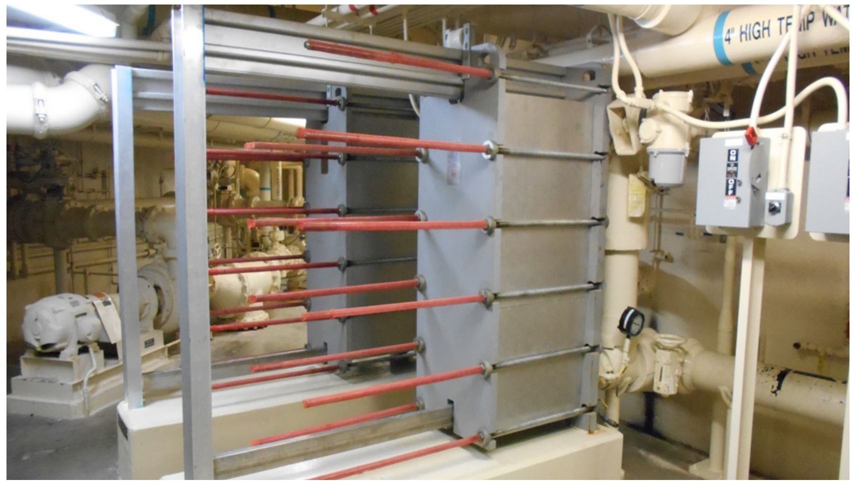
Rochester Water Reclamation Plant

2019 Facilities Plan

Technical Memorandum 11: Heat Recovery Loop Alternative

TM 11 of 13 | J4325



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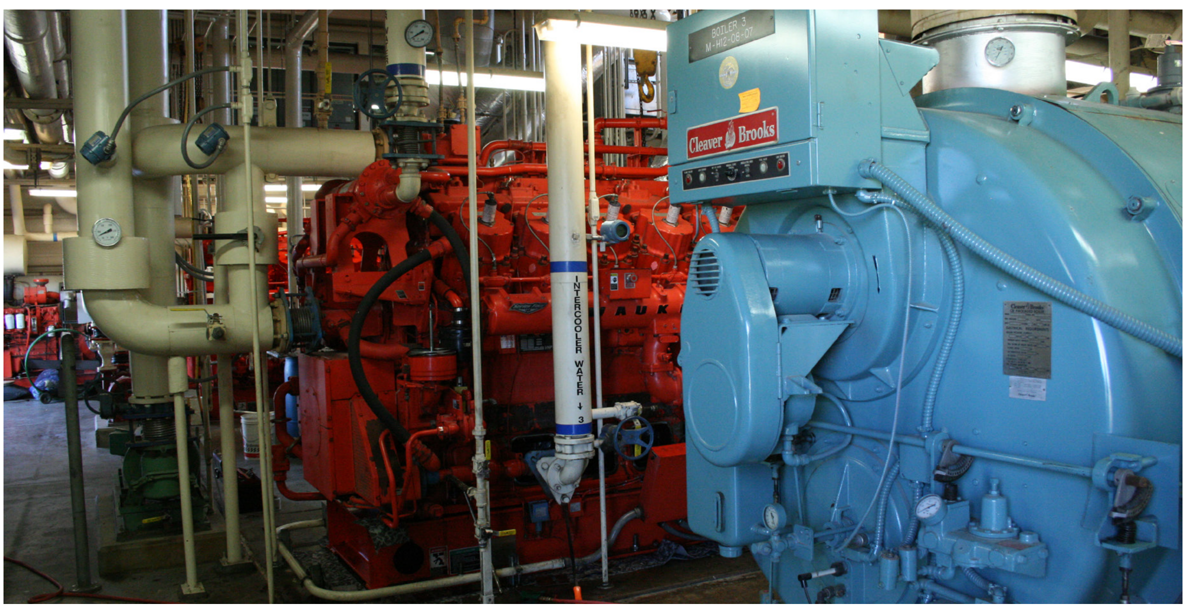

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List of Abbreviations

ºC	degree(s) Celsius
ºF	degree(s) Fahrenheit
µm	microns
AACEI	Association for the Advancement of Cost Engineering International
ABC	Aeration Basin Complex
A/O	anaerobic/oxic
Btu	British thermal unit(s)
BC	Brown and Caldwell
CCT	chlorine contact tank
cfm	cubic foot/feet per minute
City	City of Rochester
d	day(s)
DG	digester gas
FC	final clarifier
fps	foot/feet per second
ft	foot/feet
ft^2	square foot/feet
GBT	gravity belt thickener
gpm	gallon(s) per minute
hp	horsepower
HPO	high-purity oxygen
hr	hour(s)
HSW	high-strength waste
HX	heat exchanger
kWh	kilowatt-hour(s)
L	liter(s)
lb	pound(s)
LF	Linear foot/feet
LT	low temperature
m	meter(s)
MAC	oxygen system air compressor
MD	maximum day
mg	milligram(s)
mgd	million gallons per day
MM	maximum month
MT	medium temperature
NG	natural gas
NPV	net present value
O&M	Operation and Maintenance
PC3	Primary Clarifier 3
PD	positive displacement
psi	pound(s) per square inch
PW	peak week
s	second(s)
SCADA	supervisory control and data acquisition
SCFM	standard cubic feet per minute
TM	technical memorandum
VFD	variable frequency drive
VS	volatile solids
WRP	water reclamation plant

Executive Summary

The water reclamation plant (WRP) heat recovery system uses pumped effluent from the final clarifiers and heat exchangers to transfer heat to and from final effluent. During winter conditions the WRP heat recovery system reduces heat demands by capturing equipment and effluent heat. During summer conditions the system cools process equipment. This system has provided an energy benefit, but changes are required to address the following issues:

- Numerous pumps are required to circulate effluent and loop water flow.
- Particles from the final clarifier are drawn into the low temperature loop pump systems and foul the heat exchangers, requiring frequent cleaning.
- The spray water system serving the effluent loop operate at 80 psi (as needed for headworks equipment). The pump is oversized, and excess flow is relieved to Primary Clarifier (PC) 3 heating, grit washer, and the final clarifier (wasting pumping energy.
- Spray water system pumps and adjacent flush water pumps cavitate under current operating conditions, apparently due to restrictions in the intake piping.
- Conversion from high-pressure oxygen (HPO) to anaerobic/oxic (A/O) operation will remove the oxygen system compressors (MACs)—a significant heat source—from the low temperature loop.

To address these issues, the following proposed near-term improvements are proposed:

- **New effluent intake vault on final clarifier effluent.** In lieu of the effluent suction systems withdrawing flow from the final clarifiers, a new intake vault would be installed. This system would be less prone to fouling due to the cleaner water supply and would eliminate the adverse impact on clarifier performance.
- **Separate spray water from heat recovery system.** This separation allows optimization of each system for it's intended purpose to minimize cavitation and simplify controls.
- **Combined Low Temperature, ABC Low Temperature, and Primary Clarifier (PC) 3 Loops**. The low temperature, ABC low temperature, and PC3 loops can be cross-connected to minimize the number of loop circulating pumps required and to use wastewater to heat and cool using a single heat exchanger system. It is recommended that the staging of this change be considered in conjunction with the change to A/O to ensure that all connected loads will be adequately served by the combined loops.
- **Improved straining system**. Automated strainers are available with suction cleaning that could improve performance and reduce downstream maintenance from fouling.

Water reuse pumping alternatives were considered to reduce energy and maintenance in the spray water and gravity belt thickener (GBT) washwater systems. Optimization of the existing spray water system to minimize flow has a lower net present value than other alternatives that merged the two reuse systems.

Section 1: Introduction

The water reclamation plant (WRP) currently operates three heat recover loops serving different areas of the plant:

- Low Temperature (LT) Loop – High-purity oxygen (HPO) system, air compressors, digester gas cooling
- Medium Temperature (MT) Loop – Oxygen Compressor Intercooler
- ABC Low Temperature Loop– Aeration Basin Complex (ABC) and headworks
- Primary Clarifier (PC) 3 – Heat recovery and heat pump for make-up air heating

In the winter, these systems recover heat from wastewater and process equipment and use the heat in air handling unit preheating coils, reducing the energy required for boiler operation. In the summer, the equipment heat is rejected to the plant effluent via heat exchange with water from the final clarifiers.

In tandem with the thermal reuse systems, the WRP operates two major effluent reuse systems:

- Spray Water – Headworks and chemical feed water uses (this flow is also the thermal source for ABC low temperature loop and PC3 heat exchangers listed above)
- GBT Washwater – Belt washing

The following sections describe these systems and their current maintenance concerns.

1.1 Heat Recovery: Low and Medium Temperature Loop

The general arrangement of the LT and MT temperature loops is shown in Figure 1-1. The LT loop uses wastewater withdrawn from FC1 and FC2 to reject excess process equipment heat that is not recovered for space heating. The wastewater passes through a coarse automatic strainer to one of three pumps. Typically, one pump operates for wastewater heat exchange but two operate if heat demand requires it. The third withdrawal pump serves as a backup. Table 1-1 summarizes the major mechanical components of the low and medium temperature systems.

Because the winter temperature of the LT loop is roughly similar to or higher than the effluent water temperature, most of the heat is recovered from process components, and very little heat appears to be recovered from the effluent. Heat recovery in the LT HVAC systems is currently limited by HVAC equipment and control system components that are not functioning as intended. Estimated process component heat quantities are summarized in Section 2.1.

Final effluent entering the LT heat exchanger is drawn from perforated piping within the clarifier. This wastewater contains entrained solids and organic material that enter the heat exchangers and promote biofouling in the plate and frame units. As the heat exchangers foul, the flow through the system decreases. Heat exchanger fouling decreases the summer heat dissipating capacity of the system and increases pumping energy by creating excess pumping head. Every 6 weeks to 3 months, the fouled LT heat exchanger is taken out of service and cleaned with circulating citric acid to restore capacity.

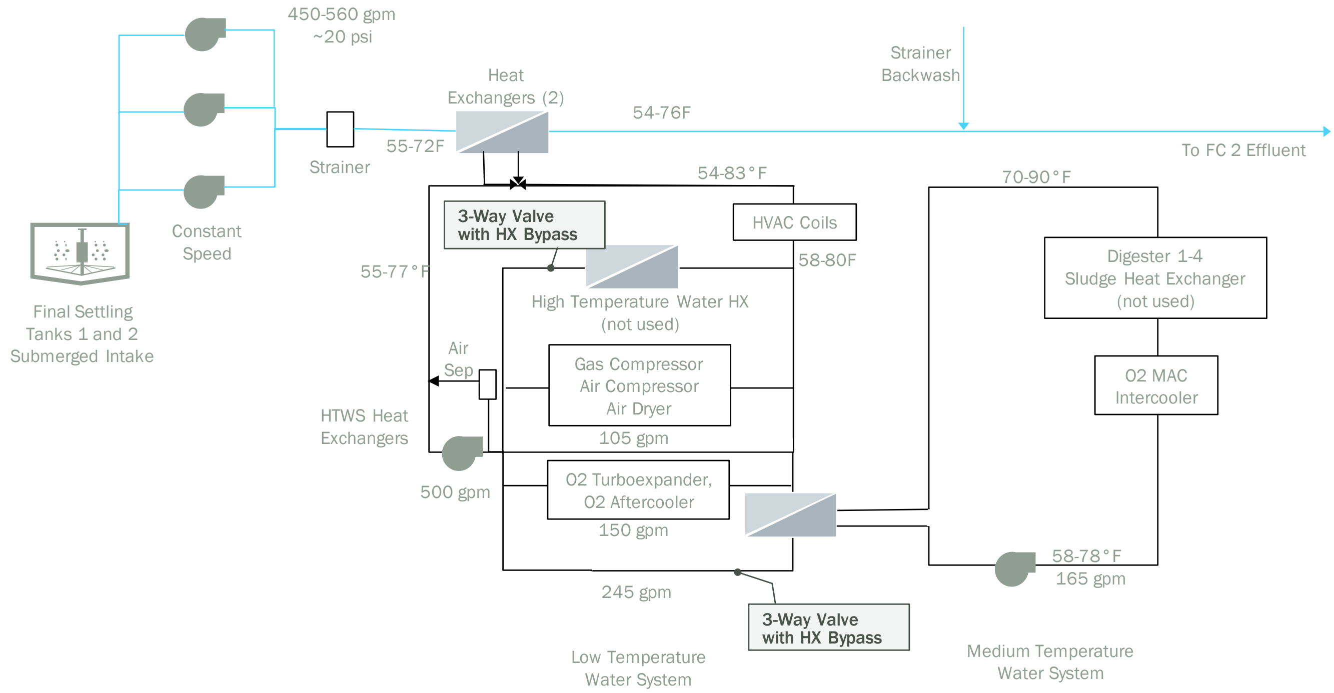


Figure 1-1. LT and MT water loops schematic

The anticipated shift from HPO to anaerobic/oxic (A/O) operations will remove the oxygen turboexpander, aftercooler, and compressor intercooler from this system. Likewise, the MT loop will be eliminated when the HPO units are removed. Two or three new blowers with oil cooling will be installed with the A/O conversion, and the oil-cooling system for these blowers can be connected to the LT loop. Figure 1-2 depicts a possible simplified configuration of the LT cooling loop configuration under these future conditions.

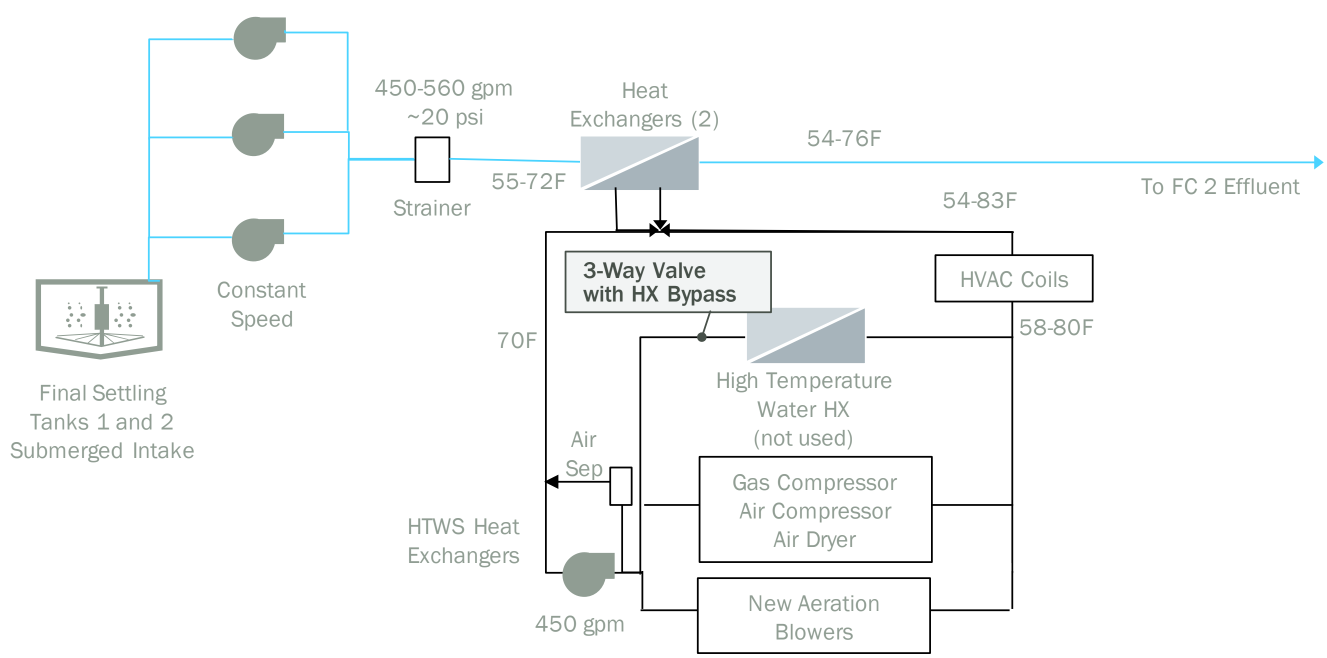


Figure 1-2. LT water loops following HPO decommissioning

Table 1-1. Low and Medium Temperature Heat Recovery Facility Characteristics		
Item	Units	Value
LT (main) effluent pumps		
Number	--	3
Flow per unit[a]	gpm	500
Discharge pressure[a]	psi	20
Motor size	hp	15
LT loop (main) pumps		
Number	--	3
Flow per unit[a]	gpm	500
Differential pressure[a]	psi	36
Motor size	hp	30
MT loop pumps		
Number	--	2
Flow per unit[a]	gpm	165
Motor size	hp	15

a. *Data from SCADA screenshots provided by the WRP*

1.2 Water Reuse: Spray Water System

The spray water pumping system currently serves:

- Heat exchangers serving the ABC low temperature water loop (see Figure 1-3)
- Spray water usage, primarily in the headworks area
- PC3's make-up air heating

Water is withdrawn from FC3 and FC4. To improve water quality, chlorine solution can be added to the system and a motorized strainer is located downstream of the pumping system. Non-potable water can supplement the spray water system if needed for peak flow conditions.

Table 1-2 summarizes the spray water usage locations. The headworks wash water requires 80 pounds per square inch (psi) pressure to provide adequate head for the equipment on the upper floors of the headworks building. The effluent pump speed is modulated to maintain an 80 to 85 psi pressure set point on the strainer outlet. Because the spray water demand is variable, flow is relieved to FC3 as needed to maintain pumping conditions. During summer months, approximately 50 to 75 percent of the 80-psi pumped flow is released through this outlet, wasting pumping energy.

Table 1-2. Spray Water Usage			
Item	Continuous (gpm)	Peak (gpm)	Notes
Screens and grit			
Screen compactor	27	81	Peak condition: 3 screens
Screen washer	14	42	Peak condition: 3 screens
Screen	30	90	Peak condition: 3 screens
Grit washer	42	42	Includes 20 gpm to west grit washer to keep drain clean
PC3 spray water	5	5	WRP estimate
FC5 spray water	--	5	Seasonal
FC1 through FC4 spray water	20	20	Future, 5 gpm per clarifier
Ferric chloride carrier water (PC, digester)	9	9	
PC scum pits	--	10	Engineer's estimate Runs when scum pump runs
PC3 HVAC		350	
Total	150	660	

Spray water is being considered for polymer make-up water in lieu of city water. A few issues may preclude this:

- Chloride concentrations of 200-300 ppm or higher can reduce polymer effectiveness (Polydyne, 2015). A recent effluent sample had a chloride concentration of 279 ppm (eDMR, April 2019).
- Water pH less than 6.5 can reduce polymer effectiveness. Plant effluent pH is approximately 6.5.
- Unchlorinated water could cause biofouling of the polymer blend unit.

Prior to converting polymer dilution to spray water, jar testing would be required to gauge the impact of these factors.

1.3 Heat Recovery: ABC Low Temperature Loop

The general arrangement of the LT and MT loops is shown in Figure 1-3. ABC low temperature loop serves the newer ABC and headworks portions of the plant. Because the ABC low temperature water loop temperature is 5°F to 10°F lower than the effluent, this system recovers more heat from the effluent under winter conditions than the low temperature loop. In addition to the heat recovery function, the effluent water in this system is used as a heat source for the heat pump serving PC3.

The following Operation and Maintenance (O&M) considerations were noted:

- The effluent water pumps are variable speed. The pumps modulate to maintain a pressure set point. Under current operating conditions, these pumps are prone to cavitation.
- During winter months, the high-temperature heat exchanger is used to maintain a minimum loop temperature and prevent freezing.
- The ABC low temperature loop heat exchanger only requires cleaning every two years.

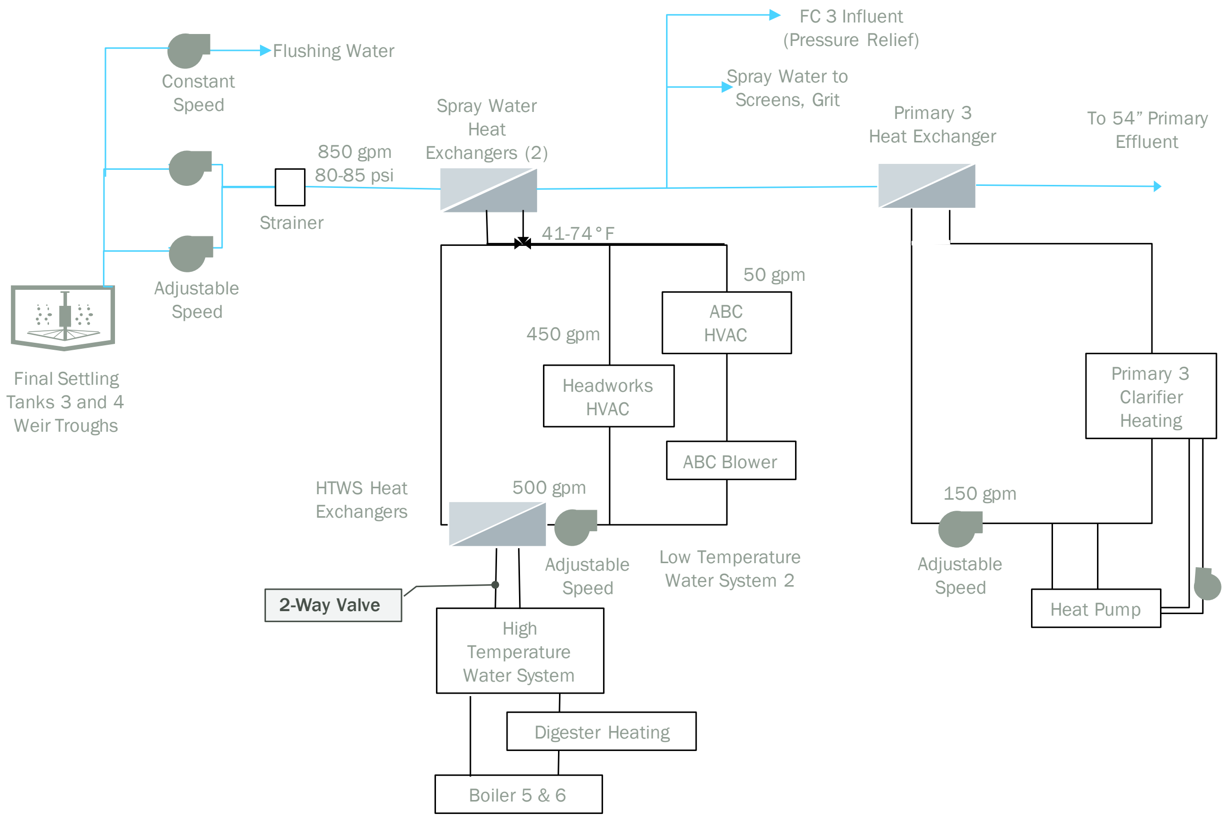


Figure 1-3. ABC low temperature loop schematic

Table 1-3. ABC Low Temperature Loop Heat Recovery Facility Characteristics		
Item	Units	Value
Effluent (spray water) pumps		
Number	--	2
Flow per unit[a]	gpm	850
Discharge pressure[a]	psi	80-85
Design head[b]	ft	225
Motor size	hp	75
ABC low temperature loop pumps		
Number	--	2
Flow per unit[a]	gpm	450
Motor size	hp	40
PC3 loop pump		
Number	--	1
Flow per unit[a]	gpm	150
Motor size	hp	10
PC3 heat pump (load) pump		
Number	--	1

Table 1-3. ABC Low Temperature Loop Heat Recovery Facility Characteristics		
Item	Units	Value
Flow per unit[a]	gpm	50
Motor size	hp	5

a. *Data from SCADA screenshots provided by WRP*

b. *Flowserve shop drawings*

1.4 Heat Recovery: Primary Clarifier 3 Heating

The PC3 heating system was added in 2011 to minimize fogging and improve personnel safety under the ABC primary clarifier dome. As depicted in Figure 1-3, the PC3 system uses effluent water (wasted from the spray water system) in two modes:

- Closed loop preheating of the make-up air
- Effluent-source heat pump

Table 1-4 summarizes the PC3 heat recovery operating conditions based on supervisory control and data acquisition (SCADA) screen information and other data furnished by WRP staff. The preheat system appears to provide roughly a third of the winter heating at current loop temperatures using heat recovered from the effluent water,

In Sections 3 and 4, possible modifications to the spray water will be presented to conserve pumping energy and reduce pumping equipment. Refer to Section 4.3 for PC3 heating modifications triggered by these proposed changes.

Table 1-4. Primary Clarifier 3 Winter Operating Conditions		
Item	Units	Value
Heat exchanger		
Effluent flow (current/design minimum)	gpm	325/100
Loop flow rate	gpm	220
Typical winter heat extracted	Btu/hr	240,000
Typical winter inlet/outlet loop temperatures	°F	54/52.5
Preheat coil		
Airflow rate	cfm	10,500
Water flow rate	gpm	150
Typical winter heat output (20°F outside air)	Btu/hr	190,000
Typical winter inlet/outlet loop temperatures	°F	51/48.5
Heat pump		
Source water flow rate	gpm	70
Hot water flow rate	gpm	45
Typical winter heat output	Btu/hr	400,000
Typical winter inlet/outlet loop source water temperatures	°F	51/48.5
Minimum source water temperature	°F	38

1.5 Water Reuse: Gravity Belt Thickener Washwater

Gravity belt thickener (GBT) washwater is withdrawn from Chlorine Basin 1 via a 20-inch pipe connection to the 1950's wet well. This piping reduces down to 14" then 6" then 4" before it increases to 6" as the flow passes through automatic strainers to the pumping system. Three pumps (replaced in 2004 upgrade) serve 3-inch and 4-inch parallel headers to the three GBT units. The manufacturer requires a minimum of 120 psi washwater at the GBT units. Table 1-5 summarizes the major GBT washwater pumping equipment characteristics.

A separate high-pressure water system serves the GBT high-pressure spray bars. This system uses non-potable water and a softener system.

Table 1-5. GBT Washwater Facility Characteristics

Item	Units	Value
Number	--	3
Flow per unit[a]	gpm	110
Discharge pressure[a]	psi	150
Design head[b]	ft	380
Motor size	hp	20

a. *Data from SCADA screenshots provided by WRP*

b. *Goulds pump curve*

Section 2: Heat Sources

This section documents the magnitude of existing and future heat sources that need to be dissipated either via HVAC preheat coils or through heat exchange to effluent water.

