumatically actuated valves, each with the level of maintenance typically required for actuated valves.
- Staff assess that the ZW500 membranes at their sites have a useful life of 10-12 years. The MetaWater membranes are anticipated to have a useful life of at least 20 years.

4 SYSTEM UPGRADES FOR MEMBRANE OPTIONS

4.1 Basis of Assessment

Budgetary quotes were received for the four membrane options to assess the ability to house the new equipment in the existing WTP, and to estimate the amount of additional housing that may be required. In addition, each membrane vendor has a set of criteria that must be met for the vendors to honour their membrane performance guarantees, including pre-treatment requirements. The feasibility of meetings these pre-treatment requirements was included as part of the feasibility assessment.

The following criteria was used as the basis of the membrane quotes for the evaluation:

- Maximum design flow of 320 L/s in the summer and 80 L/s in the winter.
- Installation of the new membrane equipment would be done in two stages, Stage 1 and Stage 2, such that at least 50% of the WTP's capacity is maintained at all times during construction.
- The membrane system would not include any redundant units or trains as standby.
- Maximum water pressure available upstream of the membranes: 3 m (4 psi).
- Minimum water pressure required downstream of the membranes: 13 m (18 psi).
- Incoming water quality as per Table 4-1.
- Raw water turbidity conditions as per Table 4-2.
- Upgrades to the existing power supply have not been incorporated into the assessment at this point.

Table 4-1 Historical Raw Water Quality

Parameter	Minimum	Average	Maximum
Total Organic Carbon (mg/L)	-	1.86 [1]	-
Dissolved Organic Carbon (mg/L)	-	1.16 [1]	-
Temperature (C)	0.0	6.1	26.9
Total Hardness (mg/L as $CaCO_3$)	17	28	41
Langelier Index		-2.7	
Total Dissolved Solids (mg/L)	19	34	51

Parameter	Minimum	Average	Maximum
Alkalinity (mg/L as $CaCO_3$)	14	31	46
True Colour (TCU)	< 5	8	12
pH	6.58	7.18	7.79
Aluminum (mg/L)	< 0.05	0.09	0.27
Barium (mg/L)	< 0.05	0.02	0.02
Magnesium (mg/L)	1.3	2.1	3.0
Manganese (mg/L)	< 0.002	0.004	0.0119
Nitrate (mg/L as N)	< 0.010	< 0.010	0.013
Nitrite (mg/L as N)	< 0.010	< 0.010	< 0.010
Strontium (mg/L)	0.016	0.026	0.035
Sulfate (mg/L)	1.4	3.5	6.5

Notes:

[1]Organic concentrations based on one raw water sample from February 2024.

Table 4-2 Historical Raw Water Turbidity (NTU)

Year	Minimum	Average	Maximum	Month of Turbidity Peak
2018	< 0.1	2.5	110.5	May
2019	0.2	1.2	8.1	March
2020	0.5	3.0	350.1	June
2021	0.1	1.2	12.9	May
2022	0.2	2.4	73.6	June
2023	0.4	1.4	31.4	May

4.2 ZeeWeed 500 Reinforced Polymeric Membranes

An illustration of how the ZW500 system could be incorporated into the Arrow Creek WTP is provided in Figure 4-1 (Appendix B). The proposed ZW500 system consists of the following equipment:

4.2.1 Membrane Train

Veolia recommended twelve units of ZW500 units to achieve a net 320 L/s treatment capacity. With a footprint of 1.75 m x 0.74 m per unit, only two units can fit into each of the existing tanks. Demolishing and building larger tanks to accommodate three ZW500 units per tank could not be completed inside the WTP building without extensive relocating of equipment and piping. Therefore, the recommended layout involves fitting two units within each of the existing tanks, and expanding the WTP building to accommodate two more parallel tanks to house the remaining four units.

In terms of staging installation, six ZW500 units would be equivalent to two ZW1000 tanks, meaning that at least three tanks would be needed for the ZW500 units to replace two ZW1000 tanks. Additional tanks outside of the existing building would need to be built as part of the first stage of construction.

For ease of constructing the concrete tanks it is recommended that the two additional tanks be constructed together in Stage 1, instead of building only one tank in Stage 1 and later connecting a second concrete tank to the first in Stage 2. The RDCK would then have the option in Stage 1 to install four of the ZW500 units in these new tanks and place the other two units in one of the existing ZW1000 tanks. This approach would allow the RDCK to keep three of their ZW1000 tanks online during construction, meaning that the WTP would be able to maintain 75% of its design capacity at all times instead of 50%.

As part of installing new membranes into the existing tanks, the tanks would require modifications to change how spent cleaning waste is discharged from the tanks, as follows:

- The ZW500 are 2.56 m tall. In comparison there is height of approximately 2.5 m from overflow weir, and 2.8 m from the top of the existing tanks to the highest point on the tanks' sloped floor. The existing tank would require that the elevation of the overflow be raised and potentially that the tank walls be raised.
- Instead of the current method of discharging the waste via the tank overflows, the waste would be directed through tank drains, which is expected to improve the removal of particulate in the tank and potentially extend membrane useful life.

Each ZW500 unit is anticipated maximum weight of 4,470 kg (9,900 lbs) when loaded with accumulated solids, and Veolia recommends that a crane with a minimum 4,500 kg (10,000 lbs) capacity be used to lift and move the ZW500 units. The existing 3,200 kg crane would require replacement and upgrading, and the structural support capacity for the crane would require investigation.

4.2.2 Pre-treatment Strainers

As part of the conditions listed in the ZW500 membrane performance guarantee, Veolia requires that water fed to the membranes be first pre-screened using a mesh, punched hole or disc filter type screen with openings no greater than 500 micron in size. Wedge wire screens would not be considered acceptable.

The Johnson static screen at the WTP's intake is 500 micron wedge wire and does not meet this stated criteria. However, Veolia has stated that they might accept the existing screen as adequate pre-screening if the Johnson screen is never bypassed and assuming that the Johnson screen has historically been successful in adequately protecting the existing ZW1000 units from damage. Assuming that the RDCK may periodically bypass the Johnson screen, or that Veolia will not alter their standard performance guarantee conditions for this site, the incorporation of non-wedgewire 500 micron strainers into the WTP layout has been included as part of the ZW500 upgrade option.

There is insufficient space within the existing WTP building to install strainers upstream of the membranes without significant concrete demolition and re-piping. At this early stage of design it is instead recommended to assume that strainers for the ZW500 option would be placed in separate housing or a building extension.

The hydraulic gradeline of the WTP allows for very little additional headloss for water to flow through the strainers on the way to the membrane tanks. The strainers will need to be kept clean and operated in a manner that minimizes headloss through the strainers. Alternatively, booster pumps may be needed upstream of the strainers to ensure there is enough water pressure to keep the membrane tanks full. The booster pumps could be installed next to the strainers in separate housing closer to the intake pipe.

4.2.3 Permeate Pumps

A total of six permeate pumps, one for each membrane tank, will be required. Details on the ZW500 pumps have not been provided at this stage, but if the existing permeate pumps have the same design operating setpoints as the ZW500, the RDCK could opt to not install new permeate pumps until the existing ones have reached the end of their useful life.

4.2.4 CIP System

Veolia recommends that the CIP tank for the ZW500 be concrete-cast with a minimum holding volume of 56,000 to 84,000 L. This is larger than the existing CIP tank and therefore a new tank would be required. There is insufficient space within the WTP to house an additional CIP tank of this size. It is recommended that the ZW500 CIP tank be built in a building extension to the WTP. The ZW500 pump could be installed adjacent to the existing CIP pump or installed in the CIP tank's housing extension. While Veolia recommended that the tank be concrete-cast, it would be recommended to consider Fibreglass reinforced plastic (FRP) or polyethylene chemical tanks as alternatives.

4.2.5 Backpulse System

The ZW500 system includes a duty and standby backpulse pump for hydraulic cleanings. If the operating setpoints for the ZW500 backpulse pumps and the ZW1000 pumps are different, then the backpulse pumps for both systems would be needed in the WTP for as long as both the ZW1000 and ZW500 membranes are in operation. It is recommended that the ZW500 backpulse pumps be installed close to the existing backpulse and CIP pumps during the first phase of membrane replacement. When all of the ZW1000 trains have been removed the ZW500 backpulse pumps could then be relocated to where the ZW1000 backpulse pumps are currently installed. If the required backpulse operating setpoints for the ZW500 system and the ZW1000 system are the same, then the existing backpulse pumps could be re-used and replacement of the backpulse pumps would not be required.

The backpulse system also requires a backpulse water supply tank. It is recommended that the existing tank be used by both the ZW1000 and ZW500 systems.

4.2.6 Air Compressors and Blowers

It is believed that the existing compressor and blower equipment used for the ZW1000 units could also be used for the ZW500 membranes, or alternatively new compressors and blowers for the ZW500 units could fit within the existing compressor room.

4.2.7 Dosing Chemicals

ZW500 system will require chemical dosing units for sodium hypochlorite, sodium bisulphite, citric acid, mineral acid (typically sulphuric acid) and sodium hydroxide, for chemical cleans and to neutralize the cleaning waste afterwards. These dosing systems could be installed in the existing chemical rooms.

4.2.8 Summary

The recommended approach to replacing the existing ZW1000 with ZW500 units in two stages involves the following key steps:

Stage 1

- Decommission one ZW1000 unit and remove all equipment from one existing tank.
- Modify the emptied membrane tank for use by ZW500 units.
- Construct WTP expansion, either as a separate building or an extension of the existing WTP.
- Install pre-filtration strainers and booster pumps in WTP expansion.
- Build additional membrane tanks in WTP expansion.
- Install four ZW500 units in the WTP expansion and two ZW500 units in one of the existing tanks.
- Install two ZW500 permeate pumps in new housing. Replace one ZW1000 permeate pump with one ZW500 permeate pump.
- Build new CIP tank and install CIP pumps in WTP expansion.
- Install backpulse pumps in existing building, near the vacuum pumps.
- Install chemical dosing equipment in existing chemical rooms.
- Install compressors and blowers in existing compressor room.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

Stage 2

- Decommission remaining ZW1000 units and remove all equipment from existing tanks.
- Modify the emptied membrane tanks for ZW500 use.
- Install six ZW5000 units in the emptied tanks.
- Remove unused compressors, blowers and chemical pumps.
- Install additional pre-filtration strainer(s) and booster pump(s) in new housing.
- Replace three ZW1000 permeate pumps with three ZW500 permeate pumps.
- Remove ZW1000 CIP tank and pump.
- Remove ZW1000 backpulse pumps and relocate ZW500 backpulse pumps.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

4.3 MetaWater Pressurized Ceramic Membranes

An illustration of how the MetaWater system could be incorporated into the Arrow Creek WTP is provided in Figure 4-2 (Appendix B). The proposed MetaWater system consists of the following equipment:

4.3.1 Membrane Train

Instead of the membranes being submerged in open tanks, the MetaWater membranes are installed in pressurized vessels on an equipment pad. To fit in the WTP the existing ZW1000 tankage would need to be demolished and a concrete equipment pad cast under the filter units. MetaWater recommends two units to match the WTP's current design capacity. The combined footprint of the two MetaWater units is smaller than the footprint of the ZW1000 system. The MetaWater membranes can fit within the existing footprint with excess floor space left over. In terms of staging construction, one MetaWater unit could be installed to replace two ZW1000 tanks in Stage 1, and the second MetaWater unit installed in Stage 2.

This assessment is based on MetaWater's proposal to use two units to meet the WTP's design capacity. However, a two-unit membrane system means that the WTP's capacity would potentially be reduced to 50% if one unit was brought offline. The Creston wells could be used to supplement water supply during this offline time. However, in the interest of maximizing the capacity of water supplies available at all times, if the MetaWater option is selected for further consideration it is recommended that revising the MetaWater package from two units to three or more be considered.

4.3.2 Pre-Treatment Strainers

MetaWater system also requires pre-filtration straining to prolong the life of the membranes. In contrast to the ZW500 system, wedge-wire type strainers are approved, with a recommended maximum orifice size of 300-400 micron. The strainers would be installed upstream of the two membrane units, in the space cleared from demolishing the ZW1000 tanks.

Due to limited amount of incoming water pressure the strainers should be installed downstream of the permeate pumps, that will produce enough head to drive water through the strainers and membranes.

4.3.3 Membrane Pumps

Unlike submerged membranes the permeate pumps for pressurized membranes are installed upstream of the membranes. One feed pump per membrane unit is required, though a standby pump is recommended to ensure the WTP can continue to operate if a duty pump goes offline.

After demolishing the ZW1000 tanks the membrane pumps would be installed in the excess space not occupied by the membrane units, upstream of the strainers.

4.3.4 CIP System

A new CIP storage tank and pump are required for membrane chemical cleanings. The recommended CIP pump is smaller than the existing pump used by the ZW1000, and the required volume of the storage tank is significantly smaller than the existing CIP tank. It is recommended that the new CIP pump and tank be installed adjacent to the existing CIP pump and tank in the chemical containment area. When all of the ZW1000 membranes have been decommissioned, the existing CIP pump and tank can also be removed.

4.3.5 Backpulse System

The MetaWater system requires differently-sized backpulse pumps for membrane hydraulic cleans, and a significantly smaller backpulse water tank. Finding space for the backpulse system during Phase 1 of construction will be challenging. It is recommended that the backpulse system be installed close to the UV system and that the workbench currently located in this area be shifted to provide more space. In Phase 2 of construction more of the ZW1000 equipment will be removed, providing space to relocate the backpulse system to either the space currently occupied by the ZW1000 backpulse equipment, or in the additional floorspace that will be available when the remaining ZW1000 tanks are demolished.

