SEWPCC Upgrading/Expansion
Conceptual Design Report

SECTION 11 - Effluent Disinfection

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11.0 Effluent Disinfection

11.1 PURPOSE OF UNIT PROCESS

Disinfection is the selective inactivation or destruction of pathogenic organisms. It does not destroy all of the organisms present but reduces the number of active pathogenic organisms to safe levels.

The disinfection of wastewater treatment plant effluents is important to ensure the receiving stream is not contaminated with unacceptable levels of disease-causing organisms. This is especially important if the water body is used for recreational purposes, aquaculture, or irrigating crops. If the receiving body is only used for recreational purposes, disinfection may only be required on a seasonal basis. In Canada, many wastewater treatment plants (WWTPs) do not disinfect their effluents during winter months. Further, some WWTPs in Canada do not disinfect at all since their receiving water uses do not require pathogen reduction for the protection of public or aquatic health.

The pathogenic microorganisms of principal concern in wastewater effluent are bacteria, viruses, and protozoa. These microorgansims are difficult to detect and quantify so indicator organisms are used to specify the presence of these pathogens. Coliform bacteria are commonly used as indicators in wastewater applications because they are present in high concentrations and show similar disinfectant sensitivity and inactivation rates as the majority of pathogenic organisms except for some protozoa and viruses. Disinfection standards for wastewater effluent are commonly expressed in terms of coliform bacteria concentrations (i.e., most probable number of organisms (MPN) per 100 mL sample). Coliform bacteria include a number of genera and species of bacteria that have common biochemical and morphological attributes. The microorganism *Escherichia coli* (*E. coli*), found in the feces of warm-blooded animals, is one of many coliform organisms. Tests have been developed that distinguish among total coliforms, fecal coliforms, and *E. coli*

Disinfectants for treating WWTP plant effluent fall under two main categories: oxidizing chemicals and ultraviolet (UV) light. Oxidizing chemicals include chlorine, bromine, ozone, potassium permanganate, hydrogen peroxide, chlorine dioxide, chloramines, peracetic acid and bromine chloride. For wastewater disinfection, the most widely used disinfectants are chlorine, ozone, and ultraviolet light. Recent licenses and newly proposed Federal Regulations limit the concentration of residual chlorine in the effluent to 0.02 mg/L. This limit increases the cost of chlorine disinfection, as a de-chlorinating agent would be required to reduce the effluent residual chlorine concentration after disinfection is achieved. The SEWPCC currently has a UV disinfection system in place and it is proposed to expand the existing system to meet the new license requirements.

11.2 EXISTING DISINFECTION FACILITY

11.2.1 Overview

The existing UV disinfect facility is comprised of a final effluent chamber, UV influent chamber, UV disinfection channels and equipment, effluent chamber, outfall chamber and a wet weather bypass chamber. Refer to Figure 11.1 for a foundation plan of the existing facility. The current licence states that:

“The Licencee shall, from the date of issuance of this Licence until and including December 30th, 2012, during periods when the wastewater influent flow is less than 98,600 cubic meters per day, not discharge effluent from the wastewater treatment plant, as sampled at the effluent monitoring station, referred to in Clause 25 of this Licence, located prior to the effluent discharge pipeline leading to the Red River where:

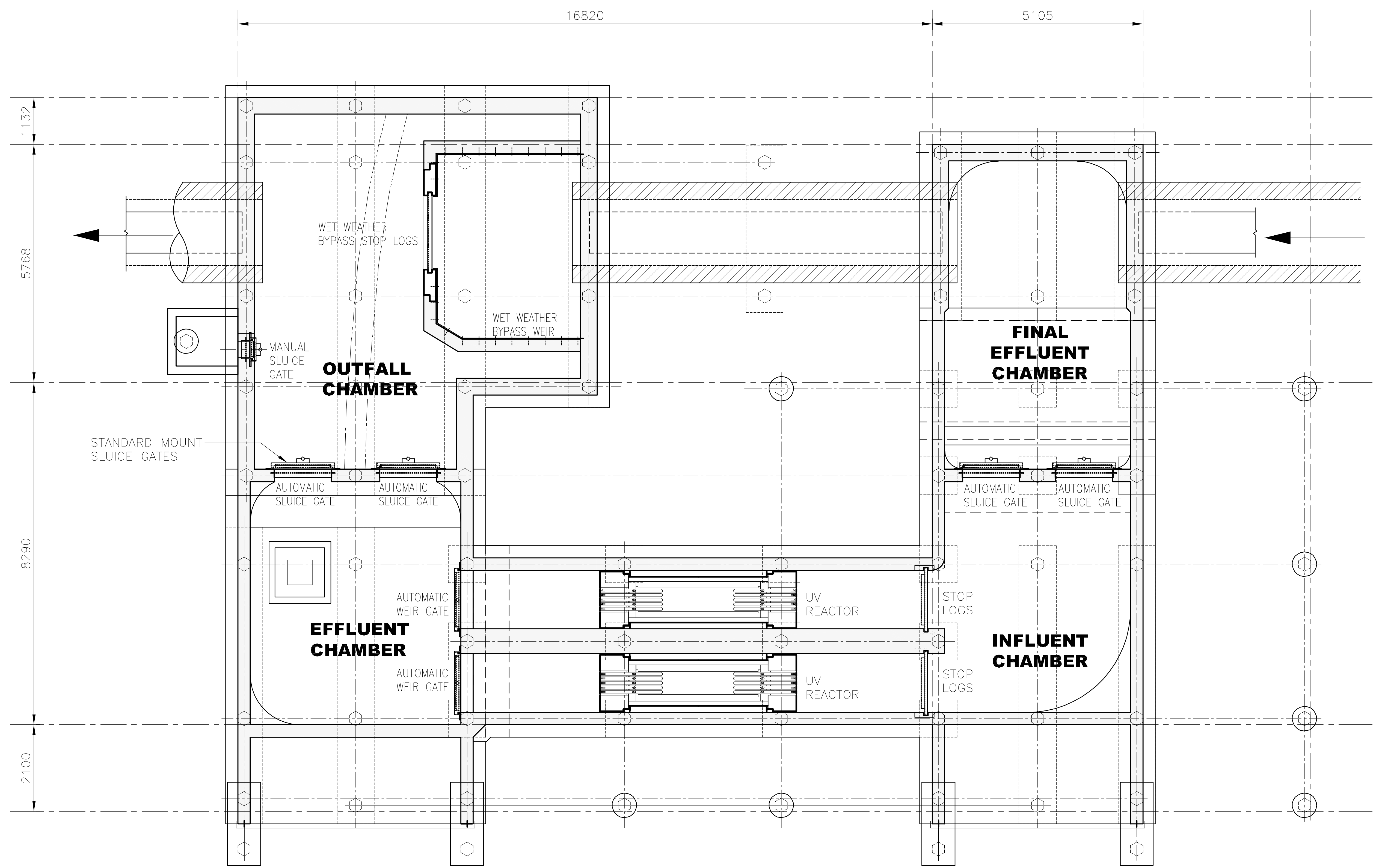
c) the fecal coliform content of the effluent, as indicated by the MPN index, is in excess of 200 per 100 millilitres of sample, as determined by the monthly geometric mean of 1 grab sample collected at equal time intervals on each of a minimum of 3 consecutive days per week; and,

