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June 2, 2023

VIA EMAIL (crystal.henwood@novascotia.ca)
Ms. Crystal Henwood, Regulatory Affairs Officer/Clerk of the Board
N.S. Utility and Review Board
3rd Floor, Summit Place, 1601 Lower Water Street
P. O. Box 1692, Postal Unit M
Halifax, NS B3J 3S3

Re: Water Supply Enhancement Program – JDK800.10 – Pretreatment and Clarification – Detailed Design & Early Works

Dear Ms. Henwood:

Halifax Water is currently seeking funding for the Water Supply Enhancement Program – JDK800.10 – Pretreatment and Clarification – Detailed Design & Early Works for an estimated total project cost of $7,300,000.

The J.D. Kline and Lake Major Water Supply Plants are entering a period of significant capital renewal, upgrade, and enhancement which is planned to occur over the next ten years. These upgrades are being driven by operational risks due to changing source water conditions driven by climate change, lake recovery, obsolescence, and historical treatment plant performance issues that have resulted in the present-day operating conditions which lack the required resiliency and are unsustainable. Additionally, there is additional emphasis on the requirement to make changes in the plants as a result of an increasingly stringent regulatory environment.

Recognizing these needs, a capital upgrade program was developed for each plant beginning in 2019. The two capital programs have developed the needs, scoping, and priority for 13 projects to be completed at both facilities over the next ten years. Given the desire to have common approaches to treatment process, process control and equipment at both facilities and the need to coordinate the timing and sequencing of major projects at both facilities, it was decided to deliver these projects through a common Water Supply Enhancement Program (WSEP). The implementation of this program will provide improved operational flexibility and reliability in the long term. It will allow a more proactive means of addressing the changing needs of the systems consistent with Halifax Water's Risk Management and Asset Management framework.

Changing source water has already had an impact on operations. Recent water quality events related to source water changes include the presence of taste and odour compounds (e.g., geosmin), coupled with algal matter and algal toxin risk. These conditions are at the forefront of the evolving treatment process needs for the utility. Until permanent changes are made in these two plants, these facilities will continue to address these challenges using as-needed interim treatment strategies and modifications.

The JDK800.10 – Pre-Treatment and Clarification project is the first WSEP project and a fundamental component of this program. This project, also referred to as the Dissolved Air Flotation (DAF) clarification project, is key to enabling the balance of WSEP projects to be executed at J.D. Kline, and for the long-term functionality of the J.D. Kline facility, both in terms of water quality and operational reliability. Since the existing plant is a direct filtration plant and hence does not have the clarification step, this project will also be a major step in equipping this facility to reliably manage the emerging challenges of changing source water. If approved, this funding will enable Halifax Water to complete detailed design and begin construction of early works in the project to maintain the schedule of the WSEP.

The DAF project is a large multi-year capital project which is estimated at a cost of $131,257,000. To date $660,000 has been spent to undergo two prior phases of early engineering developing the project, including pre-design and preliminary design. The preliminary design report is appended for reference as Attachment 1. This project is incorporated into the overall WSEP in terms of scoping, sequencing, and spending, as well as program documentation including a Project Charter and management structure. The JDK800.10 Project Charter, including key project criteria, is appended as a reference as Attachment 2. The WSEP plan and the 2023/24 capital budget anticipate starting construction in the 2023/24 fiscal year.

Given the level of technical definition provided in the completed preliminary design, and the desire to maintain schedule milestones for the project, funding is being requested for an Early Works phase of the project construction to be started in the coming year. This Early Works phase includes civil and earthworks components, in preparation for the plant expansion/building construction work. It addresses critical functionality aspects of existing systems (i.e., SCADA tower relocation); provides for site works upon which the future plant expansion will be built; and plans for procuring long delivery time large diameter piping.

Project Scope

The Detailed Design and Early Works phase includes the following:

SCADA Tower Relocation

The existing SCADA tower at the J.D. Kline site is too close to the proposed footprint of the DAF building expansion and will interfere with future construction activities of the plant expansion if not relocated. The existing tower must be relocated prior to construction of the DAF building expansion. This communications link is vital for Halifax Water SCADA systems functionality and must be maintained throughout the program. Thus, a new SCADA tower must be erected, commissioned, and made operable prior to the existing tower being removed.

Rock Removal/Building Pad Construction

The future DAF building hydraulic grade line and process tankage geometry dictate the necessary elevations and grades for new structures. The geotechnical field program has been completed and provides geotechnical data including rock characterization, structural criteria, structural fill, and backfilling requirements for the future building. Based on bedrock contour profiles it is anticipated that the DAF building will be founded on several layers of structural fill placed over top of bedrock. Existing backfill and over-burden in the area of the building expansion will be removed to bedrock in this Early Works phase to expose existing concrete structures. Structural fill will then be placed in lifts to achieve necessary founding elevations. A Combined Waste Wash Water (CWWW) tank will be constructed as a separate concrete structure founded deep into bedrock. Extensive rock removal will be required for the tank construction. As a pre-cursor to constructing the base-slabs for the DAF building and CWWW tank, rock removal plus supply and placement of structural fill will be required. This Early Works phase will include rock removal for a CWWW tank, processing the removed rock onsite to manufacture structural fill, removal of overburden and then placement of structural fill as a building pad beneath the proposed DAF building.

Raw Water Transmission

The JD Kline plant is fed by a single raw water transmission main from the JD Kline pumping station. The new DAF facility must connect to this pipeline. To mitigate the significant risk in tapping this line while in operation (hot tap), a new temporary 1.0 km raw water transmission line will be installed between the low lift pumping station and the tie in location. The temporary transmission line will also enable parallel operation of the existing facility while commissioning, testing, and enabling operation of the new DAF plant. Once the DAF plant is complete and additional storage is available the final connection to the existing raw water pipeline can be

made. This approach significantly reduces the operational and reliability risk associated with maintaining existing plant operation during construction.
The installation of a temporary parallel raw water transmission pipeline will require specialty materials (pipe and fittings) that have a long lead time, therefore, procurement of the pipe and materials, but excluding pipe installation, is included as part of the Early Works phase.

<u>Engineering and Design</u>
Most of the detailed design for the Early Works phase and the Pre-Treatment and Clarification project remain to be completed. The detailed design of the SCADA tower relocation and site civil works will be done in concert with the overall detailed design of the DAF plant expansion and remaining project elements. The tendering and construction phasing of the project will have multiple periods of activity over the coming years, however much of the detailed design can be completed in the coming fiscal year with work packages prepared for construction as deemed appropriate based on scheduling and aspects of practical implementation.

The following table provides funding that has been allocated to this project in respective fiscal years, spending to date and remaining allocation available.

<table>
<tr><th>Fiscal Year</th><th>Allocated Funding</th><th></th></tr>
<tr><td>2021/22</td><td>$ 2,273,000</td><td rowspan="3">$ 8,610,000</td></tr>
<tr><td>2022/23</td><td>$ 604,000</td></tr>
<tr><td>2023/24</td><td>$ 5,733,000</td></tr>
<tr><td>2024/25</td><td>$ 35,719,000</td><td rowspan="4">$ 123,170,000</td></tr>
<tr><td>2025/26</td><td>$ 40,910,000</td></tr>
<tr><td>2026/27</td><td>$ 39,826,000</td></tr>
<tr><td>2027/28</td><td>$ 6,715,000</td></tr>
<tr><td>Total</td><td>$ 131,780,000</td><td></td></tr>
</table>

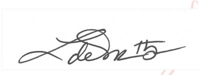
As seen from the table above, funding in the amount of $8,610,000 including net HST is available within the 2021/2022, 2022/2023, and 2023/2024 capital budget for JDK800.10 – Pre-Treatment and Clarification. Out of this, $660,000 has been spent on predesign and preliminary design activities leaving the available funding at $7,950,000 in these fiscal years. The current request for funding is $7,300,000 as explained in the table below. If approved, this will take the total approved project funding to $7,960,000. Halifax Water will request approvals for subsequent phases (construction and commissioning) in future years as costing from detailed design exercise and/or procurement solicitations for subsequent phases have been received.

A - SCADA Tower Relocation		
Supply and install new SCADA Tower	$	450,000
Foundations, U/G Ductwork and Electrical	$	200,000
Removal of Existing Tower	$	50,000
Contingency (10%)	$	70,000
Subtotal	$	770,000
B - Rock Removal/Building Pad Construction		
Mobilization	$	30,000
Rock Removal (9,500 m^3 @ $75/$m^3$)	$	712,500
Overburden Removal (12,000 m^3 @ $25/$m^3$)	$	300,000
Processing and Placement of Structural Fill (9,500 m^3 @ $15/$m^3$)	$	142,500
Stockpiling and Removal of Excess Material	$	80,000
Contingency (10%)	$	126,500
Subtotal	$	1,391,500
C - Raw Water Transmission		
Raw Water Piping (1,000 m @ 900 mm)	$	2,050,000
Contingency (10%)	$	205,000
Subtotal	$	2,255,000
D - Detailed Engineering Design		
Consulting Fees for detailed design and tender services	$	2,242,650
Subtotal	$	2,242,650
Sub-total (A+B+C+D)	$	6,659,150
Program Management (3%)	$	199,774
Halifax Water Staff Time (1%)	$	66,591
Net HST (4.286%)		$293,973
Interest & Overhead (1%)		$66,591
FUNDING REQUEST TOTAL	$	7,286,081
Rounded to nearest hundred-thousand		**$7,300,000**

The proposed expenditure meets the "NO REGRETS-UNAVOIDABLE NEEDS" approach of the 2012 Integrated Resource Plan. The proposed work meets the NR-UN criteria of "Firm regulatory requirement", "Required to ensure infrastructure system integrity and safety", and/or "Directly supports the implementation of the Asset Management program". The project meets these criteria based on the following: The current equipment is failing due to age and end of life (Asset Management), causing treatment performance/operational issues (Infrastructure System Integrity), and/or regulatory compliance failures (Firm Regulatory Requirement).

Accordingly, we are requesting approval from the Nova Scotia Utility and Review Board for the Water Supply Enhancement Program – JDK800.10 – Pretreatment and Clarification – Detailed Design & Early Works. If you have any questions with regard to this submission, please do not hesitate to contact me.

Respectfully submitted,



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Date: 2023.06.02 11:41:32 -03'00'

Louis de Montbrun, CPA, CA
Acting General Manager and CEO

Attachments:

1. Preliminary Design Report
2. Project Charter including preliminary design site plans

Water Supply Enhancement Program

J.D. Kline Water Supply Plant

JDK800.10 - Pre-Treatment and Clarification

Design Report

CBCL Hazen

Halifax Water

JDK800.10 • September 2022

Rev 00	Preliminary Design		09/01/2022	MPC
Issue or Revision		**Reviewed By:**	**Date**	**Issued By:**

CBCL

Project No. 200800.10

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1 Introduction

1.1 Background

Halifax Water (HW) operates nine water treatment plants, which includes three large Water Supply Plants (WSPs) and five additional community supply plants that supply drinking water to 360,000 customers throughout the Halifax Regional Municipality (HRM). The J. Douglas Kline Water Supply Plant (JDKWSP) is the largest WSP in Atlantic Canada with a design capacity of 220 MLD (58 MGD) and servicing approximately 201,000 customers in the communities of Halifax, Bedford, Lower Sackville, Fall River, Waverley, and Timberlea. The existing JDKWSP treatment train consists of the following processes:

Chemical Addition and Mixing

- Three rapid mix tanks in series.
- Lime ($Ca(OH)_2$).
- Potassium permanganate ($KMnO_4$).
- Aluminum sulphate (alum).
- Carbon dioxide (CO_2).
- Pre-chlorination (discontinued from 2013-2018).
- Non-ionic polymer is dosed in colder months (December to May).

Flocculation

- Four parallel trains, three-stage flocculators.

Multi-Media Filtration

- Eight dual media rapid filters.

Post Filtration Chemical Addition

- Chlorine, pH adjustment (sodium hydroxide), corrosion control (orthophosphate), and fluoride (hydrofluorosilicic acid).

Commissioned in 1977, the WSP has reached the end of its initial design horizon and is entering a period of major capital renewal, upgrades, and enhancements. These upgrades are being driven by climate change and lake recovery, aging assets, ongoing treatment plant performance requirements, and an increasingly stringent regulatory environment. Through several studies and assessments completed by HW, Hazen, and CBCL, large scale capital projects have been identified for JDKWSP and a Capital Improvement Plan (CIP) has been developed. To streamline the large capital upgrades identified, HW initiated the Water

Supply Enhancement Program (WSEP). The WSEP is an overall system wide WSP capital program for the JDKWSP and Lake Major WSP (LMWSP), capturing 15 major capital upgrade projects over a 10-year operating period.

As JDKWSP has operated as a direct filtration plant for the past 40 years, the addition of a clarification process to the treatment train was identified as a high priority in the assessments completed to meet the treatment and water quality challenges experienced by the facility. It was determined that the addition of Dissolved Air Flotation (DAF) was the most appropriate clarification treatment process to meet the operational challenges anticipated over the next operating period. The DAF upgrade at JDKWSP was assigned as a critical priority in the WSEP planning and will form the basis of upgrades at the facility, along with upgrades or improvements to the pre-treatment and plant wastewater flows.

Through the previous assessments (WSEP Project Charter (JDK-800.10) and Pre-Treatment and Clarification Predesign Report (MAJ_JDK800.10-REP-002)), the scope of the project and preliminary design parameters have been established. The scope of work presently includes:

- Addition of a new DAF-based clarification process.
- New storage and dosing systems for alum, permanganate, and polymer chemicals for pre-treatment.
- Addition of Filter-to-Waste (FTW) connections for the filters along with filter backwash recycle piping.
- Building envelope for process areas and increased lab, office, and pilot plant facilities.
- Significant electrical upgrades, including a new service entrance for the WSP.

The following Preliminary Design Report will expand on the work completed as part of the Pre-Design Report to further define the design parameters for the DAF upgrade project.

2 Water Quality & Treatment Objectives

2.1 Source Water Quality

The JDKWSP is supplied raw water from Pockwock Lake, an oligotrophic lake defined as containing low nutrient content, low turbidity, low pH and alkalinity, moderate organic concentrations, and typically clear water. Historical raw water quality data for JDKWSP between 2003 and 2020 was compiled and is summarized in Table 2.1. Over this period, the source water quality has seen a subtle, but gradual increasing trend in TOC, color, and pH. Since 2012, the occurrence of geosmin in the lake has been detected. The gradual changes result in a source water quality that varies from the original parameters used to design the WSP and has contributed to the current operational challenges currently experienced. As previously discussed in prior reports and assessments, the change in water quality has been attributed to the effects of lake recovery and climate change. With the current climate projections of increased temperature and precipitation in Nova Scotia, it can be expected that effects of lake recovery and climate change will become more significant over time and need to be considered in the design upgrades to the WSP.

Additional details and analysis on the source water quality can be found in the Pre-Design Report, MAJ_JDK800.10-REP-002.

Table 2.1: JDKWSP Raw Water Quality (as presented in MAJ_JDK800.10-REP-002)

Raw Water Quality Parameters	January 2003 - May 2020				
	Average	Range	5th Percentile	95th Percentile	Count of Datapoints
Turbidity (NTU)	0.4	0.0 – 2.0	0.1	1.0	6,102
TOC (mg/L)	3.2	0.3 – 4.5	2.6	4.0	74
Colour	18.2	4.4 – 72.3	10.0	26.1	4,898
Iron, Total (mg/L)	0.05	0.0 – 0.66	0.01	0.09	4,735
Manganese, Total (mg/L)	0.03	0.01 – 0.29	0.02	0.05	2,283
Aluminum, Total (mg/L)	0.07	0.01 – 0.64	0.03	0.11	4,887
Alkalinity (mg/L as $CaCO_3$)	1.2	0.3 – 2.5	0.5	2.5	71
UV254 (cm-1)	0.11	0.04 – 0.59	0.07	0.14	3,362
pH (pH units)	5.5	4.9 – 6.6	5.0	5.9	4,876
Temperature (°C)	12.4	0.2 – 25.7	3.7	22.3	4,888
Dissolved Oxygen (mg/L)	9.3	7.2 – 11.3	8.0	11.0	69

2.2 Treatment Objectives

Through the pre-design activities, treatment objectives were developed for the proposed upgrades. Current and future regulatory requirements, design and construction permitting, and operational goals were considered when determining the treatment objectives. The proposed upgrades will improve plant operations and efficiency while also helping the plant to meet regulatory and treatment goals:

- The addition of DAF is intended to remove most of the solids previously removed by the filters, improving filter performance by the reduced solids loading. This allows for longer filter run times and improved Unit Filter Run Volume (UFRVs).
- The addition of DAF will upgrade the plant from a direct filtration plant to a conventional filtration plant and allow for additional log removal credits due to the increased ability to treat for microbial contaminants.
- The filter-to-waste capability will further reduce microbial contaminant risk downstream of the filters by wasting filter effluent until the filters can sufficiently ripen.
- Improved TOC removal with DAF and lower potential to form disinfection by-products as effects of lake recovery continue in the source water.
- Addition of pre-oxidation tanks is to remove inorganics such as iron and manganese.
- DAF clarification in combination with potassium permanganate and chlorine will provide capabilities for the WSP to remove cyanobacteria cells and some extracellular cyanotoxins. Additional advanced treatments would be required to remove geosmin and MIB.

Table 2.2 and Table 2.3 represent the targets that would be expected to be achieved when operating the plant at the specified conditions. It is expected that these goals will be adjusted and optimized once the new facility is operational based on baseline system performance. The plants will continue to operate with the goal of meeting or exceeding all applicable NSE and Health Canada regulations.

Table 2.2: Operational Goals for Planned Upgrades

Parameter	Operational Goals	
	Average Conditions [1]	Challenging Conditions [2]
Oxidation pH	10.0	
Oxidation Reduction Potential	The target value will vary as it is dependent upon source water characteristics and preoxidants. The target value is expected to range between 300 and 600 mV	
Streaming Current / Coagulation pH	Streaming current values to help ensure optimized pretreatment as determined by jar testing and plant performance, pH: 6.3 – 6.8	
Filter Run Times	80 hours	>36 hours
UFRV	400 m^3/m^2 per run (10,000 gal/sf)	>300 m^3/m^2 per run (7,500 gal/sf)
Maximum Filter Headloss	2.15 m	
Clarified Water UV254 / TOC	Values to be determined based on raw water characteristics and treatment requirements	
Filtered Water UV254	<0.02/cm	
CWWW Recycle (CWWWR) Flow	Not to exceed 10% of instantaneous feed flow	
Floated Residuals Concentration	>2%	
Sludge Production Volume	<0.2% of total flow (by volume)	

Notes:

1 - Average conditions are defined as average flow and average water quality.

2 - Challenging conditions are defined as the maximum design flow and/or elevated water quality conditions.

Table 2.3: Treatment Goals Related to Plant Upgrades

Constituent	Regulatory Requirement	Operational Goal	Justification of Operational Goal
Turbidity			
Clarified Water Turbidity	-	< 0.5 NTU	Typical operating goal for DAF clarified water.
Filtered Water Turbidity	< 0.30 NTU; never to exceed 1.0 NTU[1]	< 0.10 NTU; never to exceed 0.3 NTU	Health Canada recommends that Filtration systems should be designed and operated to reduce turbidity levels as low as reasonably achievable and strive to achieve a treated water turbidity target from individual filters of less than 0.1 NTU.
Total Organic Carbon			
Filtered Water TOC	-	45% removal or < 2 mg/L	Typical removal target during normal operation to help achieve DBP goals.
Finished Water Colour	AO: ≤ 15 TCU	See regulatory requirements	
Disinfection By-Products			
Total THMs	0.1 mg/L	0.08 mg/L	
Total HAAs	0.08 mg/L, ALARA[2]	0.06 mg/L	
N-Nitroso dimethylamine (NDMA)	0.00004 mg/L	See regulatory requirements	
Bromodichloromethane	-	< 0.016 mg/L	Typical target
Inorganics			
Finished Water Total Iron	AO: ≤ 0.3 mg/L	< 0.3 mg/L	Target to maintain aesthetic goals.
Finished Water Total Manganese	MAC: 0.12 mg/L AO: ≤ 0.02 mg/L	< 0.015 mg/L	Target to maintain aesthetic goals.
Finished Water Total Aluminum	OG Value: 0.1 mg/L	< 0.05 mg/L	Target to maintain aesthetic and residuals goals.
Taste and Odour			
Taste	Other: Inoffensive	See regulatory requirements	
Odour	Other: Inoffensive	See regulatory requirements	

Notes:
1 - NSE / Health Canada requires < 0.30 NTU 1 in at least 95% of measurements either per filter cycle or per month; never to exceed 1.0 NTU.
2 – As Low as Reasonably Achievable.

2.3 Treatment Capacity

The technical memorandum "Design Treated Water Capacity Determination", as prepared as part of the pre-design activities, presented the rationale that was used to determine the design production capacity for the proposed upgrades. The proposed treatment capacity for the upgraded JDKWSP as agreed upon by HW and Hazen/CBCL is 145 MLD. The technical memorandum and pre-design report can be referred to for more details.

As outlined in the pre-design report, the treatment capacity of the upgrades will be 145 MLD, but the treatment processes will be designed based on an additional maximum allowance of up to 10% CWWWR. Full redundancy is not provided for the DAF basins, pre-mix tanks, flocculation tanks or backwash storage tanks, however, the design allows that individual tanks can be taken offline for maintenance or repair without negatively impacting the treatment plant performance. For future expansion, allowance for two future DAF trains has been included. Table 2.4 provides the minimum and maximum treatment capacities for the preliminary design. Figure 2.1 provided additional detail on the flows used within unit processes.

Table 2.4: JDKWSP Plant Flow Summary

Condition	Installed DAF Trains	Operating DAF units	Treatment Capacity (MLD)	Maximum Plant Recycle[1] (MLD)	DAF System Flow (MLD)	DAF Train Flow (MLD)
Initial Installation - Max Flow	6	6	145.0	14.5	159.6	26.6
Initial Installation - Min Flow		4	45.0	-	45.0	11.3
Future Expansion - Max Flow	8	8	193.0	19.3	212.4	26.6
Future Expansion - Min Flow		4	45.0	-	45.0	11.3

Notes:
1 – Maximum plant recycle is based on a 10% recycle allowance.

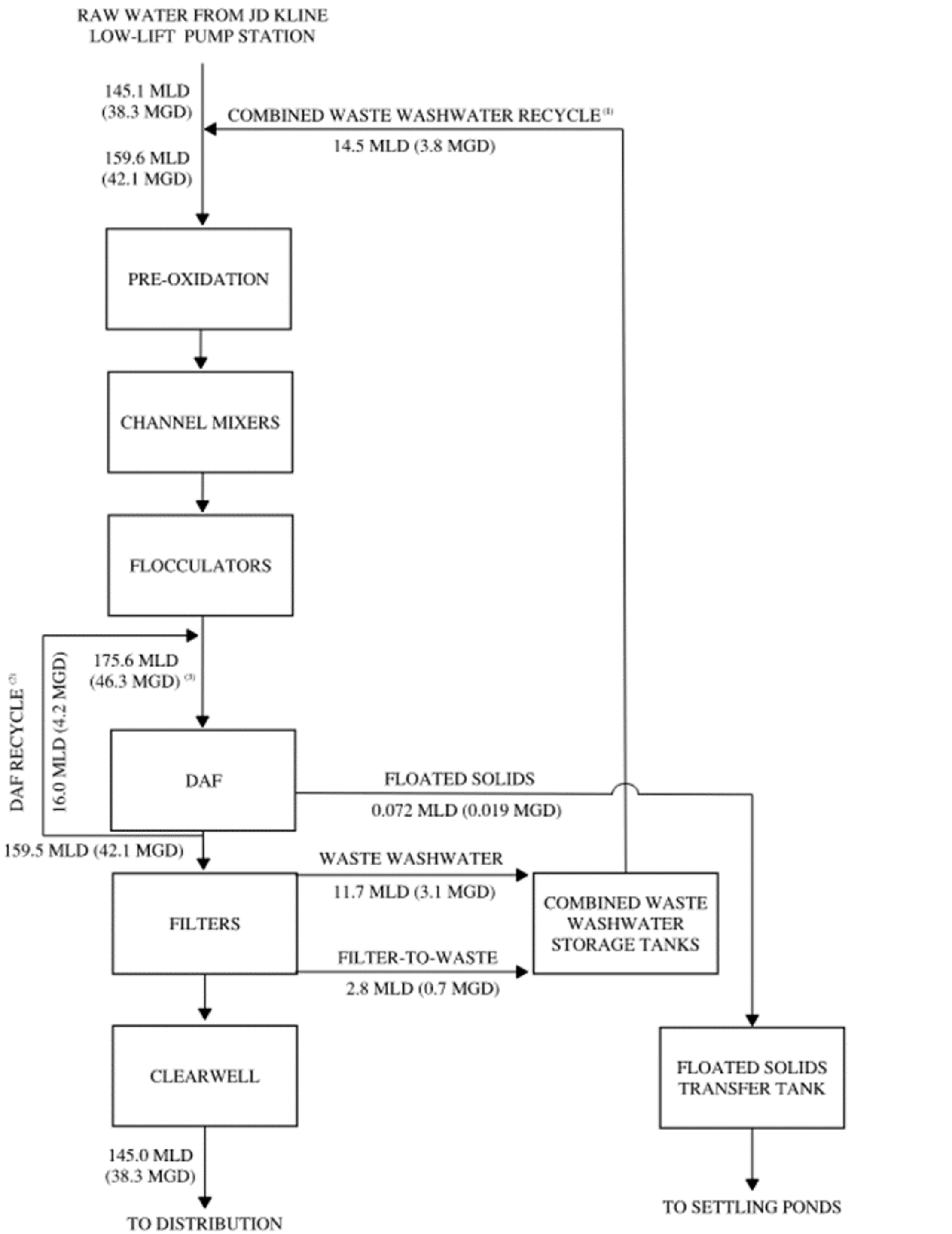
2.4 Process & Equipment Redundancy

As determined through the pre-design activities, the proposed equipment redundancy is described in Table 2.5. The "N" is the minimum required number of duty units capable of processing the design flow, and "N+" denotes additional equipment provided.