2.1 Anticipated Process Equipment Heat Sources

Table 2-1 summarizes the heat sources connected to the two heating loop systems under future A/O operation. Heat sources associated with the cryogenic plant will be eliminated by the anticipated future conversion to A/O and are not included in the long-term total heat sources. Similarly, the future blower serving the A/O system is not included in the near-term total. The oxygen compressor heat rejection is very large relative to the other heat sources, so the long-term heat recovery potential from process equipment will be significantly reduced.

The cogeneration system's lube oil heat recovery is currently dissipated via an air-cooled radiator. This heat source could be added to this system (479,000 British thermal units (Btu)/hr), but this heat would not be available when needed during cold weather if the WRP continues to switch their biogas utilization to the boiler system during winter months or migrates to a pipeline injection system.

Table 2-1.Summary of Process Equipment Heat Sources

Heat Inputs to Heat Recovery Loops	Estimated Heat Rejected per Unit (Btu/hr/unit)	Average Number Operating	Average Heat Rejected (Near Term)	Average Heat Rejected (Future)	Peak Number Operating	Peak Heat Rejected (Near Term)	Peak Heat Rejected (Future)
Large blower oil cooling	67,000	1	0	67,000[c]	1	67,000	67,000
Small blower oil cooling	44,000	0	44,000[d]	0	0	0	0
New blower oil cooling	67,000	1	0	67,000	2	0	133,000
Air compressor	25,000	1	50,000	0[a]	1	50,000	0
Air dryer[e]	13,000	1	13,000	0[a]	1	13,000	0
Digester gas cooling	72,000	1	90,000	90,000	1.25	112,000	112,000
Oxygen compressor cooling	930,000	1	930,000	0[b]	1.25	1,200,000	0
Other oxygen components	246,000	1	246,000	0[b]	1.25	308,000	0
Total (Btu/hr)			1,350,000	220,000		1,700,000	310,000

a. Assumes minimal compressed air required in the future following decommissioning of primary sludge pumps and sample pumps.

b. Following decommissioning of HPO

c. Existing KA 10

d. Existing KA2 (Less used in future)

e. Heat is rejected from refrigerated dryer and a compressed air precooler (heat exchange to LTW). Total heat rejected estimated to be roughly 50% of air compressor heat.

2.2 Blower Air Heat Recovery

This section evaluates heat recovery from the blower discharge air. The heat of compression raises the temperature of the air leaving the aeration blowers and deeper aeration tanks, such as the 25-

foot ABC basins, increase this heat. While not common, a heat recovery coil could be installed in the blower outlet duct to route some of this heat to the heat recovery loops. The future blowers that will serve the shallower HPO basins have lower discharge temperatures and are not included in this analysis.

The ABC blowers are currently lightly loaded, but airflows will increase with future plant load increases and conversion to plant-wide A/O operation. Table 2-2 summarizes typical winter operating conditions and estimated heat recovery. Table 2-3 summarizes the net savings associated with such a system, assuming the recovered heat would offset boiler natural gas use during winter months. The net savings calculation considers the additional blower electrical use required for the pressure drop across the heat recovery coil. WRP staff have optimized heating systems and lowered recent natural gas consumption, so some of this savings may not be realized if most plant heating is provided by biogas.

This blower heat recovery system would reduce some of the heat delivered to the aeration basins, but at a future plant flow of 19.6 million gallons per day (mgd), the reduction in wastewater temperature would be less than 0.001°F.

The estimated cost of the heat recovery coil is only $44,000 (Attachment A), but the coil installation to retrofit the ABC blowers with heat recovery is $330,000 because the piping connections and associated valves are fairly large. As a result, the payback for the proposed system is lengthy but would payback within the life of the project.

Table 2-2. Blower Heat Recovery Estimated Winter Conditions

Item	Units	Current	Future
Year		2019	2045
Average blower airflow	scfm	2,000	12,700
Blower inlet temperature	°F	20	20
Blower outlet temperature	°F	155	155
Heat exchanger air outlet temperature	°F	100	100
Recovered water temperature	°F	80	80
Heat recovery flow	gpm	300	300
Heat exchanger pressure drop	psi	0.2	0.2
Recovered heat	Btu/hr	120,000	750,000

Table 2-3. Approximate Blower Heat Recovery Savings

Item	Current	Future
Annual natural gas savings[a]	$3,300	$21,000
Annual blower energy costs	$500	$3,000
Net savings[b]	$2,800	$18,000
Preliminary project cost estimate		$330,000
Simple payback (years)		18

a. *Assumes 4 months of winter operation with all heat recovered offsetting boiler natural gas consumption (not biogas)*

b. *No O&M for heat exchanger cleaning or maintenance included.*

A similar system was installed at the Appleton, Wisconsin wastewater plant on blowers serving 30-foot deep aeration tanks. This system is not currently in use because the motors on the positive displacement (PD) blowers overheated, apparently due to the extra backpressure from the heat recovery heat exchanger (Shaw, 2017). This experience highlights the need to manage potential blower high-pressure issues by:

- Providing bypass piping to minimize blower head and energy consumption during summer months
- Coordinating the additional heat exchanger pressure drop with the blower design conditions
- Providing cleaning access to mitigate any fouling of the heat exchanger
- Monitoring blower discharge pressure so elevated pressure conditions can be addressed promptly

2.3 Effluent Heat Recovery

Under current conditions, the ABC low temperature loop recovers approximately 1,500,000 to 2,500,000 Btu/hr from the spray water heat exchanger. This heat is primarily used to reduce the heat demand in the headworks building. Making a rough assumption that this offsets natural gas use (versus biogas) approximately 2.5 months per year, the value of this recovered heat is on the order of $20,000/year.

As noted previously, because current LT loop temperatures are similar to effluent water temperatures, effluent heat recovery in this system appears to be minimal. Following removal of the oxygen compressors, the loop temperature may drop, and this heat recovery would increase. In addition, several of the HVAC coils that would utilize the recovered LT heat in this older system are not currently functional, which further limits the ability of this LT loop to recover heat.

2.4 Boiler Exhaust Heat Recovery

A vendor has proposed installing a Cain Industries boiler exhaust economizer on the existing boilers to increase the heat output of the boilers by 130,000 Btu/hr per boiler at boiler full load. BC does not recommend pursuing this retrofit because removing heat from the boiler exhaust gases creates acidic condensing conditions that are corrosive to the economizer. Normally, natural gas-fired boiler exhaust is maintained well above 250°F to prevent acid gas corrosion. Digester gas boiler exhaust is even more corrosive due to the hydrogen sulfide (H_2S) present in the biogas. Although the H_2S concentrations in the WRP biogas are relatively low, exhaust temperatures should be kept above 300°F to minimize corrosion. The water temperature entering the proposed Cain economizer would be much lower than these values (75°F) and the projected exhaust temperatures ranged from 123 to 208°F, so the economizer installation would be expected to corrode rapidly.

2.5 Solar Thermal

Solar thermal collectors could be used to provide additional heat input to the LT loops. This system would be similar in concept to the solar thermal system shown in Figure 2-1 that is used to supplement the District Energy system in St. Paul. This solar thermal system provides space heating in winter months and domestic hot water heat at local hospitals in summer months.

The disadvantage of solar energy is that it is fairly diffuse, especially in Minnesota, as shown in Figure 2-2. Solar incidence is even lower during winter months, reducing its effectiveness for seasonal heating. For these reasons, solar thermal installations are often limited to year-round hot water heating applications such as the District Energy system.

Table 2-4 summarizes the costs and modest anticipated natural gas savings for a hypothetical 250 square foot installation at the WRP.

Figure 2-1. 1.5 MW thermal hot water solar system on roof of St. Paul RiverCentre

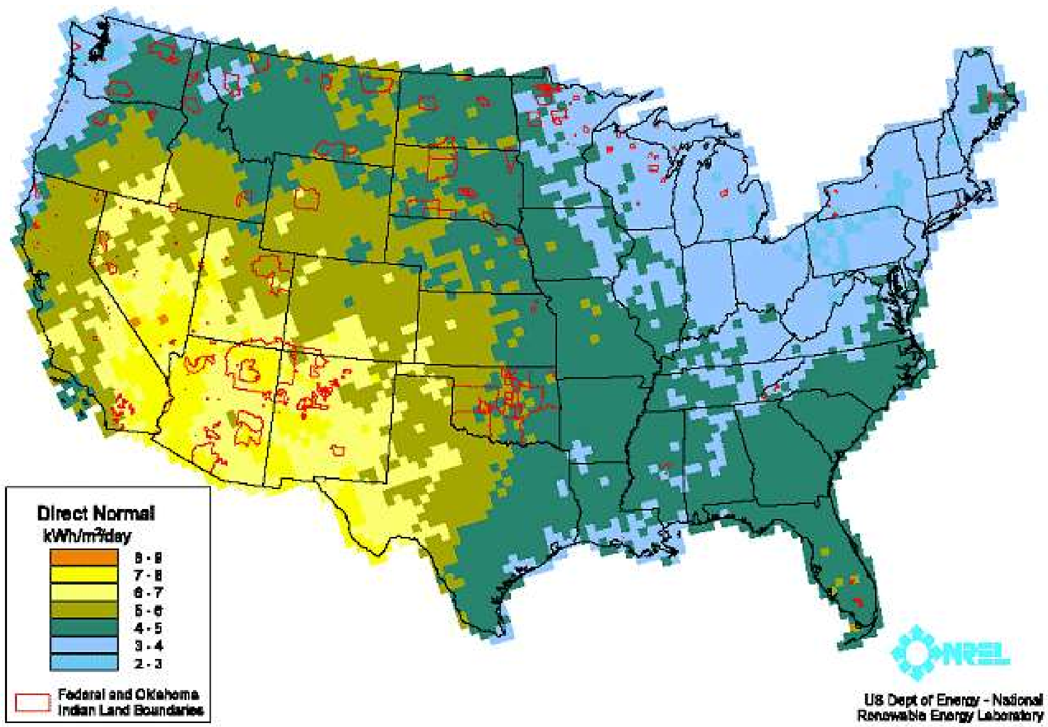


Figure 2-2. Direct normal solar incidence

Table 2-4. Approximate 250 SF Solar Thermal System Costs and Savings	
Item	**Current**
Annual natural gas savings[a]	$1,500
Approximate thermal output during heating season, average over 24 hours (Btu/hr)	600
Preliminary project cost estimate	$150,000
Simple payback (years)	100

a. *Assumes 6 months of winter operation with all heat recovered offsetting boiler natural gas consumption (not biogas)*

b. *Solar water heater, plastic collector $59/ft2 https://www.nrel.gov/analysis/tech-lcoe-re-cost-est.html*

Section 3: Heat Recovery Loop Alternatives

This section presents alternatives to reduce maintenance and energy use in the heat recovery system. These alternatives include:

- Cleaner cooling water sources serving existing heat exchangers
- Closed loop heat rejection to submerged effluent or ambient air
- Merging the LT and ABC low temperature heat recovery loops

3.1 Cooling Sources

The following sections describe alternative methods for rejecting heat. The first set of alternatives maintains the current pumped effluent concept but include revisions to reduce heat exchanger fouling. The final two alternatives eliminate effluent pumping by converting to either a submerged heat exchanger or an air-cooled radiator.

3.1.1 Maintain Pumped Water Source for Cooling

As noted in Section 1, one of the primary heat recovery system issues is the maintenance requirements of the effluent pumping and cleaning heat exchangers used for rejecting heat. The following two alternatives are configured to reduce the entrained solids that currently foul the heat exchangers by relocating the effluent intake out of the final clarifiers. This modification has the additional benefit of reducing disturbances to final clarifier settling which increases peak clarifier capacity.

The existing LT and ABC low temperature heat exchangers would continue to be used with these options, but pumps would be replaced with pumps selected for the revised flow and head conditions (refer to Table 3-1).

The spray water system is tentatively planned to be separated from the effluent pumps used with the loop heat exchangers. This separation will allow the two pumping systems and related controls to be optimized for their respective functions. Although this separation increases the number of installed pumps it does not increase expected pumping energy since it allows each system to pump only the flow and head required for their respective applications.

The loop systems are planned to be merged. Refer to Section 3.3.

Table 3-1. Approximate Future Heat Recovery System Pumping Conditions

Item	Units	Value
Effluent Pumps (Cooling Water Source)		
Flow rate, LT without HPO	gpm	250
Flow rate, ABC LT without relief or spray water	gpm	340
Flow rate, total without spray water	gpm	590
Head	ft	50
Energy consumption	bhp	13
Loop Water Pumps		

Table 3-1. Approximate Future Heat Recovery System Pumping Conditions		
Item	Units	Value
Flow rate	gpm	700
Head	ft	80
Energy consumption	bhp	24

Alternate 1: Relocate Intake to Chlorine Contact Channel

This alternative configuration would relocate the effluent water source from the final clarifiers to the chlorine contact tank (CCT). The chlorine in this flow would mitigate biofouling of the heat exchangers, but the piping associated with this alternative is lengthy (approximately 1,000 linear feet [LF]), as shown in the preliminary layout in Figure 3-1.

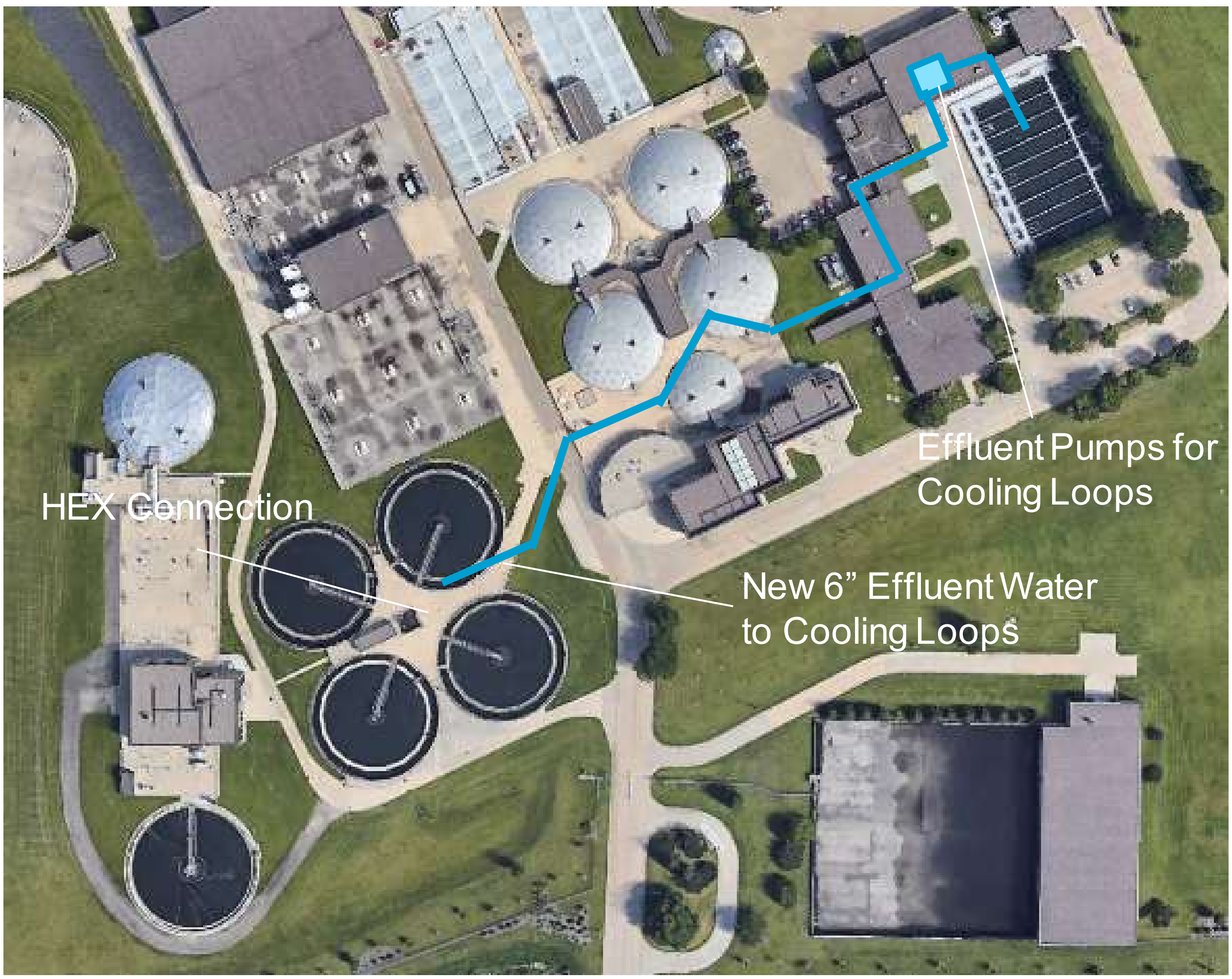


Figure 3-1. Proposed CCT intake for heat recovery loops

Image source: Google Earth

Alternate 2: Relocate Intake to New Sump on Final Clarifier Effluent

This alternative relocates the effluent water source to a new sump near the final clarifiers. This location is expected to have less solids than the current location in the clarifier's settling zone and would require less field piping than Alternative 1 but would not be chlorinated. The proposed configuration is shown in Figure 3-2.

Figure 3-2. New heat recovery intake vault and piping

Image source: Google Earth

Add Filtration to Existing Intake

In addition to revising the heat recovery water intake, more effective filtration could be added to control solids. Table 3-2 summarizes different types of strainers considered for this use. For the NPV analysis in Section 3.2, addition of a sand filter similar to the one in Figure 3-3 and Attachment B was assumed for Alternates 1 and 2. The choice of filter types and filter location will need to be refined during the project design.

Table 3-2. Filtration Alternatives Comparison

Item	Units	Filter 1 - Dual Basket	Filter 2 - Automatic Strainer	Filter 3 - Sand Filter	Filter 4 - Automatic Screen Filter
Representative manufacturer		Fluid Engineering	Fluid Engineering	Ecologix	Evoqua, Orival
Filtering size	inches/microns	1/16”	1/16”		100 microns
Pressure drop (psi)	psi		~1		7 (maximum prior to backflush)
Backwash requirements (gpm)	gpm	N/A	30-40	240	~1% of flow
Compressed air	cfm	N/A	N/A	2	N/A
Electrical requirements	hp	N/A	¼	Controls only	N/A
Equipment cost		$15,000	$14,000	$43,000	$39,000

Figure 3-3. Example sand filter configuration

3.1.2 Submerged Heat Exchange

This alternative would install a submerged heat exchanger in the CCT, similar to the example shown in Figure 3-4. This system would use the flow through the CCT to cool or heat the cooling loop in lieu of the pumped effluent systems described above, as shown in Figure 3-5. The heat exchanger would need to be mounted in a way that would be retrievable for cleaning. As an alternate to the CCT location the submerged heat exchanger could be located in a new vault near the final clarifiers, similar to the vault shown in Figure 3-2.

During heat exchanger cleaning or other outages the existing once-through non-potable water cooling system would provide back-up cooling for the aeration blower lube oil systems.

The submerged heat exchanger sized only to reject the heat sources during summer months is relatively small. A larger unit would be required for winter heat recovery to provide preheating equivalent to the existing effluent water system. Table 3-33 compares the heat exchangers needed for summer and winter conditions. Submerged HX quotations are found in Attachment C.

The capital cost for this alternate assumed 304 stainless steel heat exchanger construction. Effluent chloride concentrations would need to be confirmed to determine if a higher stainless grade is required. 316 stainless steel will provide better corrosion resistance if the chloride is more than 300 parts per million (ppm) but less than 1000 ppm. Based on April 2019 data provided by the WRP, current wastewater chloride concentrations are approximately 280 ppm, which is close enough to the threshold to warrant additional data to support the selection of metal grades. Heat exchanger welds should be a higher stainless-steel grade than the plates because they are inherently less corrosion-resistant. The heat exchanger could be located in the downstream portion of the CCT to minimize exposure to residual chlorine.

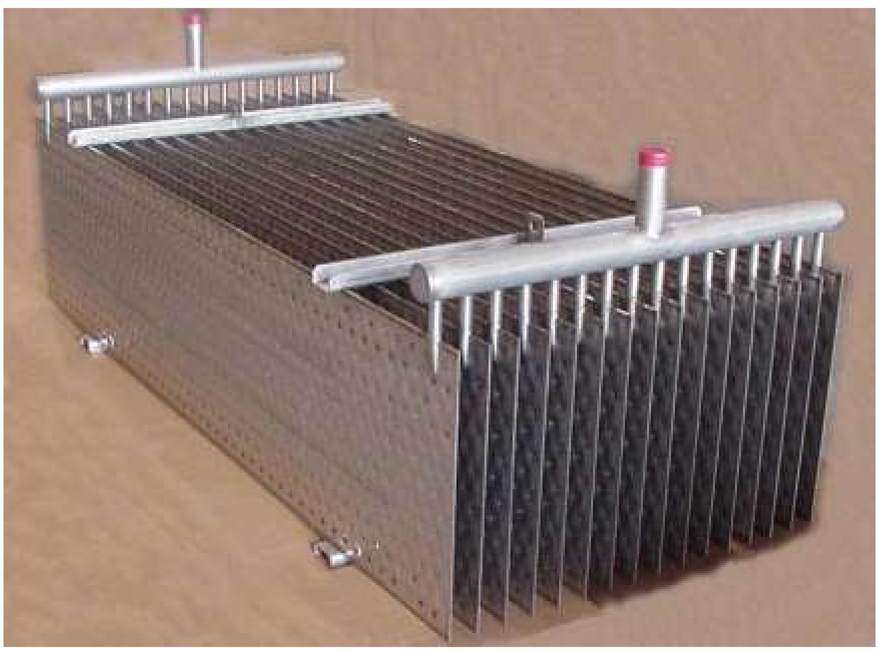


Figure 3-4. Example submerged heat exchanger configuration

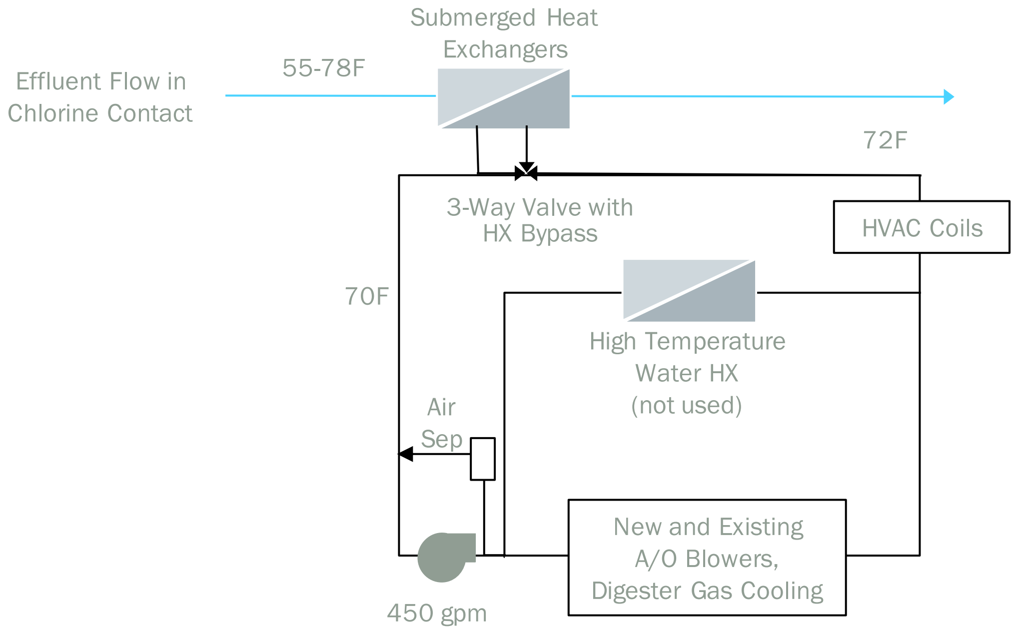


Figure 3-5. Example submerged heat exchanger schematic

Table 3-3. Summary of Submerged Heat Exchanger Design Conditions.			
	Units	Summer	Winter
Water in Chlorine Contact Tank			
Temperature	°C/°F	20/68[a]	13/55
Velocity	fps	0.02	0.02
Depth	ft	7	7
Water to be Cooled or Heated			
Inlet temperature	°F	80	43
Outlet temperature	°F	75	53
Flow rate	gpm	105	500
Heat transferred	Btu/hr	262,500[b]	2,500,000[c]
HX dimensions	inches	24"H x 25"W x 120" L	52"H x 72"W x 284"L
Budget HX cost	$	$24,000	$96,000

a. *Peak summer wastewater temperature can reach 78°F. Under these conditions a larger heat exchanger or periodic non-potable cooling would be required.*

b. *Future cooling following decommissioning of HPO*

c. *Winter conditions shown based on current cold winter day conditions in ABC low temperature loop to serve current winter heat recovery loads. Peak future LT HVAC heat loads could add a heat transfer demand on the order of 6,500,000 Btu/hr based on the LT loads in the heating coil schedule on sheet O-5 of the 1980 Expansion drawings.*

3.1.3 Dry Cooler

Dry coolers (similar to radiators) are considered "dry" because they utilize outdoor air as a cooling fluid. A dry cooler system would simplify operations by removing the requirement for effluent heat exchange and the related fouling. Under a future A/O operation, aeration blowers could be cooled through a combination of heat recovery and radiator cooling. According to Howden (Turblex), their blower cooling systems operate with fluid temperatures as high as 120ºF, which could be achieved even under summer conditions with a radiator cooling system cooling a glycol loop.

Additional research would be required to determine the temperature requirements of the oxygen components and determine if they would work with the higher summer temperatures of a cooling system served by a radiator. The current medium temperature loop was designed to operate at loop temperatures over 100°F, but currently provides cooling water at 58 to 78 ºF since this improves equipment operation. This consideration will impact whether the radiator retrofit would need to be delayed to coincide with the A/O retrofit.

A significant disadvantage of the dry cooler alternative is the loss of effluent heat recovery from the spray water system. The estimated increase in boiler natural gas (NG) consumption to compensate for this loss is included in the NPV analysis in Section 3.2.

The impact of the dry cooler alternative on the digester gas (DG) cooling system would also need to be considered. The DG cooler provides a first stage of cooling prior to chilled water cooling. Table 3-4 summarizes the DG cooler operating conditions. The precooling system saves roughly $4,600 per year in chiller energy. The dry cooler system would be able to maintain these cooling loop temperatures when the outside air temperature is less than 60°F to 70°F, but half of the pre-cooling savings could be lost if an alternative pre-cooling source is not provided for warm weather conditions. In addition, the low temperature water is used to cool the high-pressure gas entering the storage sphere, and this cooling is beneficial to control moisture on high pressure gas routed to the engine-generators and to maximize the stored DG mass for a given storage pressure. In order to replace the low temperature cooling during warm weather, the capital costs for this alternative includes routing effluent water from the GBT washwater system to the DG heat exchanger.