4.3.6 Air Compressors and Blowers

The MetaWater system requires air receiver tanks and three compressors when fully built. It is believed that this equipment could be installed in the compressor room.

4.3.7 Dosing Chemicals

The MetaWater system will require chemical dosing units for sodium hypochlorite, sodium bisulphite, citric acid, sulphuric acid and sodium hydroxide, for chemical cleanings and to neutralize the spent cleaning waste afterwards. These dosing systems could be installed in the existing chemical rooms.

4.3.8 Summary

The recommended approach to replacing the existing ZW1000 with MetaWater units in two stages involves the following steps:

Stage 1

- Decommission two ZW1000 units.
- Demolish two of the ZW1000 concrete tanks.
- Install pre-filtration strainers in the cleared concrete tank area.
- Install permeate pumps in the cleared concrete tank area.
- Install Stage 1 MetaWater membrane unit(s) and equipment pad in the cleared concrete tank area.
- Install backpulse pumps and tank near the UV system.
- Install CIP pump and tank next to the existing CIP pump.
- Install chemical dosing equipment in existing chemical rooms.
- Install compressors and air receiving units in existing compressor room.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

Stage 2

- Decommission remaining ZW1000 trains.
- Demolish remaining two ZW1000 concrete tanks.
- Remove unused compressors and chemical pumps.
- Install additional pre-filtration strainer in cleared concrete area.
- Install additional permeate pump in cleared concrete area.
- Install Stage 2 MetaWater membrane unit(s) and equipment pad in the cleared concrete tank area.

- Remove ZW1000 CIP pump and tank.
- Remove ZW1000 backpulse pump and tank, relocate MetaWater backpulse pump and tank to cleared space.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

4.4 Cerafiltec Submerged Ceramic Membranes

An illustration of how the Cerafiltec system could be incorporated into the Arrow Creek WTP is provided in Figure 4-3 (Appendix B). The proposed Cerafiltec system consists of the following equipment:

4.4.1 Membrane Train

Cerafiltec membranes would be installed in four units, sized to produce 80 L/s each. Each unit is sized to fit within the footprint of the existing ZW1000 tanks, such that one ZW1000 unit could be removed and replaced with a Cerafiltec unit that has the same capacity. Modifications will be required for the existing tanks to accommodate new piping connections, and to change the tanks from discharging spent cleaning water waste via the overflows to via tank drains. The Cerafiltec system could be installed in four stages while maintaining 75% of the WTP's capacity during construction.

Cerafiltec recommends that each tank have at least 3.7 m of useable height in the tank and a tank height of 4.1 m. In comparison, the distance from the highest point on the tanks' sloped floor to the overflow is approximately 2.5 m, and 2.8 m to the top of the tank. The height of the existing membrane tanks would need to be raised to accommodate the Cerafiltec units.

A design weight per membrane unit when loaded was solids had not been provided at the time of this report, however there is less than 0.3 m of clearance available to lift an entire membrane unit from the tanks with the existing crane at its current elevation: the minimum tank height would be 4.1 m, each membrane unit is approximately 2.4 m tall, and the existing bridge crane has a useable clearance of 6.6 m from the floor of the tanks. The existing bridge crane is already at the greatest height that it can be installed within the existing building. At this stage it is therefore assumed that the existing bridge crane would require replacement with a different type of crane, such as monorail cranes, that provide slightly more clearance to lift the membrane units out of the tanks.

4.4.2 Pre-Treatment Strainers

The Cerafiltec system also requires pre-filtration straining to prolong the life of the membranes. In this case strainers with a maximum orifice size of 1,000 micron would be accepted. There is not enough room within the existing WTP to house strainers upstream of the membrane system. A new building or building extension is recommended.

Just like the ZW500 option the hydraulic gradeline of the WTP provides little allowance for headloss that can be incurred as water flows through the strainers on its way to the membrane tanks. The strainers will need to be kept clean and operated in a manner that minimizes headloss through the strainers, or alternatively booster pumps may be installed upstream of the strainers to ensure that there is enough water pressure to keep the membrane tanks full. The booster pumps could be installed next to the strainers in the WTP expansion, closer to the intake pipe.

The existing 500 micron Johnson screen installed at the intake could potentially meet Cerafiltec's pre-filtration requirements. However, given that the RDCK may periodically bypass the Johnson screen, for this assessment it has been assumed that 1,000 micron strainers would be installed as part of the upgrade options.

4.4.3 Permeate Pumps

Each membrane unit requires its own permeate pump downstream of the units. These pumps could be installed in the same location as the existing ZW1000 permeate pumps when replacing a given unit of ZW1000 membranes.

4.4.4 CIP System

Unlike the other membrane options, the Cerafiltec CIP system uses two separate CIP chemical preparation tanks instead of one, each approximately 9,000 L in size. Each CIP tank comes with a duty and standby “sprinkler pump” to deliver the chemical solutions to the membranes. In addition, a pair of water sprinkler pumps are required to pump water from the backwash tank to the membrane unit being cleaned. There is not enough space in the existing building to house the new CIP tank and pumps during Stage 1 of construction. It is recommended that a new building or a building extension be sized to house the CIP system.

Cerafiltec’s proposed CIP system is based on the assumption that the membranes will require both acid solution chemical washes and concentrated hypochlorite washes. However, the RDCK determined that acid solution washes did not noticeably improved performance of the existing ZW1000 system, and concluded that the existing membrane does not require acid solution washes. If the same was true for the Cerafiltec membranes, then only one new CIP solution tank, one set of chemical CIP pumps and one set of water pumps would be required in the membrane replacement. Discussion with Cerafiltec and verification pilot testing would be recommended if this option were to be further explored.

4.4.5 Backpulse System

The Cerafiltec system requires a backpulse holding tank and pair of backpulse pumps for hydraulic cleans of the membranes. Cerafiltec recommended that the backwash holding tank be sized to hold 140,000 L of filtered water, which is larger than the existing backpulse tank. It is recommended that the Cerafiltec backpulse tank be constructed in a separate building or extension to the WTP structure. The backpulse pumps could be installed in the existing building or in the WTP expansion.

4.4.6 Air Compressors and Blowers

The Cerafiltec system requires air compressors and blowers when fully built. It is believed that this equipment could be installed in the compressor room.

4.4.7 Dosing Chemicals

The Cerafiltec system will require chemical dosing units for sodium hypochlorite, sodium bisulphite, citric acid, hydrochloric acid and sodium hydroxide, for chemical cleaning and to neutralize the chemical cleaning waste afterwards. These dosing systems could be installed in the existing chemical rooms.

4.4.8 Summary

The recommended approach to replacing the existing ZW1000 with Cerafiltec units in two stages would involve the following steps:

Stage 1

- Decommission two ZW1000 units.
- Modify the emptied membrane tanks.
- Install Cerafiltec units in two of the membrane tanks.
- Replace two of the ZW1000 permeate pumps with two of the Cerafiltec pumps.
- Build a new building adjacent to the WTP or construct a building extension.
- Install pre-filtration strainers and booster pumps in the WTP expansion.
- Install two CIP chemical tanks, two sets of chemical “sprinkler” pumps, and one set of water “sprinkler” pumps in the WTP expansion.
- Build backpulse holding tank and install backpulse pumps in the WTP expansion.
- Install chemical dosing equipment in existing chemical rooms.
- Install compressors and air receiving units in existing compressor room.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

Stage 2

- Decommission remaining ZW1000 trains.
- Modify the emptied membrane tanks.
- Install two Cerafiltec units in the membrane tanks.
- Remove unused compressors and chemical pumps.
- Install additional pre-filtration strainer(s) and booster pump(s) in WTP expansion.
- Replace remaining ZW1000 permeate pumps with Cerafiltec permeate pumps.
- Remove ZW1000 CIP tank and pump.
- Remove ZW1000 backpulse tank and pumps.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

4.5 ZeeWeed 1000 Polymeric Membranes

Veolia discontinued the Version 2 ZW1000 system that is currently installed in the Arrow Creek WTP. These existing modules are also referred to as ZW1000-450 because the membrane modules have a typical surface area of 450 ft^2. This option would involve upgrading the membrane units such that they use the newer ZW1000-550 membranes, that have a surface area of 550 ft^2 per module. The newer ZW1000 system also uses a different approach to draining and aerating the membranes during cleaning processes, which Veolia claims improves membrane longevity.

An illustration of how the ZW1000-500 system could be incorporated into the Arrow Creek WTP is provided in Figure 4-4 (Appendix B). The proposed ZW500 system consists of the following equipment:

4.5.1 Membrane Train

The ZW1000-550 system would be provided as four membrane units, each train sized to fit into the existing membrane tanks. Instead of installing completely new membrane units, the ZW1000-550 upgrade has the option of refurbishing the existing cassettes and frame in the ZW1000-450 units to hold the ZW1000-550 membranes. It is assumed that the lower-cost refurbishment option would be used if the RDCK were to upgrade to the ZW1000-550 membranes.

The ZW1000 upgrade would also involve modifying the membrane tanks to allow spent cleaning waste to be discharged via tank drains, instead of the current configuration of discharging via tank overflows.

The RDCK has the option of upgrading one membrane unit and tank at a time which would allow the WTP to maintain 75% of its design capacity at all times, instead of 50%.

The design weight of a solids-loaded ZW1000-550 unit was estimated at 3,000 kg. The existing crane should be capable of lifting and moving the ZW1000-550 units when needed.

4.5.2 Pre-treatment Strainers

Veolia requires that water fed to the membranes be first pre-screened using a mesh, punched hole or disc filter type screen with openings no greater than 500 micron in size. Wedge wire screens, with their rectangular-shaped orifices that can more readily allow long and thin objects through the screen, would not be considered acceptable. Unlike the ZW500 option Veolia has not indicated that the Johnson screen at the WTP intake could potentially be used to satisfy this requirement. Regardless the incorporation of non-wedgewire 500 micron strainers into the WTP layout has been included as part of this upgrade option, to reflect that the RDCK may periodically need to bypass the Johnson screen.

The hydraulic gradeline of the WTP allows for very little additional headloss for water to flow through the strainers on its way to the membrane tanks. The strainers will need to be kept clean and operated in a manner that minimizes headloss through the strainers. Alternatively booster pumps may be needed upstream of the strainers to ensure there is enough water pressure to keep the membrane tanks full. The booster pumps could be installed next to the strainers or in separate housing closer to the intake pipe.

Strainers with the booster pumps may be able to fit in the space within the WTP reserved for a future UV system by modifying the route that raw water enters the WTP and travels to the membrane tanks. Alternatively the strainers could be placed in separate housing or a building extension.

4.5.3 Permeate Pumps

Veolia confirmed that the existing permeate pumps could be used for the new ZW1000 units. Therefore, replacement of the permeate pumps was not included as part of this upgrade option.

4.5.4 CIP System

It is assumed that the existing CIP tank and pump could also be used by the new ZW1000 units. Therefore, replacement of the CIP tank or pump was not included as part of this upgrade option.

4.5.5 Backpulse System

Veolia confirmed that the existing backpulse tank and pump could also be used by the new ZW1000 membrane system and would not need to be replaced as part of the upgrade.

4.5.6 Air Compressors and Blowers

It is believed that the existing compressors and blowers could also be used for the new ZW1000 units and would not need to be replaced as part of the upgrade.

4.5.7 Dosing Chemicals

The existing dosing chemical skids could be re-used by the new ZW1000 membranes, and therefore not require replacement as part of the upgrade.

4.5.8 Summary

For upgrading from the existing ZW1000-450 membranes to newer ZW1000-550 membranes, the majority of existing membrane supporting equipment could be re-used and would not require replacement until the equipment has reached the end of its useful life.

The recommended approach to replacing the ZW1000-450 membranes with new ZW1000-550 membranes involves the following steps:

Stage 1

- Decommission two ZW1000-450 units.
- Modify the emptied membrane tanks.
- Install two ZW1000-550 units.
- Install pre-filtration strainers and booster pumps in WTP, or install in WTP expansion.
- Miscellaneous mechanical, electrical and structural upgrades in existing WTP.

Stage 2

- Decommission remaining ZW1000-450 units.
- Modify the emptied membrane tanks.
- Install two ZW1000-550 units.
- Install additional pre-filtration strainer(s) and booster pump(s).
- Miscellaneous mechanical and electrical upgrades in existing WTP.

4.6 Summary

A summary of the equipment and activities required to replace the existing ZW1000 membrane system with a different membrane system in two stages is provided in Table 4-3.