Table 2.5: JDKWSP Proposed Equipment Redundancy

Equipment Redundancy	
Pre-Oxidation Tank [1]	N+0
Channel Mixers	N+1
Floc / DAF Process Train Redundancy	N+0
DAF Recycle Pumps	N+1
DAF Recycle Strainer [2]	N+0
Saturators	N+1
Compressors	N+1
Compressed Air Receivers	N+1
Combined Waste Washwater Tank [3]	N+1
Combined Waste Washwater Pumps	N+1

Notes:
1 – The pre-oxidation tank is proposed to be provided with two sections. If maintenance is required, a section can be isolated.
2 – DAF recycle strainer will be provided with bypass piping and valving.
3 - CWWW tank will have two sections, with the total volume equal to two filter backwash volumes.



(1) CWWW recycle flows are calculated as maximum allowable 10% of the raw water flow (average conditioned expected is 4.6%).
(2) DAF recycle flows are calculated as 10% (can vary from 8-12%) of the raw water flow + CWWW recycle.
(3) The filter backwash interval is calculated as 60 hours and the unit filter run volume is 310 m3/m2 per run..
(4) The floated solids concentration is set at 2%.

Figure 2.1: JDKWSP Flow Schematic, Six DAF Trains

3 Water Treatment Process

3.1 Pre-Treatment

3.1.1 Pre-Oxidation Tank

The Water Research Foundation (WRF) Guidance for the Treatment of Manganese notes reaction times of two to four minutes for waters with a pH of 6 and greater; with increased reaction kinetics (lower required oxidation times) at higher pH. Dose, contact time, pH and temperature all impact the effectiveness of using potassium permanganate for oxidation of manganese. Doses can range as high as 1 mg/L and vary based on water quality and the point of application. Higher doses increase oxidation capabilities but must be carefully managed so that a permanganate residual does not remain in the water causing a pink colour. Higher temperature slightly increases the oxidation efficiency of potassium permanganate while a higher pH tends to significantly increase the oxidation capabilities.

Raw water pumped from Pockwock Lake's low lift pump station will combine with the Combined Waste Washwater (CWWW) recycle and flow to a pre-oxidation tank where lime and potassium permanganate will be dosed. The pre-oxidation tank will be equipped with a mechanical mixer to ensure chemical addition is dispersed uniformly. In accordance with the WRF guidance for the treatment of manganese, the tank is designed to accommodate a hydraulic detention time of 2 minutes at design flow and is sized based on the buildout flow of 212.4 MLD to minimize future construction and the number of future chemical dosing locations. The existing plant provides approximately 1.2 minutes of hydraulic detention time at design flow. For that reason, the new plant will provide additional time for oxidation to occur at elevated pH compared to the existing plant.

The pre-oxidation tank will be provided with two sections, either of which could be isolated for maintenance. In the case that a tank section is isolated and removed from service, the available HRT for manganese oxidation will be reduced. Maintenance could be scheduled at times of the year when flows are lower; however, the tanks have been sized for the maximum plant flow and a 10% allowance for the CWWWR flow and therefore, even with a tank out of service, oxidation times should be sufficient for most anticipated operating flows. An overflow located at the pre-oxidation tanks will provide overflow protection for the plant. Table 3.1 provides the design basis for the pre-oxidation tank.

Table 3.1: Pre-Oxidation Tank

Parameter	Design Basis
Design Maximum Flow (Raw Water + CWWWR) (MLD)	212.4
Hydraulic Detention Time (min)	2.3

3.1.2 Chemical Dispersion & Mixing

The purpose of the channel mixers is to disperse selected chemicals uniformly into the process flow stream prior to flocculation. Mechanical rapid mixers and static channel mixers were considered for the WSP. Based on the annual maintenance, higher capital cost, and power consumption associated with running a mechanical mixer, static mixers were selected. Static mixers are in-line or in-channel devices that do not have a motor, but rather imparts turbulence in the flow causing uniform chemical dispersion. In-channel static mixers were an ideal selection for this application based on their ability to uniformly disperse chemical additions across the full range of HW's design flows with little to no O&M costs.

Two dedicated chemical dispersion mixing channels will be located downstream of the pre-oxidation tanks; each channel containing two mixer stages. Figure 3.1 is a representative photograph of an in-channel static mixer manufactured by Komax Systems, Inc., one of the static mixer manufacturers that will be considered for this project.

Figure 3.1: In-Channel Static Mixer

Leaving the pre-oxidation tank, water will flow by gravity to the chemical dispersion mixing channel. Carbon dioxide solution will be dosed directly upstream of the first channel mixer with coagulant and polymer dosed directly upstream of the second stage. With a dedicated channel mixer for carbon dioxide solution and space between the channel mixers, the required chemical dispersion and mixing will be provided. The two stages of in-channel mixers will be sized to accommodate the plant's full range of design flow conditions.

Multiple channels will provide the plant redundancy and the flexibility to operate one or both mixing channels.

Each channel mixer will be equipped with a set of sparger-injection pipes located at the head of the mixer. Pre-treatment chemicals will be diluted with a "carrier water" stream prior to being dosed in front of the mixer. The mixers will be designed to provide a Coefficient of Variation (CoV) of 0.05 to ensure that the chemicals are properly dispersed. The design criteria for the static mixers are presented in Table 3.2.

Table 3.2: Static Mixer Design Criteria

Parameter	Design Basis
Design Maximum Flow (combined) (Raw Water + CWWWR) (MLD)	212.4
Design Maximum Flow per Mixer Train (MLD)	106.2
Design Minimum Flow per Mixer Train (MLD)	53.1
Type of Mixer	In-channel
Number of Channels	2
Number of Mixers per Channel	2
Channel Dimensions (L x W x Working Depth) (mm)	13,450 x 1,200 x 4,115
Expected Coefficient of Variance (CoV at 1–3 Hydraulic Diameters Downstream from Mixer Discharge)	0.05
Total Length of 1st Mixer Assembly (Including Spargers) (mm)	2,240
Total Length of 2nd Mixer Assembly (Including Spargers) (mm)	2,240
Maximum Headloss at 106.2 MLD per Train (m)	0.178
Minimum Flow Rate per Active Sparger	7.57 lpm (2 gpm)

Static mixers are generally designed around a CoV. CoV is a representation of the average deviation of chemical concentration on the entire flow profile (i.e., lower CoV indicates the chemical is more evenly distributed throughout the process flow). Static mixers are designed to demonstrate a CoV of 5% over the entire range of design flows. As plant flow rates decrease, velocities in the mixing channel decrease, therefore the design CoV needs to be met at minimum plant flow.

3.1.3 Flocculation

After leaving the chemical dispersion mixing channel, the water will transition into the mixed water channel. The mixed water channel will extend the full length of all six flocculation trains and will be designed to evenly distribute the process flow to each train. The inlet of each flocculation train will have a motorized butterfly valve to allow isolation of each train.

The purpose of flocculation is to provide contact time in an environment with a controlled velocity gradient to form floc particles which have the physical characteristics needed for removal by flotation. Flocculation creates collisions between particles, allowing the particles to agglomerate and form floc particles, which can be readily removed by the DAF clarification process. The mean velocity gradient (G) is a parameter used to describe the degree of agitation or energy induced for flocculation. As compared to conventional settling, flocculation prior to DAF requires a shorter period of time at a more intense velocity gradient to create smaller floc particles that more readily attach to bubbles and float to the surface of the DAF tank.

Each flocculation train will have the ability to treat a maximum flow of 26.6 MLD (7.0 MGD) which includes raw water flow as well as up to 10% CWWWR water. Each flocculation train will provide two stages of flocculation with a total minimum detention time of approximately 6.1 minutes (3.0 minutes per stage) at the maximum flow of 26.6 MLD. The equalization zone directly downstream of the flocculators and prior to the DAF injection zone will provide additional time for flocculation to occur. The total detention time, including the two flocculation stages and the equalization zone, will be approximately 9.7 minutes under maximum flow conditions.

Vertical hydrofoil-type flocculators will be provided. The motors will be located on the operating floor level of the new DAF Building and will be paired with VFDs to allow for adjustment of the desired energy transfer (enables mixing intensity (G value) between 60 and 100 sec^{-1}) under all flow conditions.

The design criteria for the flocculators are shown in Table 3.3.

Table 3.3: Flocculation Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) [1] (Raw Water + CWWWR)	159.6
Total Number of Flocculation Trains (Duty/Standby) [1]	6 (6/0)
Design Maximum Flow per Train (MLD) (Raw Water + CWWWR)	26.6
Number of Stages per Train	2
Hydraulic Detention Time per Stage (min) [2]	3.0
Total Hydraulic Detention Time (min) [3]	9.7
Minimum Volume Required per Stage (m^3)	56.1
Flocculation Basin Dimensions (L x W x H[4]) (mm)	3,700 x 3,700 x 4,100
Velocity Gradient, G, in Each Basin at 1°C (sec^{-1})	60 – 100
Impeller Type	Hydrofoil

Notes:
1 - The plant will be expandable to (8) total DAF trains through the addition of (2) DAF trains.
2 - Hydraulic detention time per stage is calculated based on the maximum flow and a 10% CWWWR.
3 - Total hydraulic detention time includes both flocculation stages and flow equalization zones and is based on the maximum flow per DAF train and a 10% CWWWR.
4 - Height listed is the water height (working elevation).

3.2 Clarification

DAF is a clarification process that removes flocculated particles from the process by attachment to microscopic air bubbles and floatation to the water surface. Coagulant addition and flocculation are still needed, but the goal of flocculation in this case is to produce a small floc that can be removed by attachment to micro-air bubbles. The typical design surface loading rate of the conventional DAF process usually varies between 14.5 to 19.5 m/hr (6 to 8 gpm/ft^2) - significantly higher than the loading rate on a conventional sedimentation basin and higher than the footprint loading rates for high-rate plate settlers. In addition, high-rate DAF processes have recently been developed at rates of 19.5 to 39.0 m/hr (8 to 16 gpm/ft^2). DAF is ideal for treating low turbidity waters and those with high levels of algae and/or NOM. DAF is more effective than conventional sedimentation in removing algae, *Giardia*, *Cryptosporidium*, and other low-density particles, since such contaminants generally tend to float. This is quite important in raw water with lower turbidities and particle counts, where DAF can increase filter runs and reduce backwash frequency compared to sedimentation processes. More recently, DAF has proven effective when applied to waters with instances of flash turbidity events. Typical outlet turbidities from a DAF clarifier under normal operating conditions are approximately 0.5 NTU.

To create the micro-bubbles, a supersaturated stream of water (8 to 12% of the total plant flow) is prepared by pressurizing the recycle water to 450 to 655 KPa (65 to 95 psig) and passing it through a packed tower. The pressurized recycled water is introduced to the inlet of the flotation tank through a pressure release device, typically fixed orifice nozzles. The nozzles are mounted on the manifolds; as the DAF recycle stream passes through the nozzles, the pressure is reduced to atmospheric pressure. As a result of the pressure drop, the supersaturated air in the pressurized DAF recycle water comes out of solution, and micro-bubbles are formed.

The DAF recycle is injected to the inlet of the flotation tank, where the flocculated water enters the DAF tank. The micro-bubbles contact and attach to the flocculated particles. The resultant bubble/floc aggregate rises to the surface of the tank and forms a foam called "float." The float is periodically removed by skimming the surface with a mechanical scraper or by hydraulic desludging. The mechanical skimming results in a denser floated solids concentration – about 2% solids by weight, while the hydraulic desludging, collects much more water along with the sludge, resulting in a floated solids stream with 0.5% solids by weight. The method for sludge removal is dependent on the downstream residual treatment or disposal options. A schematic of the DAF process is presented in Figure 3.2.

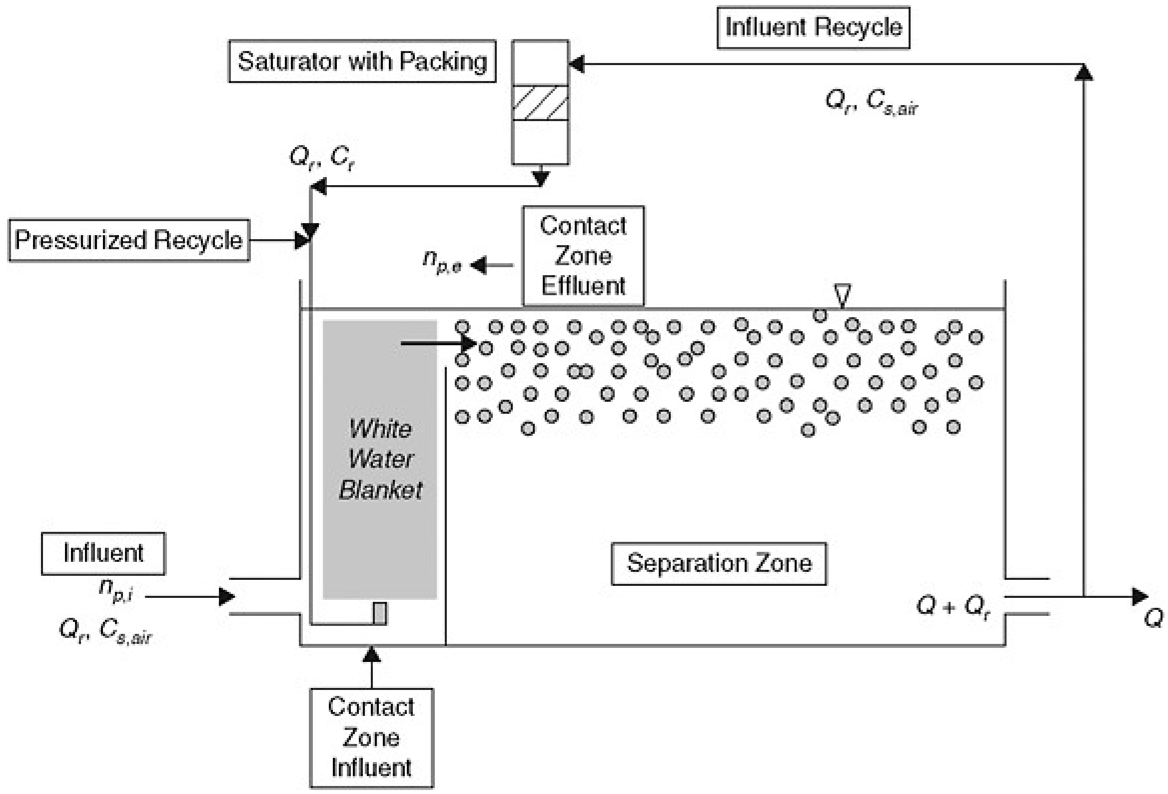


Figure 3.2: Schematic of DAF System (Edzwald, 2011)

3.2.1 Process Basin Design

The DAF basins will be sized for a nominal design loading rate of 19.3 m/hr (7.9 gpm/sf) with all six basins in service at a flow of 26.6 MLD (7.0 MGD) per DAF basin. These flows and loading rates include an allowance for up to a 10% CWWWR stream.

Water will exit the second stage of flocculation through a submerged port, pass over a submerged baffle wall, and enter the first and second flow equalization zones. These zones are used between the flocculation basins and DAF injection zone to equalize the variation in flow velocities and eliminate any turbulence prior to entering the DAF basin. The process water will then flow under a baffle and into the DAF injection zone. The saturated DAF recycle flow will be injected through piping to nozzle manifolds near the bottom of the DAF injection zone. The combined water will then travel over a submerged baffle wall into the DAF basins. This flow path will ensure mixing and contact between the microbubbles and flocculated water.

Floated water collector pipes will be located 1 ft off the floor of each DAF basin and will convey the floated water to a dedicated floated water outlet channel for each DAF unit. The water will flow over the DAF control weir, into the common floated water channel where it will flow through piping to the existing filter building and filter feed channels.

Loading rates and flow rates are defined using the entire surface of the DAF basin and contact zone, and the flows used to define the loading rates exclude the DAF recycle flow contribution. DAF basin design criteria are presented in Table 3.4.

Table 3.4: DAF Process Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) [1] (Raw Water + CWWWR)	159.6
Total Number of DAF Trains (Duty/Standby)	6 (6/0)
Design Maximum Flow per Train (MLD) (Raw Water + CWWWR)	26.6
Minimum Design Flow per Train (MLD)	11.3
Tank Dimensions (L x W) (mm)	7,400 x 7,700
Tank Area (m^2)	57.4
Loading Rate at 26.6 MLD (m/hr)	19.3
Minimum DAFR Air Content of Inflow (g/m^3)	9.0
Skimmer Type	Chain and flight mechanical skimmer

1 - The plant will be expandable to eight total DAF trains through the addition of two DAF trains.

3.2.2 DAF Recycle & Saturation

The DAF recycle system is designed to deliver air to the main process flow at a minimum of 9.0 g/m^3 at all raw water flow rates. The raw water temperature generally ranges from 1°C to 25°C. At all anticipated temperatures, solids concentrations, and plant flow rates, 10% recycle flow will be sufficient to provide 9.0 g/m^3 at saturator pressures above 450 kPa. That said, the recycle system will be designed around a maximum of 12% recycle at 655 kPa pressure in the saturators to allow for operational flexibility. A range of recycle flows will be provided to optimize bubble concentration.

The DAF recycle system will be designed to accommodate the current design of six DAF trains and will be expandable by adding an additional DAF recycle pump to support the future expansion to eight total DAF units. The DAF recycle system piping will be designed to accommodate the future plant flows associated with eight DAF trains to minimize future expansion costs.

3.2.2.1 DAF Recycle Pumps

DAF recycle pumps will be supplied water from the floated water channel and will pump DAF recycle through the saturator and into the DAF injection zone. A portion of the recycle flow will be used for spray bars at both the skimmer and the floated solids channel to wash down the solids as the skimmer “pulls” the float into the floated solids channel. An automatic strainer will be placed on the discharge piping of the pumps to protect the downstream saturators. Table 3.5 summarizes the design criteria for the DAF recycle pumps.

Table 3.5: DAF Recycle Pump Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) [1] (Raw Water + CWWWR)	159.6
Total Number of Pumps (Duty/Standby/Future) [1]	5 (3/1/1)
DAF Recycle (%)	8 to 12
Total Maximum DAF Pump Flow (lpm) (Maximum Design Flow x 12% Recycle Rate + Spray Bar Flow)	13,480
Total Minimum DAF Pump Flow (lpm) (Minimum Design Flow x 8% Recycle Rate)	2,500
Max Spray Water Flow (lpm)	190
Primary Design Flow (lpm)	4,495
Primary Design TDH (m of water)	74
Secondary Design Flow (lpm)	2,780
Secondary Design TDH (m of water)	71
Maximum Shut-Off Head of Pump (m of Water)	105 (150 psi)

1 - The DAF recycle pumps will be initially designed to support the 6 DAF train plant, with an allowance for up to a 10% CWWWR flow. The design will be expandable to support 8 DAF trains by adding an additional pump.

The DAF recycle pumps will have a shutoff head of less than 105 m of water, the maximum design pressure for the saturators, to protect the vessels from exposure to water pressures greater than they are rated for and to minimize costs of the saturator pressure vessels. The recycle system piping will be 316 L stainless steel. Each pump will be fitted with a VFD, so that the recycle flow can be modulated over the range of all plant flows.

3.2.2.2 DAF Saturator

Each saturator will be approximately 2.75 m in diameter and approximately 5.6 m tall (including concrete pad and structural supports). The saturator diameter was designed such that the loading rate will not exceed 185 m/hr (75 gpm/sf) at the maximum plant flow. The height of the saturator is sufficient to provide 1.8 m of packing depth, an operating band for the saturated water operating level, plus space for dispersal and collection manifolds. Packing material will be approximately 90 mm in diameter, with a specific packing area of 38 sf/cf. DAF saturator design criteria are presented in Table 3.6.

Table 3.6: DAF Saturator Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	212.4
Number of Saturators (Duty/Standby)	2 (1/1)
Type of Saturator	Packed
Diameter of Saturators (m)	2.75
Nominal Depth of Packing Media (m)	1.8
Minimum Specific Area of Packing Media (ft^2/ft^3)	38

3.2.2.3 Automatic Self-Cleaning Strainer

An automatic self-cleaning strainer will provide continuous particle removal from the DAF recycle stream. This process will effectively protect equipment such as valves, pumps, flow meters, and/or spray nozzles from potential high solids loading during DAF recycle operation. Table 3.7 summarizes the design criteria for the DAF recycle stream automatic self-cleaning strainer. Bypass piping around the strainer with valving will be provided to allow for strainer maintenance. To minimize future expansion construction cost and complexity, the strainer and associated pipework will be designed to accommodate flows associated with eight DAF trains.

Table 3.7: DAF Recycle Automatic Self-Cleaning Strainer Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD)[1] (Raw Water + CWWWR)	212.4
Total Number of Strainers (Duty/Standby)	1 (1/0)
Design Flow (Total Maximum DAF Recycle Pump Flow) (lpm)	17,720
Design Working Pressure (kPa)	1,000
Design Working Temperature (°C)	65
Maximum Clean Pressure Drop at 0% Clogged (kPa)	3.5
Diameter of Flanged Unit (mm)	400
Material of Construction	Fabricated carbon steel

1 – The strainer will be designed to support the eight DAF train plant design.

3.2.2.4 Compressed Air

A compressed air system is required to supersaturate the DAF recycle flow in the saturator. The compressors, air receivers, and air filters will condition and supply air to the saturators.

To minimize future expansion cost and to minimize total plant footprint, the air compressors will be sized for the future maximum plant which includes an allowance of 10% CWWWR. Oil-free rotary screw compressors will be used for the process to ensure that no hydrocarbons enter the water.

The two compressors will feed two air receivers with two sets of two-stage (coalescing and particulate) air filters provided downstream of the receivers. This air treatment will remove small particulates from the air to avoid introducing contamination into the process flow. DAF compressed air system design criteria is presented in Table 3.8.

Table 3.8: DAF Compressed Air System Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	212.4
Total Number of Compressors (Duty/Standby)	2 (1/1)
Type of Compressor	Oil-free rotary screw
Capacity at 8 Bar (m^3/min)	6.6
Number of Air Receivers (Duty/Standby)	2 (1/1)
Receiver Volume (m^3)	8

3.2.3 DAF Floated Solids Removal

Solids floated in each DAF basin will be removed by chain and flight skimmers. Each DAF basin will be equipped with a chain and flight skimmer, and a common concrete collection channel. The mechanical skimmers will operate by periodically "pulling" the blanket of floated solids over a floated solids sludge beach and into the collection channel. Low pressure spray bars above the skimmer will be used to ensure the solids enter the channel and break any adhesion between the skimmer and float. The collected floated solids, made up of 2-3% solids, will flow through the common floated solids channel to the floated solids transfer tank, prior to being directed to the existing settling ponds via two (one duty/one standby) floated solids transfer pumps.

The floated solids mechanical skimmers will operate approximately every two to six hours, for a total of four to twelve times per day. The frequency and duration of each scrape are adjustable to accommodate changes in raw water quality, flow rate, and amount of solids being produced at any given time. Operators can increase the frequency and duration of each scrape during periods of increased flow rate and/or decreased water quality due to spikes in turbidity, TOC, etc.

3.3 Combined Waste Washwater Recycle

Filter waste backwash water currently leaves the filters through plant wastewater conduits and a 1,200 mm pipe which leaves the facility. This pipe runs parallel to the plant and reservoir, connects to the reservoir overflow, reduces to 900 mm pipe, and is then routed down to the two settling ponds. Overflow from the rapid mix tanks is also directed to the settling ponds through this piping. The JDKWSP does not currently filter-to-waste following filter backwashing. Considering the filter ripening period creates the potential for lower quality effluent, many regulatory agencies require or look favorably on filtering-to-waste following a backwash. Filtering-to-waste is also generally considered good practice and will help ensure that the highest quality finished water is delivered to customers.

Settling pond effluent is discharged to the receiving environment. Spent filter waste backwash water is a dilute, high volume waste stream. This is a concern as the existing treatment lagoons do not presently perform as needed with aluminum concentrations leaving the settling ponds currently exceeding the 0.16 mg/L NSE requirement.

