West Basin Facility Plan Project 7054

TECHNICAL MEMORANDUM 4

Rock Creek Secondary Treatment Expansion

FINAL / March 2023

Produced by: carollo

Clean Water Services

Clean Water Services

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Rock Creek Secondary Treatment Expansion

FINAL / March 2023

REGISTERED PROFESSIONAL ENGINEER
66976
OREGON
JAN. 1, 2002
BRIAN R. MATSON
EXPIRES: 12/31/24

Contents

TM 4 - ROCK CREEK SECONDARY TREATMENT EXPANSION

Appendices

Tables

Figures

Abbreviations

AACE	Association for the Advancement of Cost Engineering
BPR	biological phosphorus removal
CAMP®	concentrated, accelerated, motivated, problem-solving
CBOD	carbonaceous biochemical oxygen demand
CCI	Construction Cost Index
District	Clean Water Services
ENR	Engineering News-Record
M	million
mgd	million gallons per day
mL/g	milliliters per gram
MLR	mixed liquor return
MLSS	mixed liquor suspended solids
MMDW	maximum month dry weather
NPV	net present value
O&M	operations and maintenance
PAO	phosphorus accumulating organisms
ppd	pounds per day
RAS	return activated sludge
SVI	sludge volume index
WAS	waste activated sludge
WRRF	water resource recovery facility

TM 4 ROCK CREEK SECONDARY TREATMENT EXPANSION

4.1 Executive Summary

During the West Basin Concentrated, Accelerated, Motivated, Problem-solving (CAMP®) event, the project team determined the optimum flow routing for West Basin and the projected loads for the Rock Creek Water Resource Recovery Facility (WRRF). With these loads, it was estimated that the Rock Creek secondary process would provide sufficient capacity until the year 2028 and that intensification may be required to provide sufficient capacity through buildout. This technical memorandum describes the secondary expansion alternatives evaluation that followed CAMP®. As part of this evaluation, conventional expansion was compared with intensification of two aeration basin trains using either BioMag® or inDENSE®.

Although inDENSE® could not guarantee a process capacity improvement, capacity increases can be estimated based on typical performance. For example, if the process can reliably reduce the sludge volume index (SVI) to approximately 80 milliliters per gram (mL/g), intensification of two secondary trains could provide capacity equivalent to 30 percent of an aeration basin train. Evoqua provided an estimate of process capacity improvement for BioMag® with intensification of two secondary trains providing capacity equivalent to approximately 70 percent of an aeration basin train.

A site analysis for secondary expansion at the Rock Creek WRRF determined that conventional expansion can provide sufficient capacity through buildout by building aeration basins that have 20 percent more volume and secondary clarifiers that are 150 feet in diameter. Intensification of two trains with BioMag® could potentially reduce the number of aeration basins and secondary clarifiers required at buildout by one, while intensification of two trains with inDENSE® is not anticipated to change the number of aeration basins and secondary clarifiers required at buildout.

A comparison of costs found that if inDENSE® can reduce the SVI to 80 mL/g, it would have the lowest unit net present value (NPV), while BioMag® had the highest unit NPV compared to conventional expansion.

Based on this analysis, conventional expansion is preferable over intensification with BioMag®. Due to the lower unit NPV for inDENSE® and the potential benefits to process stability, Clean Water Services (District) is exploring a try-and-buy pilot inDENSE® to confirm performance and capacity improvements.

4.2 Drivers for Rock Creek Secondary Treatment Expansion

During CAMP®, it was determined that secondary expansion would be required at the Rock Creek facility and that intensification may be required to allow the required capacity at buildout to fit on the available site. Additionally, due to anticipated near term increases in industrial loads, intensification was identified as a possible way to increase capacity and meet the schedule drivers imposed by the anticipated industrial load. This section summarizes the drivers for the secondary treatment expansion.

4.2.1 Maximize Treatment at Rock Creek

During CAMP®, the project team determined that the lowest cost conveyance alternative for the West Basin system was to route the north Hillsboro flow east to the Rock Creek WRRF. The projected flows to Rock Creek due to population and industry growth are shown in Table 4.1.

Table 4.1 Projected Flows to Rock Creek

	Year 2045	Buildout (Year 2075)
Peak Hour Flow	208 mgd	258.8 mgd
MMDW Flow	66 mgd	85.5 mgd

mgd - million gallons per day; MMDW - maximum month dry weather

4.2.2 Projected Increase in loads

Based on the information available during CAMP®, the load projections included a 50 percent increase in MMDW carbonaceous biochemical oxygen demand (CBOD) between the years 2023 and 2045 and an almost doubling of CBOD load from year 2023 through buildout of the system (estimated to occur around the year 2075).

The estimated increase in loads to the Rock Creek WRRF includes residential and industrial loads from the Rock Creek collection system along with transfer solids loads from the Hillsboro and Forest Grove WRRFs. The main industrial discharger into the Rock Creek collection system is Intel. During CAMP®, District had understood from Intel that they expected to significantly increase their CBOD discharge from the current levels of around 2,000 pounds per day (ppd) to approximately 9,000 ppd by the year 2025 and around 12,000 ppd by the year 2030 as shown by the orange line in Figure 4.1.

Subsequent to CAMP®, Intel has revised their projections to indicate that they will continue to discharge a CBOD load of approximately 2,000 ppd through the year 2040 (as is shown by the blue line in Figure 4.1). This decrease in load from intel drops the projected MMDW BOD load by approximately 10,000 ppd for year 2045 and buildout. This reduction results in a projected 40 percent increase in MMDW CBOD load from years 2023 to 2045 and 90 percent increase from year 2023 to buildout. The timing of when a secondary expansion would be required was calculated with both the original (February 2022) and revised (December 2022) Intel projections. The requirement for a new aeration basin train was shifted to 2033 though a more conservative estimate would indicate a need at 2030.

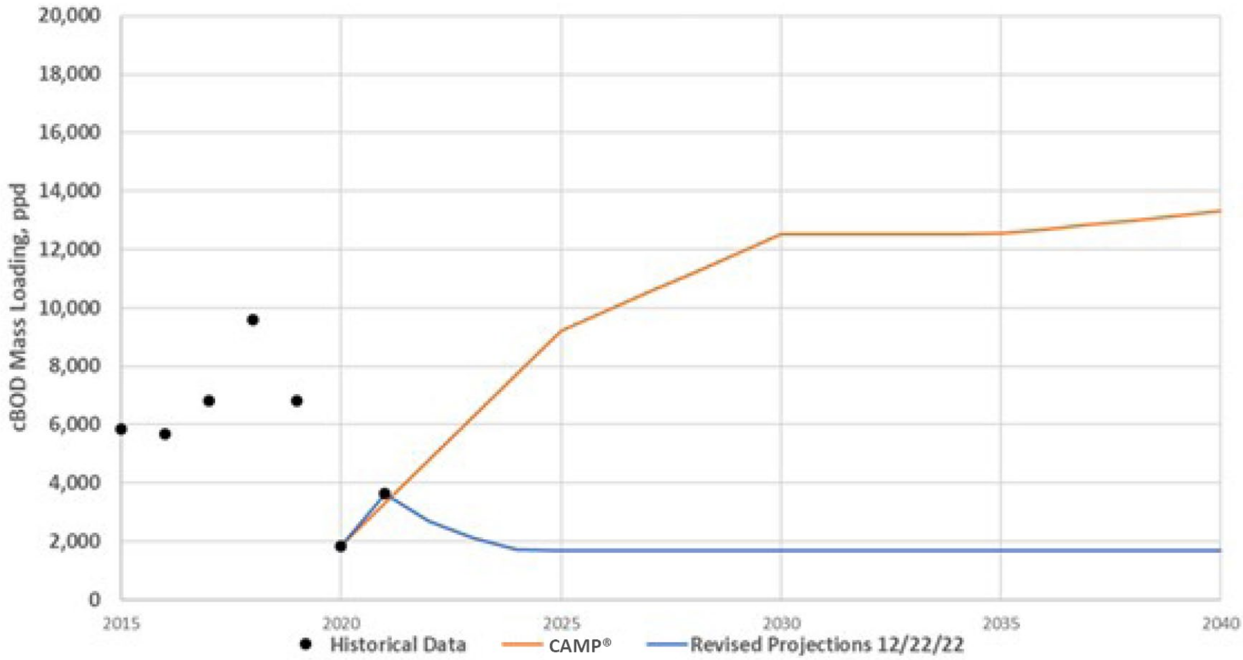


Figure 4.1 Intel CBOD Load Projections

Based on the original Intel CBOD load projections it was estimated that the secondary treatment system would run out of capacity by approximately the year 2028 as shown in Figure 4.2.

Figure 4.2 also shows that by buildout, approximately four additional aeration basins and secondary clarifiers would be required. Since construction of a fourth new secondary clarifier is not feasible due to site constraints, it was determined that intensification would likely be required at buildout as is shown in Figure 4.3.

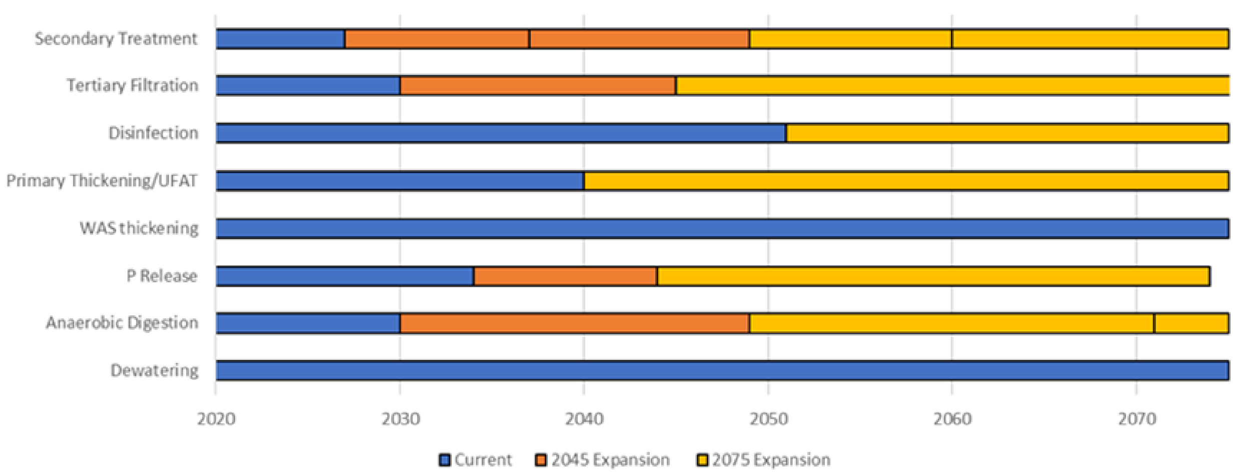


Figure 4.2 Rock Creek Capacity Limitations (based on original Intel growth projections)

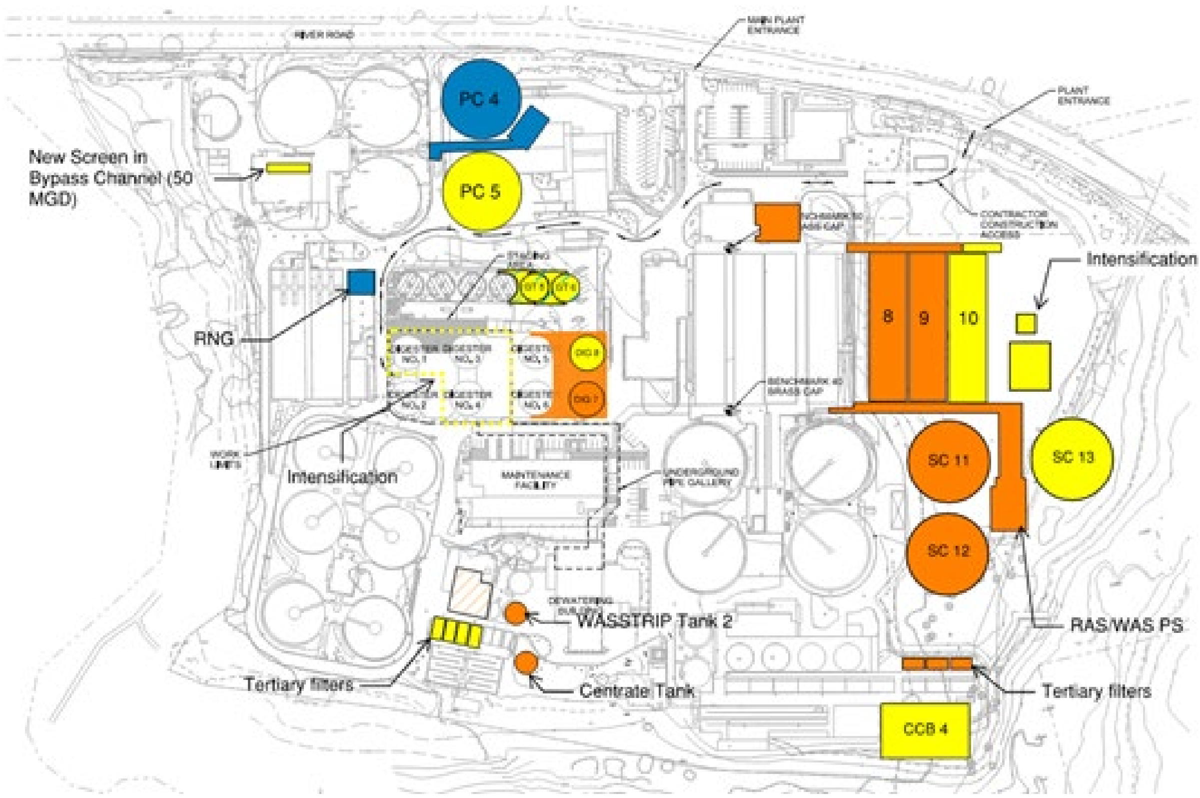


Figure 4.3 Rock Creek Site Layout (based on original Intel growth projections)

4.3 Secondary Treatment Expansion Alternatives

Due to the site limitations anticipated at buildout and the need for additional secondary capacity within the immediate future, the District evaluated how best to provide the buildout capacity and what provisions should be planned for as part of the next aeration basin expansion. This section summarizes the alternatives explored post-CAMP® to provide near term capacity as well as meet the long-term buildout requirements.

4.3.1 Conventional Expansion

During CAMP®, the secondary capacity expansion was based on the size of the existing eastside aeration basin and secondary clarifier trains. Since the site does not have suitable usable space for a fourth secondary clarifier, the fourth aeration basin was not considered, as shown in Figure 4.3. However, post-CAMP®, the conventional basin configuration was re-evaluated resulting in increasing the new aeration basin volume by approximately 20 percent and building 150-foot diameter clarifiers, which are larger than the District's current 140-foot diameter secondary clarifiers. Based on these changes, the District estimated that four new larger aeration basins coupled with three new larger secondary clarifiers could provide capacity through buildout and would fit within the existing site, as shown in Figure 4.4. Additionally, as shown in Figure 4.5, analysis of the design and construction of a new aeration basin and secondary clarifier train indicates that the new train could be operational by the time the capacity would be required to meet Intel's original growth projections.

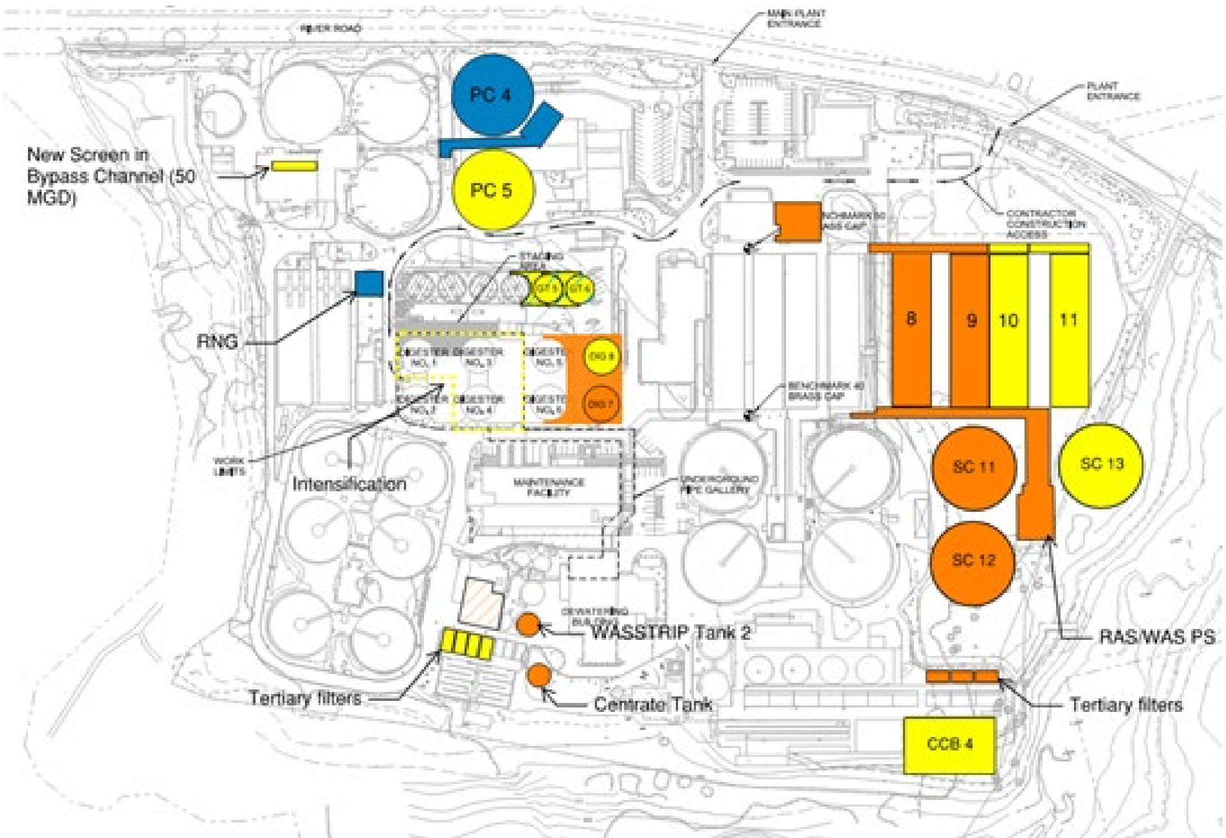
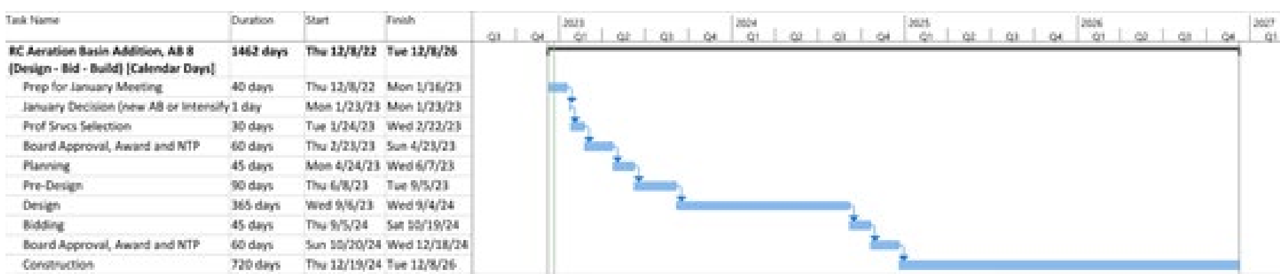


Figure 4.4 Potential Rock Creek Site Layout with Conventional Secondary Expansion Including Larger Aeration Basins and Secondary Clarifiers



Task Name	Duration	Start	Finish
RC Aeration Basin Addition, AB 8 (Design - Bid - Build) [Calendar Days]	**1462 days**	**Thu 12/8/22**	**Tue 12/8/26**
Prep for January Meeting	40 days	Thu 12/8/22	Mon 1/16/23
January Decision (new AB or Intensify	1 day	Mon 1/23/23	Mon 1/23/23
Prof Srvcs Selection	30 days	Tue 1/24/23	Wed 2/22/23
Board Approval, Award and NTP	60 days	Thu 2/23/23	Sun 4/23/23
Planning	45 days	Mon 4/24/23	Wed 6/7/23
Pre-Design	90 days	Thu 6/8/23	Tue 9/5/23
Design	365 days	Wed 9/6/23	Wed 9/4/24
Bidding	45 days	Thu 9/5/24	Sat 10/19/24
Board Approval, Award and NTP	60 days	Sun 10/20/24	Wed 12/18/24
Construction	720 days	Thu 12/19/24	Tue 12/8/26

Figure 4.5 Potential Rock Creek Conventional Basin Construction Schedule

The preferred configuration for the new aeration basins is three-pass, multi-purpose basins similar to Aeration Basins 6 and 7, with 20 percent increased volume split between larger anaerobic and anoxic volumes. As shown in Figure 4.6, the new basins would be configured to feed return activated sludge (RAS) and fermentate into the anaerobic zones, influent into the anaerobic, anoxic, and post-anoxic zones, and mixed liquor return (MLR) into the anoxic zones. This configuration would allow the District the flexibility to operate in plug flow, step-feed, contact stabilization, and RAS fermentation modes.

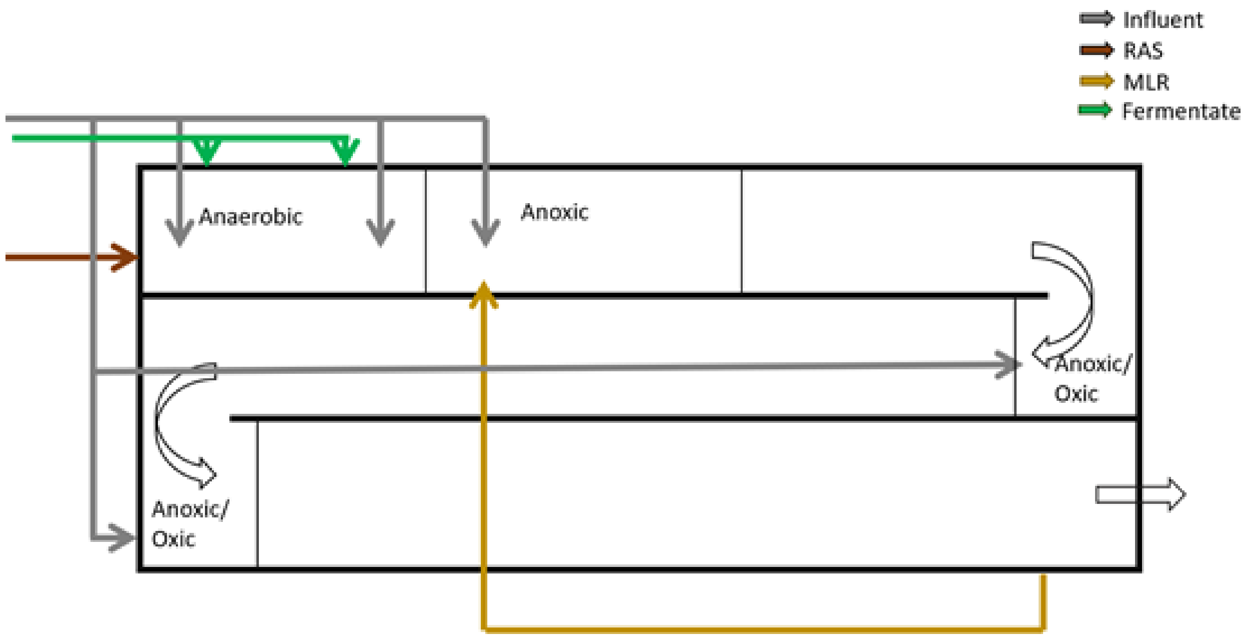


Figure 4.6 Preferred Configuration for the New Rock Creek Aeration Basins

4.3.2 Expansion with Intensification

As an alternate to conventional expansion, treatment intensification of existing aeration basins was evaluated, with possible benefits including:

- Shorter implementation schedule to allow for quicker response to increased load from industrial sources.
- Deferral of conventional secondary expansion, which may lead to capital cost savings.
- Increased treatment capacity within existing basin footprint helps to address limited space onsite to meet buildout conditions.
- Overall savings in capital, operations, and maintenance costs.

4.3.2.1 Short-listed Intensification Processes

Four intensification technologies were considered for evaluation to provide increased capacity at the Rock Creek WRRF: (1) integrated fixed film activated sludge (IFAS), (2) Nuvoda™, (3) BioMag®, and (4) inDENSE®. Of these four alternatives initially considered, both the IFAS and Nuvoda processes were eliminated from further consideration as summarized below:

- IFAS: This alternative can increase secondary capacity by providing media on which a biofilm can form. These carriers are retained within the aeration basin by screens, which allows for increased capacity within the aeration basin. Due to the slow velocities required within the aeration basin to avoid mounding on the screens, IFAS retrofits are often quite extensive and can involve changing the flow orientation through the basins. This configuration would not be compatible with the District's existing three-pass aeration basins (numbers 6 and 7) and would ultimately result in a decrease in peak flow capacity. For these reasons, IFAS was not considered for a more detailed evaluation.

- Nuvoda™: This is a process similar to IFAS which provides a ballast on which biofilm can form. In the Nuvoda™ process, this ballast consists of a renewable, plant-based material that flows freely through the process. A rotary screen is used to screen the ballast from the waste activated sludge (WAS) and the ballast is returned to the process. Since the ballast carries through to the secondary clarifier, the process can improve the sludge settleability. Given the limited number of Nuvoda™ installations, the vendor was not able to guarantee performance. Additionally, while preparing the more detailed evaluation, the vendor was slow to respond to inquiries and information was not provided when requested. For these reasons, this alternative was not considered in the more detailed evaluation.

The remaining two intensification technologies, BioMag® and inDENSE®, were short-listed for further evaluation based on the following criteria:

- Expected cost, footprint, and capacity gained from intensifying two existing aeration basins.
- Proven process performance.
- Operation and maintenance (O&M) complexity.
- Seismic resiliency.
- Implementation schedule.

4.3.2.2 BioMag®

BioMag® is a process that allows for a higher biomass concentration than conventional suspended growth by physically improving settling velocities with a weighted ballast material. This process uses very small, dense particles of magnetite introduced into the aeration basins. Magnetite is Fe_3O_4, an inert form of iron ore with a specific gravity that is five times that of biological sludge. The biomass attaches to the magnetite in the sludge, which drastically improves the settling velocity of the mixed liquor suspended solids (MLSS). The increase in settling velocity allows the activated sludge process to be designed with higher MLSS concentrations, resulting in the need for much smaller bioreactors and clarifiers volumes. WAS from the secondary process is pumped and conveyed to shear pumps and magnetic recovery drums to recover and reuse the magnetite. A sample process schematic is shown in Figure 4.7.

Evoqua was contacted to provide an estimated price and capacity benefit for intensifying Aeration Basins 6 and 7. Based on the information provided by Evoqua, intensifying two aeration basins would require:

- Eight shear mills.
- Four shear pumps.
- Two magnetite mix tank discharge pumps.
- Two WAS transfer pumps, polymer dosing, pneumatic feeder (magnetite transport from silo).

Figure 4.8 shows how this equipment could be configured within a 50-foot-by-60-foot, two story building.

Based on the capacity information provided by Evoqua, intensifying two existing aeration basins could provide the equivalent capacity of 70 percent of one aeration basin and secondary clarifier train and could potentially eliminate the need for one aeration basin and secondary clarifier at buildout as is shown in Figure 4.9.

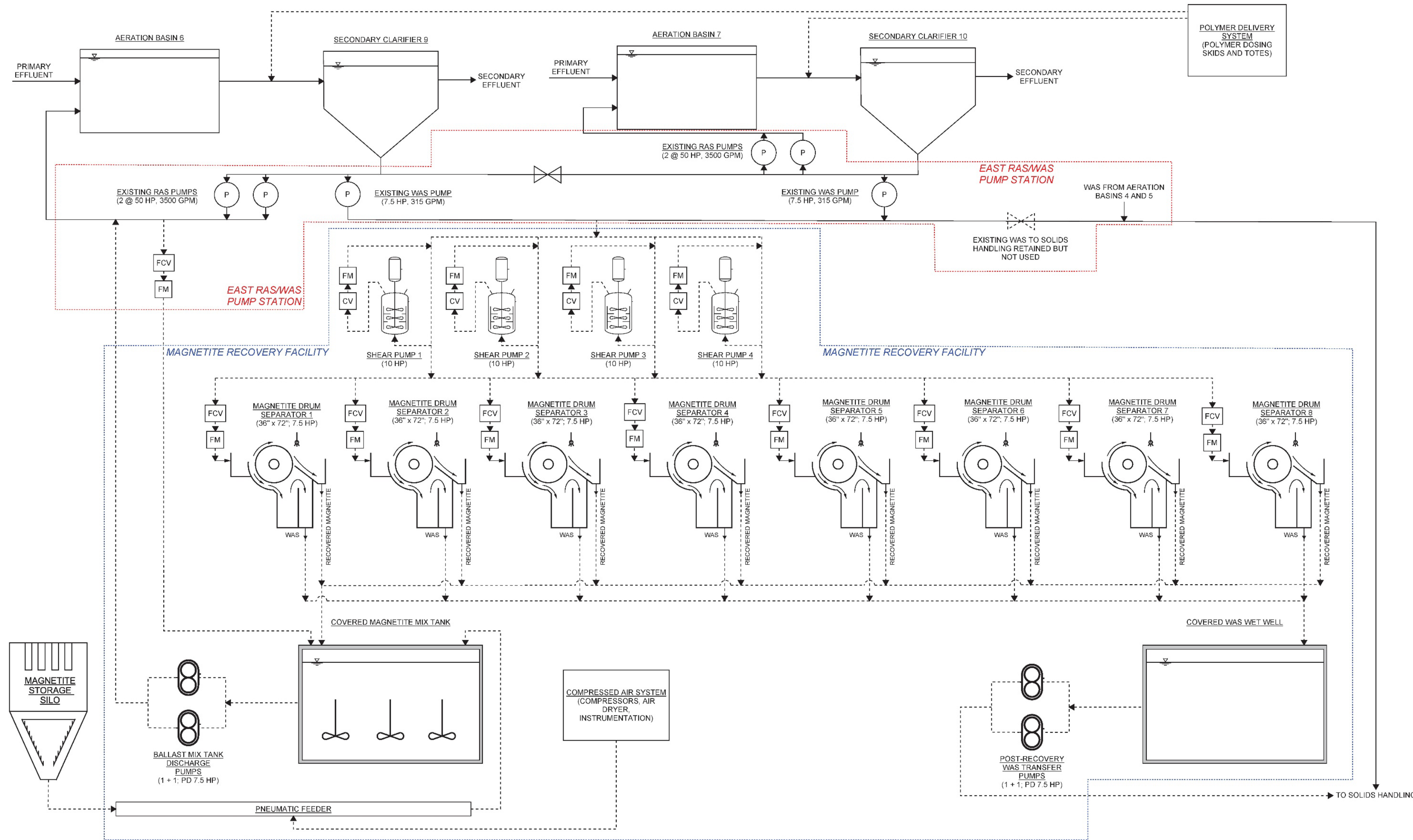


Figure 4.7 BioMag® Process Schematic

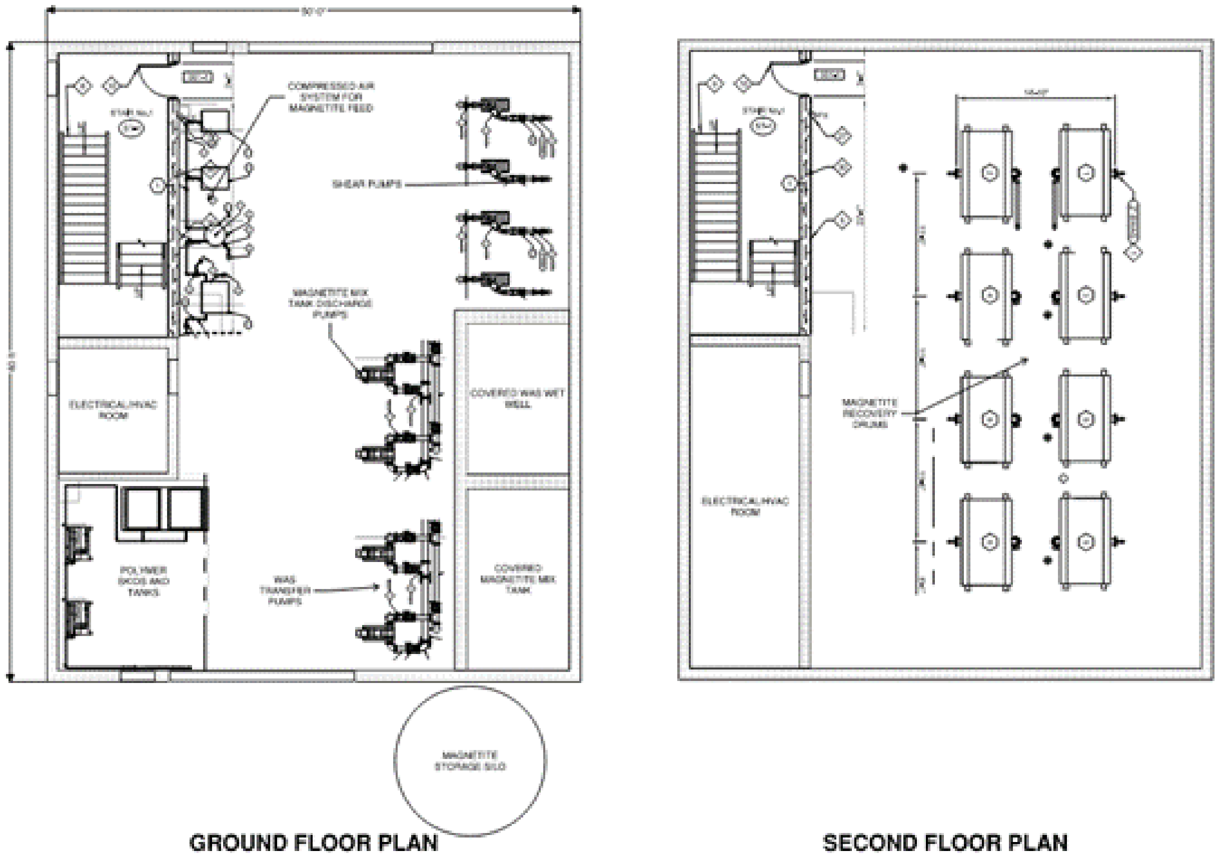


Figure 4.8 BioMag® Building Layout

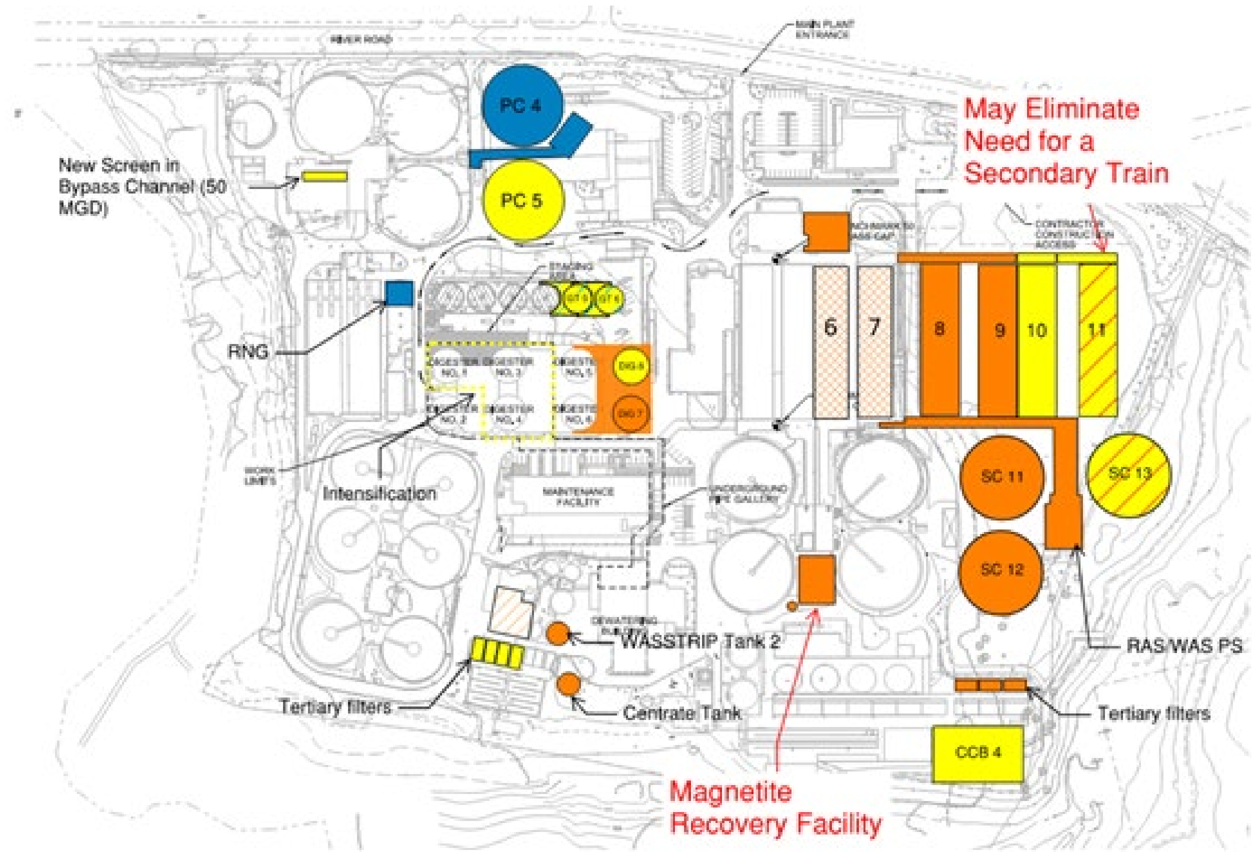


Figure 4.9 BioMag® Site Layout

Blue - currently in progress. Orange - required by 2045. Yellow - required by buildout. Orange crosshatch shows the intensified basins.