d) the E. coli content of the effluent, as indicated by the MPN index, is in excessof 200 per 100 millilitres of sample, as determined by the monthly geometric mean of 1 grab sample collected at equal time intervals on each of a minimum of 3 consecutive days per week.”

The existing facility was designed for disinfection to take place during dry weather flows between the months of May and September inclusive. Dry weather flow was defined as flows less than 100 ML/d. The UV disinfection facility has been operating year round since Manitoba Conservation issued an order to disinfect year round March 3, 2006.

Plant effluent from the secondary clarifiers is currently discharged to the existing plant bypass channel and conveyed to the final effluent chamber, which is connected to the wet weather bypass chamber via an 1830 mm diameter pipe. The wet weather bypass chamber is equipped with a weir that, under normal operating conditions - or flows less than 100 MLD, diverts all the plant effluent to the UV influent chamber via two influent channels. The UV channels house the Trojan UV4000 disinfection equipment, which is comprised of two banks of UV modules per channel. Each UV channel is also equipped with stop logs at the upstream end and an automatically controlled weir gate at the downstream end to maintain the minimum water level in the UV channels required for bulb submergence. Disinfected effluent is collected in the effluent chamber where it is diverted to the outfall chamber via two channels. Flow into the outfall chamber is discharged to the outfall sewer.

The existing facility was designed so that when flow exceeded 110 ML/d, disinfection was discontinued, however flows continue to be conveyed through the UV channels for flows up to 140 ML/d. When flows exceed 140 ML/d, the two automatically controlled sluice gates on the



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Stantec Consulting Ltd.
No. 1301 Expiry: April 30, 2009

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DATE	MAY 2008	DATE	

ENGINEER'S SEAL

TENDER NO. 2007-

Winnipeg

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

SOUTH END WATER POLLUTION CONTROL CENTRE

SEWPCC
EXISTING EFFLUENT DISINFECTION FACILITY FOUNDATION PLAN

CITY DRAWING NUMBER: FIGURE II.I

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UV influent channels close and all plant effluent is to be conveyed over the bypass weir and through the plant outfall sewer without disinfection. This set up was discontinued, as flooding occurred upstream of the UV disinfection facility when all flow was forced over the bypass weir. Currently, the automatically controlled sluice gates into and out of the UV channels remain in the open position at all times and UV disinfection occurs at all times.

11.2.2 Design Criteria for Existing System

Table 11.1 – Existing UV Disinfection Facility Design Criteria

Description	Value
Hydraulic Capacity	
Average Summer Flow	70,000 m^3/d
Peak Dry Weather Flow	100,000 m^3/d
Total Suspended Solids	
Average	7.5 ppm
Maximum	10 ppm
UV Transmissivity @ 254 nm	
Average	58%
Minimum	50%
UV Dose (250 to 260 nm, clean lamps at end of design life)	24 mWs/cm^2
Channels	
Number of UV Channels	2
Channel Length	11000 mm
Channel Width	1420 mm
Channel Depth	3300 mm
Water Depth (upstream)	1660 mm
Minimum Effluent Depth	1220 mm
Total Headloss (at Peak Flow)	440 mm
UV System	
Number of UV Banks per Channel	2
Number of Modules per Bank	5
Number of Lamps per Module	6
Number of Power Distribution Centres (2 per channel)	4
Number of UV Sensors (one per bank)	4
Number of UV Transmissivity Sensors	1

11.2.3 Controls

The Trojan UV4000 system has a dedicated Programmable Logic Controller (PLC) to control and monitor parameters related to disinfection. The system was designed to dose based on flow and UV transmissivity (UVT). A UVT monitor was installed in the channel to record the transmissivity of the effluent conveyed through the UV channels. The operators report that the UVT monitor never worked and they currently manually input the transmissivity into the PLC based on laboratory UVT results.

A flow signal is provided by the main plant Bailey System from the magnetic flow meters immediately downstream of the raw sewage pumps. UV intensity monitors are provided for each bank. The intensity monitors provide feedback regarding the dose that the effluent is receiving.

11.2.4 Issues with the Existing UV Disinfection System

The SEWPCC has experienced periods of non-compliance with respect to meeting the fecal coliform limits indicated in the existing license. Refer to Table 11.2 for 2007 sampling data relevant to the performance of the UV disinfection system. The highlighted geometric means represent license exceedances.

Table 11.2 – 2007 Final Effluent Sampling Parameters Relevant to UV Disinfection

Month	Average Flow (Daily Avg)	Final Effluent TSS (avg) **	Final Effluent TSS (max)**	Final Effluent UVT (avg)*	Final Effluent UVT (min)*	Fecal Coliform (Geo. Mean)*
January	47	10	23	n/a	n/a	201
February	45.8	13	41	n/a	n/a	838
March	66.4	11	31	n/a	n/a	1,812
April	66.8	8	29	n/a	n/a	525
May	70.9	9	28	n/a	n/a	149
June	83.2	10	19	n/a	n/a	211
July	63.8	6	14	58.9	55.6	51
August	51.2	8	23	56.7	54.2	79
September	52.4	14	36	55.9	52.8	79
October	57.4	9	24	57.8	54.7	127
November	49	8	15	56.4	52.6	122
December	47.3	9	12	55.3	51.9	225

Issues identified that may be contributing to non-conformance with the license are as follows:

- The current hydraulic configuration allows for mixing of secondary effluent, primary effluent and raw sewage upstream of UV disinfection. Flows greater than 100 MLD bypass secondary treatment and are still conveyed through the UV disinfection facility impacting the final effluent TSS and UVT. The current raw sewage pumping controls set up results in a number of spikes of flow greater than 100 MLD when a second pump starts up.