Recycling filter waste backwash water is a frequently adopted technique to decrease waste discharge and increase plant efficiency. The implementation of clarification paired with filtering-to-waste will allow for a much less dilute residuals stream entering the settling ponds and will also eliminate potential filtered water quality concerns immediately following a backwash sequence. By incorporating backwash recycle and minimizing flow to the settling pond, not only will the plant be more efficient, but the settling ponds will receive reduced volumes of wastewater (but the same mass of solids).

3.3.1 Backwash Capture & Storage

CWWW (WBW and FTW) will be conveyed to the CWWW tank and will be recycled to the head of the plant (prior to the pre-oxidation tank) to reduce the volume of wasted water discharged through the settling ponds and to the environment. Waste residuals will leave the plant in the form of DAF floated solids. The DAF floated solids residual waste stream will be stored in a separate floated solids storage tank and discharged to the settling ponds.

New wastewater conduits will be constructed to convey filter backwash waste washwater from the existing plant to the CWWW tank. The eastern clearwell will be removed from service and the space utilized to install filter-to-waste piping. Filter-to-waste water will be routed from this piping to the CWWW tank via the new wastewater conduits.

3.3.2 Combined Waste Washwater Tank

The CWWW tank is sized to store a minimum volume of WBW and FTW from two backwash cycles. For the purposes of sizing the CWWW tank, the total volume of WBW water generated by a filter backwash was estimated multiple ways. 10 States Standards recommends a minimum backwash duration of not less than 15 minutes at the design rate of wash and a minimum backwash rate of 15 gallons per minute per square foot (37 m/hr). This equates to a waste backwash volume of 1,335 m^3. A typical backwash profile was also generated for the project to determine the anticipated amount of wastewater that should be produced by a backwash cycle. Using the projected backwash profile, it was estimated that the backwash cycle would produce a waste backwash volume of 1,260 m^3. The larger of the two estimated WBW water volumes is used as a conservative design estimate; therefore, a volume of 1,335 m^3 was used to estimate the waste backwash water volume. This volume exceeds the waste backwash water volumes noted in the AECOM *J.D. Kline Water Treatment Plant Filtration Study*; however, the same report also notes concerns with the duration of peak backwash flow and that the filters could be under-washed. Sizing the CWWW tank as described above is a conservative approach that will allow for future modification of the backwash sequence, if determined to be required. For the purposes of sizing the CWWW tank, the total WBW water volume for two backwash cycles is, therefore, estimated to be approximately 2,670 m^3.

Filter ripening volume can be estimated using either the anticipated number of filter bed volumes wasted during ripening and the filter bed volume or the estimated FTW duration and the FTW rate. The AECOM *J.D. Kline Water Treatment Plant Filtration Study* notes that the filter at the JD Kline WSP each contain 145.67 m^2 of filter area. Additionally, media depths are 610 mm of anthracite and 305 mm of sand. This would translate to a total bed volume of 133.1 m^3. Based on this filter bed volume and assuming 2.5 bed volumes are wasted during ripening, the FTW water volume produced during a single ripening cycle is approximately 335 m^3. Storage tank volume capacity for the FTW water can also be estimated using the filter loading rate and the estimated duration of the ripening period. Based on a maximum loading rate of 8.7 m/hr at 213 MLD and an estimated ripening duration of 15 minutes, the required FTW water storage volume is approximately 316 m^3. The larger of the two estimated FTW water volumes is used as a conservative design estimate during design. The conservative design volume of FTW water is, therefore, approximately 335 m^3 and the total FTW water volume for two backwash cycles is estimated to be approximately 670 m^3.

Additionally, the CWWW tank has been sized to accommodate dump and drawdown volumes associated with one unit. The intent is to enable back-to-back backwashes in the event of an upset condition by having volume in the CWWW tank available for this water as opposed to needing to filter to these elevations. Dump and drawdown volume allows for the capability to quickly backwash filters back-to-back by allowing the volume above the trough (dump volume) and the volume from the top to just above the media (drawdown) to be wasted to the CWWW tank. The total volume associated with these volumes is 250 m^3.

Based on the above, the total CWWW tank volume must be sufficiently sized to contain a total volume of 3,590 m^3.

3.3.3 Pumping & Mixing

The CWWW tank will be divided into two sections with the two sections connected through a sluice gate. There will be a total of four guiderails installed for submersible pumps.

The pumps will convey the CWWW to the head of the treatment plant upstream of the pre-oxidation tank. The minimum and maximum rate of the recycled stream is 10% of the minimum and maximum raw water flow, respectively. The CWWW pumps will be expandable by adding additional pumps to accommodate the eight DAF train plant. The CWWW tank and piping will be sized for the future 8 DAF train plant to minimize major construction for the expansion. The design criteria for the recycle pumps are summarized in Table 3.9.

Table 3.9: Combined Waste Washwater Recycle Pumps

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Total Number of Recycle Pumps (Duty/Standby) [1]	2 (1/1)
Type of Pump	Submersible, VFD
Maximum Allowable Design Flow (LPM)	11,085
Minimum Design Flow (LPM)	3,475

1 – The CWWWR pumps will be designed to support the six DAF train plant and expandable to meet the eight DAF train design by adding additional pump(s).

The *USEPA Filter Backwash Recycle Rule* requires that recycle streams be introduced at a point in the treatment plant that incorporates all treatment processes such that the opportunity for recycle practices to adversely affect plant performance is reduced. The recycled water will be introduced at the head of the plant (upstream of the pre-oxidation tanks) and will be recycled at a rate of less than 10% of the raw water flow entering the plant. The plant control system will be setup to inhibit recycle flow in excess of 10% and will aim to meter in the recycled water to reduce flow variation. The submersible pumps will utilize VFDs and will be controlled using a flow meter located in the CWWWR piping.

The CWWW tank will have a slope at the bottom of the tank to facilitate the pumping of settled solids. The CWWW tank will be fitted with two submersible mixers to maintain solids in suspension.

3.3.4 Tank Isolation & Maintenance

As described above, the CWWW tank will have two separate compartments, each sized to accommodate the volume of WBW water and FTW water produced from a backwash. Each compartment will have isolation valves to remove the compartment from service for maintenance. It is anticipated that under normal operation, both compartments within the tank would be utilized, providing storage for the waste volumes produced from at least two backwash cycles. The tank will be provided with overflow which will combine with the plant overflow.

3.4 Residual Storage & Disposal

The primary purpose of the new water treatment processes is to remove particulate matter and dissolved material from the raw water. Most of the particulate matter and dissolved material will be removed by the chemical coagulation and flocculation process to form flocculated solids, which will then be removed through the DAF process. DAF can remove approximately 90-95% of solids applied to the treatment process by floating the flocculated solids to the surface of the DAF tanks.

The DAF process removal efficiency was conservatively estimated to be 95%. Floated solids skimmed from the DAF units are expected to be approximately 2-3% solids (20,000–30,000 mg/L) concentration by weight during normal operation, based on data collected from existing DAF unit installations utilizing mechanical sludge removal mechanisms.

3.4.1 Solids Load Analysis

Calculation guidelines[1] presented in various publications of the United Kingdom's Water Research Centre (WRC), as shown by Equation 1, were used to estimate the anticipated raw water solids concentration entering the treatment process after the addition of chemical coagulants.

Equation 1: Solids = Turbidity + Coagulant + Colour + Polymer

Solids (mg/L) =

(2.000 * Raw Water Turbidity, NTU) +
(0.234 * Added Coagulant Dose, mg/L as alum) +
(0.200 * Raw Water Apparent Colour, cu) +
(1.000 * Added Polymer Dose, mg/L as product)

The raw water turbidity and apparent colour values used to calculate the solids load were based on the raw water quality data. The coagulant doses used to calculate the solids load are based on using a correlation of 6.6 to 7.2 mg/l alum per mg/L TOC, as described by Edzwald and Kaminski[2].

Using the anticipated solids concentration entering the treatment process, assumed process removal efficiencies, and the design flow rates for the plant presented in earlier sections, mass balance calculations were completed to estimate the quantity and quality of each residual waste stream produced by the plant.

3.4.2 Floated Solids Waste Stream

Table 3.10 presents the estimated residuals for a range of flow rates and water quality conditions and for both 2% and 3% estimated floated solids concentration by weight. Based on the results of the mass balance calculations, the DAF process with 95% solids removal efficiency is estimated to produce floated solids with an approximate average solid loading rate of 1,440 kg/day and corresponding flow rates of 72,125 LPD and 48,085 LPD for 2% and 3% solids, respectively, when operating at the maximum raw water plant capacity of 145 MLD and average water quality conditions.

[1] Dillon, G. (1997) Application Guide to Waterworks Sludge Treatment and Disposal (TT0016). Water Research Centre

[2] Edzwald, J.K. & Kaminski, G.S., 2008. A Practical Method for Water Plants to Select Coagulant Dosing. *Journal NEWWA*

Table 3.10: Estimated Floated Solids Concentration

Parameter	Design Condition			
Design raw water flow condition (MLD)	Min, 45	Avg, 82	Max, 145	Max, 145
Raw water quality condition	Min WQ	Avg WQ	Avg WQ	Max WQ
DAF solids load (kg/day)	325	860	1,520	2,030
2% Floated solids concentration				
Floated solids flow (LPD)	15,500	40,790	72,125	96,480
Floated solids (kg/day)	310	815	1,440	1,930
3% Floated solids concentration				
Floated solids flow (LPD)	10,300	27,190	48,085	64,320
Floated solids (kg/day)	310	815	1,440	1,930

3.4.3 DAF Float Capture & Storage

The floated solids will be removed by mechanical skimmers that scrape the solids over an inclined or curved "beach" and into a collection trough. Each DAF basin will be equipped with a rotating chain and flight skimmer, and a common concrete collection channel located on one side of the DAF basins. Based on review of similar installations, the collected float and water mixture in the trough is expected to be approximately 2-3% solids (20,000-30,000 mg/L) concentration by weight during normal operation of the plant and will not undergo additional thickening. The collected floated solids, made up of 2-3% solids, will flow through the common floated solids channel to the floated solids transfer tank

A Floated Solids Transfer Tank is a small tank used to temporarily store solids produced until the solids can be pumped to the settling ponds. The tank has been sized to store two scrapes worth of the maximum solids production estimated at a maximum raw water design flow, average raw water quality, and 2% solids floated concentration. Based on a maximum scrape volume of 2.6 m^3, the floated solids transfer tank must be sufficiently sized to contain a total volume of at least 5.3 m^3.

Two submersible pumps (one duty, one standby) will operate as floated solids transfer pumps to move the floated solids from the floated solids transfer tank to the settling ponds. The floated solids transfer pumps will operate intermittently; transfer pump design criteria are included in Table 3.11.

Table 3.11: Floated Solids Transfer Pumps Design Criteria

Parameter	Design Basis
Type of Pump	Submersible Pumps
Design Flow (LPM)	270
Pump Redundancy	N+1
Total Number of Pumps (Duty/Standby)	1/1

3.5 Chemical Feed Systems

Throughout the previous assessments and pre-design report, upgrades to the chemical feed systems were deemed critical to the pre-treatment and DAF processes, along with the overall treatment plant performance. With recent upgrades to the WSP, it was determined that modifications or new systems would be necessary for the potassium permanganate, coagulant (aluminum sulphate), polymer, fluoride, caustic and orthophosphate chemicals. Upgrades to the carbon-dioxide, lime and chlorine dosing systems are not included in the scope of work at this time, but modifications to the chlorine storage room to improve accessibility have been included.

3.5.1 Aluminum Sulphate

The new aluminum sulphate (alum) system will be located in the DAF expansion building, to the rear of the new chemical amenity area. The alum will be stored in three 75 m^3 FRP tanks, located inside a secondary containment berm. This provides a total 225 m^3 of chemical storage and 30 days capacity at the design maximum flow and typical average dose. Should the facility change to using Polyaluminum Chloride (PACl) in the future for coagulant, the FRP tanks would continue to be compatible. The secondary containment will be made up of three of the chemical room walls and a concrete berm constructed in front of the tanks. The containment volume is sized to hold 125% of the capacity of one of the storage tanks i.e., 94 m^3. The containment area and containment berm wall will be epoxy coated and will include a sump for washdown and chemical removal. The containment area will be equipped with a level switch, to indicate potential loss of containment. FRP grated platform will be constructed for access to the containment area and be accessible via stairs. The platform will straddle the containment berm wall and will be equipped with access steps up to the platform, and down into the containment area. The containment area floor will be 1.0 m below the elevation of the chemical room floor slab.

A 75 mm fill port, with quick connect camlock fitting, will be located on the exterior wall for receiving chemical deliveries and will be fitted with check valve and diaphragm valve to ensure no flow reversal following delivery truck disconnection and to provide fill line restriction to control the delivery rate, respectively. The fill pipe work will be 75 mm Schedule 80 PVC piping and will traverse over the fluoride area towards the alum bulk tanks. Near the platform, the fill pipe will be manifolded to provide individual tank fill pipes, each equipped with an electrically actuated valve. Control of the actuated valves will be by manually operated hand switches to open/close the respective valves. Switches will be readily accessible from the platform, in line of sight of the actuated valves so that the position indicators can be monitored. It is intended that the WSP will receive bulk chemical deliveries in 22 m^3 tanker loads. At the design maximum plant flow and design chemical dosing rate, the storage volume provided will be available to receive a tanker delivery every 3 days. The tanks are sized so that each chemical delivery would fill 1/3 of a bulk tank. It is estimated that each tank has sufficient volume to provide one week storage of alum. If delivery is not on a three-day rolling schedule, a full bulk tank can be filled every 9-10 days using three delivery tankers.

Each tank will be equipped with a sight glass and ultrasonic level sensor to determine chemical levels in the tank. Signals from the ultrasonics will be communicated back to SCADA for monitoring.

Aluminum sulphate will be dosed as directly from the bulk storage tanks using three peristaltic pumps acting on a duty/duty/standby basis. The chemical will be able to be dosed at two different points within the mixing channel. The peristaltic pumps will be located within the containment area. This will allow for leaks/spills from the pumps to be captured within the containment area. The pumps will be flow paced and the dose will be set manually by the operators using SCADA or the local HMI.

Aluminum sulfate is corrosive and proper ventilation for the chemical room is required. A dedicated exhaust fan for the aluminum sulfate storage area will be installed, with a minimum exhaust rate of 7.5 lC/s-m². An emergency shower will be located beside the dosing pumps. As noted above

The aluminum sulphate system design criteria are presented in Table 3.12.

Table 3.12: Aluminum Sulphate Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Design Chemical Dosing Rate (mg/L)	40[1]
Design Daily Usage (m^3/day)	5.8
Total Chemical Storage (m^3)	225
Storage Capacity (days)	38
Number of Storage Tanks	3
Volume of Individual Tanks (m^3)	75
Dimensions of Tanks	4.2 m dia x 6.1 m H
Secondary Containment Volume (m^3)	94
Material of Tanks	FRP
Pump Type	Peristaltic
Frequency of Deliveries (days)	3

1 - Dosage is expressed in mass of aluminum-sulfate not mass of liquid commonly used by HW operations.

3.5.2 Fluoride

The new fluoride system will be located in the DAF expansion building, in a dedicated fluoride room within the chemical amenity area. The hydrofluorosilic acid will be stored in two 18 m³ FRP or PE tanks, located inside a secondary containment berm. This provides a total 36 m³ of chemical storage, and enough storage to receive 150% of a tanker truck delivery (assumed 22 m³ delivery). At the design maximum flow and typical average dose, this provides 83 days chemical storage capacity.

The secondary containment will be made up of three fluoride room walls and a concrete berm constructed in front of the tanks. The secondary containment area is sized to hold 125% of the capacity of an individual storage tank, which equals 22.5 m^3. The containment area and containment berm wall will be epoxy coated and will include a sump for washdown and chemical removal. The containment area will be equipped with a level switch, to indicate potential loss of containment. FRP grated platform will be constructed for access the containment area and be accessible via stairs. The platform will straddle the containment berm wall and will be equipped with access steps up to the platform and down into the containment area.

A 75 mm fill port with camlock fitting will be located on the exterior wall for receiving chemical deliveries and will be fitted with a check valve to ensure no flow reversal following delivery truck disconnection. A diaphragm valve will also be included to provide fill line restriction to control the delivery rate. The fill pipe work will be 75 mm Schedule 80 PVC piping. The fill pipe will be manifolded to provide individual tank fill pipes, each equipped with an electrically actuated valve. Control of the actuated valves will be by manually operated hand switches to open/close the respective valves. Switches will be readily accessible from the platform, in line of sight of the actuated valves so that the position indicators can be monitored. It is intended that the WSP will receive bulk chemical deliveries in 22 m^3 tanker loads. At the design maximum plant flow and design chemical dosing rate, it is estimated that a full tanker load could be delivered every 55-60 days.

Each tank will be equipped with a sight glass and ultrasonic level sensor to determine chemical levels in the tank. Signals from the ultrasonics will be communicated back to SCADA for monitoring.

Hydrofluorosilic acid will be dosed as direct chemical from the storage tanks to the clearwell. Three peristaltic pumps acting on a duty/duty/standby basis will be used and will be located within the containment area. This will allow for leaks/spills from the pumps to be captured within the containment area. The pumps will be flow paced and the dose will be set manually by the operators using SCADA or the local HMI.

Proper ventilation for the chemical room is required. A dedicated exhaust fan for the fluoride storage area will be installed, with a minimum exhaust rate of 7.5 l/s-m^2. An emergency shower will be located beside the dosing pumps.

The fluoride system design criteria are presented in Table 3.13.

Table 3.13: Fluoride System Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Design Chemical Dosing Rate (mg/L)	0.7
Design Daily Usage (m^3/day)	0.4
Total Chemical Storage (m^3)	36
Storage Capacity (days)	83
Number of Storage Tanks	2
Volume of Individual Tanks (m^3)	18
Dimensions of Tanks	2.6 m dia x 3.9 m h
Secondary Containment Volume (m^3)	45
Material of Tanks	FRP or PE
Pump Type	Peristaltic
Frequency of Deliveries (days)	55

3.5.3 Sodium Hydroxide

The new sodium hydroxide (caustic) system will be located in the previous alum room in the existing building. The room will be cleared of the existing chemical systems. Provisional space for future polymer system will also be included in this room. The sodium hydroxide will be stored in three 33 m^3 carbon steel tanks, located inside a secondary containment berm. This provides a total 99 m^3 of chemical storage and approximately 30 days capacity at the design maximum flow and typical average dose. The tanks and piping will be heat traced to maintain a chemical temperature above 15°C.

The secondary containment area will be made up of four containment berm walls constructed around the storage tanks. The secondary containment berm is sized to hold 125% of the capacity of an individual storage tank and has been sized for 45 m^3. The containment area and containment berm walls will be epoxy coated and will include a sump for washdown and chemical removal. The containment area will be equipped with a level switch, to indicate potential loss of containment. FRP grated platform will be constructed for access the containment area and be accessible via stairs. The platform with straddle the containment berm wall and will be equipped with access steps up to the platform, and down into the containment area.

A 75 mm fill port with camlock fitting will be located on the exterior wall for receiving chemical deliveries and will be fitted with a check valve to ensure no flow reversal following the delivery truck disconnection. A diaphragm valve will also be included to provide fill line restriction to control the delivery rate to the tanks. The fill pipework will be 75 mm Schedule 80 PVC piping. Near the tanks, the fil piping will be manifolded to provide individual tank fill pipes, each equipped with an electrically actuated valve. Control of the actuated valves will be by manually operated hand switches to open/close the respective valves. Switches will be readily accessible from the platform, in line of sight of the actuated valves so that the position indicators can be monitored. Each tank will be equipped with a sight glass and ultrasonic level sensor to determine chemical levels in the tank. Signals from the ultrasonics will be communicated back to SCADA for monitoring.

At the design maximum plant flow and design chemical dosing rate, storage volume will be available to receive a tanker delivery every 7 days and would fill 2/3 of each bulk tank. Each bulk tank has sufficient volume to provide approximately 10 days of storage.

Sodium Hydroxide will be dosed as direct chemical from the storage tanks. The chemical will be dosed to the clearwell. Three peristaltic pumps acting on a duty/duty/standby basis will be used and will be located within the containment area. This will allow for leaks/spills from the pumps to be captured within the containment area. The pumps will be flow paced and the dose will be set manually by the operators using SCADA or the local HMI. The suction lines to the metering pumps and discharge lines will be heat-traced and carrier water be used to transport the chemical to the injection point. Carrier water will be from the existing plant service water header, which is connected to the plant treated water high lift pumps.

Proper ventilation for the chemical room is required. A dedicated exhaust fan for the storage area will be installed, with a minimum exhaust rate of 7.5 l/s-m^2. An emergency shower will be located beside the dosing pumps.

The sodium hydroxide system design criteria are presented in Table 3.14.

Table 3.14: Sodium Hydroxide System Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Design Chemical Dosing Rate (mg/L)	17
Design Daily Usage (m^3/day)	3.5
Total Chemical Storage (m^3)	99
Storage Capacity (days)	30
Number of Storage Tanks	3
Volume of Individual Tanks (m^3)	33
Dimensions of Tanks	3.6 m dia x 4 m h
Secondary Containment Volume (m^3)	45
Material of Tanks	Carbon steel
Pump Type	Peristaltic
Frequency of Deliveries (days)	7

3.5.4 Potassium Permanganate

A new potassium permanganate system will be located within the existing building, in the retrofitted potassium permanganate and fluoride room. This area will be shared with the dry orthophosphate system.

The dividing wall between the existing potassium permanganate and fluoride rooms will be removed, creating a larger dry chemical make down room. A loading hopper and screw feeder would be located in the recessed area of the previous fluoride room. A FRP grating platform will be constructed over the area. This will allow for the hopper to be accessible to operators at a height that does not require stairs/ladder. A loading table will be included to assist with loading the dry chemical. Rotary valves, batch tanks, dosing tanks, and chemical dosing pumps will be located in the basement, below the previous fluoride room and directly under the hopper. The lower area (batching and dosing tanks) will be equipped with emergency shower and eye wash station.

Potassium permanganate will be delivered to site as dry chemical in 25 kg pails. It is anticipated that four pallets could be delivered at a time, which would provide approximately 66 days of dry chemical, at the design maximum flow and typical average dose. The dry product would be stored within the chemical room and would be accessible via an upgraded entry door.

The potassium permanganate system will consist of one loading hopper, two rotary valves feeding two screw feeders, two batch tanks, two transfer pumps, two dosing tanks, and three peristaltic flow paced pumps. The hopper can be filled with several 25 kg pails, ready for release by the rotary valves into the screw feeder, when called for.

Operators, similar to current configuration, would manually load dry chemical into the hopper. When the batch tank reaches low level, it will call for a new batch to be made. From the hopper, the piping would split to feed either screw feeder. Rotary valves located between will operate to maintain sufficient feed to the screw feeders. The screw feeder provides a measured dry product dose into the batch tank. Service water would be fed into the batch tank at the same time to prepare the potassium permanganate batch. The batch tanks is equipped with a mixer to ensure uniform consistency of the batch. Once the chemical is prepared, the potassium permanganate would be transferred to a dosing tank via transfer pump. The chemical is then dosed to the discharge point, by the peristaltic pumps, directly from the dosing tanks to the oxidation tank. Each batch tank will be sized to meet 100% of the potassium permanganate requirements. For that reason, the system has 100% redundancy for batching, transfer, and dosing tanks. The three dosing pumps will operate on a duty/duty/common standby basis.

FRP or PE tanks would be used for the batch and dosing tanks. Each tank would be equipped with a dedicated mixer to stir the chemical during batching and to prevent settling in the dosing tank. Secondary containment will be provided for each tank via concrete berm wall and epoxy coating. A common berm wall will encompass the batching and dosing tanks. The containment area will be equipped with a level switch, to indicate potential loss of containment. The containment area will also be equipped with a sump to collect spillages, for clean up purposes.

As noted above, the three peristaltic pumps will operate in duty/duty/standby and will within the containment area. This will allow for leaks/spills from the pumps to be captured within the containment area. The pumps will be flow paced and the dose will be set manually by the operators using SCADA or the local HMI.

Supply water to each batch tank will be supplied from the existing plant service water header, which is a dedicated service water system for uninterrupted service water supply.

With dry chemical systems, dust can be created when loading chemical into the hopper. With potassium permanganate specifically, the dust can cause staining. A dedicated exhaust system would be used to remove the dust and limit further dust exposure.

The potassium permanganate design criteria are provided in Table 3.15.

Table 3.15: Potassium Permanganate System Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Design Chemical Dosing Rate (mg/L)	0.3
Design Daily Usage (m^3/day)	0.6
Total Chemical Storage (m^3)	2.0
Number of Storage Tanks	2.0
Volume of Individual Tanks (m^3)	1.0
Secondary Containment Volume (m^3)	1.5
Material of Tanks	FRP or PE
Pump Type	Peristaltic
Frequency of Deliveries (days)	66

3.5.5 Orthophosphate

The corrosion inhibitor chemical currently used at JDK is based around a granular proprietary ortho-phosphate product. The chemical selection for the future corrosion inhibitor product to be used by HW is an actively evolving area of study and focus. As such, it is proposed that the existing corrosion inhibitor batching and dosing system remain in use until final decisions are made on product selection for the next operating horizon. For this stage of design, new floor space will be assigned based on dry dosing system in the future.