In addition to the process equipment and building costs, intensifying two aeration basins with the BioMag® process would also require modifications to the existing diffusers, RAS pumping, and piping. In addition to these capital costs, the BioMag® process requires continual dosing of magnetite. The lost magnetite will make its way through the solids process and will result in increased solids hauling costs. Additionally, Evoqua recommends planning on a polymer dosing system to improve effluent solids concentrations from the secondary clarifiers. Planning level capital costs were developed for intensification of two trains with the BioMag® process and are summarized in Table 4.1. Additional detail on these costs can be found in Appendix 4A. Additionally, Table 4.1 summarizes the annual cost of the magnetite, polymer and solids hauling cost.

Table 4.2 Planning Level Costs to Intensify Two Trains with BioMag®

Component	Cost(1)
Capital Cost	
Process Equipment	$18M
Building	$4M
Aeration Basin Improvements	$1.5M
Ancillary Improvements	$2.7M
Total Capital Cost	$27M
Annual Operating Costs for Chemical and Sludge Handling(2)	$0.4M

Notes:
M - million
(1) The costs estimate herein is based on our perception of current conditions at this location. The estimate reflects our professional opinion of accurate costs at the time and is subject to change as the project matures. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a “class 5” estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated construction costs are prepared consistent with the 20-City Engineering News-Record (ENR) Construction Cost Index (CCI) value of 13,500. Construction costs do not include the cost of piles and include 30% for contingency, 12% for contractor overhead and profit and 10% for general conditions.
(2) Annual operating costs assume 2,079 ppd of magnetite required at a cost of $650 per ton; 150 ppd of polymer at a cost of $2.50 per pound; and 2,079 ppd of additional sludge hauled at a cost of $19.34 per wet ton, assuming a solids content of 20%.

Intensifying two basins at Rock Creek with the BioMag® process has the following benefits and drawbacks:

- Benefits:
  - Intensifying two aeration basins should provide approximately 70 percent of the capacity of one aeration basin and secondary clarifier.
  - Can save up to six months on the construction schedule.
- Drawbacks:
  - Mechanically complex and operationally intensive.
  - Requires continual replenishment of the ballast.
  - BioMag® is not proven to be compatible with a biological phosphorus removal (BPR) process.
  - Intensifying existing basins that are not seismically resilient does not increase the seismic resiliency of the WRRF.

4.3.2.3 inDENSE®

inDENSE® is a process that allows for a higher biomass concentration than conventional suspended growth by physically improving settling velocities by selecting for dense floc. This is accomplished by sending the WAS through a hydrocyclone. The denser material from the hydrocyclone is returned back into the RAS, while the less dense floc is wasted as WAS. Full scale installations have found that the inDENSE® process can reduce the SVI to 80 mL/g. Additionally, since the phosphorus accumulating organisms (PAO) form a dense floc, separating the WAS with a hydrocyclone can help keep the PAO population in the aeration basins. A sample process schematic is shown in Figure 4.10.

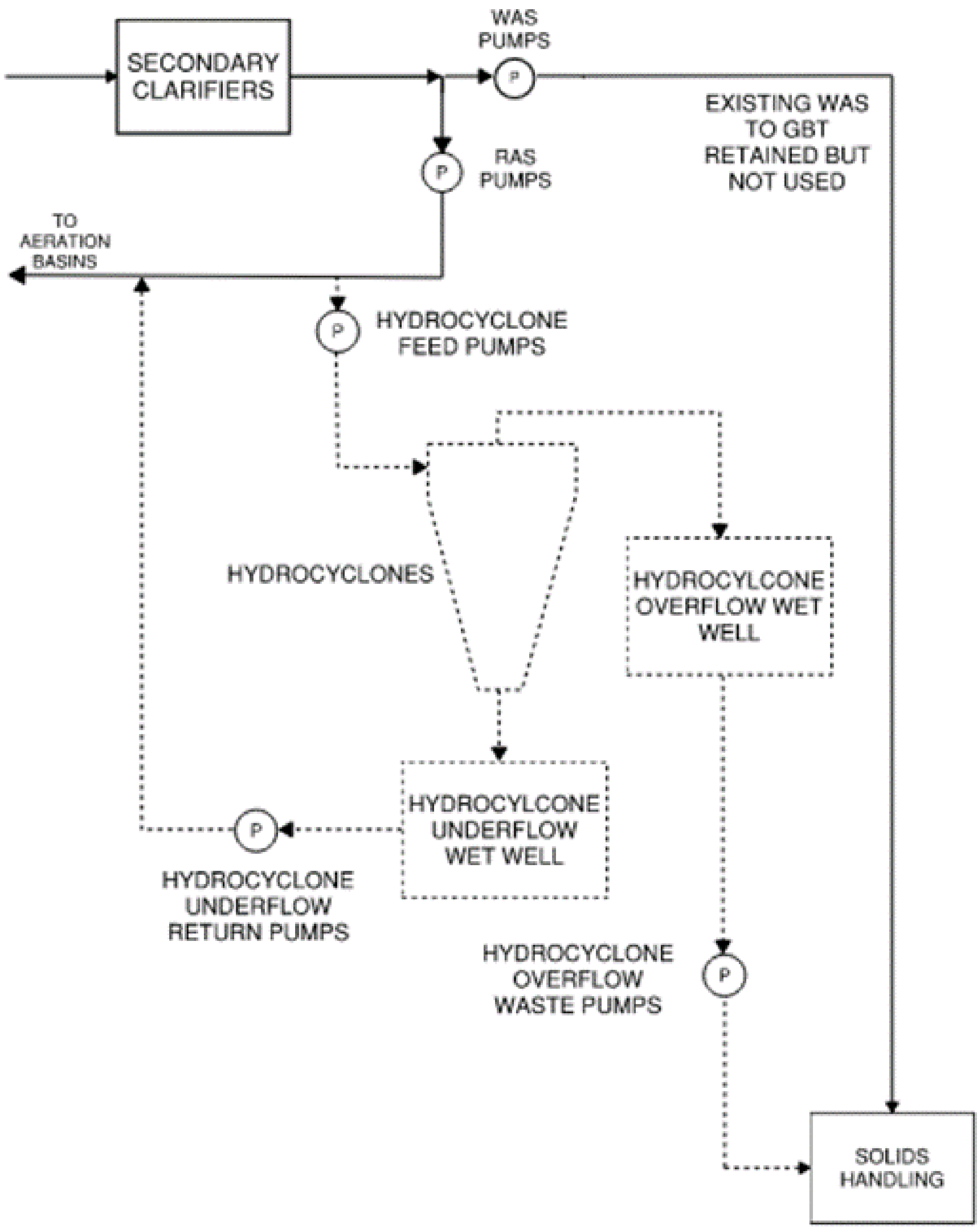


Figure 4.10 inDENSE® Process Schematic

inDENSE® provided an estimated price and capacity benefit for intensifying Aeration Basins 6 and 7. Based on the information provided by inDENSE®, intensifying two aeration basins would require:

- Two skids each with five hydrocyclones.
- Three hydrocyclone underflow transfer pumps.
- Three WAS transfer pumps.

Figure 4.11 shows how this equipment could be configured within a two story, 30-foot-by-50-foot building with a mezzanine.

inDENSE® could not provide an estimate for the capacity improvements at Rock Creek. However, based on an assumed improvement in SVI from 125 mL/g to 80 mL/g during the summer, inDENSE® could provide the equivalent capacity of 30 percent of an aeration basin and secondary clarifier. With this limited capacity saving, it is estimated that intensifying two aeration basin trains with inDENSE® will not change the total number of aeration basins and clarifiers required by buildout as is shown in Figure 4.12.

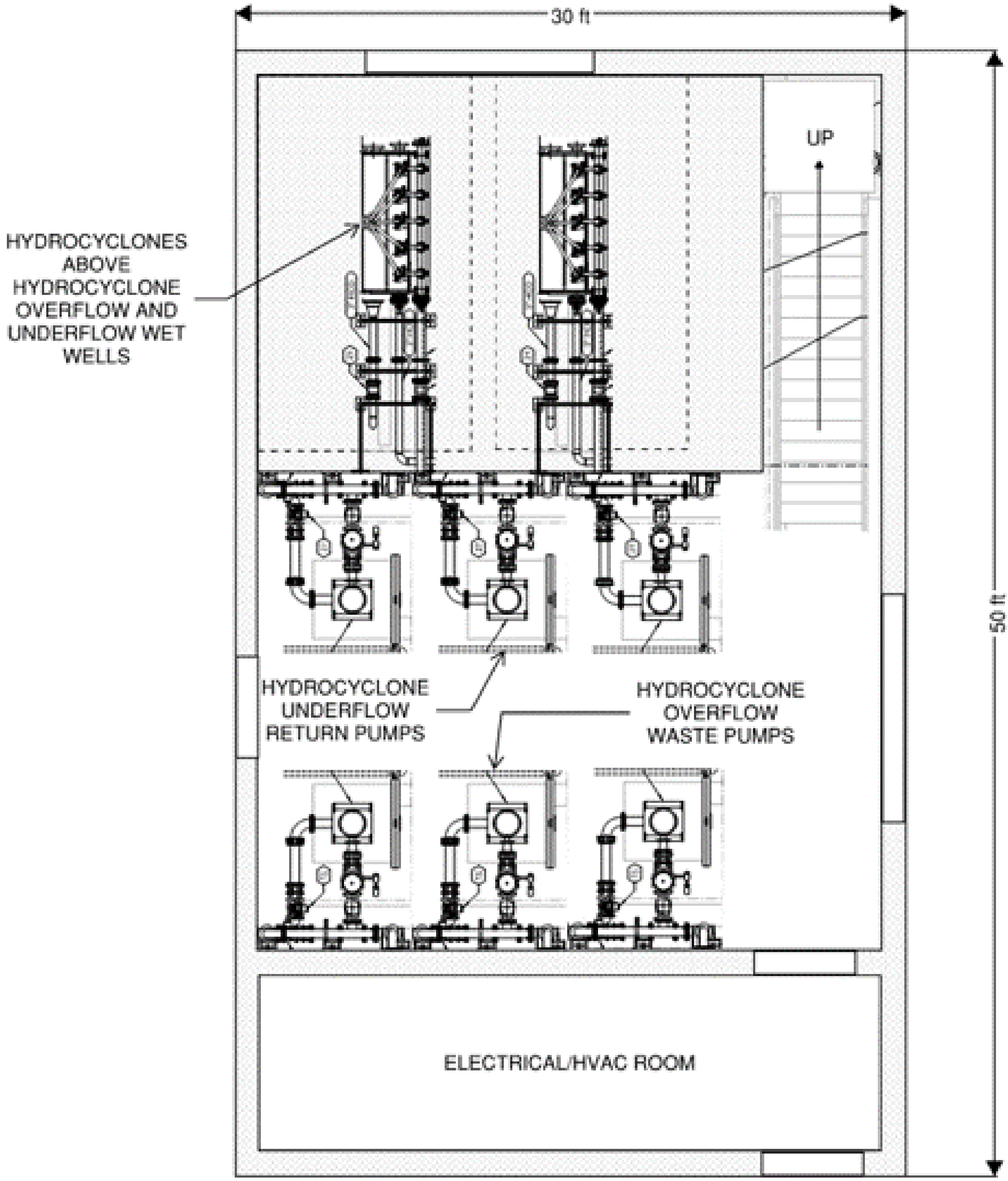


Figure 4.11 inDENSE® Building Layout

In addition to the process equipment and building costs, intensifying two aeration basins with inDENSE® would also require modifications to the existing diffusers, RAS pumping, and piping. The inDENSE® process does not require any chemicals and is not anticipated to increase the amount of sludge hauled. Planning level capital costs were developed for intensification of two trains with the inDENSE® process and are summarized in Table 4.2. Additional detail on these costs can be found in Appendix 4A.

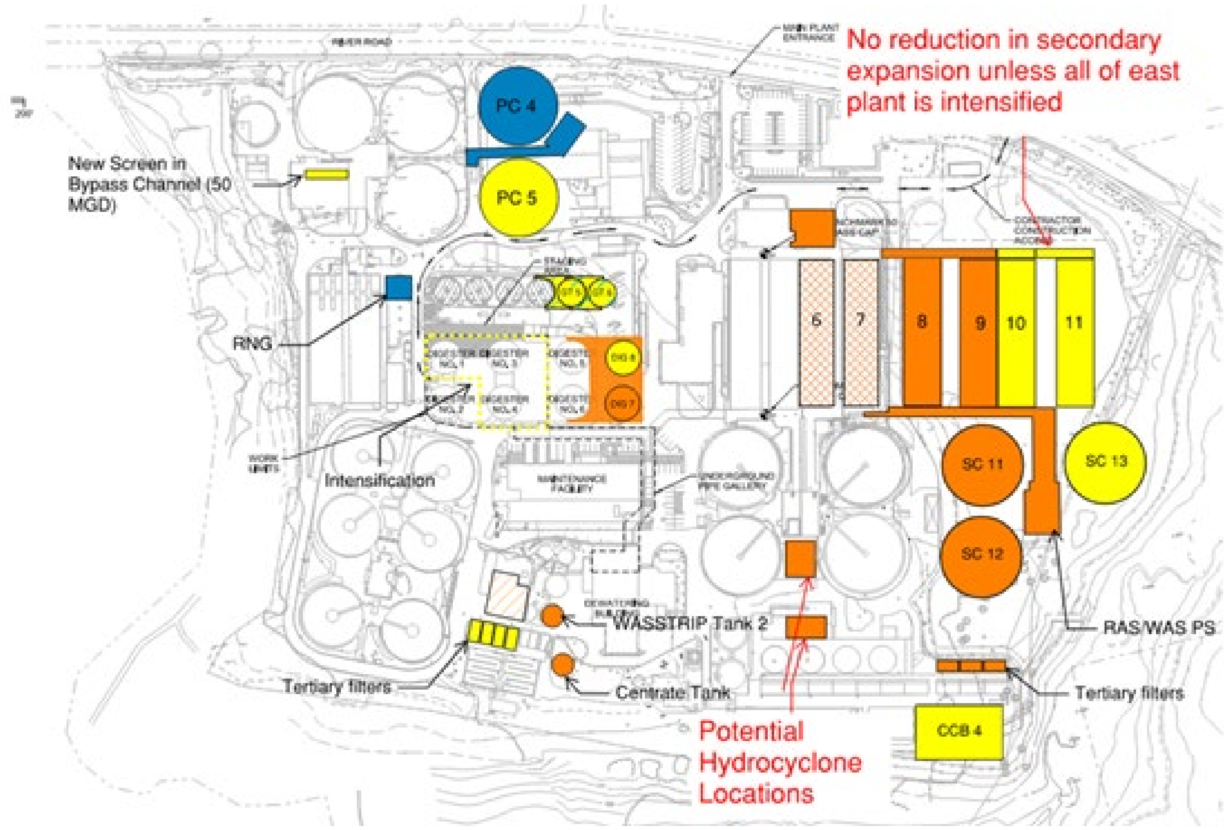


Figure 4.12 inDENSE® Site Layout

Blue - currently in progress. Orange - required by 2045. Yellow - required by buildout. Orange crosshatch shows the intensified basins.

Intensifying two basins at Rock Creek with the inDENSE® process has the following benefits and drawbacks:

- Benefits:
  - If inDENSE® can reliably improve the SVI to approximately 80 mL/g, intensifying two aeration basins should provide approximately 30 percent of the capacity of one aeration basin and secondary clarifier.
  - Compatible with a BPR process.
  - Shown to improve process stability.
  - Not as mechanically complex as BioMag®.
  - No ballast material or chemicals required.
  - Simpler to integrate into new basin design.
- Drawbacks:
  - Requires pilot testing to confirm capacity increase.

Table 4.3 Planning Level Costs to Intensify Two Trains with inDENSE®

Component	Cost(1)
Capital Cost	
Process Equipment	$3.4M
Building	$1M
Aeration Basin Improvements	$1.8M
Miscellaneous Additional Improvements	$1.9M
Total Capital Cost	$8.5M
Annual Operating Costs for Chemical and Sludge Handling	$0M

Notes:
(1) The costs estimate herein is based on our perception of current conditions at this location. The estimate reflects our professional opinion of accurate costs at the time and is subject to change as the project matures. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (AACE, 1998) designation as a "class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated construction costs are prepared consistent with the 20-City ENR CCI value of 13,500. Construction costs do not include the cost of piles and include 30% for contingency, 12% for contractor overhead and profit and 10% for general conditions.

4.3.2.4 Secondary Expansion Alternatives Comparison

Intensifying two aeration basin trains with BioMag® has the potential to increase the secondary capacity equivalent to approximately 70 percent of one new secondary train while inDENSE® has the potential to provide the equivalent capacity of 30 percent of a new secondary train. With the CBOD load projections from Intel during CAMP®, the current secondary process was expected to provide sufficient capacity through approximately 2028. Intensification with inDENSE® could extend the capacity of the existing basins by approximately three years to the year 2030, intensification with BioMag® could extend the capacity of the existing basins by approximately seven years to 2034, and construction of a new conventional aeration basin and secondary clarifier train could extend the capacity of the secondary system to the year 2037 as is shown in Figure 4.13.

However, the District received revised projections from Intel in December 2022 that lowered the projected loads initially provided in February 2022. With the revised loading projections, the current secondary process is expected to provide sufficient capacity through approximately year 2033. Intensifying two aeration basin trains with inDENSE® can extend that capacity to approximately year 2036, while BioMag® could extend that capacity to approximately year 2040 and construction of a conventional aeration basin train could provide capacity through the year 2043.

Table 4.3 summarizes a comparison of capital, chemical, and sludge hauling O&M costs and the 20-year NPV. The alternative with the lowest capital cost is inDENSE®. However, this alternative also provides the smallest anticipated increase in capacity. Both the BioMag® and conventional options have similar NPV costs, with the conventional expansion providing the most capacity. The alternative with the anticipated lowest unit NPV (the NPV divided by the capacity gain in terms of aeration basins) is the inDENSE® process.

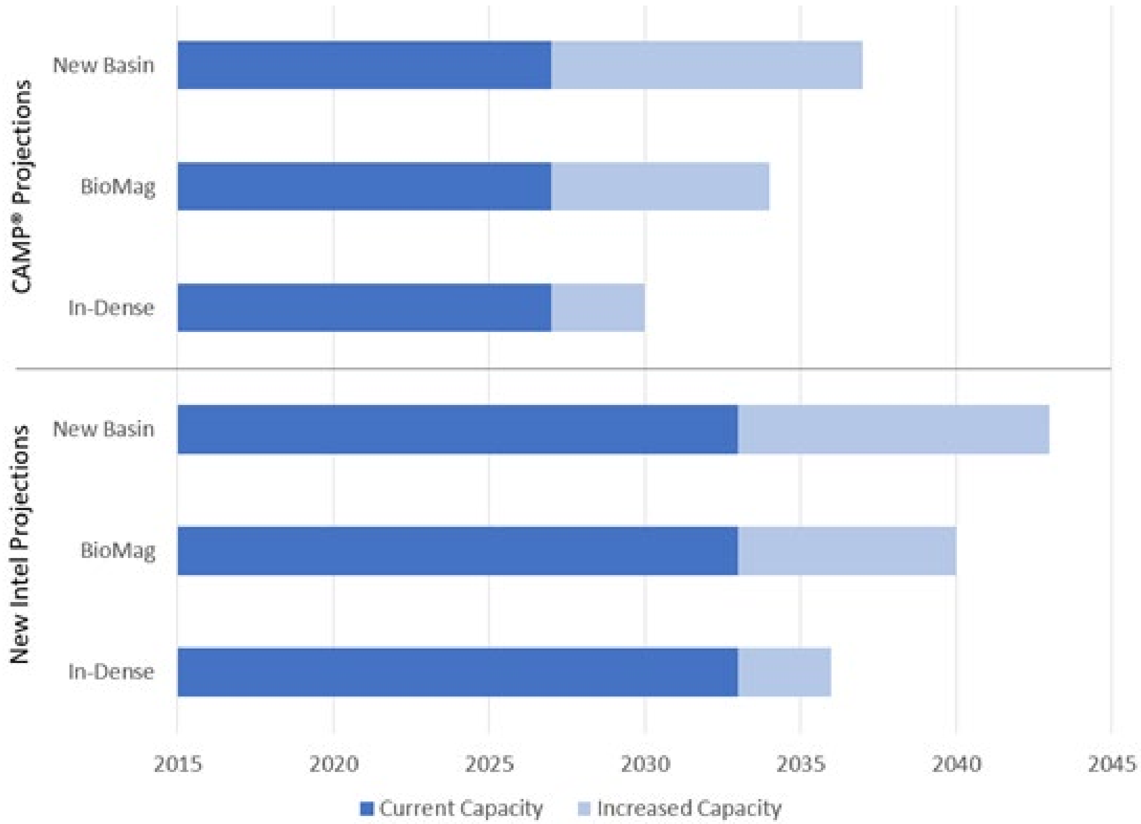


Figure 4.13 Secondary Expansion Capacity Timing Comparison

Table 4.4 Planning Level Costs And Non-Cost Comparison

	Conventional	BioMag®	inDENSE®
Construction Cost(1)	$33M	$26.6M	$8.5M
Annual O&M Difference(2)	$0	$0.4M	$0
NPV of O&M Difference(3)	$0	$7M	$0
NPV	$33M	$33.5M	$8.5M
Capacity (% of Aeration Basin 8)	100%	70%	30%
Unit NPV Cost(4)	$33M	$47.8M	$28.2M
Proven Performance	+	+	??
O&M Complexity	+	-	+
Facilitates Seismic Resiliency	+	-	-
Ability to Meet Schedule	+	+	+

Notes:
(1) The costs estimate herein is based on our perception of current conditions at this location. The estimate reflects our professional opinion of accurate costs at the time and is subject to change as the project matures. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (AACE, 1998) designation as a "class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated construction costs are prepared consistent with the 20-City ENR CCI value of 13,500. Construction costs do not include the cost of piles and include 30% for contingency, 12% for contractor overhead and profit and 10% for general conditions.
(2) O&M costs include chemical and sludge hauling costs.
(3) NPV based on 20 years with a net discount rate of 2%.
(4) Unit NPV cost determined by dividing the calculated NPV by the percent of an aeration basin capacity provided.

Of these alternatives, conventional expansion and BioMag® can provide a reasonably accurate estimate of the capacity gain, while inDENSE® requires piloting to confirm capacity gains. The O&M complexity of the inDENSE® process is similar to a conventional process, while the BioMag® process has a higher O&M complexity. Since both the BioMag® and inDENSE® intensification process would be done on aeration basins that do not have seismic resiliency, neither of these processes would increase the seismic resiliency of the plant, while a new aeration basin train could be designed on piles and could increase the plant's seismic resiliency. All three of these alternatives could be constructed and operational by the year 2027, which was the year in which additional capacity would be required with the original Intel growth projections.

4.4 Recommendation

Conventional expansion is preferable and recommended over intensification with BioMag®. The conventional expansion will include three-pass, multi-purpose basins and 150-foot diameter secondary clarifiers. Additionally, with a lower unit NPV for inDENSE® and the potential benefits to process stability, it is recommended that a try-and-buy pilot with inDENSE® be explored to confirm performance and capacity improvements. Even though conventional expansion provides sufficient capacity through buildout, it is recommended to reserve space on the site for future intensification technologies that may become available in the future.

APPENDIX 4A DETAILED COST INFORMATION

carollo Engineers...Working Wonders With Water®

PROJECT SUMMARY

Project:	**BioMag Intensification of ABs 6 and 7 at Rock Creek**	**Estimate Class:**	**5**
Client:	**Clean Water Services**	**PIC:**	**Brian Matson**
Location:	**Hillsboro, OR**	**PM:**	**Brian Matson**
Zip Code:		**Date:**	**12/12/2022**
Carollo Job #		**By:**	**Nick Guho**
		Reviewed:	**Matt Sprick**

NO.	Description		Cost
	Biomag Recovery Facility		
	Construction difficulty allowance		
	Shoring, dewatering, etc.		$ 250,000
	Building		$ 2,429,275
	Process		
	BioMag package (Evoqua Proposal)[1]		$ 9,752,000
	WAS wet well[2]		$ 233,572
	Magnetite mix tank[2]		$ 233,572
	Magnetite mix tank feed pumps[1]		$ 212,794
	Polymer skids[1]		$ 370,516
	Initial magnetite charge		
	Raw material		$ 117,838
	Freight		$ 5,000
	Odor control		
	Equipment		$ 100,100
	AB 6/7 improvements		
	Install 2000 additional diffusers in the ABs[1]		$ 265,772
	Upgrade RAS pumps (4 at 10 hp)[1]		$ 360,000
	Upgrade RAS pipes[1]		$ 285,000
	Yard piping		
	Yard piping		$ 1,370,467
	TOTAL DIRECT COST		**$ 15,985,905**
	Contingency	30.0%	$ 4,796,000
		Subtotal	$ 20,781,905
	General Conditions (mobilization, permits, bonds/insurance, etc.)	10.0%	$ 2,078,000
		Subtotal	$ 22,859,905
	Sales Tax (Applied to 50% of Total Direct Cost)	0.0%	$ -
		Subtotal	$ 22,859,905
	General Contractor Overhead and Profit	12.0%	$ 2,743,000
		Subtotal	$ 25,602,905
	Escalation to Mid-Point (3% per year)	2.0%	$1,034,000
	TOTAL ESTIMATED CONSTRUCTION COST		**$26,636,905**

Notes:

1. Includes instalation, electrical and instrumentation and control along with piping and apprutenances.
2. Includes electrical and instrumentation and control.
3. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

ROCK CREEK WWTP

HILLSBORO, OR

BIOMAG™ CONCEPTUAL PROPOSAL (WEST SIDE)

CAROLLO

December 2022

Evoqua Sales Contact:

Brett Woods
brett.woods@evoqua.com

CONTENTS

1. Introduction

Evoqua Water Technologies is pleased to present a preliminary BioMag system proposal. The BioMag system is a treatment intensification process using magnetite to ballast the biological flocs in an activated sludge process. This high-density ballast material increases the settling rate of the flocs allowing the plant to operate at elevated mixed liquor concentrations, treating more within a smaller footprint, while still achieving excellent effluent quality.

The treatment goals for this facility, in applying the BioMag system, are to:

- increase plant capacity.
- eliminate need for additional tank footprint.
- handle peak flows more reliably.

Figure 1 below is a process flow diagram showing how the components of a BioMag system are typically integrated into the RAS and WAS lines of the main secondary treatment process of a plant.

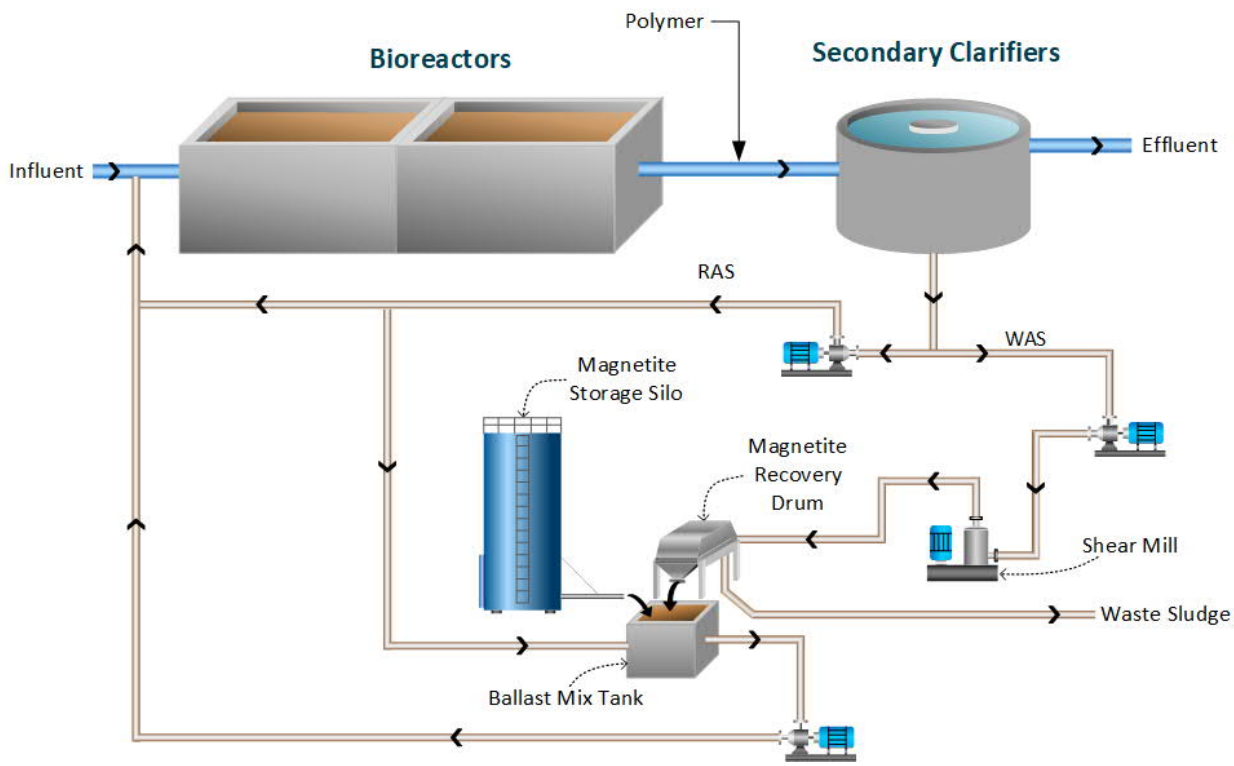


Figure 1: Typical BioMag process flow diagram.

2. Magnetite

Magnetite is a ferrimagnetic, iron oxide with chemical formula Fe_3O_4. It has a dark gray to black color and is chemically inert. Magnetite is a high-density material with a specific gravity ranging from 4.8 to 5.2 and is strongly attracted to magnets. The magnetite material used as part of the BioMag system is graded for a specific particle size range, optimized for embedment into the biological flocs of the activated sludge process. The high density and magnetic properties are key to the BioMag system. The high density leads to increased settling rates and the attraction to magnets allows the material to be recovered and reused.

Figure 2: Sample of magnetite material used with the BioMag system.

3. Design Criteria

Table 1 summarizes the design flows used as the basis for the proposed BioMag system.

Table 1: West side design flows.

Parameter	Unit	Winter	Summer
Avg/MMF Flow	MGD	47.5	27.5
Peak Flow	MGD	76.238	36.612

Table 2 summarizes the design effluent water quality from the primary clarifiers used as the basis for the proposed BioMag system.

Table 2: Design primary clarifier effluent water quality.

Parameter	Unit	Winter	Summer
Biochemical Oxygen Demand (BOD_5)	mg/L	98.1	156.7
Total Suspended Solids (TSS)	mg/L	91.1	81.6
Ammonia Nitrogen (NH_3-N)	mg/L	15.3	30.7
Total Kjeldahl Nitrogen (TKN)	mg/L	24.3	47.4

Parameter	Unit	Winter	Summer
Total Phosphorus (TP)	mg/L	3.4	6.7
Alkalinity (assumed)	mg/L as $CaCO_3$	350	350
Max Influent Temperature (assumed)	°C	20	20
Min Influent Temperature (assumed)	°C	15	15

Table 3 summarizes the effluent performance requirements used as the basis for the proposed BioMag system. These values are based on the current performance of the plant and may not reflect the actual permit requirements of the plant. Evoqua can provide effluent performance guarantees upon request depending on the scope of supply from Evoqua. An effluent guarantee for biologically treated parameters such as BOD, ammonia, and TN can be provided if the biological treatment system design, equipment, and controls are provided by Evoqua. If the scope of supply by Evoqua is limited to the BioMag feed and recovery system, as outlined in this proposal, Evoqua can offer a performance guarantee for solids separation parameters such as effluent TSS and/or TP.

Table 3: Average effluent performance.

Parameter	Unit	Winter	Summer
BOD_5	mg/L	Not provided	Not provided
TSS	mg/L	10	10
NH_3-N	mg/L	10	0.2
Ortho-P	mg/L	N/A	0.2

4. BioMag Design Summary

Table 4 summarizes Evoqua's preliminary process parameters for the proposed BioMag system. The proposed BioMag system is based on preliminary biological sizing calculations performed by Carollo. The biological sizing used as the basis for this proposal is only an estimate and biological sizing shall be confirmed for final design.