- The current system is designed for average total suspended solids (TSS) concentration of 7.5mg/L and a maximum TSS concentration of 10 mg/L. Sampling results from 2007 indicate that both the monthly average final effluent TSS and monthly max TSS (based on 24 hour composite sampling) was always greater than 7.5mg/L and 10 mg/L, respectively.

- The existing UVT monitor is no longer functioning and the UVT is manually set at 55% in the UV system PLC based on laboratory results. The City reported that the laboratory UVT results were done on a filtered sample. The filtered sample would provide a better UVT than the bulbs are actually seeing and therefore the system would be under dosing.

- The flow provided to the UV system PLC to flow pace the UV dose is from immediately downstream of the raw sewage pumps. As there is a lag time in the plant before flow reaches the UV facility, this could result in both overdosing and under dosing as flows increase or decrease.

11.3 DESIGN CRITERIA FOR EXPANDED FACILITY

Based on Manitoba Conservation's clarification letter dated June 25, 2007 the license requirement for disinfection is only applicable for flows less than or equal to 175 MLD. The draft license sets a fecal coliform and E. coli limit of 200 MPN/100mL, as determined by the monthly geometric mean of one grab sample collected at equal time intervals on each of a minimum three consecutive days per week.

11.3.1 Design Flow

The UV disinfection facility will be designed for a peak flow of 175 MLD. Flow directed to the UV disinfection facility will vary depending on the season and the influent flow to the SEWPCC. The various flow scenarios are as indicated below. Refer to Figures 11.2 and 11.3 for process flow diagrams.

Year Round (Except Summer)

- Flows ≤125 MLD will pass through the screens, grit removal, Primary Settling Tanks (PST), BNR bioreactors, and secondary clarifiers before being conveyed to the UV disinfection facility.

- Flows > 125 MLD and ≤ 175 MLD will pass through the screens, grit removal, and PSTs. 125 MLD will pass through the BNR bioreactors and secondary clarifiers before carrying on to the UV disinfection facility, while the remaining 50 MLD of the primary effluent will be conveyed around the bioreactors directly to the secondary clarifiers prior to being conveyed to the UV disinfection facility.

- Flows > 175 MLD and ≤ 200 MLD will pass through the screens, grit removal and receive chemical addition in the PSTs. 125 MLD will pass through the BNR bioreactors and secondary clarifiers before carrying on to the UV disinfection facility, 50 MLD of the primary effluent will be conveyed around the bioreactors directly to the secondary clarifiers prior to being conveyed to the UV disinfection, while the remaining 25 MLD will bypass UV disinfection and blend with the disinfected effluent downstream.

- Flows > 200 MLD and ≤ 300 MLD will pass through screens and grit removal. 100 MLD will bypass primary treatment and be conveyed directly to the BNR bioreactors and secondary clarifiers before carrying on to the UV disinfection facility. The remaining 200 MLD will pass through the PSTs with chemical addition. 25 MLD of the primary effluent will pass through the BNR bioreactors and secondary clarifiers before receiving UV disinfection, 50 MLD will bypass the BNR bioreactos and head directly to the secondary clarifiers prior to UV disinfection. The remaining 125 MLD will bypass secondary treatment and the UV disinfection facility.