Table 4-3 Summary of Membrane Upgrade Options

Membrane Option	No. Membrane Units	Plant Capacity During Construction	Pre-Filtration Needed?	Membrane Tank Modifications	Major Infrastructure Changes
ZW500	12	75%	Yes[1]	Raise overflow. Fill unused volume. Pipe connections.[2]	Housing expansion 3 x new concrete tanks. 6 x membrane units. 500 micron strainers and booster pumps.[1] 3 x permeate pumps. CIP tank and pumps. Replace building crane.
MetaWater	2 [3]	50%	Yes	Demolish	-
Cerafiltec	4	75%	Yes[1]	Raise overflow and height of tanks. Pipe connections.[2]	1,000 micron strainers and booster pumps.[1] 2 x CIP tanks. 4 x chemical sprinkler pumps. 2 x water sprinkler pumps. Backpulse tank and pumps. Replace building crane.
ZW1000-550	4	75%	Yes	Pipe connections[2]	Housing expansion [4]

Notes:
[1]The existing Johnson screen at the intake may remove the need for additional strainers and booster pumps if the screen is never bypassed.
[2]Reuse of the existing tanks will require modifications to fill in unused space and/or to accommodate different pipe connections to the tank for inlets, outlets, drains, and cleaning lines. In later stage of design the cost to upgrade the existing tanks should be compared to the cost of demolishing tanks and building new tanks in their place.
[3]Recommend splitting the two membrane units into four smaller units to improve the minimum capacity that can be maintained by the WTP if one membrane unit is offline.
[4]Strainers and booster pumps may fit in the existing building or can be housed in a WTP expansion.

5 MEDIA FILTRATION ASSESSMENT

5.1 Media Filtration Options

At the request of the RDCK, filtration options that do not involve membranes were identified and evaluated through a high-level screening process to determine what media filtration options may be viable for the Arrow Creek WTP site. The media filtration options considered were as follows:

- Conventional Treatment
- Conventional Treatment using Adsorption Clarifiers
- Direct Media Filtration
- Slow Sand Filtration
- Dissolved Air Flotation / Filtration
- Ballasted Clarification/ Filtration

5.1.1 Conventional Treatment

Conventional Treatment involves coagulation, flocculation, sedimentation, and media filtration to remove finer suspended and colloidal particles. It is based on the principle that particles tend to settle in water at a rate that increases with particle size and density. Coagulation is the addition of a chemical coagulant to the water to encourage suspended solids to floc together to form larger particles and, sometimes, greater densities. There are a variety of coagulants and flocculant aids of different properties, and bench-scale tests are required to estimate the optimum chemical doses to apply to the specific water conditions of each site, including seasonal variations in water temperature.

Flocculation follows, where the water is gently mixed at low energy to promote further aggregation and the formation of larger floc. The water then undergoes clarification, where the floc settles out of the water by gravity. The rate at which floc settles is enhanced by increasing particle size. The floc that collects at the bottom of the sedimentation basin is removed, while the clarified water is collected from the surface.

Filtration is typically used as the final particulate removal step. Media filtration involves passing water through a granular media bed, where particles are removed through contact with the media and other retained particles. The media bed usually consists of materials with varying grain sizes, such as crushed sand (quartzite) and anthracite, stacked to create varying pore spaces for the water to travel through. Conventional filtration is effective in treating high-turbidity water (>100 NTU).

Conventional Treatment systems typically require a large footprint due to the inclusion of separate components for coagulation, flocculation, and clarification. In some cases Conventional Treatment can be modified to replace flocculation and clarification with a single Adsorption Clarifier step, increasing efficiency and reducing space requirements. In an adsorption clarifier, coagulant is added as water enters from the bottom of the unit. As water flows upward, the media bed fluidizes, creating a vigorous mixing environment that encourages the formation of microflocs. These are then adsorbed by the granular media, typically buoyant plastic media, as water flows through it. Clarified water is collected at the top through a media retention screen into a trough. The system is periodically cleaned by flushing with water and air scouring to expand the media bed, eliminating the need for mechanical sludge removal.

Conventional Treatment using Adsorption Clarifiers (CTAC) are specially suitable for treating surface waters with low to moderate turbidity, iron, manganese, and color. The maximum turbidity that Adsorption Clarifiers can process is dependent on raw water quality and properties of the media used. Piloting would be recommended to confirm the performance limits of CTAC on removing turbidity. These high-rate clarifiers operate with loading rates of 19.5 to 25.5 m/h and have low retention times. Their key advantages include a small footprint, simple design, low maintenance, and reduced capital and operational costs.

5.1.2 Direct Media Filtration

Direct media filtration includes coagulation and flocculation prior to filtration without the intermediate step of clarification. Water undergoes coagulation and flocculation, then media filtration. This is typically used when the number of particulates to remove from the water is low enough that removing larger particles from the water through settling or flotation is unnecessary.

Direct media filtration has smaller footprint requirements and lower capital costs than conventional treatment, however direct filtration is only effective for lower raw water turbidity conditions (<15 NTU). If particulate levels are too high, the media can become clogged, leading to breakthrough into subsequent treatment stages. This process can also be challenging to control under rapidly changing conditions.

5.1.3 Slow Sand Filtration

Slow sand filtration is a process where water is filtered at low rates through a sand bed, allowing a biologically active layer, known as the *Schmutzdecke*, to form at the top. This layer, along with the sand beneath it, effectively removes turbidity, bacteria, and viruses, making the process suitable for treating low-turbidity raw water (< 10 NTU). The method is known for its simple design, construction, and operation, and it requires no power if gravity flow is available. Additionally, slow sand filtration generates little waste since backwashing is not required, resulting in lower lifecycle costs compared to rapid filtration.

However, the process does have some drawbacks. It requires a large footprint, and pre-treatment is necessary to reduce the frequency of *Schmutzdecke* scraping and sand replacement. Moreover, the efficiency of slow sand filtration decreases in cold temperatures due to reduced biological activity. UV is typically installed downstream of slow sand filters to offset periods where the *Schmutzdecke* is underperforming.

5.1.4 Dissolved Air Flotation / Filtration

Dissolved Air Flotation (DAF) is an alternative to traditional clarification, often used to remove low-density particles such as algae and fine suspended solids that have a tendency to float rather than settle. Instead of relying on the gravitational settling of floc, DAF introduces a cloud of “microbubbles” from the bottom of the basin, which rise to the surface. These bubbles attach to the flocculated particles, causing them to float to the top. The floating floc is then removed through skimming or an overflow design. Although DAF can be more complex and energy-intensive than conventional sedimentation, it provides efficient separation for specific water quality issues.

The DAF process is followed by a filtration step.

5.1.5 Ballasted Clarification/Filtration

Ballasted clarification, also known by the proprietary name Actiflo, is a high rate settling process that involves injecting heavy particles (microsand) into the raw water during flocculation/coagulation to enhance floc formation and accelerate clarification. Ballasted flocculation is typically highly effective for treating high-turbidity waters.

Ballasted clarification systems operate with very high surface loading rates, resulting in short detention times for flocculation and sedimentation. This enables ballasted systems to have smaller spatial footprints compared to conventional systems and allows for rapid adjustment to changes in influent quality. However, the process has some drawbacks, including higher operational costs due to the need for precise chemical mixture concentrations and the requirement for ballast addition.

This method produces a more dilute but consistent waste stream compared to traditional coagulation, flocculation, and clarification processes. The waste stream from ballasted clarification contains settled solids along with low levels of coagulant, polymer, and microsand. Most of the microsand is recycled by removing it from the settled sludge via hydrocyclones, then re-injected at the head of the plant.

The ballasted flocculation process is followed by a filtration step, similar to conventional treatment methods.

5.2 Raw Water Compatability Review

Raw water quality data for Arrow Creek was reviewed to determine whether or not characteristics of the incoming water are compatible with the media-based filtration options being considered. Where not compatible, those filtration options were rejected from further consideration in this assessment.

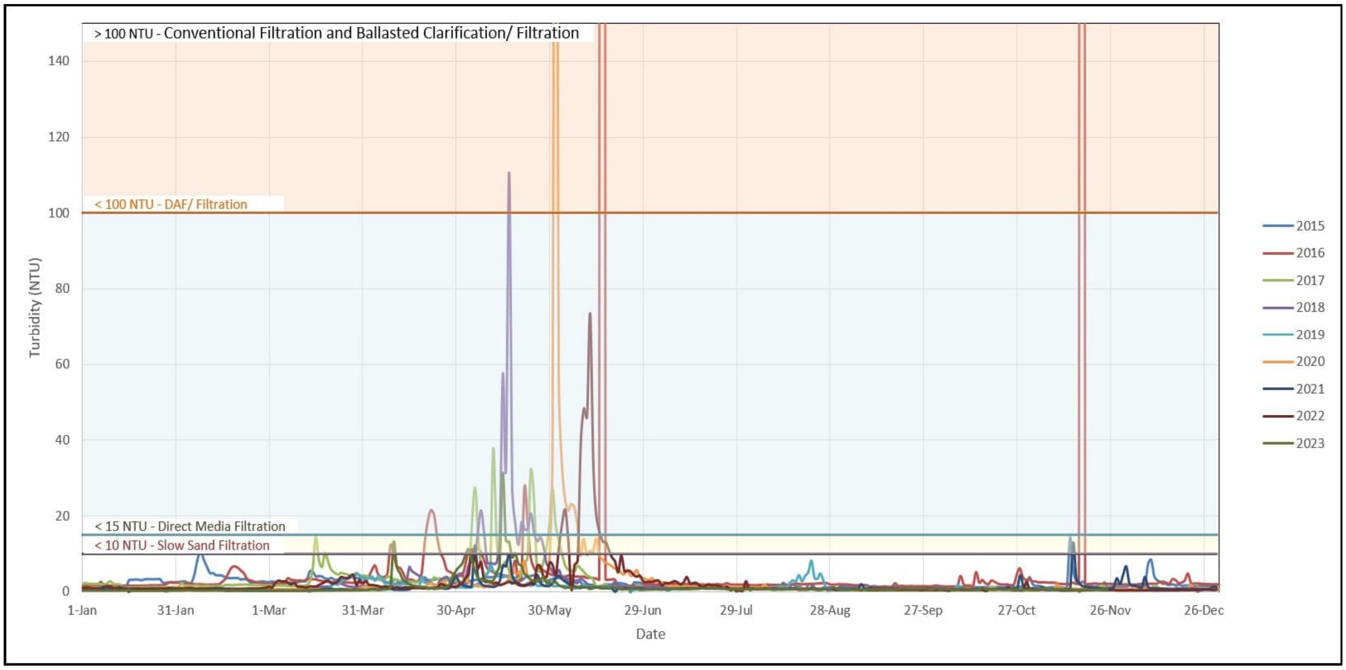
5.2.1 Turbidity Variation in Raw Water

Among the many water quality parameters, turbidity is the primary parameter of concern for designing of most suitable filtration option for a water treatment plant. Turbidity treatment processes aim to remove particulates, ending with a filtration step where suspended particles are either adsorbed or physically filtered out of the treated water.

The selection of filtration processes at water treatment plants largely depends on the range of turbidity levels in source water that need to be treated. Generally, processes capable of handling higher turbidity levels involve higher capital and operating costs compared to those designed for lower turbidity levels. Water treatment guidelines such as the Ministry of Health “Design Guidelines for Drinking Water Systems in British Columbia” (2023) provide recommended upper turbidity limits for different filtration processes, above which filtration is anticipated to not be as effective.

These recommended upper thresholds are contrasted in Figure 5-1 to historical turbidity levels recorded at the Arrow Creek WTP from 2015 to 2023, as measured by the raw water online turbidimeter located immediately upstream of the membrane units in the treatment plant.

Figure 5-1 Raw Water Turbidity (2015-2023)



The plot in Figure 5-1 illustrates that turbidity levels in the raw water source are typically less than 20 NTU, often less than 10 NTU, with periodic spikes throughout the year. The largest turbidity spike events tend to occur between April and June during spring freshet, though a significant turbidity event was also observed in November 2016.

Based on the 2015-2023 turbidity data, the percentage of the year where raw water turbidity exceeded the upper thresholds for each of the media filtration options is listed in Table 5-1.

Table 5-1 Percentage of Turbidity Level Exceed the Maximum Allowable Turbidity

Process	Maximum Turbidity (NTU)	% Exceedances of Maximum Turbidity (days per year)								
		2015	2016	2017	2018	2019	2020	2021	2022	2023
Slow sand filtration	10	0.6% (2 days)	4.2% (15 days)	3.7% (13 days)	5.2% (18 days)	0.0% (0 days)	3.6% (13 days)	0.6% (2 days)	3.9% (14 days)	1.8% (6 days)
Direct media filtration	15	0.0% (0 days)	2.0% (7 days)	2.2% (8 days)	4.0% (14 days)	0.0% (0 days)	2.5% (9 days)	0.0% (0 days)	2.2% (8 days)	0.3% (1 day)
DAF / Filtration	100	0.0% (0 days)	0.6% (2 days)	0.0% (0 days)	0.3% (1 day)	0.0% (0 days)	0.3% (1 day)	0.0% (0 days)	0.0% (0 days)	0.0% (0 days)
Ballasted Flocculati	>100	-	-	-	-	-	-	-	-	-

Process	Maximum Turbidity (NTU)	% Exceedances of Maximum Turbidity (days per year)								
		2015	2016	2017	2018	2019	2020	2021	2022	2023
on/ Filtration										
Conventional Filtration	>100 [1]	-	-	-	-	-	-	-	-	-

Notes:
[1] Upper turbidity limits for CTAC recommended to be determined via piloting.

Turbidity levels exceeding 10 NTU were recorded at least once each year, except in 2019, and surpassed 15 NTU at least once in six of the nine years monitored. Four turbidity spikes exceeding 100 NTU, lasting one day each, were documented within the nine-year monitoring period.

It may be possible to decrease the severity of the turbidity spikes through optimizing the performance of the settling ponds, and further study is recommended to test optimization options. At this time, though, based on turbidity spikes exceeding upper treatment limits for several days almost every year for some treatment options, it is recommended that slow sand filtration and direct media filtration be discarded from the media-based treatment options being considered to treat water at all times from Arrow Creek.