Table 4: West side design and process parameters.

Parameter	Value
Number of treatment trains	2
Total Volume Bioreactor Volume	~2.17 MG per train
Anaerobic tank 1	31' x 31' x 21.48' SWD per train 154,415 gallons per train

Parameter	Value
Anaerobic tank 2	31' x 31' x 21.48' SWD per train 154,415 gallons per train
Anoxic tank 1	31' x 31' x 21.48' SWD per train 154,415 gallons per train
Anoxic tank 2	31' x 31' x 21.48' SWD per train 154,415 gallons per train
Aerobic tank	62' x 169.5' x 20.95' SWD per train 1,646,933 gallons per train
Aerobic SRT	Summer: ~5.5 days Winter: ~3 days
Configuration	During the summer MLR is sent back to the first anoxic zone and the system is operated in an A2O configuration with aSRTs of around 5.5 days which provides for complete nitrification. During the winter the system is operated at shorter aSRTs of 3 days and the aeration basins do not nitrify. MLR is typically not used for this condition and the system operates in an AO mode
MLSS	Summer: 5,534 mg/L Winter: 3,195 mg/L
Mixers	Existing unaerated zones have one (1) 7.5 HP, axial blade, pedestal mounted vertical shaft mixer. The equates to 48.5 HP/MG of mixing power. Pumping capacity of each mixer is 71,809 gpm which provides a bulk fluid velocity of ~10 ft/min. Based upon preliminary review, these mixers should provide sufficient mixing with BioMag.
Aeration	Existing aeration basins have fine bubble diffusers. Evoqua typically recommends 0.2-0.3 scfm/ft^2 of diffused air at design flow.
WAS	Summer: 26,587 lb/d @ 16,602 mg/L (assumes 50% RAS) Winter: 28,771 lb/d @ 9,585 mg/L (assumes 50% RAS)
RAS requirements	Existing total RAS capacity of 30 MGD is sufficient Proposal is based on 50% RAS at ADF
Number of clarifiers, existing	4
Clarifier dimensions	110' diameter x 11.74' SWD
Clarifier type	Towbro No need to change or modify existing Towbro clarifiers. Carollo would need to validate hydraulic capacity of piping and weirs.

5. Operating Costs

As a guidance and reference, Table 5 lists the main consumables associated with the BioMag system recommended for this project.

Table 5: Estimated BioMag consumables.

Item	Guidance
Magnetite consumption	2,981 – 3,388 lb/day at avg. day (≈ $0.30/lb.)
Magnetite feed/recovery equipment power	2,705 kWhr/d at avg. day
Polymer – as dry active	0.5 to 1.5 mg/L
Coagulant	As needed to meet effluent phosphorus requirement. Facility currently meets P requirement without coagulant addition

6. Additional Design Considerations

In the event that BioMag is the selected technology for this project, the following items will need to be evaluated and discussed in more detail for a finalized design:

- Aeration equipment capacity.
- Peak flow duration.
- Waste sludge pumping capacity.
- BioMag building layout and location. Approximate building footprint for the BioMag building is estimated to be 50' L x 60' W. Actual footprint can vary based on site requirements and layout preferences. The magnetite storage silo will be located outside the building.
- Biosolids wasting strategy (BioMag design assumes 24×7 wasting).
- Chemical feed system, chemical preference.

7. System Design Responsibilities

Table 6 below helps outline which parties have primary responsibility for design of the various systems involved in the upgrade of the plant with BioMag.

Table 6: Design responsibilities

Item	Primary	Guidance
Biological system sizing, design, and equipment. This includes calculation of oxygen requirements, sludge yield, sludge age and waste sludge generation.	Others	evoqua
BioMag feed and recovery system sizing, design, and equipment.	evoqua	
BioMag equipment building layout and design	Others	evoqua
Plant hydraulics, pipe sizing and pump headloss calculations.	Others	evoqua

8. Equipment Scope of Supply

Table 7 below outlines the scope of supply from Evoqua for the proposed BioMag system. All equipment or services not specified in Table 7 are to be supplied by others.

Table 7: Evoqua scope of supply.

Item	Qty	**Description**
Ballast Storage & Feed System		
Flow control valve – ballast mix tank feed	1	Motor operated plug valve
Flow meter – ballast mix tank feed	1	Mag meter
Level transmitter – ballast mix tank (tank by others)	1	Radar
High level switch – ballast mix tank (tank by others)	1	Float style
Pump – ballast mix tank discharge	1D, 1S	Positive displacement, 15 HP
Ballast mix tank mixer	4	3 HP, vertical shaft
Magnetite storage	1	25-ton outdoor silo

Item	Qty	Description
Magnetite dry feeder	1	Up to 10' long Stinger® feed pipe extending from silo to ballast mix tank
Air compressor	2 (lead/lag)	10 HP units
Air dryer	1	Heatless desiccant
Compressed air system instrumentation	1 lot	Dew point sensor, pressure switch, pressure gauge
Ballast Recovery System		
Magnetic drum separator	12	36" x 72" drum, 7.5 HP each
Shear pump	6	10 HP each
Pump – recovery system WAS feed pump	0	Use existing assuming sufficient capacity
Pump – post recovery WAS transfer pump (after magnetite recovery)	1D, 1S	Positive displacement, 15 HP
Flow control valve – mag drum feed	12	Motor operated plug valve
Flow meter – mag drum feed	12	Mag meter
Level switch – mag drum	12	Capacitance style
Speed switch – mag drum	12	Proximity style
Level transmitter – post recovery WAS sump (sump by others)	1	Radar
High level switch – post recovery WAS sump (sump by others)	1	Float style
Chemical Feed System		
Polymer feed system	0	By others
Control System Hardware		
Control panel	1	NEMA 12 control panel, HMI, PLC, I/O
Services		
Engineering support		Engineering submittals and O&M manual

Item	Qty	Description
Installation oversight, start-up, commissioning, performance testing and training		Up to 21 days

9. Budgetary Pricing

The budgetary price for the Evoqua BioMag system, as defined herein, including engineering, field services, and equipment supply is $5,950,000.

This price makes no provision for taxes, tariffs, duties, permitting fees and other fees and charges that are not made explicit above.

All pricing is quoted at FCA, Factory (full freight allowed). No taxes, regulatory fees or other costs related to the procurement and installation of the system are included.

The initial magnetite charge for the proposed system will require approximately 200-225 ton(s) of virgin magnetite at design conditions. Evoqua can provide magnetite at a cost of $650 per ton plus freight.

The scope of supply and pricing are based on Evoqua standard equipment selection, standard terms of sale and warranty terms. Any variations from these standards may affect this budgetary quotation. Additionally, please note this budgetary quotation is for review and informational purposes only and does not constitute an offer for acceptance.

Should you have any questions regarding this quotation, or would like to request a firm proposal and order form, please contact the following Evoqua Regional Representative:

Bill Reilly
Wm. H. Reilly & Co.
503-314-8386
bill@whreilly.com

Engineers...Working Wonders With Water®

PROJECT SUMMARY

Project:	**InDense Intensification of ABs 6 and 7 at Rock Creek**	**Estimate Class:** **5**
Client:	**Clean Water Services**	**PIC:** **Brian Matson**
Location:	**Hillsboro, OR**	**PM:** **Brian Matson**
Zip Code:		**Date:** **12/12/2022**
Carollo Job #		**By:** **Nick Guho**
		Reviewed: **Matt Sprick**

NO.	Description			Cost
	Hydrocyclone facility			
	Construction difficulty allowance			
	Shoring, dewatering, etc.		$	250,000
	Building		$	607,319
	Process			
	InDense Package (World Water Works Proposal)[1]		$	717,922
	Flow transmitter, influent (1/skid)[1]		$	21,601
	Electrically actuated valve (1/hydrocyclone)[1]		$	10,800
	Flow transmitter, effluent (1/skid)[1]		$	21,601
	Hydrocyclone overflow/underflow pumps[1]		$	252,207
	Instrumentation and controls			
	Per skid		$	11,180
	Per feed pump		$	23,809
	Per wet well		$	20,169
	Process piping		$	171,315
	Electrical			
	Per skid		$	331,888
	Per feed pump		$	125,961
	Per wet well		$	38,065
	Earthwork		$	7,845
	Metal stairs, guardrail, checker plate		$	94,558
	Concrete		$	131,329
	WAS feed system control modification allowance[2]		$	180,000
	Odor control			
	Equipment		$	100,100
	AB 6/7 Improvements			
	Install 2000 additional diffusers in the ABs[2]		$	132,886
	Upgrade RAS pumps[2]		$	540,000
	Upgrade RAS pipes[2]		$	380,000
	Yard piping			
	Yard piping		$	913,644
	TOTAL DIRECT COST		**$**	**5,084,198**
	Contingency	30.0%	$	1,525,000
		Subtotal	$	6,609,198
	General Conditions (mobilization, permits, bonds/insurance, e	10.0%	$	661,000
		Subtotal	$	7,270,198
	Sales Tax (Applied to 50% of Total Direct Cost)	0.0%	$	-
		Subtotal	$	7,270,198
	General Contractor Overhead and Profit	12.0%	$	872,000.00
		Subtotal	$	8,142,197.56
	Escalation to Mid-Point (3% per year)	2.0%		$329,000
	TOTAL ESTIMATED CONSTRUCTION COST			**$8,471,198**

Notes:

1. Includes instalation along with piping and apprutenances.
2. Includes instalation, electrical and instrumentation and control along with piping and apprutenances

3. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

World water works
Clean Water and Energy from Wastewater

DATE
December 15, 2022

PROPOSAL
Carollo - RockCreek East Side - inDENSE

CLIENT
Carollo - Seattle

END USER
Rockcreek, OR

REPRESENTATIVE
Kristin Faulkner, Treatment Equipment CO (TEC)-BellevueWA

DATE:	December 15, 2022
TO:	Anne Conklin, Carollo - Seattle
FROM:	Jason Boyd, World Water Works, Inc. (WWW)
CC:	Graham Hoppe, WWW
RE:	inDENSE BUDGETARY PROPOSAL

Dear Anne,

Thank you for your interest in World Water Works and our separation technologies. We have prepared this preliminary proposal for you based on the design criteria provided. Please review and we look forward to hearing back from you. We encourage you to reach out to our references to understand how others have enjoyed the experience of working with World Water Works.

The document has been organized to provide:

1) OVERVIEW
2) DESIGN BASIS
3) SCOPE OF SUPPLY
4) PRICING & DELIVERY
5) CONTRACTUAL

WWW has the technology, team and record of customer satisfaction to provide you the assurance of success and long-term value. WWW delivers:

- A passionate and technical team
- A track record of customer satisfaction
- Lasting technology that is capitally and operationally cost effective
- The ability to achieve the desired goals consistently
- An industry leading warranty and performance guarantee

We look forward to partnering with you for lasting success! Let's schedule a time in the near future to review this proposal in detail and to move on to the next steps of refining project details and developing a formal sales agreement.

Best Regards,

Jason Boyd

Jason Boyd
World Water Works, Inc.

TABLE OF CONTENTS

DESIGN BASIS

1. TECHNOLOGY OVERVIEW

inDENSE™

World Water Works inDENSE™ system increases process throughput and performance through the selection of dense sludge aggregates with improved settling rates and the promotion of enhanced biological phosphorus removal (EBPR).

inDENSE is a gravimetric selection technology that provides a method for retaining the denser biomass while wasting out the light fraction of the MLSS in the treatment system. Increased density can lead to improved settling characteristics, which allows for the prevention of biomass loss and subsequent treatment disruption, especially during wet weather scenarios.

Selection for faster settling particles, and process configuration and physical forces can encourage aerobic granular sludge. The hydrocyclones select dense granules through the underflow while the lighter solids are wasted via overflow. The use of an external selector for improving settleability and stabilizing EBPR, with or without the use of formal anaerobic selector, is a **low capital cost investment for wastewater treatment plants.** With conventional activated sludge (CAS) being the predominant wastewater treatment technology globally. One key requirement of this technology is the ability to effectively separate the liquid and solid fractions. Floating or bulking sludge, at least temporarily, has affected the treatment capacity and performance of many of these facilities. World Water Works' inDENSE technology solves this problem.

In the operation of the CAS process, the treated wastewater is separated from the biomass after having passed through the biological reactor basins. In the secondary clarifiers, the activated sludge solids separate via gravity and settle to the bottom while the treated water is discharged through the effluent launder. To maintain the process, a large portion of the sludge is returned to the biological reactor basins as return activated sludge (RAS). This maintains the proper food to mass (F/M) ratio and solids retention time (SRT) to assure proper biological performance. The remainder of the sludge is removed from the process as waste activated sludge (WAS) and is disposed of via digesting, dewatering and/or otherwise handled.

Filamentous and other undesirable bacteria with poor settling properties can become more abundant and outcompete other desirable bacteria, negatively impacting settling. Poor settleability prevents the appropriate operation of the overall CAS system, leading to possible permit violations. Furthermore, by preferentially selecting for the denser bacteria, organisms such as PAOs are naturally selected. This provides the opportunity to achieve EBPR in the existing system for chemical-free phosphorous removal.

Benefits

- Achieves bio-P without process change
- Allows for denser sludge selection
- Solution for poor settling MLSS
- Reduced and/or eliminated chemistry
- Easily integrated into any existing plant
- Rapid return on investment
- Minimization of sludge loss
- Operational stability

2. DESIGN BASIS

It is critical that the basis of design is accurate and meets the facility's current and future demands. The following information relates to the design basis used for this proposal. Any changes will likely impact design and costs.

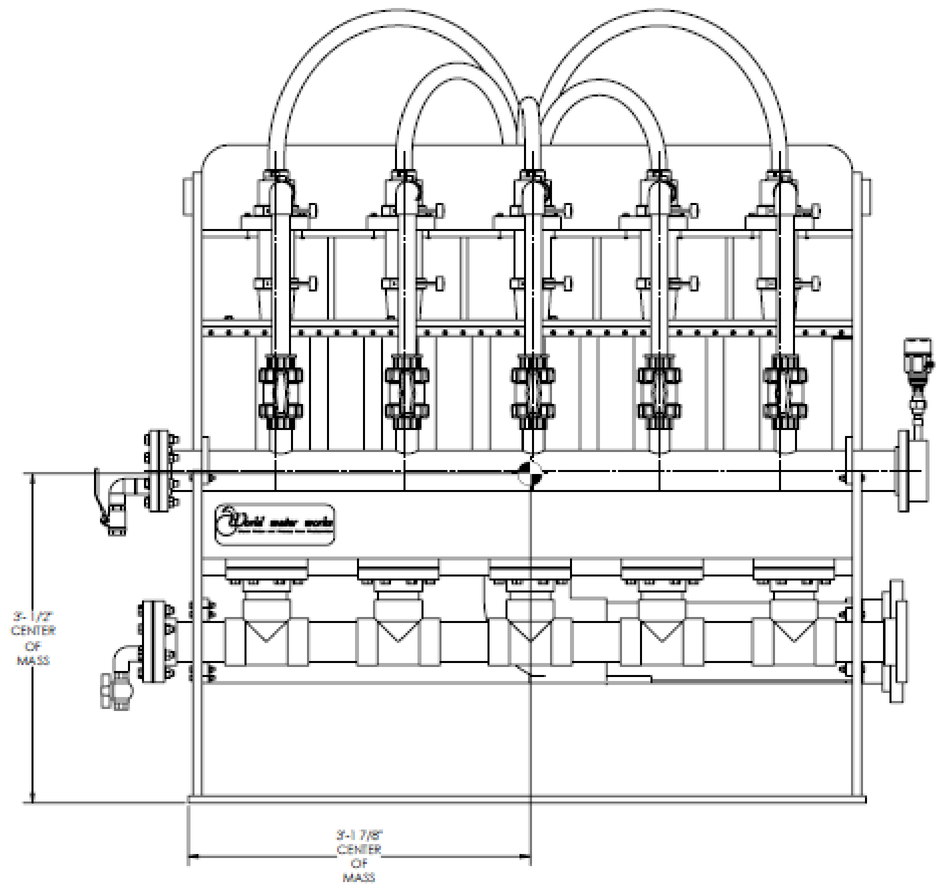
WAS Design Information:

Wasting Operational (hours/day):	24
Minimum WAS Rate (GPD):	150,000
Average WAS Rate (GPD):	170,000
Maximum WAS Rate (GPD):	190,000
Minimum WAS Concentration (mg/L):	9,155
Average WAS Concentration (mg/L):	10,500
Maximum WAS Concentration (mg/L):	11,933
Minimum WAS Concentration (lb/day):	16,900
Average WAS Concentration (lb/day):	15,750
Maximum WAS Concentration (lb/day):	14,630

inDENSE Design Scenarios:

Scenario	Influent	Overflow	Underflow	Cyclones in Service
1	176 GPM	141 GPM	35 GPM	4
	17,631 lb/day	11,460 lb/day	6,171 lb/day	22 hr/day
2	220 GPM	176 GPM	44 GPM	5
	26,045 lb/day	16,930 lb/day	9,116 lb/day	20 hr/day
3	220 GPM	176 GPM	44 GPM	5
	22,333 lb/day	14,516 lb/day	7,817 lb/day	22 hr/day
4	220 GPM	176 GPM	44 GPM	5
	25,614 lb/day	16,649 lb/day	8,965 lb/day	22 hr/day
DESIGN	220 GPM	176 GPM	44 GPM	5
	22,333 lb/day	14,516 lb/day	7,817 lb/day	22 hr/day

inDENSE Skid Drawing:



WWW reserves the right to change product design and specification at anytime without notice. All pictures shown are for illustration purposes only and the actual product design may vary due to product enhancement. Please contact our sales department to ask if an image is current.

SCOPE OF SUPPLY

3. SCOPE DOCUMENT

The below model numbers and equipment selection is based upon the information and data provided. In order to provide this proposal, certain assumptions were made. For example, items as transfer pump designs, blower designs and VFDs (where applicable) may be adjusted based upon final layouts, head pressures and other elements that could impact the selections.

Project Mgt, Eng & Design				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	DRAW-BP	Process Engineering, Design & Project Management	Drawing Package - Basic Package - IS Project	WWW

inDENSE Skid				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	inDEN-PT	Pressure Transmitter (Ships Loose)	inDENSE Cyclone Pressure Transmitter, 0-10 bar	WWW
5	CYC-3-10	inDENSE Cyclone	Hydrocyclone - 3 inch - 10 m3/hr (2.1 Bar Pressure Requirement)	WWW
1	Lot	Spigots		WWW
1	inDEN-SKID-50	Mounting Structure	inDENSE Cyclone Mounting Skid - Five 10 m3/hr Cyclones	WWW

QC & Shipping				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	QCSH-	Factory QA/QC		WWW
1	QCSH-	FOB Destination (Off-Loading BY OTHERS)		WWW

Startup and Training				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	SERV-FSO-3M	Startup and Training Services	Field Service - 3 Days On Site, 2 Travel Days, 1 Trip, Expenses Included	WWW

4. UTILITIES (To Be Provided By Others; Subject to Final Design)

POWER	
High Voltage Power	460V, 3 Phase, TBD Amps
Control Power	24 VDC
Low Voltage Power	
Ancillary	110 V, 1 Phase 20 Amp
Chemical Feed(s)	110 V, 1 Phase 20 Amp

5. DRAFTING ENGINEERING SERVICES

World Water Works offers a variety of drafting and engineering package options from basic packages to full design/build engineering packages. Based upon the scope of supply and client discussions the following package has been selected. Please let us know if a different level of drawings and engineering services are required.

Basic Integrated Solution Engineering Package (limited to WWW's Scope of supply)

The Basic Integrated Solution Engineering Package includes:

- Piping & Instrument Diagrams (P&ID) for all unit processes of equipment provided
- General Equipment Layouts for all equipment provided within scope of supply
- Electrical Panel Layouts and PLC panels (if applicable)
- Equipment Cut Sheets

6. FACTORY TESTING – QUALITY CONTROL

World Water Works conducts numerous tests over the course of the manufacturing process to meet the highest of quality standards. WWW documents and keeps on record these tests, which are available to our clients. WWW invites the engineer and/or the client to witness this testing in Oklahoma City, OK.

7. FIELD SUPPORT, STARTUP & TRAINING SERVICES

The success of any system relies not only in the excellence of the technology and the proper design; it also relies upon proper operational ownership. With years of experience, WWW has developed highly effective training methods to assure success. World Water Works offers a variety of field service package options that can be tailored to best meet the project needs and treatment goals. The scope of supply lists out the services provided.

Important Notice: All onsite service is based on Travel on Monday and Fridays with days on site Tuesday, Wednesday, and Thursday. If weekend travel and/or onsite service is required, additional costs will be applied. Travel is based on notification two weeks in advance to be on site for meetings, service, etc.

PRICING and DELIVERY

8. TIMELINE

Submittal Preparation	2 – 3 weeks
Equipment Construction	16 – 20 weeks after submittal approval
Inspection & Shipment	1 – 2 weeks

Note: Project delivery timing will be subject to timing of the order and timely approvals and payments by the customer. WWW manufactures its technology fully in-house, which gives us greater flexibility in meeting scheduling demands. **Please inquire about special timing requirements that may be available and potentially subject to additional fees.**

9. SHIPPING

Incoterm	FOB Destination
Shipping & Handling Terms	Freight Allowed
Desired Delivery Date	TBD

10. PAYMENT TERMS

50% Upon Drawing Approval

50% Upon Shipping

11. BUDGETARY PRICE

The following pricing is budgetary and will be finalized based upon final design and refinement of terms and options selected.

Budget Price ....$ 275,000 USD
(Startup and Training/Shipping Included)

This includes the specified equipment and services in the scope section labeled “WWW”, but are not inclusive of any of the items labeled “BY OTHERS”, “OPTIONAL”, “EXISTING”, or the responsibilities of the Customer itemized in the section below titled “CUSTOMER TO SUPPLY” and “CUSTOMER RESPONSIBILITIES”. This pricing also does not include any applicable local, state, and federal sales and use taxes, tariffs, duties, import taxes, brokerage fees, bonding, system installation costs and equipment shipping costs beyond what is stated.

CONTRACTUAL INFORMATION

12.MECHANICAL WARRANTY & PERFORMANCE GUARANTEE

Equipment will be warranted from defects in materials, workmanship and design for a period of 12 months from the date upon which the goods are used or put into operation or 18 months from shipment, whichever occurs first. Warranty is contingent upon the system being stored, installed, operated and maintained in accordance with World Water Works' instructions. Extended warranties are available for an additional cost. World Water Works will provide a Performance Guarantee based upon final design and scope mutually agreed upon.

13.CUSTOMER TO SUPPLY (Unless Otherwise Specified in This Document)

- All Costs of Installation to include, but not be limited to: System Unloading, Piping and Electrical Installation, any/all Building/Foundation work, Permitting Costs, etc.
- Sufficient room for the equipment, sufficient water, sufficient heating and/or cooling, and sufficient compressed air to meet the requirements of the project.
- All utilities, sewer and solid waste disposal systems, chemicals, and laboratory testing required to operate the system to include, but not be limited to: phone/internet, electrical power supply, potable water at proper pressures and compressed air.
- Customer shall inform Company of any third-party inspection requirements. Customer shall pay any and all charges, which may be incurred for third party approval. Licenses and permits as required.
- Personnel trainable in operation and control of system and that follows WWW's recommendations.
- The above listed materials are based on the Company's interpretation of the plans and specifications. Any changes to this proposal are subject to price revision.
- Additional Customer requirements may be defined based upon final design and scope mutually agreed upon.

14.TERMS AND CONDITIONS

WWW Standard Terms and Conditions of sale are available upon request.

World water works

Clean Water and Energy from Wastewater

DATE
December 15, 2022

PROPOSAL
Carollo - RockCreek West Side - inDENSE

CLIENT
Carollo - Seattle

END USER
Rockcreek, OR

REPRESENTATIVE
Kristin Faulkner, Treatment Equipment CO (TEC)-BellevueWA

DATE: December 15, 2022
TO: Anne Conklin, Carollo - Seattle
FROM: Jason Boyd, World Water Works, Inc. (WWW)
CC: Graham Hoppe, WWW
RE: inDENSE BUDGETARY PROPOSAL

Dear Anne,

Thank you for your interest in World Water Works and our separation technologies. We have prepared this preliminary proposal for you based on the design criteria provided. Please review and we look forward to hearing back from you. We encourage you to reach out to our references to understand how others have enjoyed the experience of working with World Water Works.

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Best Regards,

Jason Boyd

Jason Boyd
World Water Works, Inc.

1-800-607-PURE | 4000 SW 113TH STREET, OKLAHOMA CITY, OK 73173 | WWW.WORLDWATERWORKS.COM

TABLE OF CONTENTS

DESIGN BASIS

1. TECHNOLOGY OVERVIEW

inDENSE™

World Water Works inDENSE™ system increases process throughput and performance through the selection of dense sludge aggregates with improved settling rates and the promotion of enhanced biological phosphorus removal (EBPR).

inDENSE is a gravimetric selection technology that provides a method for retaining the denser biomass while wasting out the light fraction of the MLSS in the treatment system. Increased density can lead to improved settling characteristics, which allows for the prevention of biomass loss and subsequent treatment disruption, especially during wet weather scenarios.

Selection for faster settling particles, and process configuration and physical forces can encourage aerobic granular sludge. The hydrocyclones select dense granules through the underflow while the lighter solids are wasted via overflow. The use of an external selector for improving settleability and stabilizing EBPR, with or without the use of formal anaerobic selector, is a **low capital cost investment for wastewater treatment plants.** With conventional activated sludge (CAS) being the predominant wastewater treatment technology globally. One key requirement of this technology is the ability to effectively separate the liquid and solid fractions. Floating or bulking sludge, at least temporarily, has affected the treatment capacity and performance of many of these facilities. World Water Works' inDENSE technology solves this problem.

In the operation of the CAS process, the treated wastewater is separated from the biomass after having passed through the biological reactor basins. In the secondary clarifiers, the activated sludge solids separate via gravity and settle to the bottom while the treated water is discharged through the effluent launder. To maintain the process, a large portion of the sludge is returned to the biological reactor basins as return activated sludge (RAS). This maintains the proper food to mass (F/M) ratio and solids retention time (SRT) to assure proper biological performance. The remainder of the sludge is removed from the process as waste activated sludge (WAS) and is disposed of via digesting, dewatering and/or otherwise handled.

Filamentous and other undesirable bacteria with poor settling properties can become more abundant and outcompete other desirable bacteria, negatively impacting settling. Poor settleability prevents the appropriate operation of the overall CAS system, leading to possible permit violations. Furthermore, by preferentially selecting for the denser bacteria, organisms such as PAOs are naturally selected. This provides the opportunity to achieve EBPR in the existing system for chemical-free phosphorous removal.

Benefits

- Achieves bio-P without process change
- Allows for denser sludge selection
- Solution for poor settling MLSS
- Reduced and/or eliminated chemistry
- Easily integrated into any existing plant
- Rapid return on investment
- Minimization of sludge loss
- Operational stability

2. DESIGN BASIS

It is critical that the basis of design is accurate and meets the facility's current and future demands. The following information relates to the design basis used for this proposal. Any changes will likely impact design and costs.

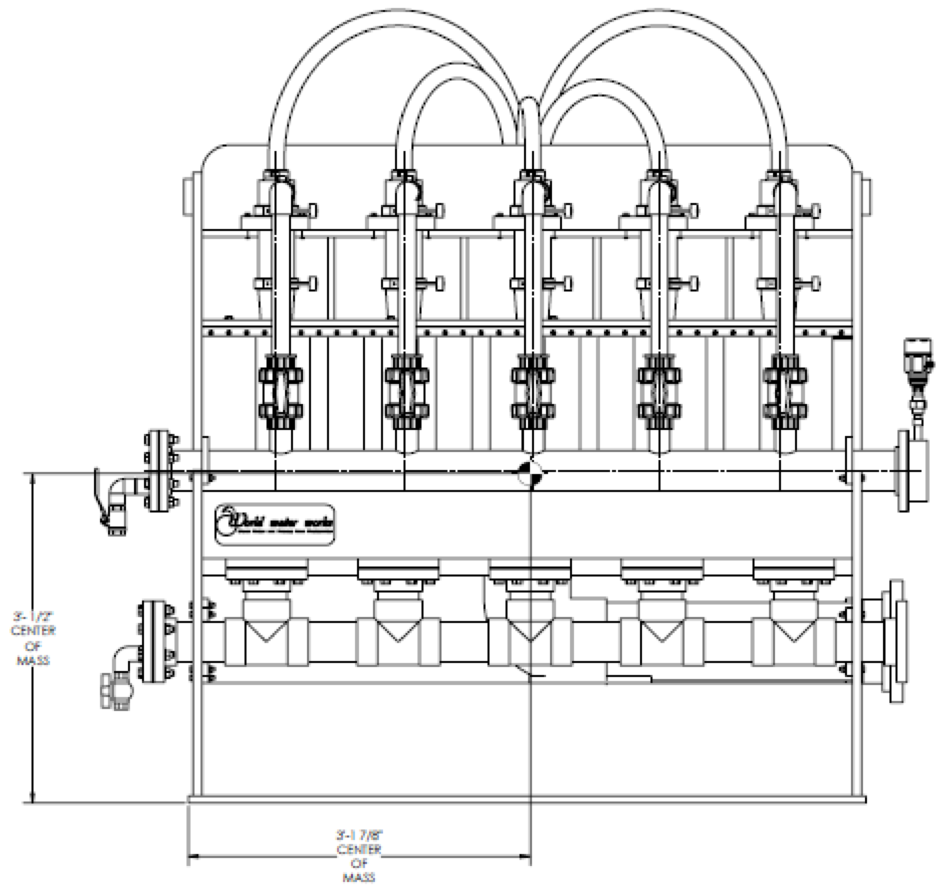
WAS Design Information:

Wasting Operational (hours/day):	24
Minimum WAS Rate (GPD):	150,000
Average WAS Rate (GPD):	190,000
Maximum WAS Rate (GPD):	360,000
Minimum WAS Concentration (mg/L):	7,755
Average WAS Concentration (mg/L):	9,400
Maximum WAS Concentration (mg/L):	11,185
Minimum WAS Concentration (lb/day):	17,900
Average WAS Concentration (lb/day):	20,500
Maximum WAS Concentration (lb/day):	23,300

inDENSE Design Scenarios:

Scenario	Influent	Overflow	Underflow	Cyclones in Service
1	176 GPM	141 GPM	35 GPM	4
	14,935 lb/day	9,708 lb/day	5,227 lb/day	22 hr/day
2	220 GPM	176 GPM	44 GPM	5
	27,285 lb/day	17,735 lb/day	9,550 lb/day	22 hr/day
3	396 GPM	317 GPM	79 GPM	9
	35,844 lb/day	23,299 lb/day	12,545 lb/day	23 hr/day
4	396 GPM	317 GPM	79 GPM	9
	43,447 lb/day	28,241 lb/day	15,207 lb/day	23 hr/day
DESIGN	396 GPM	317 GPM	79 GPM	9
	35,844 lb/day	23,299 lb/day	12,545 lb/day	23 hr/day

inDENSE Skid Drawing:



WWW reserves the right to change product design and specification at anytime without notice. All pictures shown are for illustration purposes only and the actual product design may vary due to product enhancement. Please contact our sales department to ask if an image is current.

SCOPE OF SUPPLY

3. SCOPE DOCUMENT

The below model numbers and equipment selection is based upon the information and data provided. In order to provide this proposal, certain assumptions were made. For example, items as transfer pump designs, blower designs and VFDs (where applicable) may be adjusted based upon final layouts, head pressures and other elements that could impact the selections.

Project Mgt, Eng & Design				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	DRAW-BP	Process Engineering, Design & Project Management	Drawing Package - Basic Package - IS Project	WWW

inDENSE Skid				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	inDEN-PT	Pressure Transmitter (Ships Loose)	inDENSE Cyclone Pressure Transmitter, 0-10 bar	WWW
9	CYC-3-10	inDENSE Cyclone	Hydrocyclone - 3 inch - 10 m3/hr (2.1 Bar Pressure Requirement)	WWW
1	Lot	Spigots		WWW
2	inDEN-SKID-50	Mounting Structure	inDENSE Cyclone Mounting Skid - Five 10 m3/hr Cyclones	WWW

QC & Shipping				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	QCSH-	Factory QA/QC		WWW
1	QCSH-	FOB Destination (Off-Loading BY OTHERS)		WWW

Startup and Training				
Quantity	**Model**	**Equipment Description**	**Description**	**Provided By**
1	SERV-FSO-3M	Startup and Training Services	Field Service - 3 Days On Site, 2 Travel Days, 1 Trip, Expenses Included	WWW

4. UTILITIES (To Be Provided By Others; Subject to Final Design)

POWER	
High Voltage Power	460V, 3 Phase, TBD Amps
Control Power	24 VDC
Low Voltage Power	
Ancillary	110 V, 1 Phase 20 Amp
Chemical Feed(s)	110 V, 1 Phase 20 Amp

5. DRAFTING ENGINEERING SERVICES

World Water Works offers a variety of drafting and engineering package options from basic packages to full design/build engineering packages. Based upon the scope of supply and client discussions the following package has been selected. Please let us know if a different level of drawings and engineering services are required.

Basic Integrated Solution Engineering Package (limited to WWW's Scope of supply)

The Basic Integrated Solution Engineering Package includes:

- Piping & Instrument Diagrams (P&ID) for all unit processes of equipment provided
- General Equipment Layouts for all equipment provided within scope of supply
- Electrical Panel Layouts and PLC panels (if applicable)
- Equipment Cut Sheets

6. FACTORY TESTING – QUALITY CONTROL

World Water Works conducts numerous tests over the course of the manufacturing process to meet the highest of quality standards. WWW documents and keeps on record these tests, which are available to our clients. WWW invites the engineer and/or the client to witness this testing in Oklahoma City, OK.

7. FIELD SUPPORT, STARTUP & TRAINING SERVICES

The success of any system relies not only in the excellence of the technology and the proper design; it also relies upon proper operational ownership. With years of experience, WWW has developed highly effective training methods to assure success. World Water Works offers a variety of field service package options that can be tailored to best meet the project needs and treatment goals. The scope of supply lists out the services provided.

Important Notice: All onsite service is based on Travel on Monday and Fridays with days on site Tuesday, Wednesday, and Thursday. If weekend travel and/or onsite service is required, additional costs will be applied. Travel is based on notification two weeks in advance to be on site for meetings, service, etc.

PRICING and DELIVERY

8. TIMELINE

Submittal Preparation	2 – 3 weeks
Equipment Construction	16 – 20 weeks after submittal approval
Inspection & Shipment	1 – 2 weeks

Note: Project delivery timing will be subject to timing of the order and timely approvals and payments by the customer. WWW manufactures its technology fully in-house, which gives us greater flexibility in meeting scheduling demands. **Please inquire about special timing requirements that may be available and potentially subject to additional fees.**

9. SHIPPING

Incoterm	FOB Destination
Shipping & Handling Terms	Freight Allowed
Desired Delivery Date	TBD

10.PAYMENT TERMS

50% Upon Drawing Approval

50% Upon Shipping

11.BUDGETARY PRICE

The following pricing is budgetary and will be finalized based upon final design and refinement of terms and options selected.