The new orthophosphate system will be located within the existing building, in the retrofitted potassium permanganate and fluoride room. The new potassium permanganate system has also been included in this room.

The loading hopper and screw feeder would be located in the recessed area of the previous fluoride room. A FRP grating platform will be constructed over the area. This will allow for the hopper to be accessible to operators at a height that does not require stairs/ladder. A loading table will be included to assist with loading the dry chemical. The rotary valves, batch tanks and chemical dosing pumps will be located in the basement, below the previous fluoride room and directly under the hopper. As described with the potassium permanganate system, an emergency shower and eyewash station will be located in the basement where the batching and dosing tanks would be located.

The dry orthophosphate system will consist of one loading hopper, one screw feeder, two rotary valves, two batch tanks, two transfer pumps, two dosing tanks, and three peristaltic flow paced pumps. Operators would manually load dry chemical into the hopper and screw feeder, which would be located above the batch tanks. From the hopper, the piping would split to feed either batch tank. An automatic rotary valve included in the piping to each tank would be used to control which batch tank the dry chemical is directed to when the screw feeder is initiated. Service water would be fed into the tank at the same time to prepare the potassium permanganate batch. Once the chemical is prepared, the orthophosphate would be dosed to the clearwell via the dosing pumps. Each batch tank will be sized to meet 100% of the orthophosphate requirements.

Stainless steel tanks would be used for the batch tanks. Each tank would be equipped with a dedicated mixer to stir the chemical during batching and to prevent settling in the dosing tank. Secondary containment will be provided for each tank via concrete berm wall and epoxy coating. A common berm wall will encompass the batching and dosing tanks. The containment area will be equipped with a level switch, to indicate potential loss of containment. The containment area will also be equipped with a sump to collect spillages, for clean up purposes.

Dry orthophosphate will be delivered to site as dry chemical in 18 L pails. It is anticipated that four pallets could be delivered at a time, which would provide approximately 70 days of dry chemical, at the design maximum flow and typical maximum dose. The dry product would be stored within the chemical room and would be accessible via the existing overhead door.

As mentioned, three peristaltic pumps, operating in duty/duty/standby will be used, and will within the batching tank containment area. This will allow for leaks/spills from the pumps to be captured within the containment area. The pumps will be flow paced and the dose will be set manually by the operators using SCADA or the local HMI.

Supply water to each batch tank will be supplied from the existing plant service water header, which is connected to the plant treated water high lift pumps.

With dry chemical systems, dust can be created when loading chemical into the hopper. With potassium permanganate specifically, the dust can cause staining. A dedicated exhaust system would be used to remove the dust and limit further dust exposure.

The orthophosphate design criteria are provided in Table 3.16.

Table 3.16: Orthophosphate System Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Design Chemical Dosing Rate (mg/L)	2.5
Design Daily Usage (m^3/day)	7.5
Total Chemical Storage (m^3)	4
Number of Storage Tanks	4
Volume of Individual Tanks (m^3)	1
Secondary Containment Volume (m^3)	1.5
Material of Tanks	FRP or PE
Pump Type	Peristalitc
Frequency of Deliveries (days)	3

3.5.6 Polymer

Provisional space for a polymer system has been included in the existing alum room, where the existing polymer system is located. It will be located in the same room as the new caustic tanks and dosing system.

Polymer batching will be done using dry polymer chemical, manually loaded into the batching system. Two identical batching systems are provided, each capable of meeting 100% of the polymer batching requirements. Loading of bulk bags into the batching system will be done by operations staff from a work platform. Both batching systems will be enclosed by a concrete containment berm.

Dry polymer is metered into a mixing tank on a volumetric basis using the screw feeder and diluted to a fixed concentration in the batch tank. The initial wetting and aging of the polymer will use the plant services water to ensure proper preparation of polymer solution. Once the polymer is prepared, the chemical will be transferred to the dosing tanks.

The polymer area will include three progressive cavity chemical metering pumps. The polymer pumps will withdraw from a common suction header connected to each polymer batch supply tank, each of which may be isolated for servicing while any pump remains in operation. The pumps will operate in duty/duty/standby under normal operating conditions.

Supply water to each batch system will be from the existing plant service water header, which is connected to the plant treated water high lift pumps. Also connected to the service header will be a supply line for polymer carrier water, to convey and dilute polymer form the dosing pump discharge to the process application points. The batching water will be heated to a minimum 10°C to assist in the polymer preparation process, using a hot water storage tank and thermostatic mixing valve.

The design criteria for the polymer system is provided in Table 3.17.

Table 3.17: Polymer System Design Criteria

Parameter	Design Basis
Design Maximum Plant Flow (MLD) (Raw Water + CWWWR)	159.6
Design Chemical Dosing Rate (mg/L)	0.5
Design Daily Usage (m^3/day)	6.3
Total Chemical Storage (m^3)	4
Number of Storage Tanks	4
Volume of Individual Tanks (m^3)	1
Secondary Containment Volume (m^3)	1.5
Material of Tanks	Stainless Steel
Pump Type	Positive Displacement
Frequency of Deliveries (days)	3

3.5.7 Carbon Dioxide (Existing)

The existing plant's carbon dioxide storage and feed systems will remain in service and be used for the upgraded plant as these systems were upgraded in 2021. Liquified carbon dioxide is stored in a leased storage tank with a vaporization system which is located outside the existing plant building. Carbon dioxide gas is delivered under pressure to a vacuum regulating valve (located within the chlorine storage room in the existing plant) and is then drawn under vacuum through a V-notch gas regulator to control the flow of gas to the process. The V-notch gas regulators and injectors are located in the CO_2 Machine Room in the existing, original plant. The gas then flows to injectors, where it is dissolved, as an acid, with plant service water.

The rate at which gas is being delivered is displayed on a 4,000 PPD (1,814 kg/day) rotameter on the face of the feeder. At present, it is estimated that the existing 100 mm (4") injectors each require approximately 320 US gpm (for full 4,000 PPD) and operate at approximately 50 psi. It should be noted that either raw or treated water can be used to supply water to the injectors. The amount of water is considerable, thus a separate, dedicated water supply using raw, untreated water should be considered. The existing carbon dioxide system is designed for the following chemical feed rates:

- Maximum design feed rate: 4,080 kg/d.
- Typical, present high feed rate: 1,782 kg/d.
- Typical, present low feed rate: 520 kg/d.

The future maximum, rated production flow at 35 mg/L results in feed rate of 5,285 kg/d. It should be noted that the existing CO_2 system has room to add another injector which would increase the capacity of the system to 5,346 kg/d.

3.5.8 Lime (Existing)

The existing handling, storage, and metering systems at the plant will remain in service, however, new feed and metering systems for two of the silos will be required as well as other modification. Modifications to the lime system are not part of the pretreatment and clarification project at this time but are highlighted here for completeness. HW intends to undertake lime system upgrades as part of ongoing capital project planning. The lime system is located in the existing, original treatment plant building. Lime is typically delivered in bulk shipments. The hydrated lime is loaded from the transport pneumatically into the three lime storage silos. The existing system was upgraded in 2018. The extent of the upgrade was a new lime feeder/batch/mixing tank installed for one lime silo and two peristaltic lime feed pumps were installed. The remaining two lime silos have the original "BIF" lime feeder/batch/mixing units.

3.5.9 Chlorine (Existing)

The liquified gas chlorination system was upgraded in 2014 and will remain in service for the upgrades. The work in 2014 included replacement of the gas takeoff, piping, metering and injection systems, along with new ventilation systems and facility upgrades. The upgrades were designed based on a future water demand of 159 MLD which matches the current design parameters. Three new chlorinators, each rated for 1,120 kg/day were included in the upgrades, based on a design maximum gas feed rate of 795 kg/day.

With the upgrades completed on the chemical feed system, issues with the material handling and concerns for health and safety have been identified for the chlorine storage room. Through discussions, it was determined that modifications would be made to the existing storage room rather than adding a new storage room in the building expansion to address these issues/concerns.

The existing monorail system will be modified to provide two individual monorails and eliminate the tight radius turn at the end of the current system. A new overhead crane is to be installed, which will allow for the cylinders to be moved between monorails with minimized handling and will provide operators more flexibility with moving the chlorine cylinders within the room. At this time, allowance for an electro-mechanical lift system has been included.

The existing concrete pad for cylinder storage will be extended, which will allow for the chlorine cylinder to be repositioned closer to the center of the room. This will provide additional space between the cylinders and the wall and improve the moveability throughout the room. The gas header and switch over modules will be relocated to the front of the concrete pad and cylinders to improve accessibility for operators to perform maintenance. With the modifications, a second switchover vacuum regulator will also be included to provide redundancy.

Upgrades to the ventilation system in the room will be completed to ensure the area meets current requirements and standards.

3.6 Clearwell Conversion to Filter Gallery

As part of the project, the eastern clearwell will be converted to a new gallery which will contain filtered water piping and filter-to-waste piping. The new piping will allow filtered water to be routed to the existing reservoir through the backwash supply tank, to the existing treated water chamber and out to distribution or out of the plant to the future reservoir.

Each filter will be piped and equipped with actuated valves such that filtered water from an individual filter can be directed to the filtered water header or to the filter-to-waste header and to the CWWW tank. Block and bleed valves will be provided on each filter pipe to separate filtered water from filter-to-waste water. When a unit is filtering, the two block valves will be closed to provide two barriers of protection separating the filter-to-waste header from the filtered water. In addition, when a unit is filtering, the bleed valve will be open to drain the section between the block valves and to prevent pressurizing this section of pipe. The bleed valve will be directed to a drain with an air gap for visual indication of draining.

The combined filter water header will also be equipped with flange connections points suitable for the future installation of UV disinfection or UV advanced oxidation.

3.7 Instrumentation & Controls

3.7.1 Overview

The facility control system shall be designed to aid in the management and operation of the facility by providing information and control to the operational personnel. Monitoring and control information shall be gathered and centrally maintained by the SCADA system to allow remote monitor and operation of the facility by a minimum of personnel. The SCADA system shall be equipped with various automation sequences, alarms, and indications such that the system can relieve the operator of routine monitoring, decisions, and equipment manipulation. Except where specifically noted or required, control room personnel shall be capable of all functions required for normal operations. Specific operations or processes may require personnel to be physically present for safety or management purposes, but these situations should be limited in time and scope.

While normally intended for remote control, the system shall provide the operator the capability of taking local control of selected processes and devices for troubleshooting, startup, shutdown, maintenance, and control in emergency or off-normal situations. Exercise of local control shall be indicated by a Local/Remote selection status signal so that the control system and remotely located personnel maintain situational awareness. To the extent practical, the control system shall be designed for robust and reliable operation. Redundancy and diversity shall be incorporated as required to limit the extent and impact of single point failures and allow continued operation of the facility.

3.7.2 Field Instrumentation

3.7.2.1 Process Measurement

Field instruments provided for all process measurements shall be new, industrial grade and suitable for the application. Field instruments are expected to include:

- Magnetic flow meters.
- Turbidity analyzers.
- pH analyzers.
- Streaming current detectors.
- UV254 analyzers.
- Differential pressure transmitters.
- Temperature transmitters.
- Ultrasonic level transmitters.
- Radar level transmitters.
- Level sight glass with transmitter.
- Float level switches.
- Pressure transmitters and local gauges.
- Pressure switches.
- Alarm detection devices.

3.7.2.2 Motor Operated Valves & Gates

Each motor operated valve/gate will be furnished with a Local Control Station (LCS) integral to the valve actuator or mounted remotely at a convenient location near the valve if the valve is not readily accessible to the operator. The operator will be capable of controlling each valve from the valve's LCS in local mode or from the SCADA system in remote mode.

The valve actuators will be wired to remote input/output modules of the SCADA system. On/Off valves will be wired for six discrete signals for control and monitoring. Two discrete outputs for open/close commands, two discrete inputs for full-open/full-close position, one discrete signal for fault conditions, and one discrete input to indicate valve in remote mode and available for SCADA commands. Modulating valves will incorporate four signals for control and monitoring. One analog output for 0-100% position command, one analog input for 0-100% position indication, one discrete input signal for fault conditions and one discrete input to indicate valve in remote mode and available for SCADA commands. Where required and shown on the P&IDs, hardwired interlocks may be used to override local and remote commands to enforce a safe valve operation. Software interlock and sequences may be over-ridden in the field by placing the valve in the "Local" condition and assuming local control of the valve. Unless noted otherwise, valves will fail in "last position" on loss of power.

3.7.2.3 Remote Motor Control

Motors and motorized equipment will normally be provided LOCAL/OFF/REMOTE selector switches near the motor for operator access. Remote controls for motors shall be wired for four discrete signals for control and monitoring. A single discrete output shall command the motor to run when energized and stop when de-energized. One discrete input will monitor for fault conditions, one for motor run status and one for motor in remote mode and available for SCADA commands. Where provided, E-Stop operation will over-ride both local and remote commands and force the motor to de-energize.

3.7.2.4 Field Device Communications

On-site communication between PLC input/output hardware, control elements, and field instruments will be hardwired. Signal levels shall typically be 4-20 ma at 24vdc for analog signals and 24vdc for discrete. Where required, discrete signals may also be 120vac level. Unless specifically noted otherwise, field alarm contacts will be designed for normally closed, open to alarm operation to implement fail-safe design. Discrete outputs will be designed to for closed contact to energize the circuit or device.

Communication between PLCs, Remote Input/Outputs, OITs, and all connected digital equipment will be via Ethernet network using CAT6 copper Ethernet cable and/or fiber optic cable.

3.7.3 Process Control System

3.7.3.1 SCADA

During construction and startup of the new facility with its SCADA system, the existing facility SCADA (Supervisory Control and Data Acquisition) system will remain operational and in control of the existing facility. The new facility will be compatible with the existing system in both hardware and functionality.

The new DAF facility will include space for a new control room and SCADA server rooms. The new SCADA system will be designed to include new SCADA servers, historian, network switches, routers, communications equipment to be installed in the new SCADA server room. Operator consoles, WorkStation computers, displays and interface equipment will be installed in the new control room.

During detailed design, the existing SCADA system hardware and software will be evaluated, and a decision made as to if it is economically and technically better to replace the existing field controllers or integrate them into the new SCADA system by re-configuring their communications and controlling programs. It is anticipated that the existing field instrumentation and wiring will be retained and reused with no major modifications required.

Once the new system is operational, the sections and functions of the existing facility that are supplanted by the new system may be selectively de-commissioned and removed from service. The de-commissioning and eventual removal of the existing system is outside the scope of this work.

Key components of the new SCADA system include PLCs (Programmable Logic Controllers), RIO (Remote Input/Output) panels with a fiber optic and/or copper Ethernet network. It is acknowledged that the existing plant PLC systems are presently undergoing significant upgrade. It is expected that the new DAF plant will integrate to the updated PLC systems through remote racks and/or ethernet switches.

The new SCADA system will be primarily based in the new building expansion in the following locations:

- New SCADA Room – Access controlled room containing primary and secondary SCADA system servers, UPS (Uninterruptible Power Supply), historian server, ethernet switches, fiber optic patch panel and auxiliary equipment. Virtualization software may be implemented on the servers to improve maintenance and reliability of the various software environments required.
- New Control Room – Access controlled room containing three operator workstations, a large screen display controller. In addition to the SCADA equipment, additional space and equipment may be allocated for general purpose computers and facility security monitoring systems.
- New PLC Enclosures – PLCs with redundant network configured in a self-healing fiber-optic loop. The PLC’s responsibilities will be segmented to control portions of the facility so that if one PLC is unavailable the remainder of the facility can continue operations. Enclosures will include PLC, power supplies, UPS, ethernet switches, fiber-optic patch panels and supporting hardware and auxiliary equipment. This configuration requires consideration against the PLC upgrades presently underway.
- New RIO Enclosures – Remote I/O panels with redundant network connections to the controlling PLC located to be reasonably close to the field devices being controlled. RIO panels will include RIO, I/O cards and racks, local OIT displays for field operator use, dual power supplies, UPS, and supporting hardware and auxiliary equipment.

- Vendor packaged controls – Where specified, vendor packaged systems may be provided with pre-engineered controls up to and including PLC's and OITs for control of the vendor package. Such vendor provided controls will be interfaced to the plant SCADA system using hardwired I/O for basic control and monitoring but may have additional digital interfaces for auxiliary commands and monitoring. Where provided, digital interfaces will be Modbus protocol over ethernet as a default standard. Vendor packaged systems will be avoided in the project, unless specifically required on a case-by-case basis. The intent is to have all automation, PLCs, and I/O within the existing and new or expanded PLC enclosures.

The SCADA system will be designed to utilize open architecture hardware and software components to match the currently installed system to maximize upgradability and expandability and to minimize the use of proprietary components. The existing system software and operator interface standards and techniques will be used and extended to ensure that the overall system retains a familiar look and feel to ease operator training and familiarization to the new system.

Control strategy descriptions for the new system will be developed during detailed design. All statuses and alarms available from the PLCs and control panels will be available in the graphical displays of the SCADA system. The graphical displays will be configured to indicate alarms, allow operator adjustment of control strategy settings, and allow operational data archiving, trending, and reporting.

- Where appropriate, updates and/or revisions to the existing control strategies, interlocks, graphics, and documentation will be suggested, but their implementation and detailed design is outside of this scope of work.

The new portions of the control system will be designed to have enough extra IO (Inputs and Outputs) capacity in the new facility to accommodate 20% spare IO.

3.7.3.2 Security

The servers, PLCs and OITs will have password protection to prevent unauthorized changes. PLC and RIO panels will have door switches to alarm on intrusion detection. Additional physical and cybersecurity measures may be provided based on the final system design.

3.7.3.3 Power Supply

All control panels will require 120 VAC external power supply. Control Panels will include Main Surge Protection Devices (SPDs) for surge protection. All control panels and remote input/output panels will have UPS for backup power supply with a minimum of 45 minutes of back-up run time. Field instruments that are loop powered will inherently have backup power via their respective control panel UPS. Externally powered field instruments that are deemed critical to safety will be identified during detailed design for provision of additional backup power during the normally short time that the plant will be "black" from the onset of a utility outage to successful transition to on-site power via standby generators.

3.7.3.4 Control Panels & Enclosures

PLC-based control panels, Remote Input/Output panels, Local Control Stations and Local Alarm Stations will provide monitoring and control of all process systems. The panels will include:

- PLC.
- OIT with graphical controls and status displays.
- Remote or local Input-Output modules with appropriate racks.
- Surge protection and noise filtering for panel devices.
- Gateway protocol converters as required.
- Signal conditioners.
- 24 VDC power supplies.
- Industrial grade, managed Ethernet switches.
- Fiber optic media converters and patch panels as required.
- Uninterruptible power supplies.
- NEMA 12 painted steel enclosures in air-conditioned spaces.
- NEMA 4X stainless steel enclosures in unairconditioned spaces and outdoors.
- NEMA 4X non-metallic enclosures (rated for specific chemical) in chemical storage and feed areas.
- Air conditioners and heaters as required when installed outside of conditioned spaces.

3.7.4 Control System Operator Interface

3.7.4.1 Remote Operator Access & Control

Operator access to the new SCADA system will be available from the existing operator interfaces as well as touchscreen Operator Interface Terminals (OITs) installed on the Programmable Logic Controllers (PLC) and RIO enclosures of the new system.

OIT displays will be password protected and designed to provide the operator with process status information and the ability to execute commands as required to control local processes.

3.7.4.2 Local Operator Access & Control

Where applicable, local control panels will be provided to allow operator information and control from selected field locations and processes to facilitate manual operations. Panel mounted instruments/devices such as selector switches, push buttons, indicating lights, digital panel meters, horns, and strobes will be provided to allow for limited local/manual operations.

Motor operated valves shall be provided with an operator interface local to the valve actuator to allow local field operation of the valve for maintenance and off-normal situations.

4 Site & Building Features

4.1 Geotechnical

4.1.1 General

The site configuration in the area of the DAF building expansion has been reviewed using available records from the initial plant construction and the more recent blower building addition. No geotechnical field work has been completed to date specifically for this project, though a work program has been scoped and proposed separately to HW. This field work, and resulting design criteria, will be necessary to advance the project into detailed design.

The DAF building hydraulic grade, process tankage geometry, and tie points to the existing facility conduits dictate the necessary elevations and grades for new structures. Based on bedrock contour profiles provided with the initial plant design it is anticipated that the DAF building will be founded on several layers of structural fill placed over top of bedrock. The existing facility was constructed using a combination of bedrock removal and fill placement, which will be similar during the DAF expansion. Existing backfill and over-burden in the area of the building expansion will be removed to bedrock and to expose existing concrete structures. Structural fill will then be placed in lifts to achieve necessary founding elevations.

The CWWW tank will be a separate concrete structure founded deep into bedrock. Extensive rock removal will be required for the tank construction. The geotechnical field program is expected to better inform the rock conditions and the anticipated methods of rock removal that will be required.

A more complete tabulation of geotechnical data, including seismic classification, structural criteria, and backfilling requirements will be provided during the detailed design phase.

4.1.2 Yard Piping

Yard piping includes all raw water, treated water and wastewater piping on the site. Each line is discussed in more detail below. In general, it is proposed that piping material will be as follows:

- Gravity Piping – Reinforced Concrete Pipe (RCP).
- Pressure Piping – Ductile Iron up to 750mm, Prestressed Concrete Cylinder Piping (PCCP) for 900mm and larger.

The existing large diameter pressure piping are PCCP and are nearing a service life of 50 years and we are not aware of issues of this piping. Steel and Ductile Iron may be suitable alternative materials for the large diameter pressure piping (900 mm and up) and each will have their advantages and disadvantages. Should PCCP piping not be preferred by HW, we will conduct a more through materials analysis for this piping as the design progresses.

Operating pressures of pressure piping are relatively low (less than 25 psi). For that reason, large diameter pressure piping will use restrained joints to resist the thrust forces consistent with the approached used for the existing piping. Thrust blocking will be used where it is not feasible to achieve a sufficiently restrained piping system. Supplemental thrust blocks for fully restrained joints will be considered, if feasible. Smaller diameter pressure piping will utilize thrust block and restrained joints.

4.1.3 Raw Water Transmission

The raw water line will be 1,200 mm (48”) diameter and will tie to the existing 1,200 mm diameter PCCP immediately north of the main access road. Elevations are such that the line will be laid with a high point and an air release valve chamber will be required, located in the traffic island. The new raw water line will parallel the existing raw water line extending to the DAF building and reducing to 1,050 mm (42”) as it enters the building. A flushing hydrant will be provided on the new raw water line. Based on record drawings, bedrock will be near or at surface as the line crosses the existing parking area. The piping is shown with a 10 m offset from the existing line, however, this may be adjusted to minimize risk of disturbance of the existing piping.

The connection of the new raw water line to the existing raw water line will be completed using live tapping (or hot tapping) methods. We are assuming that a 1,050 mm (42”) hot tap outlet can be made on the existing 1,200 mm diameter piping. Should a two pipe size reduction (900 mm diameter) be necessary, we will evaluate the need for a double hot tap at that time. We have engaged a capable contractor and will continue to refine the connection details in the design development process. We have considered using a cut-in tee; however, the anticipated shutdown time and associated risks are high and is not considered a viable solution at this time.

The existing raw water line will be isolated downstream of the tie-in point and abandoned following commissioning of the upgrades. A temporary blank or isolation on the existing raw water line, downstream of the tie-in, will be necessary in the interim period where flow to both the new and existing pre-treatment will be required.

4.1.4 Clarified Water and Backwash Water Conduits

There are two new liquid carrying concrete conduits that run side by side, in the east-west direction between the existing water treatment plant building and the existing blower building. One conduit is a clarified water conduit which directs clarified water from the new DAF process to the existing, western 'Floc Water Conduit' (West Settled Water Conduit) that feeds water to the filter units #1, #3, #5, and #7 (west bank of filters). The other conduit is a wastewater conduit that collects backwash wastewater from both the west and east bank of filters and conveys this flow by gravity to the CWWW tank. Filter-to-waste will also be piped to this conduit to direct the flow to the CWWW tank. The conduits are reinforced concrete structures than run beneath the concrete access ramp that provides access into the existing filter gallery. A portion of these structures are also integrated into the structure that supports the pedway between existing water treatment plant building and the new DAF building.

As presently conceived, the two conduits are constructed side by side with a common floor elevation to assist in constructability. The floor elevation is 166.548 m EL CGVD2013 (548.25 ft). Note that metric conversions of stated elevations within this report account for a current geodetic reference of CGVD 2013. Where elevations are stated in imperial units, they are from the original plant record drawings which are not converted and remain in CGVD 1928. CGVD 2013 is 0.64 m lower than CGVD 1928.