Table 3-4. Digester Gas Pre-Cooling Heat Exchanger Operating Conditions

Criterion	Value
DG inlet temperature (°F)	98
DG outlet temperature (°F)	67 (or warmer when LT loop temperature is high)
LT inlet water temperature (°F)	55-77
LT water temperature increase across heat exchanger (°F)	7
LT water flow (gpm)	20-25

Figure 3-6 shows a preliminary location and approximate dry cooler sizing for heat rejection from both the existing and future heat rejection scenarios. Figure 3-7 shows the integration of dry coolers in the heat recovery loop schematic.

Figure 3-6. Preliminary dry cooler location

Image Source: Google Earth

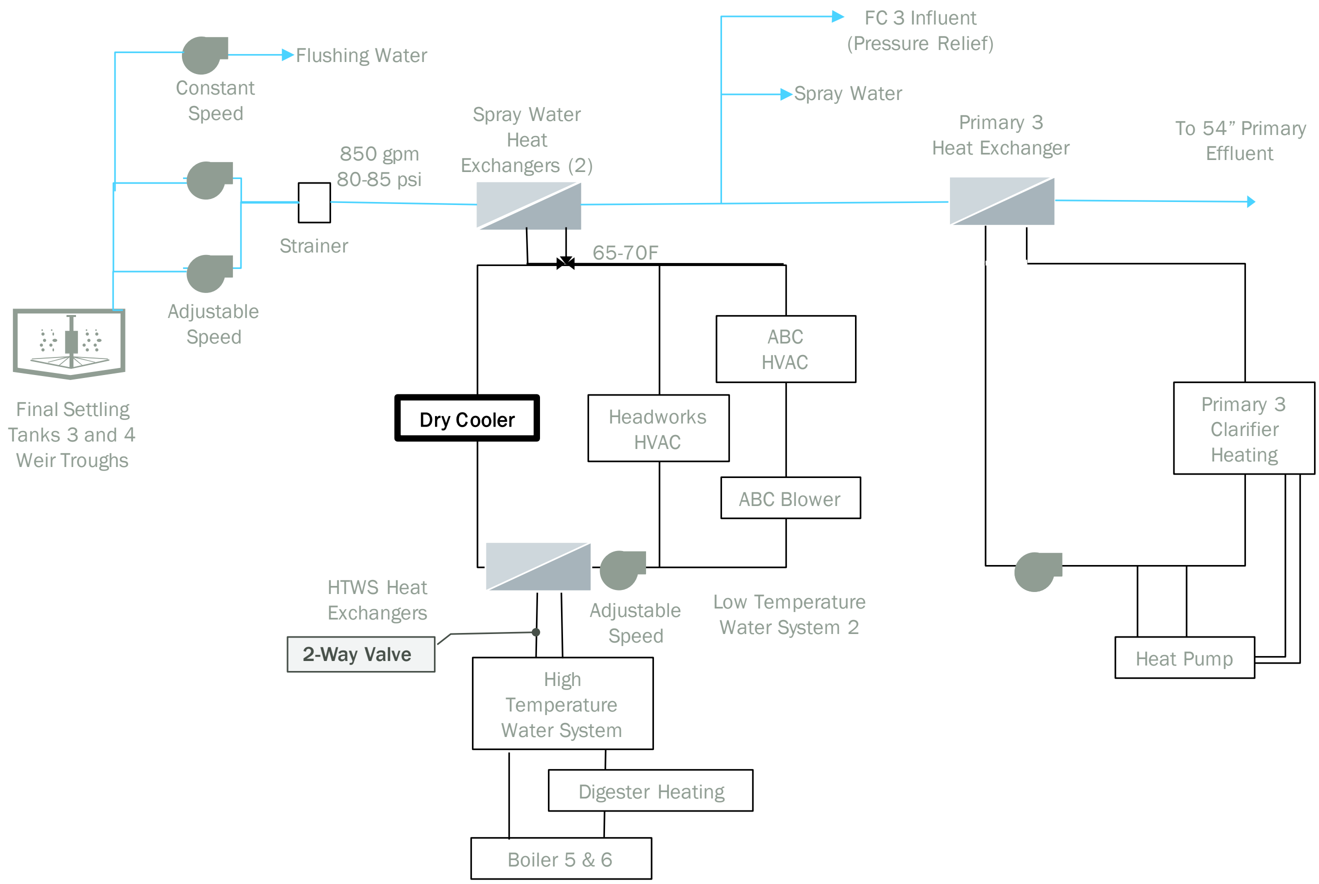


Figure 3-7. Potential dry cooler addition to ABC low temperature cooling loop configuration

3.2 Net Present Value Evaluation

3.2.1 Estimating Assumptions

Comparative capital costs were developed for each alternative, along with operating costs and life cycle present worth. Developed costs represent Class 5 estimates for Conceptual Level Planning and alternative comparison in accordance with the Association for the Advancement of Cost Engineering International (AACEI). Expected accuracy for Class 5 estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. The economic analysis uses the assumptions provided in Table 3-5 and Table 3-6 below.

Table 3-5. Project Cost Assumptions	
Item	Percentage of Cost
Net cost markups	
Labor (employer payroll burden)	15
Materials and process equipment	10
Equipment (construction-related)	10
Subcontractor	10
Sales tax	8.125
Material shipping and handling	2
Gross cost markups	
Contractor general conditions	15
Start-up, training, and O&M	2
Construction contingency	50
Builders risk, liability, and auto insurance	2
Performance and payment bonds	2
Escalation to midpoint of construction	3

Table 3-6. Annual Operating Cost and Net Present Value Assumptions	
Item	Cost
Electricity unit cost[a]	$0.096 per kWh
Labor rate (operations and maintenance staff)[b]	$55 per hr
Pump maintenance	0.2 hrs/day/pump
Heat exchanger maintenance (current)	96 hrs/year
Interest rate	3%
Discount rate	5%
Life-cycle cost period	20 years

a. *Based on electricity bills received from the City for the WRP from January, February, and May in 2017.*

b. *Assumed based on similar projects*

3.2.2 Operating Cost Comparison

Table 3-7 summarizes the estimated operating costs for the heat recovery alternatives. The submerged heat exchanger in the CCT has the lowest operating costs due to reduced pumping energy and pump maintenance.

Table 3-7. Cooling and Heat Recovery Annual Operating Costs					
Item	Final Clarifier Cooling Source (Status Quo)	CI Contact Cooling Source	FC Effluent Sump Cooling Source	Submerged HX in CI Contact	Air-Cooled Radiator
Pumping energy	$30,000	$28,000	$24,000	$16,500	$11,000
Natural gas					$9,000[b]
Pump maintenance	$40,000	$24,000	$24,000	$12,000	$12,000
HX maintenance	$5,000	$1,500	$1,500	$2,500	--
Filter maintenance	$2,000	$2,000	$2,000	--	--
Blower maintenance	--	--	--	--	$2,500[a]
Dry cooler energy					$1,800
Dry cooler maintenance	--	--	--	--	$5,000
Operating total	$77,000	$57,500	$53,500	$31,000	$41,000

a. *Assumes small maintenance increase from higher lubrication temperature*

b. *Increased natural gas to compensate for loss of heat recovery in ABC low temperature loop during winter months*

3.2.3 Net Present Value

A presentation of the capital costs and net present values of each alternative are presented in Table 3.8 below.

The final clarifier effluent sump and air cooled radiator alternatives had the lowest (most economical) NPV. The submerged HX in the CCT had a slightly higher NPV than these alternatives due to its higher estimated capital cost.

This analysis includes the O&M factors in Table 3-6. The NPV calculation did not include the increased potential for additional effluent heat recovery on the LT loop if the HVAC systems are repaired.

Table 3-8. Cooling and Heat Recovery Capital Costs and Net Present Value					
Item	Final Clarifier Cooling Source (Status Quo)	CI Contact Cooling Source	FC Effluent Sump Cooling Source	Submerged HX in CI Contact	Air-Cooled Radiator
Piping and pumps		$185,000	$60,000	$142,000	$25,000
Dry cooler					$24,000
Submerged heat exchanger				$110,000	
HX installation				$40,000	$37,000
GBT washwater to DG cooling					$5,000
Sand Filter		69,000	69,000		
Electrical				$20,000	$20,000
Markups		$230,000	$120,000	$280,000	$100,000
Engineering and administration (20%)		$71,000	$23,000	$120,000	$43,000
Total capital cost		$590,000	$300,000	$710,000	$260,000
NPV of O&M costs	$1,400,000	$1,000,000	$900,000	$570,000	$745,000
NPV	$1,400,000	$1,600,000	$1,250,000	$1,300,000	$1,000,000

a. *Cost presented in 2020 dollars*

b. *Includes $200,000 for engineering and administration related to developing and testing the performance*

3.2.4 Alignment with WRP Goals

Table 3-9 summarizes the advantages and disadvantages of the cooling and heat recovery alternatives relative to WRP facility planning goals and other considerations. The submerged HX scores favorably in some aspects of this comparison, but this approach is not proven in a wastewater setting and the effort required to keep the heat exchanger clean in unknown.

The air-cooled radiator alternative does not offer heat recovery without ancillary effluent heat exchange, so this alternative was eliminated from further consideration.

Table 3-9. Cooling and Heat Recovery Comparison					
Item	Final Clarifier Cooling Source (Status Quo)	CI Contact Cooling Source	FC Effluent Sump Cooling Source	Submerged HX in CI Contact	Air-Cooled Radiator
Reduces pumping energy	0	0	0	+	+
Minimizes natural gas consumption	0	0	0	0	—
Reduces maintenance	—	+	0	0	+

Table 3-9. Cooling and Heat Recovery Comparison					
Item	Final Clarifier Cooling Source (Status Quo)	CI Contact Cooling Source	FC Effluent Sump Cooling Source	Submerged HX in CI Contact	Air-Cooled Radiator
Ease of constructability	+	–	0	–	+
Compatibility with existing heat sources	+	+	+	+	–
Proven approach	0	+	+	–	+

a. Symbols: + positive attribute, 0 neutral, - negative attribute

3.3 Merge Low Temperature Water Loops

Any of the heat recovery alternatives noted above could be implemented with merged LT and ABC low temperature water loops. Merging the loops would eliminate at least two pumps and their associated maintenance. The three LT loop pumps are designed for 500 gallons per minute (gpm) at 20 psi, with one pump typically in service and the ABC low temperature effluent loop pump capacity is 450 gpm. Based on the pipe sizes in the pumping area (8-inch), the LT loop pumps would appear to be the best candidates for serving the merged loop. A detailed hydraulic analysis would be needed to determine whether the existing pump's flow and head characteristics would be suitable for the merged loop conditions, both under current conditions and future conditions following conversion to A/O. This evaluation could also consider the potential energy benefit of retrofitting these pumps with variable frequency drives (VFDs).

3.4 Low Temperature Loop Economic Viability

Although the low temperature heat recovery system provides an innovative means of reducing boiler heating demand, there are energy and maintenance costs associated with operating the system. This section considers the cost effectiveness of the branch of the ABC low temperature system serving the headworks.

Eliminating the heat recovery serving the headworks would add approximately 10% to the winter boiler heating load. During spring and fall months, the additional load would represent approximately 50% of the available recovered heat while the CHP system is running, decreasing the number of weeks per year that the CHP system would be able to provide adequate heat for the high temperature loop.

Table 3-10 summarizes the operating assumptions used to estimate the net savings for this heat recovery system. Table 3-11 summarizes the estimated operating costs and savings. Based on this analysis there is a net benefit of roughly $13,000 per year for this heat recovery system.

Table 3-10. Headworks Low Temperature Loop Operating Assumptions		
Item	Units	Value
ABC low temperature loop pump		
Flow	gpm	500
Head	ft	121
System operation	months/year	5

Table 3-10. Headworks Low Temperature Loop Operating Assumptions		
Item	Units	Value
Energy	bhp	22
Maintenance	hours/pump/day	0.2
Spray water pump		500
Flow	gpm	300
HX head	ft	48
System operation	months/year	5
Energy	bhp	5
HVAC Airflow		
Total (grit, screenings, influent pump)	cfm	47,000
Coil pressure drop	inches w.c.	0.8[a]
Energy	bhp	8.3
System operation	months/year	12
Heat recovery		
Natural gas savings duration	months/year	2.5[b]
Recovered heat, headworks typical	Btu/hr	1,500,000
Additional CHP		
Operation duration	weeks/year	4
Output	kW	600

a. *Based on 1980 expansion coil schedule (drawing O-5)*

b. *Assumes biogas is used for heating during the remaining heating season*

Table 3-11. Headworks Low Temperature Loop Net Cost Evaluation	
Item	Annual Cost ($)
Loop pump energy[a]	5,600
Spray water additional energy	3,200
Fan Energy	5,200
Loop Pump Maintenance	8,000
HVAC and LT HX Maintenance	2,000
Natural Gas Savings[b]	(20,800)
Additional Fall/Spring Electrical Production[c]	(13,000)
Net Savings	(7,800)

a. *$0.096/kWh*

b. *$0.76/therm*

c. *CHP electrical savings: $0.06 $/kWh with no demand. O&M: $0.028 $/kWh*

Section 4: Reuse Water Alternatives

As described previously in Section 1, there are three major effluent re-use systems: low temperature heat recovery, spray water, and GBT washwater. Section 3 presented alternate cooling sources to reduce heat exchanger maintenance. The analysis in this section assumes that the spray water is separated from the ABC low temperature effluent heat exchanger, either via the submerged heat exchanger or separate low-pressure pumps serving the existing heat exchanger.

In addition, this section considers:

- Alternatives to providing a heat source to PC3 if the effluent water source is decommissioned
- Upgrades to the reuse water strainer systems.

4.1 Water Reuse Pumping Alternatives

Table 4-1 summarizes the design conditions for the two remaining reuse water systems. The following sections present alternatives to optimize these systems.

Table 4-1. Reuse Water Design Conditions

Item	Continuous (gpm)	Peak (gpm)	Future Continuous/Peak (gpm)	Pump Differential Pressure (psi)
Spray water	130	280	130/280	80
GBT washwater	110	110	150/205[a]	170
Total	240	390	280/485	--

a. Includes 10 gpm for scrubber water chlorinators, 10 gpm for future disinfection chlorinators, 20 gpm for carrier water, and washwater increased by 50% for potential future fourth GBT (increase from 2 to 3 GBTs in service)

4.1.1 Separate Spray and GBT Water Systems

This alternative would continue to keep the spray and GBT pumping systems separate as shown in Figure 4-1. The two existing spray water pumps would be replaced with two new pumps to reduce the rated pump flow from 850 gpm to 280 gpm, selecting a pump that would address the cavitation observed in the current pumping system. The existing FC3 and FC4 intake configuration would be modified to use a new inlet sump as shown in Figure 3-2. The GBT pumps would remain in their current configuration and have adequate capacity for future conditions.

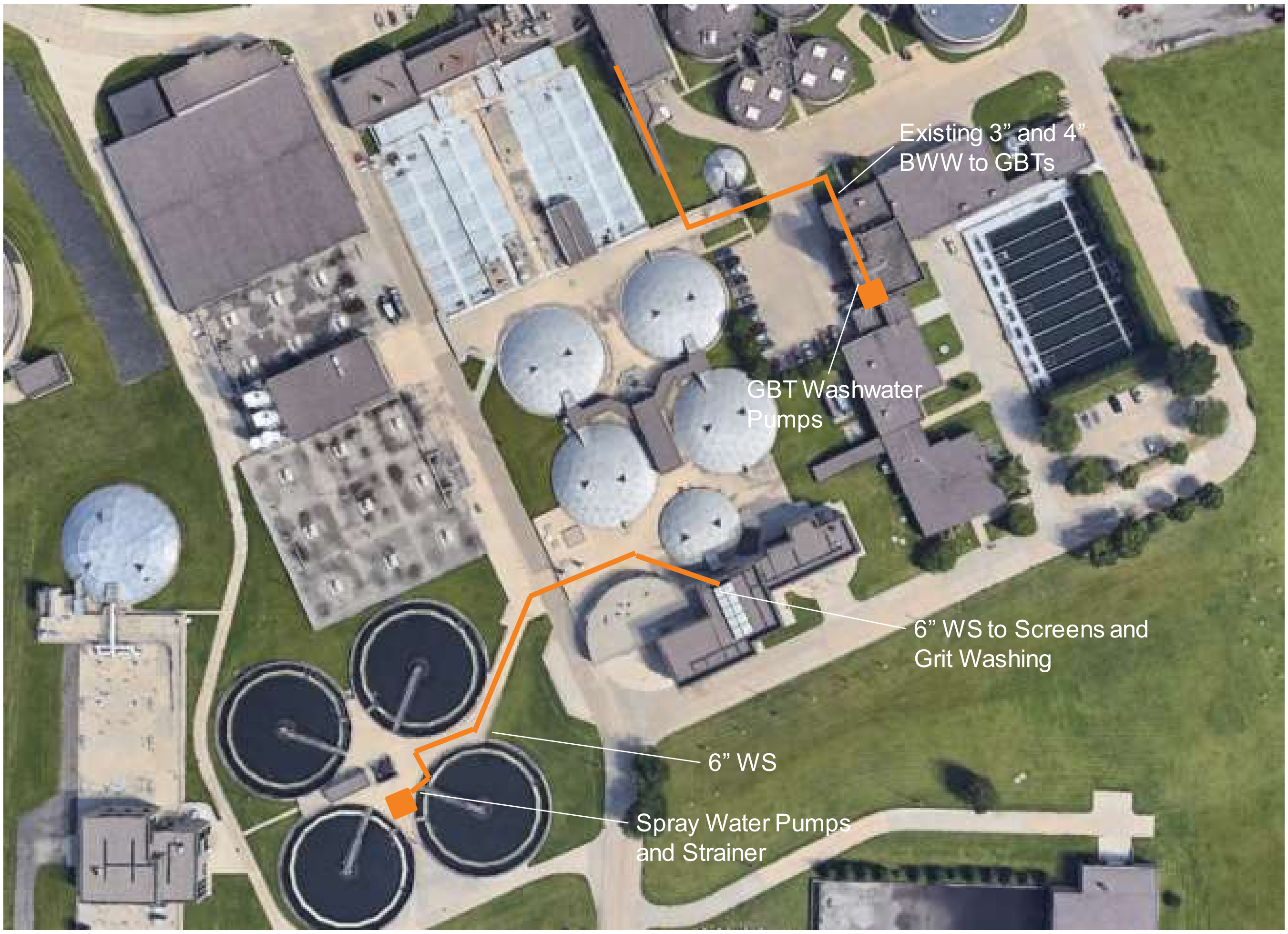


Figure 4-1. Separate spray water and GBT washwater pumping systems

Image Source: Google Earth

4.1.2 Merged Spray Water and GBT Wash Water – Chlorine Contact Basin

This alternative would merge the two water reuse systems in order to reduce the number of pumping systems needing maintenance. This configuration would also provide chlorinated effluent for the spray water system. Figure 4-2 shows one possible configuration for the cross-connection piping required to merge the two systems and the pressure reducing valve required to throttle the pressure in the spray water system. The 3- and 4-inch piping serving the combined spray water and GBT systems would see somewhat high velocities under peak conditions, so alternate routing could be considered during final design. The three existing GBT pumps only have a combined capacity of 330 gpm. The estimated capital cost for this alternative includes three new pumps to supply future peak operating conditions.

This configuration increases pumping energy relative to the separate systems because all pumping would operate at 170 psi.

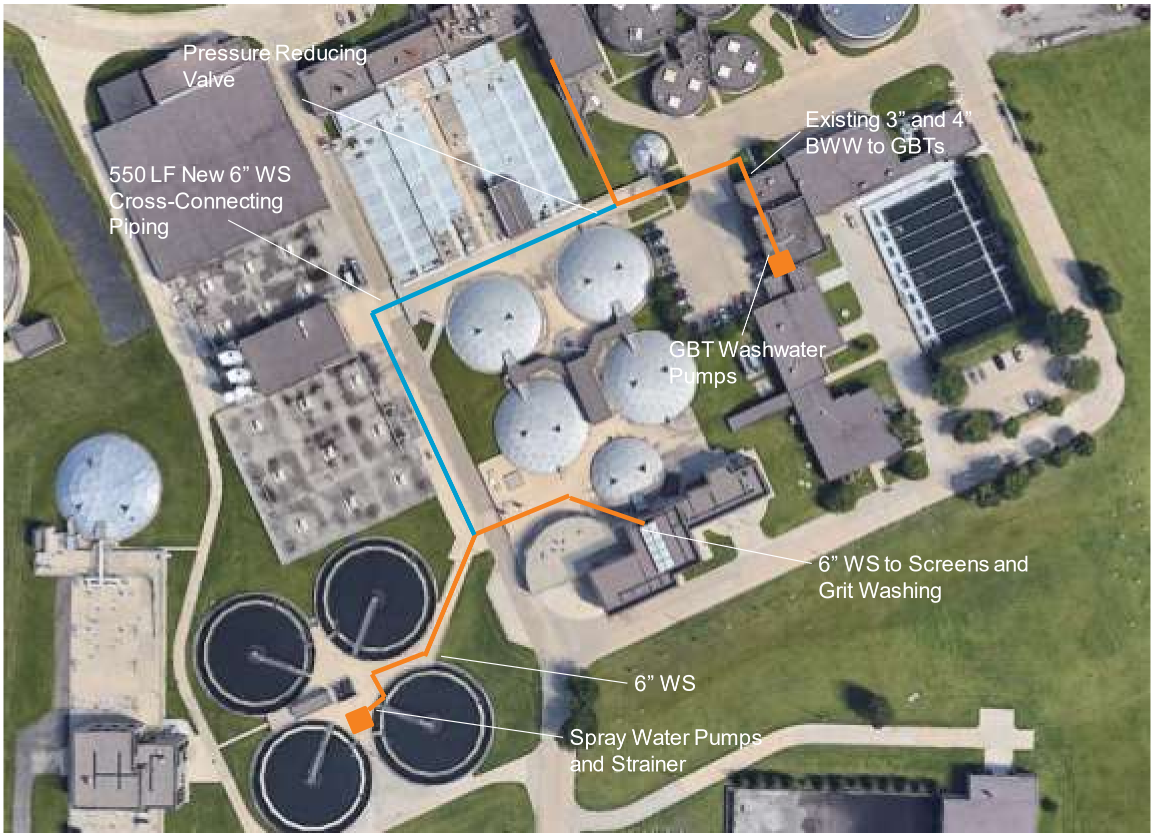


Figure 4-2. Cross-connection piping to merge spray water and GBT washwater systems

Image Source: Google Earth

4.1.3 Merged Water Systems with GBT Booster Pump

This alternative would replace the existing GBT washwater pumps with 80 psi pumps sized to provide the total flow requirements listed in Table 4-1. New 10 horsepower (hp) booster pumps would be added to each GBT to provide adequate flow and pressure belt washing. The cross-connection piping configuration would be similar to that shown in Figure 4-2 (without the pressure reducing valve).

4.2 Net Present Value Evaluation

This section presents the net present value evaluation for the water reuse alternatives. The assumptions used in this analysis are the same as those presented in Section 3.2.1.

4.2.1 Operating Cost Comparison

Table 4-2 summarizes the annual operating costs for the three reuse water alternatives. The alternatives presented below all reduce pump energy consumption by at least $30,000 per year relative to current pumping conditions, primarily by reducing the average flow through the spray water system. Refer to Section 4.3 for additional scope related to separating the spray water from the PC3 heating system.

Of the future alternatives, the merged spray and GBT systems alternative has the lowest estimated operating cost due to the predicted reduction in pump maintenance, which offsets the increase in energy cost.

Table 4-2. Cooling and Heat Recovery Annual Operating Costs			
Item	Separate Spray Water and GBT Washwater Systems	Merged Spray and GBT Systems	Merged Spray and GBT Systems with GBT Booster Pumps
Pumping energy	$17,000	$22,000	$20,000
Pump maintenance	$20,000	$12,000	$24,000
Strainer maintenance and chlorination	$1,000	--	--
Operating total	$38,000	$34,000	$44,000

4.2.2 Net Present Value

A presentation of the capital costs and NPVs of each alternative are presented in Table 4-3. The separate spray water and GBT washwater system alternative has the most favorable NPV due to the lower capital cost. This analysis assumes that the existing GBT washwater pumps are suitable for continued use over the planning period, with no capital costs included for replacing these pumps.

Table 4-3. Water Reuse Capital Costs and Net Present Value			
Item	Separate Spray Water and GBT Washwater Systems	Merged Spray and GBT Systems	Merged Spray and GBT Systems with GBT Booster Pumps
Piping	5,000	56,000	52,000
Pump replacement	30,000	95,000	100,000
Revised pump intake	154,000[a]		
Electrical and instrumentation	11,000	54,000	56,000
Markups	140,000	211,000	212,000
Engineering and Administration (20%)	70,000	83,000	84,000
Total Capital Cost	410,000	500,000	500,000
NPV of O&M Costs	700,000	770,000	800,000
NPV	$1,100,000	$1,300,000	$1,300,000

a. *Capital cost for pump intake vault also included in LT loop alternative BCE in Table 3-7.*

4.2.3 Alignment with WRP Goals

Table 4-4 summarizes the advantages and disadvantages of the effluent reuse alternatives relative WRP facility planning goals and other considerations. Separate reuse water systems scores most favorably in this comparison.

Table 4-4. Water Reuse Alternative Comparison			
Item	Separate Spray Water and GBT Washwater Systems	Merged Spray and GBT Systems	Merged Spray and GBT Systems with GBT Booster Pumps
Reduces pumping energy	+	0	+
Reduces maintenance	0	+	0
Ease of constructability	+	0	0

Symbols: + positive attribute, O neutral, - negative attribute

4.3 Primary Clarifier 3 Heat Source

The PC3 heating system is described in Section 1.4. This system will be impacted by the proposed changes to the heat recovery section described in Section 3, especially if the submerged heat exchanger alternative is selected. This section compares two alternatives for revising the PC3 heating system.

4.3.1 Route Headworks Spray Water Through Existing Heat Exchanger

This alternative assumes that effluent flow to the PC3 HVAC heat exchanger is provided by one of the water reuse pumping systems above, with the pumped flow being returned to the spray water system instead of wasted to the primary clarifier effluent. The new piping is shown in Figure 4-3 and a schematic is shown in Figure 4-4.