Budget Price ....$ 425,000 USD

(Startup and Training/Shipping Included)

This includes the specified equipment and services in the scope section labeled "WWW", but are not inclusive of any of the items labeled "BY OTHERS", "OPTIONAL", "EXISTING", or the responsibilities of the Customer itemized in the section below titled "CUSTOMER TO SUPPLY" and "CUSTOMER RESPONSIBILITIES". This pricing also does not include any applicable local, state, and federal sales and use taxes, tariffs, duties, import taxes, brokerage fees, bonding, system installation costs and equipment shipping costs beyond what is stated.

CONTRACTUAL INFORMATION

12. MECHANICAL WARRANTY & PERFORMANCE GUARANTEE

Equipment will be warranted from defects in materials, workmanship and design for a period of 12 months from the date upon which the goods are used or put into operation or 18 months from shipment, whichever occurs first. Warranty is contingent upon the system being stored, installed, operated and maintained in accordance with World Water Works' instructions. Extended warranties are available for an additional cost. World Water Works will provide a Performance Guarantee based upon final design and scope mutually agreed upon.

13. CUSTOMER TO SUPPLY (Unless Otherwise Specified in This Document)

- All Costs of Installation to include, but not be limited to: System Unloading, Piping and Electrical Installation, any/all Building/Foundation work, Permitting Costs, etc.
- Sufficient room for the equipment, sufficient water, sufficient heating and/or cooling, and sufficient compressed air to meet the requirements of the project.
- All utilities, sewer and solid waste disposal systems, chemicals, and laboratory testing required to operate the system to include, but not be limited to: phone/internet, electrical power supply, potable water at proper pressures and compressed air.
- Customer shall inform Company of any third-party inspection requirements. Customer shall pay any and all charges, which may be incurred for third party approval. Licenses and permits as required.
- Personnel trainable in operation and control of system and that follows WWW's recommendations.
- The above listed materials are based on the Company's interpretation of the plans and specifications. Any changes to this proposal are subject to price revision.
- Additional Customer requirements may be defined based upon final design and scope mutually agreed upon.

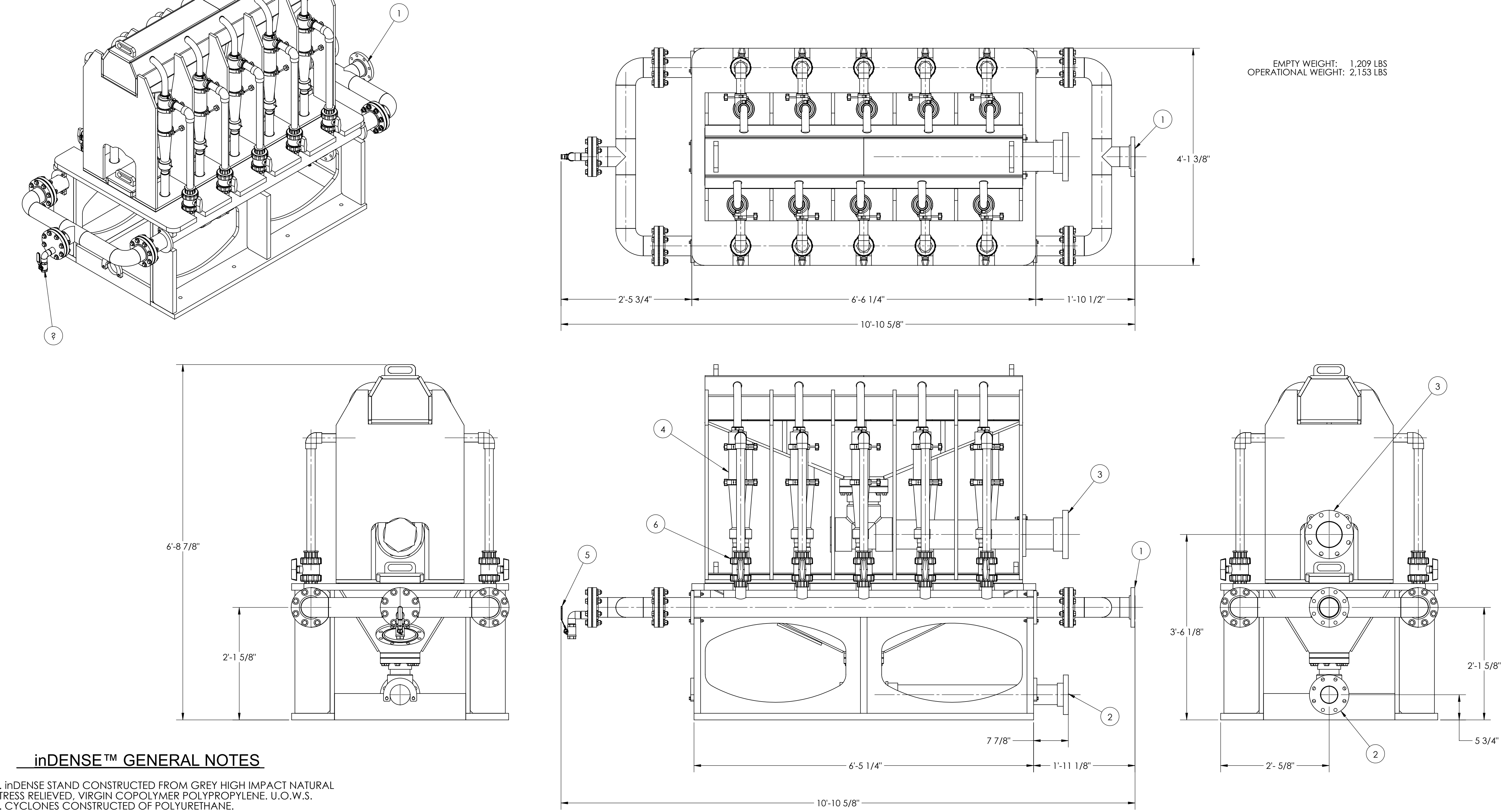
14. TERMS AND CONDITIONS

WWW Standard Terms and Conditions of sale are available upon request.

8/10 inDENSE CYCLONE

ITEM NO.	DESCRIPTION
1	FEEDFLOW, 4" FLANGE 150 LB - STAINLESS STEEL
2	UNDERFLOW, 4" FLANGE 150 LB - PVC
3	OVERFLOW, 6" FLANGE 150 LB - PVC
4	HYDROCLONE, 3" POLYURETHANE
5	SAMPLE PORTS , 1" - SS & PVC
6	ISOLATION VALVE, 2" PVC HAYWARD TRUEUNION

EMPTY WEIGHT: 1,209 LBS
OPERATIONAL WEIGHT: 2,153 LBS



inDENSE™ GENERAL NOTES

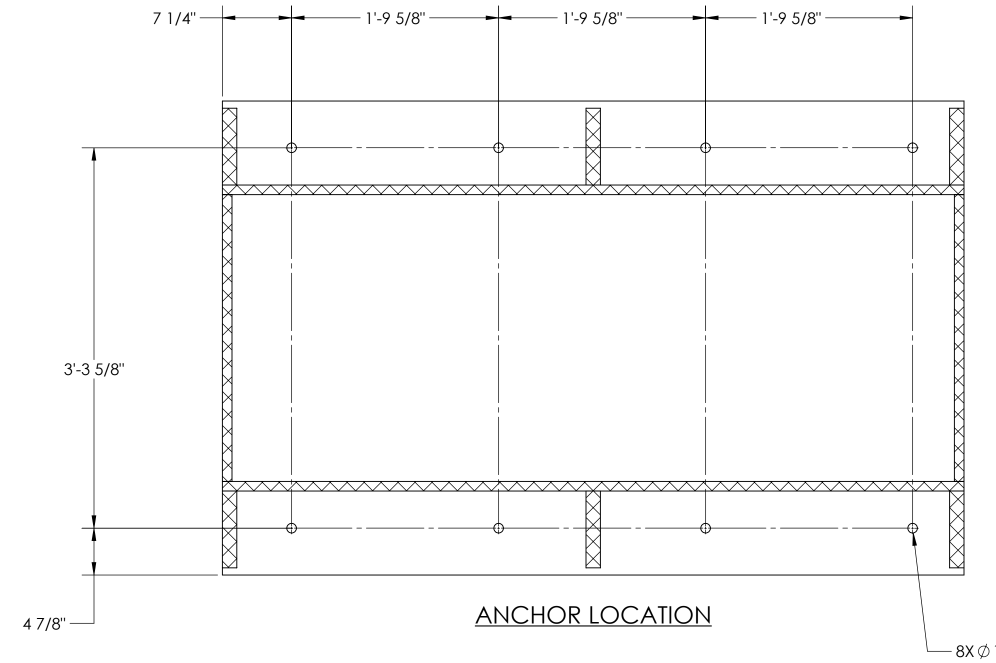
1. inDENSE STAND CONSTRUCTED FROM GREY HIGH IMPACT NATURAL STRESS RELIEVED, VIRGIN COPOLYMER POLYPROPYLENE. U.O.W.S.
2. CYCLONES CONSTRUCTED OF POLYURETHANE.
3. FLOW PER CYCLONE 44 GPM; NUMBER OF CYCLONES IN SERVICE CAN BE ADJUSTED.
4. MAXIMUM OPERATING PRESSURE 38 PSIG.
a. MAXIMUM PRESSURE FOR THE CYCLONES 40PSIG
5. MAXIMUM OPERATING TEMPERATURE NOT TO EXCEED 122 F (50 C).
6. OUTDOOR INSTALLATION WILL REQUIRE PROPER FREEZE AND UV PROTECTION.
7. OVERFLOW PIPING TO BE INSTALLED PER EFFLUENT DESIGN.
a. TO BE INSTALLED WITH EITHER LEFT HAND OR RIGHT HAND DISCHARGE.
8. ANCHOR BOLTS NOT SUPPLIED.

REV	DATE	DESCRIPTION	BY

World water works

CLIENT:
LOCATION:
FILE NAME: 10 INDENSE CYCLONE
DESCRIPTION: GENERAL ARRANGEMENT

FOR APPROVAL
P.O.#:
DRAWN BY: SS
CHECKED BY: SB
DATE: 06/21/22
SCALE: 1:12
JOB #:
DRAWING #
SHEET: 1 OF 2 SHEETS



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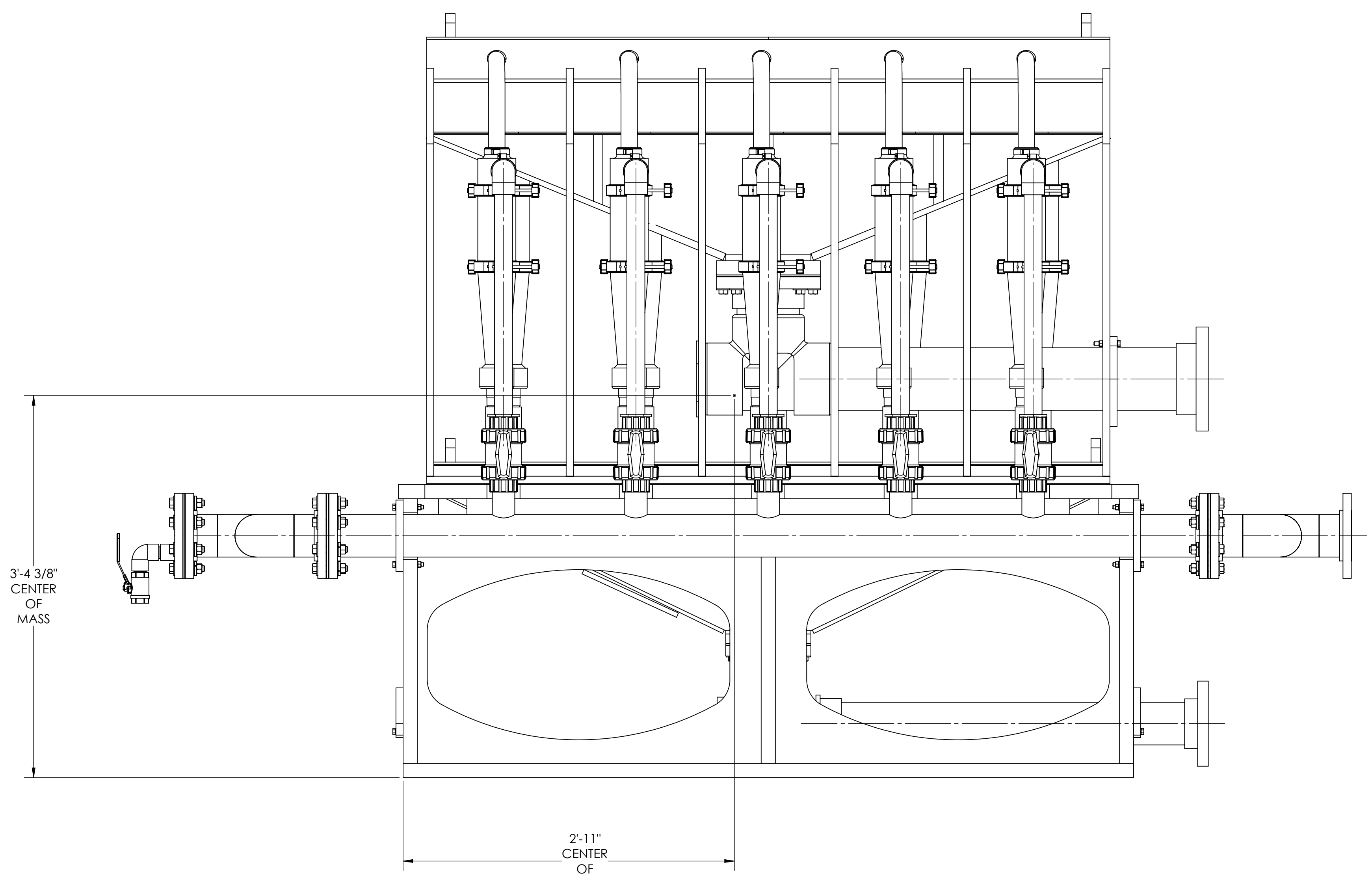
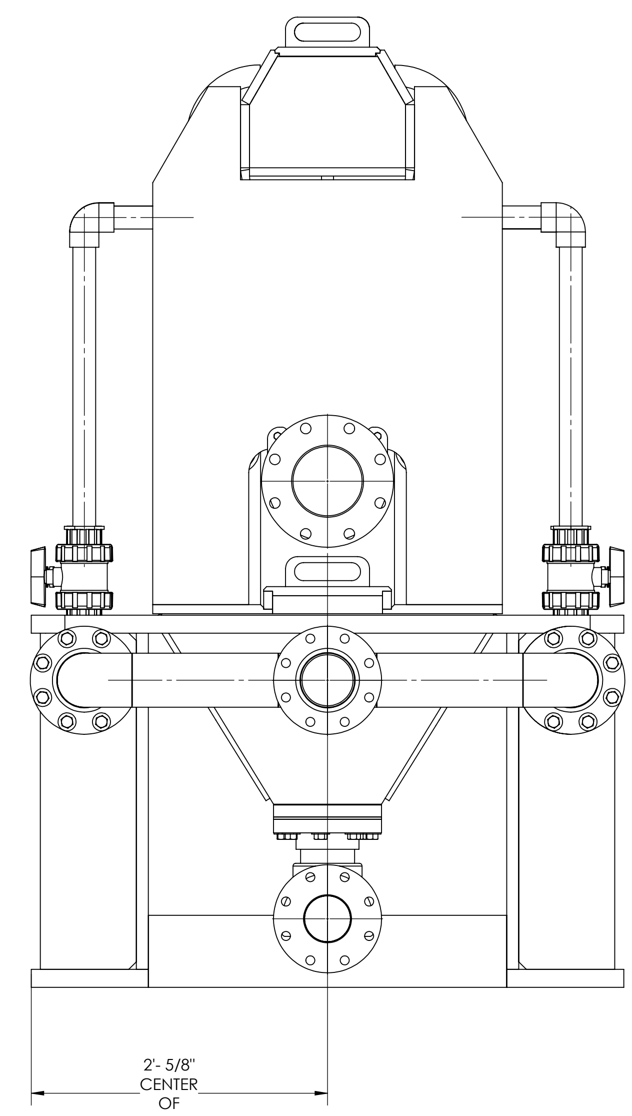




REV	DATE	DESCRIPTION	BY

World water works

CLIENT:
LOCATION:
FILE NAME: 10 INDENSE CYCLONE
DESCRIPTION: GENERAL ARRANGEMENT

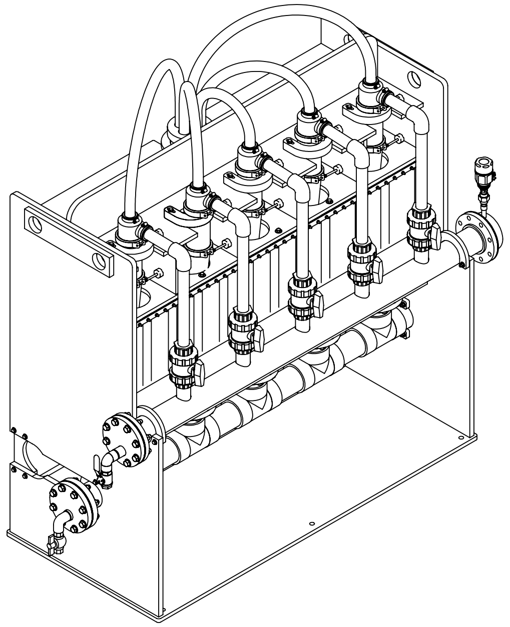
WWW CONFIDENTIAL

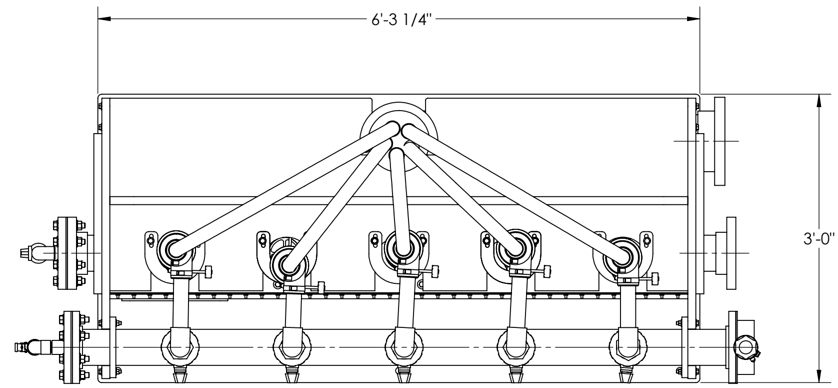
FOR APPROVAL
P.O.#:
DRAWN BY: SS
CHECKED BY: SB
DATE: 06/21/22
SCALE: 1:8
JOB #:
DRAWING #
SHEET: 2 OF 2 SHEETS

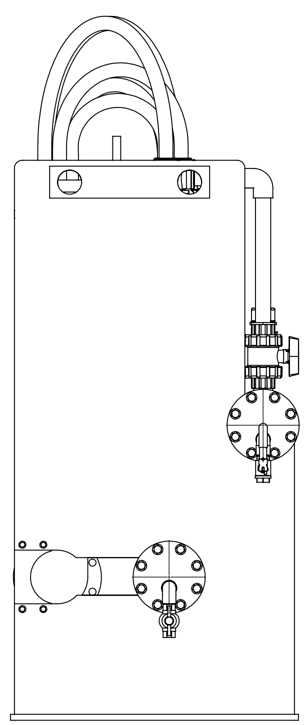
FIVE inDENSE ™

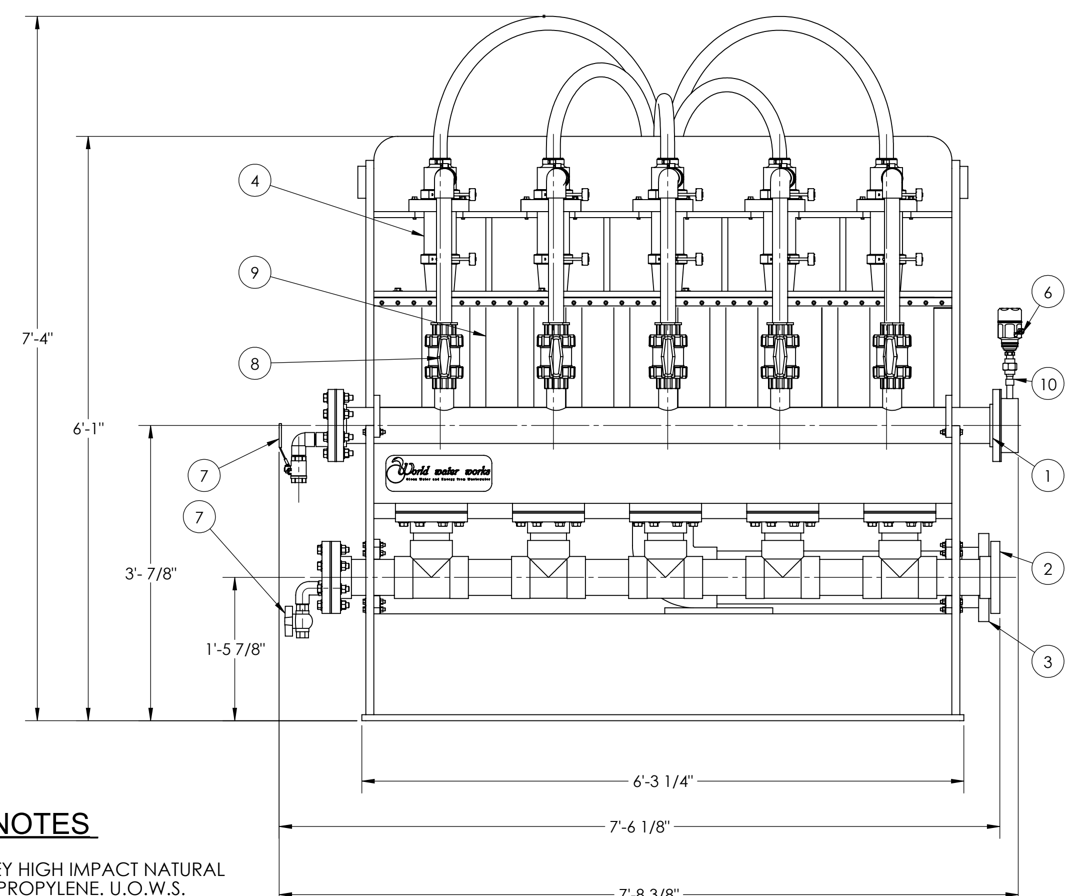
ITEM NO.	DESCRIPTION
1	FEEDFLOW, 4" FLANGE 150 LB - STAINLESS STEEL
2	UNDERFLOW, 4" FLANGE 150 LB - PVC
3	OVERFLOW, 6" FLANGE 150 LB - PVC
4	HYDROCLONE, 3" POLYURETHANE
5	PRESSURE GAUGE
6	PRESSURE TRANSMITTER - E & H
7	SAMPLE PORTS , 1" - SS & PVC
8	ISOLATION VALVE, 2" PVC HAYWARD TRUEUNION
9	PVC STRIPS
10	ISOLATER RING 4"- SS

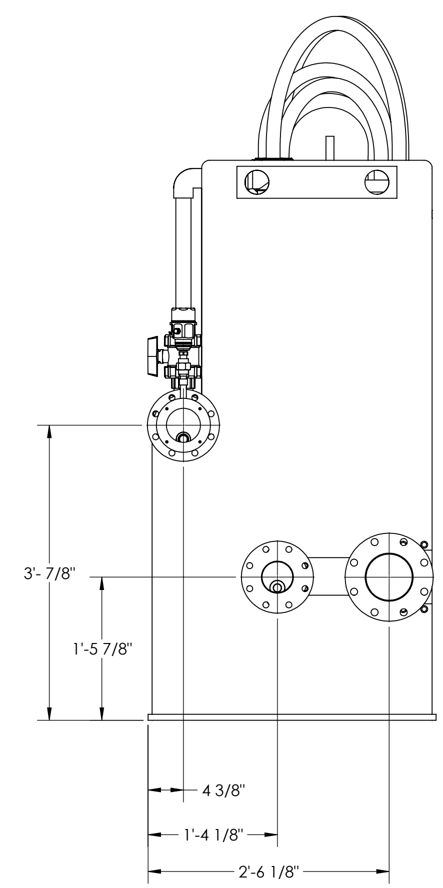
EMPTY WEIGHT: 830 LBS
OPERATIONAL WEIGHT: 1034 LBS

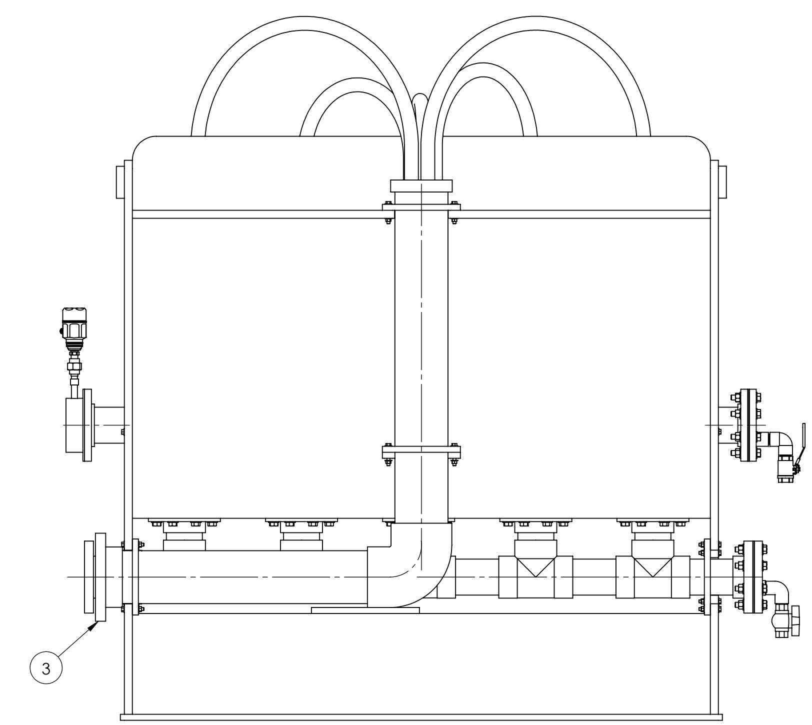












inDENSE™ GENERAL NOTES

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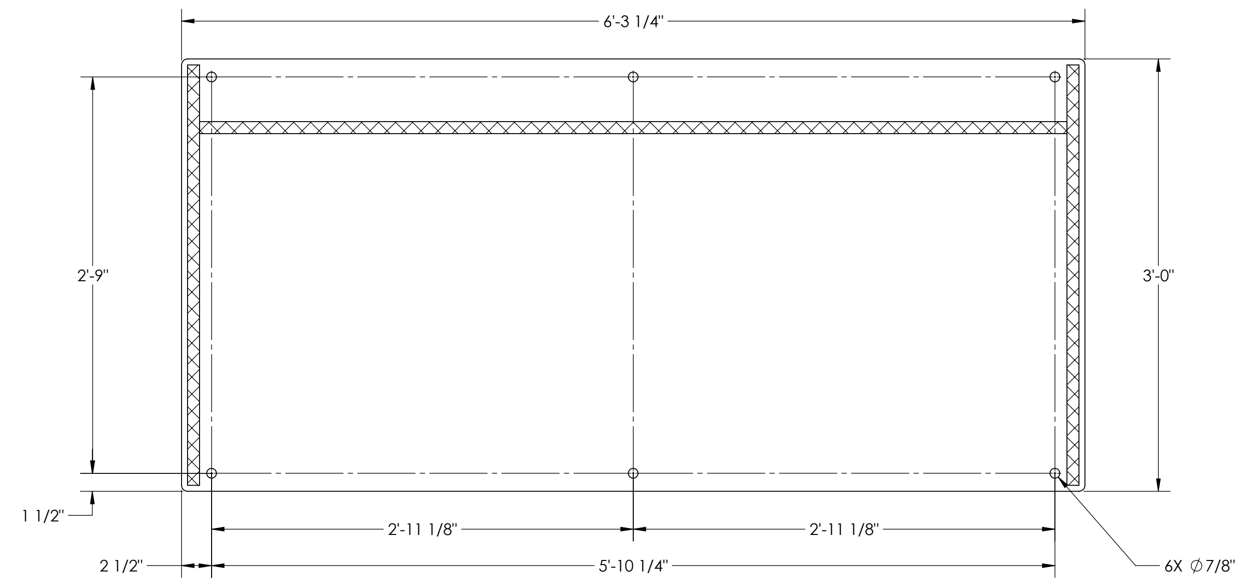
2. CYCLONES CONSTRUCTED OF POLYURETHANE.
3. FLOW PER CYCLONE 44 GPM; NUMBER OF CYCLONES IN SERVICE CAN BE ADJUSTED.
4. MAXIMUM OPERATING PRESSURE 38 PSIG.
a. MAXIMUM PRESSURE FOR THE CYCLONES 40PSIG
5. MAXIMUM OPERATING TEMPERATURE NOT TO EXCEED 122 F (50 C).
6. OUTDOOR INSTALLATION WILL REQUIRE PROPER FREEZE AND UV PROTECTION.
7. OVERFLOW PIPING TO BE INSTALLED PER EFFLUENT DESIGN.
a. TO BE INSTALLED WITH EITHER LEFT HAND OR RIGHT HAND DISCHARGE.
8. ISOLATOR RING AND PRESSURE TRANSMITTER TO BE SHIPPED LOOSE.
a. TO BE INSTALLED EITHER LEFT HAND OR RIGHT HAND FEED.
9. ANCHOR BOLTS NOT SUPPLIED.

REV | DATE | DESCRIPTION | BY

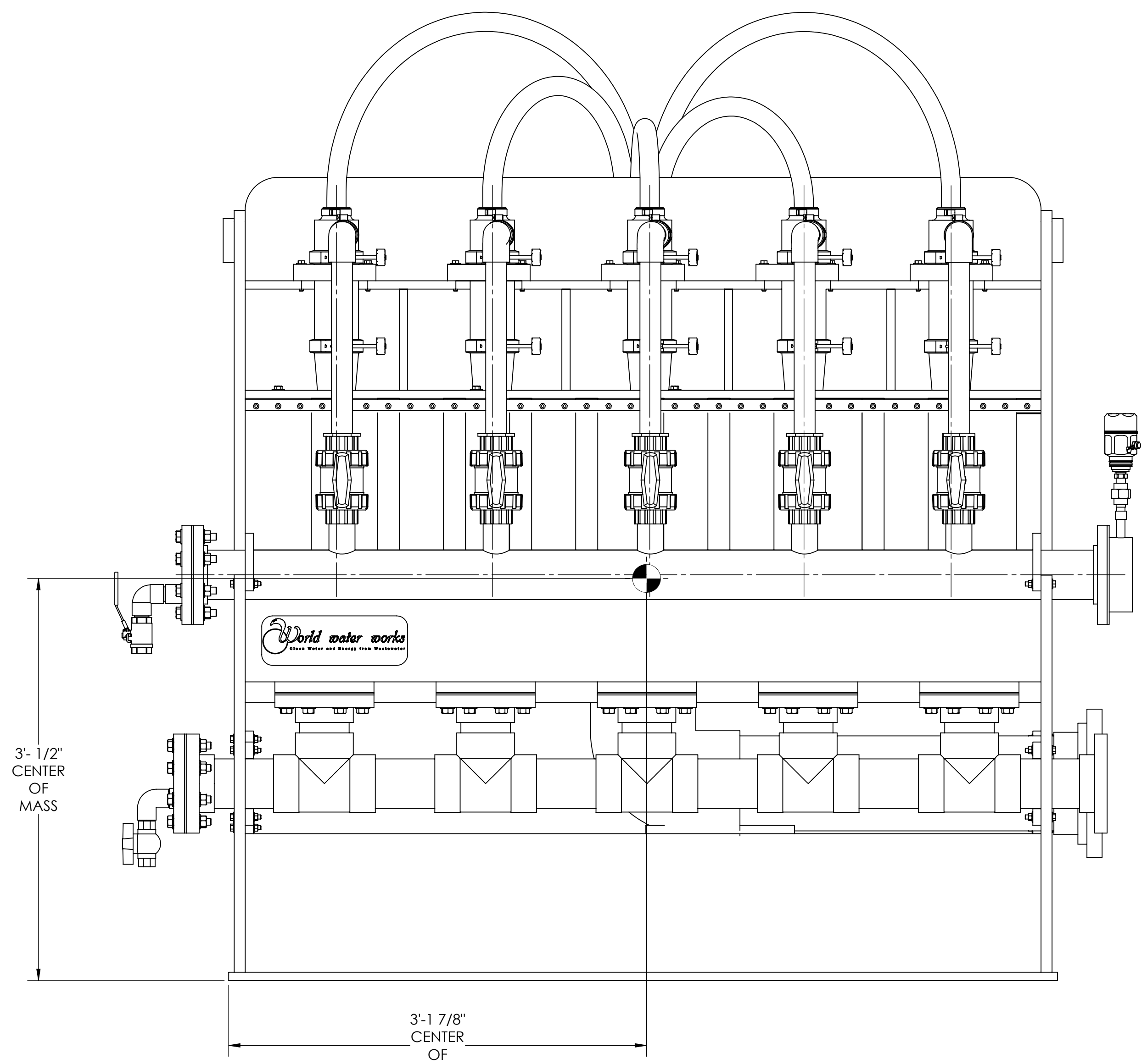
World water works

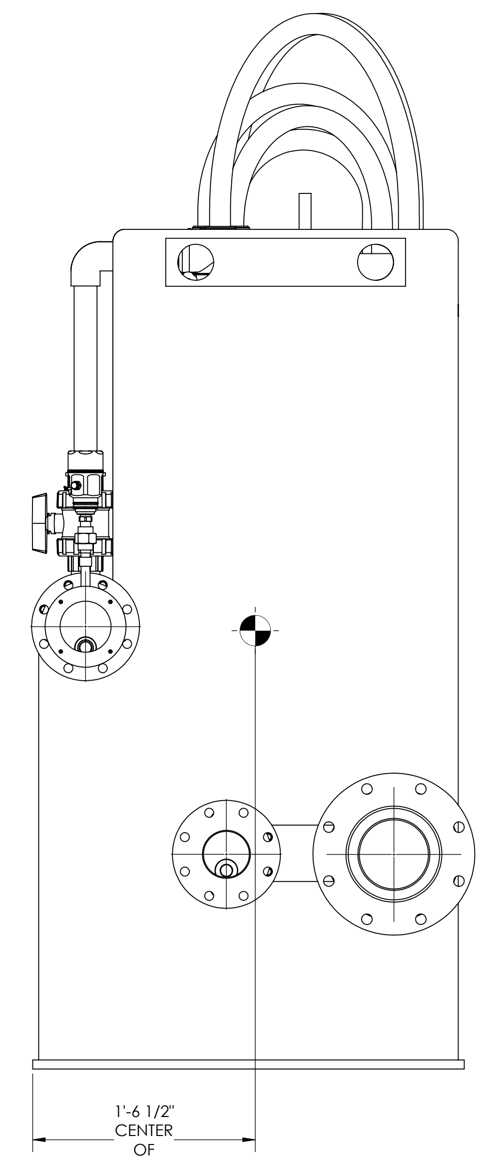
CLIENT:
LOCATION:
FILE NAME: SALES DRAWING-INDENSE CYCLONE
DESCRIPTION: SALES DRAWING

SALES DRAWING
P.O.#:
DRAWN BY: SS
CHECKED BY:
DATE: 12/15/21
SCALE: 1:12
JOB #:
DRAWING #
SHEET: 1 OF 2 SHEETS



ANCHOR LOCATION





WWW CONFIDENTIAL

REV	DATE	DESCRIPTION	BY

World water works

CLIENT:
LOCATION:
FILE NAME: SALES DRAWING-INDENSE CYCLONE
DESCRIPTION: SALES DRAWING

FOR APPROVAL

P.O.#:
DRAWN BY: SS
CHECKED BY:
DATE: 12/15/21
SCALE: 1:8
JOB #:
DRAWING #

SHEET: 2 OF 2 SHEETS

INDENSE™ SYSTEM INSTALLATION, OPERATION, & MAINTENANCE MANUAL

ENGINEER EQUIPMENT NAME:

inDENSE Process

WORLD WATER WORKS CONTACT INFORMATION:

World Water Works, Inc.
4000 SW 113th Street
Oklahoma City, OK 73173
1-800-607-PURE
www.worldwaterworks.com

DATE: **September 4, 2020**

TABLE OF CONTENTS

1. PREFACE

This manual covers the World Water Works' inDENSE Selective Wasting Process.