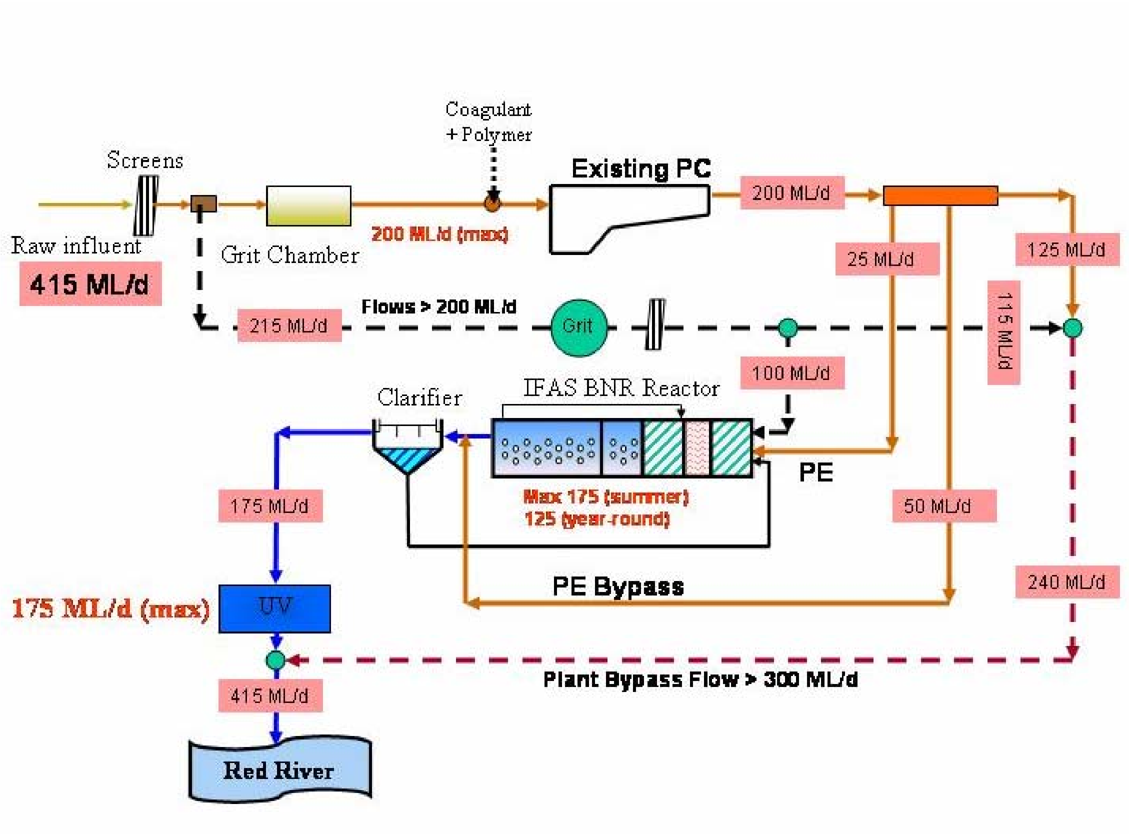


Figure 11.2: Year Round (Except Summer) Process Flow Diagram

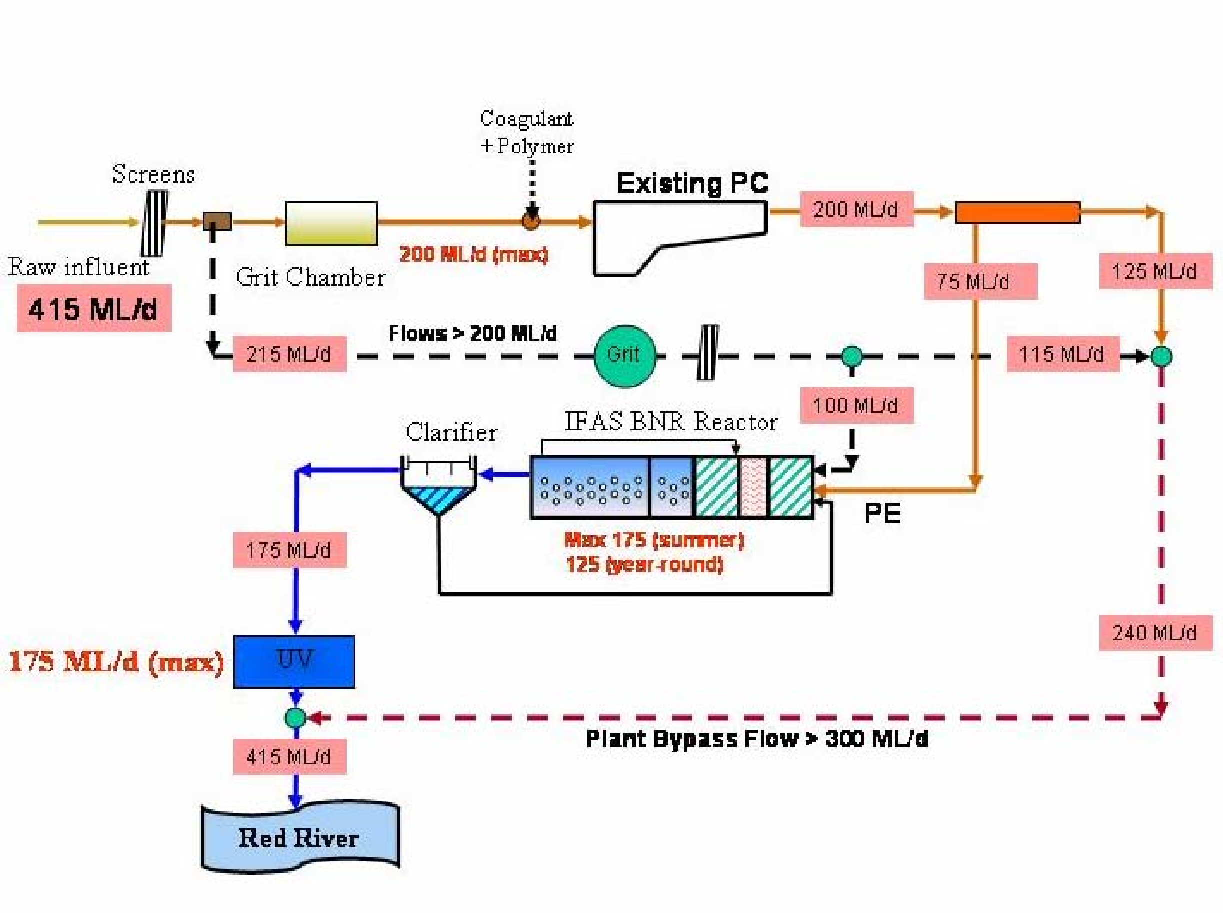


Figure 11.3: Summer Process Flow Diagram

Summer

- Flows ≤175 MLD will pass through the screens, grit removal, PSTs, BNR bioreactors, and secondary clarifiers before being conveyed to the UV disinfection facility.

- Flows > 175 MLD and ≤ 200 MLD will pass through the screens, grit removal and receive chemical addition in the PSTs. 175 MLD will pass through the BNR bioreactors and secondary clarifiers before carrying on to the UV disinfection facility, while the remaining 25 MLD will bypassed UV disinfection and blend with the disinfected flow downstream.

- Flows > 200 MLD and ≤ 300 MLD will pass through screens and grit removal. 100 MLD will bypass primary treatment and be conveyed directly to the BNR bioreactors and secondary clarifiers before carrying on to the UV disinfection facility. The remaining 200 MLD will pass through the PSTs with chemical addition. 75 MLD of the primary effluent will pass through the BNR bioreactors and secondary clarifers before receiving UV disinfection, while the remaining 125 MLD will bypass secondary treatment and the UV disinfection facility.

11.3.2 Design Effluent Quality

The UV disinfection equipment will be sized to meet the license requirements in terms of fecal coliform and E. coli based on the UVT and TSS concentration in the final effluent conveyed to the facility. The worst case scenario is when flow is greater or equal to 175 MLD in the spring or fall. Modeling of the design year indicates that there will be 8 days where the average flow is greater than 125 MLD. Refer to Figure 11.4 for an hourly depiction of the number of times flow will be greater than 25 MLD.

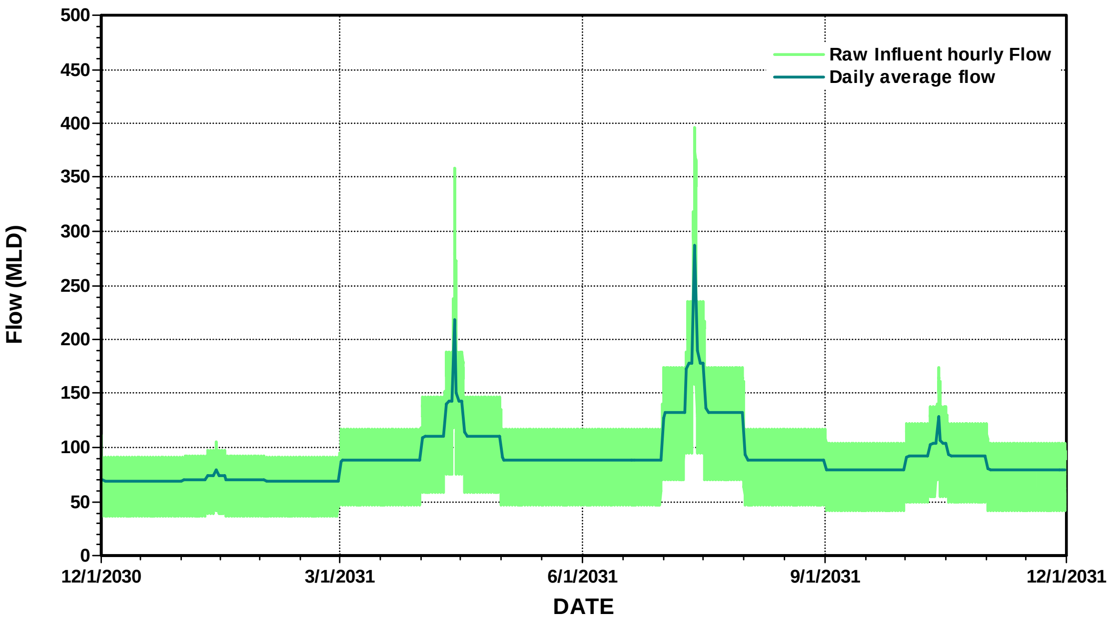


Figure 11.4: Anticipated Flow to the SEWPCC in the Design Year (2031)

It is anticipated that the UVT from the secondary treatment process will be 60% or greater. The UVT of the primary effluent was monitored starting March 30, 2008. Preliminary data indicates that the average filtered UVT from the primary effluent is 36%, with a minimum value of 31%. The City has added non-filtered primary effluent UVT to the list of parameters to be sampled at the SEWPCC and preliminary data indicates that the non-filtered UVT could be as low as 8%. A mass balance of the blended flow using a primary effluent UVT of 8% and a secondary effluent UVT of 60% indicates that the anticipated worst-case blended UVT would be 45%. It is recommended to gather further data on the UVT of the primary effluent when flows are greater than 125 MLD, as it is anticipated that the UVT could improve during wet weather events due to dilution. Chemically enhanced primary treatment (CEPT) could also be triggered at flows greater than 125 MLD in the spring to provide an improved UVT in the primary effluent. Wet weather jar testing conducted during the preliminary design stage indicated a 27% increase in UVT with an alum dose of 60 mg/L.

The anticipated TSS of the effluent directed to the UV disinfection facility in the design year of 2031 is shown in Figure 11.5. Trojan Technologies recommends sizing the UV disinfection equipment based on the TSS license requirement of 25mg/L on a 30 day rolling average.

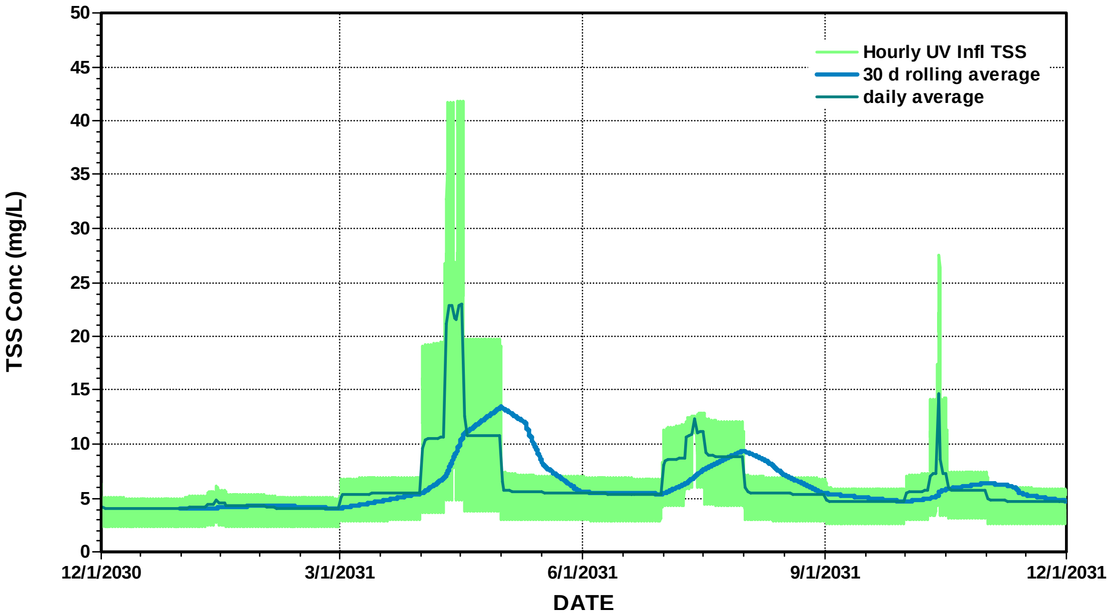


Figure 11.5: Anticipated TSS in the Final Effluent Conveyed to the UV Disinfection Facility

11.4 PROPOSED UV DISINFECTION FACILITY

The existing UV disinfection facility would be expanded to the south. The existing fixed weir in the wet weather bypass chamber will be modified so that 175 MLD is diverted into the UV disinfection facility. Two (2) additional UV channels are required to accommodate the flow and effluent quality conveyed to the UV facility. The additional channel would be constructed parallel to the existing UV channels. The new UV channels would be connected to the existing influent and effluent channels. The flow would be split evenly between the four channels and therefore each channel would receive a maximum flow of 43.75 MLD.

The new UV channels would include one (1) Trojan UV4000 Plus reactor per channel. The existing Trojan UV 4000 system is no longer available and has been replaced by the Trojan UV 4000 Plus. Each reactor would be comprised of two (2) banks, each of which contains three (3) modules. Each module would contain ten (10) lamps for a total of one hundred and twenty (120) new lamps. The proposed lamps would be 28” long, while the existing lamps at the SEWPCC are 24” long and therefore they would not be interchangeable. The proposed lamps would be the same as those installed at the NEWPCC and therefore would be interchangeable. The ballasts would be interchangeable with those currently at the SEWPCC and at the NEWPCC.