Figure 4-3. Piping to route effluent water from PC3 HVAC back to spray water

Image Source: Google Earth

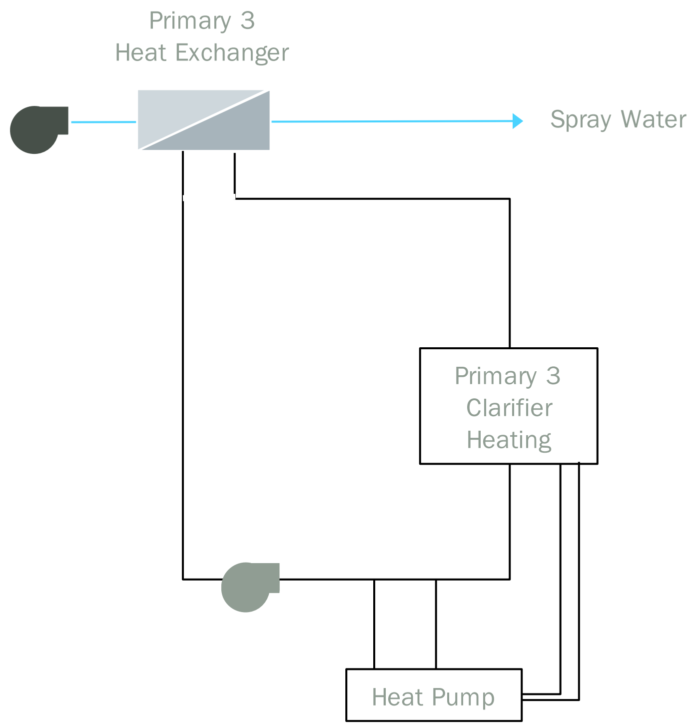


Figure 4-4. Spray water routed through PC3 HX

4.3.2 Replace Heat Exchanger with Effluent Water Cooling Loop

This alternative assumes that the PC3 heating loop would be connected to the main heat recovery loop. The PC3 heating system withdraws approximately 250,000 Btu/hr from the effluent water system. Under this condition, the PC3 heat withdrawal would need to be made up through some combination of increased effluent heat exchange or extra hot water system (boiler) use. This analysis assumes that the additional heat exchange is provided by enlarging the submerged heat exchanger. In addition, approximately 600 LF of 4-inch piping would be required to connect PC3 to the effluent water loop in the ABC blower building.

This alternative has two advantages:

- Elimination of maintenance associated with two PC3 loop pumps and HX
- Elimination of HX pumping energy in loop

4.3.3 Net Present Value

Table 4-5 compares the capital cost and NPV for the two PC3 modification alternatives. Merging the PC3 and ABC low temperature cooling loops has the most economical NPV, primarily due to reduced pump maintenance through the elimination of the PC3 loop pumps.

Another potential heat recovery strategy would be to route tunnel exhaust to the PC3 air handling unit. This option would require a building code review and investigation of the available exhaust airflow and ducting required.

Table 4-5. PC3 Heat Source Capital Cost and NPV Comparison		
Item	Route Spray Water through PC3 Heat Exchanger	Merge PC3 and Effluent Cooling Loops
Piping	$60,000	$80,000
Larger submerged heat exchanger	$10,000	
Markups	$92,000	$100,000
Engineering and administration (20%)	$18,000	$35,000
Total capital cost	$180,000	$215,000
NPV of O&M costs	$160,000[a]	$7,600[b]
NPV	$340,000	$220,000

a. *$8,000/year PC3 loop pump and HX maintenance, $900/year pump energy*
b. *$400/year pump energy*

4.4 Strainer Upgrades

The ABC low temperature effluent water and GBT washwater systems have automated strainers. The low temperature loop has a coarse strainer that is pressure-differential backflushed. WRP staff have indicated that they would like to remove additional solids from the reuse water using upgraded straining systems.

The appropriate mesh size for water reuse can be based on the maximum particle size or solids concentration that can be tolerated by downstream equipment. For example, one GBT manufacturer (Alfa Laval) states that the solids concentration in washwater can be as high as 200 mg/L.

Alternatively, the mesh size can be determined based on the typical particle size in reuse water. The WRP occasionally experiences pin floc, especially in the HPO system final clarifiers. Pin flocs are often smaller than 50μm. A mesh size of 270 or smaller would provide openings in this size range. Brown and Caldwell's treatability lab could perform a sieve analysis to confirm this mesh recommendation based on actual particle sizes.

Section 5: Recommendations

This Technical Memorandum (TM) presented several evaluations of the heat recovery and water reuse systems. Table 5-1 summarizes the capital improvements based on the conclusions. Figure 5-1 depicts the recommended heat recovery loop configuration. The final clarifier effluent vault water intake was chosen as a water source for both the heat recovery system over the submerged heat exchanger alternative because this approach is more proven and there is less uncertainty about the effort needed to keep the heat exchanger clean. This vault will also be used for the spray and flushing water system's intakes.

Current heat recovery and water reuse system operating costs were estimated to be roughly $125,000 per year. The modified effluent water intake, merged water loops, and spray water modifications are estimated to save approximately $35,000 per year in pumping energy and $20,000 per year in reduced pump and heat exchanger maintenance, reducing the estimated future annual operating cost to $70,000.

Table 5-2 summarizes the heat sources and sinks in the heat recovery system, including the low temperature HVAC, headworks HVAC, ABC HVAC, and primary 3 HVAC. Table 5-3 suggests preliminary design conditions for a new heat exchanger to serve the combined low temperature systems. A preliminary quote for this heat exchanger, with 8 mm openings for solids passing, is in Attachment F. Wider plate spacing lowers the velocity of the flow between the plates and under low summer flow rates, so the design needs to be optimized to avoid laminar conditions which reduce heat transfer and could lead to particle settling. Future refinement of the heat exchanger design may require two heat exchangers with only one operating in summer conditions to balance the advantages of wider plate spacing against the potential for low flow velocity,

Table 5-1. Immediate Capital Improvements Opinion of Probable Costs[a]

Item	Cost [a, b]	Objective
Effluent water intake vault and suction piping near final clarifiers	$138,000	Reduce maintenance and pumping energy
Merged LT water loops	$50,000[c]	Reduce pump maintenance
Reuse spray water pumping and piping revisions	$115,000[e]	Reduce pumping energy
PC3 HVAC heat source revisions	$180,000	Reduce pumping energy
Strainer upgrades	$100,000	Minimize maintenance of equipment served by spray water and GBT washwater systems
Demolish MT cooling loop	--[d]	Loop no longer required following conversion of secondary treatment to A/O
Total	$590,000	

a. *Refer to Section 3.2.1 for accuracy, contingency, mark ups, and engineering and administration assumptions*

b. *AACEI Class 5 estimate*

c. *Rough estimate without developed scope of improvements*

d. *Cost included in* liquid *treatment estimate*

e. *Spray water pump replacement and connection to new effluent water intake vault*

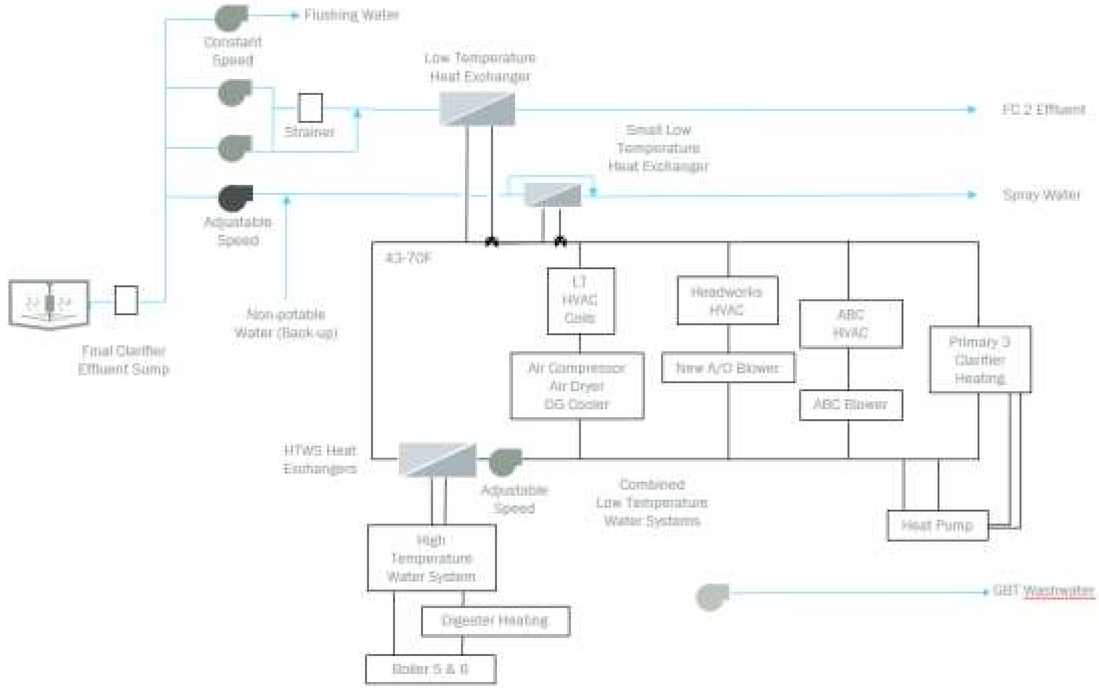


Figure 5-1. Proposed heat recovery and water reuse system

Note: Following conversion to A/O

Table 5-2. Heat Recovery System Summary

Item	Average Heat Use/Rejection (Btu/hr)	
	Current	Future
Heat users		
LT HVAC	0[a]	4,900,000[b]
Headworks HVAC	1,700,000[c]	1,700,000[c]
ABC HVAC	200,000[d]	200,000[d]
Primary 3 HVAC	430,000	430,000
Total	2,330,000	7,230,000
Heat rejection sources		
HPO	1,200,000	0
ABC aeration blowers	44,000	67,000
A/O aeration blower		67,000
Air compressor equipment	63,000	0
Digester Gas Equipment	90,000	90,000
Total	1,350,000	220,000

a. *Minimal current heat recovery because loop temperature is close to effluent temperature and HVAC controls are in poor repair*

b. *75% of maximum based on HVAC coil schedule in design drawing*

c. *Average based on "typical" SCADA information*

d. *Estimated to be roughly 10% of headworks HVAC*

Table 5-3. Preliminary Heat Exchanger Design Conditions		
Item	**Loop**	**Effluent**
Fluid	40% Glycol	Treated Wastewater
Winter Flow Rate (gpm)	1500	1500
Winter Inlet Temperature	40	57
Winter Outlet Temperature	51.5	47
Winter Heat Exchange	7,000,000[a]	
Summer Flow Rate	500	500
Summer Inlet Temperature	83	72
Summer Outlet Temperature	74	80
Summer Heat Exchange	2,000,000	

a. *Winter heat demand minus future heat sources.*

Section 6: References

Polydyne, presentation “Laboratory Jar Testing” presented to the Michigan Water Environment Association, East Lansing, MI, April 29, 2015

EDMR, Rochester Discharge Monitoring Report, May 16, 2019

Shaw, Chris. Email exchange with Appleton Utilities Director regarding blower heat recovery, September 22, 2017.

Attachment A: Blower Heat Recovery Coil Drawing and Quote

XCHANGER INDUSTRIAL HEAT EXCHANGERS
1401 7th STREET S.
HOPKINS, MN 55343
952-933-2559
XCHANGER.COM

Brown & Caldwell
30 East 7th Street
Suite 2500
St. Paul, MN 55101

May 3, 2019
Proposal 56547GF

Attn : Nancy Andrews
Subject : Air cooler - 25,000 SCFM

In response to your request, we are pleased to offer the following quotation for one Xchanger, Inc. heat exchanger with specifications per the attached data sheet.

Model C-600, ref data sheet #141719 . . . . $ 45,070.00 Each

- Includes a Heresite coating on the internal core

Due to volatile market conditions, prices are valid for 15 days from date of quotation and are subject to an adjustment based on current material prices and tariffs.

Standard lead time to shipment is 10 weeks after drawing approval. Lead time options and commercial information are on the following supplement. Design options are shown on the configuration page.

Please contact me if you have any questions.

Sincerely,

Gregg Fayer

Xchanger, Inc.	**Rating for Model C-600 ref #141719**	**Page 1 of 1**
Engineer: Gregg Fayer		May 3, 2019
Prepared for:		
Brown & Caldwell		

PERFORMANCE	**PROCESS MEDIA SIDE**	**SERVICE MEDIA SIDE**
Fluid Circulated	Air	Water
Volumetric Flow Rate	25,000.0 Std. ft^3/min	297.8 gal/min
Total Fluid Entering	112,503. lb/hr	148,384.7 lb/hr
Liquid		148,384.7 lb/hr
Vapor		
Non-Condensibles	112,503.9 lb/hr	
Vaporized or (Cond.)		
Temperature In	155.0 °F	70.0 °F
Temperature Out	100.0 °F	80.0 °F
Inlet Pressure (Absolute)	28.696 lb/in^2	
Velocity (Standard)	1,000.0 ft/min	6.7 ft/sec
Pressure Loss	0.09 lb/in^2	8.5 lb/in^2
Fouling Factor	0.00050 ft^2-°F-hr/BTU	0.00100 ft^2-°F-hr/BTU
Total Heat Exchanged: 1,483,467 BTU/hr		

AVERAGE MEDIA PROPERTIES		
Thermal Conductivity	0.016 BTU/hr-ft-°F	0.349 BTU/hr-ft-°F
Specific Heat	0.240 BTU/lb-°F	1.000 BTU/lb-°F
Absolute Viscosity	0.048 lb/ft-hr	2.288 lb/ft-hr
Density (MW)	(29.0)	62.128 lb/ft^3
Latent Heat of Vapor		

CONSTRUCTION		
Design Temperature	300 °F	200 °F
Design Pressure (Gauge)	15.0 lb/in^2	100.0 lb/in^2
Test Pressure (Gauge)		300.0 lb/in^2
Test Procedure	No Test	Bubble Test
ASME Code Stamp	Not Applicable	Not Applicable

Tube Material : Carbon Steel	Housing Material : Galvanized Steel
Fin Material : Aluminum	Casing Material : Galvanized Steel
Sealant Material : Silicone	Phenolic Coating : Fin/tube core
Removable Core : Yes, Front & Rear	Mist Eliminator : None
Tube Circuit Type: Nontrapped	Gas Flow Dir. : Right Hand Horizontal
Dry Weight : 2,527 lb	Wet Weight : 2,693 lb
Thermometers : None	Mod. Water Valve : None
Diff. Pres. Gauge: None	Auto. Drain Trap : None

CONNECTIONS
Process Inlet : 34" ANSI 150 lb pattern FFF, 3/8" thick
Process Outlet : 34" ANSI 150 lb pattern FFF, 3/8" thick
Service Inlet : 3" C.S. ANSI 150 lb RFF
Service Outlet : 3" C.S. ANSI 150 lb RFF

NOTES
Approximate unit dimensions (inches): A = 82, B = 110, C = 85, D = 42
Construction material suitability must be determined by customer.
The process flow must be uniform, smooth, and free of pulsation.
This unit must be protected from freezing.
This unit is not designed for cycling process gas pressure.

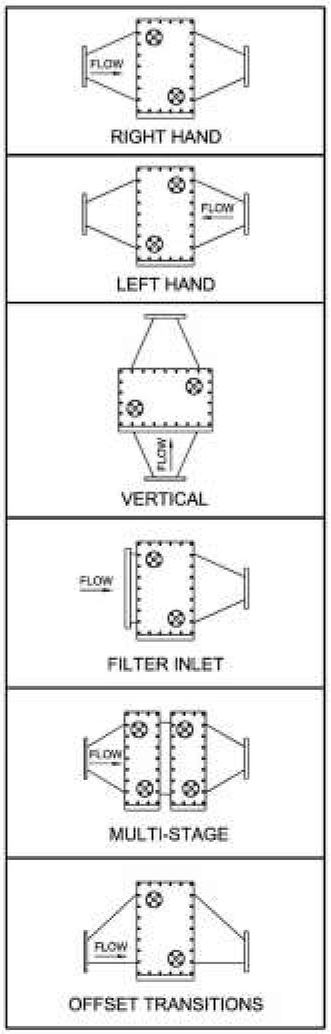
xchanger.com 952-933-2559

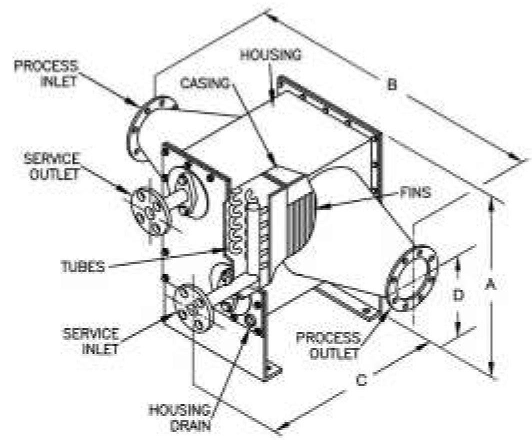
XCHANGER INDUSTRIAL HEAT EXCHANGERS

1401 7th STREET S.
HOPKINS, MN 55343
952-933-2559
XCHANGER.COM

C Series Heat Exchanger

C Series exchangers can heat, cool, dehumidify & filter air at pressures from -15 to +50 PSI with under 0.2 PSI pressure loss. Service can be cooling water, refrigerant, steam, & cryogenic liquids. C Series exchangers consist of fin-tube core(s) inside an air-tight housing. The service fluid flows inside the tubes, air flows across the fins. The air should be filtered and pulsating flow, such as that produced by rotary lobe blowers, should be dampened by a chambered silencer prior to entering the heat exchanger. Cores can optionally be removed through the front or rear covers.





SEE LINE #54 OF DATA SHEET FOR APPROXIMATE DIMENSIONS

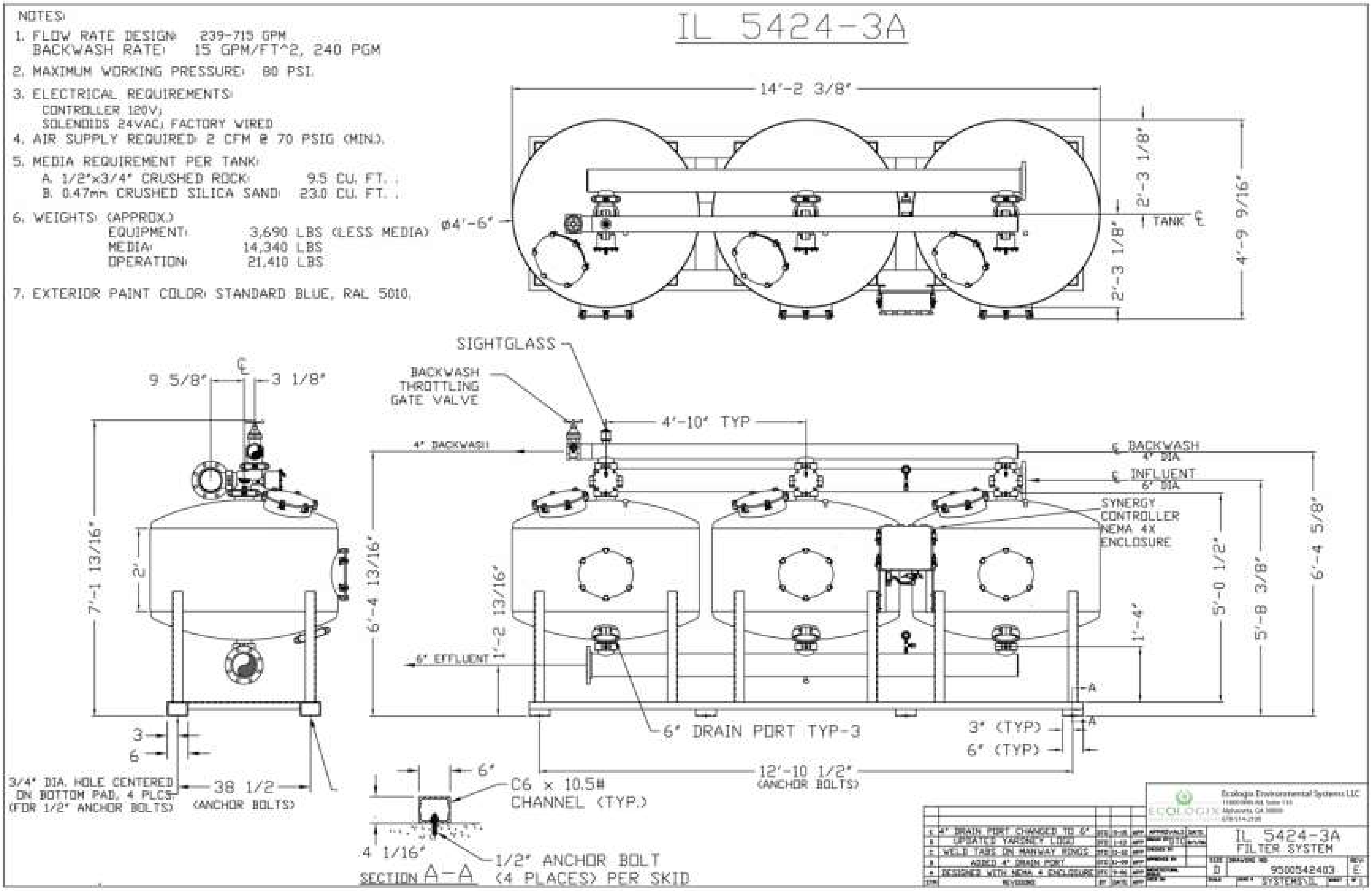
Design Options:

- Connection types: tube, pipe, flange, NPT, ferrule, etc
- Materials of construction: carbon or stainless steel, copper, aluminum, cupro-nickel, Hastelloy, etc
- Epoxy phenolic coating for corrosion protection of the core
- Mist eliminator to prevent condensate carryover
- Inspection/Access ports
- Air filters: HEPA pleated, metal, etc
- Units can be built to required dimensions
- Drainable tube circuiting for freezing protection

Accessories:

• Instrument Coupling	$ 60
• Thermometer (Includes Coupling)	$ 90
• Differential Pressure Gauge	$ 280
• Automatic Drain Trap (3/4", 330 lb/hr)	$ 390
• Temperature Control Valve (Regulates coolant flow to maintain a constant exiting gas temperature)	
3/4", 30 GPM	$ 750
1", 50 GPM	$ 790
2", 100GPM	$ 2,500
• Others available upon request	

Attachment B: Sand Filter Drawing and Quote


NOTES:
1. FLOW RATE DESIGN: 239-715 GPM
BACKWASH RATE: 15 GPM/FT^2, 240 PGM
2. MAXIMUM WORKING PRESSURE: 80 PSI.
3. ELECTRICAL REQUIREMENTS:
CONTROLLER 120V;
SOLENOIDS 24VAC; FACTORY WIRED
4. AIR SUPPLY REQUIRED: 2 CFM @ 70 PSIG (MIN.).
5. MEDIA REQUIREMENT PER TANK:
A. 1/2"x3/4" CRUSHED ROCK: 9.5 CU. FT.
B. 0.47mm CRUSHED SILICA SAND: 23.0 CU. FT.
6. WEIGHTS: (APPROX.)
EQUIPMENT: 3,690 LBS (LESS MEDIA)
MEDIA: 14,340 LBS
OPERATION: 21,410 LBS
7. EXTERIOR PAINT COLOR: STANDARD BLUE, RAL 5010.
IL 5424-3A
14'-2 3/8"
ø4'-6"
2'-3 1/8"
2'-3 1/8"
TANK ℄
4'-9 9/16"
SIGHTGLASS
BACKWASH THROTTLING GATE VALVE
4'-10" TYP
4" BACKWASH
℄ BACKWASH 4" DIA
℄ INFLUENT 6" DIA
SYNERGY CONTROLLER NEMA 4X ENCLOSURE
9 5/8"
3 1/8"
7'-1 13/16"
2'
6'-4 13/16"
1'-2 13/16"
6" EFFLUENT
1'-4"
5'-0 1/2"
5'-8 3/8"
6'-4 5/8"
6" DRAIN PORT TYP-3
3" (TYP)
6" (TYP)
12'-10 1/2" (ANCHOR BOLTS)
3
6
3/4" DIA. HOLE CENTERED ON BOTTOM PAD, 4 PLCS. (FOR 1/2" ANCHOR BOLTS)
38 1/2 (ANCHOR BOLTS)
6"
C6 x 10.5# CHANNEL (TYP.)
4 1/16"
1/2" ANCHOR BOLT (4 PLACES) PER SKID
SECTION A-A
4" DRAIN PORT CHANGED TO 6"
UPDATED YARDNEY LOGO
WELD TABS ON MANWAY RINGS
ADDED 4" DRAIN PORT
DESIGNED WITH NEMA 4 ENCLOSURE
REVISIONS
ECOLOGIX
Ecologix Environmental Systems LLC
IL 5424-3A FILTER SYSTEM
9500542403
E
SYSTEMS\IL

Attachment C: Submerged Heat Exchanger

OMEGA THERMO PRODUCTS

Omega Thermo Products
PO Box 141
205 Sunset Avenue
Stratford, WI 54484 USA
Phone: (715) 687-8102
Fax: (715) 687-8053

Quote No: SJ17618
Friday, March 8, 2019
Prices are Valid Until Sunday, April 7, 2019

Page 1 of 1

Attention: **Nancy Andrews**

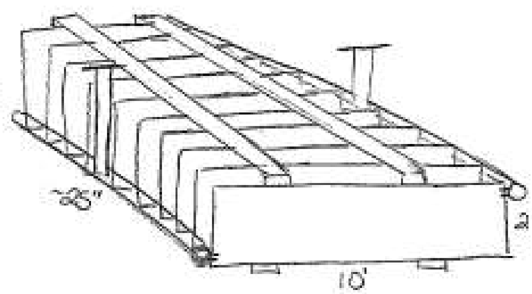
Brown and Caldwell
201E. Washington St. Suite 500
Phoenix, AZ 85004

Sales Contact:
Kemper, Chelsey
Phone: 715-687-8102 **Extension:** 222
Email: ckemper@laser-plate.com

Q = 105gpm x 500 x 5F = 262,500 BTU/hr
LMTD = 9.27F
A = 262,500 BTU/hr / (9.27F x 75 BTU/hr ft2 F) = 377.56 ft2

Line: ***5*** *Part ID:* ***SUBMERGED HX***

Plate Bank
Double Embossed Laser-Plate Bank Assembly
(10) plates banked on 2" centers (Plate type 003, no baffles)
Plates: 16 Ga. (0.0595") x 24" x 120" SA-240 304Lss 2B/2B
Plate Inlet: 3/4" NPS Sch 40, Pipe
Plate Outlet: 3/4" NPS Sch 40, Pipe
Assembly Inlet: 3" NPS Sch 40 Pipe x 150# RFSO flange
Assembly Outlet: 3" NPS Sch 40 Pipe x 150# RFSO flange
Non-Code, Rated For:
MAWP: 150 PSI @ 400°F MDMT: -20°F @ 150PSI
Media Type: Water
T Header
Connections in opposite corners
Seal weld edges



Quantity	Unit Price	Total Price
1.00 EA	11,110.00	$11,110.00

Payment Terms: 30% Dn, Net 30 **Shipping Method:** FOB, SHIPPING POINT
Billing Type: Charge with Invoice

Lead Times: Drawings 1-2 Weeks Shipping 5-6 Weeks

Due to the current volatility surrounding surcharges on stainless steel, Omega reserves the right to review and adjust the material pricing upon receipt of the purchase order.

1) Omega Thermo Products is not responsible for the corrosion resistance or suitability of the material. The process operating conditions and environment, which include cleaning and other factors may contain a corrosive element (acids, bleach, chlorides, bromine, cupric ions, ferric ions, sulfide ions, etc.), which is beyond the control of the equipment fabricator. Therefore the user of the equipment is responsible for corrosion resistance and suitability of material in the process.

2) The delivery stated represents Omega's current production load. Changes occur on a daily basis that may alter the delivery. Please contact Omega if you require delivery other than that being proposed.

CK

Fri 5/24/2019 8:50 AM

Chelsey Kemper <ckemper@laser-plate.com>

RE: Submerged Heat Exchanger Proposal Request

To Nancy Andrews

Quote 17939.PDF
89 KB

Good Morning Nancy,
I have quoted this a few different ways.

1) You can buy the small bank I previously quoted you for the summer and then one large bank that is included in this quote labeled winter to use in the winter. This would then give you 2 banks, one for each season and would be the more cost effective method.
2) You can buy 8 of the banks labeled winter/summer. In the summer you would only run water through one bank. In the winter you would need to daisey chain all 8 together and run in series to get your desired results.

For the winter conditions you want to get the water to 53F using 55F water. I'm not sure that you will be able to get the outlet temperature of the water up that close to the temperature of the process water. I'm waiting to get more guidance on this from one of our experts and will be in touch with what I find.

Have a great weekend,

Chelsey Kemper
Sales Engineer

OMEGA
THERMO PRODUCTS

OMEGA THERMO PRODUCTS

Omega Thermo Products
PO Box 141
205 Sunset Avenue
Stratford, WI 54484 USA
Phone: (715) 687-8102
Fax: (715) 687-8053

Quote No: 17939
Wednesday, May 22, 2019
Prices are Valid Until Friday, June 21, 2019

Attention: **Nancy Andrews**

Brown and Caldwell
201E. Washington St. Suite 500
Phoenix, AZ 85004

Sales Contact:
Kemper, Chelsey
Phone: 715-687-8102 **Extension:** 222
Email: ckemper@laser-plate.com

Line: ***5*** *Part ID:* ***SUBMERGED HX - WINTER/SUMMER***

Plate Bank
Double Embossed Laser-Plate Bank Assembly
(20) plates banked on 2" centers (Plate type 003, no baffles)
Plates: 16 Ga. (0.0595") x 24" x 120" SA-240 304Lss 2B/2B
Plate Inlet: 1 1/2" NPS Sch 40, Pipe
Plate Outlet: 1 1/2" NPS Sch 40, Pipe
Assembly Inlet: 6" NPS Sch 40 Pipe x 150# RFSO flange
Assembly Outlet: 6" NPS Sch 40 Pipe x 150# RFSO flange
Non-Code, Rated For:
MAWP: 150 PSI @ 400°F MDMT: -20°F @ 150PSI
Media Type: Water
Straight Header
Connections in opposite corners
Seal weld edges

Quantity	*Unit Price*	*Total Price*
1.00 EA	25,649.00	$25,649.00
8.00 EA	23,870.00	$190,960.00

Line: ***10*** *Part ID:* ***SUBMERGED HX - WINTER***

Plate Bank
Double Embossed Laser-Plate Bank Assembly
(34) plates banked on 2" centers (Plate type 003, no baffles)
Plates: 16 Ga. (0.0595") x 48" x 260" SA-240 304Lss 2B/2B
Plate Inlet: 1 1/2" NPS Sch 40, Pipe
Plate Outlet: 1 1/2" NPS Sch 40, Pipe
Assembly Inlet: 6" NPS Sch 40 Pipe x 150# RFSO flange
Assembly Outlet: 6" NPS Sch 40 Pipe x 150# RFSO flange
Non-Code, Rated For:
MAWP: 150 PSI @ 400°F MDMT: -20°F @ 150PSI
Media Type: Water
Straight Header
Connections in opposite corners
Seal weld edges

Quantity	*Unit Price*	*Total Price*
1.00 EA	96,335.00	$96,335.00

Payment Terms: 30% Dn, Net 30 **Shipping Method:** FOB, SHIPPING POINT
Billing Type: To Be Determined

Lead Times: Drawings and shipping to be determined

Continued ...

Quote No: **17939**

Wednesday, May 22, 2019
Prices are Valid Until Friday, June 21, 2019

Due to the current volatility surrounding surcharges on stainless steel, Omega reserves the right to review and adjust the material pricing upon receipt of the purchase order.

1) Omega Thermo Products is not responsible for the corrosion resistance or suitability of the material. The process operating conditions and environment, which include cleaning and other factors may contain a corrosive element (acids, bleach, chlorides, bromine, cupric ions, ferric ions, sulfide ions, etc.), which is beyond the control of the equipment fabricator. Therefore the user of the equipment is responsible for corrosion resistance and suitability of material in the process.

2) The delivery stated represents Omega's current production load. Changes occur on a daily basis that may alter the delivery. Please contact Omega if you require delivery other than that being proposed.

Attachment D: Air Cooled Radiator

Company Address	13601 Algonquin Road, Suite 925 Rolling Meadows, IL 60008 USA	Created Date	3/7/2019
		Expiration Date	4/30/2019
		Quote Number	00057754
Opportunity Name	Minnesota Dry Cooler		
Prepared By	Alex Schafer	Contact Name	Nancy Andrews
Phone	(224) 407-7289	Phone	651.468.2043
Email	alex.schafer@guentner.com	Email	nandrews@brwncald.com
Bill To Name	Brown and Caldwell	Ship To Name	Brown and Caldwell
Bill To	201 North Civic Drive, Suite 300 Walnut Creek, CA 94596		

Product	Line Item Description	Quantity	Total Price
GFH	S-GFH 067A/3-N(2)-F6/6P.M	1.00	USD 12,262.32

Grand Total USD 12,262.32

Notes

Notes	Price does not include freight or any applicable taxes
Delivery Time	8 to 9 weeks after receipt of order and technical approvals
Delivery Term	FCA Laredo, TX
Payment Terms	30 DAYS NET

Standard Güntner Terms and Conditions unless stated otherwise.

*

Brown and Caldwell		Date:	2019-03-07
Nancy Andrews		Enquiry dated:	
		Project:	
		Quotation-no.:	075212
		Item:	Dry Cooler
		Reference:	AS

Drycooler **S-GFH 067A/3-N(2)-F6/6P.M**

Capacity:	360000 Btu/h	**Medium:**	Water (R718)
Surface reserve:	2.1 %	Inlet:	127.1 °F
Air flow:	22379 cfm	Outlet:	115.0 °F
Air velocity:	716 ft/min		
Air inlet:	100.0 °F	Pressure drop:	8.15 psi
Altitude:	1000.000 ft	Volume flow:	60.00 gpm
Heat transf. coeff.:	6.81 Btu/(h·ft²·°F)	Mass flow:	29691 lb/h

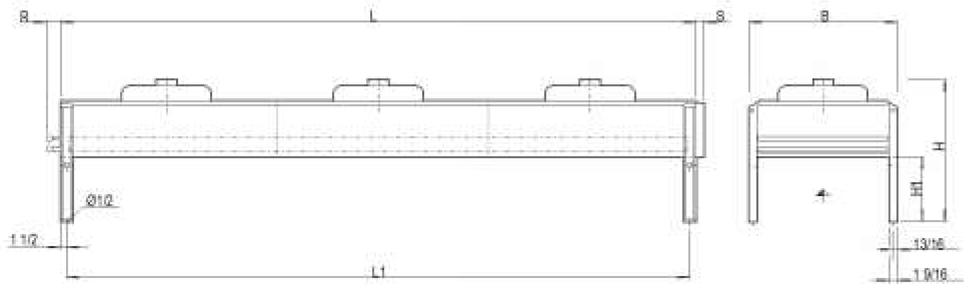
Fans:	3 Piece(s) 3~460V 60Hz	Fan diameter:	25 9/16 in
Data per motor (nominal data):		Noise pressure level:	59 dB(A)
Speed:	1300 rpm	at a distance of:	32.8 ft
Capacity:	1.83 kW, 2 hp mech.		
Current:	2.80 A		

Casing:	Galv. Steel, light grey	Tubes:	Stainl. Steel AISI 304[1]
Surface:	4300 ft²	Fins:	Epoxy[1]
Tube volume:	1.488 ft³	Connections per unit:	
Fin spacing:	12.7 FPI	Inlet:	2" NPS
Dry weight:	733 lb[2]	Outlet:	2" NPS
Max. operating pressure:	232.1 psi		
Dimensions:[2]			
Length:	115 9/16 in	Outlet header:	2" NPS
Width:	45 1/16 in	Inlet header:	2" NPS
Height:	37 3/8 in[2]	Face Area:	30.8 ft²
No. of legs:	4	Circuits:	1N
		Distributions:	21

(S = Special coil, Special fan VT03017U.1 3~400V 5060Hz)

S-GFH 067A/3-N(2)-F6/6P.M

Project:	
Quotation-no.:	075212
Item:	Dry Cooler
Reference:	AS



File: EMFsk3_INCH.emf

L	= 109 1/4 in	B	= 45 1/16 in	H	= 37 3/8 in
R	= 4 5/16 in	L1	= 106 5/16 in	H1	= 15 3/4 in
S	= 1 15/16 in				

Attention: Drawing and dimensions not valid for all accessory options!

Accessories	Piece(s)
Special design	1
Extra accessories	
EC Fan Motors	3
Mounted Panel#CECC03 - 0280ML - NAUBUNN - N 1 x GMM EC/04 UL RD; 3 x MSP, 2.5-4.0A, 1HP; 1 x Non Fused Disconnect, Nema 4X, 30 A; 1 x Control Transformer 230/460 - 115 VAC /300VA, 50/60Hz; 1 x Panel Heater 200W 120V; 1 x Temperature Sensor for Güntner Controller; 1 x NEMA 4 Steel Enclosure (WxHxD) 600x800x250 [mm] / 23.62x31.5x9.84 [Inch]; 1 x Cabinet Mounting Kit 600; Panel Data: Operating Range = -40°C to 44.2°C / -40°F to 111.56°F Electrical Power = 3/460V/60Hz - Y Control Voltage = 115VAC 50/60Hz Largest Load [A] = 2.8 FLA [A] = 8.4 MCA [A] = 9.1 MOP [A] = 10	1

Important remarks / explanatory notes:

(1) The unit may not be suitable for very corrosive atmospheres (close to shores, in smoke rooms, etc.). For further information see program menu "?", "Material recommendations brochure", or ask your sales partner.

(2) Dimensions and weights are not valid for all possible options! They may differ for units with accessories or special units (S-...).

Attachment E: Cost Estimating

Estimator	Ryan Manocchio
BC Project Manager	Harold Voth
BC Office	Saint Paul
Est Version Number	2
QA/QC Reviewer	William Agster
QA/QC Review Date	1-25-2019
BC Project Number	150811.009.091

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01 TOTALS										
01 Disinfection and Effluent Modifications										
01 Bypass Pumping										
33999 Bypass Pumping										
72" Inflatable Pipe Plug	BC-0176	33-01-10.21	1.00 ea	250.06 /ea	6,464.00 /ea	-	-	-	6,714.06 /ea	6,714
Bypass pumping, 30 days. 15,000gpm sewage flow @ suction lift 10'. 24" dia. byp	BC-0106	46-06-20.00	1.00 ls	40,933.13 /ls	-	57,137.89 /ls		-	98,071.02 /ls	98,071
Bypass Pumping			**1.00 LS**	**41,183.19 /LS**	**6,464.00 /LS**	**57,137.89 /LS**	**/LS**	**/LS**	**104,785.08 /LS**	**104,785**
01 Bypass Pumping										**104,785**
02 Concrete Flume										
03330 Slab on Grade, 9" Thick										
Aggregate, stone, 3/4" to 1-1/2", prices per C.Y., includes material only	1050	03-05-13.25	2.22 cy	-	33.50 /cy	-	-	-	33.50 /cy	74
C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes er	3050	03-11-13.65	34.50 sfca	5.91 /sfca	0.69 /sfca	-	-	-	6.60 /sfca	228
Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for ac	0600	03-21-10.60	0.15 ton	1,361.50 /ton	960.00 /ton	-	-	-	2,321.50 /ton	348
Reinforcing in place, unloading & sorting, add to above - slabs	2005	03-21-10.60	0.15 ton	52.87 /ton	-	-	6.00 /ton	-	58.87 /ton	9
Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sanc	0300	03-31-05.35	3.50 cy	-	128.00 /cy	-	-	-	128.00 /cy	448
Structural concrete, placing, slab on grade, direct chute, over 6" thick, includes vibr	4600	03-31-05.70	3.50 cy	21.36 /cy	-	-	0.32 /cy	-	21.67 /cy	76
Concrete finishing, floors, monolithic, screed and bull float(darby) finish	0100	03-35-29.30	120.00 sf	0.46 /sf	-	-	-	-	0.46 /sf	56
Concrete finishing, floor, dustproofing, solvent-based, 1 coat	3800	03-35-29.30	120.00 sf	0.34 /sf	0.16 /sf	-	-	-	0.50 /sf	60
Curing, sprayed membrane curing compound	0300	03-39-13.50	1.20 csf	11.98 /csf	12.10 /csf	-	-	-	24.08 /csf	29
Fine grading, fine grade for slab on grade, machine	1100	31-22-16.10	13.33 sy	1.20 /sy	-	-	0.63 /sy	-	1.83 /sy	24
Slab on Grade, 9" Thick			**120.00 cy**	**5.15 /cy**	**6.03 /cy**	**/cy**	**0.09 /cy**	**/cy**	**11.27 /cy**	**1,352**
03345 Concrete Walls, 9" Thick										
C.I.P. concrete forms, wall, job built, plywood, over 8' to 16' high, 4 use, includes er	2550	03-11-13.85	1,196.00 sfca	9.97 /sfca	0.78 /sfca	-	-	-	10.75 /sfca	12,862
Form oil, up to 800 S.F. per gallon, coverage, includes material only	3050	03-15-05.95	3.19 gal	-	21.50 /gal	-	-	-	21.50 /gal	69
Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessorie	0700	03-21-10.60	0.75 ton	1,043.82 /ton	960.00 /ton	-	-	-	2,003.82 /ton	1,499
Reinforcing in place, unloading & sorting, add - walls, cols, beams	2010	03-21-10.60	0.75 ton	52.87 /ton	-	-	6.03 /ton	-	58.90 /ton	44
Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sanc	0300	03-31-05.35	17.44 cy	-	128.00 /cy	-	-	-	128.00 /cy	2,233
Structural concrete, placing, walls, direct chute, 15" thick, includes vibrating, exclud	5300	03-31-05.70	17.44 cy	33.56 /cy	-	-	0.50 /cy	-	34.06 /cy	594
Finishing: break ties & patch voids (walls, cols or beams)	0010	03-35-29.60	1,196.00 sf	1.19 /sf	0.04 /sf	-	-	-	1.23 /sf	1,472
Concrete Walls, 9" Thick			**598.00 cy**	**24.68 /cy**	**6.69 /cy**	**/cy**	**0.02 /cy**	**/cy**	**31.39 /cy**	**18,773**
05999 Handrail and Ladder										
Ladder, shop fabricated, steel, 20" W, bolted to concrete, excl cage	0100	05-51-33.13	10.00 vlf	40.42 /vlf	36.50 /vlf	-	1.18 /vlf	-	78.10 /vlf	781
Hand rail, aluminum, 3 rail	1500	09-69-13.10	34.00 lf	44.46 /lf	117.00 /lf	-	-	-	161.46 /lf	5,489
Handrail and Ladder			**1.00 ls**	**1,915.69 /ls**	**4,343.00 /ls**	**/ls**	**11.81 /ls**	**/ls**	**6,270.50 /ls**	**6,271**
26001 Electrical and Instrumentation										
Level transmitter and power/control wiring, allowance	FACTORED	26-00-00.02	1.00 ls	-	-	5,000.00 /ls	-	-	5,000.00 /ls	5,000
Electrical and Instrumentation			**1.00 ls**	**/ls**	**/ls**	**5,000.00 /ls**	**/ls**	**/ls**	**5,000.00 /ls**	**5,000**
31315 Excavation and Backfill										
Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150	0020	01-54-36.50	2.00 ea	160.75 /ea	-	-	83.67 /ea	-	244.42 /ea	489
Soils for earthwork, common borrow, spread with 200 HP dozer, includes load at pi	0200	31-05-13.10	252.78 cy	3.62 /cy	12.75 /cy	-	4.01 /cy	-	20.38 /cy	5,153
Excavating, bulk bank measure, 3 C.Y. capacity = 260 C.Y./hour, backhoe, hydraul	0300	31-23-16.42	252.78 bcy	0.61 /bcy	-	-	1.08 /bcy	-	1.69 /bcy	427
Hauling, excavated or borrow material, loose cubic yards, 10 mile round trip, 0.6 loa	1120	31-23-23.18	349.07 lcy	7.55 /lcy	-	-	7.77 /lcy	-	15.32 /lcy	5,347
Excavation and Backfill			**349.07 cy**	**11.54 /cy**	**9.23 /cy**	**/cy**	**11.93 /cy**	**/cy**	**32.70 /cy**	**11,415**
32740 Sidewalks, 4" Thick										
Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	0100	31-22-16.10	15.00 sy	0.63 /sy	-	-	0.33 /sy	-	0.95 /sy	14
Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.	0310	32-06-10.10	135.00 sf	3.13 /sf	2.01 /sf	-	-	-	5.14 /sf	694
Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick b	0450	32-06-10.10	135.00 sf	0.70 /sf	0.43 /sf	-	0.02 /sf	-	1.14 /sf	154
Sidewalks, 4" Thick			**135.00 sf**	**3.90 /sf**	**2.44 /sf**	**/sf**	**0.05 /sf**	**/sf**	**6.39 /sf**	**863**
33999 FRP Insert										
Cncr blck,fndt wall,trwl cut jnts,nrml wt,sold,2000 psi,6"8"16",incld mortr and hrznt jc	0500	04-22-10.26	806.00 sf	7.07 /sf	2.99 /sf	-	-	-	10.06 /sf	8,112
FRP insert, 48" Parshal Flume, see quote fromTracom	MISC	33-99-99.99	1.00 ls	800.00 /ls	7,540.00 /ls		200.00 /ls	-	8,540.00 /ls	8,540
FRP Insert			**1.00 ls**	**6,501.85 /ls**	**9,949.94 /ls**	**/ls**	**200.00 /ls**	**/ls**	**16,651.79 /ls**	**16,652**

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
02 Concrete Flume										**60,325**
03 Cascade Aeration Steps										
03330 Slab on Grade, 12" Thick										
Aggregate, stone, 3/4" to 1-1/2", prices per C.Y., includes material only	1050	03-05-13.25	19.44 cy	-	33.50 /cy	-	-	-	33.50 /cy	651
C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes er	3050	03-11-13.65	106.00 sfca	5.91 /sfca	0.69 /sfca	-	-	-	6.60 /sfca	699
Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for ac	0600	03-21-10.60	1.17 ton	1,361.50 /ton	960.00 /ton	-	-	-	2,321.50 /ton	2,709
Reinforcing in place, unloading & sorting, add to above - slabs	2005	03-21-10.60	1.17 ton	52.88 /ton	-	-	6.02 /ton	-	58.90 /ton	69
Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sanc	0300	03-31-05.35	27.22 cy	-	128.00 /cy	-	-	-	128.00 /cy	3,484
Structural concrete, placing, slab on grade, pumped, over 6" thick, includes vibratin	4650	03-31-05.70	27.22 cy	25.81 /cy	-	-	5.14 /cy	-	30.95 /cy	843
Concrete finishing, floors, monolithic, screed and bull float(darby) finish	0100	03-35-29.30	700.00 sf	0.46 /sf	-	-	-	-	0.46 /sf	325
Concrete finishing, floor, dustproofing, solvent-based, 1 coat	3800	03-35-29.30	700.00 sf	0.34 /sf	0.16 /sf	-	-	-	0.50 /sf	349
Curing, sprayed membrane curing compound	0300	03-39-13.50	7.00 csf	11.97 /csf	12.10 /csf	-	-	-	24.07 /csf	169
Fine grading, fine grade for slab on grade, machine	1100	31-22-16.10	77.78 sy	1.20 /sy	-	-	0.63 /sy	-	1.83 /sy	143
Slab on Grade, 12" Thick			**700.00 cy**	**5.31 /cy**	**7.89 /cy**	**/cy**	**0.28 /cy**	**/cy**	**13.49 /cy**	**9,440**
03345 Concrete Walls, 5' x 20' x 12"										
C.I.P. concrete forms, wall, job built, plywood, over 8' to 16' high, 1 use, includes er	2400	03-11-13.85	400.00 sfca	14.07 /sfca	3.05 /sfca	-	-	-	17.12 /sfca	6,848
Form oil, up to 800 S.F. per gallon, coverage, includes material only	3050	03-15-05.95	1.07 gal	-	21.50 /gal	-	-	-	21.50 /gal	23
Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessorie	0700	03-21-10.60	0.33 ton	1,043.80 /ton	960.00 /ton	-	-	-	2,003.80 /ton	667
Reinforcing in place, unloading & sorting, add - walls, cols, beams	2010	03-21-10.60	0.33 ton	52.88 /ton	-	-	6.04 /ton	-	58.92 /ton	20
Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sanc	0350	03-31-05.35	7.78 cy	-	131.00 /cy	-	-	-	131.00 /cy	1,019
Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes r	5350	03-31-05.70	7.78 cy	39.79 /cy	-	-	7.93 /cy	-	47.72 /cy	371
Finishing: break ties & patch voids (walls, cols or beams)	0010	03-35-29.60	400.00 sf	1.19 /sf	0.04 /sf	-	-	-	1.23 /sf	492
Concrete Walls, 5' x 20' x 12"			**200.00 cy**	**33.90 /cy**	**12.99 /cy**	**/cy**	**0.32 /cy**	**/cy**	**47.20 /cy**	**9,441**
03345 Concrete Walls, 15' x 50' x 12"										
C.I.P. concrete forms, wall, job built, plywood, over 8' to 16' high, 1 use, includes er	2400	03-11-13.85	3,000.00 sfca	14.07 /sfca	3.05 /sfca	-	-	-	17.12 /sfca	51,363
Form oil, up to 800 S.F. per gallon, coverage, includes material only	3050	03-15-05.95	8.00 gal	-	21.50 /gal	-	-	-	21.50 /gal	172
Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessorie	0700	03-21-10.60	2.50 ton	1,043.82 /ton	960.00 /ton	-	-	-	2,003.82 /ton	5,010
Reinforcing in place, unloading & sorting, add - walls, cols, beams	2010	03-21-10.60	2.50 ton	52.88 /ton	-	-	6.02 /ton	-	58.90 /ton	147
Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sanc	0350	03-31-05.35	58.33 cy	-	131.00 /cy	-	-	-	131.00 /cy	7,642
Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes r	5350	03-31-05.70	58.33 cy	39.79 /cy	-	-	7.93 /cy	-	47.72 /cy	2,784
Finishing: break ties & patch voids (walls, cols or beams)	0010	03-35-29.60	3,000.00 sf	1.19 /sf	0.04 /sf	-	-	-	1.23 /sf	3,693
Concrete Walls, 15' x 50' x 12"			**1,500.00 cy**	**33.90 /cy**	**12.99 /cy**	**/cy**	**0.32 /cy**	**/cy**	**47.21 /cy**	**70,811**
13999 Misc. Special Construction Work										
Weir plate, fiberglass, with slots	BC-0001	06-62-10.00	20.00 sqft	26.45 /sqft	18.41 /sqft	-	-	-	44.86 /sqft	897
Misc. Special Construction Work			**1.00 ls**	**529.08 /ls**	**368.20 /ls**	**/ls**	**/ls**	**/ls**	**897.28 /ls**	**897**
31315 Excavation and Backfill										
Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150	0020	01-54-36.50	2.00 ea	160.75 /ea	-	-	83.67 /ea	-	244.42 /ea	489
Soils for earthwork, common borrow, spread with 200 HP dozer, includes load at pi	0200	31-05-13.10	4,642.59 cy	3.62 /cy	12.75 /cy	-	4.01 /cy	-	20.38 /cy	94,633
Excavating, bulk bank measure, 3 C.Y. capacity = 260 C.Y./hour, backhoe, hydraul	0300	31-23-16.42	4,642.59 bcy	0.61 /bcy	-	-	1.08 /bcy	-	1.69 /bcy	7,846
Hauling, excavated or borrow material, loose cubic yards, 10 mile round trip, 0.6 loa	1120	31-23-23.18	6,346.30 lcy	7.55 /lcy	-	-	7.77 /lcy	-	15.32 /lcy	97,208
Excavation and Backfill			**6,346.30 cy**	**10.70 /cy**	**9.33 /cy**	**/cy**	**11.52 /cy**	**/cy**	**31.54 /cy**	**200,176**
32740 Sidewalks, 4" Thick										
Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	0100	31-22-16.10	15.00 sy	0.63 /sy	-	-	0.33 /sy	-	0.95 /sy	14
Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.	0310	32-06-10.10	135.00 sf	3.13 /sf	2.01 /sf	-	-	-	5.14 /sf	694
Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick t	0450	32-06-10.10	135.00 sf	0.70 /sf	0.43 /sf	-	0.02 /sf	-	1.14 /sf	154
Sidewalks, 4" Thick			**135.00 sf**	**3.90 /sf**	**2.44 /sf**	**/sf**	**0.05 /sf**	**/sf**	**6.39 /sf**	**863**
03 Cascade Aeration Steps										**291,628**
04 Remove and Replace 72" RCP										
32920 Soil Prep and Seeding										
Rake topsoil, site material, by hand	X9010	32-91-19.13	4.20 msf	56.87 /msf	-	-	-	-	56.87 /msf	239
Spread conditioned topsoil, skid steer loader and hand dress	X9020	32-91-19.13	51.85 cy	6.46 /cy	11.34 /cy	-		-	17.80 /cy	923
Seeding, mechanical seeding, 44 lb/M.S.Y.	0100	32-92-19.13	466.67 sy	0.26 /sy	0.20 /sy	-	0.10 /sy	-	0.56 /sy	263
Soil Prep and Seeding			**4,200.00 sf**	**0.17 /sf**	**0.16 /sf**	**/sf**	**0.01 /sf**	**/sf**	**0.34 /sf**	**1,425**

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
33500 Trench for Utilities, 72" RCP at 20' Deep										
Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 14' t	1310	31-23-16.13	2,037.04 bcy	2.66 /bcy	-	-	1.90 /bcy	-	4.55 /bcy	9,277
Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with sheepsfoot roller	2300	31-23-23.13	1,749.06 ecy	1.49 /ecy	-	-	2.67 /ecy	-	4.15 /ecy	7,264
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 loac	0150	31-23-23.18	287.98 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	3,417
Trench box and jacks, cost per sfca trench wall, monthly rental	X9010	31-41-13.10	800.00 sf	-	-	7.81 /sf	-	-	7.81 /sf	6,249
Utility line signs, markers, and flags, underground tape, detectable, reinforced, alum	0400	33-05-97.10	3.00 clf	3.79 /clf	9.00 /clf	-	-	-	12.79 /clf	38
Trench for Utilities, 72" RCP at 20' Deep			**275.00 lf**	**37.07 /lf**	**0.10 /lf**	**22.72 /lf**	**35.55 /lf**	**/lf**	**95.44 /lf**	**26,245**
33530 72" RCP Outfall Pipe										
Utility removal, pipe, sewer/water, 72" diameter, remove, excludes excavation	3000	02-41-13.23	275.00 lf	20.48 /lf	-	-	23.99 /lf	-	44.47 /lf	12,228
Connect inlet to existing 72" outfall	BC-0126	22-05-00.10	1.00 ea	1,559.38 /ea	559.44 /ea	-	120.77 /ea	-	2,239.59 /ea	2,240
Public storm utility drainage piping, reinforced concrete pipe (RCP), 72" diameter, 8	2100	33-41-13.60	275.00 lf	105.41 /lf	283.00 /lf	-	25.34 /lf	-	413.75 /lf	113,781
72" RCP Outfall Pipe			**275.00 lf**	**131.56 /lf**	**285.03 /lf**	**/lf**	**49.77 /lf**	**/lf**	**466.36 /lf**	**128,249**
04 Remove and Replace 72" RCP										**155,919**
05 Outfall Bulkhead										
33635 Outfall/Headwall										
Excavate pit, common earth, hyd backhoe, 3/4 CY bucket	X9010	31-23-16.13	106.67 cy	14.16 /cy	-	-	7.59 /cy	-	21.75 /cy	2,320
Backfill, trench, air tamped compaction, add	2000	31-23-23.13	91.73 ecy	15.32 /ecy	-	-	3.64 /ecy	-	18.96 /ecy	1,739
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 loac	0150	31-23-23.18	14.94 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	177
Headwall and tapered wings, form, reinf., place/finish, 8" thick	X9050	33-49-13.10	4.00 cy	1,095.49 /cy	178.00 /cy	-	60.57 /cy	-	1,334.06 /cy	5,336
Outfall/Headwall			**1.00 ea**	**7,410.88 /ea**	**712.00 /ea**	**/ea**	**1,449.71 /ea**	**/ea**	**9,572.59 /ea**	**9,573**
05 Outfall Bulkhead										**9,573**
06 Transition Structures										
33999 Transition Structures										
Transition structure, from 72" pipe to concrete channel flume, allowance	MISC	33-99-99.99	1.00 ea	5,000.00 /ea	15,000.00 /ea		2,500.00 /ea	-	22,500.00 /ea	22,500
Transition structure, from flume to concrete steps, allowance	MISC	33-99-99.99	1.00 ea	5,000.00 /ea	15,000.00 /ea		2,500.00 /ea	-	22,500.00 /ea	22,500
Transition Structures			**1.00 ea**	**10,000.00 /ea**	**30,000.00 /ea**	**/ea**	**5,000.00 /ea**	**/ea**	**45,000.00 /ea**	**45,000**
06 Transition Structures										**45,000**
07 PVC Piping										
40500 PVC Piping Sch 80, 2" Diameter										
Pipe, plastic, with fittings, 1" thru 3" diameter, selective demolition	2162	22-05-05.10	1,170.00 lf	4.04 /lf	-	-	-	-	4.04 /lf	4,723
Demo ejector system	2194	22-05-05.10	3.00 ea	4,596.91 /ea	-	-	-	-	4,596.91 /ea	13,791
Heat trace, allowance	4050	23-83-33.10	1.00 ls			1,500.00 /ls	-	-	1,500.00 /ls	1,500
Pipe Plain End-PVC--Sch 80 2 Inch (50mm), and 3" containment pipe	1120	33-52-13.16	1,170.00 lf	6.15 /lf	25.50 /lf	-	-	-	31.65 /lf	37,033
Pipe Erection-Make Up Cemented Plastic Socket Joint-Non-Specific 2 Inch (50mı	L093461000000	40-05-05.00	48.00 ea	58.12 /ea	-	-	-	-	58.12 /ea	2,790
Pipe Erection-Handle Fittings-Plastic-Sch 80 2 Inch (50mm)	L093466100001	40-05-05.00	24.00 ea	10.95 /ea	-	-	-	-	10.95 /ea	263
Field Testing-Hydrotest-Non-Specific 2 Inch (50mm)	L099048000000	40-05-05.00	1,170.00 lf	1.45 /lf	-	-	-	-	1.45 /lf	1,700
Hilti-Chemical Anchor - Pipe Support Size 2 Inch (50mm)	A096043000000	40-05-07.00	48.00 ea	19.37 /ea	10.00 /ea	-	-	-	29.37 /ea	1,410
Pipe Support 2 Inch (50mm)	A096044000000	40-05-07.00	48.00 ea	48.44 /ea	12.00 /ea	-	-	-	60.44 /ea	2,901
Hanger Rod 2 Inch (50mm)	A096045000000	40-05-07.00	48.00 ea	29.06 /ea	15.00 /ea	-	-	-	44.06 /ea	2,115
Fitting Socket Weld-PVC-Ell90-Sch 80 2 Inch (50mm)	A092212100000	40-05-31.13	24.00 ea	-	18.65 /ea	-	-	-	18.65 /ea	448
Pipe Erection-Straight Run-PVC-Sch 80 2 Inch (50mm)	L0940021000P1	40-05-31.13	1,170.00 lf	8.14 /lf	-	-	-	-	8.14 /lf	9,520
PVC Piping Sch 80, 2" Diameter			**1,170.00 lf**	**38.15 /lf**	**27.40 /lf**	**1.28 /lf**	**/lf**	**/lf**	**66.83 /lf**	**78,193**
07 PVC Piping										**78,193**
07a Misc. Equipment										
11999 Misc. Equipment										
Chlorination equipment, see quote from Vesco	MISC	11-99-99.99	1.00 ls	5,625.00 /ls	-	75,000.00 /ls	1,500.00 /ls	-	82,125.00 /ls	82,125
Misc. Equipment			**1.00 ls**	**5,625.00 /ls**	**/ls**	**75,000.00 /ls**	**1,500.00 /ls**	**/ls**	**82,125.00 /ls**	**82,125**
07a Misc. Equipment										**82,125**
01 Disinfection and Effluent Modifications										**827,548**
02 Biogas Flare and Piping										
08 Slab On Grade										

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
03330 Slab On Grade, 8' x 20' x 9"										
Aggregate, stone, 3/4" to 1-1/2", prices per C.Y., includes material only		1050 03-05-13.25	2.96 cy	-	33.50 /cy	-	-	-	33.50 /cy	99
C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes er		3050 03-11-13.65	42.00 sfca	5.91 /sfca	0.69 /sfca	-	-	-	6.60 /sfca	277
Sawcut control joints, slab on grade	X9000	03-15-05.25	28.00 lf	0.78 /lf	0.75 /lf	-	0.27 /lf	-	1.79 /lf	50
Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for ac		0600 03-21-10.60	0.20 ton	1,361.50 /ton	960.00 /ton	-	-	-	2,321.50 /ton	464
Reinforcing in place, unloading & sorting, add to above - slabs		2005 03-21-10.60	0.20 ton	52.90 /ton	-	-	6.00 /ton	-	58.90 /ton	12
Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sanc		0300 03-31-05.35	4.67 cy	-	128.00 /cy	-	-	-	128.00 /cy	597
Structural concrete, placing, slab on grade, direct chute, over 6" thick, includes vibra		4600 03-31-05.70	4.67 cy	21.36 /cy	-	-	0.32 /cy	-	21.68 /cy	101
Concrete finishing, floors, monolithic, screed, float and broom finish		0150 03-35-29.30	160.00 sf	1.00 /sf	-	-	-	-	1.00 /sf	160
Concrete finishing, floor, dustproofing, solvent-based, 1 coat		3800 03-35-29.30	160.00 sf	0.34 /sf	0.16 /sf	-	-	-	0.50 /sf	80
Curing, sprayed membrane curing compound		0300 03-39-13.50	1.60 csf	11.98 /csf	12.10 /csf	-	-	-	24.08 /csf	39
Fine grading, fine grade for slab on grade, machine		1100 31-22-16.10	17.78 sy	1.20 /sy	-	-	0.63 /sy	-	1.83 /sy	33
Slab On Grade, 8' x 20' x 9"			**160.00 cy**	**5.67 /cy**	**6.15 /cy**	**/cy**	**0.13 /cy**	**/cy**	**11.95 /cy**	**1,912**
08 Slab On Grade										**1,912**
09 Piping										
32920 Seeding										
Rake topsoil, site material, by hand	X9010	32-91-19.13	7.00 msf	56.87 /msf	-	-	-	-	56.87 /msf	398
Spread conditioned topsoil, skid steer loader and hand dress	X9020	32-91-19.13	86.42 cy	6.46 /cy	11.34 /cy	-		-	17.80 /cy	1,539
Seeding, mechanical seeding, 44 lb/M.S.Y.		0100 32-92-19.13	777.78 sy	0.26 /sy	0.20 /sy	-	0.10 /sy	-	0.56 /sy	438
Seeding			**7,000.00 sf**	**0.17 /sf**	**0.16 /sf**	**/sf**	**0.01 /sf**	**/sf**	**0.34 /sf**	**2,375**
33500 Trench for Utilities										
Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6		0110 31-23-16.13	1,057.41 bcy	4.25 /bcy	-	-	2.28 /bcy	-	6.53 /bcy	6,899
Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with sheepsfoot roller		2300 31-23-23.13	982.66 ecy	1.49 /ecy	-	-	2.67 /ecy	-	4.15 /ecy	4,081
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 loac		0150 31-23-23.18	74.74 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	887
Trench box and jacks, cost per sfca trench wall, monthly rental	X9010	31-41-13.10	200.00 sf	-	-	7.81 /sf	-	-	7.81 /sf	1,562
Utility line signs, markers, and flags, underground tape, detectable, reinforced, alum		0400 33-05-97.10	11.00 clf	3.79 /clf	9.00 /clf	-	-	-	12.79 /clf	141
Trench for Utilities			**1,142.00 lf**	**5.74 /lf**	**0.09 /lf**	**1.37 /lf**	**4.69 /lf**	**/lf**	**11.88 /lf**	**13,570**
40500 PVC Piping Sch 80, 1" NG										
Pipe Erection-Make Up Cemented Plastic Socket Joint-Non-Specific 1 Inch (25mı	L063461000000	40-05-05.00	4.00 ea	48.44 /ea	-	-	-	-	48.44 /ea	194
Pipe Erection-Handle Fittings-Plastic-Sch 80 1 Inch (25mm)	L063466100001	40-05-05.00	2.00 ea	7.66 /ea	-	-	-	-	7.66 /ea	15
Field Testing-Hydrotest-Non-Specific 1 Inch (25mm)	L069048000000	40-05-05.00	442.00 lf	1.16 /lf	-	-	-	-	1.16 /lf	514
Pipe Plain End-PVC--Sch 80 1 Inch (25mm)	A061002100000	40-05-31.13	442.00 lf	-	0.78 /lf	-	-	-	0.78 /lf	345
Fitting Socket Weld-PVC-Ell90-Sch 80 1 Inch (25mm)	A062212100000	40-05-31.13	2.00 ea	-	6.50 /ea	-	-	-	6.50 /ea	13
Pipe Erection-Straight Run-PVC-Sch 80 1 Inch (25mm)	L0640021000P1	40-05-31.13	442.00 lf	8.14 /lf	-	-	-	-	8.14 /lf	3,597
PVC Piping Sch 80, 1" NG			**442.00 lf**	**9.77 /lf**	**0.81 /lf**	**/lf**	**/lf**	**/lf**	**10.58 /lf**	**4,677**
40525 HDPE Piping, 18" SDR 11										
Pipe Erection-Make Up Cemented Plastic Socket Joint-Non-Specific 18 Inch (450	L213461000000	40-05-05.00	8.00 ea	87.18 /ea	-	-	-	-	87.18 /ea	697
Pipe Erection-Handle Fittings-Plastic-Non-Specific 18 Inch (450mm)	L213466000001	40-05-05.00	4.00 ea	87.18 /ea	-	-	-	-	87.18 /ea	349
Field Cut & Roll Grooved Joint-Std 18 Inch (450mm)	L216064010000	40-05-05.00	8.00 ea	334.20 /ea	-	-	-	-	334.20 /ea	2,674
Field Testing-Hydrotest-Non-Specific 18 Inch (450mm)	L219048000000	40-05-05.00	700.00 lf	29.26 /lf	-	-	-	-	29.26 /lf	20,478
Pipe Plain End-HDPE--SDR11 18 Inch (450mm)	A211002a20000	40-05-33.00	700.00 lf	-	39.36 /lf	-	3.00 /lf	-	42.36 /lf	29,652
Fitting Socket Weld-HDPE-Ell90-SDR11 18 Inch (450mm)	A212212a20000	40-05-33.00	4.00 ea	-	435.53 /ea	-	-	-	435.53 /ea	1,742
Pipe Erection-Straight Run-HDPE-Non-Specific 18 Inch (450mm)	L2140020000P1	40-05-33.00	700.00 lf	34.87 /lf	-	-	3.00 /lf	-	37.87 /lf	26,511
HDPE Piping, 18" SDR 11			**700.00 lf**	**69.44 /lf**	**41.85 /lf**	**/lf**	**6.00 /lf**	**/lf**	**117.29 /lf**	**82,103**
09 Piping										**102,726**
10 Equipment										
11999 Biogas Flare Equipment										
Biogas flare equipment, see quote from Varec Biogas, dated 1-11-2019	MISC	11-99-99.99	1.00 ls	14,400.00 /ls	162,618.00 /ls		3,500.00 /ls	-	180,518.00 /ls	180,518
Biogas Flare Equipment			**1.00 ls**	**14,400.00 /ls**	**162,618.00 /ls**	**/ls**	**3,500.00 /ls**	**/ls**	**180,518.00 /ls**	**180,518**
10 Equipment										**180,518**
11 Electrical and Instrumentation										
26001 Electrical and Instrumentation										
Electrical, controls and SCADA, (10% factored)	FACTORED	26-00-00.02	1.00 ls	-	-	28,100.00 /ls	-	-	28,100.00 /ls	28,100

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
Electrical and Instrumentation			**1.00 ls**	**/ls**	**/ls**	**28,100.00 /ls**	**/ls**	**/ls**	**28,100.00 /ls**	**28,100**
11 Electrical and Instrumentation										**28,100**
02 Biogas Flare and Piping										**313,256**
03 Flow Splitting MLSS										
12 Alternative 2										
01999 Mobilization and Demobilization										
Mobilization	BC-0027	01-00-10.00	2.00 day	-	-		126.60 /day	-	126.60 /day	253
Demobilization	BC-0028	01-00-10.00	2.00 day	-	-		126.60 /day	-	126.60 /day	253
Mobilization and Demobilization			**1.00 ls**	**/ls**	**/ls**	**/ls**	**506.40 /ls**	**/ls**	**506.40 /ls**	**506**
02999 Misc Existing Conditions or Demolition										
Minor site demolition, pipe, sewer/water, 20" diameter, remove, excludes excavatio	2960	02-41-13.33	200.00 lf	15.36 /lf	-	-	11.99 /lf	-	27.35 /lf	5,471
Misc Existing Conditions or Demolition			**1.00 ls**	**3,071.88 /ls**	**/ls**	**/ls**	**2,398.83 /ls**	**/ls**	**5,470.71 /ls**	**5,471**
40120 Ductile Iron Pipe, 32" Diameter										
Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	09-91-06.41	1,675.52 sqft	0.94 /sqft	0.89 /sqft	-	-	-	1.83 /sqft	3,068
Pipe Erection-Handle Fittings-Metal-Std 32 Inch (800mm)	L323466010000	40-05-05.00	3.00 ea	268.81 /ea	-	-	-	-	268.81 /ea	806
Field Testing-Hydrotest-Non-Specific 32 Inch (800mm)	L329048000000	40-05-05.00	200.00 lf	90.28 /lf	-	-	-	-	90.28 /lf	18,057
Hilti-Chemical Anchor - Pipe Support Size 32 Inch (800mm)	A326043000000	40-05-07.00	8.00 ea	48.44 /ea	65.00 /ea	-	-	-	113.44 /ea	907
Pipe Support 32 Inch (800mm)	A326044000000	40-05-07.00	2.00 ea	174.37 /ea	250.00 /ea	-	-	-	424.37 /ea	849
Hanger Rod 32 Inch (800mm)	A326045000000	40-05-07.00	2.00 ea	145.31 /ea	650.00 /ea	-	-	-	795.31 /ea	1,591
Pipe Plain End-Ductile Iron--C-151 32 Inch (800mm)	A321002200000	40-05-19.20	200.00 lf	-	315.00 /lf	-	12.00 /lf	-	327.00 /lf	65,400
Fitting Flanged & Bolted-Ductile Iron-Ell45-Non-Specific 32 Inch (800mm)	A322411000000	40-05-19.20	1.00 ea	-	12,116.71 /ea	-	300.00 /ea	-	12,416.71 /ea	12,417
Fitting Flanged & Bolted-Ductile Iron-Ell90-Non-Specific 32 Inch (800mm)	A322412000000	40-05-19.20	2.00 ea	-	8,827.00 /ea	-	300.00 /ea	-	9,127.00 /ea	18,254
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 32 Inch (800mm)	L3240020000P1	40-05-19.20	200.00 lf	156.93 /lf	-	-	6.00 /lf	-	162.93 /lf	32,586
Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 32 Inch (800mm)	L324062006200	40-05-51.00	2.00 ea	809.64 /ea	-	-	-	-	809.64 /ea	1,619
Ductile Iron Pipe, 32" Diameter			**200.00 lf**	**272.38 /lf**	**482.89 /lf**	**/lf**	**22.50 /lf**	**/lf**	**777.77 /lf**	**155,554**
40120 Ductile Iron Pipe, 54" Diameter										
Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	09-91-06.41	1,272.35 sqft	0.94 /sqft	0.89 /sqft	-	-	-	1.83 /sqft	2,330
Electrical, allowance	MISC	26-99-99.99	1.00 ls	-	-	80,000.00 /ls	-	-	80,000.00 /ls	80,000
Pipe Erection-Handle Fittings-Metal-Std 54 Inch (1350mm)	L543466010000	40-05-05.00	8.00 ea	428.65 /ea	-	-	-	-	428.65 /ea	3,429
Field Testing-Hydrotest-Non-Specific 54 Inch (1350mm)	L549048000000	40-05-05.00	90.00 lf	255.16 /lf	-	-	-	-	255.16 /lf	22,964
Hilti-Chemical Anchor - Pipe Support Size 54 Inch (1350mm)	A546043000000	40-05-07.00	4.00 ea	48.44 /ea	75.00 /ea	-	-	-	123.44 /ea	494
Pipe Support 54 Inch (1350mm)	A546044000000	40-05-07.00	1.00 ea	290.61 /ea	750.00 /ea	-	-	-	1,040.61 /ea	1,041
Hanger Rod 54 Inch (1350mm)	A546045000000	40-05-07.00	1.00 ea	193.74 /ea	750.00 /ea	-	-	-	943.74 /ea	944
Pipe Plain End-Ductile Iron--C-151 54 Inch (1350mm)	A541002200000	40-05-19.20	7.67 lf	-	1,982.00 /lf	-	22.00 /lf	-	2,004.00 /lf	15,367
Fitting Flanged & Bolted-Ductile Iron-Ell90-Non-Specific 54 Inch (1350mm)	A542412000000	40-05-19.20	4.00 ea	-	14,950.00 /ea	-	400.00 /ea	-	15,350.00 /ea	61,400
Fitting Flanged & Bolted-Ductile Iron-Tee-Non-Specific 54 Inch (1350mm)	A542414000000	40-05-19.20	4.00 ea	-	60,128.38 /ea	-	400.00 /ea	-	60,528.38 /ea	242,114
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 54 Inch (1350mm)	L5440020000P1	40-05-19.20	90.00 lf	266.78 /lf	-	-	8.00 /lf	-	274.78 /lf	24,730
Pipe Erection-Handle Valves-Metal-Non-Specific 54 Inch (1350mm)	L544062000000	40-05-51.00	2.00 ea	3,419.32 /ea	-	-	-	-	3,419.32 /ea	6,839
Valve Flanged & Bolted-Cast Steel-Butterfly-Cls 150, 54 Inch, includes electric actu	A546434016200	40-05-64.00	2.00 ea	-	72,000.00 /ea	-	-	-	72,000.00 /ea	144,000
Ductile Iron Pipe, 54" Diameter			**90.00 lf**	**656.89 /lf**	**5,138.24 /lf**	**888.89 /lf**	**45.43 /lf**	**/lf**	**6,729.45 /lf**	**605,650**
12 Alternative 2										**767,181**
13 Alternative 4 and 4B										
01999 Mobilization and Demobilization										
Mobilization	BC-0027	01-00-10.00	2.00 day	-	-		126.60 /day	-	126.60 /day	253
Demobilization	BC-0028	01-00-10.00	2.00 day	-	-		126.60 /day	-	126.60 /day	253
Mobilization and Demobilization			**1.00 ls**	**/ls**	**/ls**	**/ls**	**506.40 /ls**	**/ls**	**506.40 /ls**	**506**
40120 Ductile Iron Pipe, 54" Diameter										
Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	09-91-06.41	2,403.32 sqft	0.94 /sqft	0.89 /sqft	-	-	-	1.83 /sqft	4,401
Electrical, allowance	MISC	26-99-99.99	1.00 ls	-	-	100,000.00 /ls	-	-	100,000.00 /ls	100,000
Pipe Erection-Handle Fittings-Metal-Std 54 Inch (1350mm)	L543466010000	40-05-05.00	8.00 ea	428.65 /ea	-	-	-	-	428.65 /ea	3,429
Field Testing-Hydrotest-Non-Specific 54 Inch (1350mm)	L549048000000	40-05-05.00	170.00 lf	255.16 /lf	-	-	-	-	255.16 /lf	43,376
Hilti-Chemical Anchor - Pipe Support Size 54 Inch (1350mm)	A546043000000	40-05-07.00	7.00 ea	48.44 /ea	75.00 /ea	-	-	-	123.44 /ea	864
Pipe Support 54 Inch (1350mm)	A546044000000	40-05-07.00	2.00 ea	290.61 /ea	750.00 /ea	-	-	-	1,040.61 /ea	2,081
Hanger Rod 54 Inch (1350mm)	A546045000000	40-05-07.00	2.00 ea	193.74 /ea	750.00 /ea	-	-	-	943.74 /ea	1,887
Pipe Plain End-Ductile Iron--C-151 54 Inch (1350mm)	A541002200000	40-05-19.20	170.00 lf	-	1,982.00 /lf	-	22.00 /lf	-	2,004.00 /lf	340,680

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40120 Ductile Iron Pipe, 54" Diameter										
Fitting Flanged & Bolted-Ductile Iron-Ell90-Non-Specific 54 Inch (1350mm)	A542412000000	40-05-19.20	4.00 ea	-	14,950.00 /ea	-	150.00 /ea	-	15,100.00 /ea	60,400
Fitting Flanged & Bolted-Ductile Iron-Tee-Non-Specific 54 Inch (1350mm)	A542414000000	40-05-19.20	4.00 ea	-	60,128.38 /ea	-	150.00 /ea	-	60,278.38 /ea	241,114
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 54 Inch (1350mm)	L5440020000P1	40-05-19.20	170.00 lf	266.78 /lf	-	-	-	-	266.78 /lf	45,353
Pipe Erection-Handle Valves-Metal-Non-Specific 54 Inch (1350mm)	L544062000000	40-05-51.00	3.00 ea	3,419.32 /ea	-	-	-	-	3,419.32 /ea	10,258
Valve Flanged & Bolted-Cast Steel-Butterfly-Cls 150, 54 Inch, includes electric actu	A546434016200	40-05-64.00	3.00 ea	-	72,000.00 /ea	-	-	-	72,000.00 /ea	216,000
Ductile Iron Pipe, 54" Diameter			**170.00 lf**	**623.47 /lf**	**5,052.43 /lf**	**588.24 /lf**	**29.06 /lf**	**/lf**	**6,293.19 /lf**	**1,069,843**
13 Alternative 4 and 4B										**1,070,349**
03 Flow Splitting MLSS										**1,837,530**
04 Cooling Water Piping and Pumps										
14 Alternate 1: Effluent and New Pumps										
02221 Sidewalk Demolition										
Minor site demolition, sidewalk, concrete, mesh reinforced, 4" thick, remove, exclud	4200	02-41-13.33	105.56 sy	11.96 /sy	-	-	2.12 /sy	-	14.09 /sy	1,487
Minor site demolition, for disposal to 5 miles, excludes hauling, add	4500	02-41-13.33	11.61 cy	7.95 /cy	-	-	8.37 /cy	-	16.32 /cy	189
Rubbish handling, dumpster, 40 C.Y., 13 ton capacity, weekly rental, includes one (	0840	02-41-19.23	1.00 week	-	775.00 /week	-	-	-	775.00 /week	775
Sidewalk Demolition			**950.00 sf**	**1.43 /sf**	**0.82 /sf**	**/sf**	**0.34 /sf**	**/sf**	**2.58 /sf**	**2,452**
03330 Concrete Equipment Pad, 4' x 12'-6" x 9"										
Aggregate, stone, 3/4" to 1-1/2", prices per C.Y., includes material only	1050	03-05-13.25	1.85 cy	-	33.50 /cy	-	-	-	33.50 /cy	62
C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes er	3050	03-11-13.65	48.00 sfca	5.91 /sfca	0.69 /sfca	-	-	-	6.60 /sfca	317
Sawcut control joints, slab on grade	X9000	03-15-05.25	20.00 lf	0.78 /lf	0.75 /lf	-	0.27 /lf	-	1.80 /lf	36
Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for ac	0600	03-21-10.60	0.13 ton	1,361.50 /ton	960.00 /ton	-	-	-	2,321.50 /ton	290
Reinforcing in place, unloading & sorting, add to above - slabs	2005	03-21-10.60	0.13 ton	52.90 /ton	-	-	6.00 /ton	-	58.90 /ton	7
Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sanc	0300	03-31-05.35	2.92 cy	-	128.00 /cy	-	-	-	128.00 /cy	373
Structural concrete, placing, slab on grade, direct chute, over 6" thick, includes vibra	4600	03-31-05.70	2.92 cy	21.36 /cy	-	-	0.32 /cy	-	21.67 /cy	63
Concrete finishing, floors, monolithic, screed, float and broom finish	0150	03-35-29.30	100.00 sf	1.00 /sf	-	-	-	-	1.00 /sf	100
Concrete finishing, floor, dustproofing, solvent-based, 1 coat	3800	03-35-29.30	100.00 sf	0.34 /sf	0.16 /sf	-	-	-	0.50 /sf	50
Curing, sprayed membrane curing compound	0300	03-39-13.50	1.00 csf	11.97 /csf	12.10 /csf	-	-	-	24.07 /csf	24
Fine grading, fine grade for slab on grade, machine	1100	31-22-16.10	11.11 sy	1.20 /sy	-	-	0.63 /sy	-	1.83 /sy	20
Concrete Equipment Pad, 4' x 12'-6" x 9"			**100.00 cy**	**6.98 /cy**	**6.32 /cy**	**/cy**	**0.14 /cy**	**/cy**	**13.43 /cy**	**1,343**
22999 30 HP Pumps										
Misc. pluming piping, fittings and connection to pumps, allowance	MISC	22-99-99.99	1.00 ls	-	-	4,000.00 /ls	-	-	4,000.00 /ls	4,000
Electrical and I&C for pumps, allowance	BC-0001	26-00-00.01	1.00 ls	-	-	3,000.00 /ls	-	-	3,000.00 /ls	3,000
Pump, cntfgl, horiz mtd, end suct,vert splt,sgl stg,750GPM,30HP,4"D	BC-0101	46-06-18.00	2.00 ea	1,915.38 /ea	4,550.00 /ea	-	450.00 /ea	-	6,915.38 /ea	13,831
30 HP Pumps			**2.00 ea**	**1,915.38 /ea**	**4,550.00 /ea**	**3,500.00 /ea**	**450.00 /ea**	**/ea**	**10,415.38 /ea**	**20,831**
32740 Sidewalks, 4" Thick										
Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	0100	31-22-16.10	105.56 sy	0.63 /sy	-	-	0.33 /sy	-	0.95 /sy	101
Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.	0310	32-06-10.10	950.00 sf	3.13 /sf	2.01 /sf	-	-	-	5.14 /sf	4,885
Sidewalks, driveways, and patios, sidewalks, concrete, excludes base, for 4" thick t	0450	32-06-10.10	950.00 sf	0.70 /sf	0.43 /sf	-	0.02 /sf	-	1.14 /sf	1,087
Sidewalks, 4" Thick			**950.00 sf**	**3.90 /sf**	**2.44 /sf**	**/sf**	**0.05 /sf**	**/sf**	**6.39 /sf**	**6,072**
33500 Trench for Utilities, 6" DIP										
Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 10' t	1000	31-23-16.13	1,104.44 bcy	2.36 /bcy	-	-	1.69 /bcy	-	4.05 /bcy	4,470
Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with sheepsfoot roller	2300	31-23-23.13	1,100.83 ecy	1.49 /ecy	-	-	2.67 /ecy	-	4.15 /ecy	4,572
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 loac	0150	31-23-23.18	3.61 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	43
Trench box and jacks, cost per sfca trench wall, monthly rental	X9010	31-41-13.10	400.00 sf	-	-	7.81 /sf	-	-	7.81 /sf	3,124
Utility line signs, markers, and flags, underground tape, detectable, reinforced, alun	0400	33-05-97.10	5.00 clf	3.79 /clf	9.00 /clf	-	-	-	12.79 /clf	64
Trench for Utilities, 6" DIP			**497.00 lf**	**8.63 /lf**	**0.09 /lf**	**6.29 /lf**	**9.69 /lf**	**/lf**	**24.69 /lf**	**12,273**
40120 Ductile Iron Pipe, 6" Diameter										
Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	09-91-06.41	1,880.24 sqft	0.94 /sqft	0.89 /sqft	-	-	-	1.83 /sqft	3,443
Pipe Erection-Handle Fittings-Metal-Std 6 Inch (150mm)	L153466010000	40-05-05.00	21.00 ea	63.06 /ea	-	-	-	-	63.06 /ea	1,324
Field Testing-Hydrotest-Non-Specific 6 Inch (150mm)	L159048000000	40-05-05.00	1,197.00 lf	4.84 /lf	-	-	-	-	4.84 /lf	5,798
Pipe Plain End-Ductile Iron--C-151 6 Inch (150mm)	A151002200000	40-05-19.20	1,197.00 lf	-	20.00 /lf	-	-	-	20.00 /lf	23,940
Fitting Flanged & Bolted-Ductile Iron-Ell45-Cls 150 6 Inch (150mm)	A152411006200	40-05-19.20	6.00 ea	-	252.86 /ea	-	60.00 /ea	-	312.86 /ea	1,877
Fitting Flanged & Bolted-Ductile Iron-Ell90-Cls 150 6 Inch (150mm)	A152412006200	40-05-19.20	13.00 ea	-	405.00 /ea	-	60.00 /ea	-	465.00 /ea	6,045
Fitting Flanged & Bolted-Ductile Iron-Tee-Cls 150 6 Inch (150mm)	A152414006200	40-05-19.20	2.00 ea	-	491.38 /ea	-	60.00 /ea	-	551.38 /ea	1,103
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 6 Inch (150mm)	L1540020000P1	40-05-19.20	1,197.00 lf	30.51 /lf	-	-	2.50 /lf	-	33.01 /lf	39,518

Brown AND Caldwell

Estimate Detail Report

1/30/2019 8:29 AM
BC Project Number: 150811.009.091
Estimate Version Number: 2
Estimate Date: 1-30-2019
Lead Estimator: Ryan Manocchio

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40120 Ductile Iron Pipe, 6" Diameter										
Insulation-Urethane Foam Aluminum Jacket 6 Inch (150mm) Dia 2 Inch (50mm)	A1500917409	40-42-13.00	1,197.00 lf	28.61 /lf	21.05 /lf	-	-	-	49.66 /lf	59,440
Ductile Iron Pipe, 6" Diameter			**1,197.00 lf**	**66.56 /lf**	**48.93 /lf**	**/lf**	**3.55 /lf**	**/lf**	**119.04 /lf**	**142,487**
14 Alternate 1: Effluent and New Pumps										**185,458**
15 Alternate 2: Effluent and Wet Well Vault										
33635 Utility Vault										
Roof hatch, with curb, 1" fiberglass insulation, galvanized steel curb & cover, 4' x 4'	1140	07-72-33.10	1.00 ea	332.90 /ea	1,100.00 /ea	-	-	-	1,432.90 /ea	1,433
Excavate pit, common earth, hyd backhoe, 3/4 CY bucket	X9010	31-23-16.13	74.07 cy	14.16 /cy	-	-	7.59 /cy	-	21.75 /cy	1,611
Backfill, trench, air tamped compaction, add	2000	31-23-23.13	42.90 ecy	15.32 /ecy	-	-	3.64 /ecy	-	18.96 /ecy	813
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 load	0150	31-23-23.18	31.17 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	370
Trench box and jacks, cost per sfca trench wall, monthly rental	X9010	31-41-13.10	800.00 sf	-	-	7.81 /sf	-	-	7.81 /sf	6,249
Utility structures, utility vaults precast concrete, meter pit, 6' x 10', 20' deep, exclude	BC-0091	33-12-19.41	1.00 ea	4,486.68 /ea	18,554.00 /ea	-	1,194.00 /ea	-	24,234.68 /ea	24,235
Utility Vault			**1.00 ea**	**6,761.27 /ea**	**19,654.00 /ea**	**6,248.80 /ea**	**2,046.67 /ea**	**/ea**	**34,710.74 /ea**	**34,711**
40120 Ductile Iron Pipe, 8" Diameter										
Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	09-91-06.41	314.16 sqft	0.94 /sqft	0.89 /sqft	-	-	-	1.83 /sqft	575
Pipe Erection-Handle Fittings-Metal-Std 8 Inch (200mm)	L163466010000	40-05-05.00	6.00 ea	84.96 /ea	-	-	-	-	84.96 /ea	510
Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	40-05-05.00	150.00 lf	7.46 /lf	-	-	-	-	7.46 /lf	1,119
Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	40-05-07.00	6.00 ea	29.06 /ea	25.00 /ea	-	-	-	54.06 /ea	324
Pipe Support 8 Inch (200mm)	A166044000000	40-05-07.00	3.00 ea	96.87 /ea	25.00 /ea	-	-	-	121.87 /ea	366
Hanger Rod 8 Inch (200mm)	A166045000000	40-05-07.00	3.00 ea	38.75 /ea	150.00 /ea	-	-	-	188.75 /ea	566
Pipe Plain End-Ductile Iron--C-151 8 Inch (200mm)	A161002200000	40-05-19.20	142.67 lf	-	20.00 /lf	-	-	-	20.00 /lf	2,853
Fitting Flanged & Bolted-Ductile Iron-Ell45-Non-Specific 8 Inch (200mm)	A162411000000	40-05-19.20	1.00 ea	-	413.78 /ea	-	80.00 /ea	-	493.78 /ea	494
Fitting Flanged & Bolted-Ductile Iron-Ell90-Non-Specific 8 Inch (200mm)	A162412000000	40-05-19.20	5.00 ea	-	725.00 /ea	-	80.00 /ea	-	805.00 /ea	4,025
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 8 Inch (200mm)	L1640020000P1	40-05-19.20	150.00 lf	34.00 /lf	-	-	3.00 /lf	-	37.00 /lf	5,550
Insulation-Urethane Foam Aluminum Jacket 8 Inch (200mm) Dia 2 Inch (50mm)	A1600917409	40-42-13.00	150.00 lf	33.91 /lf	25.67 /lf	-	-	-	59.58 /lf	8,937
Ductile Iron Pipe, 8" Diameter			**150.00 lf**	**84.62 /lf**	**77.98 /lf**	**/lf**	**6.20 /lf**	**/lf**	**168.80 /lf**	**25,319**
15 Alternate 2: Effluent and Wet Well Vault										**60,030**
16 Alternate 3: Sand Filter										
26999 Electrical Work										
120 Volt electrical connection to skid and SCADA connections, allowance	MISC	26-99-99.99	1.00 ls	-	-	10,000.00 /ls	-	-	10,000.00 /ls	10,000
Electrical Work			**1.00 ls**	**/ls**	**/ls**	**10,000.00 /ls**	**/ls**	**/ls**	**10,000.00 /ls**	**10,000**
33999 Sand Filter										
Automatic backwash sand filter, see quote from Ecologix	MISC	33-99-99.99	1.00 ls	5,200.00 /ls	-	43,000.00 /ls	1,600.00 /ls	-	49,800.00 /ls	49,800
Sand Filter			**1.00 ls**	**5,200.00 /ls**	**/ls**	**43,000.00 /ls**	**1,600.00 /ls**	**/ls**	**49,800.00 /ls**	**49,800**
40120 Ductile Iron Pipe, 8" Diameter										
Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	09-91-06.41	83.78 sqft	0.94 /sqft	0.89 /sqft	-	-	-	1.83 /sqft	153
1" Compressed air connection	X9630	22-05-05.10	1.00 ea	605.49 /ea	400.00 /ea	-	-	-	1,005.49 /ea	1,005
Pipe Erection-Handle Fittings-Metal-Std 8 Inch (200mm)	L163466010000	40-05-05.00	3.00 ea	84.95 /ea	-	-	-	-	84.95 /ea	255
Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	40-05-05.00	40.00 lf	7.46 /lf	-	-	-	-	7.46 /lf	298
Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	40-05-07.00	2.00 ea	29.06 /ea	25.00 /ea	-	-	-	54.06 /ea	108
Pipe Support 8 Inch (200mm)	A166044000000	40-05-07.00	1.00 ea	96.87 /ea	25.00 /ea	-	-	-	121.87 /ea	122
Hanger Rod 8 Inch (200mm)	A166045000000	40-05-07.00	1.00 ea	38.75 /ea	150.00 /ea	-	-	-	188.75 /ea	189
Pipe Plain End-Ductile Iron--C-151 8 Inch (200mm)	A161002200000	40-05-19.20	40.00 lf	-	20.00 /lf	-	-	-	20.00 /lf	800
Fitting Flanged & Bolted-Ductile Iron-Ell90-Non-Specific 8 Inch (200mm)	A162412000000	40-05-19.20	2.00 ea	-	725.00 /ea	-	80.00 /ea	-	805.00 /ea	1,610
Fitting Flanged & Bolted-Ductile Iron-Tee-Non-Specific 8 Inch (200mm)	A162414000000	40-05-19.20	1.00 ea	-	1,202.55 /ea	-	80.00 /ea	-	1,282.55 /ea	1,283
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 8 Inch (200mm)	L1640020000P1	40-05-19.20	40.00 lf	34.00 /lf	-	-	2.50 /lf	-	36.50 /lf	1,460
Insulation-Urethane Foam Aluminum Jacket 8 Inch (200mm) Dia 2 Inch (50mm)	A1600917409	40-42-13.00	40.00 lf	33.91 /lf	25.67 /lf	-	-	-	59.58 /lf	2,383
Ductile Iron Pipe, 8" Diameter			**40.00 lf**	**103.70 /lf**	**129.47 /lf**	**/lf**	**8.50 /lf**	**/lf**	**241.67 /lf**	**9,667**
16 Alternate 3: Sand Filter										**69,467**
04 Cooling Water Piping and Pumps										**314,955**
05 Digester Gallery Rehab										
17 Mechanical and Electrical Upgrades										
23550 HVAC Equipment, Conceptual										
General exhaust fans, roof mount, avg. cost per cfm	X9710	23-34-13.10	6,000.00 cfm	0.07 /cfm	0.57 /cfm	-	-	-	0.64 /cfm	3,825

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
23550 HVAC Equipment, Conceptual										
Smoke exhaust fans, roof mount, avg. cost per cfm	X9730	23-34-13.10	6,000.00 cfm	0.07 /cfm	0.57 /cfm	-	-	-	0.64 /cfm	3,825
Toilet exhaust fans, direct drive or v-belt, avg. cost per cfm	X9740	23-34-13.10	350.00 cfm	0.18 /cfm	0.82 /cfm	-	-	-	1.00 /cfm	349
Multizone package unit, gas heat/DX cooling, curbs, to 125 tons	X9610	23-74-33.10	15.00 ton	270.02 /ton	2,125.00 /ton	-	-	-	2,395.02 /ton	35,925
HVAC Equipment, Conceptual			**5,000.00 sf**	**0.99 /sf**	**7.79 /sf**	**/sf**	**/sf**	**/sf**	**8.79 /sf**	**43,924**
26999 Electrical Work										
Electrical and low voltage replacement, 5,000 SF, see quote	MISC	26-99-99.99	1.00 ls	-	-	210,000.00 /ls	-	-	210,000.00 /ls	210,000
Misc. electrical for HVAC replacement, including automatic controls and sensors (fa	MISC	26-99-99.99	1.00 ls	-	-	38,100.00 /ls	-	-	38,100.00 /ls	38,100
Electrical Work			**1.00 ls**	**/ls**	**/ls**	**248,100.00 /ls**	**/ls**	**/ls**	**248,100.00 /ls**	**248,100**
17 Mechanical and Electrical Upgrades										**292,024**
05 Digester Gallery Rehab										**292,024**
06 Bottom Bio Solids Load Out										
18 Miscellaneous Upgrades										
03330 Concrete Apron and Curb										
Aggregate, stone, 3/4" to 1-1/2", prices per C.Y., includes material only	1050	03-05-13.25	37.04 cy	-	33.50 /cy	-	-	-	33.50 /cy	1,241
C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes er	3050	03-11-13.65	180.00 sfca	5.91 /sfca	0.69 /sfca	-	-	-	6.60 /sfca	1,187
Sawcut control joints, slab on grade	X9000	03-15-05.25	40.00 lf	0.78 /lf	0.75 /lf	-	0.27 /lf	-	1.80 /lf	72
Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for ac	0600	03-21-10.60	2.50 ton	1,361.50 /ton	960.00 /ton	-	-	-	2,321.50 /ton	5,804
Reinforcing in place, unloading & sorting, add to above - slabs	2005	03-21-10.60	2.50 ton	52.88 /ton	-	-	6.02 /ton	-	58.90 /ton	147
Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sanc	0300	03-31-05.35	58.33 cy	-	128.00 /cy	-	-	-	128.00 /cy	7,467
Structural concrete, placing, slab on grade, direct chute, over 6" thick, includes vibra	4600	03-31-05.70	58.33 cy	21.36 /cy	-	-	0.32 /cy	-	21.67 /cy	1,264
Concrete finishing, floors, monolithic, screed, float and broom finish	0150	03-35-29.30	2,000.00 sf	1.00 /sf	-	-	-	-	1.00 /sf	2,006
Concrete finishing, floor, dustproofing, solvent-based, 1 coat	3800	03-35-29.30	2,000.00 sf	0.34 /sf	0.16 /sf	-	-	-	0.50 /sf	997
Curing, sprayed membrane curing compound	0300	03-39-13.50	20.00 csf	11.97 /csf	12.10 /csf	-	-	-	24.07 /csf	481
Fine grading, fine grade for slab on grade, machine	1100	31-22-16.10	222.22 sy	1.20 /sy	-	-	0.63 /sy	-	1.83 /sy	407
Cast-in place concrete curbs & gutters, radius, machine formed, 6" high curb, 6" thi	0446	32-16-13.13	100.00 lf	4.04 /lf	6.75 /lf	-	1.33 /lf	-	12.12 /lf	1,212
Concrete Apron and Curb			**2,000.00 cy**	**4.74 /cy**	**6.25 /cy**	**/cy**	**0.16 /cy**	**/cy**	**11.14 /cy**	**22,285**
22999 Misc. Plumbing Work										
Valve Butt Weld-Alloy Steel-Plug-Cls 600 (PN100) 10 Inch (250mm)	A176137046700	40-05-62.00	1.00 ea	1,100.00 /ea	50,947.20 /ea	-	200.00 /ea	-	52,247.20 /ea	52,247
10" Flow Meter	BC-1350	46-06-04.00	1.00 ea	1,058.16 /ea		-		7,950.00 /ea	9,008.16 /ea	9,008
Misc. Plumbing Work			**0.00**	**/LS**	**/LS**	**/LS**	**/LS**	**/LS**	**/LS**	**61,255**
26999 Misc Electrical Work										
Field control panel on building, allowance	MISC	26-99-99.99	1.00 ls	-	-	5,000.00 /ls	-	-	5,000.00 /ls	5,000
Misc Electrical Work			**1.00 ls**	**/ls**	**/ls**	**5,000.00 /ls**	**/ls**	**/ls**	**5,000.00 /ls**	**5,000**
33500 Trench for Utilities, 12" Pipe										
Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 10' t	1000	31-23-16.13	111.11 bcy	2.36 /bcy	-	-	1.69 /bcy	-	4.05 /bcy	450
Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with sheepsfoot roller	2300	31-23-23.13	109.66 ecy	1.49 /ecy	-	-	2.67 /ecy	-	4.15 /ecy	455
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 loac	0150	31-23-23.18	1.45 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	17
Trench box and jacks, cost per sfca trench wall, monthly rental	X9010	31-41-13.10	400.00 sf	-	-	7.81 /sf	-	-	7.81 /sf	3,124
Utility line signs, markers, and flags, underground tape, detectable, reinforced, alum	0400	33-05-97.10	1.00 clf	3.79 /clf	9.00 /clf	-	-	-	12.79 /clf	13
Trench for Utilities, 12" Pipe			**50.00 lf**	**8.80 /lf**	**0.18 /lf**	**62.49 /lf**	**9.72 /lf**	**/lf**	**81.19 /lf**	**4,060**
33530 Sanitary Sewer Piping, 12" PVC										
Public sanitary utility sewerage piping, piping polyvinyl chloride pipe, B & S, 13' leng	2160	33-31-13.25	50.00 lf	6.92 /lf	12.90 /lf	-	0.41 /lf	-	20.23 /lf	1,011
Sanitary Sewer Piping, 12" PVC			**50.00 lf**	**6.92 /lf**	**12.90 /lf**	**/lf**	**0.41 /lf**	**/lf**	**20.23 /lf**	**1,011**
33635 Catch Basins										
Excavate pit, common earth, hyd backhoe, 3/4 CY bucket	X9010	31-23-16.13	81.48 cy	14.16 /cy	-	-	7.59 /cy	-	21.75 /cy	1,772
Backfill, trench, air tamped compaction, add	2000	31-23-23.13	60.52 ecy	15.32 /ecy	-	-	3.64 /ecy	-	18.96 /ecy	1,147
Hauling, excavated or borrow material, loose cubic yards, 3 mile round trip, 2.1 loac	0150	31-23-23.18	20.96 lcy	7.55 /lcy	-	-	4.32 /lcy	-	11.87 /lcy	249
Trench box and jacks, cost per sfca trench wall, monthly rental	X9010	31-41-13.10	880.00 sf	-	-	7.81 /sf	-	-	7.81 /sf	6,874
Utility area drain, catch basins or manholes frames and covers, cast iron, heavy tra	2100	33-42-33.13	2.00 ea	230.09 /ea	263.00 /ea	-	40.85 /ea	-	533.94 /ea	1,068
Storm drainage manholes, frames and covers, concrete, cast place, 4' x 4', 8" thick,	1000	33-49-13.10	2.00 ea	4,032.48 /ea	1,125.00 /ea	-	26.11 /ea	-	5,183.59 /ea	10,367
Storm drainage manholes,frames and covers,concrete,cast place,4'dm,8"thick,exclu	1100	33-49-13.10	4.00 vlf	504.06 /vlf	123.00 /vlf	-	3.27 /vlf	-	630.33 /vlf	2,521

Spreadsheet Level	Item	Phase	Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
Catch Basins			**2.00 ea**	**6,390.42 /ea**	**1,634.00 /ea**	**3,436.84 /ea**	**537.92 /ea**	**/ea**	**11,999.18 /ea**	**23,998**
40120 Ductile Iron Pipe, 12" Diameter										
Minor site demolition, pipe and elbows	2930	02-41-13.33	5.00 lf	12.29 /lf	-	-	9.59 /lf	-	21.88 /lf	109
Pipe Erection-Handle Fittings-Metal-Std 12 Inch (300mm)	L183466010000	40-05-05.00	4.00 ea	128.94 /ea	-	-	-	-	128.94 /ea	516
Field Testing-Hydrotest-Non-Specific 12 Inch (300mm)	L189048000000	40-05-05.00	40.00 lf	15.11 /lf	-	-	-	-	15.11 /lf	604
Pipe Plain End-Ductile Iron--C-151 12 Inch (300mm)	A181002200000	40-05-19.20	32.17 lf	-	35.00 /lf	-	-	-	35.00 /lf	1,126
Fitting Flanged & Bolted-Ductile Iron-Ell90-Non-Specific 12 Inch (300mm)	A182412000000	40-05-19.20	3.00 ea	-	1,375.00 /ea	-	90.00 /ea	-	1,465.00 /ea	4,395
Fitting Flanged & Bolted-Ductile Iron-Tee-Non-Specific 12 Inch (300mm)	A182414000000	40-05-19.20	1.00 ea	-	1,991.32 /ea	-	90.00 /ea	-	2,081.32 /ea	2,081
Pipe Erection-Straight Run-Ductile Iron-Non-Specific 12 Inch (300mm)	L1840020000P1	40-05-19.20	40.00 lf	60.16 /lf	-	-	4.00 /lf	-	64.16 /lf	2,566
Ductile Iron Pipe, 12" Diameter			**40.00 lf**	**89.70 /lf**	**181.05 /lf**	**/lf**	**14.20 /lf**	**/lf**	**284.95 /lf**	**11,398**
18 Miscellaneous Upgrades										**129,008**
06 Bottom Bio Solids Load Out										**129,008**
01 TOTALS										**3,714,322**

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		8,239.686 hrs	769,288	
Material			2,092,346	
Subcontract			687,020	
Equipment		2,304.784 hrs	157,718	
Other			7,950	
			3,714,322	**3,714,322**
Labor Mark-up	15.000 %		115,393	
Material Mark-up	10.000 %		209,235	
Subcontractor Mark-up	10.000 %		68,702	
Construction Equipment Mark-up	10.000 %		15,772	
Other - Process Equip Mark-up	8.000 %		636	
			409,738	**4,124,060**
Material Shipping & Handling	2.000 %		41,847	
Material Sales Tax	6.875 %		143,849	
Other - Process Eqp Sales Tax	6.875 %		547	
Net Markups			**186,243**	**4,310,303**
Contractor General Conditions	15.000 %		646,545	
			646,545	**4,956,848**
Start-Up, Training, O&M	2.000 %		99,137	
			99,137	**5,055,985**
Undesign/Undevelop Contingency	30.000 %		1,516,795	
			1,516,795	**6,572,780**
Bldg Risk, Liability Auto Ins	2.000 %		131,456	
			131,456	**6,704,236**
Payment and Performance Bonds	1.500 %		100,564	
			100,564	**6,804,800**
Escalation to Midpoint (ALL)	5.540 %		376,986	
Gross Markups			**376,986**	**7,181,786**
Total				**7,181,786**

Attachment F: Heat Exchanger Quotation

Tranter via Electric Pump

TRANTER
The heat transfer people

Performance Specification

Customer:	Brown and Caldwell	Date:	11/8/2019
	Nancy Andrews	Proposal No.:	
Email:	nandrews@brwncald.com	Run No.:	1185319
Cust. Reference:	Rochester WWTP	Item No.:	
		Technician:	Abresch
Model:	**GXD-051-H-5-NR-189**	Units Required:	1

Intended End Use: Heat exchanger to heat 40% EthGlycol (aq) 11.5 °F using 57 °F Effluent with pressure drop at or below 15 psi on hot side and at or below 15 psi on cold side.

		Hot Side		***Cold Side***		
Fluid Name		Effluent		40% EthGlycol (aq)		
OPERATING DATA		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Total Liquid flow	GPM	1,500.00	1,500.00	1,500.00	1,500.00	GPM
Operating Temperature	°F	57.00	47.02	40.00	51.50	°F
Pressure drop (allowed / calc.)	psi	15.00 / 14.92		15.00 / 14.84		psi
Total Heat Exchanged	Btu/h		7,529,437			
U-Service	Btu/(h·ft²·°F)		1,092			
Total Heat Transfer Area	ft²		1,107.07			
LMTD	°F		6.23			
FLUID PROPERTIES		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Specific Gravity	-	1.00	1.00	1.06	1.06	
Specific Heat	Btu/(lb·°F)	1.00	1.01	0.82	0.83	
Thermal Conductivity	Btu/(h·ft·°F)	0.34	0.33	0.26	0.26	
Viscosity (avg.)	cP	1.31	1.49	4.79	3.79	
CONNECTIONS						
Position		S1	S3	S2	S4	
Type		STUDDED	STUDDED	STUDDED	STUDDED	
Liner		no liner	no liner	no liner	no liner	
Size		6"	6"	6"	6"	
Rating		ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	
Material		SA-516-70 Carbon Steel		SA-516-70 Carbon Steel		
CONSTRUCTION						
Pass Arrangement		1		1		
Channel Arrangement		75HS+19HD		19HS+75HD		
A-Dimension / C-Dimension	in	28.27 / 94				
Plate Material (Material/Thickness)		304 SS / 0.5 mm				
Gasket Material (Hot/Cold)		NBR		NBR		
No. of Plates		189				
Frame material / Paint / Color		SA-516-70 Carbon Steel / Enamel / RAL 5012 (Royal Blue)				
Tightening Bolts/Nuts/Finish		SA-193-B7 / 8/2H Tie Nuts / FZB				
Pressure (design / test)	psi(g)	150.00 / 195.00		150.00 / 195.00		
Temperature (min / design)	°F	14.00 / 150.00		14.00 / 150.00		
Weight empty / flooded (per unit)	lbs	2,832 / 3,547				
Pressure vessel code		ASME				

Remarks:

Plate Gap is 4.00 MM

The performance guarantee, if applicable, is based on the accuracy of the data presented above, and the customers ability to supply product and operating conditions in conformance with the above.

Tranter, Inc. C/O Electric Pump, Inc. 201 4th Avenue SW New Prague, Minnesota 56071
Phn: 612-889-7251 Fax: 515-265-8079 Email: craiga@electricpump.com

TRANTER® The heat transfer people

Quotation

Customer: Brown and Caldwell
Nancy Andrews
Email: nandrews@brwncald.com
Cust. Reference: Rochester WWTP

Model: GXD-051-H-5-NR-189

Date: 11/8/2019
Proposal No.:
Run No.: 1185319
Item No.:
Technician: Abresch
Units Required: 1

Pass Arrangement: 1 x 1
Plates Material: 304 SS
Fitting Material: SA-516-70 Carbon Steel
Gasket Material: NBR / NBR

Total Heat Transfer Area: 1,107.07 ft²

HEAT EXCHANGER PRICING (USD)			
ITEM	UNIT PRICE	QTY	TOTAL
GXD-051-H-5-NR-189	**20,914.00**	**1**	**20,914.00**
Shroud	**191.00**	**1**	**191.00**
GRAND TOTAL:			**21,105.00**

Please address any Purchase Order resulting from this quotation to Tranter, Inc. C/O Electric Pump, Inc.

Our normal shipping estimate is 8 weeks after receipt of order. This estimate is based upon *after receipt of order and after final drawing approvals*, as required.

Shipping terms are F.O.B. Wichita Falls, Texas, freight collect.

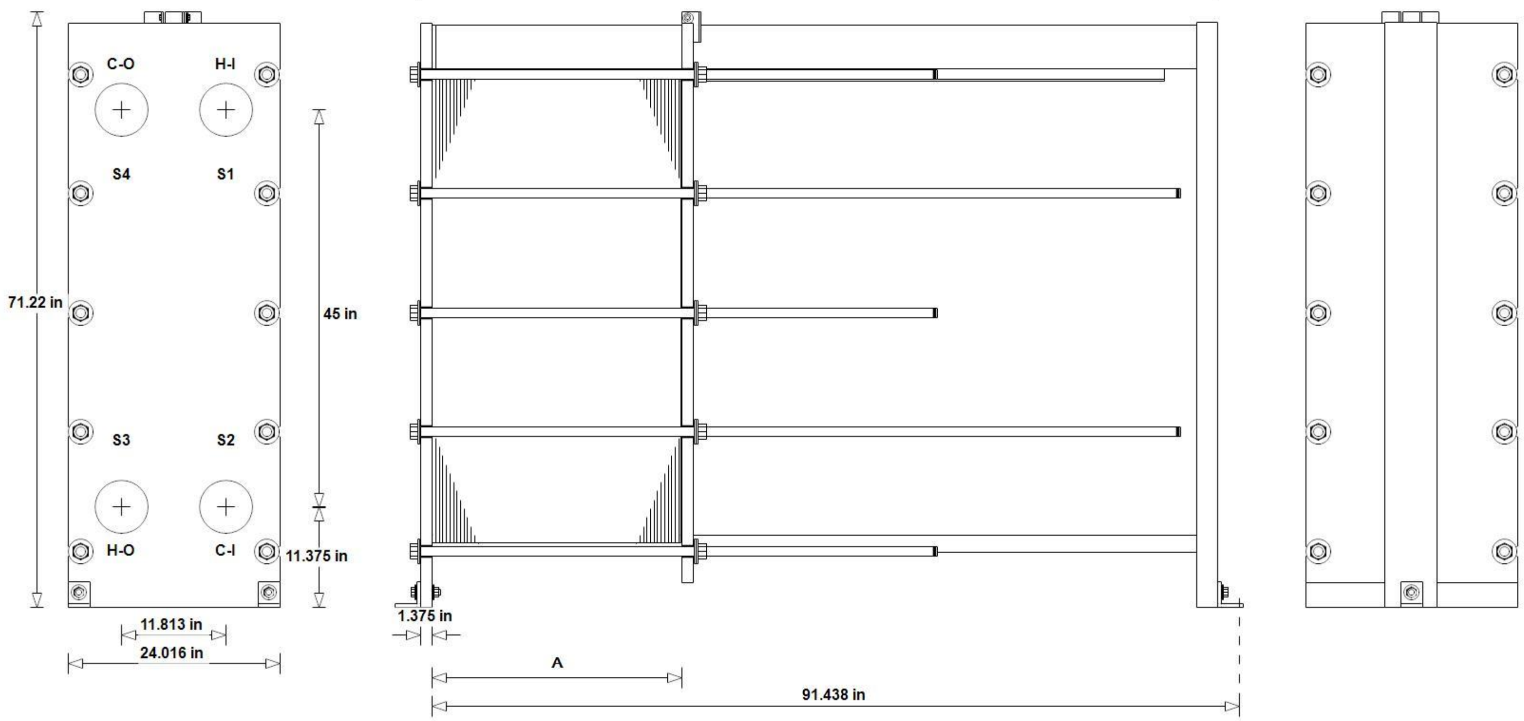
Prices are firm for sixty days and subject to change without notice thereafter. Our payment terms are **Net Thirty Days**. No provision is made for Federal, State, or Municipal taxes. All orders are subject to credit approval and acceptance by Tranter, Inc.. The terms of this agreement incorporate and are subject to Tranter, Inc's standard terms of sale.

Sales and Support Contact:
Tranter, Inc. C/O Electric Pump, Inc.
201 4th Avenue SW
New Prague, Minnesota 56071
612-889-7251
515-265-8079(Fax)
craiga@electricpump.com

The performance guarantee, if applicable, is based on the accuracy of the data presented above, and the customers ability to supply product and operating conditions in conformance with the above.

SUPERCHANGER ASSEMBLY
GXD-051-H-5-NR-189

Sizing Number
1185319



A: 28.274 in
A(Minimum): 27.424 in
A(Maximum): 29.125 in
Guide Bar Length : 89 in

Hot Inlet(H-I)	Hot Outlet(H-O)	Cold Inlet(C-I)	Cold Outlet(C-O)
Type: STUDDED	Type: STUDDED	Type: STUDDED	Type: STUDDED
Size: 6"	Size: 6"	Size: 6"	Size: 6"
Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#
Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel

Dimensions are for reference purposes only and are not to be used for construction.

TRANTER® The heat transfer people

Performance Specification

Customer:	Brown and Caldwell	Date:	11/8/2019
	Nancy Andrews	Proposal No.:	
Email:	nandrews@brwncald.com	Run No.:	1186187
Cust. Reference:	Rochester WWTP	Item No.:	
		Technician:	Abresch
Model:	**GXD-051-H-5-NR-189**	Units Required:	1

Intended End Use: Heat exchanger to heat 40% EthGlycol (aq) 11.5 °F using 57 °F Effluent with pressure drop at or below 15 psi on hot side and at or below 15 psi on cold side.

		Hot Side		***Cold Side***		
Fluid Name		Effluent		40% EthGlycol (aq)		
OPERATING DATA		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Total Liquid flow	GPM	1,500.00	1,500.00	1,500.00	1,500.00	GPM
Operating Temperature	°F	57.00	47.02	40.00	51.50	°F
Pressure drop (allowed / calc.)	psi	15.00 / 14.92		15.00 / 14.84		psi
Total Heat Exchanged	Btu/h		7,529,437			
U-Service	Btu/(h·ft²·°F)		1,092			
Total Heat Transfer Area	ft²		1,107.07			
LMTD	°F		6.23			
FLUID PROPERTIES		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Specific Gravity	-	1.00	1.00	1.06	1.06	
Specific Heat	Btu/(lb·°F)	1.00	1.01	0.82	0.83	
Thermal Conductivity	Btu/(h·ft·°F)	0.34	0.33	0.26	0.26	
Viscosity (avg.)	cP	1.31	1.49	4.79	3.79	
CONNECTIONS						
Position		S1	S3	S2	S4	
Type		STUDDED	STUDDED	STUDDED	STUDDED	
Liner		no liner	no liner	no liner	no liner	
Size		6"	6"	6"	6"	
Rating		ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	
Material		SA-516-70 Carbon Steel		SA-516-70 Carbon Steel		
CONSTRUCTION						
Pass Arrangement		1		1		
Channel Arrangement		75HS+19HD		19HS+75HD		
A-Dimension / C-Dimension	in	28.27 / 94				
Plate Material (Material/Thickness)		316 SS / 0.5 mm				
Gasket Material (Hot/Cold)		NBR		NBR		
No. of Plates		189				
Frame material / Paint / Color		SA-516-70 Carbon Steel / Enamel / RAL 5012 (Royal Blue)				
Tightening Bolts/Nuts/Finish		SA-193-B7 / 8/2H Tie Nuts / FZB				
Pressure (design / test)	psi(g)	150.00 / 195.00		150.00 / 195.00		
Temperature (min / design)	°F	14.00 / 150.00		14.00 / 150.00		
Weight empty / flooded (per unit)	lbs	2,832 / 3,547				
Pressure vessel code		ASME				

Remarks:

Plate Gap 4.00 MM

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TRANTER® The heat transfer people

Quotation

Customer: Brown and Caldwell
Nancy Andrews
Email: nandrews@brwncald.com
Cust. Reference: Rochester WWTP

Model: GXD-051-H-5-NR-189

Date: 11/8/2019
Proposal No.:
Run No.: 1186187
Item No.:
Technician: Abresch
Units Required: 1

Pass Arrangement: 1 x 1
Plates Material: 316 SS
Fitting Material: SA-516-70 Carbon Steel
Gasket Material: NBR / NBR

Total Heat Transfer Area: 1,107.07 ft^2

HEAT EXCHANGER PRICING (USD)			
ITEM	UNIT PRICE	QTY	TOTAL
GXD-051-H-5-NR-189	**21,827.00**	**1**	**21,827.00**
Shroud	**191.00**	**1**	**191.00**
GRAND TOTAL:			**22,018.00**

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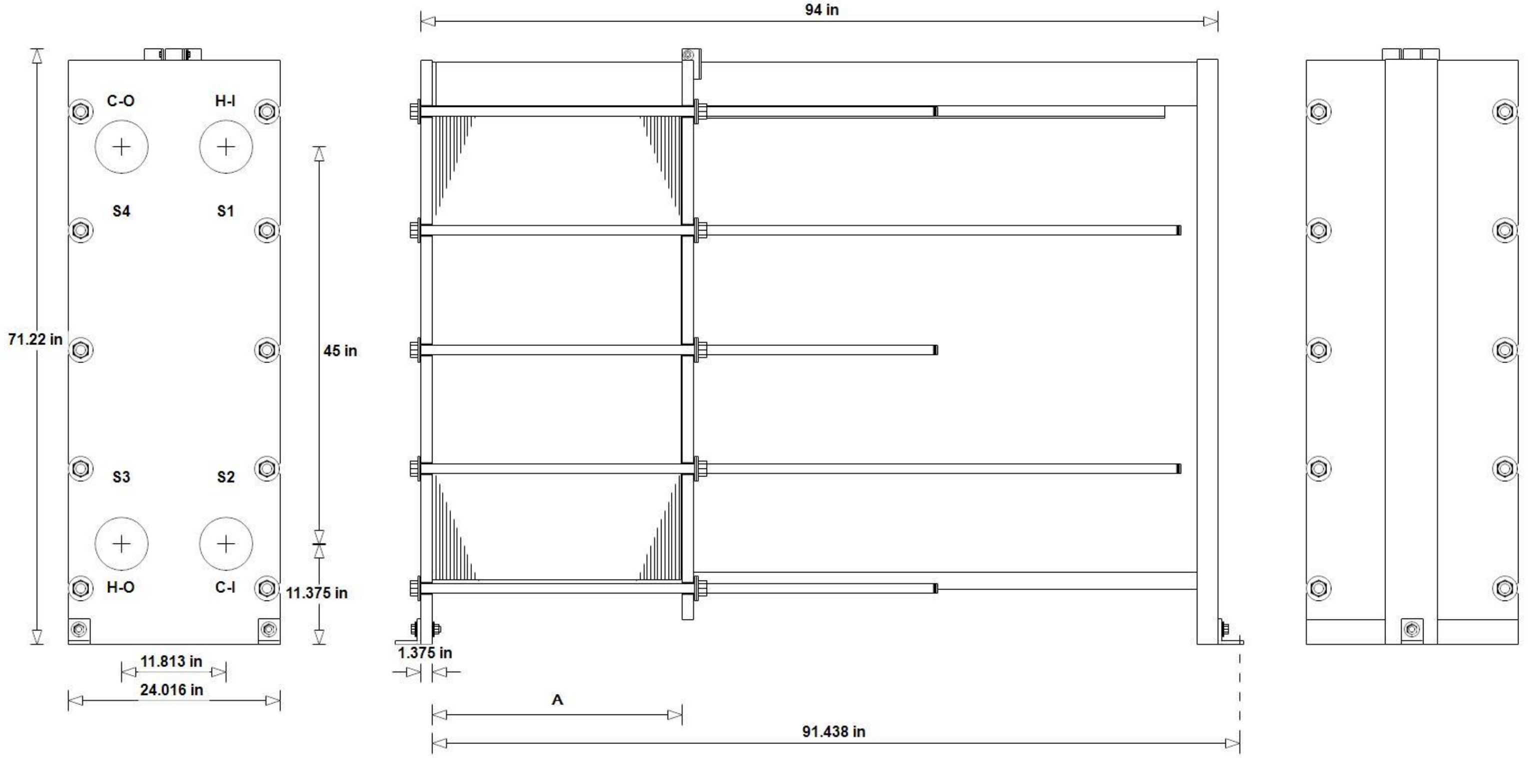
SUPERCHANGER ASSEMBLY
GXD-051-H-5-NR-189

Sizing Number
1186187



A: 28.274 in
A(Minimum): 27.424 in
A(Maximum): 29.125 in
Guide Bar Length : 89 in

Hot Inlet(H-I)	Hot Outlet(H-O)	Cold Inlet(C-I)	Cold Outlet(C-O)
Type: STUDDED	Type: STUDDED	Type: STUDDED	Type: STUDDED
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Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#
Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel

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TRANTER®
The heat transfer people

Performance Specification

Customer:	Brown and Caldwell	Date:	11/12/2019
	Nancy Andrews	Proposal No.:	
Email:	nandrews@brwncald.com	Run No.:	1186426
Cust. Reference:	Rochester WWTP	Item No.:	
		Technician:	Abresch
Model:	**GXD-051-H-5-NR-189**	Units Required:	1

Intended End Use: Heat exchanger to cool 40% EthGlycol (aq) 9.03 °F using 72 °F Effluent with pressure drop at or below 1.68 psi on hot side and at or below 1.75 psi on cold side.

		Hot Side		***Cold Side***		
Fluid Name		40% EthGlycol (aq)		Effluent		
OPERATING DATA		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Total Liquid flow	GPM	500.00	500.00	500.00	500.00	GPM
Operating Temperature	°F	83.00	73.97	72.00	79.97	°F
Pressure drop (allowed / calc.)	psi	15.00 / 1.68		15.00 / 1.75		psi
Total Heat Exchanged	Btu/h		1,991,925			
U-Service	Btu/(h·ft²·°F)		731			
Total Heat Transfer Area	ft²		1,107.07			
LMTD	°F		2.46			
FLUID PROPERTIES		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Specific Gravity	-	1.05	1.05	1.00	1.00	
Specific Heat	Btu/(lb·°F)	0.85	0.84	1.00	1.00	
Thermal Conductivity	Btu/(h·ft·°F)	0.26	0.26	0.35	0.35	
Viscosity (avg.)	cP	2.20	2.54	1.06	0.95	
CONNECTIONS						
Position		S1	S3	S2	S4	
Type		STUDDED	STUDDED	STUDDED	STUDDED	
Liner		no liner	no liner	no liner	no liner	
Size		6"	6"	6"	6"	
Rating		ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	
Material		SA-516-70 Carbon Steel		SA-516-70 Carbon Steel		
CONSTRUCTION						
Pass Arrangement		1		1		
Channel Arrangement		19HS+75HD		75HS+19HD		
A-Dimension / C-Dimension	in	28.27 / 94				
Plate Material (Material/Thickness)		316 SS / 0.5 mm				
Gasket Material (Hot/Cold)		NBR		NBR		
No. of Plates		189				
Frame material / Paint / Color		SA-516-70 Carbon Steel / Enamel / RAL 5012 (Royal Blue)				
Tightening Bolts/Nuts/Finish		SA-193-B7 / 8/2H Tie Nuts / FZB				
Pressure (design / test)	psi(g)	150.00 / 195.00		150.00 / 195.00		
Temperature (min / design)	°F	14.00 / 150.00		14.00 / 150.00		
Weight empty / flooded (per unit)	lbs	2,832 / 3,543				
Pressure vessel code		ASME				

Remarks:

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and the customers ability to supply product and operating conditions in conformance with the above.

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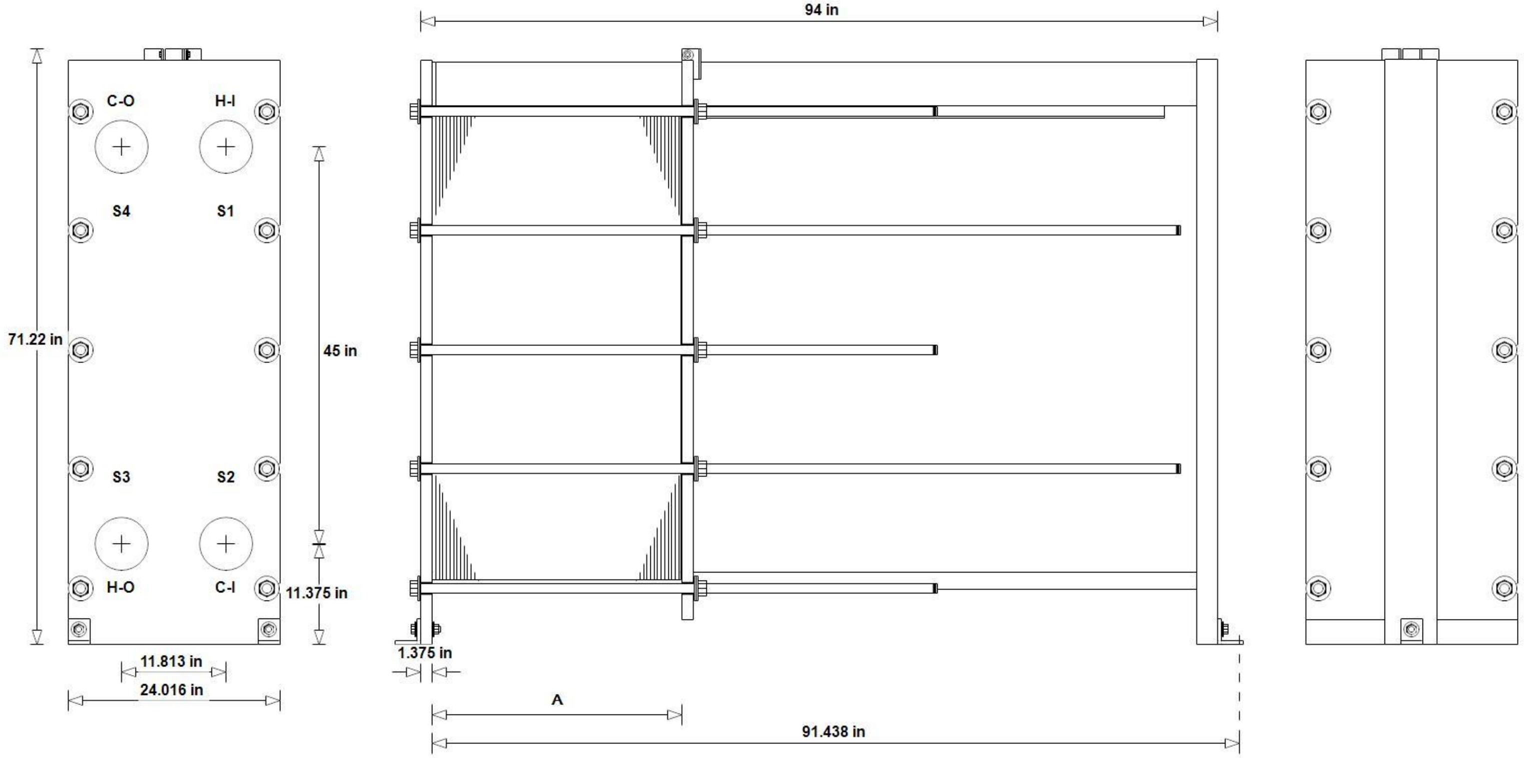
SUPERCHANGER ASSEMBLY
GXD-051-H-5-NR-189

Sizing Number
1186426



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Type: STUDDED	Type: STUDDED	Type: STUDDED	Type: STUDDED
Size: 6"	Size: 6"	Size: 6"	Size: 6"
Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#	Rating: ANSI 16.5 150#
Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel	Material: SA-516-70 Carbon Steel

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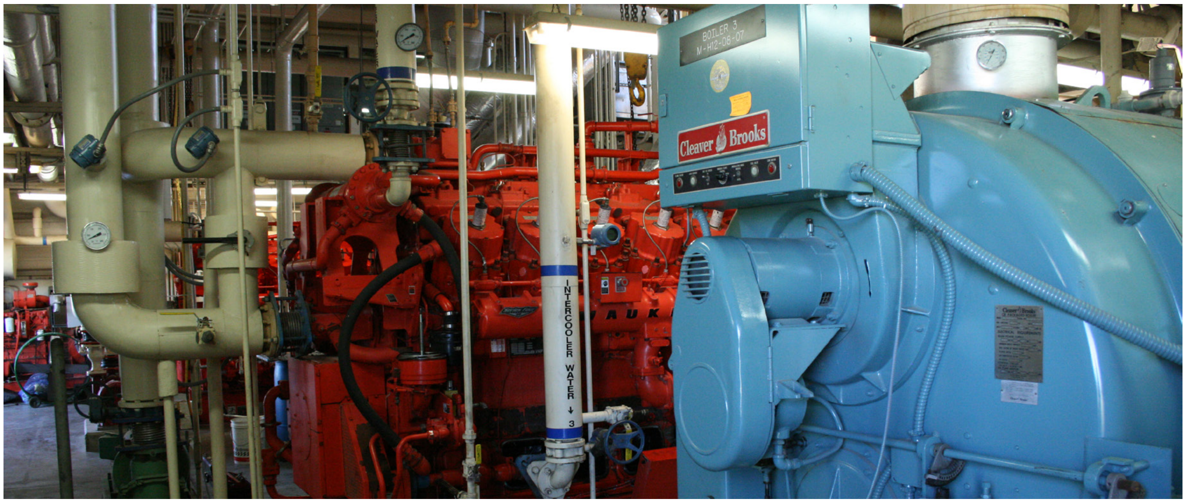
LOWER ENERGY // CLEAN DESIGN

DECREASED MAINTENANCE // INNOVATIVE PROCESSES



Technical Memorandum 1	Influent Flows and Loadings
Technical Memorandum 2	Wastewater Characterization and BioWin Calibration
Technical Memorandum 3	Plant Hydraulic Evaluation
Technical Memorandum 4	Primary Clarifier Computational Fluid Dynamics Modeling
Technical Memorandum 5	Final Clarifier Computational Fluid Dynamics Modeling
Technical Memorandum 6	Liquid Stream Alternative Evaluation
Technical Memorandum 7	Solids Alternative Evaluation
Technical Memorandum 8	Digester Gas Management
Technical Memorandum 9	Disinfection and Outfall Evaluation
Technical Memorandum 10	Whole Plant Evaluation
Technical Memorandum 11	Heat Recovery Loop Alternative
Technical Memorandum 12	NPDES Permitting Process
Technical Memorandum 13	Industrial Discharge Wasteloads and Practices