This manual has been developed to provide the operator with a general overview of the system operation, controls, and procedures; it includes a list of components and an avenue to responsive customer service.

The purpose of integrating the inDENSE system into a municipal conventional activated sludge wastewater treatment plant is to provide the ability to classify and selectively waste activated sludge. The process utilizes gravimetric pressures allowing the less dense bacteria to be removed and more dense bacteria to be recycled back into the biological process. Benefits are provided below:

- Improves settled sludge volume for improved clarifier operation
- Decreases SVI
- Enhances nitrogen and phosphorus removal
- Improves sludge inventory management

2. MANUFACTURER INFORMATION

This section provides the contact information for ordering replacement and spare parts. See below for details.

For parts, please contact:

John Schnecker
World Water Works, Inc.
4000 SW 113th Street
Oklahoma City, OK 73173
Schnecker@worldwaterworks.com
1-405-813-7879
www.worldwaterworks.com

3. SAFETY

Operators of this equipment should follow all facility safety requirements.

To ensure maximum safety, it is important that all operators of the World Water Works' Treatment systems read and understand the contents of the manual before any equipment is operated. Special attention must be paid to all caution or warning labels or symbols along with any lock-out tag-out tags placed on the equipment. Failure to comply with the instructions can result in damage to the system or personal injury.

The safety requirements mentioned in this manual are not intended to cover all warnings or hazards. Additional site specific safety reviews and procedures may be needed.

Review all individual equipment manuals thoroughly before attempting to install, operate, or maintain this system. Only trained operators should attempt to operate or maintain this system.

Potential Personnel Hazards

1. Exposure to pathogens in municipal waste water sludge
2. Exposure to sludge spray when opening sample valves and access areas
3. Fittings or pipe failure is possible if system is overpressured
4. Exposure to sustained loud noise if installation is near pumps or other high noise equipment
5. Polyurethane may release toxic fumes if burned. Take care to keep cyclones away from heat sources. Do not weld in the vicinity of the cyclones.

PPE for Hazard Mitigation

6. Eye protection
    1. Safety glasses or goggles
    2. Face shield is optional but recommended for extra protection from splashing in the face
7. Hand Protection
    1. Follow plant protocol for hand protection when handling sludge.
    2. Elbow-length or over-elbow gloves optional but recommended when collecting samples and disassembling portions of the hydrocyclones.
8. Ear Protection
    1. Ear plugs – only as necessary

4. OPERATOR SERVICE REQUIREMENTS

The daily waste volume will be determined per normal plant protocol. Check to be sure the inDENSE units(s) have the correct number of cyclones open and ready for flow. Check to be sure all necessary flow paths are open to allow flow through the feed, overflow, and underflow piping to and from the unit(s). Visually inspect the cyclone spray pattern daily for clogs. Check for consistency between the pressure gauges and the pressure transmitter to confirm reading accuracy.

Fully Automated Operation

The operator will input the target waste volume into the facility's chosen controls system and initiate the run for that day. The system may be operated continuously until the target waste volume is reached. Waste volume is totalized from overflow flow meter readings. Ensure flow meter readings are accurate to ensure proper wasting rates. The system may also be operated intermittently in cycles throughout the day if necessary.

Manual Operation

The operator will estimate the run time to achieve the previously calculated target waste volume for that day and initiate the run by starting the feed pumps and any auxiliary systems. Once the elapsed time nears the target elapsed time for that day's processing, the operator will need to monitor the waste volume totalizer closely. Waste volume is totalized from overflow flow meter readings. Ensure flow meter readings are accurate to ensure proper wasting rates. Once the waste volume has been reached, the operator will stop the feed pumps and auxiliary systems.

Total Suspended Solids (TSS) measurement of the influent, overflow, and underflow should be conducted daily through the first 3 months of operation. This will enable the facility to determine mass splits for more accurate Solids Retention Time (SRT) control.

5. SHIPPING & INSTALLATION

Shipping

The inDENSE unit(s) will come assembled per the drawing and will be shipped in wooden crates with up to two units per crate. The unit(s) will be bolted down to the crate base(s) for stabilization during transport. Recommended tools for removing the unit(s) from the crate(s): drill/driver; screwdriver bit set including flat head, Philips, and star bits; two 9/16" wrenches.

Recommendations:

- Inspect unit(s) upon receipt.
- Store unit(s) in shipping crates until ready for placement and installation
- Offloading and placement
    - The units can be moved using the lifting lugs provided at the top of the inDENSE unit(s)' side walls. It is recommended to use 4 polyester round slings with a forklift or crane.
        - Slings Recommendation: Bishop Lifting Products BLR4 or similar
            - 6 ft long
            - 10,600 lb vertical
            - 8,500 lb choker
            - 21,200 lb basket

Estimated weight of a crate with one unit: 1,000 lbs
Estimated weight of a crate with two units: 2,800 lbs

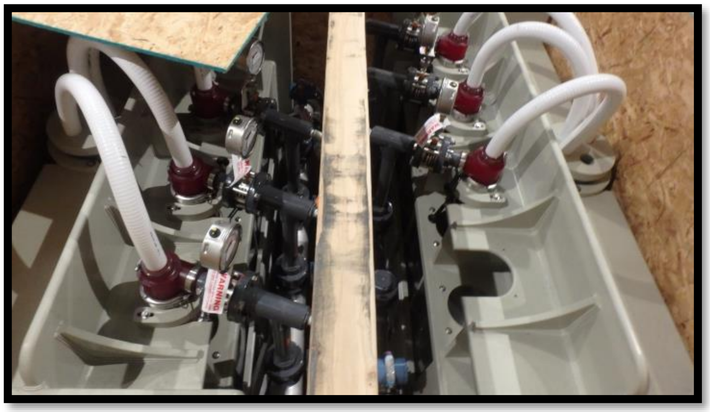


Figure 1 – Example of Crated InDENSE Units

Installation Checklist

- MLR RAS Pump
  - Plumbing and process flow is correct and complete per design engineer's recommendations.
  - Pump is properly installed and fully functional per manufacturer's recommendations. Pump rotation and alignment verified.
  - All elements at risk of freezing are protected appropriately.
- Flow Meter for MLR RAS Pump
  - Installation is complete and the instrument is functional – with termination of power and control wiring in appropriate control panel(s).
- System Piping
  - Leak testing complete. All elements at risk of freezing are protected appropriately – heat tracing, insulation, etc.
- inDENSE Skid
  - Pressure transmitter is functional and properly installed with termination of power and control wiring in appropriate control panel(s).
  - Pressure gauges are functional and properly installed
  - All necessary piping into and out of the skid is fully installed and connected to the unit(s).
    - Feed line from MLR RAS Pump(s) - pressurized
    - Overflow line – gravity flow
    - Underflow line – gravity flow
    - Sample Ports are accessible
- Overflow Piping
  - Piping is configured and sized per design engineer's recommendations allowing for unrestricted flow.
  - All elements at risk of freezing are protected appropriately – heat tracing, insulation, etc.
- Underflow Piping
  - Piping is configured and sized per design engineer's recommendations allowing for unrestricted flow.
  - All elements at risk of freezing are protected appropriately – heat tracing, insulation, etc.
- Controls System PLC
  - Flow meter(s) connected and properly communicating with PLC, SCADA, DSC, etc.
  - VFD(s) for all pump(s) connected and properly communicating with PLC, SCADA, DSC, etc. All data verified with physical motor nameplate.
  - Pressure transmitter is connected and properly communicating with PLC, SCADA, DSC, etc.
  - Control Logic is complete and I/O checks are confirmed and ready to govern the inDENSE™ system operations.
- Other Instrumentation
  - If any other instrumentation in the process directly affects the operation of the inDENSE™ system, it should be checked for functionality, proper installation, and communication ability with the PLC, SCADA, DCS, etc.
- Performance Testing
  - Confirm that extra cyclone spigot nozzle tips (included) are onsite and where they are stored.
  - Confirm location of testing and availability of a water source. A test kit is either included with the project, or materials need to be available for testing.

Inspections

- Demonstrate and verify that the systems' installation is correct and complete.
    - Inspect cyclone selective wasting system
        - Piping integrity
            - Check for damage
                - Feed piping to the system
                - Underflow piping in and from the system
                - Overflow piping in and from the system
        - InDENSE unit integrity
            - Check for level installation
            - Check for damage
        - Hydrocyclones are intact and fully assembled
        - Instrumentation is installed correctly
            - Pressure transmitter
            - Pressure gauges
    - Inspect associated equipment per manufacturers' recommendations
        - Feed pumps
        - Flow meters
        - Piping systems

6. INITIAL STARTUP & TESTING

Initial System Start-up and Testing

Initial system startup should take place as part of functional and operational testing.

Temporary Piping – In order to recycle the Overflow and/or Underflow, temporary piping is recommended for plumbing the inDENSE Overflow and Underflow headers back to the feed tank to recirculate the water used during this testing. This option may not always be available depending on the installation and site conditions.

Acceptable Liquid Medium Options – Potable water, non-potable water, plant effluent water, and plant service water. If none of these liquid mediums are available to run the inDENSE system, *Functional Testing* may be performed with process sludge during *Operational Testing*.

Water Source – When plant water is required for feeding the inDENSE system, plant water hose bibs can be drawn from to initially fill and maintain the lower operational limit in the feed tanks (when applicable).

Water Discharge Points – It is recommended to recirculate an acceptable liquid medium through the inDENSE system during *Functional Testing* to minimize dilution of RAS and WAS for the duration of *Functional Testing*. If this is not possible, the plant needs to be able to handle sending the Underflow to the biological process and the Overflow to solids handling. The effect of sending "clean" water to these areas must be evaluated and approved by the plant before commencing the test.

If sufficient volumes of clear water are unavailable for initial system testing, process sludge will have to be used. The initial system startup shall commence once all connections are finalized (pumping, electrical, and control) and will consist of both the pumping system and cyclone system. Ensure all fittings are adequately tightened and valves are in the appropriate positions before initiating flow. For pump startup and optimization, please see pump manufacture's recommendations. The cyclone system startup will require the pumping system to be in operation.

Once the system is operational and all leaks and equipment issues are resolved, any temporary piping should be removed and reverted back to the intended process piping. Then the system may start processing sludge. The process sludge entering and exiting the inDENSE system may be tested to confirm spigot selection by settling testing.

7. DAILY START-UP, SHUTDOWN, & POST-SHUTDOWN

Daily Start-up

Before starting the system, the total volume to be wasted for that day should be calculated using standard practices for the facility. A calculation workbook file, inDENSE Calc Sheet.xlsx, will also be provided to aid in wasting calculations. If the system is automated, the total volume should be entered into the controls system before initiating flow. The system should operate until the target waste volume for that day has been reached.

Shutdown

To shut down the system, the feed pump(s) should be stopped. Any automated feed valve(s) should be closed. Any discharge/transfer pumps should be stopped. If the system is manually operated, the operator will need to estimate the run time based on wasting rate which is a function of spigot size and the number of cyclones in operation. This time can be estimated using the inDENSE Calc Sheet. When the system nears the estimated run time for that day or interval, the operator should be present to monitor the waste volume. Once the waste volume has been reached, the operator should stop the pumps until the next wasting cycle is ready to begin. If the system is automated, the pumps should automatically turn off when the waste volume totalizer reaches the set point for that day.

Post-shutdown

Once the system has been shut-off, especially during freezing conditions, please verify the unit has been completely drained. In the case that all cyclones in a unit are in the off position for more than a few hours, it is recommended that the feed manifolds be drained to prevent issues from settling and freezing conditions. If the system is taken out of service for cleaning or repairs, be sure to stop any automatic timers for the pump(s) and isolate the system. Follow standard lock-out tag-out procedures when necessary. For extended shutdowns, it is recommended that the units be flushed with clear water to prevent residual sludge solidification. The Underflow boxes (Figure 15) should also be cleaned of excess solids.

8. NORMAL OPERATIONS

Routine Normal Operating Sequences

See Section 19. PARTS IDENTIFICATION for labelled diagrams. The number of pumps and cyclones in operation is dependent on the requirements of the facility. The number of cyclones in operation can be manually changed as needed. Taking a cyclone out of service requires the closure of its isolation feed valve. Wasting is a daily operation; the operations staff determines the amount wasted. Each cyclone is capable of treating a certain volume at a specific pressure, ≈ 44 gpm at 35 psig (Figure 12). Wasting through a cyclone system requires higher feed flows than the normal wasting rate because a portion of the volume processed is returned to the system. The amount returned is dependent on a number of operational parameters with the cyclone spigot size being the most important. The spigot size is based on start-up testing results and will be selected and installed by start-up personnel. The cyclone can be negatively impacted by larger solids and rags, so flow through each unit needs to be verified daily. It is also very important that the cyclones have no backpressure (must be open to atmosphere) on the underflow and overflow as this will affect operation and performance. To ensure system efficiency, no modifications should be made to the overflow and underflow portions of the cyclones.

- Prior to initializing the daily wasting, the proper number of cyclones need to be ready with the corresponding manual isolation valves placed in the open position.
- All spray curtains should be flush with inside the underflow box fronts.
- All flush and sample valves should be closed.
- Feed pump should be turned on, and speed should adjust to reach the target pressure of 35 psig while not exceeding 40 psig.
- System should run for the calculated time and/or intervals to achieve target wasting volumes.

Cleaning of the cyclone system should be conducted periodically. The period of time should be based on operational experience and should be done consistently. Basic cleaning requires all cyclones and manifolds to be cleaned with plant water.

Factors influencing the optimal mode of operation include capacity of the plant system feeding the inDENSE system, capacity of the plant system to accept WAS (overflow) from the inDENSE system, capacity of the plant system to accept RAS (underflow) from the inDENSE system. The modes of operation are listed below for 24 hour periods (in order from most simple to most complex):

1. All cyclones open for a set shorter duration
    a. Feed runs through all cyclones available until the totalizer reaches the target waste volume.
    b. System shuts down until the system is restarted by the operator the next day.
2. Select cyclones open for a set longer duration
    a. Feed runs through select cyclones until the totalizer reaches the target waste volume.
    b. System shuts down until the system is restarted by the operator the next day.
    c. This option is generally preferred for 24 hr operations but may run slightly short of 24 hrs.
3. Select cyclones open for set intervals of specified durations
    a. Feed runs through open cyclones at set intervals throughout the designated run time for the day until the totalizer reaches the target waste volume.
    b. System shuts down until the system is restarted by the operator the next day.
    c. The option is generally preferred if there are volume limitations at the plant level for delivering feed, accepting WAS, or accepting RAS, and desired times of the day to operate the inDENSE system.

For modes 1 and 2, use the following equation to estimate daily operating time required to achieve the target wasting volume. Vary the number of open cyclones to vary the hours of operation. As the number of open cyclones decreases, the hours of operation increase.

$$Hours\ of\ Operation = \frac{(Target\ WAS\ Volume\ in\ gal)(1\ hr)(1\ min)}{(Overflow\ Mass\ Split\ \%)(60\ min)(44\ gal)(\#\ Cyclones\ Open)}$$

For mode 3, use the follow equation to estimate how many intervals are required of the specified duration to achieve the target wasting volume.

$$Number\ of\ Intervals = \frac{(Target\ WAS\ Volume\ in\ gal)(1\ hr)(1\ min)}{(Overflow\ Mass\ Split\ \%)(60\ min)(44\ gal)(\#\ Cyclones\ Open)(Interval\ Duration\ in\ hrs)}$$

For reference: Target Cyclone Feed Volume in gal = (Target WAS Volume in gal)/(Mass Split %)

Operating Characteristics

Design Points			
Design Option	GPD	lb/day	mg/L
Design	100,000	2,000	2,937

Table 1 – Design Points

Design Scenarios							
Design Option	Units	Feed Influent WAS	Overflow Effluent WAS	Underflow RAS	Cyclones in Service	Service Hrs/day	Service Days/Week
# 1	GPM	62	49	12	2	24	7
	lb/day	1,156	751	404			
# 2	GPM	123	98	25	3	24	7
	lb/day	5,521	3,589	1,932			
# 3	GPM	171	137	34	4	24	7
	lb/day	3,210	2,086	1,123			
# 4	GPM	171	137	34	4	27	7
	lb/day	5,136	3,338	1,797			
Design	GPM	171	137	34	4	24	7
	lb/day	3,210	2,086	1,123			

Table 2 – Design Scenarios

Performance Curves

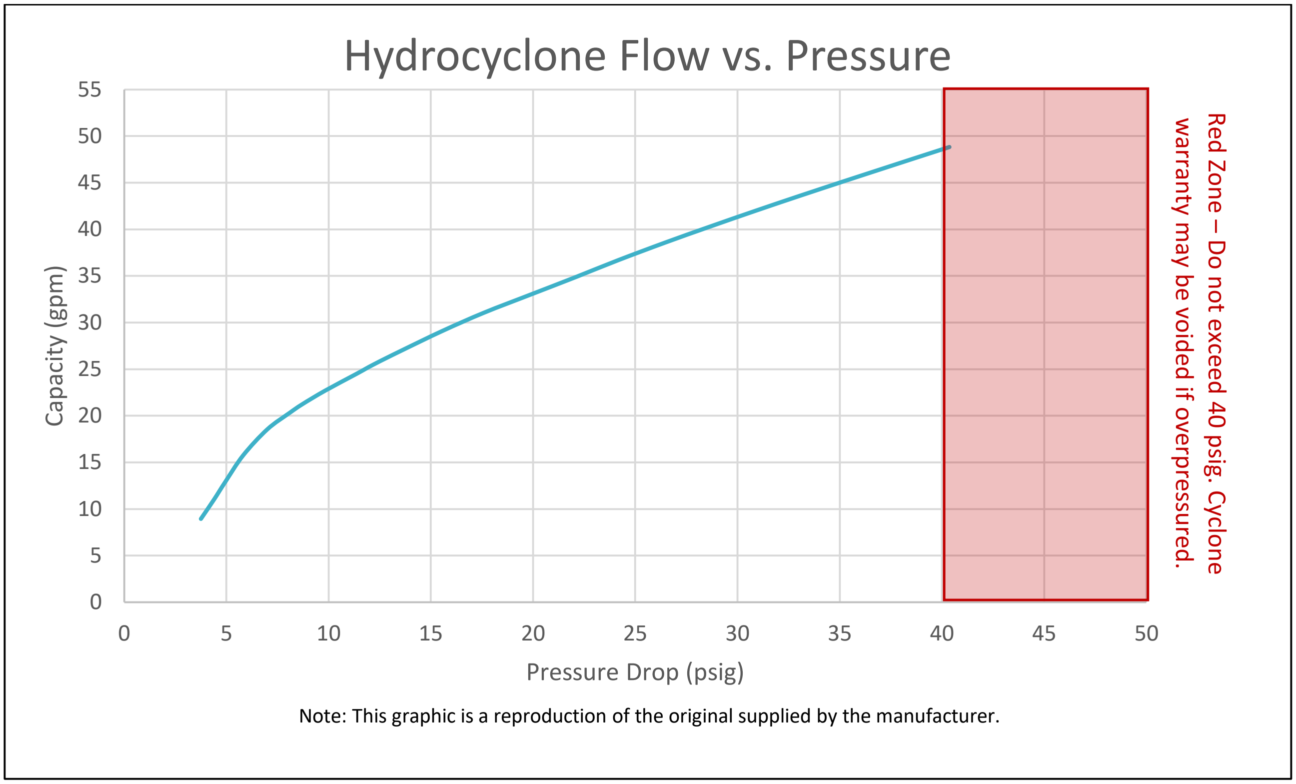


Figure 2 – Cyclone Performance Curve

9. ENVIRONMENTAL CONDITIONS

Special Considerations

Freeze protection is recommended for all piping per climate and installation conditions. Hoses and piping with minimal or no flow are most likely to freeze. These include the ends of the 4" manifolds with the flush valves. Freeze protection is up to owner discretion. Ensure system is fully drained when the system is shut down in freezing conditions.

Limiting Conditions

Maximum operating pressure not to exceed 40 psi (2.8 bar).
Maximum operating temperature not to exceed 122°F (50°C).

Storage Conditions

The inDENSE System is to be evaluated upon delivery to the site to confirm that damage did not occur during shipping and to confirm all components included in the scope of the project were received. An acknowledgement of receipt shall be sent to World Water Works. If the site is not ready to install the units upon receipt, the units shall remain in the shipping crate to prevent damage to the units. If the shipping crate is not utilized, the inDENSE system can be stored outside for an extended period of time, but it is recommended that the units be covered in tarp or shrink wrapped to protect the units.

10. EMERGENCY OPERATIONS

In an emergency situation, the primary action is to press the E-stop button. If there is no E-stop button, turn off the feed pumps.

11. PREVENTATIVE MAINTENANCE PLAN & SCHEDULE

First 50 Hours

- Check all piping and valves for leaks.
- Check tightness of t-bolt clamps on the top of the cyclones: target torque 5 ft-lbs | 60 in-lbs | 6.78 N-m.

Daily

- Check spray pattern on cyclones to ensure no clogging.

Monthly

- Washdown underflow box inside the inDENSE units.
- Check tightness of t-bolt clamps on the top of the cyclones: target torque 5 ft-lbs | 60 in-lbs | 6.78 N-m.

The inDENSE System is designed for durability and long-life. However, following some basic maintenance procedures will maximize the life of the system and the components. It is always recommended to maintain a clean and safe environment.

It is recommended that the system be protected from freezing as water in pipes, hoses, fittings, and other areas may expand and cause damage. The temperature of the water feeding the system should not exceed 122°F. Ensure the lines are drained during an extended shut-down event.

Cleaning – Outside of System

The outside of the system can be washed down with water periodically to prevent dust and debris buildup.

Cleaning – Inside of System

The system should be drained and washed down periodically. The frequency of cleaning will depend upon many variables, including but not limited to: care in operation, swings in loadings, hours of operation/day, etc. The system should be cleaned a minimum of once every 6 months. Performance of the system will dictate if more frequent wash- downs are necessary.

12. CONTROL DIAGRAMS

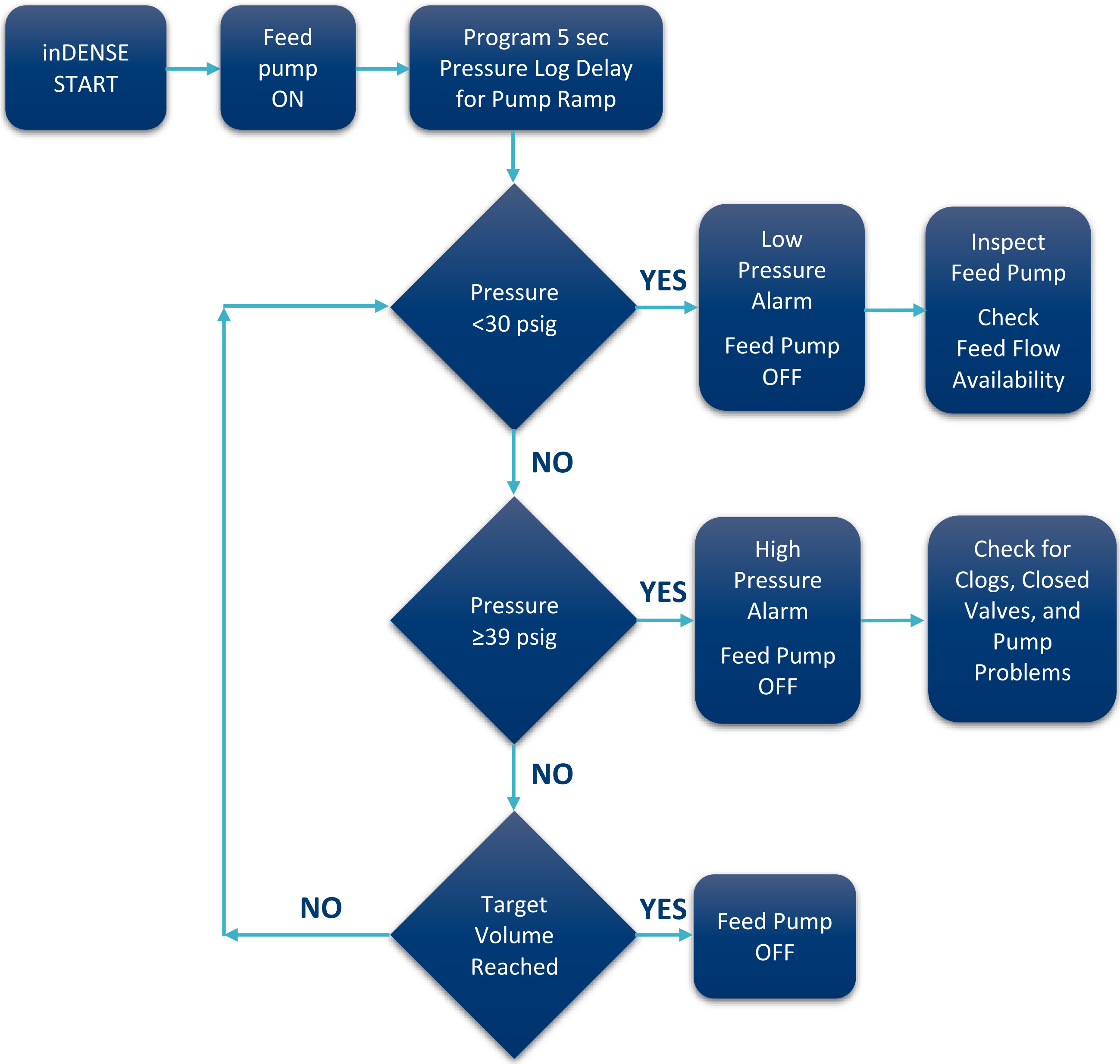


Figure 3 – Control Diagram

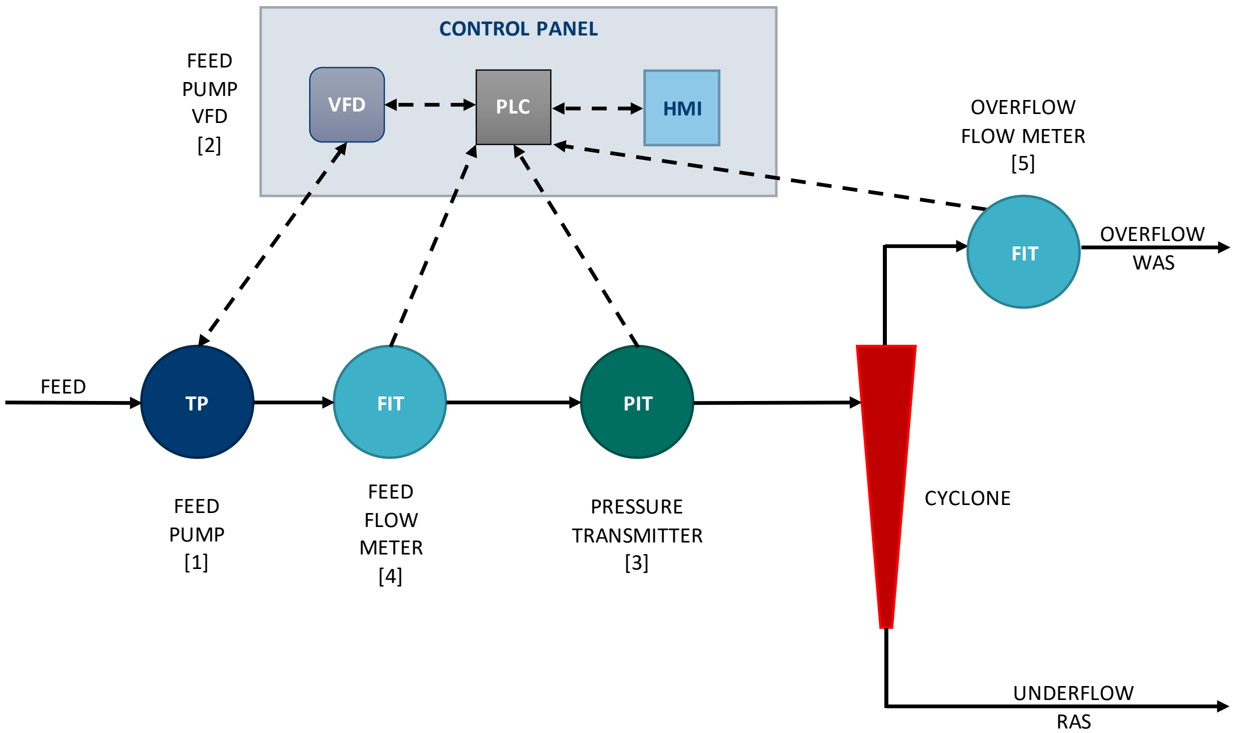


Figure 4 – Basic Process Flow Diagram with Instrumentation

EQUIPMENT	TAG #	DESCRIPTION	REFERENCE #
inDENSE Feed Pump 1		Feed Sludge to inDENSE Unit	[1]
inDENSE Feed Pump VFD 1		Provide Feed Pump Control	[2]
Pressure Indication Transmitter 1		inDENSE Feed Manifold Pressure	[3]
Flow Meter 1		Feed Flow Measurement to inDENSE Unit	[4]
Flow Meter 2		Overflow Flow Measurement from inDENSE Unit	[5]

Table 3 – Equipment and Instrumentation Used in the Controls System

13. TROUBLESHOOTING GUIDES & DIAGNOSTIC TECHNIQUES

inDENSE Unit

PROBLEM	POSSIBLE CAUSES	ACTION
Low/High pressure	High pressure in inDENSE piping	• Verify flow is not obstructed through overflow and underflow from cyclones.
	Low Pressure in inDENSE piping	• Verify operation of inDENSE feed pumps both on PLC and visually at the unit. If feed pumps are not operational, refer to drive not ready alarm.
	Pressure transmitter malfunction	• Ensure the PLC pressure reading matches the pressure gauge reading. • Refer to pressure transmitter manual if malfunctioning.

Table 4 – Troubleshooting

14. MAINTENANCE & REPAIR PROCEDURES

inDENSE Unit Flush

Depending on system configuration, either push plant effluent water through the system with the feed pumps or connect a plant effluent water hose to the feed flush valve to allow clean water to flush the system. If flowing through the feed flush valve, ensure the entrance to the feed manifold is isolated to avoid flow back through the pump(s). Allow water to flow through each unit for about 5 minutes. If odor becomes an issue, it is possible there is sludge build up in the dead space of the overflow and underflow manifolds. This space can be flushed by connecting a water hose up to the flush valves on the end caps of those manifolds.

Underflow Box Washdown

Use a water hose to spray down the inside of the underflow boxes to remove excess solids buildup. Use a rag or soft brush to remove any stubborn or dried on solids.

Resolving Clogs

If an inDENSE unit flush does not resolve a clog, you may be required to dismantle a portion of the system. The spray pattern should indicate which cyclone is clogged. Follow the instructions for Hydrocyclone Disassembly and Reassembly in the next section. Removal and Replacement Instructions. Once disassembled, check for clogs. If no clog is found, look up inside the body extension to see if anything is clogging the vortex finder. Once clog has been removed, reassemble the cyclone and resume flow to check the spray pattern to confirm the clog has been fully removed.

15. LUBRICATION DATA

The inDENSE System and its components do not require lubrication. Flange fasteners require standard lubrication.

16. REMOVAL & REPLACEMENT INSTRUCTIONS

Hydrocylone Disassembly & Reassembly

Figure 5 – Assembled and disassembled hydrocyclone assembly. In order from left to right: vortex finder with two t-bolt clamps, v-clamp, body extension, v-clamp, main body, retainer ring, spigot (tip, nozzle, etc.), spigot retainer cap, spray guard.

To disassemble a cyclone, ensure the cyclone is isolated by turning the corresponding isolation feed valve to the closed position. Pressure should read zero on the corresponding pressure gauge.

This portion and method of the disassembly is the most common and is often used when changing spigots or clearing clogs:
Reach through the splash curtains until you can reach the bottom of the cyclone. Twist and pull downward on the gray pvc pipe section to slip off the spray guard and set aside. Slide the retainer ring up onto the body (conical) section. Pry the spigot retainer cap from the body section. Push the tip of the spigot back up through the spigot retainer cap and pull the spigot top to remove it from the retainer cap. If no clog is found in the spigot, loosen the lowest v-clamp to remove the body section and check for clogs.

This portion of the disassembly is rare and only needed during troubleshooting cyclone malfunctions:
Loosen the v-clamps by turning the black nob until the clamps can be unlatched. Hold the section under the clamp securely to prevent dropping it once it is worked loose from the clamp. Loosen the t-bolt clamps with a flat head or socket screw driver, and work the feed pipe and overflow hose free from the side and top of the vortex finder. The vertical pipe section can also be removed from the true union ball valve by loosening the top (effluent end) of the valve. It is recommended to not perform a full disassembly when the unit is operating.

To reassemble and reinstall a cyclone, reinsert the feed pipe and overflow hose into the vortex finder, and secure both connections with the t-bolt clamps to a torque of 5 ft-lbs | 60 in-lbs | 6.78 N-m. Attach the body extension to the bottom of the vortex finder with a v-clamp, making sure the body extension seats properly into the vortex finder. Attach the conical section to the body extention with the other v-clamp. Insert the spigot into the spigot retainer cap. Pop the retainer cap back onto the main body. Secure the retainer cap with the retainer ring by sliding the ring down into place. Push the spray guard onto the retainer cap. Check to be sure the curtains are flush with the inside of the underflow box fronts. Reassembly is complete.

Critical Bolt Torques

Lubricate bolt and nut threads with Silver Grade Anti-Seize compound.