An automated weir gate would be installed at the downstream end of each of the new channels to maintain the channel level and allow for even flow distribution through all channels. Stop logs or slide gates would be installed upstream of the UV channel to allow for channel isolation if the UV disinfection equipment is out of service for maintenance. Refer to Figure 11.6 for the proposed foundation plan and Figure 11.7 for the proposed floor plan for the expanded facility.

Dosing of the UV disinfection equipment would be based on UVT and flow. Flow rates would be provided by the final effluent flow monitoring station located immediately down stream of the UV disinfection facility. The license requires this flow monitoring device to be accurate to 2% and therefore a velocity profiler flow meter is recommended. Manitoba Conservation has yet to confirm the location of the flow monitoring station and therefore flow monitoring will be revisited later in the conceptual design.

UVT would be provided by a new HACH UVT sensor. The sensor comes with a self-cleaning wiper and has a built in diagnostics routine to minimize the need for extensive calibration and maintenance. Semi-annual inspection and replacement of the wiper and seals is recommended by the supplier.

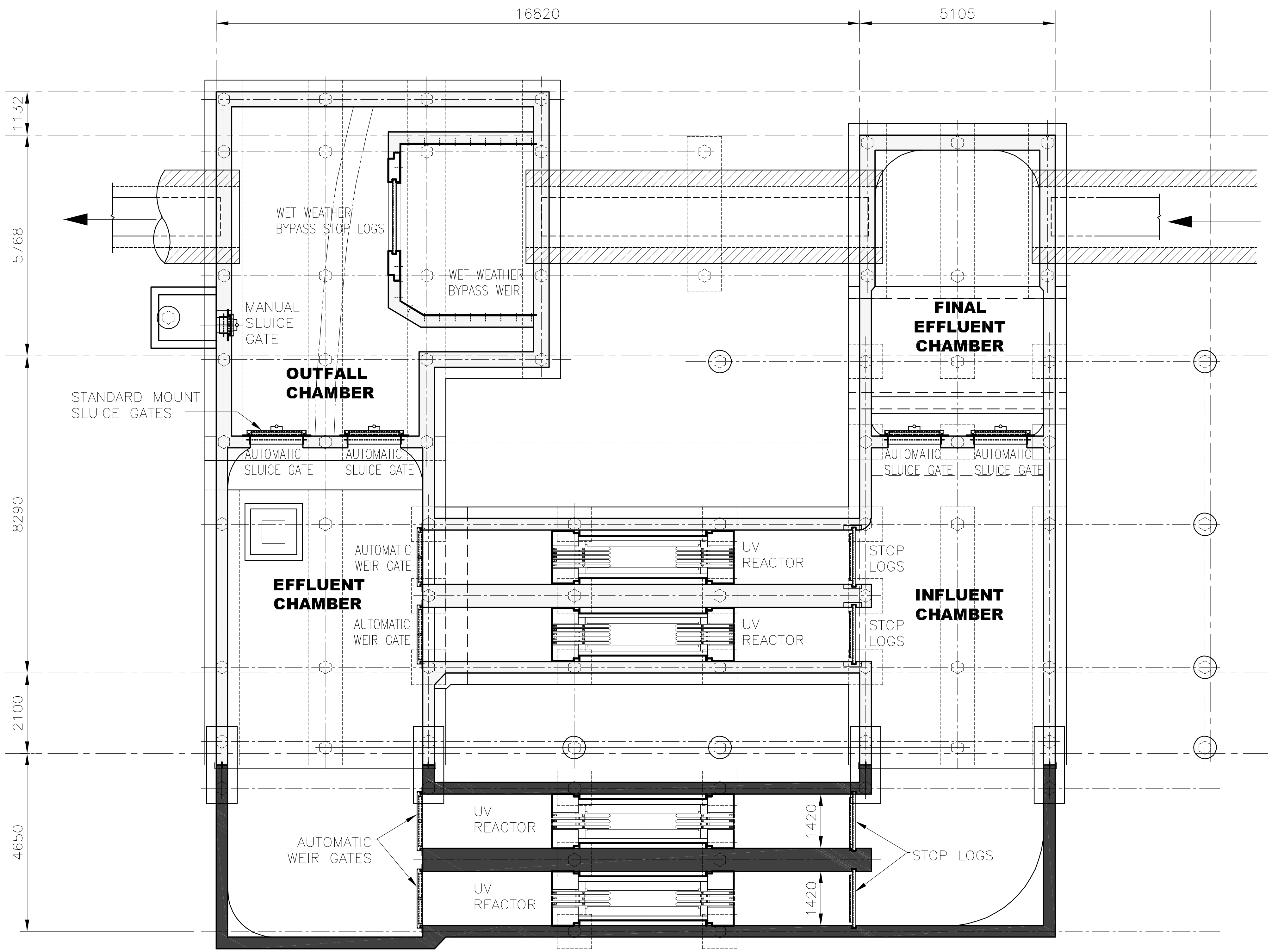
The expanded building would have a tyndall stone exterior to match the existing building. The operators indicate that the double doors to the existing building ice up in the winter due to the direction of the prevailing wind and lack of a vestibule. The operators commented that they would like a vestibule and the double doors located on the east side of the proposed facility and this request has been incorporated into the design.

It was also noted that the there is a mosquito problem in the building during the summer. Stantec will investigate this issue further during the detailed design stage.

11.5 HYDRAULICS

During normal operation flow will be split evenly between all four (4) channels. This will be accomplished by using Trojan’s proprietary control algorithm. The algorithm separately controls the depth in each channel using a dynamic set point technique and an adjustment feedback loop to constantly monitor, compare and adjust flow in each channel. Flow is adjusted by dynamically changing the depth and hence the hydraulic gradient of each channel to compensate for any imbalances to within 5% of nominal. Since the corrective strategy uses a dynamic depth setpoint, the regulated water levels at the level sensors are specified to within a +/- 0.1m tolerance. The depth will be dynamically adjusted within this range to ensure that flow remains balanced at all times and at all operating conditions.

During dry weather flow two of the channels can be taken out of service, as only two channels are required to accommodate the average day dry weather flow of 64 MLD. Stop logs are the existing method to isolate individual channels and it is proposed to install stop logs to allow for isolation of the new channels.



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THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

SOUTH END WATER POLLUTION CONTROL CENTRE

SEWPCC
EFFLUENT DISINFECTION FACILITY FOUNDATION PLAN

CITY DRAWING NUMBER: FIGURE II.6
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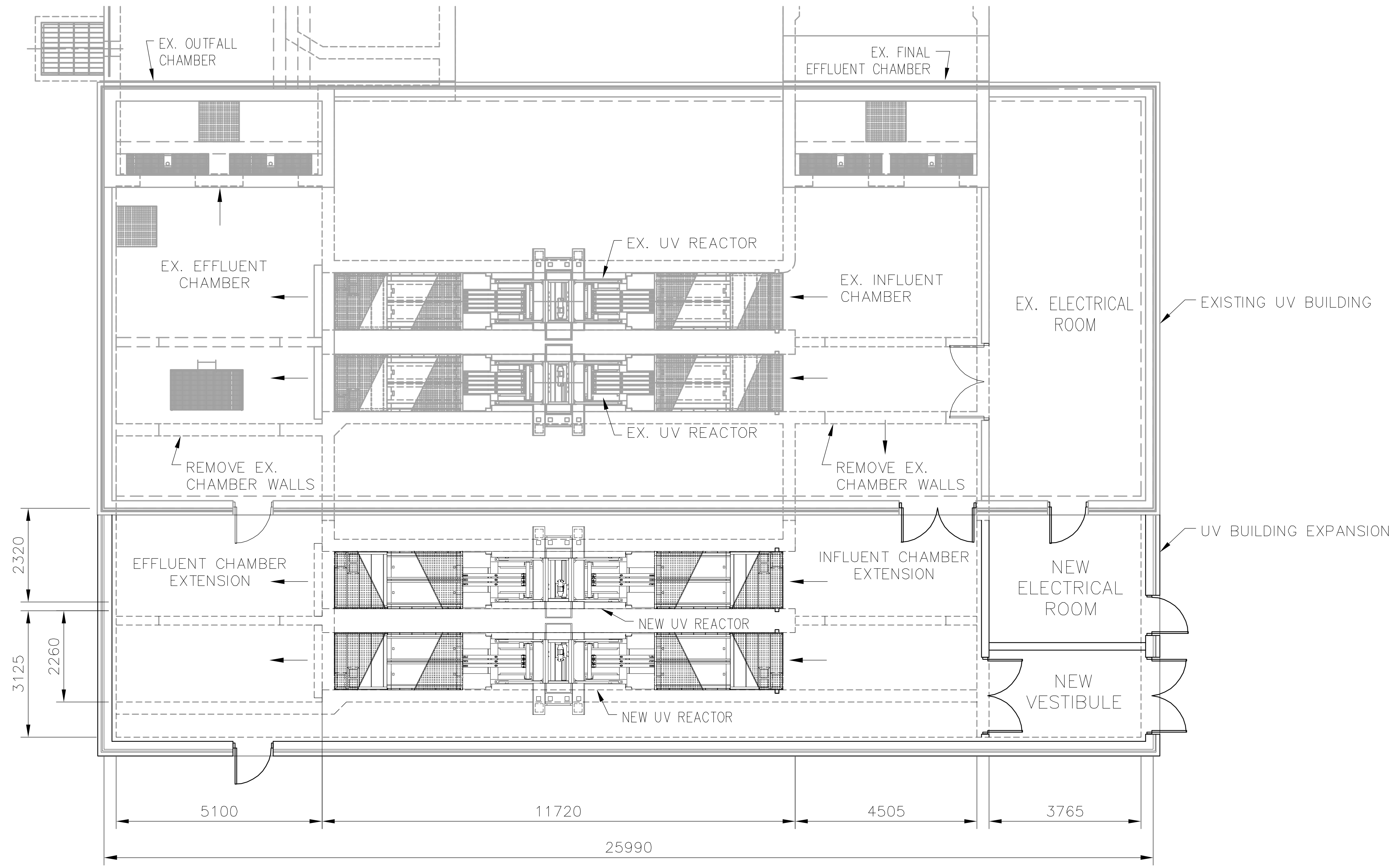

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THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

SOUTH END WATER POLLUTION CONTROL CENTRE
SEWPCC
DISINFECTION FACILITY EXPANSION FLOOR PLAN

CITY DRAWING NUMBER: FIGURE II.7
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It was previously noted in the PDR that the UV system cannot operate when the Red River is above the 1:5 year spring level (228.10 m) and flows are greater than 360 MLD, or when the Red River is above the 1:20 year spring level (228.40 m) and flows are greater than 320 MLD. Further discussion with Trojan indicates that the maximum downstream water level required for the UV system operation can be increased to accommodate the 1:20 year spring river level at 415 MLD by increasing the upstream water level by 100 mm to 231.33 mm. The upstream water level can be increased by widening the new UV channels from 1,070 mm (originally proposed) to 1,420 mm. The UV disinfection system can remain in operation for flows greater than the maximum pumping capacity of 415 MLD during summer river levels (227.21 m). The hydraulics of the outfall in conjunction with the UV facility operation are discussed in further details in Section 12 - Outfall and Yard Piping.

11.6 ELECTRICAL

The existing UV Building is presently powered from a power panel fed from a circuit breaker in the plant main power distribution MCC. This existing system is capable of accommodating the additional power requirements for the new UV system being installed under this upgrade.

Plant operating personnel have expressed concern over the facility being fed from a single power source. This arrangement leaves the UV Building vulnerable to outages and is inconsistent with the electrical power system design philosophy presently incorporated at the plant. All other plant areas are provided with two MCCs, each fed from separate sections of the main power distribution. Each of these sections is fed from one of two separate Manitoba Hydro feeder lines. A tie breaker between each MCC in each area allows operators to power the MCCs from either feeder should one be out of service for an extended period of time. The existing UV Building electrical system does not have this capability.

A new second power panel will be installed in the UV Building to power the new UV system equipment. The panel will be fed from a new breaker in the opposite main MCC section from the existing breaker via a new set of feeder conductors. All equipment will be sized similarly to the existing system to accommodate the total power requirements for the expanded facility. A tie breaker between the two power panels will allow both panels to be fed from either feeder source. The new system will fall in line with the existing plant established power design philosophy and provide true redundant power to the expanded UV facility.

11.7 TUNNEL EXTENSION TO THE UV DISINFECTION FACILITY (OPTIONAL)

The SEWPCC project team has expressed an interest in connecting the UV facility to the rest of the facility for more convenient access in poor weather conditions. With construction of the new secondary clarifiers, the existing pipe gallery and main floor walkways will be extended toward the UV facility. This reduces the amount of walkway required to connect the UV facility to the secondary clarifier walkway / gallery, increasing the viability of this option.

The UV building is 21 meters away from the walkway and pipe gallery extension identified in Section 10. Unfortunately, a straight 21 meter extension of the pipe gallery or walkway west terminates at the UV facility electrical room where additional access is not viable. An extension further west is not possible due to the UV Building influent and effluent chambers. Most of the east side of the facility contains the electrical rooms where new access cannot be made. Thus the closest connection that can be made to the UV facility is at the south east corner where the proposed main entrance is located. To get to this location, either a 21 meter west and 21 meter south corridor could be constructed or a 30 meter diagonal southwest corridor could be constructed.

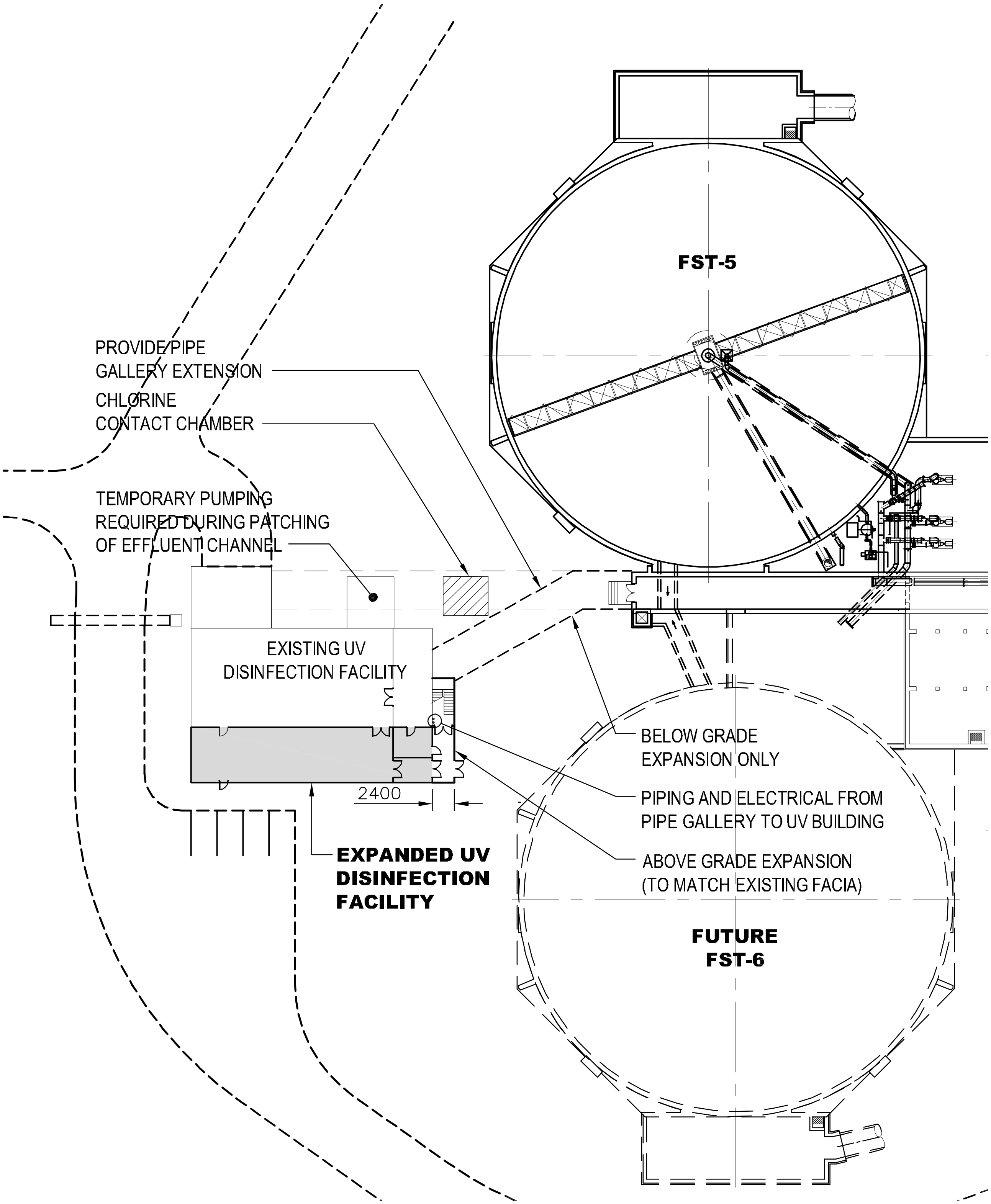
For a diagonal southwest access way, the most logical type of construction would be a slab on grade with superstructure. The benefit of this is the shorter 30 meter distance. The downside is that this would not connect to the pipe gallery making it difficult to route items from the pipe gallery to the UV building and it would require all new construction. It also would block outside access north-south in the area.

For a 21 meter west and 21 meter south access way, a combination of below grade and above grade construction would be utilized as shown in Figure 11.8. Extending the existing pipe gallery from the secondary clarifiers to the east portion of the Chlorine Contact Chamber would permit piping and cabling to be run fully exposed and the existing effluent channel would act as the floor and foundation for the pipe gallery extension for a portion of the underground construction. Above grade construction would be minimized, thus maintaining north-south access.

Extension of the existing pipe gallery 21 meters west combined with a new 21 meter above grade walkway extending south provides both man access and the ability to extend piping and electrical in an accessible fashion to the UV Building. This is the recommended option for connecting the UV facility to the remainder of the SEWPCC. The opinion of probable cost for this work is $490,000, or $1,056,000 when contingency, engineering, estimating allowance and inflation are factored in.

11.8 CONSTRUCTABILITY

The new UV disinfection facility can be constructed adjacent to the existing facility with minimal interruptions to the operation of the existing facility. The existing channel stub walls were constructed with waterstop cast-in-place to facilitate a water tight connection to the expanded channels. Temporary shutdowns of the UV system will be required for interconnections between the new and existing influent and effluent channels and for modifications to the existing wet weather weir.



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DATE	08.06.27	DATE	

ENGINEER'S SEAL

TENDER NO.

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

SOUTH END WATER POLLUTION CONTROL CENTRE

UV BUILDING / CLARIFIER WALKWAY

CITY DRAWING NUMBER: FIGURE II.8

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