5.2.2 Other Water Quality Parameters

The historical ranges for other water quality parameters was presented in Table 4-1. Anecdotally the RDCK operations staff have also stated that they have not experienced an issue with algae formation

The water quality data listed Table 4-1 meets current BC drinking water standards, with the exception of pH which has occasionally dipped below the Operational Guideline of 7.0-10.5. This lower pH is not anticipated to have a direct impact on the safety or aesthetics of the drinking water, but may create an aggressive water environment that encourages corrosion of distribution piping and plumbing appurtenances over time. pH and alkalinity adjustment chemicals such as sodium hydroxide or sodium carbonate are commonly used to reduce corrosion potential.

A drinking water target for organic materials has not been established in BC, but organic concentrations in surface water are commonly used as an indicator of the potential for disinfection byproducts to form during treatment. From the single water sample where total organic carbon (TOC) and dissolved organic carbon (DOC) were measured, TOC and DOC concentrations were low relative to typical surface water sources. With just one measurement available, however, it cannot be determined whether organic concentrations are low year-round or whether they vary seasonally, and it is recommended that additional sampling for TOC and DOC be conducted to develop a seasonal profile of these parameters.

In terms of the impact of raw water parameters on the performance of media filtration, none of the water quality parameters listed in Table 4-1 show an incompatibility with the media filtration options that would rule out their suitability at the Arrow Creek WTP. However, if there is not a significant presence of organic material or algae in Arrow Creek the DAF option does not present an advantage over Conventional Filtration, while in comparison DAF is more sensitive to changes in incoming water quality than Conventional Filtration. Therefore, it is recommended that DAF be discarded as an option for Arrow Creek in favour of Conventional Filtration or CTAC.

5.3 Conceptual level sizing

The following options were examined to determine their onsite footprint requirements:

- Conventional Treatment
- Conventional Treatment using Adsorption Clarifiers (CTAC)
- Ballasted Clarification/ Filtration

5.3.1 Sizing of Treatment Equipment

A conceptual layout was developed for each option to estimate their required dimensions and overall footprint at the plant. Sizing of the Conventional Filtration option was based on Associated's experience with these processes and on BC and North American waterworks design guidelines for typical loading rates, retention times, and dimensions. Sizing for the CTAC options was based on proposals provide by two suppliers (AWC and WesTech). The Ballasted Clarification/Filtration system uses Veolia's Actiflo package systems (ACP2-45 Model) as pretreatment, followed by a set of gravity media filtration tanks, sized using BC and North American design guidelines.

All three options include downstream low-lift pumps to deliver treated water to the distribution system, and a new clearwell with backwash pumps to periodically clean the filtration media. It is believed that the low-lift and backwash pumps could be housed inside the existing WTP.

The design criteria and assumptions used to develop process sizing are provided in Table 5-2, and the sizing of each treatment step for the filtration options is provide in Table 5-3.

Table 5-2 Treatment Process Design Criteria

Conventional Filtration	CTAC	Ballasted clarification/Filtration
Mechanical Flash Mixing Tank: • 20 s mixing time in the tank • 3 tanks in parallel • Assumed 3.2 m depth of tank • No redundant tanks Vertical Shaft Rectangular Flocculator: • 30 minute detention time • 3-stage flocculation in series • 3 tanks in parallel • Assumed 3.2 m depth of tank • Tube settler module angle installed at 60^0 • Average floc settling velocity assumed 0.00025 m/s • No redundant flocculators Sedimentation Tank with high-rate Tube Settlers: • 30 minute detention time	Static Mixing Tank: • Injected with coagulant and polymer and mixed using a flash mixer Adsorption Clarifier: • 22.3 m/h hydraulic loading rate • No mechanical flocculator • No redundant AC unit [1] • Water flush rate is 88.3 L/s for 10 minutes per AC unit • Air flush rate is 807 m^3/h Gravity Media Filter: • Filtration rate 15 m/h. • Assumed 3.3 m tank width. • No redundant gravity filtration units. [1] • 4 filter tanks in parallel.	Actiflo system: • Include two coagulation tanks, flocculation tanks with Turbomix and Settling tanks with Lamella plates (tanks in parallel) • Feed water temperature in 0.1-25^0C range Gravity Media Filter: • Filtration rate 15 m/h • Assumed 3.3 m tank width • No redundant gravity filtration units [1] • 4 filter tanks in parallel • Effective size of sand in filter media 0.45 mm with 40% porosity • Effective size of anthracite 1.1 mm with 50% porosity

Conventional Filtration	CTAC	Ballasted clarification/Filtration
• 3 tanks in parallel • Assumed 3.2 m depth of tank • Assumed 4.5 m tank width • No redundant tanks Gravity Media Filter: • Filtration rate 15 m/h • Assumed 3.3 m tank width • No redundant gravity filtration units [1] • 4 filter tanks in parallel • Effective size of sand in filter media 0.45 mm with 40% porosity • Effective size of anthracite 1.1 mm with 50% porosity • Average feed water temperature 15^{0}C • Backwash involves 7 minutes of low-rate backwash and 5 minutes of high-rate backwash per filter • Low-rate backwash water loading rate 88.3 L/s • High-rate backwash water loading rate 265 L/s Clearwell: • Designed to contain three filter backwash volumes • Assumed clearwell tank height 4 m • Lowlift and backwash pumps installed inside the existing WTP.	• Effective size of sand in filter media 0.45 mm with 40% porosity. • Effective size of anthracite 1.1 mm with 50% porosity. • Average feed water temperature 15^{0}C. [2] • Backwash involves seven minutes of low-rate backwash and five minutes of high-rate backwash per filter. • Low-rate backwash water loading rate 88.3 L/s. • High-rate backwash water loading rate 265 L/s. Clearwell: • Designed to contain 3 filter backwash volumes • Assumed clearwell tank height 4 m • Lowlift and backwash pumps installed inside the existing WTP.	• Average feed water temperature 15^{0}C • Backwash involves 7 minutes of low-rate backwash and 5 minutes of high-rate backwash per filter • Low-rate backwash water loading rate 88.3 L/s • High-rate backwash water loading rate 265 L/s Clearwell: • Designed to contain 3 filter backwash volumes. • Assumed clearwell tank height 4 m • Lowlift and backwash pumps installed inside the existing WTP. •

Notes: [1] – Redundant clarification and filtration tanks are recommended as standard best practice for drinking water treatment facilities, to allow the WTP to run at full capacity while one unit is offline for maintenance or for cleaning activities. However, as the existing ZW100-450 membrane system in the WTP does not include redundancy, for a fair comparison redundant clarification and filtration units have not been included in this assessment of media-based options.

[2] – Water temperatures lower than 15ºC will slow particulate removal rates, but will be offset by lower water demands and required capacity in the WTP.

Table 5-3 Assumed sizing for media filtration options

		Length (m)	Width (m)	Surface Area per unit (m^2)	No of Units	Footprint (m^2)	Total Footprint required (m^2)
Conventional Filtration	Mechanical Flash Mixing Tanks	0.8	0.8	0.7	3	2	473
	Vertical Shaft Rectangular Flocculators	14.1	4.5	63.5	3	190	
	Sedimentation Tanks with high-rate Tube Settlers	22.3	4.5	100.3	2	201	
	Media Filter Tanks	8.1	3.3	26.7	3	80	
CTAC	Coagulation and Adsorption Clarifier Tanks	5	3.6	18.0	4	72	156
	Media Filter Tanks	7.1	3.6	25.6	4	102	
Ballasted clarification/Filtration	Actiflo package system	9.5	3.6	34.2	2	68	149
	Media Filter Tanks	8.1	3.3	26.7	3	80	

Notes:
Dimensions in this table do not include spacing for walkways and access stairs to the top of the tanks.
Footprint estimates in this table do not include the size of clearwells detailed in the next Section of this document.

5.3.2 Sizing of Treated Water Clearwell

A treated water clearwell is recommended downstream of the WTP to supply water for backwashes of the media filters. The Adsorption Clarifiers also require periodic cleaning in the form of forward rinses using raw water, but do not require treated water from the clearwell for their maintenance. Table 5-4 lists the proposed dimensions for the treated water clearwell designed for the Conventional Treatment, Ballasted Clarification/Filtration and CTAC options, sized to hold the required volume of three filter backwashes.

Table 5-4 Assumed sizing Treated Water Clearwell for Media Filtration Options

No. Backwashes	Volume required (m^3)	Depth (m)	Diameter (m)	Surface Area (m^2)
3	349.8	4	10.6	87.5

5.3.3 Footprint Impacts on WTP Site

Figure 5-2 illustrates the plant layout with the Conventional Filtration system, showing the relative footprint Conventional Treatment would require relative to the existing WTP. Figure 5-3 shows the change in Conventional Filtration's size if using Adsorption Clarifiers, and Figure 5-4 shows the more compact arrangement with the Ballasted Clarification/Filtration system,