The wastewater conduit will have a layer of grout applied at 1% grade to allow the conduit to drain. The elevation of this conduit allows for the existing west wastewater conduit (existing floor of conduit 551.25 ft), in the existing water treatment plant building, to be intercepted by modifying the existing wastewater/overflow shaft structure (Chamber 2). More complicated modifications must be made to intercept the wastewater for the east bank of filters, which presently discharges flow to the east wastewater conduit (existing floor of conduit 541.25 ft) in the existing water treatment plant building. The current design requires that the backwash discharge of filter units #2, #4, #6, and #8 be modified. The deep sluice gates will be removed, and the base of the existing drop shaft (at each filter) filled with lean concrete or grout to an elevation of 553.75 ft. A new opening will be cut though the existing wall and a new sluice gate installed to direct backwash wastewater from these filters into the existing "Future Settled Water Conduit". The base of the existing "Future Settled Water Conduit" will be raised to 551.25 ft with lean concrete or grout. The wastewater conduit will intercept the backwash wastewater from the existing "Future Settled Water Conduit" by modifying the existing wastewater/overflow shaft structure (Chamber 3). Detailed hydraulic calculations will be performed during detailed design which may adjust the above proposed elevations.

Constructing a new conduit, to deliver clarified water from the new DAF process to the existing western 'Floc Water Conduit' (or the West Settled Water Conduit), is required to removed, the concrete 'chimney' conduit (floc water tunnel) that travels through the existing clearwells and presently connects the East Settled Water Conduit to the West Settled Water Conduit. This configuration is a cross-connection risk due to potential leakage from the chimney that allows untreated to contaminate treated water in the clearwells. The present configuration is also problematic because it does not allow for the east and west bank of filters to be independently isolated. This independent isolation will be required to permit certain required modifications within the existing plant. The new common clarified water conduit, which collects clarified water from all the DAF process trains in the new DAF building, splits into two conduits, with one conduit connecting to the existing and East Settled Water Conduit and the other connecting to the West Settled Water Conduit. The new conduit, which directs clarified water to the West Settled Water Conduit, will always be fully flooded and will operate under pressure. The dimensions of the conduit are such that the water velocities must be sufficiently low so that the west and east bank of filters have relatively equal top water levels. Sluice gates will be provided on each new clarified water conduit (where they split). Each new clarified water conduit will connect into the respective east or west existing Settled Water Conduits by connecting to and modifying the existing wastewater/overflow shaft structures (Chamber 2 and Chamber 3).

4.1.5 Treated Water Transmission

A new 1,500 mm (60") diameter new treated water line will connect to the 1,200 mm (48") diameter outlet of the new piping gallery at the south wall of the east clearwell at a centreline elevation of 165.71 m. The pipe will continue south at a positive slope, parallel to the existing DAF building. At 78 m the pipe will be directed southwest to connect to a treated water reservoir at a centreline elevation of 162.58m. Connections to the existing 1,500 mm (60") treated water piping both upstream and downstream of the reservoir will be provided using a1,500 mm (60") diameter piping. Consistent with the raw water line, connections to existing will be made using hot tapping methods. It is assumed that a 1,350 mm (54") diameter outlet can be made on the existing 1,500 mm (60") pipe. That said, should a two pipe size reduction (1,200 mm diameter) be necessary, we will evaluate the need for a double hot tap.

For these purposes of this submission, the size, configuration, and siting of the possible reservoir is consistent with the recommendations and options presented in the JDK Storage Needs Analysis memorandum, August 29, 2022. The elevations and hydraulic grades of the new storage will need to match existing storage for interoperability.

4.1.6 Combined Waste Washwater Recycle

A 1,050 mm (42") CWWWR line will intercept the existing backwash waste conduit downstream of the existing chamber beside the west clearwell. The flow will be directed south by gravity to either cell of the CWWWR storage tank. Isolation valves are provided on the inlet of each cell to control flow. The CWWW will be pumped from the tank to the DAF facility inlet through a 400 mm (16”) diameter forcemain. The forcemain alignment will be pumped south, west, and north to the DAF facility inlet. The west leg of the alignment will be located at least 6 m south of the edge of the proposed access road to allow for sufficient clearance for possible future expansion of the DAF facility. The forcemain will cross the treated transmission main, floated solids forcemain, and overflow piping. Conflicts and interferences with this forcemain and the other yard piping will be checked in detailed design.

Consideration is being given to the interconnection of raw water transmission main and CWWWR forcemain immediately outside of the DAF building. The purpose of this interconnection would be to provide an alternative flow path for the raw water should the raw water inlet flow meter need to go out of service for maintenance or replacement.

4.1.7 Floated Solids

Floated solids will be pumped from the DAF facility to the backwash ponds through a dedicated 100mm (4”) forcemain. The forcemain will leave the west side of the DAF facility and be directed south then west crossing over the existing 1500 mm (60”) transmission main and 900mm (36”) backwash waste lines. The floated solids line will then turn south and parallel the existing backwash waste line until terminating at the existing backwash ponds.

4.1.8 Overflows

A 1,050 mm (42”) raw water overflow from the DAF facility will be conveyed south of the DAF building and will turn west to parallel the floated solids line. This overflow line will pickup the CWWWR tank 900 mm (36”) diameter overflow directly south of the tank. The 1,050 mm overflow line will tie in to the existing 900 mm (36”) backwash waste line after crossing over the existing 1,500 mm (60”) transmission main.

4.1.9 Site Grading

All new services and associated infrastructure will be designed as per the latest editions of the following standards:

- Halifax Water Design Specifications.
- Standard Specifications for Municipal Services.
- National Building Code of Canada (NBC).

Minimum grades of 2% will be maintained for unpaved surfaces and slopes of 1:3 will not be exceeded. Minimum grades of 1% will be maintained for paved surfaces and parking areas. Water will be directed to swales and ditches which will be then directed to existing drainage ditches to the south-west toward the wastewater lagoons.

Sufficient areas must provided for construction activities and temporary laydown during construction. An area to the south-east of the existing building will be allocated for marshalling, laydown and temporary trailers, during construction. This is the area presently used for storage as well as additional areas to the east. Areas to be cleared and grubbed will be minimized. Disturbed areas will be topsoiled and hydroseeded (some sodding in limited areas) with attention given to minimizing areas requiring ongoing maintenance.

New 2.44 m high, galvanized chain link fence will be provided to enclose the new and existing buildings, driveways and parking areas. A new gate will be provided the rear of the existing building (south-east) which will allow delivery traffic to exit toward the main entrance to the site. This configuration will allow vehicles to access the existing wind turbines (located to the south) as well the existing wastewater lagoons without passing through an access gate.

4.1.10 Roads

During construction, there will be regular small vehicle traffic, chemical delivery traffic and maintenance activities around the existing facility at the rear of the existing building. This access must ne maintained throughout construction. To facilitate bulk chemical delivery to the new DAF building expansion, a new, paved access road (which encircles the new and existing plant buildings) will be constructed as part of this project. This will allow chemical delivery trucks to traverse the site without needing to turn around and reverse course.

The proposed roadways and parking lots will be used by light traffic, small trucks, and bulk chemical tractor trailers. The recommended pavement and gravel thickness will be reviewed during detailed design, however, the following thicknesses are assumed at this time:

- 40 mm of Surface Pavement, mix Type C-HF.
- 50 mm of Base Pavement, mix Type B-HF.
- 200 mm of Gravel Base, Type 1.
- 200 mm of Gravel Sub-base, Type 2.

All gravels and pavement materials will meet the Nova Scotia Transportation and Infrastructure Renewal specifications.

The parking areas presently provided on the north side the existing building will be maintained. The existing parking spaces appear to be sufficient for the administration/staff as well as visitors for the main reception as well as ongoing activities associated with the modified spaces for the existing building. Paved access to the existing maintenance/storage building, on the east side of the site, will be maintained. Existing paved areas will be reinstated/paved as part of the future JDK800.65 project (Access Road Repair).

The new paved area to the east of the new DAF building will provide for parking, chemical delivery, fuel delivery for the new generators, access to the building's maintenance shop and delivery and removal of equipment withing the plant. Fourteen parking spaces will be provided with eight spaces for HW maintenance/operations staff plus six additional spaces for contractor/visitors.

Though not presently shown on the drawings, the parking areas and roadways will have area lighting similar to the lighting masts presently in use at the existing facility. This lighting will be supplemented with area lighting mounted on the new buildings.

4.2 Building Structure

4.2.1 General

The structural design will be in accordance with the following codes and standards:

- National Building Code of Canada (2015).
- CSA A23.3:19 – Design of Concrete Structures.
- CSA S16:19 – Design of Steel Structures.
- CSA S304-14 (R2019) – Design of Masonry Structures.

In addition to the Canadian codes and standards listed above, the design of liquid retaining structures will be designed to ACI 350-20 – Code Requirements for Environmental Engineering Concrete Structures. The provisions in CSA A23.3 do not provide guidance on the design of liquid retaining structures and therefore, these structures will be designed at the Serviceability Limit State (SLS) to ACI 350 to provide a liquid-tight structure.

The NBCC classifies water treatment facilities as post-disaster buildings and defines such as a building that is necessary for the provision of essential services to the general public in the event of disaster. As a result, the water treatment plant building will be classified as post-disaster which will have implications on the selection and detailing of the Seismic-Force Resisting System (SFRS) as well as increase the specified design loads for snow, wind, and seismic in comparison to a normal importance building.

Snow, wind, and seismic loads have been calculated based on the climatic data in the NBCC for Halifax, Nova Scotia.

4.2.2 New DAF Building

The new DAF building will be a two-storey concrete structure utilizing a mixture of:

- Cast-in-place concrete walls, columns, and slabs.
- Precast concrete beams and columns.
- Precast concrete hollow core planks.

Durability and moisture resistant characteristics are paramount in the selection of the structural system. Alternative structural system were considered such as steel, cast-in-place concrete beams and columns, cast-in-place flat plate slabs, and loadbearing masonry.

A steel structure consisting of beams, columns, braces, open web steel joists, and steel deck would be ideal for erection above level 2 to support the roof structure however, durability is a concern in the treatment plant environment. Corrosion of the steel over time would be a risk which makes steel a less desirable option. Coatings can improve durability, however, maintenance may be required over time to ensure the structure remains serviceable.

Cast-in-place concrete is ideal for tank construction and could be used for the level 2 and roof construction however, formwork considerations above the tank areas could be problematic. A flat plate suspended slab system would be preferable in comparison to beams and columns in order to reduce formwork costs however, tighter gridlines would be required for an efficient design. Due to the formwork considerations above level 2, cast-in-place concrete is not recommended for the roof system.

Precast concrete is ideal for erection of the roof and supporting beams and columns. Precast concrete should lead to a faster and more cost-effective construction sequence than cast-in-place concrete while also providing a durable superstructure for the water treatment plant environment. Using cast-in-place concrete for level 2 and below and precast concrete from level 2 to the roof will provide a good balance of durability, construction sequencing, and should be cost effective.

4.2.2.1 Gravity Loads

The gravity loads consist of the self-weight of all building components and finishes, mechanical and electrical equipment loads, live loads, snow loads, water pressure, earth pressure, and surcharge loads.
The snow load will be calculated based on a 1-in-50 year which includes:

- Dead load (building component and finishes): self-weight.
- Mechanical and electrical allowance: 1.00 kPa.
- Roof snow load: 2.65 kPa.
- Floor live load: 4.80 kPa.
- Water density: 10.0 kN/m^3.
- Soil density: varies.
- Surcharge: 12 kPa, minimum (varies).

4.2.2.2 Lateral Loads

Wind load is calculated based on a 1-in-50-year hourly wind pressure of 0.58 kPa. Wind loads on the building will be determined in accordance with the NBCC and will vary depending on the location on the structure. Both internal and external wind pressure will be considered, and the building will be classified as Category 3 for internal wind pressure. Category 3 internal wind pressure is recommended for post-disaster structures in order to achieve a higher level a reliability. Specified wind pressure will include an importance factor of 1.25 at the Ultimate Limit States (ULS).

Seismic loads will be determined using the equivalent static force method in the NBCC. The seismic force will include an importance factor of 1.5 at ULS. The following site-specific seismic data will be used to generate the seismic demand on the lateral load resisting system:

- $S_a(0.2)$ = 0.11.
- $S_a(0.5)$ = 0.082.
- $S_a(1.0)$ = 0.053.
- $S_a(2.0)$ = 0.029.
- $S_a(5.0)$ = 0.0076.
- $S_a(10.0)$ = 0.0032.
- PGA = 0.064.
- PGV = 0.068.

4.2.2.3 Superstructure

The roof structure consists of 250 mm thick precast hollow core planks which will be supported on 450 mm wide x 800 mm deep precast concrete beams and 450 mm thick cast-in-place concrete walls. The beams will be supported by 450 mm x 450 mm precast concrete columns and 450 mm thick cast-in-place concrete walls. The floor for level 2 will consist of 300 mm thick cast-in-place concrete suspended slabs that will be supported by 450 mm x 450 mm cast-in-place concrete columns or 450 mm and 600 mm thick cast-in-place concrete walls.

The post-disaster classification of the building has implications in the selection of the SFRS. The NBCC requires post-disaster buildings to be designed with a system that achieves some degree of ductility under seismic loading. The SFRS for the WTP building will be moderately ductile squat shear walls to satisfy this NBCC requirements. The hollow core roof panels will transfer diaphragm shear from wind and seismic loads into the concrete shear walls which will then transfer the loads to the building foundations.

4.2.2.4 Foundations

Foundations for the building will consist of cast-in-place concrete base slabs, strip footings, and spread footings. The foundations which form part of the tanks will be built integral with the concrete walls to form a liquid-tight joint between the walls and base slab. PVC waterstops will be cast within the construction joint to eliminate leaks through the joint.

Outside of the tank areas, spread footings will transfer the column loads to the supporting soil and strip footings will be used to support shear walls and the non-loadbearing precast wall panels. The size of the spread footings and strip footings will be based on the geotechnical recommendations for bearing pressure. The non-loadbearing precast wall panels which enclose the areas adjacent to the tanks will be supported on thickened slab projections.

Foundations will be lowered to frost depth, where possible, and insulation will be installed under slabs and extended beyond their footing projections where not possible to prevent frost heave, as per geotechnical recommendations.

4.2.3 Pre-Treatment Tanks

The pre-treatment tanks will be cast-in-place concrete. The wall thickness for the pre-oxidation tanks will be 600 mm and the base slab will be 650 mm thick. The wall heights at the pre-oxidation tanks are 9.601 m.

The raw water channel, channel mixer, flocculator inlet channel, and flocculator tank walls will range in thickness between 450 mm and 600 mm and the base slab will be 600 mm thick. The height of the walls will be 5.562 m.

The tanks will be designed to ACI 350 at SLS to limit crack widths and leakage, and to CSA A23.3 at ULS. The exposure condition will be considered normal environmental exposure in accordance with ACI 350 and concrete exposure will be N in accordance with CSA A23.3. The minimum specified concrete strength at 28 days will be 35 MPa.

The tanks, channels, and troughs will be designed for the following loading conditions:

- Leak test with liquid to the maximum water level, without backfill in place.
- Any tank, troughs, or channels full of liquid with adjacent tanks, troughs, or channels empty.
- Backfill in place with soil backfilled to finished grade, surcharge loading, without liquid in the tanks, troughs, or channels.

4.2.4 DAF Tanks

The DAF tanks will be cast-in-place concrete. Tank walls range in thickness between 300 mm to 600 mm based on the water pressure, soil, and surcharge loads which vary depending on location, size, and depth of the tank. The base slabs will be 600 mm and intermediate slabs will be 200 mm to 300 mm thick. The walls in the DAF tanks, floated solids channel, DAF effluent channel, and clarified water channel are 5.562 m high.

The tanks will be designed to ACI 350 at SLS to limit crack widths and leakage, and to CSA A23.3 at ULS. The exposure condition will be considered normal environmental exposure in accordance with ACI 350 and concrete exposure will be N in accordance with CSA A23.3. The minimum specified concrete strength at 28 days will be 35 MPa.

The tanks, channels, and troughs will be designed for the following loading conditions:

- Leak test with liquid to the maximum water level, without backfill in place.
- Any tank, troughs, or channels full of liquid with adjacent tanks, troughs, or channels empty.
- Backfill in place with soil backfilled to finished grade, surcharge loading, without liquid in the tanks, troughs, or channels.

4.2.5 Combined Waste Washwater Tank

The CWWW tank will be a cast-in-place concrete tank with two cells separated by an interior divider wall. Each cell has interior dimensions of 19.0 m by 19.0 m and varies in height to accommodate a sloped base slab. The height of the walls ranges between 9.066 m at the north, south, and west exterior walls to 11.066 m at the sumps located along the east wall. The sumps are 2.40 m x 2.40 m x 1.15 m deep and will be located on each side of the interior divider wall. There will be an overflow trough located on the west side that will be integral with the tank.

The tank will be designed to ACI 350 at SLS to limit crack widths and leakage, and to CSA A23.3 at ULS. The exposure condition will be considered normal environmental exposure in accordance with ACI 350 and concrete exposure will be F-1 in accordance with CSA A23.3 to provide durability with freeze-thaw cycles. The minimum specified concrete strength at 28 days will be 35 MPa.

The tank will be designed for the following loading conditions:

- Leak test with liquid to the maximum overflow level, without backfill in place.
- Either cell with liquid to the maximum overflow level with the other cell empty.
- Backfill in place to finished grade and surcharge, without liquid in the tank.

It is a possibility that the tank will encounter high buoyancy forces due to groundwater pooling within limits of excavation during service. Based on the geotechnical information, bedrock is relatively high, and the excavation will go deep into the bedrock. Drainage of groundwater away from the structure may not be feasible. Therefore, the tank will be designed to resist hydrostatic uplift forces up to the top of bedrock at elevation 166.000 m. The self-weight of the structure in combination with the weight of backfill above the footing projections will resist the buoyancy effects that may develop due to groundwater.

The north, south, and west exterior walls will be 1,200 mm thick and the interior divider wall and east exterior wall will be 1,350 mm thick. The base slab will be 1,500 mm thick and projects beyond the exterior walls by 1,750 mm. The overflow trough consists of 300 mm thick walls and a 300 mm thick cantilever slab.

4.3 Architectural

4.3.1 Existing Building

4.3.1.1 Removals

As areas of the existing building will be refurbished, existing areas of the lower and upper floors will be demolished. On the lower level the masonry wall between the Potassium and Fluoride room will be removed and the connection to other walls, floor and ceiling where masonry was removed will be repaired. On the upper level, the masonry walls, except for the walls of the Lunchroom area, of the administration area are the be demolished. All suspended and other ceiling materials are to be removed as well as all flooring in those areas. It is anticipated that removals in the existing building will be sequenced during construction to occur after the new DAF facility is fully operational.

4.3.1.2 Additions/Refurbishment

Areas of the existing building that are going to be developed and/or renovated include:

- Male Washroom.
- Female Washroom.
- Office.
- Conference Room.
- Storage Room.
- An area for three cubicles.
- Entry.
- Corridor.
- Elevator.

New walls will be constructed of masonry concrete block and painted. New doors and frames will be butt mounted painted pressed steel. The new ceiling will be a suspended t-bar with acoustical tile except for the washrooms which will have gypsum board. New flooring will be installed throughout the new areas. The new washrooms will meet NBCs latest edition as well as CSA B651 2018, Accessible Design for the Built Environment and Handbook.

The flooring to be used in the new areas varies. Sheet vinyl will be installed in the Washrooms, Storage Room, Corridor and Entry. Carpet tile will be installed in the Office, Conference Room and Cubicle Area.

A new pitless elevator will be installed for easier access to the existing upper level. Elevator will conform to CSA B44, current edition.

4.3.2 New DAF Building

4.3.2.1 General

The architectural design will be in accordance with the NBC, 2015 edition, as well as all other codes having jurisdiction. The structure is a two-story building falling under Group “F”, Division 3, Major Occupancy Classification of the NBC.

4.3.2.2 Exterior Walls

The majority of the building exterior will be comprised of non-load bearing, insulated concrete sandwich panels with an area of the building having aluminum curtain wall to provide day lighting into the administration area of the building on the upper level. The catwalk leading from the existing building to the new building will be steel framed with aluminum curtain wall. The aluminum curtain wall is to meet CSA A440.6:20 as well as NBC and National Energy Code of Canada, latest edition. Exterior doors will be placed within the maximum travel distance required by the NBC for the Major Occupancy, Group “F”, Division 3.

4.3.2.3 Roof

The roof assembly is comprised of a two ply modified bitumen roof membrane over tapered insulation sitting on a flat concrete hollow core plank system and will be drained by mechanical roof drains. The roof will be designed by calculating wind uplift pressures, based on the current NBC.

4.3.2.4 Interior Walls

The interior walls will be constructed of concrete masonry block and cast in place concrete and span from floor slab to the underside of slab above. To meet the requirements of the NBC to keep the Group “F”, Division building unsprinklered, fire-rated wall assemblies will be used to break the building up in smaller areas. All fire- rated wall assemblies will have all penetrations sealed with fire batt and fire caulk and areas where fire- rated walls meet the slab above as well as around all doors. All doors installed in fire-rated walls to be rated 75% of fire-rating of wall. Areas requiring sound dampening will receive resilient channel and gypsum board over the concrete block to reach a comfortable STC level. (Sound transmission class) Offices will have borrowed light installed to help with daylighting into the corridor.

4.3.2.5 Ceilings

A suspended t-bar ceiling with acoustical tile will be installed in the administration areas on the upper floor as well as on the lower floor in the male and female locker rooms and corridor. All other areas with be open to the underside of the slab above.

4.3.2.6 Floors

The flooring for the administration areas will vary depending on the area. There will be sheet vinyl installed in the Male and Female locker rooms, Storage rooms, Electrical room, Pilot rooms, Lab, Lunch Room, Janitors Closet, Sever Room. Carpet tile will be installed in the Offices and epoxy coating in the Shop/Maintenance Area.

4.4 Building Mechanical

4.4.1 Ambient Design Conditions & Criteria

In general, the facility has two space functions; the process areas and administration areas. The facility is classified as an Industrial Building. The following section provides a summary of the ambient design conditions for the building mechanical system under consideration for the upgrades.

Exterior Design Conditions

- 2.5% design criteria for January (heating) and July (cooling) for Halifax, NS as specified in the NBC.

Heating

- Heating design.
- NBCC 2.5%: -16°C DB (dry bulb)

Cooling

- Cooling design.
- NBCC 2.5%: 26°C DB, 20°C WB

Table 4.1: Interior Design Conditions – As per ASHRAE

	Dry Bulb Temperature (°C)	Relative Humidity
Office	20-24	30-60%
Labs	20-24	30-60%
Administrative	20-24	30-60%
Workshop	18-24	25-60%
Treatment Areas	15-26	25-80%
Chemical Storage	15-26	25-80%
Open Water Tanks	No Criteria	

4.4.1.1 Interior Heat Gain

The following, including Table 4.2 and Table 4.3, is a summary of the typically expected interior heat gains that will be used in HVAC load calculations. Energy use and heat gain from lighting systems will be considered and developed by the project electrical engineer during detailed design. For preliminary HVAC calculations the prescriptive Building Area Method allowance from the 2011 NECB for lighting heat gain will be used (i.e., 10.7 W/m² or 1.0 W/ft²).

Table 4.2: Cooling Loads from Occupants

Per Occupant Heat Gain:	
Per Person Heat Gain: (Office activity)	67.4W per Person Sensible, 35.2W per person latent
Per Person Heat Gain: (Workshop Staff activity)	86.5W per Person Sensible, 133.3W per person latent
Per Person Heat Gain: (Admin Staff activity)	71.8W per Person Sensible, 60.1W per person latent

Table 4.3: Equipment Heat Gain

Equipment Heat Gain	
Admin Areas	10.8 W per sq. m.
Common Areas (staff, support services, etc.)	5.4 W per sq. m.
Process, Pilot, Lab, and Maintenance Areas	Based on equipment heat gain

4.4.1.2 Ventilation Rates (Non-Process Areas)

For the administration areas (non-process areas) the minimum ventilation rates shall be determined in accordance with Table 6.1 from ASHRAE 62.1-2019. Table 6.1 indicates the minimum outdoor air ventilation rate the ventilation system be required to provide based on number of people and floor area and this has been reproduced in Table 4.3.

Table 4.4: Ventilation Rates (reproduced from ASHRAE 62.1, Table 6.1)

Occupancy Category	l/s per person	l/s per m^2	Occupant Density #/100 m^2	Exhaust rate l/s-m^2 (or per fixture)
Office Space	2.5	0.3	5	
Breakroom	2.5	0.6	50	-
Occupiable Storage Rooms	2.5	0.3	2	
Reception	2.5	0.3	30	
Meeting Room	2.5	0.3	50	
Computer Room	2.5	0.3	4	
Copy, Printing Rooms				2.5
Laboratories				As required
Chemical Storage				7.5
Locker Rooms				1.25
Washroom				35
Janitor Closet	-			5.0

Ventilation rates for confined rooms, compartments, pits, and any enclosures below ground may be supplied at six air changes per hour (ACH), where applicable, to remove any excess heat or odors.