After flange assembly and all nuts have been run down by hand, start wrench tightening following the sequence of the numbers indicated (marking the number on the flange with a crayon aids in the keeping track of the tightening process).

During all of the following steps, maintain an even gap between flanges around the entire circumference of the flanges and start each nut with a full turn onto the end of each bolt.

- First time around just snug the nuts with a hand wrench.
- Second time around tighten the nuts firmly with hand wrench.
- Third time around apply approximately 25% of recommended torque.
- Fourth time around apply approximately 75% of recommended torque.
- Fifth time around apply 100% of recommended torque.
- A final round should be made to confirm the torque is even at full load.
- It may be necessary to re check torque after 24 hours. Most preload loss of bolts or compression of polymer flanges occurs within 24 hours.

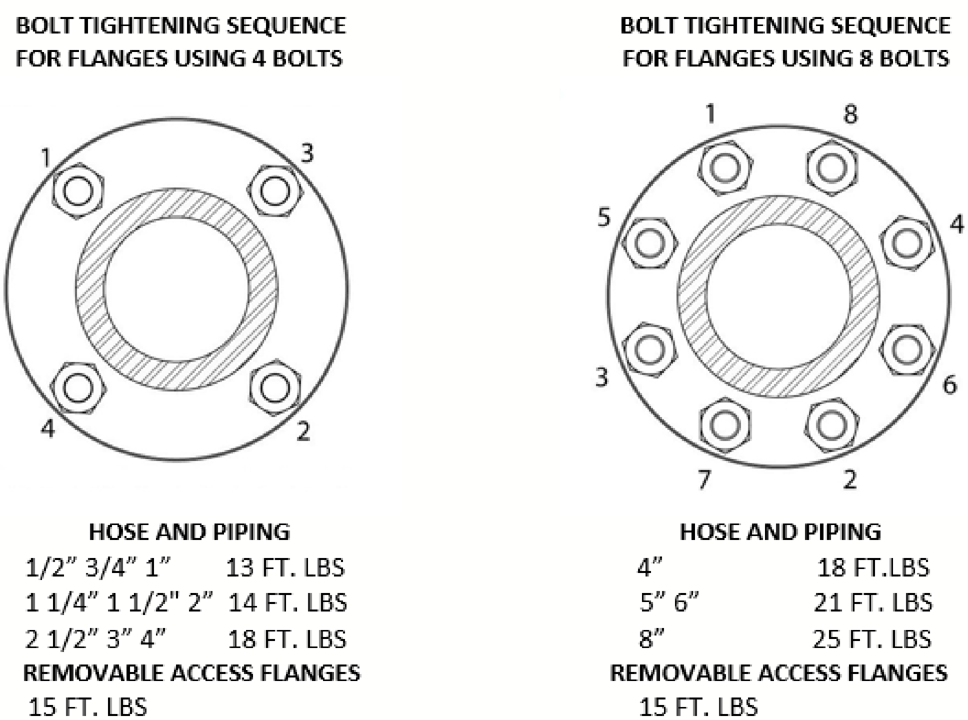


Figure 6 – Bolt torques for reassembly after maintenance.

17. SPARE PARTS & REPLACEMENT PARTS

Recognized Spare Parts			
Item	**Manufacturer**	**Model #**	**Part #**
Pressure Gauge Assembly w/ Isolator Ring	Onyx	PSW	00021
Pressure Transmitter w/ Isolator Ring	Endress+Hauser Onyx	2088G2S22A1M4 (Transmitter) PSW (Isolator Ring)	E-10440

Table 5 - Spare Parts List

Part Number	Part Description
87799	HydroCyclone (10m3/hr) 3" Cyclone
87914	Vortex Finder, 25 mm S3VF25-P, for 3" Hydrocyclone
87921	Conical Body, S3BS10-P, for 3" Hydrocyclone
87920	Spigot, S5Sp20-P, for 3" Hydrocyclone
87922	Spigot, S5Sp18-P, for 3" Hydrocyclone
	Spigot, S5Sp15-P, for 3" Hydrocyclone
	Body Extension
	V-Clamp
	Spigot Retainer Cap
	Retainer Ring
99428	SPRAY GUARD ATTACHMENT PIPE, PIPE, 2”X14”, SCH80 PVC GRAY
60069	HYDROCYCLONE GASKET, 4.094” X 3.780” X 1/16", FULL FACE, BUNA
82760	PVC Strip, 3’ 3” x 8” Standard Smooth
98460	POLYPRO BLIND FLANGE WITH VALVE ASSY
98048	SS BLIND FLANGE WITH VALVE ASSY
55265	VALVE, 1"T QIC Ball, PVC, QV1T100TE
50169	VALVE, 1"T BALL, 1000# SS316
55325	VALVE, 2" TrueUnion Ball, Viton Seal, SCH80 PVC, TB1200ST
60003	GASKET, 2" X 3/16" FULL FACE, EPDM
60000	GASKET, 4" X 3/16" FULL FACE, EPDM
00021	PRESSURE GAUGE, ONYX 4.5" DIAL SIZE WITH 1.5" WAFER STYLE ISOLATER RING

Table 6 – Replacement InDENSE Unit Parts

18. CORRECTIVE MAINTENANCE MAN-HOURS

The inDENSE system has no moving parts other than manual valves. The only corrective actions anticipated are clearing clogs from cyclones. In the event that this occurs, it should take a maximum of 60 minutes to restore the system to normal working order.

19. PARTS IDENTIFICATION

System & Component Function – One inDENSE Unit with Four Cyclones

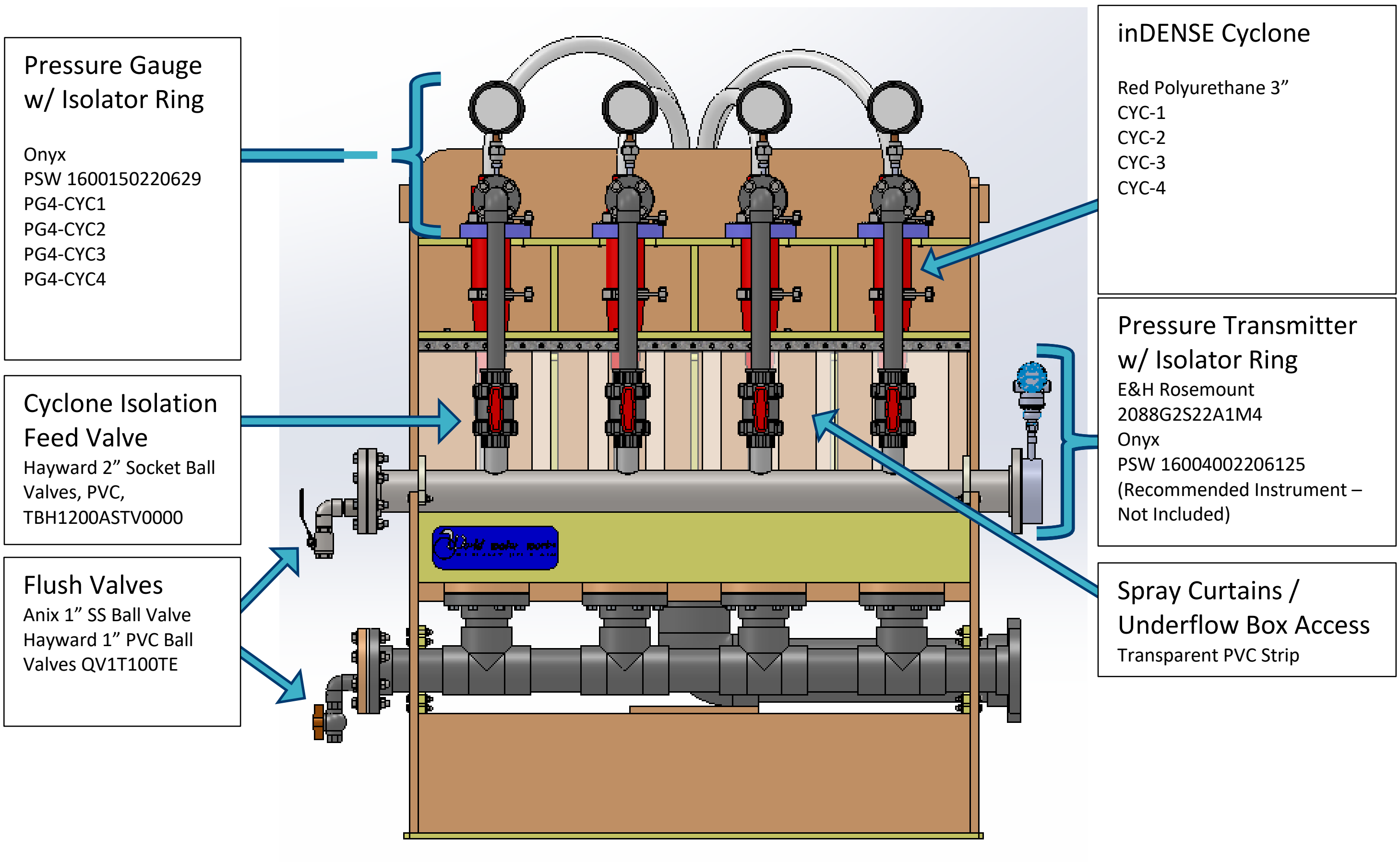


Figure 7 – System Front Overview

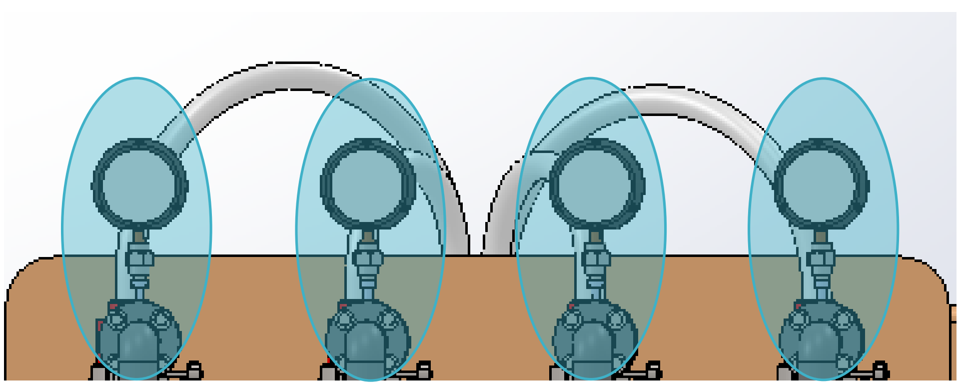


Figure 8 – Influent Pressure Gauge Assemblies

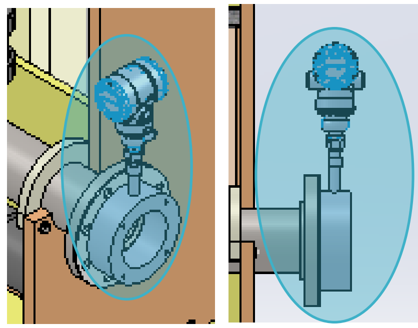


Figure 9 – Influent Pressure Transmitter with Isolator Ring

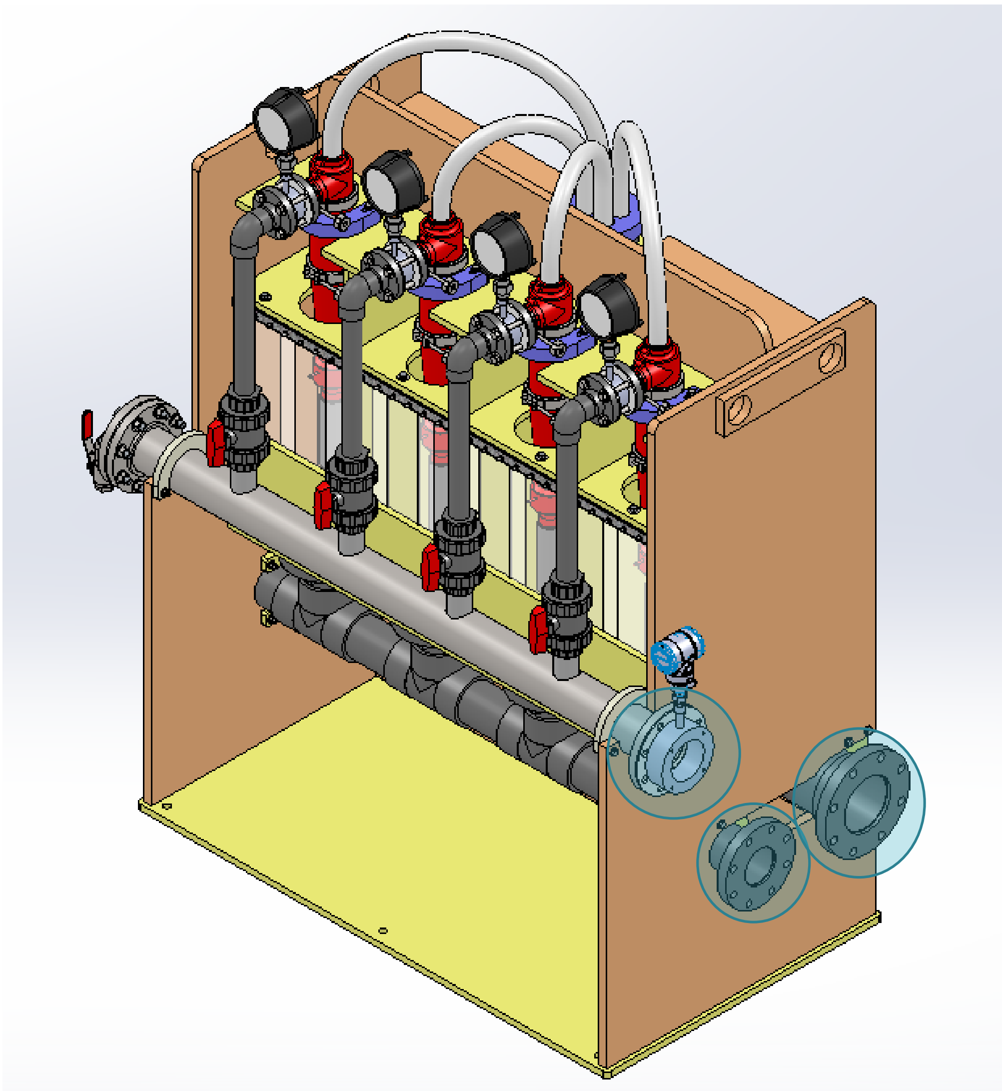


Figure 10 – Inlet and outlet flanges for process connections from left to right: Feed, Underflow, Overflow

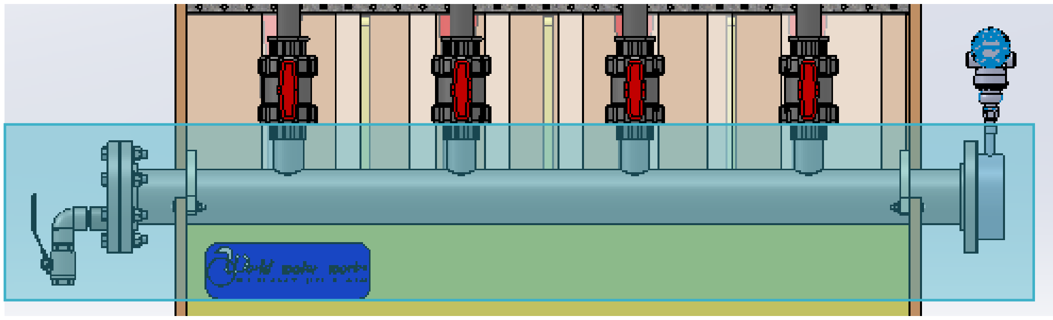


Figure 11 – Feed Manifold

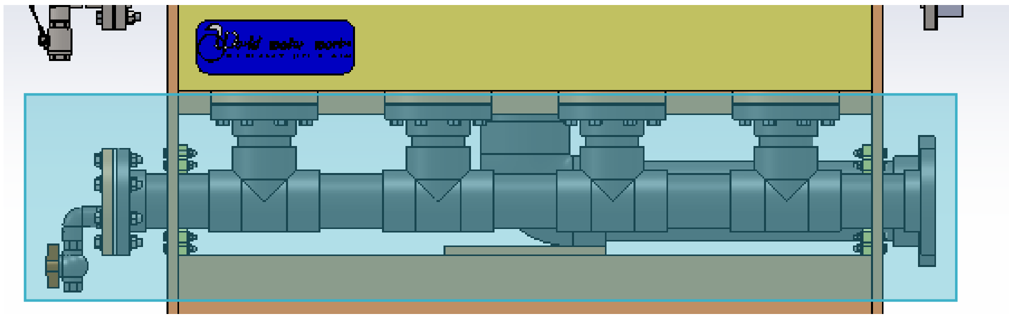


Figure 12 – Underflow Manifold

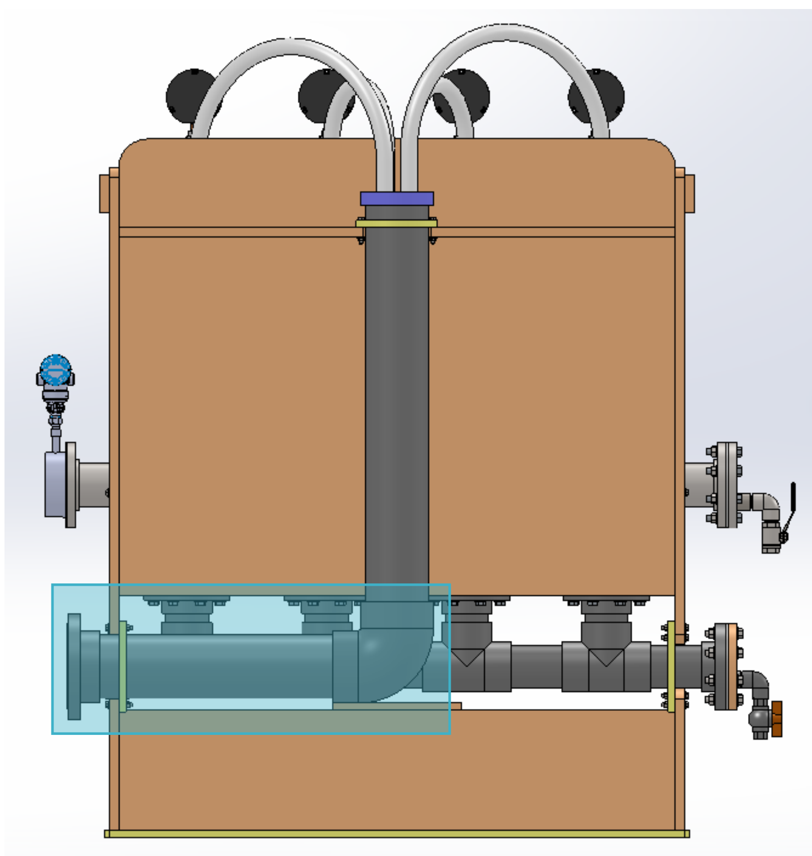


Figure 13 – Overflow Manifold

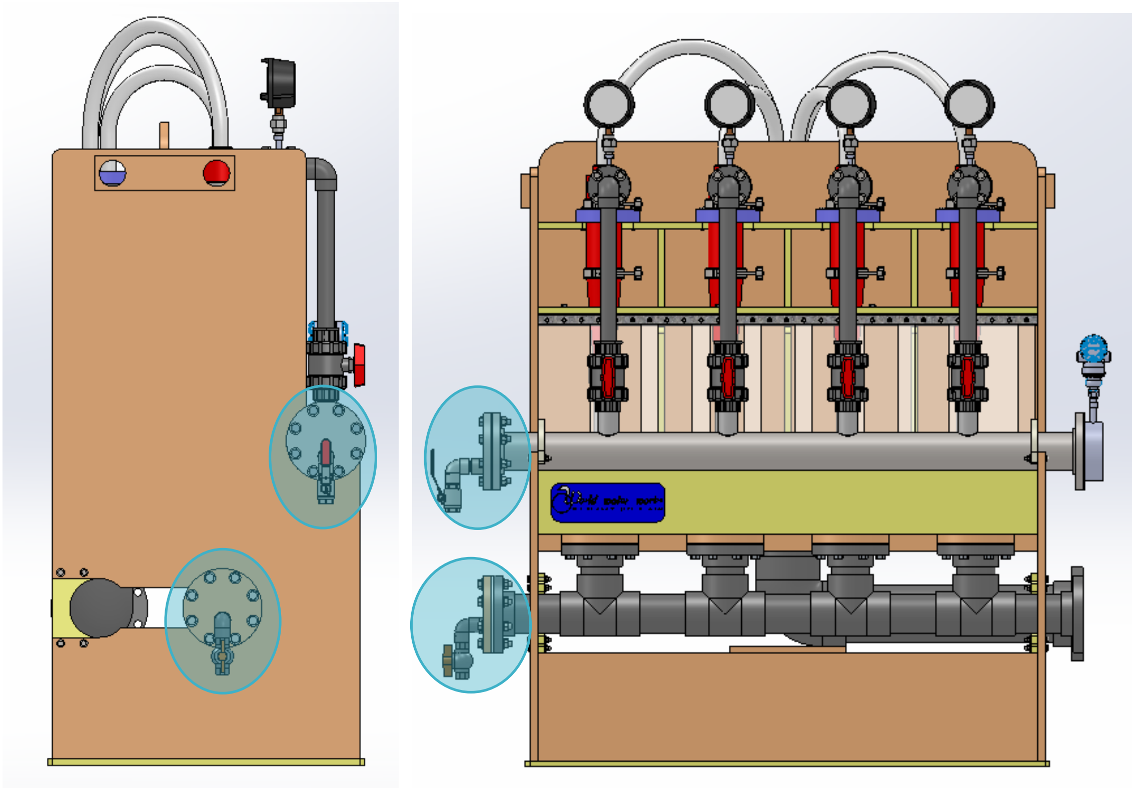


Figure 14 – Flush ports from top to bottom: Feed, Underflow

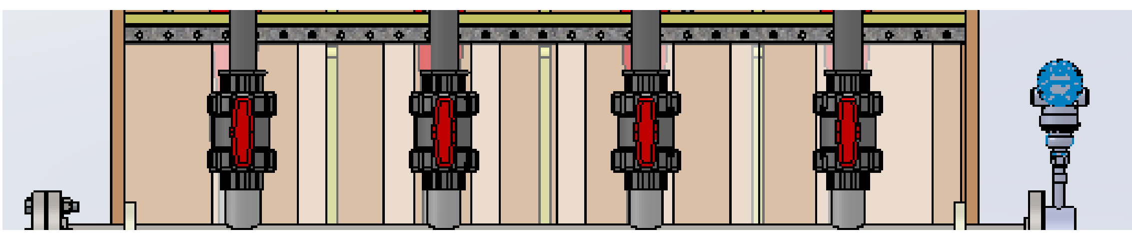


Figure 15 – Access Area to Underflow Boxes

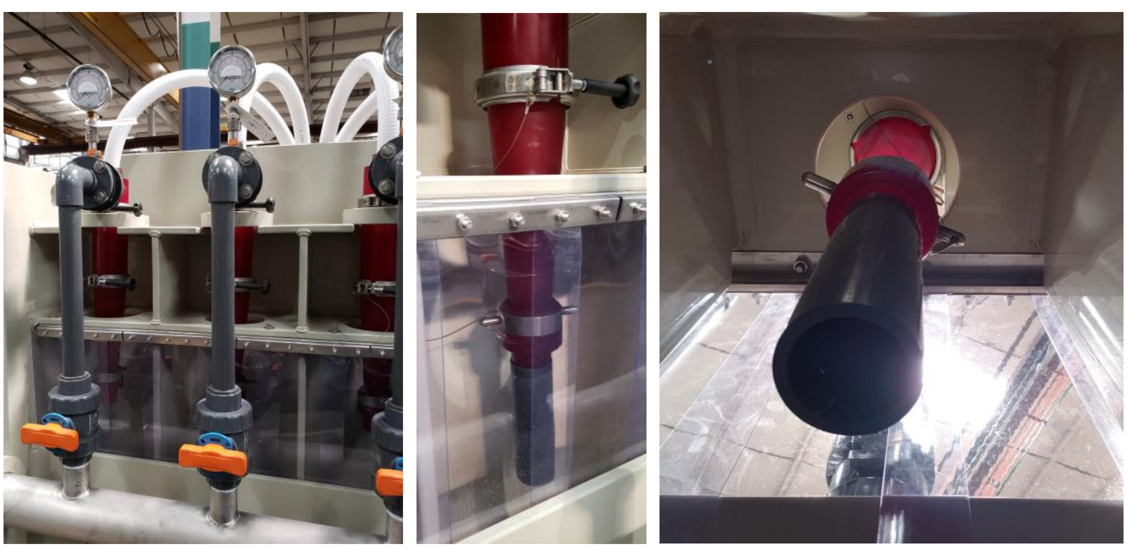


Figure 16 – Installed and Assembled Hydrocyclone / Inside Underflow Box

Figure 17 – Cyclone Spigots

Figure 18 – Assembled (top) and disassembled (bottom) hydrocyclone assembly. In order from left to right: vortex finder with t-bolt clamps, v-clamp, body extension, v-clamp, main body, retainer ring, spigot (tip, nozzle, etc.), spigot retainer cap, spray guard.

20. WARRANTY INFORMATION

See sales or rental agreement for warranty information.

21. SPECIAL TOOL INFORMATION & TESTING

- Special Tools
  - Tools for tightening t-bolt clamps
    - Torque wrench capable of measuring 5 ft-lbs | 60 in-lbs | 6.78 N-m
    - 7/16 inch socket
- Electrical Testing
  - Ensure all necessary safety equipment is installed and PPE is donned
  - Power up all systems
  - Check to be sure all electrical systems and instruments are powered properly
  - Perform any electrical systems checks recommended by the equipment manufacturers
  - Resolve and recheck any systems requiring attention
- Leak Testing
  - Ensure all necessary safety equipment is installed and PPE is donned
  - Fill all pipes and vessels with non-potable water from the existing system
  - Check for leaks in all piping, vessels, and pipe connections
  - Resolve and recheck any systems requiring attention
- System Component Testing
  - Ensure all necessary safety equipment is installed and PPE is donned
  - Test each equipment component for proper function
    - Ensure all flow paths are configured correctly for this testing
    - Perform any performance tests recommended by the equipment manufacturers
  - Test all equipment part of the inDENSE as one system
    - Ensure all flow paths are configured correctly for this testing
    - Check controls systems performance in controlling the various components of the system
    - Check instrumentation accuracy
    - Watch pressures and check for potential pipe obstructions
    - Check for leaks

- Hydrocyclone Settling Testing
    - This testing is necessary for determining optimal spigot size for the system. Please reference the inDENSE Settling Testing Procedure.
        - ISV
        - SVI 5
        - SVI 30
        - Mass and Hydraulic Split

<u>Initial Settling Velocity Measurements (ISV)</u>
Measurements should be conducted on the underflow (UF), overflow (OF), and feed (F) fractions of the cyclones as well as on the plant aeration basin effluent. The mixed liquor from each sample point is either diluted or concentrated to 2500 mg L-1 MLSS, which represents typical secondary treatment operating values (this can vary based on the facility). The adjusted sample is settled in a 2 L graduated cylinder. Milliliter graduations are used to record level measurements. A calculation sheet is used to determine the most linear slope which is used to determine the ISV in cm/min and m/hr. In addition, SSV5 and SSV30 are used to find SVI5 and SVI30 for each mixed liquor fraction following the method of Mohlman, 1934.

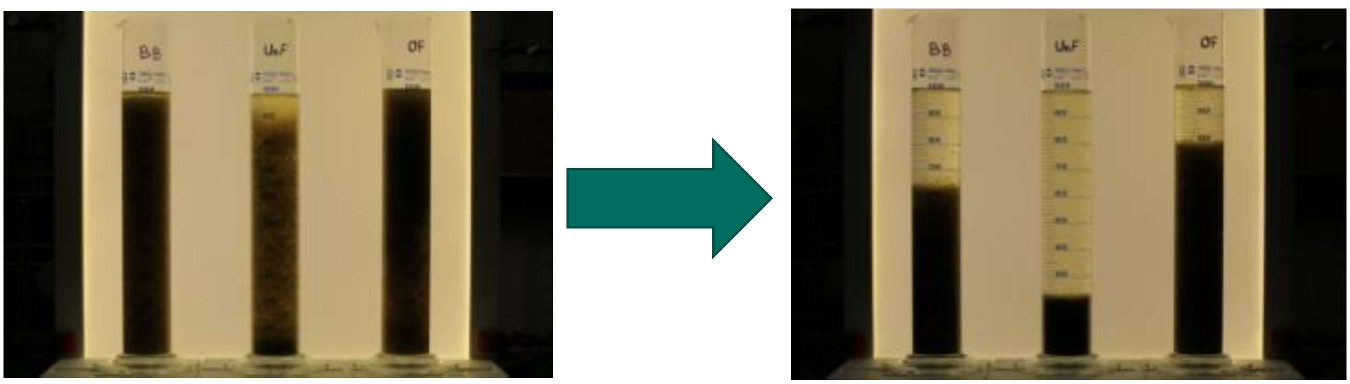


Figure 19 – Each picture has three cylinders with the Feed (F), Underflow (UF) and Overflow (OF) from left to right. The photo to the left is at time = 0 min and the photo to the right is at time = 5 min.

22. P&ID, EQUIPMENT LIST, & DRAWINGS

WWTP UPGRADE
PROCESS & INSTRUMENTATION DRAWINGS

PO#: TBD
JOB#: TBD

TBD

WORLD WATER WORKS
4000 SOUTHWEST 113TH STREET
OKLAHOMA CITY, OK 73173
USA

WWW CONFIDENTIAL

REV	DATE	DESCRIPTION	BY
0	6/29/2020	FOR INTERNAL REVIEW	PY
1	6/30/2020	FOR APPROVAL	PY

World water works
1-800-607-PURE
4000 SW 113th * OKLAHOMA CITY, OK 73137

CLIENT: TBD
LOCATION:
FILE NAME: XX-XXX inDENSE STANDARD PILOT
DESCRIPTION: WWTP UPGRADE

FOR INFORMATION
P.O.#: TBD
DRAWN BY: PY
CHECKED BY: CW
DATE: 6/29/2020
SCALE: N/A
JOB #: TBD
DRAWING #: 0601
SHEET: 1 OF 5 SHEETS

06-P&ID

Drawing	Description
01	COVER PAGE
02	Drawing List
03	P&ID KEY
04	CYCLONE DETAIL
05	EQUIPMENT LIST

REV	DATE	DESCRIPTION	BY
0	6/29/2020	FOR INTERNAL REVIEW	PY
1	6/30/2020	FOR APPROVAL	PY

World water works
1-800-607-PURE
4000 SW 113th * OKLAHOMA CITY, OK 73137

CLIENT: TBD
LOCATION:
FILE NAME: XX-XXX inDENSE STANDARD PILOT
DESCRIPTION: WWTP UPGRADE

FOR INFORMATION
P.O.#: TBD
DRAWN BY: PY
CHECKED BY: CW
DATE: 6/29/2020
SCALE: N/A
JOB #: TBD
DRAWING #: 0602
SHEET: 2 OF 5 SHEETS

LINE IDENTIFICATION

- WASTEWATER / MAIN PROCESS
- WASTEWATER / SLUDGE / AIR
- CHEMICAL / PNEUMATIC TUBING
- FLEXIBLE HOSE / INSTRUMENT CABLE
- ELECTRICAL / CONTROLS
- PROCESS - HEAT TRACED
- PROCESS - INSULATED
- DRAIN / SEWER

CONNECTION / SPECIAL FITTINGS IDENTIFICATION

- FLANGED
- BLIND FLANGE
- HOSE COUPLING
- NPT COUPLING
- SILENCER
- IN-LINE FILTER
- STRAINER
- EXPANSION JOINT

EQUIPMENT SCOPE IDENTIFICATION

- WWW EQUIPMENT BATTERY LIMITS

VALVE IDENTIFICATION & SYMBOLS

- NC VALVE NORMALLY CLOSED
- KNIFE VALVE
- GATE VALVE
- BALL VALVE
- DIAPHRAGM VALVE
- GLOBE VALVE
- BUTTERFLY VALVE
- NEEDLE VALVE
- CHECK VALVE
- 3-WAY VALVE
- PINCH VALVE
- PLUG VALVE

IN-LINE INSTRUMENTS AND ACCESSORIES

- IA / AFC — DIAPHRAGM ACTUATED CONTROL VALVE WITH ELECTROPNEUMATIC CONVERTOR OR ELECTROPNEUMATIC POSITIONER
- M — ELECTRICAL ACTUATED CONTROL VALVE M=MOTOR S=SOLENOID
- SPRING LOADED / MASS LOADED — RELIEF VALVE, SAFETY VALVE
- VENTURI TUBE, FLOW NOZZLE
- FLOW ORIFICE
- DOUBLE ACTING PNEUMATIC ACTUATOR
- SPRING RETURN PNEUMATIC ACTUATOR

INSTRUMENTATION / CONTROL SYMBOLS

- LICSA 101 — LOCALLY MOUNTED INSTRUMENT
- LICSA — FREEZE PROTECTED INSTRUMENT
- VFDxx xx-xx — VARIABLE FREQUENCY DRIVE
- xIC xx-xx — CONTROL PARAMETER INDICATED CONTROL (PRESSURE, FLOW, LEVEL, ETC.)
- IA — INSTRUMENT AIR CONNECTION POINT
- PW — POTABLE WATER CONNECTION POINT
- CONTROLS INTERLOCK

TAG NUMBER IDENTIFICATION

AB 12 34 -56

- EQUIPMENT TYPE PREFIX
- PROCESS LOCATION NUMBER
- EQUIPMENT TYPE NUMBER
- EQUIPMENT ID NUMBER

EQUIPMENT TYPE PREFIX

LETTERS	EQUIPMENT TYPE
AC	AFTER COOLER HEAT EXCHANGER
AE	ANALYSIS METER (pH, DO, TURBIDITY etc.)
AFR	AIR FLOW REGULATOR
AG	AERATION GRID COMPONENTS
BL	BLOWER
BM	BIOMEDIA
C	COMPRESSOR, FAN
CP	CHEMICAL PUMP
CV	CONTROL VALVE
DAF	DISSOLVED AIR FLOTATION UNIT
DP	DISSOLVED AIR GENERATOR PUMP
DW	DE-WATERING UNIT / SLUDGE FILTER PRESS
FE	FLOW METER
FS	FLOW SWITCH
LE	LEVEL TRANSMITTER
LS	LEVEL SWITCH
M	MOTOR
MX	AGITATOR, MIXER
PE	PRESSURE TRANSMITTER
PS	PRESSURE SWITCH
RG	RAKE GEAR
RP	RECIRCULATION PUMP
SM	SOLENOID MANIFOLD
SP	SLUDGE PUMP
SV	SOLENOID VALVE
TK	TANK / BASIN
TP	TRANSFER PUMP
V	MANUAL VALVE
_IT	INSTRUMENT CONTROLLER / TRANSMITTER
__S	SCREEN OR SIEVE