Figure 5-2 Plant layout with Conventional Filtration system

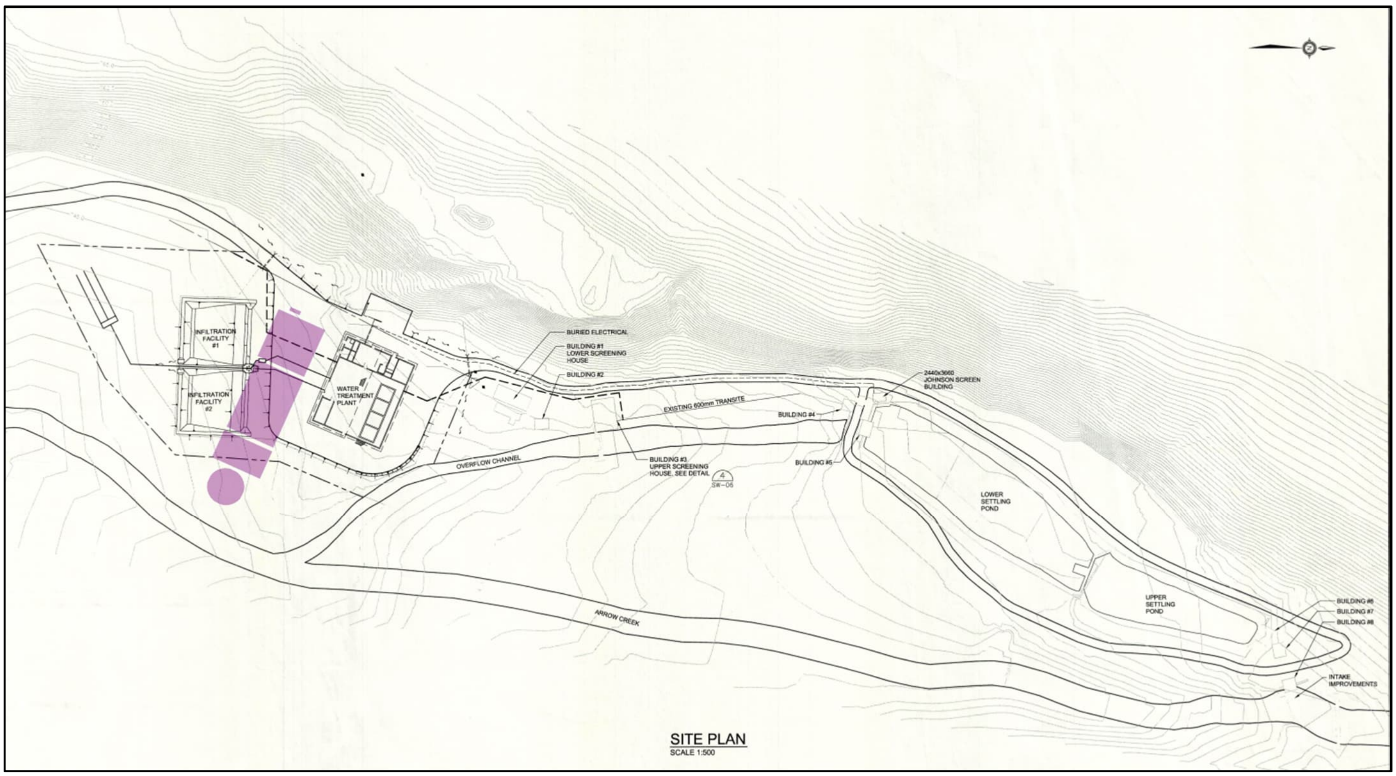


Figure 5-3 Plant layout with Conventional Filtration with Adsorption Clarifier

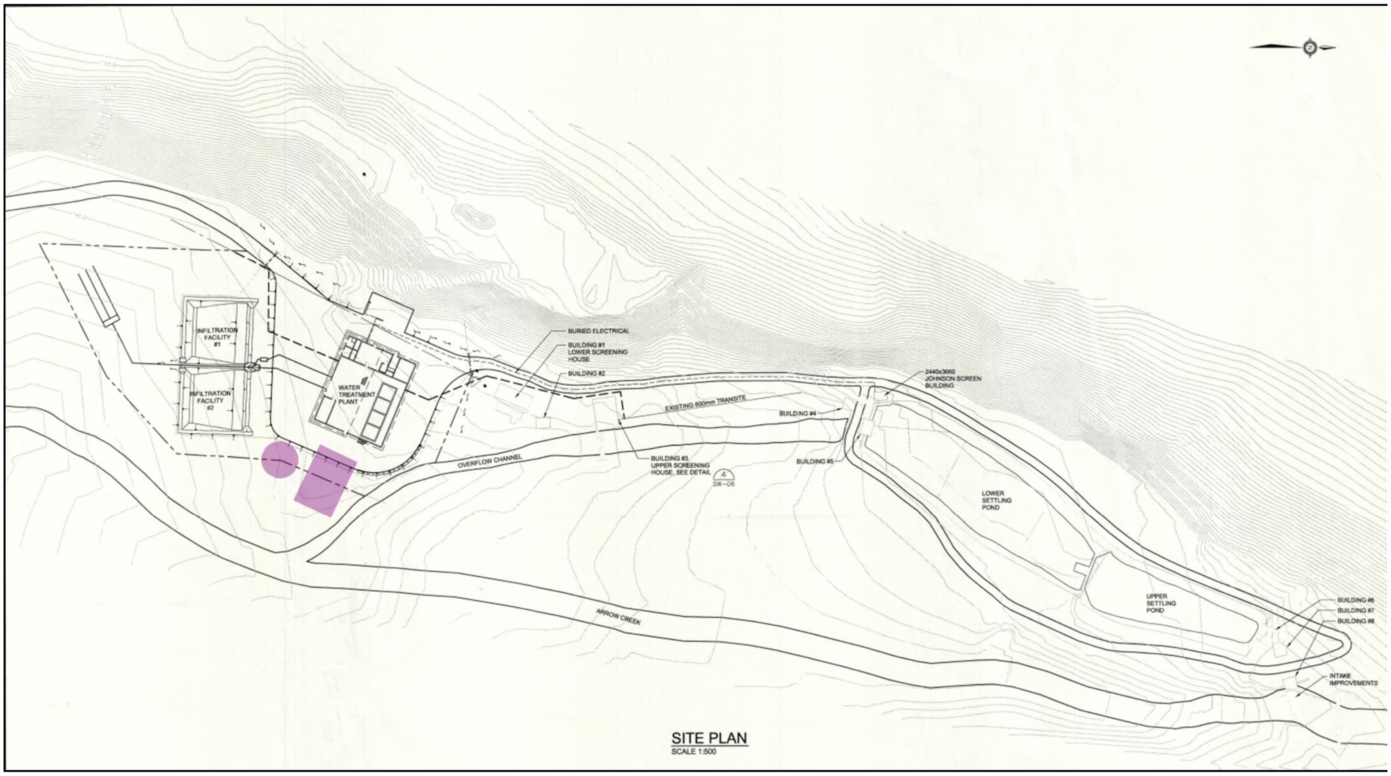
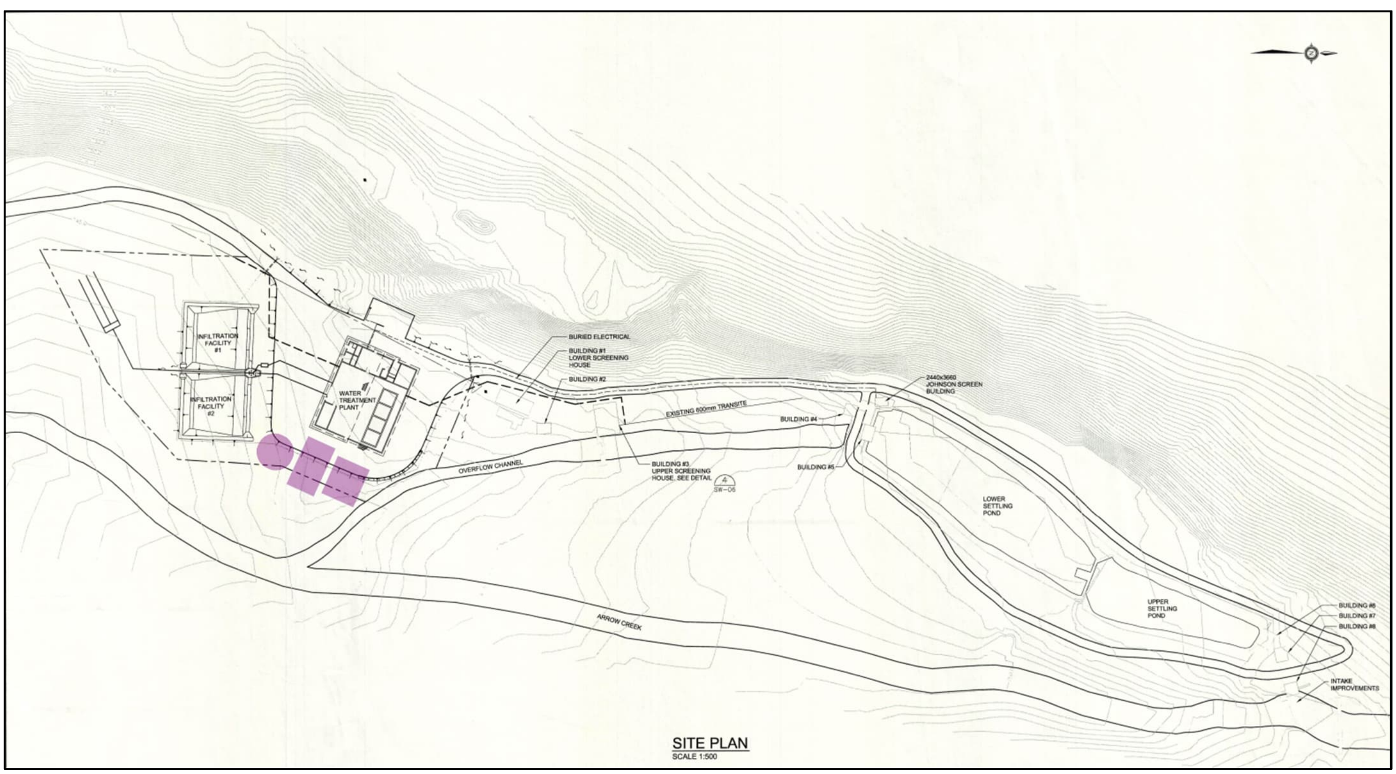


Figure 5-4 Plant layout with Ballasted Clarification/Filtration system



The Conventional Treatment Option requires a large footprint for its infrastructure and would require the relocation of the existing lagoon system or to be located downhill from the existing WTP site. In comparison the Conventional Treatment with Adsorption Clarifiers, and the Ballasted Clarification options have smaller footprints that, while larger than membrane footprint requirements, could likely be retrofitted into the existing WTP site.

Based on the difficulty in fitting the treatment option on site it is recommended that Conventional Treatment be discarded as an option for the Arrow Creek WTP.

5.3.4 Media Filtration Summary

Upon completing a high-level assessment of multiple media filtration upgrade options, the following options were identified as potentially suitable options for the Arrow Creek WTP:

- CTAC
- Ballasted Clarification and Filtration

Of these two options, the RDCK has expressed concern over the following aspects of Ballasted Clarification/Flocculation:

- Inefficiency of microsand system during the more common periods of low turbidity in raw water.
- Volume of waste residuals generated.
- Potential complexity of the treatment system, including the microsand recovery process.

Therefore, it is recommended that CTAC be short-listed as a potential media filtration option for the Arrow Creek WTP, for further consideration.

6 FILTRATION OPTIONS SHORT-LIST

Upon consultation with RDCK, the recommended short-list of filtration options to conduct the next level of analysis for the Arrow Creek WTP is as follows:

- MetaWater pressurized ceramic membranes.
- ZW1000-550 submerged polymeric membranes.
- Convention media filtration using an Adsorbent Clarifier (CTAC).

These options provide a lower amount of modifications to the existing WTP building and site in comparison to their equivalent counterparts, are anticipated to maintain their filtration objectives under the different raw water conditions typically seen throughout the year, and with an operational complexity similar to, or less than, the complexity of the existing membrane system.

6.1 Hydraulic Requirements

The preferable hydraulic configuration for an upgrade to the Arrow Creek WTP would involve water being gravity driven through any pre-treatment and media filtration. Water leaving the filters would then travel through booster pumps to match the hydraulic gradeline required for the distribution system, as well as to pump water to an onsite clearwell for filter backwashing.

According to the WTP's record drawings, water entering at 320 L/s has 3.8 - 5.0 m of totally dynamic hydraulic head (5 – 7 psi) available to drive through any filtration processes via gravity alone. The amount of headloss anticipated to occur in a CTAC system running at 320 L/s would be between 5.6 and 9.0 m of total dynamic head (8 – 13 psi).

There is insufficient hydraulic pressure to allow complete gravity flow through an Adsorption Clarifier system if installed at the same elevation as the existing WTP. To drive water through Adsorption Clarifiers it is recommended that the new treatment system be installed at a lower elevation, or that process pumps be added at the head of the WTP to pump water through the filtration system. Because the CTAC system uses open-to-atmosphere tanks, low-lift pumps would also be installed downstream of the media filters to boost water pressure up to distribution system requirements.

As addressed in Section 4, it is anticipated that there is sufficient gravity pressure for water to flow to the MetaWater membrane feed pumps, which will drive water through the strainers and membranes, and with enough surplus pressure to meet distribution system requirements.

Feed pumps may be required for the ZW1000-550 option to drive water through pre-membrane strainers to the membrane tanks. Permeate pumps would still be required downstream of the membrane tanks to bring water pressure back up to distribution system requirements.

6.2 Residuals Generation

Operating of the filtration systems will generate residuals requiring disposal: the membrane options will generate hydraulic cleaning waste, as well as chemical cleaning waste that will be chemically neutralized before disposal. CTAC require forward washes of the Adsorption Clarifiers and backwashes followed by forward rinsing of the media filters. Estimates on the waste generated, and the design assumptions used to calculate residuals volumes, is provided in Table 6-1.

Table 6-1 Residuals Generation Estimates

Option	MetaWater Pressurized Ceramic Membranes	ZW1000-550 Submerged Polymeric Membranes	CTAC
Design Assumptions	• Average 100 L/s flowrate • 98% recovery	• Average 100 L/s flowrate • 95% recovery	• Daily cleanings of the Adsorption Clarifiers and media filters • AC forward rinsing (88 L/s for 10 minutes per tank; can use raw water for this step) • Filter backwashing consisting of low-rate backwash (88 L/s for 7 minutes per tank), high-rate backwash (265 L/s for 5 minutes per tank) , and forward rinsing (88 L/s for 5 minutes per tank).
Daily Residuals Generation (m^3)	173	432	780 (to clean 4 tanks)

An assessment has not been done on how effectively the lagoon system currently processes residuals from the existing ZW1000-450 system. However, it is assumed that the lagoon is currently performing as intended, and therefore upgrades to the lagoon would not be needed for the MetaWater or ZW1000-550 options. In contrast it is assumed that the existing lagoon would require expansion to process the higher rate of residuals generated by the Conventional Treatment/Adsorption Clarifier Option. An allowance to expand the lagoon system is recommended when considering the media filtration option.

6.3 Cost Estimates

A Class "D" Opinion of Probable Costs (Cost Estimate) was developed for the installation of the short-listed filtration options at the Arrow Creek WTP site. The design assumptions used to develop the cost estimated are summarized in Table 6-2. The capital cost estimates for each treatment filtration option, and a 20-year lifecycle estimate, are provided in Table 6-3.

Table 6-2 Cost Estimate Assumptions

Options	Design Assumptions
All options	• Cost estimates based on upgrading the filtration system in a single stage. • Filtration sized for 320 L/s maximum capacity and future daily average capacity of 100 L/s. • Membrane systems include chemical systems to neutralize waste from chemical cleanings. • Includes $100,000 allowance for BC Hydro service upgrades, if required. • Does not include any costs for upsizing or upgrading the residuals-receiving lagoon, if required. • Chemical costs do not include chemicals (sodium hypochlorite) used for existing disinfection system downstream of filtration system. • Average power rate of $0.15 / kWh. • Annual costs include 1% of mechanical and electrical costs, and 0.2% of structural (housing and concrete formwork) costs for miscellaneous maintenance and replacement parts. • Used 4% Annual Discount Rate for present value of lifecycle costs.
MetaWater Membranes	• Assumed 20 hours of operator time on site each week at a rate of $75/hr for the membrane system. Does not include operator time for other equipment and duties on site. • Chemical consumption costs based on weekly hypochlorite cleanings and monthly acid/hypochlorite cleanings. • Replace membranes every 20 years. Note that the lifespan of these membranes at other WTPs have generally exceeded 20 years. • Replace feed pumps, permeate pumps, compressors and blowers every 15 years. • Replace chemical pumps every ten years.
ZW1000-550 Membranes	• Assumed that the majority of existing equipment could be reused and does not include costs for new pumps, compressors, or tanks in the capital estimates. • Assumed 20 hours of operator time on site each week at a rate of $75/hr for the membrane system. Does not include operator time for other equipment and duties on site.

Options	Design Assumptions
	• Assumed that the existing permeate pumps, CIP and backpulse tanks and pumps, compressors and chemical systems can be used by the ZW1000-550 system and would not require replacement. • Chemical consumption costs based on weekly hypochlorite cleanings and monthly acid/hypochlorite cleanings. • Includes costs for feed pumps and strainers upstream of membranes, in new housing. • Replace membranes every eight years. • Replace permeate pumps, compressors and blowers every 15 years. • Replace chemical pumps every ten years.
CTAC	• Clearwell sized to hold three consecutive backwashes. Clearwell size could potentially be reduced if the timing of each backwash is far enough apart for the clearwell to adequately refill. • Assumed 20 hours of operator time on site each week at a rate of $75/hr for the CTAC system. Does not include operator time for other equipment and duties on site. • Design criteria used to size CTAC system listed in Table 5-2. • Assumed pretreatment doses of 30 mg/L coagulant and 1 mg/L of filter aid. • Includes costs for feed pumps upstream of Adsorption Clarifiers. • Includes allowance for expanding the residuals lagoon system. • Replace media every 20 years. • Replace compressors every 15 years. • Replace chemical pumps every ten years.