Ventilation rate for the Laboratory will depend on the required exhaust rate from the fume hood. Typical fume hood exhaust rates range from 200 L/s to 600 L/s depending on size. The lab will be supplied with 100% outdoor air that will be varied to match the exhaust, minus an offset, to maintain a negative pressure in the lab. This will be accomplished with a dedicated make up air unit that will pre-heat and cool the outdoor air as required. The fume hood will be outfitted with dedicated critical controls to monitor the sash height of the hood and vary the exhaust air to maintain containment within the hood and control the outdoor air.

4.4.1.3 Ventilation (Process Areas)

Ventilation (including heating, cooling, and air-conditioning) requirements for the process areas of the plant will be determined on a case-by-case basis for the different process areas and the activities, equipment, and conditions within those spaces. Humidity control or insulating cold surfaces is beneficial in areas where cool water, within tanks or piping, tends to create condensation from fresh air supplied to these areas. Dry chemical areas may require ventilation with source-capture to control dust. These chemical handling and storage areas can also benefit from humidity control to reduce corrosion to assist in keeping chemical product and feed systems dry which will increase service life of the equipment and reduce maintenance attention. Bulk chemical storage areas generally require separate, dedicated ventilation and ventilation rates suitable for corrosion control. The spaces must also be maintained at temperature suitable for product storage and dispensing. The large open tanks areas, which constitute a significant portion of the new DAF Building, will be maintained at temperatures and ventilation rates, as low as practical to stay above freezing temperatures and keep humidity at reasonable levels. Practical approaches are required to reduce energy costs for open tanks areas, as temperature and humidity control can be energy intensive due the exposed water surfaces.

4.4.1.4 Building Envelope

The building envelope is a critical component for building energy efficiency and space heating plant sizing. The thermal performance of walls, windows, floors, and the roof, along with the air tightness of the building will determine the amount of space heating required. Space heating is the dominant component of energy use in an office building, followed by lighting and fan energy. For the preliminary heating and cooling calculations, the following assumptions were made:

- A minimum overall solid wall thermal resistance of R19.
- A minimum overall window thermal resistance shall be R3, including window frame effects.
- A roof overall thermal resistance of R29.
- Floors in contact with the ground (slab on grade) have a thermal resistance of R7.5 for 1.2 m in from the perimeter.
- Floors in contact with the ground (slab on grade) where the floor is also used for in-floor heating, have a thermal resistance of thermal resistance for the entire floor shall be R7.5.

4.4.1.5 Airtightness

Airtightness in large commercial buildings is a poorly defined characteristic and rarely measured in finished buildings. Nonetheless, the building is required to have a *continuous air barrier* and should have a specified air tightness of no more than 0.125 L/m² (0.05 cfm/ft²) of gross above-ground wall and roof area. It is noted that in performance based NECB energy simulations an infiltration rate of 0.25 L/m² (0.1 cfm/ft²) is required in both the proposed and reference simulations (Reference 2017 NECB).

4.4.1.6 Applicable Building Codes & Standards

The following is a partial list of codes and standards applicable to this building:

- NPC - Canadian National Plumbing Code.
- NBC - Canadian National Building Code.
- NFC - Canadian National Fire Code.
- NFPA – Applicable sections of the National Fire Protection Association standards.
- NFPA 10 – Standard for Portable Fire Extinguishers.
- NFPA 13 – Standard for the installation of sprinkler systems.
- CSA - Applicable sections of the Canadian Standards Association.
- ASHRAE – American Society of Heating Refrigeration and Air-Conditioning Engineers, Handbooks.
- ASHRAE Standard 55-2013 – Thermal Environmental Conditions for Human Occupancy.
- ASHRAE Standard 62.1-2019 – Ventilation for Acceptable Air Quality.
- SMACNA - Applicable sections of the Sheet Metal and Air-Conditioning Contractors National Association standards.
- NECB 2017 – National Energy Code for Buildings.

4.4.2 Building Heating, Ventilation and Air Conditioning Systems

4.4.2.1 HVAC Equipment (Existing Plant Building)

The existing HVAC consists of:

- One 10-ton VRF System with seven indoor units.
- One rooftop Heat Recovery Ventilator (HRV) for Control Building.
- Miscellaneous exhaust fans for chemical storage and treatment areas - exhaust fans (EF-1 to 20).
- Dedicated exhaust fan for Fluoride Room (EF-21).
- Dedicated exhaust for alum storage basement (EF-22).
- Dedicated exhaust fan for alum storage extraction arms (EF-23).
- Dedicated exhaust fan for Electrical Room (EF-24).
- Dedicated lab fume hood exhaust (EF-?).

Approximate sizes of the ventilation units are provided in Table 4.4.

Table 4.5: Existing Ventilation Sizing

Equipment Tag	Location	Areas Served	Total Airflow (LPS)
HRV-1	Roof	Control Building	239
EF-21	Roof	Fluoride Room	495
EF-22	Inline	Alum Basement	1127
EF-23	Roof	Alum Store	425
EF-24	Low Lift Pump Station	Electrical Room	708
MISC	Wall/Roof	Storage rooms/Workshops	ND

The exhaust from washrooms and locker rooms are directed through HRV-1 along with the general exhaust from the administration spaces. The exhaust streams are run separate from each other to a plenum at the unit. Fresh air from HRV-1 is ducted to the returns of the VRF fan coils.

There are several wall mounted propeller fans serving the workrooms and chemical storage areas that are original to the building. The capacity of these fans are unknown at this time.

The VRF indoor units consist of fan coils and wall mounted console units serving spaces in the Administration areas, corridors, and Pipe Gallery areas. The fan coils are located it the ceiling space and ducted to the rooms they serve. The VRF system and HRVs were installed in 2016 and generally have a service life of 25 years and as such are in good condition and should continue to provide service for another 20 years.

It is proposed that the baseline systems, for the administration areas in the new DAF building, would be similar to the existing: a rooftop HRV unit serving the washroom exhaust, general exhaust and fresh air requirements for the occupied spaces and process areas ventilated with dedicated exhaust fans and dedicated outdoor air intakes. Heating and air conditioning provided by indoor fan coil units and a Variable Refrigerant Flow (VRF) heat pump.

4.4.2.2 Existing Heating Plant

The existing perimeter heating system supplements the VRF system for the administration areas and provides heating for the corridors and stairwells. The perimeter hot water system is fed from two, oil-fired, cast-iron heating boilers located in the basement boiler room. The boilers have a capacity of 360 Kw each for a total of 720 kw, each would have a combustion efficiency rating of 86%. The heating water distribution piping is arranged in a primary/secondary configuration with the three secondary loops feeding separate areas of the facility with a dedicated circulating pump. The pumps are arranged as single duty only and do not have a back up.

Most of the perimeter radiation and unit heaters are original to the construction of the building, circa 1979. The boilers have been recently (2016) replaced and should have a service life of 25 years.

4.4.2.3 Proposed Heating & Cooling Plant

Three heating/cooling plants proposed for this facility are:

- Option 1: Baseline - oil fired boiler, HRV and air-cooled VRF system.
- Option 2: Air-water heat pump system with 4-pipe fan coil and electric boiler back-up heating.
- Option 3: Water-water heat pump system with 4 pipe fan coil, electric boiler back-up heating.

The heating/cooling plant for the new DAF building will be sized for the heating and cooling loads calculated at design conditions with a 25% warm-up (heating only), and with the largest heat recovery device (e.g., HRV-1 assumed to be out of service).

The preliminary heating and cooling loads for facility are provided in Table 4.5.

Table 4.6: Preliminary Heating & Cooling Loads

	Exist Building Load	New Building (Admin. Areas) Load	Total Load
Heating	185 KW	25 KW	210 KW
Cooling	20KW	20 KW	40 KW

The mechanical equipment will generally be located on the roof and in the mechanical room. The HRV unit will be located on the roof of the facility and fitted with an electric heating coil to temper the outdoor air during cold periods and when defrost is activated.

Hot water piping shall be constructed as follows:

- New hot water piping: Schedule 40 steel complete with threaded or welded joints. Grooved mechanical joints are acceptable.
- Thermal expansion joints, anchors, hangers, guides, and bends will be provided in the system, as required.

4.4.2.4 Option 1: Baseline - Oil Fired Boiler, HRV, VRF System

This system will use the existing boilers to provide space heating and a HRV for ventilation with an additional VRF system providing the main source of heating and cooling for the spaces. The existing VRF systems will remain in place with minor renovations to suite the new layout. The existing boilers are capable of developing hot water at 90°C and have sufficient capacity to provide perimeter heating to the new and existing spaces.

The existing boilers will be maintained and provided with duty/backup pumping arrangement, with the lag pump activated on a specific time period for run time or when the lead pump fails. New schedule 40 steel piping will be run to the new addition with perimeter baseboard heaters in the occupied admin areas and force flow unit heaters in the process areas. Any exterior entrance will be provided with a force flow cabinet heater.

The boilers are sized at 255 kw each, for a total capacity of 510 kw (1,740 MBH).

The new VRF system outdoor unit will be located on the roof of the new building, refrigerant piping will provide the interior fan coils with the source of heating or cooling as required. The VRF system will be capable of simultaneous heating and cooling year-round.

The new HRV will be roof mounted and provide the outdoor air and exhaust air requirements for the administration areas.

The hydronic system pumps shall be variable speed, inline, split-coupled complete with inverter duty rated premium efficiency motors and integral VFDs. The following pumps shall be provided, each sized for 50% of the total system capacity and operated in a duty/standby arrangement. N+1

- P-1 a&b Existing Primary Boiler Heating Loop = 5.5 l/s each (Qty: 2).
- P-2 a&b Existing Basement Loop = 2.4 l/s each (Qty: 2).
- P-3 a&b Existing Treatment area Loop = 1.7 l/s (Qty: 2).
- P-4 a&b Existing Upper Level loop = 0.76 l/s (Qty: 2).
- P-5 a&b New Building Loop = 1 l/s (Qty: 2).

Oil storage is from existing storage tanks located on the existing plant building's exterior.

4.4.2.5 Option 2: Air-Water Heat Pump System with 4-Pipe Fan Coils System & Electric Backup Boiler

Figure 4.1: Air-Water Heat Pump

This system will use air-water heat pumps to provide both hot and chilled water to meet the heating and cooling demands of the building. The heat pumps will use outdoor air as a heat source/sink to produce hot or chilled water. The units will have a four-pipe design with separate hot and chilled piping connections. This allows the units to produce hot and chilled water simultaneously by transferring heat from the chilled water to hot water side. Each unit will have multiple compressor stages for capacity control. The system will be designed for a heating supply water temperature of 43.3°C and a chilled water supply temperature of 6.7°C. Both the hot and chilled water to the water-air heat pump will be glycol solutions to prevent freezing. The units will be capable of producing hot water down to -13°C ambient conditions. Two air-water heat pumps will be provided with each one sized for approximately 67% of the total heating load at -13°C ambient conditions (140 kW each), the units will also be capable or exceeding the required cooling at design conditions.

Similar to the VRF system, rooftop HRVs will provide the ventilation requirements for the spaces. Separate hot and cold buffer tanks will be installed between the heat pumps and heating/cooling loads to hydraulic de-couple the heat pumps from the building loads and to ensure stable operation at part load conditions. Separate pump sets will circulate the glycol solution from each buffer tank to the water-air heat pumps. The buffer tanks will be sized in accordance with the manufactures recommendation which is 14 liters / KW of nominal capacity.

Hot glycol from the hot buffer tank will be circulated to fan coil heating coils and a glycol-water heat exchanger. This heat exchanger will be used to produce hot water for the buildings space heating systems. Chilled glycol from the cold buffer tank will be circulated to fan coil cooling coils to provide space cooling.

One electric back-up boiler will be installed to take over the heating load if the ambient conditions are below the heat pumps rated condition. The boilers will also provide additional capacity to supplement the air to water heat pumps in case of an HRV device failure. The boiler will be sized for approximately 50% of the heating load to provide some redundancy. Back-up heating water from the electric boilers will be separated from the main glycol heating water by a heat exchanger. Glycol will be circulated through the heat exchanger to inject supplemental heat into the system when required.

The hydronic system pumps shall be variable speed, inline, split-coupled complete with inverter duty rated premium efficiency motors and integral VFDs. The following pumps shall be provided, each sized for 100% of the total system capacity and operated in a duty/standby arrangement, N+1.

- Primary Air-Water Heat Pump Glycol Heating Loop (Qty: 2).
- Hot Water Fan Coil Heating Loop (Qty: 2).
- Low Temp Heating Loop (Qty: 2).
- Back-up Boiler Heating Loop (Qty: 2).
- Back-up Hot Water Heating - Glycol HX Loop (Qty: 2).
- Air Cooled Chiller – AHU Coil Loop (Qty: 2).
- Primary Air-Water Heat Pump Chilled Glycol Loop (Qty: 2).
- Fan Coil Cooling Loop (Qty: 2).

4.4.2.6 Option 3: Water-Water Heat Pump System with 4-Pipe Fan Coils Simultaneous Heating & Cooling

Figure 4.2: Water-Water Heat Pump

This system will use water-water heat pumps to provide both hot and chilled water to meet the heating and cooling demands of the building. The heat pumps will be piped to geothermal well field to use as a source/sink to produce hot or chilled water. The units will have a four-pipe design with separate hot and chilled piping connections. This allows the units to produce hot and chilled water simultaneously by transferring heat from the chilled water to hot water side. Each unit will have multiple compressor stages for capacity control. The system will be designed for a heating supply water temperature of 43.3°C and a chilled water supply temperature of 6.7°C. Both the geothermal and chilled water to the water-water heat pump will be glycol solutions to prevent freezing, the heating side will contain pure water. Two water-water heat pumps will be provided with each one sized for approximately 50% of the building heating load (455 KW each).

Similar to Option 2 above, rooftop HRVs will provide the ventilation requirements for the spaces.

A glycol solution will be pumped through the heat pumps to a closed loop geothermal well field to reject or absorb heat from the ground depending on the operating mode of the heat pump. The geothermal well field will consist of a number of wells drilled vertically to a depth of 150 m. Polyethylene piping will be installed in the well to make a loop and grouted into place. The well fields will be piped together using buried piping and brought back to a manifold in the Level 1 Mechanical Room where it will transition to carbon steel piping.

An alternative to the vertical well field is to utilize the raw process water as a source/sink for the heat pump system. This would involve piping the raw water through a double wall heat exchanger with the glycol solution on the heat pump side. A further study on the water temperature profile indicates that with the water temperature of Pockwock Lake at a low of 2°C during the peak heating season, it is not recommended to pursue this option further.

Separate hot and cold buffer tanks will be installed between the heat pumps and heating/cooling loads to hydraulic de-couple the heat pumps from the building loads and to ensure stable operation at part load conditions. Separate pump sets will circulate water/glycol from each buffer tank to the water-water heat pumps. The buffer tanks will be sized in accordance with the manufactures recommendation which is 14 L/kW of nominal capacity.

Hot water from the hot buffer tank will be circulated to the buildings space heating systems and a water to glycol heat exchanger. This exchanger will be used to heat glycol being supplied to the fan coil heating coils. Chilled glycol from the cold buffer tank will be circulated to fan coil cooling coils to provide space cooling.

One electric back-up boiler would be required to provide back-up heating and additional capacity to supplement the water-to-water heat pumps in case of a failure. The boiler will be sized for 67% of the full heating loading (approximately 90 KW) to provide sufficient heating to prevent freezing. Back-up heating water from the electric boiler will be separated from the main glycol heating water by a heat exchanger. Glycol will be circulated through the heat exchanger to inject supplemental heat into the system when required.

The hydronic system pumps shall be variable speed, inline, split-coupled complete with inverter duty rated premium efficiency motors and integral VFDs. The following pumps shall be provided, each sized for 50% of the total system capacity and operated in a duty/standby arrangement, N+1.

- Primary Air-Water Heat Pump Glycol Heating Loop (Qty: 3).
- Primary Ground Loop Pumps: (Qty: 3).
- Hot Water Fan Coil Heating Loop (Qty: 2).
- Low Temp Heating Loop (Qty: 2).

- Back-up Boiler Heating Loop (Qty: 2).
- Back-up Hot Water Heating - Glycol HX Loop (Qty: 2).
- Air Cooled Chiller – AHU Coil Loop (Qty: 3).
- Primary Air-Water Heat Pump Chilled Glycol Loop (Qty: 2).
- Fan coil Cooling Loop (Qty: 2).

4.4.2.7 Recommended Heating & Cooling Plant

The present design is proceeding on the basis of Option 2, where air-water heat pumps (with a back-up electric boiler) will provide both hot and chilled water to meet the heating and cooling demands of the new DAF Building. The rational for selecting this system is based primarily on sustainability but also on the relative pros/cons as well as cost and energy impacts for the above-described options. The system is consistent with current sustainability goals established by number of local and national government entities.

Though the project does not presently have established sustainability goals, it is assumed that the new DAF Building addition will be required to be held to a higher standard of sustainability goals than the recent 2016 HVAC upgrades to the existing plant. As a minimum, the existing baseline system is required to meet the National Energy Code for Buildings 2017 (NECB 2017). As the design progresses the baseline systems will be compared to the proposed systems to allow HRWC to determine the best solution. If Halifax Water requires a detailed investigation and comparison of the available options, this can be done at the outset of the detailed design phase.

4.4.2.8 Heating Zone Equipment

Heating will be provided to every space in several different ways:

- Entrance vestibules will have force flow fan assisted heaters for rapid warm-up of these vestibules.
- Unit heaters will be used at treatment areas and in workshop and storage spaces
- Spaces such within the administrative area will be heated using the fan coil heating coils. Heating coils will be sized sufficiently to allow for the perimeter heating load and the ventilation load with the HRV out of service.

Generally, heating with the building's ventilation system will be avoided to maximize the ventilation distribution efficiency by supply air that is slightly cooler than the typical room air temperature.

4.4.2.9 Equipment Room Cooling Units

Where necessary electrical, elevator, and telecommunication rooms which contain heat producing equipment will be cooled with dedicated air conditioning units. The units will be selected will be capable of low ambient cooling down to -40°C for year-round cooling. If cooling loads are minor, a dedicated exhaust fan will be used.

4.4.2.10 Building Control System

The building will have a complete building management, Direct Digital Control (DDC) system. The DDC system will consist of a network of standalone application specific and building controllers connected to new electronic devices. All control points and programming will be accessible through the building controllers and via a dedicated IP server allowing access from any internet connected PC through a web browser.

Each heating zone shall have an intelligent temperature sensor/controller with LCD display of the space temperature and current set point. Adjustment of the space temperature will be provided in individual spaces. Bands will be applied to this temperature adjustment so that they cannot be set to unreasonable values. In areas where tampering is unwanted, sensors will be plate sensor type.

4.4.3 Building Plumbing Systems

4.4.3.1 Overview

Plumbing systems presented in this report will address the potable water systems, sanitary, and storm. Fire protection systems will be covered separately.

4.4.3.2 Potable Water Supply

Modifications are being made, as part of this project, in the existing plant which may relocate the location where potable water is available for onsite domestic use. A single point, equipped with a back-flow preventer, will be identified for potable water use. Both the existing water distribution system, in the existing building, and the domestic system, within the new DAF Building, will be supplied from this location. A new 50 mm domestic cold water line will be extended from the new, single potable water supply location to the new DAF Building. A local, point of use electric hot water tank will be located in the new DAF Building to provide domestic hot water requirements.

4.4.3.3 Plumbing Fixtures

All domestic plumbing fixtures will be water conserving type in order to minimize water consumption, associated cost, associated sanitary fluid flow. They will also be robust and simple in operation appropriate to the use. Some product types are indicated below for information and to demonstrate products that meet specific performance objectives.

<u>Water Closets</u>

- Floor mounted ADA vitreous china lined flush tank.

<u>Lavatories (staff washrooms)</u>

- Lavatories will be vitreous china complete with sensor operated faucets and low water consumption aerators.
- Lavatories will be barrier free where indicated on the floor plans.

- Hot and cold water will be run to each lavatory and a mixing valve will be installed under the sink to provide tempered water to the faucet.
- Faucets will be electronically operated and hard wired to the building's electrical system.

Janitor's Sink

- Floor mounted, terrazzo mop sinks will be provided complete with 12" high base, stainless steel end caps, and wall guard.

Kitchen Sinks in supporting areas

- Various counter mounted sinks will be required for the facility. Generally, these sinks will be single or double bowl, stainless steel, counter mounted sinks with kitchen faucets a maximum of 5.7 LPM.

Emergency Eyewash

- The Laboratory area and chemical storage areas will require emergency eyewashes and showers. This equipment will require tepid supply water to meet ANSI Standard 358.1. Fixture placement will be coordinated with user groups.

4.4.3.4 Sanitary Sewer System

A complete sanitary sewer piping system will be provided to direct gravity sanitary drainage to a point of connection to the existing site sanitary drainage system. The mechanical contractor shall provide a complete sanitary sewer piping system to a point 1.5m outside the building for continuation by the civil contractor.

Sanitary sewer piping below grade shall be PVC complete with solvent joints. Above ground sanitary sewer piping shall be cast iron with mechanical joints, or copper with sweated connections. PVC piping is not acceptable inside the building although consideration will be given to fire rated coated PVC products rated for sanitary drainage and that meet the required 25/50 flame and smoke ratings.

Condensate drainage from any mechanical equipment shall be insulated, copper piping connected to the sanitary sewer via funnel floor drains or indirect connections. Automatic electronic trap priming system will be specified for all floor drains with p-traps in the facility. Minimum sixteen (16) x 20 manifold stations may be required. Home run water piping will be distributed to each p-trap.

Some form of onsite treatment will be required to treat sanitary flow from the existing plant building as well as the new DAF building. The original drawings indicate a septic tank and tile field to the northwest of the reservoir on site. It appears that this original system is still in use. Though it would appear likely that the system would need to be upgraded, the system must be investigated to determine whether it is adequate for future use. At this time, it is assumed that the new sanitary flows, from within the new DAF building, will be pumped to the location of the existing septic system, while also flows from the original plant will continue to flow by gravity to this location.

4.4.3.5 Storm Sewer Piping

All storm drainage from the building roof will be collected at the roof drains and piped underground to connect to the building storm sewer system. The mechanical contractor shall provide a complete storm water system to a point 1.5m outside the building for continuation by the civil contractor.

Storm drainage piping shall match the specification requirements for the sanitary drainage systems listed above for cast iron system only. All rainwater leader piping shall be insulated with 40mm thick (R5) fibreglass and complete with vapour barrier. Exposed rainwater leader piping shall be complete with a hammered aluminum or white PVC jacketing.

4.4.3.6 Domestic Water System (Potable)

The domestic water distribution system will serve all plumbing fixtures and systems in the building. The installation will, as a minimum, meet the requirements of the National Plumbing Code. The scope of the mechanical contractor's work will comprise of renovations within the existing renovated admin area and the new system in the addition. The system to be extended from the exiting service in the basement of the existing facility.

Backflow preventers for make-up water assemblies will be provided for mechanical hydronic systems that require it, for example:

- Heating hot water.
- Propylene Glycol antifreeze hydronic loops.

All domestic cold water piping will be insulated with 25mm (R3.3) thick fibreglass insulation. Exposed piping will be complete with a hammered finish aluminium jacket, or PVC jacket. Concealed piping will be enclosed with all service jacket. Consideration will also be given to self-adhesive jacketing products that provide mechanical protection and a robust vapour barrier.

4.4.3.7 Domestic Hot Water

A point of use domestic hot water system will be provided in the new addition. It is assumed the existing domestic hot water systems will be reused and renovated for the existing renovated areas. The new domestic hot water tank will be an electric tank, sized for the 1-hour fixture demand load or the emergency shower load, whichever is greater. A recirculation system will be provided to maintain piping distribution temperature at 60 degrees C (140 F).

All domestic hot water piping will be insulated with 40mm (R5) thick fibreglass insulation complete with vapour barrier and ASJ service jacket. Exposed piping will be complete with hammered finish aluminium jacket or white PVC. The distribution system will include recirculation of hot water back to the tank to ensure quick response at all the fixtures. This recirculation system will extend within the washroom walls and down under the lavatory vanities to ensure that hot water is readily available despite the low water use fixtures.

4.4.4 Building Fire Protection Systems

4.4.4.1 Overview

It is assumed that the new addition will not be provided with a sprinkler system as the building is classified as an Industrial Occupancy and, provided the required fire separations are provided, a sprinkler system is not required by NBCC.

Fire extinguishers in lockable semi recessed cabinets shall be provided to the requirements of the National Fire Code, NFPA 10, and the local authorities having jurisdiction.

4.5 Electrical

4.5.1 General

The following sections outline the electrical requirements for power, lighting, telecommunications, security, fire alarm, and grounding.

All electrical equipment required will be new (complete with full manufacturer's warranties), of a proven design for each application, and shall comply with the latest applicable regulations, codes, and standards.

All work will be completed in accordance with the latest edition of the *Canadian Electrical Code*, HW requirements, and the local electrical inspection authority having jurisdiction.