PROCESS /EQ TYPE NUMBER

NUMBER	PROCESS LOCATION	EQ TYPE NUMBER
01		MAJOR EQUIPMENT
02	TRANSFER SYSTEM	TANKS
03	PRE-SCREENING	AERATION GRID COMPONENT
04	TRANSFER SYSTEM	MANUAL VALVES
05	EQUALIZATION	CONTROL VALVES (ON/OFF)
06	TRANSFER SYSTEM	DISCREET OUTPUT
07	PRIMARY SEPARATION	DISCREET INPUT
08	TRANSFER SYSTEM	ANALOG OUTPUT
09	BIOLOGICAL PROCESS	ANALOG INPUT
10	SECONDARY SEPARATION	PUMPS
11	TRANSFER SYSTEM	CHEMICAL PUMPS
12	FILTRATION	BLOWERS
13	TRANSFER SYSTEM	COMPRESSORS
14	WATER REUSE	HEAT EXCHANGERS
15	SLUDGE STORAGE	MIXERS
16	DEWATERING	
17		
18		
19		
20		MISCELLANEOUS

EQUIPMENT SYMBOLS

- CENTRIFUGAL / DAG PUMP
- AERATION BLOWER
- CHEMICAL METERING PUMP
- CHEMICAL PERISTALTIC PUMP
- STATIC MIXER
- DISSOLVED AIR FLOTATION
- ROTARY SCREEN
- SIDEHILL SCREEN
- MIXER
- BAR SCREEN
- BIOMEDIA
- AFTERCOOLER

ELECTRICAL SYMBOLS

- FIELD-MOUNTED START PUSH-BUTTON
- FIELD-MOUNTED STOP PUSH-BUTTON
- SS — FIELD-MOUNTED SAFETY STOP PUSH-BUTTON
- FIELD-MOUNTED START/STOP PUSH BUTTON
- FIELD-MOUNTED SELECTOR SWITCH
- PANEL-MOUNTED PILOT LIGHT "RUNNING"
- PANEL-MOUNTED PILOT LIGHT "ALARM"
- PANEL-MOUNTED START/STOP PUSH-BUTTONS
- PANEL-MOUNTED SELECTOR SWITCH
- M — MOTOR
- G — GENERATOR

WWW CONFIDENTIAL

REV	DATE	DESCRIPTION	BY
0	6/29/2020	FOR INTERNAL REVIEW	PY
1	6/30/2020	FOR APPROVAL	PY

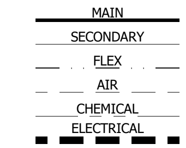
World water works
1-800-607-PURE
4000 SW 113th * OKLAHOMA CITY, OK 73137

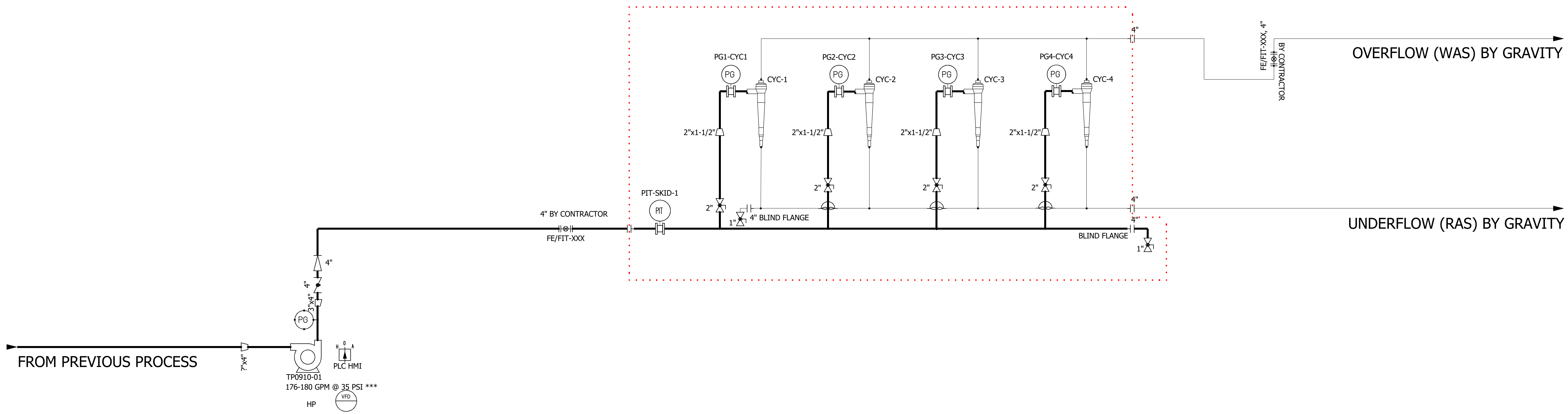
CLIENT: TBD
LOCATION:
FILE NAME: XX-XXX inDENSE STANDARD PILOT
DESCRIPTION: WWTP UPGRADE

FOR INFORMATION
P.O.#: TBD
DRAWN BY: PY
CHECKED BY: CW
DATE: 6/29/2020
SCALE: N/A
JOB #: TBD
DRAWING #: 0603
SHEET: 3 OF 5 SHEETS

NOT FOR CONSTRUCTION

1. WWW SCOPE DEFINED BY RED DOTTED LINES
2. CUSTOMER PIPING SHALL BE INDEPENDENTLY SUPPORTED
3. inDENSE FEED PUMP(s), VFD(s), PUMP CONTROLS & FLOWMETER(s) BY OTHERS
4. CONTROL PANEL w/PLC BY OTHERS





*** CYCLONE OPERATING PRESSURE WITHOUT CONSIDERING FRICTION & STATIC HEADLOSSES.

REV	DATE	DESCRIPTION	BY
0	6/29/2020	FOR INTERNAL REVIEW	PY
1	6/30/2020	FOR APPROVAL	PY

World water works
1-800-607-PURE
4000 SW 113th * OKLAHOMA CITY, OK 73137

CLIENT: TBD
LOCATION:
FILE NAME: XX-XXX inDENSE STANDARD PILOT
DESCRIPTION: CYCLONE DETAIL

FOR INFORMATION
P.O.#: TBD
DRAWN BY: PY
CHECKED BY: CW
DATE: 6/29/2020
SCALE: N/A
JOB #: TBD
DRAWING #: 0604
SHEET: 4 OF 5 SHEETS

01-MAJOR EQUIPMENT

TAG NUMBER	EQUIPMENT LOCATION	EQUIPMENT NAME	WWW PART NUMBER	MANUFACTURER	MODEL NUMBER	MATERIAL OF CONSTRUCTION	MAX FLOW	MAX PRESSURE	DIMENSIONS	PROCESS FLUID	HP	VOLTAGE
CYC-1	CYCLONE SKID (HDC-8211)	HYDROCYCLONE	E-10281	WWW		POLYURETHANE	44 GPM	36 PSIG	3"	RAS/WAS		
CYC-2	CYCLONE SKID (HDC-8211)	HYDROCYCLONE	E-10281	WWW		POLYURETHANE	44 GPM	36 PSIG	3"	RAS/WAS		
CYC-3	CYCLONE SKID (HDC-8211)	HYDROCYCLONE	E-10281	WWW		POLYURETHANE	44 GPM	36 PSIG	3"	RAS/WAS		
CYC-4	CYCLONE SKID (HDC-8211)	HYDROCYCLONE	E-10281	WWW		POLYURETHANE	44 GPM	36 PSIG	3"	RAS/WAS		

12-INSTRUMENTATION

TAG NUMBER	EQUIPMENT LOCATION	EQUIPMENT NAME	WWW PART NUMBER	MANUFACTURER	MODEL NUMBER	MATERIAL OF CONSTRUCTION	MAX FLOW	MAX PRESSURE	DIMENSIONS	PROCESS FLUID	HP	VOLTAGE
PG1-CYC1	CYCLONE SKID-1	PRESSURE ISOLATER WAFER STYLE W/PROCESS GAUGE	E-10440	ONYX VALVE	1.5" PSW, 1600150220629					RAS/WAS		
PG2-CYC2	CYCLONE SKID-1	PRESSURE ISOLATER WAFER STYLE W/PROCESS GAUGE	E-10440	ONYX VALVE	1.5" PSW, 1600150220629					RAS/WAS		
PG3-CYC3	CYCLONE SKID-1	PRESSURE ISOLATER WAFER STYLE W/PROCESS GAUGE	E-10440	ONYX VALVE	1.5" PSW, 1600150220629					RAS/WAS		
PG4-CYC4	CYCLONE SKID-1	PRESSURE ISOLATER WAFER STYLE W/PROCESS GAUGE	E-10440	ONYX VALVE	1.5" PSW, 1600150220629					RAS/WAS		
PIT-SKID-1	CYCLONE SKID-1	PRESSURE ISOLATER WAFER STYLE W/PRESSURE TRANSMITTER	E-10447	ONYX & ROSEMOUNT	4" PSW w/ROSEMOUNT 2088G2S22A1M4				4" ISOLATOR RING w/ 1/2" INSTRUMENT CONNECTION	RAS/WAS		

WWW CONFIDENTIAL

REV	DATE	DESCRIPTION	BY
0	6/29/2020	FOR INTERNAL REVIEW	PY
1	6/30/2020	FOR APPROVAL	PY

World water works
1-800-607-PURE
4000 SW 113th * OKLAHOMA CITY, OK 73137

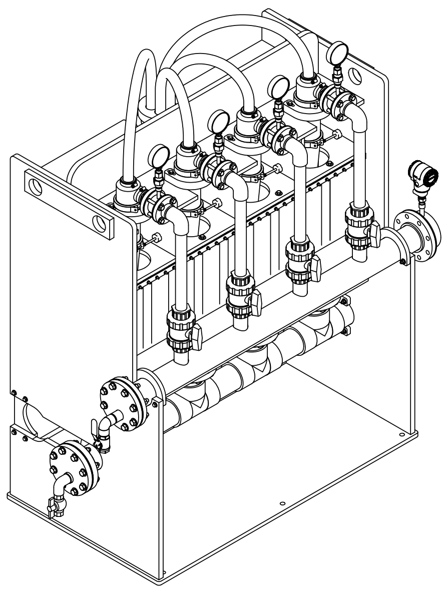
CLIENT: TBD
LOCATION:
FILE NAME: XX-XXX inDENSE STANDARD PILOT
DESCRIPTION: EQUIPMENT LIST

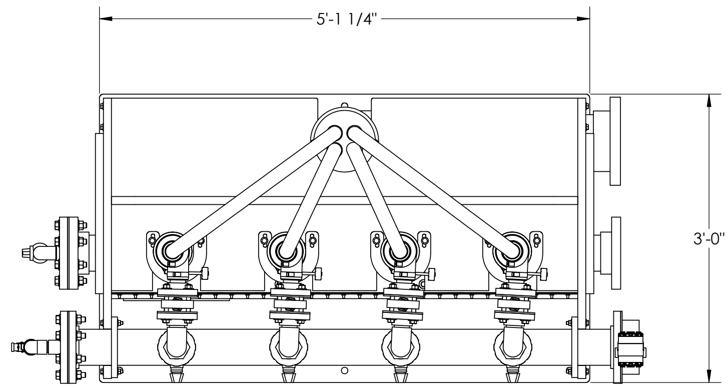
FOR INFORMATION
P.O.#: TBD
DRAWN BY: PY
CHECKED BY: CW
DATE: 6/29/2020
SCALE: N/A
JOB #: TBD
DRAWING #: 0605
SHEET: 5 OF 5 SHEETS

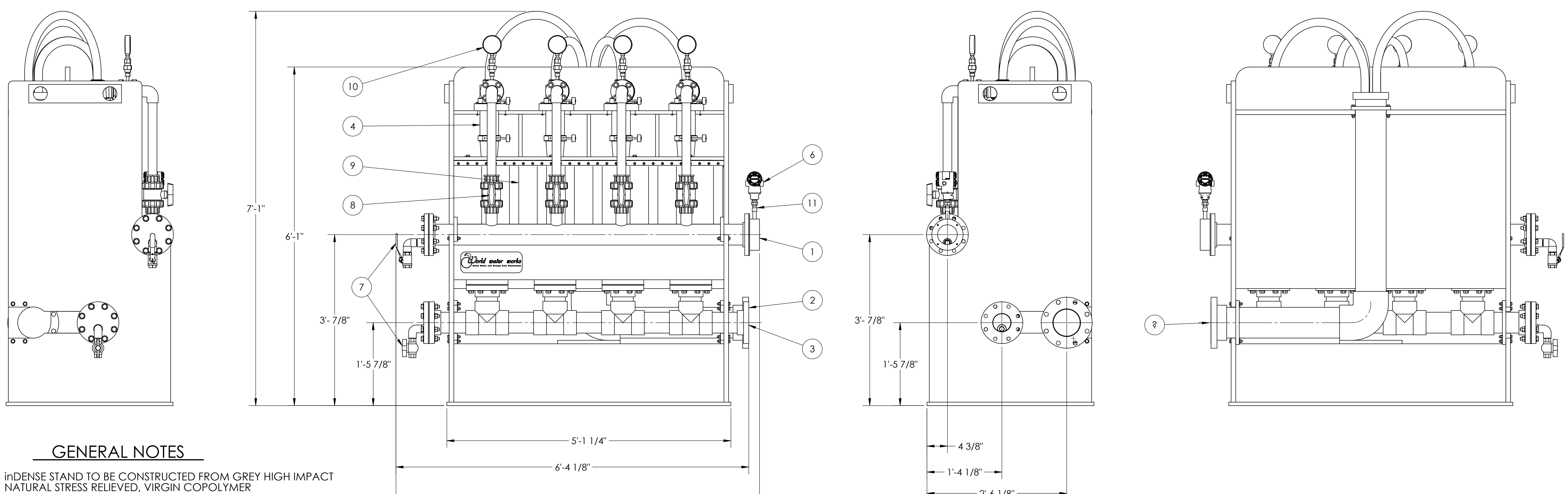
INDENSE CYCLONE

ITEM NO.	DESCRIPTION
1	FEEDFLOW, 4" FLANGE 150 LB - STAINLESS STEEL
2	UNDERFLOW, 4" FLANGE 150 LB - PVC
3	OVERFLOW, 6" FLANGE 150 LB - PVC
4	HYDROCLONE, 3" POLYURETHANE
5	PRESSURE GAUGE
6	PRESSURE TRANSMITTER
7	SAMPLE PORTS
8	ISOLATION VALVE, 2" PVC HAYWARD TRUEUNION
9	PVC STRIPS
10	ISOLATER RING 1-1/2"- SS
11	ISOLATER RING 4"- SS

EMPTY WEIGHT: 877 LBS
OPERATIONAL WEIGHT: 1,020 LBS







GENERAL NOTES

1. inDENSE STAND TO BE CONSTRUCTED FROM GREY HIGH IMPACT NATURAL STRESS RELIEVED, VIRGIN COPOLYMER POLYPROPYLENE. U.O.W.S
2. SERVICE: WASTE WATER @ 40°F ~ 130°F
3. ALL FLANGES TWO-HOLED TO THE CENTER LINE
4. STEEL REINFORCEMENTS TO BE: 304 STAINLESS STEEL
5. ALL DIMENSIONS SHOWN APPLY TO ROOM TEMPERTURE
6. A SPREADER BEAM IS REQUIRED TO BE DESIGNED TO ENSURE VERTICAL OR MINIMUM OUTWARD LIFT
7. SOME HIDDEN LINES AND COMPONENTS OMITTED FOR CLARITY
8. TANKS TO BE TRANPORTED EMPTY
9. ALL GASKET MATERAIL TO BE 3/16" THK. EPDM
10. ALL FASTENERS TO BE 304 SS
11. HYDRO. TEST TO BE ADMINISTERED BEFORE SHIPMENT
12. ALL FLANGE FACES TO BE PROTECTED WITH WOOD BLANKS FOR SHIPPING
13. FEEDFLOW ISOLATER RING WILL BE SHIPPED LOOSE

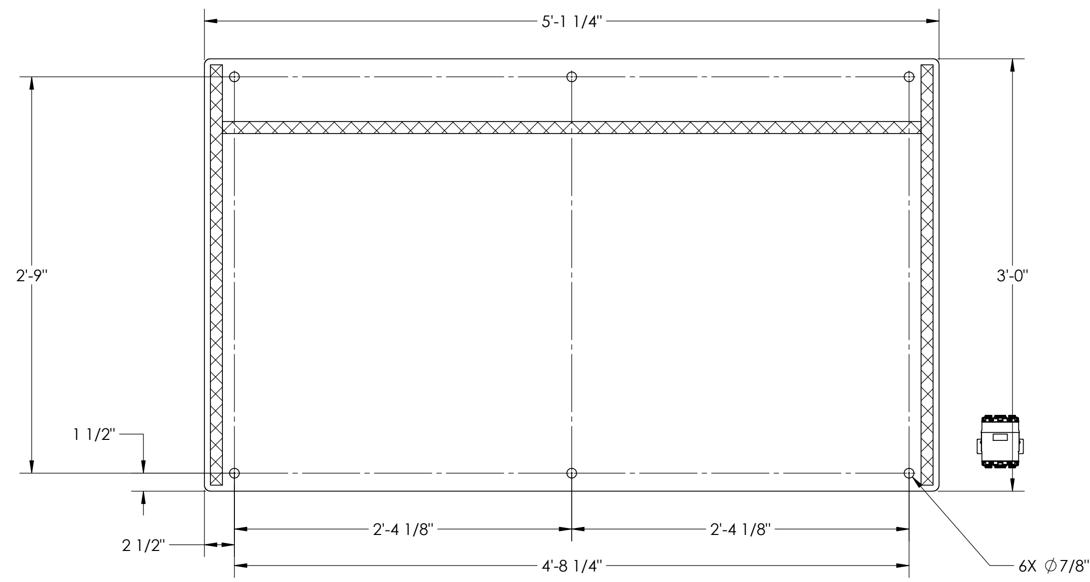
WWW CONFIDENTIAL

REV	DATE	DESCRIPTION	BY

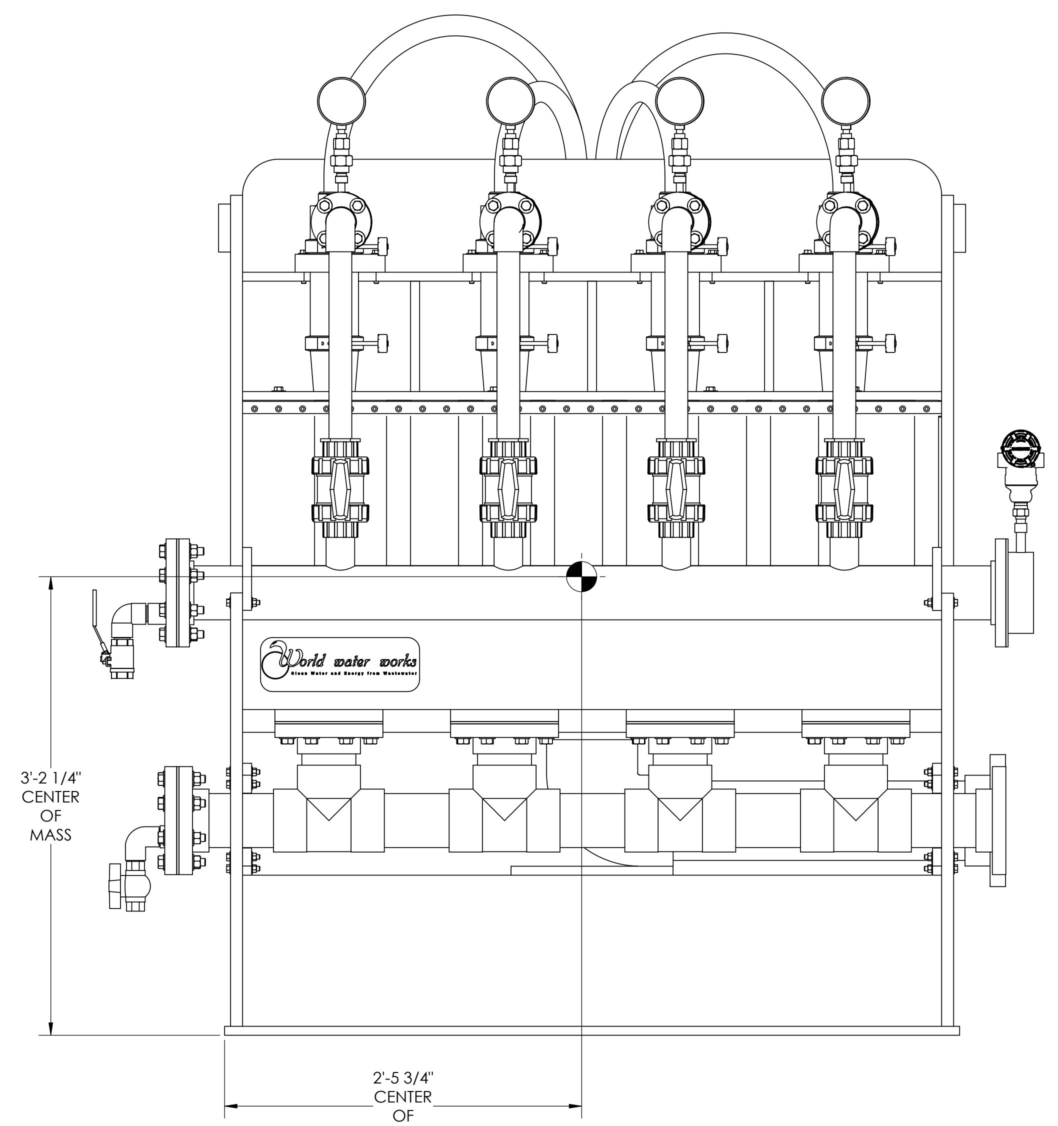
World water works

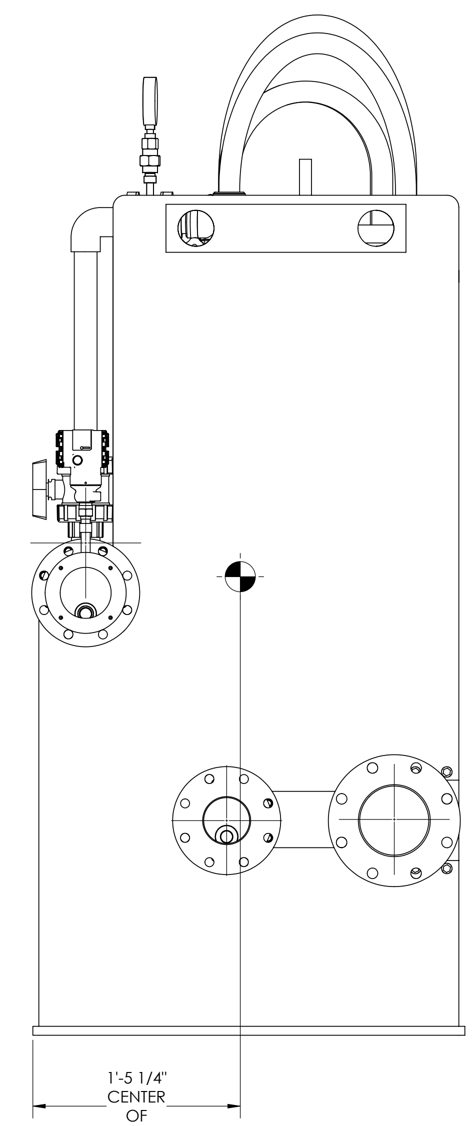
CLIENT:
LOCATION:
FILE NAME: SALES DRAWING-INDENSE CYCLONE
DESCRIPTION: SALES DRAWING

SALES DRAWING
P.O.#:
DRAWN BY: AWH
CHECKED BY:
DATE: 06/02/20
SCALE: 1:12
JOB #:
DRAWING #
SHEET: 1 OF 2 SHEETS



ANCHOR LOCATTIONS





WWW CONFIDENTIAL

CONFIDENTIAL
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REV	DATE	DESCRIPTION	BY

World water works
1-800-607-PURE
4000 SW 113th * OKLAHOMA CITY, OK 73137

CLIENT:
LOCATION:
FILE NAME: SALES DRAWING-INDENSE CYCLONE
DESCRIPTION: SALES DRAWING

FOR APPROVAL
P.O.#:
DRAWN BY: AWH
CHECKED BY:
DATE: 06/02/20
SCALE: 1:8
JOB #:
DRAWING #
SHEET: 2 OF 2 SHEETS

MOB™ System Proposal and Sample Trial Agreement

Prepared for

Rock Creek WWTP – West Side
Hillsboro, OR

December 21, 2022

Contents

First, we would like to thank you for giving Nuvoda your consideration.

Founded in 2006, Nuvoda is a group of passionate engineers and researchers dedicated to innovative, sustainable, and renewable biotechnologies geared directly towards advancing the frontier of modern wastewater treatment techniques. Our core competency lies in researching, developing, manufacturing, integrating, and delivering state-of-the-art biofilm and granular technologies.

Headquartered in Raleigh, NC with an engineering design team in Blacksburg, VA, Nuvoda continues to break the mold and deliver award-winning solutions for clients across the globe – municipalities and industries alike.

Introduction and Process Overview

Nuvoda's Mobile Organic Biofilm™ (MOB™) process is an innovative and sustainable wastewater treatment process that is implemented by our clients to address stringent nutrient removal requirements, improve secondary sludge settleability, and intensify secondary treatment process capacities to address existing bioreactor footprint and configuration limitations. The patented MOB™ process is a 100% plant-derived hybrid technology that combines the advantages of integrated fixed-film activated sludge (IFAS) and aerobic granular sludge (AGS). The process utilizes a highly renewable, lignocellulosic plant material as a medium for biofilm growth. The ballasted media core, when introduced to a bioreactor, sequencing batch reactor (SBR), oxidation ditch, or similar, provides a backbone for the establishment of organically ballasted granular sludge. The biomedia acts as an adsorptive ballast, which provides a high degree of stability that enhances and de-risks the flow-through granular sludge process.

MOB™ granules are fully mobile and free to circulate throughout wastewater treatment plant's (WWTP's) secondary treatment processes. The granules grow a stratified microbial community that facilitates robust and versatile simultaneous biological nutrient removal. Since the particles are free to circulate into the secondary clarifiers, the improved settleability associated with sludge granulation reduces effluent total suspended solids, increases secondary clarifier capacity, and improves sludge dewaterability. Figure 1 provides an illustration of how the MOB™ process would be implemented at Rock Creek WWTP – West Side.

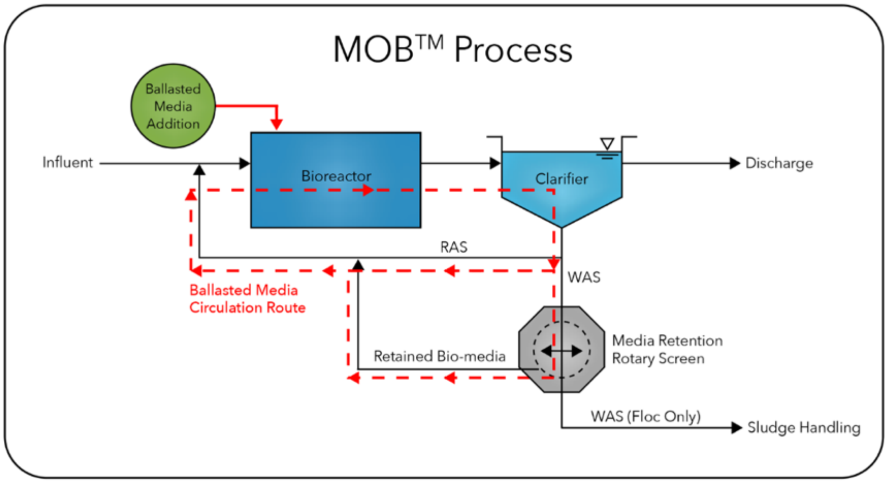


Figure 1. MOB™ Process Flow Diagram.

We have based our MOB™ process design for Rock Creek WWTP – West Side on a 1.25% ballasted media fill rate in the bioreactors. This media fill rate results in 250 m^2 surface area of ballast per 1 m^3 of bioreactor volume. The media will circulate with activated sludge and work as a substratum for stratified biofilm growth. Once the media enters the secondary clarifiers, the excellent settleability of the ballasted granular sludge will help to reduce the sludge blanket depth and will improve effluent TSS. The granular sludge is returned to the bioreactors with the recycled activated sludge (RAS). Ballasted granules in the waste activated sludge (WAS) stream will be separated and retained by a rotary drum screen and then directed back to the bioreactor(s) as well. The MOB™ Process is a closed loop system; loss of media is minimal and can be easily replenished when necessary. On an annual basis, approximately 0 to 2 percent of the initial fill fraction is supplemented per year. The biomedia is a lignocellulosic fiber, which prevents media breakdown under aerobic conditions, but will biodegrade if it makes its way to the WWTP's anaerobic digesters.

In addition to significant process improvements, one of the major benefits of the MOB™ process is the operational simplicity and maintainability of the system. Implementing the MOB™ process in a conventional BNR plant does little to change how the facility is operated. The only major equipment addition is the WAS screen(s), which requires minimal operations and maintenance attention. There are no complex carbon management requirements to achieve granulation with the biomedia backbone; our clients often report that they don't need to train their operations and maintenance staff on how to run the MOB™ process because it's operated in exactly the same manner as their BNR process was operated pre-implementation.

Implementing the MOB™ process at Rock Creek WWTP – West Side is as simple as it seems – drum screens are installed on the WAS service and the biomedia media is added to the bioreactors. Within weeks, the WWTP will experience major process benefits. Depending on the goals of the application and how the aeration system is operated, Rock Creek WWTP – West Side will observe some (or all) of the following benefits:

1) Significantly increased BNR and BOD-removal capacity;
2) Enhanced process stability during peak flow events;
3) Improved secondary sludge settleability (the ballasted granular sludge will have a Sludge Volume Index (SVI_{15}) typically between 40 and 80 mL/g);
4) Reduced energy consumption associated with lower aeration rates; and
5) Simple, stable operation.

We are pleased to submit a budgetary proposal with detailed design criteria for a MOB™ process installation at the Rock Creek WWTP – West Side. Our goal is to provide a cost-effective, highly customizable, and excitingly innovative solution that will meet the specific needs of your plant.

Facility and Process Information

A. Existing Facility Design Parameters

Basin 1	***Unit***	***Value***
Configuration	-	A2/O (AO in winter)
Anaerobic 1	gal	154,415
Anaerobic 2	gal	154,415
Anoxic 1 (Anaerobic Swing)	gal	154,415
Anoxic 2 (Anaerobic Swing)	gal	154,415
Aerobic	gal	1,646,933
Total Working Volume	gal	2,170,000

Basin 2	***Unit***	***Value***
Configuration	-	A2/O (AO in winter)
Anaerobic 1	gal	154,415
Anaerobic 2	gal	154,415
Anoxic 1 (Anaerobic Swing)	gal	154,415
Anoxic 2 (Anaerobic Swing)	gal	154,415
Aerobic	gal	1,646,933
Total Working Volume	gal	2,170,000

Secondary Clarifiers	***Unit***	***Value***
Number of Tanks Online	-	4
Diameter	ft	110
SWD	ft	11.74
Total Surface Area Online	ft^2	38,013

B. Primary Effluent Characteristics

Parameters	Unit	Winter	Summer
Design Flow	MGD	38.4	18.5
Peak Flow	MGD	61.7	24.7
cBOD	mg/L	98.1	156.7
TSS	mg/L	91.1	81.6
NH3-N	mg/L	15.3	30.7
TKN	mg/L	24.3	47.4
TN	mg/L	1.6	3.1
TP	mg/L	3.4	6.7
Temp	°C	14.6	15.2

C. Effluent Targets

Parameters	Unit	Winter	Summer
TSS	mg/L	10	10
NH3-N	mg/L	10	1
OP	mg/L	-	1

As per instructions received from the Customer's consulting engineer, this proposal is based on implementing the MOB™ process to achieve and maintain target concentrations listed in the above table at the design flows, loads, and temperatures. If there are different goals for the MOB™ process (e.g., process intensification with current effluent criteria or improving sludge settleability to debottleneck the WWTP's secondary clarifiers), Nuvoda can complete process modeling, using Sumo (by Dynamita) or SIMBA# (by inCTRL Solutions), to confirm estimated process performance for different effluent criteria.

Prcoess Design Proposal

A. Process Design Overview

Based on the effluent criteria presented above and the design flows/loads, Nuvoda has developed a MOB™ process retrofit plan for the Rock Creek WWTP – West Side. The following subsections detail the design principals and parameters of the implementation of MOB™ process.

- Process Selected: MOB™ process integrated into existing aeration basins
- Total Bioreactor Volume: 4.34 gal

B. MOB™ Process Design Parameters

MOB™ Process Properties	***Unit***	***Value***
Media Outer Surface Area	m²/g	0.076
Media Total Surface Area (Including Pores)	m²/g	1.76
Media Dry Density	kg/m³	263
Media Specific Surface Area (Outer)	m²/m³	20,000
Media Specific Surface Area (Total)	m²/m³	463,000
Desired Net SSA (Outer)	m²/m³ tank	250
Desired Net SSA (Total)	m²/m³ tank	5,785
Media Fill Fraction	m³ media / m³ tank x 100%	1.25
Media Addition in Reactors	kg/m³ tank	3.29
Media Specific Gravity (wet)	-	1.056
Media SVI_5 (wet)	mL/g	10
Typical SVI_{15} Range	mL/g	40 to 80
Maximum Annual Media Supplementation	%	0.025% (2% of 1.25% Initial Fill)

C. Process Modeling Design Parameters

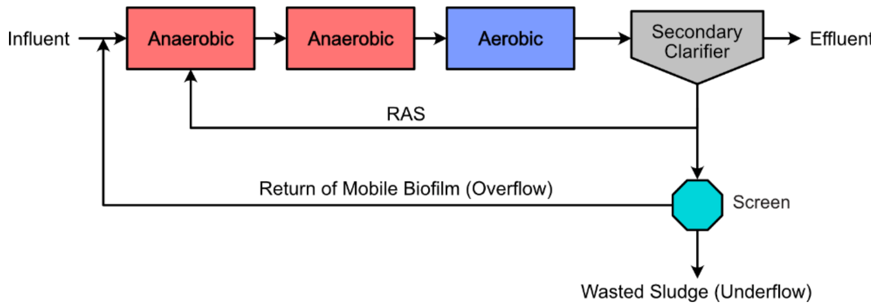
- Modeling Assumptions

1. Assume all trains run in parallel.
2. All influent fractionations were closely matched with customer/engineer supplied data, but may not be exact.

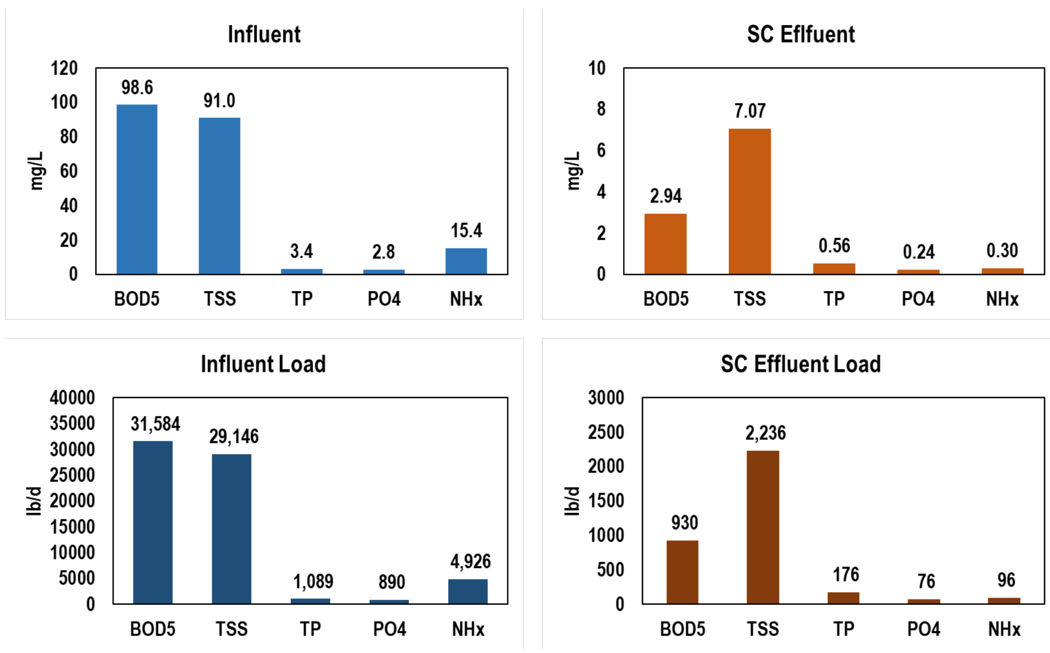
Parameters	***Unit***	***Winter***	***Summer***
Design Flow	MGD	38.4	18.5
Reactor Capacity	Mgal	4.34	4.34
Anaerobic Capacity	Mgal	1.17	0.59
Anoxic Capacity	Mgal	0.00	0.59
Aerobic Capacity	Mgal	3.17	3.17
DO in Aerobic	mg/L	2.0	2.0
Total Oxygen Demand	lb/d	52,684	43,114
Temperature	°C	14.0	15.2
RAS	%Inf	30	30
Internal Recycling	%Inf	0	350
aSRT	day	3	5.5

D. Process Modeling Results

- Winter Flow Diagram

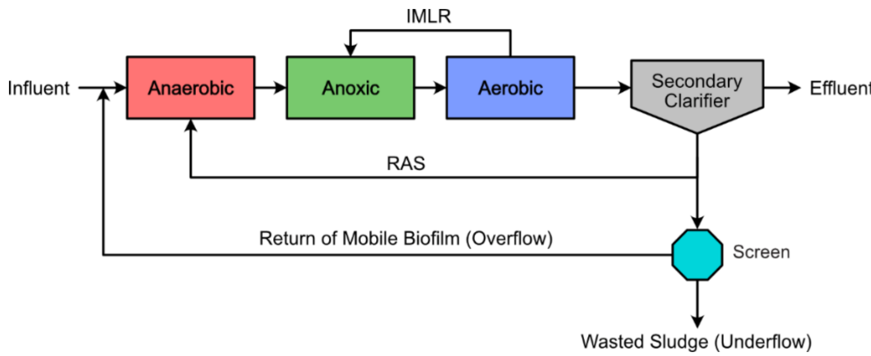


- Winter Modeling Results

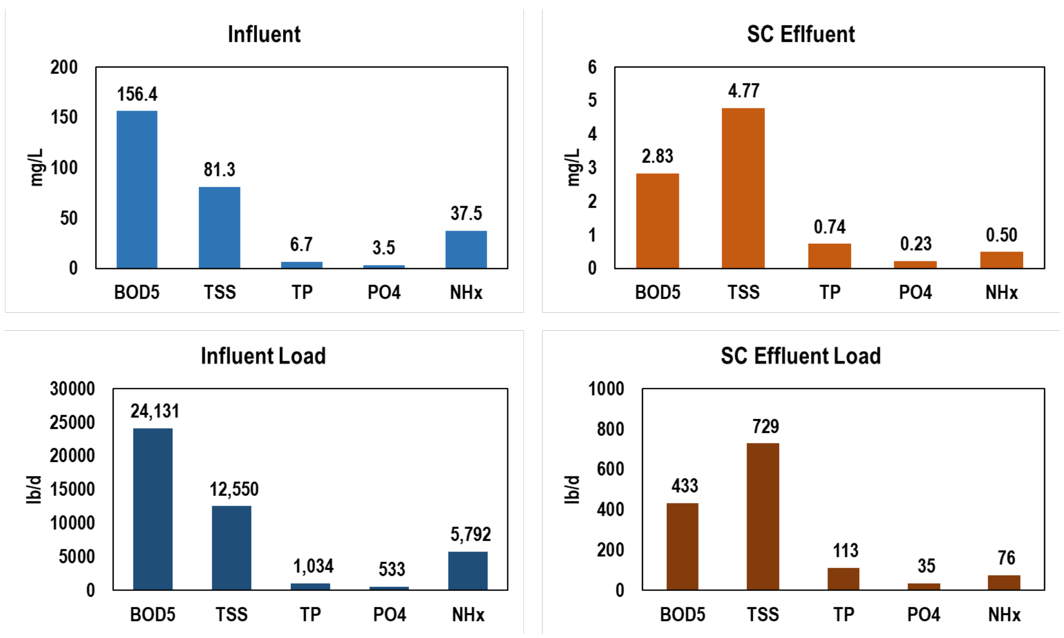


Components	***Unit***	***Influent***	***SC Effluent***
BOD5	mg/L	98.6	2.94
TSS	mg/L	91.0	7.07
TP	mg/L	3.4	0.56
PO4	mg/L	2.8	0.24
TN	mg/L	24.3	15.34
NHx-N	mg/L	15.4	0.30
NO2	mg/L	0.0	0.05
NO3	mg/L	0.0	13.13

- Summer Flow Diagram



- Summer Modeling Results



Components	Unit	Influent	SC Effluent
BOD5	mg/L	156.4	2.83
TSS	mg/L	81.3	4.77
TP	mg/L	6.7	0.74
PO4	mg/L	3.5	0.23
TN	mg/L	47.4	26.83
NHx-N	mg/L	37.5	0.50
NO2	mg/L	0.0	0.10
NO3	mg/L	0.0	24.37

Budgetary Proposal

Below is a list of equipment and services required for the installation of the MOB™ process at Rock Creek WWTP – West Side. The provided pricing is valid for 90 days from December 21, 2022 and is based on Nuvoda's standard equipment offering. All Prices are exclusion of works.

A. Equipment List

EQUIPMENT	CONTENT	UNIT	QUANTITY
MOB™ Process	Bio-media	m^2	4,116,633
Media Retention Screens	Perforation	µm	500
	Bio-media Chute	ea	1
	Washdown System	ea	1

B. System Cost

DESCRIPTION	QUANTITY	LINE TOTAL
MOB™ Process	1	$2,879,000USD
Media Retention Screens	2 (1 Duty, 1 Standby)	Included
Process Start-up	1	Included
	TOTAL	$2,879,000 USD (excl. shipping and handling)

C. Additional Items

DESCRIPTION	QUANTITY	LINE TOTAL
Additional Process Modelling	N/A	TBD if Required
Engineer On-site Support	Per Day	$2,000 USD plus travel expenses
Technician On-site Support	Per Day	$1,600 USD plus travel expenses
6-Month Pilot/Trial[1]	N/A	$ USD
12-Month Pilot/Trial[1]	N/A	$ USD
3rd Party Engineer for Pilot Validation	N/A	TBD if Required

[1] Refer to page 15 of this proposal for a sample pilot/trial agreement.

DESCRIPTION	QUANTITY	LINE TOTAL
Annual Media Supplementation[2]	2% of Initial Fill Fraction[3]	$ USD (per year)

D. Billing Terms

MILESTONE	DESCRIPTION	TERMS	PERCENTAGE
1	Purchase Order	NET 30	10%
2	Upon Submission of Design Package	NET 30	30%
3	Prior to Shipment, Ex Works	NET 30, not to exceed 60 days past milestone 2	50%
4	Commissioning/Start-Up Complete	NET 30, not to exceed 60 days past milestone 3	10%

E. Process Guarantee

Upon startup, Nuvoda guarantees annual average BOD and TSS of 10 mg/L based on the influent design parameters included in this proposal. Influent design parameters to stay within stated maximum or minimum ranges.

F. Exclusions

- Additional Design
  The engineering work described in this report does not include the design of a permanent facility to house the WAS media retention screens or other ancillary equipment.
- Equipment Offloading
  The engineering work described in this report does not cover the cost of equipment off-loading, lifting and unloading equipment, concrete, grading, or anything outside what is provided in the Nuvoda scope of supply.
- Installation
  Installation is not included.
- Laboratory Sampling Fees
  The engineering work described in this report does not include any costs for fees related to analytical sample analysis that may be conducted by a third-party laboratory.

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[2] Annual media costs are the maximum annual price, not accounting for inflation, that the Rock Creek WWTP – West Side will pay for media supplementation based on a 2% annual supplementation rate. Actual annual cost will be adjusted to account for inflation, as measured by the United States Consumer Price Index (CPI), between this proposal date and the date of ordering supplemental media. The maximum annual price, plus inflation, will be valid until December 31, 2042.

[3] If less than 2% of the initial media fill fraction is replaced per year, the Customer will pay proportionally less for the media. If more than 2% of the initial media fill fraction is replaced per year, the Customer will pay only the maximum amount (plus inflation) presented herein provided the MOB™ system is operated as directed by Nuvoda.

- Permitting
  The engineering work described in this report does not include any costs for mechanical/electrical/other permitting and/or engineering drawings related to this effort.
- Freeze Protection
  The engineering work described in this report does not include any costs to provide freeze protection to piping, equipment and/or pumps that are external to the supplied equipment installed at job-site.
- Electrical Connection or Energy Usage
  The engineering work described in this report does not include any costs to provide and connect power to equipment or run low-voltage conduit, nor does it cover any costs for the electrical usage, heating, and cooling consumed by the unit.
- Equipment Anchoring & Seismic Calculations
  Report does not include any seismic calculations or seismic drawings. Anchor tabs or holes are included on all screen skids. Strapping for tanks is not included. Client to provide anchor bolts and anchor skids to existing substrate based on local requirements.
- Other Site-Specific Engineering Requirements
  No other specific local, customer, or site-specific engineering or code requirements have been incorporated at this time.
- Taxes/Fees
  Pricing does not include applicable duties, taxes, or brokerage fees of any kind. Pricing does not include any sales taxes, GST, HST, provincial, municipal & government taxes of any kind and any charged or required to be remitted or withheld will be in addition to the proposal pricing and the responsibility of the customer The Purchaser shall procure all permits, licenses, registrations, certificates, etc., if any, required for the installation and operation of any equipment quoted above.

Conclusion

We look forward to working with the Rock Creek WWTP – West Side and helping your facility achieve its discharge goals. We are confident that we can meet the challenges ahead and stand ready to partner with you in delivering an effective process upgrade solution. Please do not hesitate to reach out through email or phone if you have any questions about this proposal or the MOB™ process.

Sincerely,

Brian Jones

Director of Sales

brianjones@nuvodaus.com

(501) 416-8928

Jason Calhoun

Chief Technology Officer

jasoncalhoun@nuvodaus.com

(540) 266-2024

Sample Trial Agreement

Between Nuvoda, LLC and Rock Creek WWTP – West Side

The purpose of this Trial Agreement ("Trial Agreement") is to establish the terms of a trial and license of Nuvoda's patented Mobile Organic Biofilm ("MOB™") System by the Rock Creek WWTP – West Side. All exhibits hereto are incorporated by reference.

Trial Terms

A. Parties

- Nuvoda, LLC (the "Company") located at 608 Gaston Street, Raleigh, North Carolina 27603.
- Rock Creek WWTP – West Side ("Customer") located at Hillsboro, OR.

B. Timing

- Nuvoda will supply the screening device and ballasted media to the site no later than [ ], 202[ ] for use with the MOB™ System, further described in Exhibit A, at the Rock Creek WWTP – West Side Wastewater Treatment Plant (the "Facility"), further described in Exhibit B.
- The MOB™ Trial will begin [ ], 202[ ] and operate through [ ], 202[ ]. Success will be determined by achieving the Trial Period Minimum Performance Goals, further described in Exhibit C.
- CUSTOMER has the option to purchase the MOB™ System at any point during the Trial.

C. Cost

- NUVODA to provide Rotary Drum Screen and MOB Bio-media.
- CUSTOMER is responsible for all costs related to shipping of equipment and media and installation costs.
- CUSTOMER will pay [ ] USD, which includes for engineering and start-up support services, for the Trial.
- At any point during the MOB™ Trial, CUSTOMER may elect to purchase the screening equipment, ballasted media, and perpetual license to use the MOB™ System. Any money paid for the MOB™ Trial will be credited towards the MOB™ Purchase Price by executing the Purchase and Licensing Agreement attached hereto as Exhibit D.
- Each party to analyze their own process and/or laboratory samples. Each party to pay for the analysis of their own samples. Results will be shared with the other party regularly, and no less than one month after obtaining the results.

D. Termination

- At any point, CUSTOMER, at their sole discretion with thirty (30) day notice, may terminate trial without purchasing the MOB™ System by providing written confirmation of that decision.
- All charges accumulated before the notification will be due. No additional charges subsequent to the termination shall be incurred.
- CUSTOMER will promptly disconnect the screening device and notify Nuvoda of a point of pick up for the equipment. Nuvoda may observe the disconnection and will remove the screening device at the customer's cost.
- The ballasted media will initially remain in the system. No mechanism will be installed to artificially retain or remove the ballasted media. The ballasted media will be wasted over time as a normal part of the plant's operations. Those disposal costs will be the responsibility of the Customer.

E. Licensing, Intellectual Property and Confidentiality

- Customer will be granted a limited, non-exclusive, non-transferable, and non-sublicensable royalty-free license to use the MOB™ System and associated equipment provided by Nuvoda for the period of the trial and any extensions, solely at the Facility.
- License will be terminated thirty (30) days after the end of the trial, and its extensions, unless MOB™ purchase is completed.
- Customer shall take commercially reasonable actions to ensure that its affiliates do not, directly or indirectly, violate the license or any intellectual property rights owned by Nuvoda.

F. MOB™ System Purchase Price

- The purchase price shall be [ ] USD.
- Separate MOB™ System Purchase and Perpetual Royalty Free Licensing Agreement to be executed in the form attached hereto as Exhibit D shall be entered into prior to the payment of the purchase price.
- Customer as part of the above reference Purchase and Licensing Agreement will be granted a perpetual, limited, personal, non-exclusive, non-transferable, non-sublicensable right, and royalty free license for the use of the process schemes identified or permitted under Patent Numbers US7841934B2, US10138148B2, and US10189730B2 (the "Nuvoda Patents").

G. Additional Provisions

- Screening equipment will remain the property of Nuvoda until completion of trial or final purchase of the MOB™ System.

- CUSTOMER must keep adequate mixing of 0.3 to 0.5 m/s within their basins at all times.
- Trash collection or inadequate screening will be the responsibility of CUSTOMER.
- If the MOB™ System is removed at the direction of CUSTOMER and then the full MOB™ System is purchased at a later date, the requested re-installation will result in additional fees dependent upon the status of the ballasted media.
- During the trial and subsequent to any MOB™ System purchase, CUSTOMER may modify the equipment and process. Upon request by Nuvoda, CUSTOMER shall consult with Nuvoda and review the reasoning for process changes and share performance data regarding modifications that directly or indirectly impact the performance of the MOB™ process.
- Trial performance is based on the influent parameters and equipment parameters as outlined in Nuvoda's proposal dated [ ], 202[ ]. A Pre-Trail Checklist as shown in Exhibit E will be reviewed by both parties prior to start of the Trial.
- Nuvoda warrants that it has the rights to the MOB™ process, which is a patented process set forth in the Nuvoda Patents, and will at all times indemnify and hold CUSTOMER harmless from any and all claims, causes of action, and expenses (including reasonable attorneys fees) as a result of any claim by a third party relating to Nuvoda's ownership and right to enter into this Trial Agreement. Nuvoda further warrants such patent rights encompass the MOB™ System and that Nuvoda is not aware of any other claims to the ownership of such patent rights.
- Nothing contained in this Trial Agreement shall prevent CUSTOMER from performing such additional tests as it may deem necessary to evaluate the MOB™ System and its processes.
- Any notice shall be deemed served on the other party upon its mailing if the notice is sent certified mail, return receipt requested and regular mail.
- EXCEPT IN THE EVENT OF NUVODA'S BREACH OF ITS WARRANTY OF OWNERSHIP AND LACK OF KNOWLEDGE OF OTHER CLAIMS TO ITS PATENT RIGHTS AS DESCRIBED IN THIS AGREEMENT, NUVODA'S LIABILITY UNDER THIS TRIAL AGREEMENT SHALL NOT EXCEED THE TOTAL AMOUNT PAID BY CUSTOMER TO NUVODA UNDER THIS TRIAL AGREEMENT. NO ACTION AGAINST NUVODA ARISING OUT OF THIS TRIAL AGREEMENT MAY BE BROUGHT BY THE OTHER PARTY MORE THAN ONE YEAR AFTER THE CAUSE OF ACTION HAS ARISEN.
- Nothing contained in this Agreement shall be construed as creating a joint venture, partnership, agent, or employment relationship between Nuvoda and CUSTOMER.
- Neither party shall assign, delegate, or otherwise transfer in any way either this Trial Agreement or any of its rights, duties, and/or obligations hereunder without the prior written consent of the other party.

[Signature page]

Nuvoda, LLC	Rock Creek WWTP – West Side
Signature	Signature
Print Name	Print Name
Title	Title
Date	Date

Appendix

A. Winter Primary Effluent

Id		Value	Unit
S_VFA	VFAs	5.85	g COD/m³
S_F	Fermentable substrate	40.94	g COD/m³
S_MEOL	Methanol	1.00E-02	g COD/m³
C_B	Colloidal biodegradable substrate	17.76	g COD/m³
X_B	Slowly biodegradable substrate	79.05	g COD/m³
S_U	Soluble unbiodegradable organics	11.7	g COD/m³
C_U	Colloidal unbiodegradable organics	0.1794	g COD/m³
X_U	Particulate unbiodegradable organics	19.5	g COD/m³
X_PHA	Stored PHA	0.01	g COD/m³
X_E	Endogenous decay products	0.1	g COD/m³
X_OHO	Ordinary heterotrophs	19.5	g COD/m³
X_MEOLO	Anoxic methanol utilizers	0.1	g COD/m³
X_PAO	Phosphorus accumulating organisms	0.1	g COD/m³
X_AOO	Aerobic ammonia oxidizers	0.1	g COD/m³
X_NOO	Nitrite oxidizing organisms	0.1	g COD/m³
S_NHx	Total ammonia	15.38	g N/m³
S_NO2	Nitrite	0.01	g N/m³
S_NO3	Nitrate	0.001	g N/m³
S_N2	Dissolved Nitrogen	0.0001	g N/m³
S_N_F	Soluble biodegradable organic N (from S_F)	2.047	g N/m³
X_N_B	Particulate biodegradable organic N	3.557	g N/m³
S_N_U	Soluble unbiodegradable organic N	0.585	g N/m³
X_N_U	Particulate unbiodegradable organic N	0.78	g N/m³
S_PO4	Orthophosphate	2.779	g P/m³
X_PP_LO	Releasable stored polyphosphate	1.00E-03	g P/m³
X_PP_HI	Non-releasable stored polyphosphate	1.00E-03	g P/m³
S_P_F	Soluble biodegradable organic P (from S_F)	0	g P/m³
X_P_B	Particulate biodegradable organic P	0	g P/m³
S_P_U	Soluble unbiodegradable organic P content	0	g P/m³
X_P_U	Particulate unbiodegradable organic P content	0	g P/m³
S_O2	Dissolved oxygen	0.01	g O2/m³
X_IG	Inorganic suspended solids	15.87	g TSS/m³
X_MeOH	Metal hydroxide compounds	1.00E-02	g Me/m³
X_MeP	Metal phosphate compounds	0.001	g Me/m³
S_ALK	Alkalinity	6	eq/m³
Flow rate	Flowrate	38.4	Mgal/d

Id	Value	Unit
TSS: Total Suspended Solids	91.01	g TSS/m³
VSS: Volatile Suspended Solids	73.01	g VSS/m³
ISS: Inorganic Suspended Solids	18	g ISS/m³
TN: Total Nitrogen	24.3	g N/m³
TKN: Total Kjeldahl Nitrogen	24.29	g N/m³
N_fil: Filtered Nitrogen (incl. colloidals)	18.56	g N/m³
N_sol: Soluble Nitrogen (w/o colloidals)	18.02	g N/m³
NOx-N: Sum of NO2 and NO3	0.011	g N/m³
TP: Total Phosphorus	3.4	g P/m³
COD: Total Chemical Oxygen Demand	195	g COD/m³
COD_fil: Filtered Chemical Oxygen Demand (incl. colloidals)	76.44	g COD/m³
COD_sol: Soluble Chemical Oxygen Demand (w/o colloidals)	58.5	g COD/m³
cBOD5: Total Carbonaceous Biological Oxygen Demand within 5 days	98.62	g BOD5/m³
cBOD5_fil: Filtered Carbonaceous Biological Oxygen Demand within 5 days	45.77	g BOD5/m³
cBOD5_sol: Soluble Carbonaceous Biological Oxygen Demand within 5 days	33.23	g BOD5/m³
Volume of total suspended solids	0	m3/m3
Volume of volatile suspended solids	0	m3/m3
Total S content	0	kg S/m3

B. Winter Secondary Clarifier Effluent

Id		Value	Unit
S_VFA	VFAs	3.18E-04	g COD/m³
S_F	Fermentable substrate	1.656	g COD/m³
S_MEOL	Methanol	2.02E-07	g COD/m³
C_B	Colloidal biodegradable substrate	4.19E-03	g COD/m³
X_B	Slowly biodegradable substrate	0.1276	g COD/m³
S_U	Soluble unbiodegradable organics	11.7	g COD/m³
C_U	Colloidal unbiodegradable organics	1.31E-04	g COD/m³
X_U	Particulate unbiodegradable organics	2.059	g COD/m³
X_PHA	Stored PHA	4.07E-02	g COD/m³
X_E	Endogenous decay products	1.301	g COD/m³
X_OHO	Ordinary heterotrophs	2.884	g COD/m³
X_MEOLO	Anoxic methanol utilizers	7.16E-03	g COD/m³
X_PAO	Phosphorus accumulating organisms	4.90E-01	g COD/m³
X_AOO	Aerobic ammonia oxidizers	0.1223	g COD/m³
X_NOO	Nitrite oxidizing organisms	0.06722	g COD/m³
S_NHx	Total ammonia	0.862	g N/m³
S_NO2	Nitrite	0.1322	g N/m³
S_NO3	Nitrate	8.861	g N/m³
S_N2	Dissolved Nitrogen	8.852	g N/m³
S_N_F	Soluble biodegradable organic N (from S_F)	0.8891	g N/m³
X_N_B	Particulate biodegradable organic N	7.82E-03	g N/m³
S_N_U	Soluble unbiodegradable organic N	0.585	g N/m³
X_N_U	Particulate unbiodegradable organic N	8.22E-02	g N/m³
S_PO4	Orthophosphate	0.3444	g P/m³
X_PP_LO	Releasable stored polyphosphate	1.70E-01	g P/m³
X_PP_HI	Non-releasable stored polyphosphate	3.72E-02	g P/m³
S_P_F	Soluble biodegradable organic P (from S_F)	0.02443	g P/m³
X_P_B	Particulate biodegradable organic P	2.00E-03	g P/m³
S_P_U	Soluble unbiodegradable organic P content	3.70E-100	g P/m³
X_P_U	Particulate unbiodegradable organic P content	9.38E-05	g P/m³
S_O2	Dissolved oxygen	1	g O2/m³
X_IG	Inorganic suspended solids	1.661	g TSS/m³
X_MeOH	Metal hydroxide compounds	2.57E-04	g Me/m³
X_MeP	Metal phosphate compounds	8.94E-04	g Me/m³
S_ALK	Alkalinity	4.223	eq/m³
Flow rate	Flowrate	37.91	Mgal/d

Id	Value	Unit
TSS: Total Suspended Solids	7.878	g TSS/m³
VSS: Volatile Suspended Solids	5.111	g VSS/m³
ISS: Inorganic Suspended Solids	2.767	g ISS/m³
TN: Total Nitrogen	11.76	g N/m³
TKN: Total Kjeldahl Nitrogen	2.767	g N/m³
N_fil: Filtered Nitrogen (incl. colloidals)	11.33	g N/m³
N_sol: Soluble Nitrogen (w/o colloidals)	11.33	g N/m³
NOx-N: Sum of NO2 and NO3	8.993	g N/m³
TP: Total Phosphorus	0.686	g P/m³
COD: Total Chemical Oxygen Demand	20.46	g COD/m³
COD_fil: Filtered Chemical Oxygen Demand (incl. colloidals)	13.36	g COD/m³
COD_sol: Soluble Chemical Oxygen Demand (w/o colloidals)	13.36	g COD/m³
cBOD5: Total Carbonaceous Biological Oxygen Demand within 5 days	3.205	g BOD5/m³
cBOD5_fil: Filtered Carbonaceous Biological Oxygen Demand within 5 days	1.173	g BOD5/m³
cBOD5_sol: Soluble Carbonaceous Biological Oxygen Demand within 5 days	1.17	g BOD5/m³
Volume of total suspended solids	0	m3/m3
Volume of volatile suspended solids	0	m3/m3
Total S content	0	kg S/m3
Oxygen Demand	23897.00	kg S/m3
Oxygen Demand	52683.80	lb O2/d
WAS Flow	0.34	Mgal/d
WAS TSS	7818.00	g TSS/m³
WAS VSS	5056.00	g VSS/m³
WAS Loading	22030.23	lb/d
Secondary Clarifier Flow	49.59	Mgal/d
Secondary Clarifier TSS	1822.00	g TSS/m³
Secondary Clarifier TSS + Kenaf (Max Possible)	3822.00	g TSS/m³
Secondary Clarifier SLR	19.82	lb/d/ft2
Secondary Clarifier SLR + Kenaf (Max Possible)	41.58	lb/d/ft2
Secondary Clarifier SOR	1304.42	gal/d/ft2

C. Summer Primary Effluent

Id		Value	Unit
S_VFA	VFAs	68.75	g COD/m³
S_F	Fermentable substrate	2.74	g COD/m³
S_MEOL	Methanol	1.00E-02	g COD/m³
C_B	Colloidal biodegradable substrate	92.57	g COD/m³
X_B	Slowly biodegradable substrate	43.49	g COD/m³
S_U	Soluble unbiodegradable organics	11	g COD/m³
C_U	Colloidal unbiodegradable organics	0.935	g COD/m³
X_U	Particulate unbiodegradable organics	27.5	g COD/m³
X_PHA	Stored PHA	0.01	g COD/m³
X_E	Endogenous decay products	0.1	g COD/m³
X_OHO	Ordinary heterotrophs	27.5	g COD/m³
X_MEOLO	Anoxic methanol utilizers	0.1	g COD/m³
X_PAO	Phosphorus accumulating organisms	0.1	g COD/m³
X_AOO	Aerobic ammonia oxidizers	0.1	g COD/m³
X_NOO	Nitrite oxidizing organisms	0.1	g COD/m³
S_NHx	Total ammonia	37.54	g N/m³
S_NO2	Nitrite	0.01	g N/m³
S_NO3	Nitrate	0.001	g N/m³
S_N2	Dissolved Nitrogen	0.0001	g N/m³
S_N_F	Soluble biodegradable organic N (from S_F)	0.1644	g N/m³
X_N_B	Particulate biodegradable organic N	2.609	g N/m³
S_N_U	Soluble unbiodegradable organic N	0.66	g N/m³
X_N_U	Particulate unbiodegradable organic N	1.65	g N/m³
S_PO4	Orthophosphate	3.457	g P/m³
X_PP_LO	Releasable stored polyphosphate	1.00E-03	g P/m³
X_PP_HI	Non-releasable stored polyphosphate	1.00E-03	g P/m³
S_P_F	Soluble biodegradable organic P (from S_F)	0.0548	g P/m³
X_P_B	Particulate biodegradable organic P	0.8698	g P/m³
S_P_U	Soluble unbiodegradable organic P content	0.22	g P/m³
X_P_U	Particulate unbiodegradable organic P content	0.55	g P/m³
S_O2	Dissolved oxygen	0.01	g O2/m³
X_IG	Inorganic suspended solids	13.33	g TSS/m³
X_MeOH	Metal hydroxide compounds	1.00E-02	g Me/m³
X_MeP	Metal phosphate compounds	0.001	g Me/m³
S_ALK	Alkalinity	6	eq/m³
Flow rate	Flowrate	18.5	Mgal/d

Id	Value	Unit
TSS: Total Suspended Solids	81.34	g TSS/m³
VSS: Volatile Suspended Solids	65.04	g VSS/m³
ISS: Inorganic Suspended Solids	16.3	g ISS/m³
TN: Total Nitrogen	47.4	g N/m³
TKN: Total Kjeldahl Nitrogen	47.39	g N/m³
N_fil: Filtered Nitrogen (incl. colloidals)	41.18	g N/m³
N_sol: Soluble Nitrogen (w/o colloidals)	38.38	g N/m³
NOx-N: Sum of NO2 and NO3	0.011	g N/m³
TP: Total Phosphorus	6.7	g P/m³
COD: Total Chemical Oxygen Demand	275	g COD/m³
COD_fil: Filtered Chemical Oxygen Demand (incl. colloidals)	176	g COD/m³
COD_sol: Soluble Chemical Oxygen Demand (w/o colloidals)	82.5	g COD/m³
cBOD5: Total Carbonaceous Biological Oxygen Demand within 5 days	156.4	g BOD5/m³
cBOD5_fil: Filtered Carbonaceous Biological Oxygen Demand within 5 days	117.9	g BOD5/m³
cBOD5_sol: Soluble Carbonaceous Biological Oxygen Demand within 5 days	52.5	g BOD5/m³
Volume of total suspended solids	0	m3/m3
Volume of volatile suspended solids	0	m3/m3
Total S content	0	kg S/m3

D. Summer Secondary Clarifier Effluent

Id		Value	Unit
S_VFA	VFAs	4.48E-04	g COD/m³
S_F	Fermentable substrate	1.848	g COD/m³
S_MEOL	Methanol	3.00E-09	g COD/m³
C_B	Colloidal biodegradable substrate	2.54E-02	g COD/m³
X_B	Slowly biodegradable substrate	0.1034	g COD/m³
S_U	Soluble unbiodegradable organics	16.92	g COD/m³
C_U	Colloidal unbiodegradable organics	7.69E-04	g COD/m³
X_U	Particulate unbiodegradable organics	1.217	g COD/m³
X_PHA	Stored PHA	4.62E-02	g COD/m³
X_E	Endogenous decay products	0.7396	g COD/m³
X_OHO	Ordinary heterotrophs	2.076	g COD/m³
X_MEOLO	Anoxic methanol utilizers	3.10E-03	g COD/m³
X_PAO	Phosphorus accumulating organisms	4.29E-01	g COD/m³
X_AOO	Aerobic ammonia oxidizers	0.1006	g COD/m³
X_NOO	Nitrite oxidizing organisms	0.06061	g COD/m³
S_NHx	Total ammonia	0.4895	g N/m³
S_NO2	Nitrite	0.09713	g N/m³
S_NO3	Nitrate	24.03	g N/m³
S_N2	Dissolved Nitrogen	13.28	g N/m³
S_N_F	Soluble biodegradable organic N (from S_F)	0.8982	g N/m³
X_N_B	Particulate biodegradable organic N	6.05E-03	g N/m³
S_N_U	Soluble unbiodegradable organic N	1.015	g N/m³
X_N_U	Particulate unbiodegradable organic N	7.18E-02	g N/m³
S_PO4	Orthophosphate	0.2382	g P/m³
X_PP_LO	Releasable stored polyphosphate	1.29E-01	g P/m³
X_PP_HI	Non-releasable stored polyphosphate	3.13E-02	g P/m³
S_P_F	Soluble biodegradable organic P (from S_F)	0.03101	g P/m³
X_P_B	Particulate biodegradable organic P	1.93E-03	g P/m³
S_P_U	Soluble unbiodegradable organic P content	1.69E-01	g P/m³
X_P_U	Particulate unbiodegradable organic P content	2.37E-02	g P/m³
S_O2	Dissolved oxygen	2	g O2/m³
X_IG	Inorganic suspended solids	0.5527	g TSS/m³
X_MeOH	Metal hydroxide compounds	9.25E-05	g Me/m³
X_MeP	Metal phosphate compounds	3.66E-04	g Me/m³
S_ALK	Alkalinity	2.834	eq/m³
Flow rate	Flowrate	18.32	Mgal/d

Id	Value	Unit
TSS: Total Suspended Solids	4.819	g TSS/m³
VSS: Volatile Suspended Solids	3.422	g VSS/m³
ISS: Inorganic Suspended Solids	1.397	g ISS/m³
TN: Total Nitrogen	26.84	g N/m³
TKN: Total Kjeldahl Nitrogen	2.72	g N/m³
N_fil: Filtered Nitrogen (incl. colloidals)	26.53	g N/m³
N_sol: Soluble Nitrogen (w/o colloidals)	26.53	g N/m³
NOx-N: Sum of NO2 and NO3	24.12	g N/m³
TP: Total Phosphorus	0.6997	g P/m³
COD: Total Chemical Oxygen Demand	23.57	g COD/m³
COD_fil: Filtered Chemical Oxygen Demand (incl. colloidals)	18.79	g COD/m³
COD_sol: Soluble Chemical Oxygen Demand (w/o colloidals)	18.77	g COD/m³
cBOD5: Total Carbonaceous Biological Oxygen Demand within 5 days	2.85	g BOD5/m³
cBOD5_fil: Filtered Carbonaceous Biological Oxygen Demand within 5 days	1.324	g BOD5/m³
cBOD5_sol: Soluble Carbonaceous Biological Oxygen Demand within 5 days	1.306	g BOD5/m³
Volume of total suspended solids	0	m3/m3
Volume of volatile suspended solids	0	m3/m3
Total S content	0	kg S/m3
Oxygen Demand	19556.00	kg S/m3
Oxygen Demand	43113.55	lb O2/d
WAS Flow	0.18	Mgal/d
WAS TSS	11030.00	g TSS/m³
WAS VSS	7804.00	g VSS/m³
WAS Loading	16942.82	lb/d
Secondary Clarifier Flow	23.87	Mgal/d
Secondary Clarifier TSS	2568.00	g TSS/m³
Secondary Clarifier TSS + Kenaf (Max Possible)	4568.00	g TSS/m³
Secondary Clarifier SLR	13.45	lb/d/ft2
Secondary Clarifier SLR + Kenaf (Max Possible)	23.92	lb/d/ft2
Secondary Clarifier SOR	627.82	gal/d/ft2