Table 6-3 Opinions of Probable Cost

Option	MetaWater Pressurized Ceramic Membranes	ZW1000-550 Submerged Polymeric Membranes	CTAC
Capital Costs			
Treatment Equipment [1]	$5.5 m	$2.8 m	$4.5 m
Vendor Allowance [2]	$0.6 m	$0.4 m	$0.2 m
Supporting Equipment [3]	$0.7 m	$0.7 m	$0.3 m
Demolition [4]	$0.1 m	$0.1 m	$0.1 m
Additional Housing	-	$0.1 m	$1.6 m
Labour Costs	$0.3 m	$0.3 m	$0.3 m
New Clearwell	-	-	$0.9 m
Expanded Lagoon Allowance	-	-	$0.4 m
BCH Allowance	$0.1 m	$0.1 m	$0.1 m
Contractor Mark-up and Overhead (20%)	$1.4 m	$0.9 m	$1.6 m
Subtotal	$8.6 m	$5.5 m	$9.9 m

Option	MetaWater Pressurized Ceramic Membranes	ZW1000-550 Submerged Polymeric Membranes	CTAC
Engineering and Contingency (35%)	$3.0 m	$1.9 m	$3.5 m
Total	$11.6 m	$7.4 m	$13.4 m
Annual Costs			
Annual Labour Costs Annual Chemical Costs Annual Power Costs [5] Misc. Spare Parts	$78,000 $25,000 $13,000 $65,000	$78,000 $25,000 $26,000 $38,000	$78,000 $193,000 $22,000 $51,000
Total Annual Costs	$181,000 /year	$167,000 /year	$344,000 /year
Lifecycle Costs (Present Value in 2024 Dollars)	$16.8 m	$13.5 m	$19.8 m

Notes:
1 – Cost as quoted by filtration system vendor.
2 - Vendor Allowance is the anticipated cost for remote and on-site support from vendor during installation, start-up, training, and troubleshooting.
3 – Supporting Equipment covers cost of equipment not included in the vendor-provided quotes. Includes chemical neutralizing equipment, feed pumps, strainers and piping for MetaWater option; strainers, feed pumpsand piping for ZW1000; feed pumps and piping for CTAC.
4 – Includes demolition of structural (concrete) infrastructure as well as the decommissioning or removal of existing equipment and process piping.
5 – Power costs for pre-treatment and filtration equipment only, and does not include power consumption for other existing equipment in the WTP.

With the smallest amount of new equipment required, upgrading with the ZW1000-550 system has the lowest anticipated capital and 20-year lifecycle costs. In contrast, CTAC had the highest anticipated capital and lifecycle costs.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Membrane Filtration

The following membrane replacement options were reviewed for the Arrow Creek WTP:

- Submerged, reinforced polymeric membranes (ZW500).
- Pressurized ceramic membranes (MetaWater).
- Submerged ceramic membranes (Cerafiltec).
- Submerged polymeric membranes (ZW1000-550).

The assessment of these options considered the following factors:

- Their proven track record at other similar installations in North America.
- The ability to install the membranes without requiring significant changes to the existing infrastructure.

Constructability plans were developed for each option that would allow the WTP to be upgraded in stages, such that the plant would always be able to maintain at least 50% capacity during construction.

The results of this assessment can be summarized as follows:

ZW500

- Has been successfully used at similar installations across North America.
- This option would require two additional membrane tanks to be built.
- This upgrade would require an additional building or a building extension to house the new membrane tanks, pre-filtration strainers and raw water booster pumps.
- The existing crane system would require upgrading.

MetaWater

- Only one drinking water facility in North America currently in operation, and a second is currently being built.
- The upgrade could fit in the existing building.
- The existing membrane tanks would need to be demolished as part of the upgrade.

Cerafiltec

- No drinking water facilities currently in North America. One wastewater reclamation plant in North America was identified.
- This upgrade would require an additional building or building extension to house the pre-filtration strainers and raw water booster pumps, as well as the tanks and pumps required for the membrane hydraulic and chemical cleaning equipment.
- The existing crane system would require upgrading.

ZW1000 – 550

- The newer version of the ZW1000 membranes (ZW1000-550) have been used in multiple WTPs across North America, though no examples could be identified where Version 2 of the ZW1000 membranes (ZW1000-450) were replaced with the ZW1000-550 and as a result saw a significant reduction in fibre breakage.
- This upgrade may require an additional building or building extension to house the pre-filtration strainers and raw water booster pumps.

7.2 Media Filtration

The following non-membrane filtration options were considered for the Arrow Creek site:

- Conventional Treatment
  - With flocculator and sedimentation tanks
  - With Adsorption Clarifiers or roughing filters (CTAC)
- Direct Media Filtration
- Slow Sand Filtration
- Dissolved Air Flotation / Filtration (DAF)
- Ballasted Clarification / Filtration

The results of this assessment are summarized in Table 7-1.

Table 7-1 Summary of Non-Membrane Filtration Options

Treatment Description	Raw Water Quality Compatability	Footprint of Treatment Tankage (m^2)	Hydraulic Considerations	Recommendation
Conventional Treatment	No issues.	600 [1]	Can gravity flow through treatment.	Not recommended due to footprint.
CTAC	Piloting recommended to confirm upper turbidity limit that can be treated.	218 [1]	Upstream feed pumps required or filters to be installed at lower elevation than WTP	Recommended for further consideration.
Direct Media Filtration	Not reliable for turbidity spikes > 15 NTU	-	-	Not recommended due to compatibility with turbidity spikes.
Slow Sand Filtration	Not reliable for turbidity spikes > 10 NTU	-	-	Not recommended due to compatibility with turbidity spikes.
Dissolved Air Flotation	Not reliable for turbidity spikes > 100 NTU	-	-	Not recommended due to compatibility with turbidity spikes and footprint.
Ballasted Clarification	No issues during turbidity spikes. Optimization required during low-turbidity periods.	210 [2]	-	Not recommended over concerns of microsand recovery during common periods of low-turbidity, volume of residuals generated, and operational complexity.

Notes:

[1] Does not include footprint for treated water clearwell / backwash supply tank, approximately 11 m in diameter.

[2] Typical footprint requirements not calculated for filtration options that cannot reliably treat during turbidity spike events.

7.3 Filtration Option Short-List

From the filtration options identified, the following three were selected for further assessment:

- Metawater pressurized ceramic membranes
- ZW1000-550 submerged polymeric membranes
- Conventional Treatment with Adsorption Clarifiers

Pumping will be required for water to travel through treatment and to reach the distribution system at the water pressures required, as follows:

- Metawater:
  - Feed pumps upstream of the new strainers and membranes.
- ZW1000-550:
  - Feed pumps upstream of the new strainers and membrane tanks; and
  - Permeate pumps downstream of the membrane tanks.
- Conventional Treatment:
  - Feed pumps upstream of the Adsorption Clarifiers
  - Low-lift pumps downstream of the media filters

The filtration processes generate residuals that must be discharged as waste. The average amount of residuals generated by each of the options, based on an average 100 L/s treatment flowrate, would be as follows:

- Metawater: 173 m^3 /day
- ZW1000-550: 432 m^3 /day
- Conventional Treatment: 780 m^3 /day

Class "D" Opinions of Probable Cost were developed for the capital costs and 20-year lifecycle costs of each option, as summarized in Table 7-2.

Table 7-2 Opinions of Probable Cost Summary

Option	MetaWater Pressurized Ceramic Membranes	ZW1000-550 Submerged Polymeric Membranes	CTAC
Capital Cost	$11.6 m	$7.4 m	$13.4 m
Annual Costs (at 100 L/s average)	$181,000 / year	$167,000 / year	$344,000 /year
20-year Lifecycle Cost	$16.8 m	$13.5 m	$19.8 m

7.4 Recommendations

Based on the high capital and lifecycle costs of the CTAC option, and the large amount of new infrastructure that would need to be built outside of the existing WTP, it is recommended that CTAC be discarded as an upgrade option for the Arrow Creek WTP.

It is recommended that upgrading the existing ZW1000-450 membrane system be upgraded with either ZW1000-550 submerged polymeric membranes or with Metawater pressurized ceramic membranes.

The ZW1000-550 option has the lowest anticipated capital and lifecycle costs, but it could not be determined at this time whether these membranes would experience fibre breakage as frequently as their older ZW1000-450 counterparts. If the ZW1000-550 membranes require replacement every five years, instead of every eight years, the lifecycle costs for ZW1000-550 would increase from $13.5m to $16.5 m, roughly equal to the lifecycle costs for the Metawater option.

The Metawater ceramic membranes had the next lowest capital and lifecycle costs, and are reputed to be more resilient to physical stress than polymeric membranes. However, their use in North American drinking water facilities has been limited and their performance in treating Arrow Creek water specifically should be confirmed.

It is recommended that assessment of these two membrane options continue to address these uncertainties, with next steps as listed below.

7.4.1 Filtration Exemption

It is Associated's understanding that the RDCK is currently reviewing with Interior Health the feasibility getting approval for Filtration Exemption at the Arrow Creek site. If approved, the primary objectives for treatment upgrades at the WTP would shift from improving pathogen removal via filtration to maximizing the performance of the disinfection processes.

It is recommended that the RDCK confirm with Interior Health whether or not they can pursue an application for Filtration Exemption before proceeding with modifications of their existing filtration processes.

7.4.2 Piloting

It is recommended that performance and resilience of the ceramic membrane option be piloted at reduced scale for a period that represents both the turbidity spikes that typically occur in the spring, as well as the low-turbidity periods more commonly observed during the rest of the year. The objectives of the piloting would be used to confirm that the filtration option could operate as intended during both turbidity spike events and under low-turbidity conditions, as well as assess the resiliency of the membrane options to breakage and fouling.

It would be challenging to pilot the ZW1000-550 option for a long enough duration to feasibly assess whether the rate of fibre failure is less than the current ZW1000-450 membranes. Instead, it is recommended that the RDCK consider modifying one of the four membrane units to assess whether the change will lead to a significant improvement in ZW1000 resilience. If such modifications improve the lifespan of the existing ZW1000-450 units, the ZW1000-550 units would reasonably see a similar lifespan. Namely, the following single-unit modifications should be considered:

- Install 500 micron self-cleaning strainer and booster pump upstream of one of the membrane units.
- Modify one membrane tank and its controls so that the tank removes accumulated sediment via a drain at the bottom of the tank instead of lifting sediment to the overflow lines.

Furthermore, it is recommended that the RDCK consider the option of expanding holding times in the settling ponds to reduce the magnitude of turbidity spikes that reach the inlet of the WTP, and thereby reduce turbidity loads on the treatment equipment. This would involve conducting sediment settling bench-scale simulations using Creek raw water from a turbidity event as part of the pilot program.

7.4.3 Confirmation of Assumptions

Several assumptions were identified in this interim report related to pre-filtration strainer requirements, re-use of existing equipment, compressor and air compressor footprint, and adequate sizing of existing piping. It is recommended that these assumptions be verified for the short-listed options and, if needed, update the Opinions of Probable Cost to reflect any changes to the assumptions.

7.4.4 Staged Filter Upgrades

Considerations for replacing the existing membranes in incremental stages was addressed in Sections 4.3 and 4.5 of this report. It is recommended that the RDCK confirm their plans for staging upgrades to the Arrow Creek WTP, including:

- How many stages should the upgrade be broken into
- What are the target years for implementing each stage
- The minimum flow from the WTP that should be maintained during construction
- The potential for WTP treatment capacity to be increased during the upgrades

7.4.5 Redundancy of Filtration Equipment

Currently the WTP does not have a redundant filtration unit that would allow the WTP to run at full capacity while one membrane unit is offline for maintenance or repair. It is recommended that the RDCK confirm whether redundancy, and to what level, should be incorporated into the filtration system when the WTP is upgraded.

CERTIFICATION PAGE

This report presents our findings regarding the Regional District of Central Kootenay Arrow Creek Ceramic Filter Feasibility Study Final Report

Respectfully submitted,

Associated Engineering (B.C.) Ltd.

Written by:	Reviewed by:
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KK/KA/nhd

APPENDIX A - INTERVIEW RESULTS

Associated

Question	Metawater Pressurized Ceramic	Cerafiltec Immersed Ceramic	ZeeWeed 500 Reinforced Polymeric Site 1	ZeeWeed 500 Reinforced Polymeric Site 2	ZeeWeed 500 Reinforced Polymeric Site 3
1. What is your source water (groundwater, surface water, industry waste)? What is the application? What is the capacity?	60 million gallon reservoir, serving community for 120 years. previous treatment was disinfection.	Industrial reuse facility (sanitary, FOG), first Cerafiltec plant in North America. Membrane bioreactor, followed by RO. Design capacity 75,000 gallons/day. observed: average 40,000 gallons/day	Surface water, protected watershed. Capacity = 116 MLd. MDD observed 78 MLd during heat dome. Organics are dependent on temperature. Lake flip	Surface water. Drinking water. Capacity = 160 MLD	North Saskatchewan River (surface), WTP, 4 million L/day, increases to 6 in summer
2. What is pre-treatment? Any special screening upstream? pH adjustment? What is post-treatment? pH boost with caustic? CO2 stripping?	3 parallel 300 micron Amiad self-cleaning strainer. ACH before membrane. pH adjustment, disinfection, corrosion control with orthophosphate (post-treatment).	pH adjustment with NaOH in MBR. 2mm perforated drum screen.	Coarse (clean by ops, 2x/year usually) and fines screens (timer self wash). Soda ash to increase alkalinity. Aluminum Chlorohydrate (ACH). Soda ash and ACH must be added together to maintain warranty. Must have 15mg/L alkalinity after ACH. 7-13 mg/L when organics are high. Chlorine gas after. No minerals in water. Citric acid to remove ACH. Seasonal heated acid cleans increases permeability 2x/year, scheduled for when water doesn't need to be heated as much.	No pre-treatment. Bar screen followed by rotating screen. No pH adjust. Only filter and then chlorinate.	Amiad filters (strainer) prior to floc tank, suggest pH adjustment. poly aluminum chloride injected then flock tank. no secondary membranes. sulfuric acid injection used initially. did not see benefit in using many chemicals. massive spike in turbidity in following year. pH fluctuates between 7.2-8.4. higher pH seen in spring.
3. What is the make and model of the membranes and what year were they installed?	Metawater - only one model. Commissioned May 2017.	Aluminum oxide and silicone carbide membranes.	ZeeWeed 1000D (by gravity) for primary, ZeeWeed 500D for secondary. Primary tank capacity is 45.5 m^3, secondary capacity is 14.5 m^3. December 3, 2015 was when water was first treated and supplied to the City. February 2016 commissioned	5000 440 squared feet and 340 squared feet The membranes that exist in the plant were installed in 2004, 2013, 2023	Sept 2015 commission, ZW500D
4. What is the design flux and what is the actual performance like at that flux?	69 GFD design. membrane rated for higher. performance at design flux is good. CIP 2-3 times a year (before and after irrigation season), weekly maintenance clean. clean water backwash every 4-6 hours (60 second process). 10 racks of 10, independent of each other	Running 12 GFD currently.	Design flux for primary is 51 LMH, secondary 34 LMH. Usually runs in 20s. No issues with TMP. -60 to -70 psi would be worrisome. Usually -20 psi.	Actual approx. = 34 LMH TC Flux approx. = 43 LMH	Capable of 18 million L/day, never close to capacity average 3.5 million L/day no flux issues observed.
5. How was the installation process? Were there any challenges or unexpected issues?	Installation was complicated. Metawater bought Aqua-Aerobic during install period. SCADA system is working well, all integrated. 1 year for construction, membrane install 4-5 months during construction. Membranes were assembled on site. Consider clearance during install. Membranes were dry during shipping.	Installation October 2021. Installation was straightforward. Same permeate pumps, flow meters, valves as before. Only needed to change permeate connections and blower connections. Built internal baffle wall to channel flow across ceramic membranes. Polymeric hollow fiber membranes were used before - not designed to handle FOG load.	Issues with tolerances. Tank sizes did not provide enough clearances. Epoxy coating was damaged during installation. Lifting device was modified (from one point to four point). Contractor installed mounting brackets wrong. Had to grind tabs and pickle stainless steel. High chlorine issues. New analyzer has different sampling frequency. CIP tanks are undersized, don't hold enough flush water	Installation was smooth, possible options with how to flush glycerine	Installation process went smoothly. a lot of flushing (glycol) and sampling had to be done. fairly easy to remove and install.
6. Have you experienced maintenance or repair issues? What kind of maintenance/repair has been done? Please describe.	Actuators are biggest maintenance issue (rebuild actuator, Bray). Spares are kept on hand. Micro switches replace as needed. Many valves and actuators on each rack. Moisture issue initially - air dryer was installed after plant was constructed. 2 membrane modules failed - negligence during installation by subcontractor. Backwash water is run through clarifier and recovery unit (polymer).	CEB, every few months, relatively infrequently compared to polymeric. Last fall, TMP had been high, system shutdown and restart for new UF system. No repairs done.	Epoxy was repaired before commissioning. Only repaired membrane once in 8 years. Some communication/electrical issues. Neutral block wasn't tightened to MCC cabinet.	Original (2004) membranes have a glue strip interface problem. The 2013 membranes do not have this issue. Fibre repair. Some plastic replacements.	Make sure enough clearance between fibers and tank design. external aeration for back pulse shakes fibers and creating abrasion point between fiber and tank wall. pulling water directly from river without setting (construction). aeration stayed on after construction, causing additional abrasion. 2019 - Veolia repaired. plugged fibers at abrasion point. warranty period 5 years. before 5 years were up, entered membrane replacement agreement with Veolia, locked price.
7. Are there any rapidly wearing parts? Are motors and pumps doing well?	No rapidly wearing parts. Pumps and motors not associated with filtration process (gravity fed through membranes). Air driven process.	No rapidly wearing parts. Motors and pumps are doing well.	No rapidly wearing parts. Pumps and motors are okay. Starting to see issues with chemical pumping.	No rapidly wearing parts. Age of plastics is a concern. Plastic tabs breaking off the aeration, noiced around 18 years of age.	Pumps/motors performing well. a few VFD failures (unrelated to pumps). floc tank mixer pushing flow directing into mixer shaft, causing side to side swing, damaging rubber couplers. installed baffle. no issues observed with CIP pumps. supplier forgot to put in oil in pump. Problem with one CIP heater, installed upside down. supplier replaced and fixed original and gave back
8. Are you getting the performance that was promised? Does this change seasonally, with water quality, or with temperature?	Performance is as expected. No change with seasons, water quality (only backwash interval changes). CEB higher concentration as needed. Temperature ranges 60 °F (15.6 °C), winter 34-35 °F (1-2 °C)	Performance is good. Temperature varies. MBR facility is outdoors with above ground tanks. Slight change in permeability observed with cold water. No difference in normalized permeability.	Getting performance that was promised. Plant runs below capacity so no performance change observed with temperature change.	Yes getting performance promised. No does not change seasonally.	No turbidity in winter months, so don't see fouling as often. don't add coagulant in winter, only add coagulant 3 months in a year. 1.7°C-22°C. temp taken at source. performance is not an issue.
9. Have there been any problems with flow observed?	No issues with flow.	No issues with flow observed.	No	No problems	No issues observed. population decreased. 7 million L/day before upgrade.

Associated

Question	Metawater Pressurized Ceramic	Cerafiltec Immersed Ceramic	ZeeWeed 500 Reinforced Polymeric Site 1	ZeeWeed 500 Reinforced Polymeric Site 2	ZeeWeed 500 Reinforced Polymeric Site 3
10. Could you comment on the frequency of membrane element replacement? Is it as expected or more frequent?	Only two modules replacements (due to poor installation). 412 modules in plant. No replacement expected.	Ceramic membranes have not been replaced.	No membrane replacement yet. May replace at 12 years. Likely less frequent than expected.	2013 replaced 10 trains. New replacement frequency now with new contract. Replace 2 trains per replacement to stagger age of parts.	No replacements yet. NA. 10 years replacement expected. at current rate, may last longer. two trains. will replace one train at a time. will recycle good modules.
11. How often does the system need to be cleaned? After cleaning, does it return to new condition or similar?	Back to original conditions (baseline permeability) after every CIP.	CEB with hypochlorite every few months (when TMP is 1). Hypochlorite, citric acid, and caustic was used to recover permeability (once, when UF system was installed). After CEB, returns to similar to new condition.	Primary membranes are washed 5x/month. 2 hypo maintenance cleans and 2 acid maintenance cleans per month. Hypo first and then acid on same day. Hypo clean (not heated) once a month. Secondary 9 hypo maintenance cleans. 1 non-heated hypo recovery clean a month. 1 acid clean per month. Returns to similar to new condition after cleaning. Test hypo and top up if needed.	Twice per year. Very good recovery.	GE advised low ppm clean once a day, high ppm clean monthly. one maintenance clean (low ppm) a week. recovery clean (high ppm) varies. clean when 200 L/m2/h. 3 times a year approximately right now. after cleaning, returns to 300 L/m2/h.
12. Could you comment on if fouling is an issue? If so, please describe.	Fouling was an issue 2 times, during summer (manganese and iron) and decrease in permeability. Fouling removed with CIP.	During normal ops, fouling is not noticeable.	No major fouling issues observed. A bit of mud build up that is difficult to clean, but not causing an issue. Top of cassettes were worst.	No concerns, aeration, backpulse, and chemical cleans must work properly.	Not an issue in the winter. In summer, if turbidity is low, plant will do 96% recovery. when turbidity>60 NTU, system automatically triggers to 85% recovery. external aeration through production cycle.
13. If you upgraded to these membranes, what did you use for filtration previously? Has the upgrade resulted in more or less O&M time?	New plant. Chlorine gas disinfection used previously.	Polymeric before. Weekly CEB with polymeric to quarterly with ceramics.	Not upgraded, N/A.	N/A	No upgrade in new plant. previously sand filtration. less O&M time by far compared to previous plant. plant has remote access.
14. Have you experienced challenges with servicing such as communication or delays? Are you charged for servicing?	Good communication with Aqua-Aerobic, very responsive. Only need programmer at times. No charge for servicing.	No servicing has been required.	Haven't contacted Veolia often, N/A. Only had tech on-site one time (Ethan) - charged for site visit.	Very slow response time and poor communication in the past. Improved with a lot of pressure and moving complaints up their coporate ladder.	Servicing is included in MRA. 24 hour tech support at the beginning minimal cost (~$12,000/year). MRA still currently has 24 hour tech support. also sends daily reports. send bi-weekly insight reports. performance and status of system. tips and instructions for cleaning. Communications are fast with Veolia. MRA doesn't include inspections, but offered to for free recently.
15. How responsive are the membrane suppliers? Membrane manufacturers?	Very responsive.	Quick response times.	N/A, see #14.	Okay. Have seen great improvements reccently	Very responsive
16. How user friendly are the controls and programming?	Learning curve at beginning, but very user friendly. SCADA system works smoothly.	Controls were existing. Set points changed.	Very user friendly. If programming changes are required, need to contact Veolia.	User friendly, have made a lot of changes over almost 20 years of operation.	Controls and programming are simple. programming glitches at beginning, getting alarms, lasted 3-4 months. internal programming of certain equipment in plant (not in Veolia's scope).
17. Did the membranes come with a guarantee and/or warranty? If so, what were the conditions?	20 year warranty for membrane modules, full replacement. Actuator warranty was 3 years. Warranty conditions reasonable. Log dosage changes.	Unknown.	5 years (?) for ZW1000 and 500D. Conditions: chemical dosage, chemical changes approved by Veolia, aluminum based products must be approved by Veolia, water quality requirements. Reasonable conditions.	24 months - only on the membrane modules	5 years guaranteed membrane replacement value. reasonable conditions. warranty 3 years. tank abrasions happened after warranty expired, but Veolia honoured.
18. Have you made any warranty claims? If so, please describe the process and comment on whether the issue was resolved by the supplier.	Two warranty claims. Service tech was sent out first time. Resolution was fast. Two spares kept on site.	No issues.	No claims.	Not on the 2013 and newer modules.	Abrasion CIP heater both were resolved by Veolia at no cost.
19. Which vendor(s) did you consider for the filters? What was the justification for selection of the current vendor? Are you satisfied?	ZeeWeed, Pall, Metawater. 20 year life cycle analysis. Ceramic best option, despite higher upfront costs. Piloted May-September. Positive experience.	No other membranes were considered. Satisfied.	Design started in 2009. Looked into various treatment options.	N/A	Turbidity is an issue; not a lot of settling in settling basin, needed more robust membrane (3000 NTU, in June).
20. Have you experienced any unforeseen capital costs?	Air dryer that was required to address moisture issue ($15,000 USD installed by ops).	No unforeseen costs.	Glycol flushing after delivery of membranes. Will incur $150k in capital costs when new membranes will be installed, if delivered in glycol.	No	No

Question	Metawater Pressurized Ceramic	Cerafiltec Immersed Ceramic	ZeeWeed 500 Reinforced Polymeric Site 1	ZeeWeed 500 Reinforced Polymeric Site 2	ZeeWeed 500 Reinforced Polymeric Site 3
21. What lessons have you learned? What advice would you give to a plant considering a similar filter replacement? Would you do anything differently?	Start up, discharging filtrate to blowoff. Work with programmer for sequencing. Install air dryer to remove all moisture, especially important in cold environment.	Permeate piping connection. Rigid header piping was used (sched 80 PVC), difficult to work with (engineering issue). Flexible piping would preferred. Make sure enough freeboard.	Bigger tanks for clearance. Follow cleaning strategy for at least a year before changing the strategy.	No comments	Abrasion, tank clearance. Chemical injection pumps - not positive displacement (air actuated), move air fast, limited water. pumps are aggressive, sched 80 PVC failures. Need shock absorber, suction line. At beginning of project, GE Complete tank drain, CIP pump kicks in, sends back to CIP tank and need to neutralize before sending to waste. Sodium bi-sulfite to neutralize sodium hypochlorite (pH 10). Recommended calcium thiosulfite (pH 6). pH isn't low enough to bring pH to neutral. Struggled to bring to pH of 7. Switched back to sodium bi-sulfite. Chemical tank design- suggest not doing transfer into separate tank. Run chemicals off tote from supplier. Problems with transfer from tote to glass tank. Overflow line went into containment area. Corrosion issues. Sodium hypochlorite, citric acid to remove inorganic fouling. If cold, don't place citric acid by exterior wall; freezes quickly. Tank lids fit like puzzle pieces, fit together. Any shift will cause slide. difficult to move. Veolia is working to design new lid (general). Vent line on top of tank 10 inch sched 80 PVC to remove vent lines during inspection (annual). Recommend flexible tubing with quick connect rather than flange. Not pressurized, no need for sched 80.
22. What is the permeability square foot/meter on the surface of the membranes? What is the tank footprint?	permeability corrected to 10°C. 15-30 Each module is 269 sqft filtration.	12 GFD/psi. Tank (designed for polymeric) is much larger than required. 16.5' L x 8' W x 8' H.	From July 2018: average 200 sqft/m February 2018: 330 sqft/m	Primary: 440 squared metre per module with 4320 modules Secondary: 340 squared metre per module with 1536 modules	Do not know.
Additonal comments:	Very positive experience. Goals achieved. Maintenance and performance good. If fewer than 10 independently operating racks would be helpful, to simplify. Fewer valves and actuators if possible.	-	95% water to primary. secondary (5%) uses 95% of power. 84/96 secondary slots. 56/64 secondary slots.	-	-

APPENDIX B – MEMBRANE LAYOUT DRAWINGS

Figure 4-1. ZW500 Layout in WTP

Figure 4-2. MetaWater Layout in WTP

Figure 4-3. Cerafiltec Layout in WTP

Figure 4-4. ZW1000 Layout in WTP

APPENDIX C – LIFECYCLE COSTS

Arrow Creek Ceramic Filter Feasibility Study
Opinion of Probable Cost

OPTION: METAWATER CERAMIC FILTRATION

Annual Costs

Description	Total
Labour (Assumes 20 hrs per week, 52 weeks per year, $75/hr rate)	$ 78,000
Chemical Consumption	$ 24,571
Power	$ 13,369
Misc. mechanical & EIC (1% of mechanical costs)	$ 65,354
Misc. structural (0.2% of structural costs)	$ 20
Subtotal	$ 181,314

Assumed costs

Description	Total
Year 1 capital upgrades	$ 11,626,726
Replace membranes every 20 years (Year 21)	$ 3,500,000
Replace permeate pumps in 15 years (Year 16)	$ 40,000
Replace chemical pumps every 10 years (Year 11, 21)	$ 40,000
Replace compressors every 15 years (Year 16)	$ 50,000
Annual discount rate	4%

Year	Cap Costs	Annual Costs	Subtotal (F)	Subtotal (P)
1	$ 11,626,726	$ 356,314	$ 11,983,039	$ 11,983,039
2		$ 356,314	$ 356,314	$ 342,609
3		$ 356,314	$ 356,314	$ 329,432
4		$ 356,314	$ 356,314	$ 316,761
5		$ 356,314	$ 356,314	$ 304,578
6		$ 356,314	$ 356,314	$ 292,864
7		$ 356,314	$ 356,314	$ 281,600
8		$ 356,314	$ 356,314	$ 270,769
9		$ 356,314	$ 356,314	$ 260,355
10		$ 356,314	$ 356,314	$ 250,341
11	$ 40,000	$ 356,314	$ 396,314	$ 267,735
12		$ 356,314	$ 356,314	$ 231,454
13		$ 356,314	$ 356,314	$ 222,552
14		$ 356,314	$ 356,314	$ 213,993
15		$ 356,314	$ 356,314	$ 205,762
16	$ 90,000	$ 356,314	$ 446,314	$ 247,822
17		$ 356,314	$ 356,314	$ 190,239
18		$ 356,314	$ 356,314	$ 182,922
19		$ 356,314	$ 356,314	$ 175,886
20	$ 40,000	$ 356,314	$ 396,314	$ 188,107
			$ 18,922,996	$ 16,758,821

Notes:

Year 1 capital costs include: Treatment equipment, site work, labor, contractor markup and overhead, engineering and contingency.

Annual costs include: Annual labour, chemical and power costs, misc. spare parts, allocation of large equipment reserve funds (saving up for Year 21 membrane replacement in years 1-20)

Subtotal (F) is present value of costs

Subtotal (P) is present value of future costs assuming 4% annual discount rate.

Arrow Creek Ceramic Filter Feasibility Study
Opinion of Probable Cost

OPTION: ZW1000 POLYMERIC FILTRATION (8 YEAR MEMBRANE REPLACEMENT)

Annual Costs

Description	Total
Labour (Assumes 20 hrs per week, 52 weeks per year, $75/hr rate)	$ 78,000
Chemical Consumption	$ 24,509
Power	$ 26,111
Misc. mechanical & EIC (1% of mechanical costs)	$ 38,377
Misc. structural (0.2% of structural costs)	$ 376
Subtotal	$ 167,373

Assumed costs

Description	Total
Year 1 capital upgrades	$ 7,370,064
Replace membranes every 8 years (Year 9, 17, 26)	$ 2,419,200
Replace chemical pumps every 10 years (Year 2, 12)	$ 40,000
Replace permeate pumps in 15 years (Year 2, 17)	$ 40,000
Replace compressors every 15 years (Year 2, 17)	$ 50,000
Replace feed pumps in 15 years (Year 16)	$ 40,000
Annual discount rate	4%

Year	Capital Costs	Annual Costs	Subtotal (F)	Subtotal (P)
1	$ 7,370,064	$ 167,373	$ 7,537,437	$ 7,537,437
2	$ 130,000	$ 167,373	$ 297,373	$ 285,935
3		$ 167,373	$ 167,373	$ 154,746
4		$ 167,373	$ 167,373	$ 148,794
5		$ 167,373	$ 167,373	$ 143,071
6		$ 167,373	$ 167,373	$ 137,568
7		$ 167,373	$ 167,373	$ 132,277
8		$ 167,373	$ 167,373	$ 127,190
9	$ 2,419,200	$ 167,373	$ 2,586,573	$ 1,889,983
10		$ 167,373	$ 167,373	$ 117,594
11		$ 167,373	$ 167,373	$ 113,071
12	$ 40,000	$ 167,373	$ 207,373	$ 134,705
13		$ 167,373	$ 167,373	$ 104,541
14		$ 167,373	$ 167,373	$ 100,520
15		$ 167,373	$ 167,373	$ 96,654
16	$ 40,000	$ 167,373	$ 207,373	$ 115,147
17	$ 2,509,200	$ 167,373	$ 2,676,573	$ 1,429,044
18		$ 469,773	$ 469,773	$ 241,169
19		$ 469,773	$ 469,773	$ 231,893
20		$ 469,773	$ 469,773	$ 222,974
			$ 16,763,121	$ 13,464,313

Notes:

Assumes end-of-life of existing permeate pumps, chemical pumps and compressors, that are being re-used for this option, would require replacement in Year 2

Year 1 capital costs include: Treatment equipment, site work, labor, contractor markup and overhead, engineering and contingency.

Annual costs include: Annual labour, chemical and power costs, misc. spare parts, equipment replacement (saving up for Year 26 membrane replacement in years 18-25)

Subtotal (F) is present value of costs

Subtotal (P) is present value of future costs assuming 4% annual discount rate.

Arrow Creek Ceramic Filter Feasibility Study
Opinion of Probable Cost

OPTION: CONVENTIONAL TREATMENT - ABSORPTION CLARIFIER

Annual Costs

Description		Total
Labour (Assumes 20 hrs per week, 52 weeks per year, $75/hr rate)	$	78,000
Chemical Consumption	$	192,822
Power	$	21,877
Misc. mechanical & EIC (1% of mechanical costs)	$	47,200
Misc. structural (0.2% of structural costs)	$	4,550
Subtotal	$	344,448

Assumed costs

Description		Total
Year 1 capital upgrades	$	13,433,092
Replace chemical pumps every 10 years (Year 11, 21)	$	20,000
Replace feed pumps, booster pumps and backwash pumps in 15 years (Year 16)	$	90,000
Replace compressors every 15 years (Year 16)	$	30,000
Replace media every 20 years (Year 21)	$	2,000,000
Annual discount rate		4%

Year	Cap Costs	Annual Costs	Subtotal (F)	Subtotal (P)
1	$ 13,433,092	$ 444,448.20	$ 13,877,540	$ 13,877,540
2		$ 444,448.20	$ 444,448	$ 427,354
3		$ 444,448.20	$ 444,448	$ 410,917
4		$ 444,448.20	$ 444,448	$ 395,113
5		$ 444,448.20	$ 444,448	$ 379,916
6		$ 444,448.20	$ 444,448	$ 365,304
7		$ 444,448.20	$ 444,448	$ 351,254
8		$ 444,448.20	$ 444,448	$ 337,744
9		$ 444,448.20	$ 444,448	$ 324,754
10		$ 444,448.20	$ 444,448	$ 312,263
11	$ 20,000	$ 446,448.20	$ 466,448	$ 315,116
12		$ 446,448.20	$ 446,448	$ 290,004
13		$ 446,448.20	$ 446,448	$ 278,850
14		$ 446,448.20	$ 446,448	$ 268,125
15		$ 446,448.20	$ 446,448	$ 257,813
16	$ 120,000	$ 446,448.20	$ 566,448	$ 314,529
17		$ 446,448.20	$ 446,448	$ 238,362
18		$ 446,448.20	$ 446,448	$ 229,195
19		$ 446,448.20	$ 446,448	$ 220,379
20		$ 446,448.20	$ 446,448	$ 211,903
			$ 22,482,056	$ 19,806,436

Notes:

Year 1 capital costs include: Treatment equipment, site work, labor, contractor markup and overhead, engineering and contingency.

Annual costs include: Annual labour, chemical and power costs, misc. spare parts, equipment replacement (saving up for Year 21 media replacement in years 1-20, and Year 21 chemical pump replacement in years 11-20)

Subtotal (F) is present value of costs

Subtotal (P) is present value of future costs assuming 4% annual discount rate.

Regional District of Central Kootenay
Unaudited Service Statement

S251 Water Utility-Area B (Arrow Creek)

Period: June 2025

REVENUE

Account		Workorder		Current Month	Year To Date Actuals	Total Year Budget	Budget Remaining	Budget Utilization
42030	User Fees			0	0	705,306	705,306	0%
45000	Transfer from Reserves			0	0	814,250	814,250	0%
45500	Transfer from Other Service			0	0	608,113	608,113	0%
49100	Prior Year Surplus			0	57,664	57,881	217	100%
Revenue				0	57,664	2,185,550	2,127,886	3%

OPERATING EXPENSES

Account		Workorder		Current Month	Year To Date Actuals	Total Year Budget	Budget Remaining	Budget Utilization
51010	Salaries			0	37,861	127,000	89,139	30%
51020	Overtime			0	122	3,500	3,378	3%
51030	Benefits			1,492	15,023	45,675	30,652	33%
51050	Employee Health & Safety			125	125	456	331	27%
51500	Directors - Allowance & Stipend			(1,110)	0	1,847	1,847	0%
51560	Directors - Travel			0	0	220	220	0%
51565	Directors - Mileage			0	0	918	918	0%
52010	Travel			0	0	47	47	0%
52030	Memberships, Dues & Subscriptions			0	0	227	227	0%
53020	Admin, Office Supplies & Postage			0	182	79	(103)	230%
53030	Communication			224	1,345	3,108	1,763	43%
53040	Advertising			0	0	251	251	0%
53050	Insurance			3,402	13,453	24,301	10,848	55%
53080	Licence & Permits			0	20	481	461	4%
54030	Contracted Services			7,170	28,207	31,250	3,043	90%
55010	Repairs & Maintenance			109	11,702	20,440	8,738	57%
55020	Operating Supplies			100	(719)	10,000	10,719	-7%
55025	Chemicals			10,768	25,176	72,705	47,529	35%
55030	Equipment			51	324	3,170	2,846	10%
55040	Utilities			7,621	32,685	110,000	77,315	30%
55050	Vehicles			0	94	445	351	21%
55060	Rentals			0	43	158	115	27%
Operating Expenses				29,952	165,644	456,278	290,634	36%

CAPITAL EXPENSES

Account		Workorder		Current Month	Year To Date Actuals	Total Year Budget	Budget Remaining	Budget Utilization
60000	Capital Expenditures			10,075	136,971	803,000	666,029	17%
Capital Expenses				10,075	136,971	803,000	666,029	17%

NON-OPERATING EXPENSES

Account		Workorder		Current Month	Year To Date Actuals	Total Year Budget	Budget Remaining	Budget Utilization
56010	Debenture Interest			0	27,453	97,062	69,609	28%
56020	Debenture Principal			0	29,003	91,172	62,169	32%
59000	Contribution to Reserve			0	0	479,151	479,151	0%
59500	Transfer to Other Service			12,300	12,300	36,972	24,672	33%
59510	Transfer to Other Service - General Admin. Fee			0	0	20,042	20,042	0%
59520	Transfer to Other Service - IT Fee			0	0	9,739	9,739	0%
59550	Transfer to Other Service - Environmental Services Fee			0	0	192,134	192,134	0%
Non-Operating Expenses				12,300	68,756	926,272	857,516	7%

Total Service				(52,327)	(313,707)	0		