4.5.2 Applicable Building Codes & Standards

Following is a partial list of codes and standards applicable to this building:

- NBC - Canadian National Building Code.
- NFC - Canadian National Fire Code.
- NFPA – Applicable sections of the National Fire Protection Association standards.
- Nova Scotia Provincial Building Regulations.
- NEBC – National Energy Code of Canada for Buildings (2017).
- CSA - Applicable sections of the Canadian Standards Association.
- CSA C22.1-22 – Canadian Electrical Code, Part I.
- ASHRAE/IES Standard 90.1-2019 – Energy Standard for Buildings except low rise residential.
- IES – Applicable sections of the Illuminating Engineering Society Recommended Practices (RP).

- IES - Illuminating Engineering Society (IES) HB-10-11, 10th Edition of the Lighting Handbook.
- BICSI Telecommunications Distribution Methods Manual (TDMM) 14th Edition.
- ANSI/TIA-568-C, Commercial Building Telecommunications Cabling Standards.
- ANSI/TIA-569-C, Commercial Building Standards for Telecommunications Pathways and Spaces.
- ANSI/TIA-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications.

4.5.3 Electrical Site Services

4.5.3.1 Utility Power Supply

The main utility power supply and Nova Scotia Power (NSPI) substation 102H is located at the low lift pump station. The NSPI substation has a pad mounted power transformer which steps the voltage down to a 4160V utilization voltage at the low lift pump station. The WSP is then sub-fed from the low lift pump station through a 4,160V overhead line between the two sites. At the WSP, the overhead line transitions to an underground ductbank into the building. The existing utility service to the low lift pump station will remain as is.

The existing 25 kV utility overhead line which presently ends just past the low lift pump station entrance roadway will be extended up the WSP. Preliminary routing of the new overhead line will be along the existing roadway up to the WSP with final routing to be confirmed with NSPI during detailed design.

A new electrical service will be installed to the WSP from a utility pad mounted transformer located on the site. Refer to the drawings for the proposed location. The new pad mounted transformer will be installed per NSPI standard requirements. The primary service to the transformer will be installed underground from a 25 kV utility pole and will consist of a concrete encased ductbank with either 100 mm or 125 mm diameter conduits as required. The 600V secondary service from the transformer shall be direct buried rigid PVC conduit to the main service entrance switchgear assembly located in the new main electrical room of the building. Spare underground conduits will be provided between the Utility padmount transformer and the service entrance switchboard for future.

There is an existing abandoned overhead distribution line that presently runs along the wind turbine/transmission access road, around the back of the WSP and then down to the low lift pump station. This line will be removed starting at the corner pole next to the wind turbine/transmission access road down to the low lift pump station. The 4,160V overhead line between the low lift pump station and WSP will be removed once the new electrical service to the WSP is in place. The existing poles could remain in place for routing telecommunications from the WSP to the low lift pump station. A safe clearance report from NSPI will be required to complete any work on these lines or near these lines.

4.5.3.2 Telecommunications Service Supply

The telecommunications utility new voice and data incoming services will be routed along the new overhead utility pole line up to the WSP and then underground from a new utility service pole into the new main electrical room at the WSP. The underground telecommunications ductbank will consist of a concrete encased ductbank with two 100 mm diameter conduits. The existing utility voice and data incoming services to the WSP will be removed as they appear to be routed on the same poles with the 4,160V overhead power to the WSP.

4.5.4 Power Distribution Systems

4.5.4.1 Main Service Entrance

The existing power service to the WSP is 4,160V, 3 phase to a 2,000 kVA dry type transformer located within the plant which steps the utilization voltage down to 600V, 3 phase. A 4,160V, 600A fused load break switch is installed upstream of the transformer in the same room for local isolation and protection. There is an existing Neutral Grounding Resistor (NGR) installed for the 600V system which limits the ground fault current to 2.5A. In the event of a ground fault on the 600V system, downstream breakers and fuses do not trip to maintain plant operation while the ground fault is located and repaired. The 2,000 kVA transformer feeds existing 600V Motor Control Centre (MCC) No. 3 which then feeds all the WSP loads. As part of the DAF plant upgrades, the 4,160V load break switch and the 4,160V-600/347V transformer will no longer be required and will be turned off and disconnected for removal in a future project. Existing MCC No. 3 will then be re-fed from the new electrical service to the plant.

A 600V service entrance switchgear assembly will be installed in the new main electrical room. The switchgear will be an arc-flash resistant assembly with arc flash protection and draw-out type air circuit breakers with electronic trip units. The switchgear assembly will be complete with a utility metering section, an Owner's metering section with digital power meter, a Surge Protective Device (SPD), tin-plated copper busbar and a main incoming bussed wireway. The circuit breakers will be capable of being remotely operated for personnel safety. Preliminary load calculations estimate the new electrical service size to be 600V, 2,500A, 3 phase, 4 wire. Service equipment will be rated 3,000A for future loads.

The neutral on the incoming 600/347V power will be solidly grounded which is different than what is installed now at the WSP. One reason for this proposed change is that NSPI supplied transformers are normally supplied with a wye-wye winding configuration and a resistance grounded neutral requires a delta-wye transformer for proper operation. If HW prefers a resistance grounded neutral, further discussions with NSPI would be required. Some disadvantages with a solidly grounded system is that ground fault magnitudes are much higher which can cause equipment damage and selective coordination of overcurrent protective devices (breakers, fuses, etc.) may not be possible.

4.5.4.2 Standby Power System

The low lift pump station has a 4,160V, 1,750 kW, 3 phase standby diesel generator to provide backup power to both the low lift pump station and the WSP. If the 4,160V overhead line between the WSP and low lift pump station is damaged, then this standby generator will not be able to provide backup power to the WSP. The WSP does have a 600V, 365 kW, three phase standby diesel generator that provides backup power to selected WSP loads. There is also a connection for a 600V portable generator in MCC No. 3 at the WSP to provide standby power if needed.

For transfer to standby power at the low lift pump station, there is a soft load transfer scheme in place. In a normal power outage, the generator is automatically started to provide standby power to the site. Upon resumption of utility power, power is then transferred back to utility power and the generator automatically shuts down. In this type of transfer scheme, utility power is paralleled with generator power for a short duration during transfer while the two power sources are synchronized and load is offloaded from one source to the other. Load transfer between the two power sources is done through automatic control of the main and generator circuit breakers and a Woodward diesel engine generator controller. At the WSP, there is an automatic transfer switch in MCC No. 4 that transfers load between normal and generator power and starts/stops the standby generator at the WSP.

For the upgrades, the standby power system at the low lift pump station will remain in place but it will no longer provide backup power to the WSP. The existing standby generator and automatic transfer at the WSP will become redundant as part of this upgrade and will be removed as part of a future project.

For new standby power at the WSP, two 600V, three phase standby diesel generators will be installed to match the LMWSP. Each generator will be an exterior packaged unit consisting of the generator complete with circuit breaker, control panel, sub-base fuel tank suitable for a minimum of 24 hours of continuous operation at full load, and a weatherproof, sound attenuated, non-walk-in enclosure. Each generator assembly will be installed on a concrete pad near the new main electrical room as indicated on drawing C-01. The generators will be sized to operate in parallel to maintain plant operation. If one generator fails, selected building and process loads will need to be shutoff to prevent overloading the remaining generator. Alternate generator configurations can be reviewed in further detail during detailed design.

For the transfer scheme between utility and generator power, a soft load transfer scheme with automatic breaker control to match the existing transfer schemes at JDK low lift pump station and LMWSP will be installed. Considering the utility is paralleled with generator power during transfer, this will require approval by the NS Chief Electrical Inspector and NSPI. Alternately, a 600V, three phase automatic transfer switch, either an open transition type with in-phase monitor or closed transition type would be installed. The 600V generator paralleling switchgear assembly will be installed in the new main electrical room.

The switchgear will be an arc-flash resistant assembly and draw-out type air circuit breakers with electronic trip units and generator/breaker controls. A connection for a resistive load bank will be installed for generator testing at full load.

4.5.4.3 Building Power Distribution

Power distribution throughout the building will be at 600/347V, 3 phase, 3 or 4 wire and 120/208V, 3 phase, 4 wire as necessary. Power will be provided to process, mechanical, security, intrusion alarm and other base building system devices as necessary.

A 600V distribution switchgear assembly will be installed in the new main electrical room to allow connection of a portable standby generator in the event of a failure of the upstream distribution and standby power equipment. This switchgear assembly will feed all WSP loads as noted on the single line diagrams in Appendix A. This switchgear will be an arc-flash resistant assembly with arc flash protection, draw-out type air circuit breakers with electronic trip units, an Owner's metering section with digital power meter, tin-plated copper busbar and a Surge Protective Device (SPD). The circuit breakers will be capable of being remotely operated for personnel safety.

Based on preliminary load information and equipment locations, two new 600V MCCs will be installed in the DAF building for new process and mechanical equipment. One MCC will be installed in the main electrical room and the second in the upper floor electrical room. A third 600V MCC will be installed in the upper floor electrical room for the equipment at the CWWW tanks. The MCC's will include circuit breakers, fused disconnect switches, adequately sized NEMA Full Voltage Non-Reversing Motor (FVNR) starters and VFDs as required for the process and mechanical equipment. VFDs will be complete with line reactors (minimum 3%) for harmonic mitigation and output dv/dt filters for motor protection. Space will be allocated for future equipment.

Switchboards and panelboards complete with circuit breakers will be installed as necessary for new building loads. Switchboards will be located within electrical rooms. Panelboard locations will be selected to suit load locations with consideration to limit conductor size to a maximum of #6 AWG to meet CEC voltage drops requirements. Where possible, panels will be located within electrical rooms or similar service rooms such a mechanical room. Separate lighting panels will be installed for energy monitoring of lighting.
Dry type transformers with copper windings will be installed for 120/208V branch circuit panels and as otherwise required. 45 kVA units and smaller will be wall mounted above the associated panel in which they supply or installed on 4" thick concrete housekeeping pads. Transformers larger than 45 kVA will be floor mounted on concrete housekeeping pads. Transformers will meet or exceed the energy performance requirements of NRCAN 2019 (or latest edition). Consideration will also be given to selection of dry type transformers with 115°C or 80°C temperature rise versus 150°C temperature rise as lower temperature rise transformers generally incur lower no-load and load losses.

Local disconnect switches will be installed for each motor and motorized valve for local isolation.

4.5.4.4 Harmonic Filters

A circuit breaker will be reserved in the 600V distribution switchgear for connection of an active harmonic filter with a space allowance in the main electrical room. Once operational, the building harmonic profile can be measured for sizing the new harmonic filter to reduce overall harmonics. The harmonic filter will then be installed in a future project.

4.5.4.5 Uninterruptible Power Supply

The existing UPS and downstream UPS panel at the WSP will remain in place to feed existing PLC controls and other critical loads. Similarly, a new central UPS and downstream UPS panel will be installed for new critical loads in the DAF expansion project. The UPS will be a true on-line, double conversion type UPS with bypass.

New UPS units will either be installed in the new telecommunication racks for rack mounted equipment or this equipment will be fed from the new central UPS as determined during detailed design.

4.5.4.6 Receptacles

General use receptacles will be installed throughout the DAF expansion to suit the proposed layout and room usage requirements. Exterior building mounted receptacles will be installed at each exterior door and at outdoor mounted equipment where required for maintenance. General use receptacles will be specification grade and CSA 5-15R and CSA 5-15/20RA configurations. GFCI protected receptacles will be installed near sinks, showers, outdoors and in other locations required by the CEC. Split receptacles will be provided at kitchen counters. In wet or damp areas, receptacles will be complete with weatherproof covers.

4.5.4.7 Wiring & Conduit

New electrical power distribution will be installed to meet project requirements. Conduits will be installed in accordance with the CEC and will be sized 21 mm diameter or larger. EMT will be used indoors in dry areas. Rigid aluminum or galvanized steel conduit will be used in wet or damp areas and outdoors. Final connections to equipment subject to movement or vibrations (motors, transformers, generators, etc.) will be made with liquid tight flexible conduit.

Galvanized steel or aluminum cable tray, sized to meet project requirements, will be installed for routing armoured power and control cables. Power cables will be de-rated in accordance with the Canadian Electrical Code. Separate cable trays will be installed for instrumentation and communication cables.

Power conductors will be 600V stranded copper, type RW90. Armoured power cables will be copper TECK90 cables. The minimum power conductor size will be #12 AWG. Instrumentation cables will be armored or unarmored, multi-paired or triad (shielded & twisted) cables with tinned stranded copper conductors. Control cables will be armored or unarmored multi-conductor cables with stranded copper conductors. Single conductor control cables will be 600V, stranded copper, type RW90. All unarmoured cables will be installed in conduit.

In areas with concealed ceilings such as office areas, AC90 (BX) armoured cabling will be installed above T-bar ceilings for final connection to lighting fixtures from a local junction box. Local junction boxes will be generally located within 5 m of fixture locations with no more than four fixture drops from each box. In process areas, final drops to lighting fixtures will be in liquid tight flexible conduit or SOW type cable from a local junction box.

4.5.4.8 Grounding & Bonding

A new grounding triad comprised of three copper clad steel ground rods will be installed for the new electrical service and will be connected to a new ground bus located in the main electrical room. A new ground bus will also be installed in the upper-level electrical room and server room. Existing ground buses in existing electrical rooms will be connected to the new building ground system.

Bare stranded copper conductors will be used for below grade grounding conductors and bonding conductors in galvanized steel cable trays. All other bonding and grounding conductors will be stranded copper type RW90 conductors (green coloured insulation). Bonding and grounding will be installed in accordance with CEC requirements.

4.5.5 Lighting Systems

4.5.5.1 Interior Lighting System

Lighting will be installed in all areas of the DAF expansion. The maximum lighting power density allowable under the NECB or ASHRAE 90.1-2019, whichever is more stringent, will be followed. The current design target will be as far below this density as practical, to be as efficient as possible.

To minimize the overall lighting power density, lighting fixtures utilizing LED sources are proposed for all lighting. Final fixture selection will be made in coordination with HW based on the building layout, ceiling type and height, and room function. Light fixtures will be suitable for their environment. Most LED fixtures can dim without the extra cost of a special dimming driver. The use of dimmable fixtures in association with appropriate controls will maximize energy savings obtained via daylight harvesting if applicable, and user control. Lighting levels will be designed to meet IES recommendations and all applicable Code requirements. Table 4.8 outlines the proposed lighting levels throughout the expansion.

Table 4.7: Lighting Illuminance Targets

Space	Illuminance Target (Lux)
Process Room	300
Locker Room	200
Shop/Maintenance	300
Storage Room	200
Pilot Room	300
Offices	500
Janitors Closet	100
Stairwells	200
Corridors	200
Electrical/Mechanical Rooms	300
Lab	500
Control Room	300
Lunch Room	300
Server Room	500

4.5.5.2 Exterior Lighting System

Exterior lighting shall consist of building mounted luminaires lighting areas immediately adjacent the building as well as pole mounted area lighting for access roadways and parking areas. Exterior lighting fixtures will be LED, enclosed and gasketed and suitable for outdoor installation.

The exterior lighting system shall be designed to meet the performance and illumination recommendations of IESNA RP-33, Lighting for Exterior Environments. Lighting power densities for exterior lighting will be at or below NECB or ASHRAE 90.1-2019, requirements whichever is more stringent.

4.5.5.3 Lighting Controls

The interior and exterior lighting will be controlled by a lighting management system that includes computer-based software for control, configuration, monitoring, alerting, and reporting of the lighting system. The system will be expandable for future upgrades to the remainder of the WSP.

The lighting control system will have the ability to interface with the building automation system via standard communication protocol such as BacNet and other auxiliary equipment such as AV control systems, motorized shades, and security systems. In general, the interior lighting controls will be provided by a number of sources including occupancy sensors, vacancy sensors, time clock, daylight sensors and local switching/dimming control. Areas with access to natural lighting will be controlled via daylight sensors which will control the light output (dimming control) of the electric lighting system within the control zone.

Corridor lighting will generally be controlled both through occupancy sensors and time of day controls but also be allowed to be controlled through override switches.

Office lighting and similar spaces will be controlled through occupancy sensors, daylight sensors (where applicable) and dimming controls.

No automatic controls will be installed in mechanical and electrical rooms for safety reasons.

Exterior lighting control shall be provided by the lighting control systems astronomical time clock or a stand-alone astronomical time clock and lighting contractors. Exterior lighting can be zoned and controlled to allow for some of the exterior area lighting to be turned off overnight while maintaining appropriate security light levels.

4.5.5.4 Emergency & Exit Lighting

Emergency lighting and exit signs shall be provided along egress routing and exit doors to meet the requirements of the National and Provincial Building Codes. This will be in the form of a combination of emergency lighting battery units and remote heads. Each will use LED lamps to reduce the overall power consumption while maintaining a safe level of lighting for egress in the event of a power outage. New emergency lights will be suitable for their environment. Battery units will be supplied from the nearest lighting circuit. Remote heads will be fed at 12 Vdc from the nearest battery unit.

Exit lights will be the green exit pictogram (Running Man) conforming to the requirements of CAN/ULC S572. Exit units shall be cast aluminum or other construction suitable for the environment, c/w LED light source and have internal battery backup. Exit lights will be supplied at 120V from the nearest power panel.

4.5.6 Telecommunication Systems

A telecommunications cabling and raceway system will be installed, generally including but not limited to, telecommunication racks, cross connects, patch panels, BIX blocks, cable management, grounding, cable pathways, horizontal cabling, backbone cabling, equipment line and patch cords, and telecommunication outlets. Active components including ethernet switches, routers, wireless access points and firewalls are not included but space will be reserved in data racks for installation by HW's IT group.

A complete cable pathway and management system from the work outlets to the Main Communications Room (MCR) including outlet boxes, conduit, cable trays, pull boxes, and cable management will be installed.

The server room will be the main telecommunications room (MCR) that will house the new voice and data service entrance for the WSP as well as serve as the telecommunications backbone cabling distribution center for the remainder of the plant. The MCR shall also provide voice and data distribution to the common areas of the building and house the horizontal cabling system termination sub systems and shall serve as the connection point between backbone cabling and horizontal cabling.

Telecommunications racks in the MCR shall be industry standard 19” racks, floor mounted, complete with rack mounted power distribution bars and UPS systems. Final rack details to be determined during detailed design.

New voice/data outlets will be provided in the new DAF expansion to suit the proposed layout and room usage requirements. These outlets will be fed from the MCR telecommunications patch panels. Additional patch panels, BIX blocks, cross connects, and other components will be provided if required.

Horizontal data cabling shall generally consist of CAT 6A standards compliant copper cabling. Horizontal voice cabling shall generally consist of CAT 5e standards compliant copper cabling assuming that new voice will match existing. If Voice-Over-IP (VOIP) is to be used for new telephone, horizontal voice cabling will be changed to CAT 6A standards. Horizontal cabling shall not exceed 90 m in total length in compliance with the Category 6A standards. Cabling shall be terminated in CAT 6A patch panels in a telecommunications rack. The routing of horizontal cabling will be separated from pathways and spaces that generate Electromagnetic Interference (EMI). New horizontal cabling will be installed in conduit.

New data and voice backbone cables will be installed from the MCR as required for interconnection of existing data and telephone infrastructure. Fibre type data backbone cables will be installed if runs are longer than 90 m in length. Voice backbone cables would be multi-pair minimum CAT 3.

Horizontal data cabling would be installed to wireless access points in accordance with HW requirements.

The telecommunications system will be standards compliant and provided by a single manufacturer.

4.5.7 Fire Alarm System

There is no existing fire alarm system at the WSP and a new fire alarm system has not been included in this upgrade.

Electrical rooms and other critical spaces like server rooms will be monitored by smoke or heat detectors. These devices will be connected to the Plant PLC control system for annunciation and alarming.

4.5.8 Intercom System

Intercom will be installed at new access-controlled gates and will be connected to the control room similar to the existing gates.

4.5.9 Security Systems

4.5.9.1 Intrusion Alarm

There is presently an intrusion alarm system covering all perimeter doors at the main building and outbuildings. For the new DAF expansion, all new perimeter doors will be added to the existing security system for monitoring and alarming. Additional arm/disarm keypads will be added if required.

The worker down/distress system will be extended to the new expansion areas.

4.5.9.2 Access Control System

There is an existing access control system at the site which controls doors at both the low lift pump station and WSP and controls entry gates. New access controls will be added in this project and will be tied into the existing access control system. New access controls will be installed at new selected exterior perimeter doors for entry into the new building. Selected rooms within the DAF expansion building such as the server room, electrical room and other rooms required by HW will also be installed with access controls. Lastly, any new vehicle gate requiring access controls will be installed for gate control.

New door controllers will be up to 4 door type controllers and will be installed to suit door locations. Where possible, they will be installed in the server room or other secure location.

Access controlled doors will be complete with an electric strike, door contact, card reader and a Request to Exit (REX) detector. These devices will be wired back to its respective door controller.

Access controlled vehicular gates with be complete with card reader, intercom and local door controller mounted in a weatherproof enclosure. Access controls will be interconnected with the new electric gate operator for open/close operation.

4.5.9.3 CCTV System

The is an existing CCTV system at the plant with cameras located at vehicular gates, the low lift pump station and the WSP. The cameras are connected over ethernet and monitored by a Network Video Recorder (NVR) in the communications room. The existing system is integrated with the access control system to be able to open and close gates on screen.

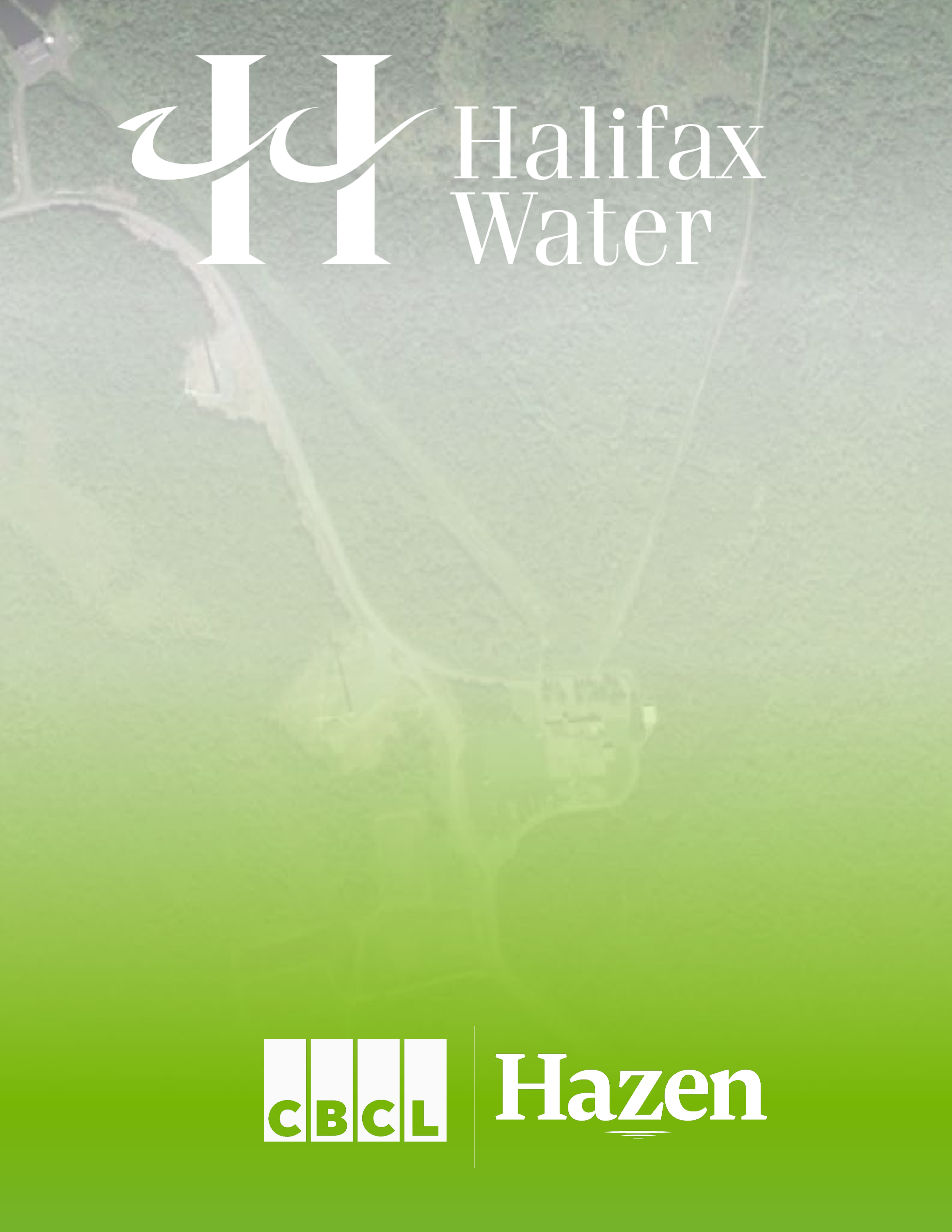
For the new DAF expansion project, new cameras will be installed along the building perimeter, at new vehicular gates and within the buildings to suit the building layout and HW requirements. Final locations will be verified with HW. New cameras will be network IP digital, high-resolution type with pan-tilt-zoom capability where required. New camera's will be connected over ethernet to a NVR located in the server room or to existing infrastructure as determined during design. A POE network switch will be installed for camera connectivity and power.

End of Report

Prepared by: Mike Chaulk, M.A.Sc., P.Eng. Manager, Process Department	Reviewed by: Kevin Murphy, P.Eng. Senior Project Manager

APPENDIX A

Preliminary Design Drawings


Halifax
Water
CBCL
Hazen

ATTACHMENT 2

Project Charter

Project Name	WSEP – JDK Pre-Treatment and Clarification		
Project #	JDK-800.10	Date	March 2023
Project Start	January 2021	Prepared by	Mike Chaulk
Project End	October 2026	Reviewed by	Kevin Murphy
Revision #	3		

1. Business Need

The source water for the JD Kline Water Supply Plant (JDKWSP) from Pockwock Lake has been evolving over several years with an increase in pH, total organic carbon, and instances of toxins and bacteria from blue green algae. The evolution in the source water has resulted in an increase in chemical costs, residual handling challenges, shorter filter runs at the WSP, and taste and odor complaints from customers. As a result of the present-day water quality and the anticipated continued evolution of the Pockwock Lake and Lake Major source waters, clarification alternatives were evaluated. The resulting 2019 Hazen and CBCL report, titled *The Recommendation of Appropriate Clarification Process for the JD Kline and Lake Major Water Supply Plants*, concluded that the addition of Dissolved Air Flotation (DAF) was the most appropriate clarification treatment process to address the turbidity, natural organic matter, color, and total organic carbon concerns that the WSP is experiencing.

A new DAF-based clarification process is proposed to be added to the WSP in this project. The DAF process is a robust and non-proprietary system resilient to variations in water quality and requires less chemical addition than conventional clarification processes. It is also an established treatment process for algae and biomass removal from source waters.

Further to the existing periodic filter run time issues experienced when filters are placed back online, there is a period of filter ripening that results in a lower quality filtered water. With the continued evolution of the source water quality and climate risk, there is concern that this issue will be further pronounced. Development of a filter-to-waste connection for the filters to direct the ripening water to waste treatment or a disposal system is recommended. For that reason, modifications to the filter outlets will be made as part of the project to implement filter-to-waste. During the preliminary engineering phase, mechanical and piping options to achieve filter-to-waste implementation will be assessed, and the selected option will be incorporated into the detailed design.

The existing waste conduit currently conveys spent filter backwash to two backwash waste settling ponds and drying beds. With the addition of the filter-to-waste piping, the settling ponds will be overwhelmed with a high volume of dilute wastewater, which will exacerbate current regulatory non-compliances for lagoon discharge to reduce settling pond loading. For that reason, it is recommended to implement filter backwash recycle at the WSP. This will require a new spent backwash holding tank and pump system, and an overall process design intended to function in this manner.

The existing storage for aluminum sulphate (alum), potassium permanganate, and polymer are insufficient for current operations. New storage and dosing systems for alum, permanganate, and polymer will be required for pre-treatment of the new DAF clarification system.

Additionally, the lab and office space are largely original to the WSP and are inadequate for the day-to-day needs of the WSP. There is currently insufficient office space for staff and inadequate space to hold meetings. A new office and administration space will be accounted for in the new DAF building along with a new controls area. Furthermore, a pilot plant will also be included.

Additional information supporting the development of this project can be found in the main report and Appendix 2 of *Capital Upgrade Strategy Report for the JD Kline Water Supply Plant* by CBCL Limited and Hazen Sawyer, dated April 13, 2021.

2. Project Goals

The following project goals have been identified with respect to the new DAF clarification system:

- To create a robust clarification system that will adapt to source water quality changes expected through continued lake recovery.
- Design and construct a safe and operator friendly process.
- Provide appropriate storage and containment for alum, permanganate, and polymer.
- Reduce the load on the wastewater settling ponds.
- Replace aging infrastructure.
- On-time delivery of project design and construction.
- Develop a modular and long-term process solution.
- Allow for continued treatment at full capacity during construction.
- Provide adequate administration and lab space to facilitate day-to-day activities.

- A consistent and cohesive treatment strategy within Halifax Water's WSPs.
- Ensure the coagulation / flocculation / clarification strategy is aligned with the pre-oxidation strategy.

3. Scoping

The following section provides a general overview of the scope of the JD Kline Pre-Treatment and Clarification project. To date, pre-design and preliminary design phases of the project have been completed and filed as:

- Pre-Treatment and Clarification Predesign – JD Kline and Lake Major Water Supply Plants – WSEP, February 2022, CBCL and Hazen.
- WSEP – JD Kline Water Supply Plant – JDK800.10 Pre-Treatment and Clarification – Design Report, September 2022, CBCL and Hazen.

These two reports describe the evolution of the design basis in detail, including the present design parameters and preliminary drawings.

The overall scope comprises of all the necessary phases of work from predesign to design, tender, construction, and commissioning. The design scope primarily includes the construction of a new DAF treatment building on the south side of the existing WSP, east of the newly constructed blower building. The DAF facility will house the new DAF trains, rapid mix systems, chemical storage and dosing systems, office and meeting spaces, and space for a new pilot plant. The construction of a new building allows for continued operation of the existing treatment process while the upgrades are completed.

The existing rapid mix and hydraulic flocculation process ahead of the existing filters will be abandoned. A new rapid mix system and oxidation tank are included in the scope along with new raw water piping.

New filter-to-waste piping will be installed at the outlet of the filters. A portion of the existing clearwell space will be converted to an operating gallery to allow for individual filter to waste as well as consolidation of combined filtered water into a new piped header capable of conveying water around the current reservoir and directly to transmission. Filter to waste water will flow to a new backwash holding tank located to the west of the new DAF facility. This tank will receive inflow from filter backwash processes and filter-to-waste operation. The holding tank will be underground and equipped with pumping systems for recycling the tank contents to the inlet of the WSP where it will blend with raw water, thereby enabling filter backwash water recycling as part of the project.

The DAF system design concept is based on a total flow of 145 MLD +10% recycle with six (6) active DAF trains. The table below identifies summary design parameters, taken from the Design Report noted above.

Design Basis – Key Process Features

Number of Trains	6
Number of Flocculation Stages Per Train	2
Orientation	Side by Side
Size per Train (L x W x D)	22.1 m x 8.1 m x 4.1 m
Flow per Train	26.6 MLD
Hydraulic Retention Time	9.7 minutes
Loading Rate	19.3 m^3/hr
DAF Overall Length	22.1 m
DAF Overall Width	48.9 m
Overall Building Size (L x W)	57.4 m x 35.7 m
Backwash Holding Tank Volume	3,590 m^3

The project scope summary, therefore, includes:

- Two (2) new pre-oxidation tanks.
- Two (2) new parallel chemical mixing channels (coagulation and pH adjustment)
- New DAF system comprising of six (6) new DAF basins, twelve (12) flocculation tanks, and associated piping, valving, and pumps.
- A floated solids residual collection system.
- Nozzles, equipment, and skimmers/scrapers.
- New and upgraded chemical systems for fluoride, alum, permanganate, and caustic.
- New primary power service with internal distribution to existing facility and dedicated backup power supply.
- Interior space for new pilot facilities.
- New lab.
- New office space.
- New control room.
- Reconfiguration of existing lab and control room as meeting space and work stations.
- Two (2) new filter-to-waste headers connecting the outlet of the filters to the waste conduit.
- New backwash water holding tank sized for multiple backwash events, complete with pumping systems, recycle piping, control chamber, and pump house.

The overall project site plan, as included as part of the Design Report is appended for reference as *Appendix A*.

4. Project Constraints

The following section provides a list of initial project-specific technical constraints for the JD Kline Pre-Treatment and Clarification project.

This list includes constraints known at this time and is not considered to be all-inclusive.

- Maintaining the existing treatment system in operation while installing or commissioning the DAF system.
- The system must be able to perform consistently with variations in intake water quality.
- Operational constraints with connecting new DAF system piping into the existing raw water piping and existing filter inlet piping and associated shut down period.
- Resiliency to operate under unusual or extreme weather conditions or during planned or unplanned maintenance activities.
- DAF system configured for individual trains to be taken offline to allow future components of the system to be maintained or replaced without disrupting the entire DAF system.
- Access road and fencing around the WSP to be modified to accommodate the new DAF structures.
- Controls at the new DAF facility must be fully integrated into the WSP.
- Conduct work within environmental permit requirements.

Schedule and budget constraints are discussed in Section 5 – Schedule, and Section 6 – Budget, respectively.

5. Project Schedule

An overview of the project schedule of the JD Kline Pre-Treatment and Clarification project is included below. The schedule generally comprises of all necessary phases of work from predesign to design, tender, construction, and commissioning. Milestones, sequencing, and approximate durations are listed below.

Project Schedule by Phase & Duration

Phase	Start Date	End Date	Duration (Months)
Concept / RFP	May 2021	May 2022	13
Design / Tender	June 2022	November 2024	30
Construction & Commissioning	November 2023	October 2026	36
		Total	79

Timelines and sequencing are based on best current estimates and are subject to change as the project implementation becomes more defined. It is anticipated that the execution may include multiple construction phases to facilitate fiscal and schedule goals. This project is the first project to be completed in the overall Water Supply Enhancement Program (WSEP) and is the core project in creating the next generation JDKWSP.

6. Budget

The project budget is presently estimated to be **$131,257,488** including engineering, construction costs, contingencies, and net HST.

- The current Project Budget is attached as ***Appendix B***.

The project budget is based on best current design parameters and is subject to change as the project scope becomes more defined.

Based on the project budget and schedule, the following table presents the current projected project spending by year (differences from the Project Budget result from rounding).

Cash Flow Summary

Fiscal Year	Project Spending
2021/2022	$2,273,000
2022/2023	$604,000
2023/2024	$5,733,000
2024/2025	$35,719,000
2025/2026	$40,910,000
2026/2027	$39,286,000
2027/2028	$6,715,000
Total	$131,779,000

*Values report in (000's)

7. Project Meetings

Project meetings are carried out on a weekly basis or other milestone interval as needed. Attendees include relevant Halifax Water staff, design leads, program leads, advisors, and contractor staff. A list of typical project milestone meetings can be found in the Project Meetings List in Chapter 11 of the *Program Plan* document.

8. Risks

The following section provides a list of project-specific risks for the JD Kline Pre-Treatment and Clarification project. This list includes major risks that could affect scope, schedule, and budget, and is not considered to be all-inclusive at the current level of project definition.

Project Risks & Mitigation Measures

Risk	Mitigation
Through project workshops it has been agreed that, due to the lack of existing clarification at JDKWSP and risks to filter operation, there is a high level of concern regarding reliability of the WSP.	New construction in an entirely new building allows for construction without disruption to the existing WSP. This will be the first major project in the WSEP and is aimed to be completed as efficiently as possible.
Tie-ins of the new DAF system to the existing raw water piping and existing filtration inlet are required.	Execution of WSP tie-ins will directly impact the commissioning of the DAF system and the construction schedule. The development of an appropriate construction sequencing plan during design is critical to reducing process and schedule upsets during construction of the tie-ins.
Clarification is not present at the existing WSP and DAF clarification system is significantly different than the existing clarification systems used at other Halifax Water WSPs. The system will be unfamiliar to the existing WSP operators and may be more complex than current systems.	Development of operator friendly controls, operating screens, as well as sufficient operator training during the commissioning phase will be key to the success of the DAF system. DAF is a stable technology that has been around for more than 40 years and implemented at many other similar facilities in the region.
The addition of filter-to-waste valving could create potential for a cross connection of the waste conduit and clearwell.	The new filter-to-waste piping will not run through an operating clearwell but instead be located in a re-purposed clearwell avoiding any potential cross connection. Block and bleed valves may be utilized at the connection to the existing reducer exiting the filter.
Schedule delays due to length of time required for environmental and other regulatory approvals.	Pre-consultation with all regulatory bodies will be conducted early on in the project stage to enhance project understand and accelerate approvals timeline.

Risk	Mitigation
Distribution system water quality change creates unanticipated outcomes for corrosion control, including stability of existing corrosion by-products, or other related aspects.	Continually assess potential future treated water quality based on piloting data and other ongoing testing. Maintain current coagulant selection and corrosion inhibitor during initial period of operation to limit aspects of water quality that may change.

During the design phase, the project is expected to proceed through a formal design and construction risk assessment that will further refine, prioritize, and formalize project risks.

9. Environmental Requirements

The following section provides a list of possible environmental requirements for the JD Kline Pre-Treatment and Clarification project. Work will have to be completed in accordance with the requirements of each permit that is required. The list is not considered to be exhaustive, and the applicability of each requirement should be investigated.

- NSECC Approval to Construct.
- Erosion and Sediment Control.

10. Project Team

The following section provides a list of major project team participants. Names can be filled in as they are determined or changed.

Name	Organization	Responsibility
Sanjeev Tagra	Halifax Water	Oversight and Approvals
Colin Waddell	Halifax Water	Operations
Tom Gorman	Halifax Water	Engineering
Mike Chaulk	CBCL	Program Management
Kevin Murphy	CBCL	Project/Design Management
Matt Valade	Hazen	Treatment Plant Design
Eric Segal	Hazen	Treatment Plant Process Design
Alysha Mogensen	CBCL	Program Administration
(To be determined)		Design Technical
(To be determined)		Construction Administration
(To be determined)		

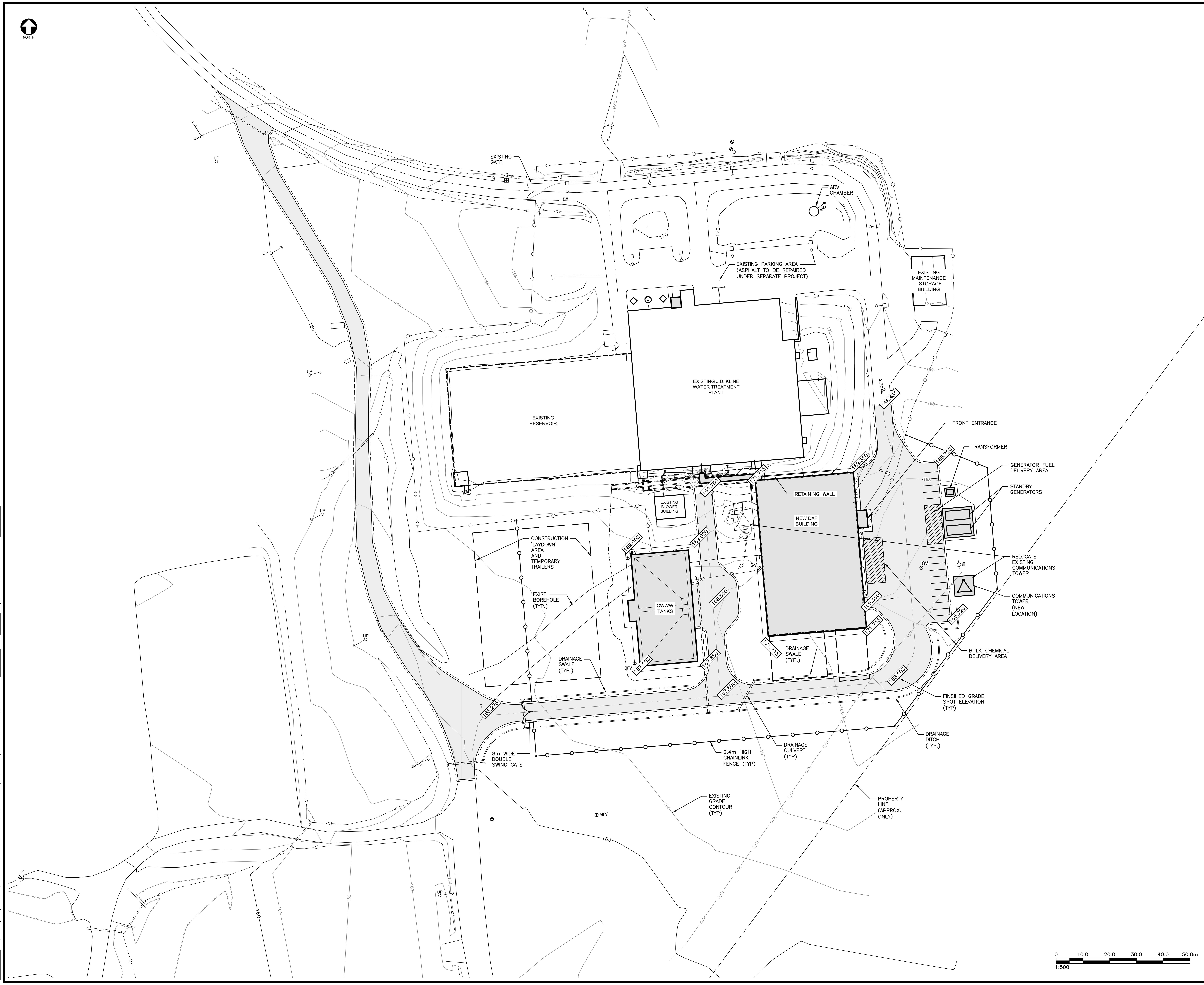
Appendices

A Civil Site Plan

B Project Budget

APPENDIX A

Civil Site Plan



No.	DESCRIPTION	DATE	BY	CHKD
A	PRELIMINARY DESIGN	08/31/22		

STAMP

CBCL

Hazen

Halifax Water

WATER SUPPLY ENHANCEMENT PROGRAM

PROJECT
J.D. KLINE WSP
PRE-TREATMENT & CLARIFICATION
CIVIL

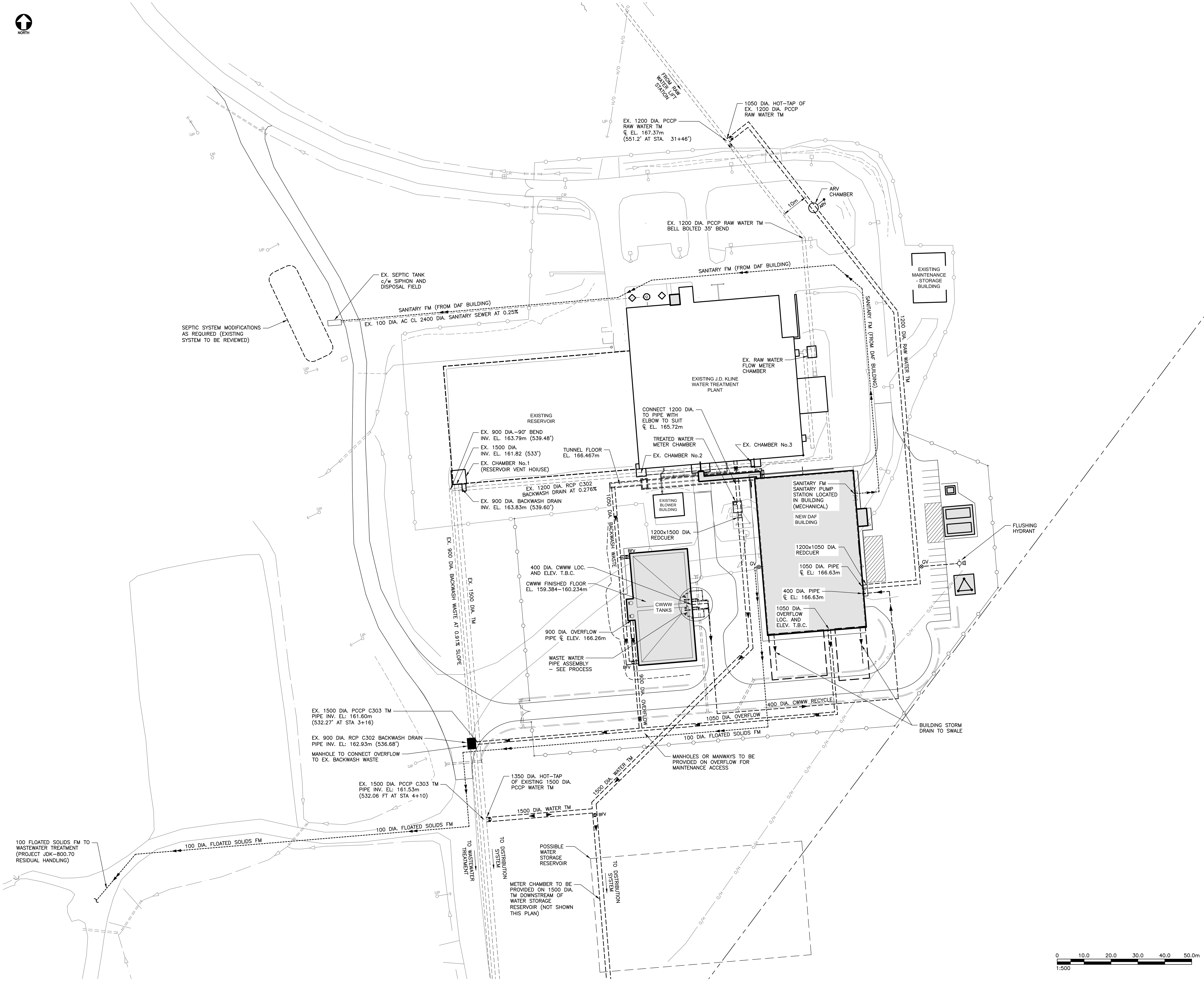
SITE PLAN

DRAWN	NM	SCALE (PLAN)	1:500
DESIGNED	JC	SCALE (PROFILE)	N/A
APPROVED	KM	DATE	MAY 2022

PROJECT No. JDK-800.10

DWG. No. C01

CBCL No. CBCL#



ABBREVIATIONS:

CWWW	COMBINED WASH WASTE WATER
EX.	EXISTING
PCCP	PRESTRESSED CONCRETE CYLINDER PIPE
RCP	REINFORCED CONCRETE PIPE
AC	ASBESTOS CEMENT
CL	CLASS
TM	TRANSMISSION MAIN
FM	FORCEMAIN

No.	DESCRIPTION	DATE	BY	CHKD
A	PRELIMINARY DESIGN	08/31/22		

STAMP

CBCL

Hazen

Halifax Water

WATER SUPPLY ENHANCEMENT PROGRAM

PROJECT
J.D. KLINE WSP
PRE-TREATMENT & CLARIFICATION
CIVIL

YARD PIPING PLAN

DRAWN	NM	SCALE (PLAN)	1:500
DESIGNED	JC	SCALE (PROFILE)	N/A
APPROVED	KM	DATE	MAY 2022

PROJECT No. JDK-800.10

DWG. No. C02

CBCL No. CBCL#

DRAWING NAME: Y:\HALIFAX\DATA\PROJECTS\200800.10 JDK PRETREATMENT & CLARIFICATION\10 DRAFTING\01 CIVIL\200800.10_JDK_C01.DWG LAYOUT NAME: C02 PLOT DATE: September 1, 2022 3:36:44 PM CAD OPERATOR: NSELM

APPENDIX B

Project Budget

PROJECT BUDGET

Water Supply Enhancement Program

J. D. Kline WSP - Clarification and Pretreatment

DATE:	April 10, 2023
PROJECT No.:	JDK-800.10
ESTIMATE CLASS:	Class 3
ESTIMATE Rev. :	Rev 07

	DESCRIPTION		COST	
	CONSTRUCTION COSTS			
	Civil Work		$	15,568,000
	Reinforced Concrete		$	22,507,000
	Masonry and Walls		$	1,506,000
	Roof Structure and Roofing		$	430,000
	Miscellaneous Metals		$	1,904,000
	Building Interior and Finish		$	1,687,000
	Process Equipment		$	7,418,000
	Process Mechanical		$	7,994,000
	Material Handling and Building Equipment		$	499,000
	Mechanical HVAC & Plumbing		$	4,017,000
	Electrical (Including Process Instrumentation & Controls)		$	6,376,000
	General Contractor, Fees, Overheads and Profit	10%	$	6,990,600
	SUB-TOTAL COSTS (Excl. below allowances & contingencies)		**$**	**76,896,600**
	Design Development Contingency	20%	$	15,379,320
	Escalation / Inflation (Escalated to year **2024** - const. start)	13%	$	12,010,634
	Location Factor	1.00	$	-
	Construction Contingency	0%	$	-
		CONSTRUCTION COSTS (A)		**$104,287,000**
	ENGINEERING and OTHER COSTS			
	Concept Design & Studies and Survey	3%	$	3,130,000
	Preliminary & Detailed Design Services (allowance)	6%	$	6,260,000
	Construction Admin. & Inspection (allowance)	6%	$	6,260,000
	Halifax Water Engineering Allowance	1%	$	1,050,000
	Interest and Internal Overhead (Halifax Water)	1%	$	1,210,000
		ENGINEERING and OTHER COSTS (B)		**$17,910,000**
		ESTIMATE OF PROBABLE COST FOR PROJECT (taxes not included) A + B		**$122,197,000**
		Program Management (3%)	$	3,666,000
		Net HST (4.286%)	$	5,394,488
		TOTAL ESTIMATE OF PROBABLE COST FOR PROJECT (taxes included) A + B		**$131,257,488**

General comments regarding this 'Project' Budget revision: