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Richard A. Heyman Environmental Protection Facility

Energy Master Plan

Final

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Fleming Key, City of Key West, Florida

Richard A. Heyman Environmental Protection Facility Energy Master Plan

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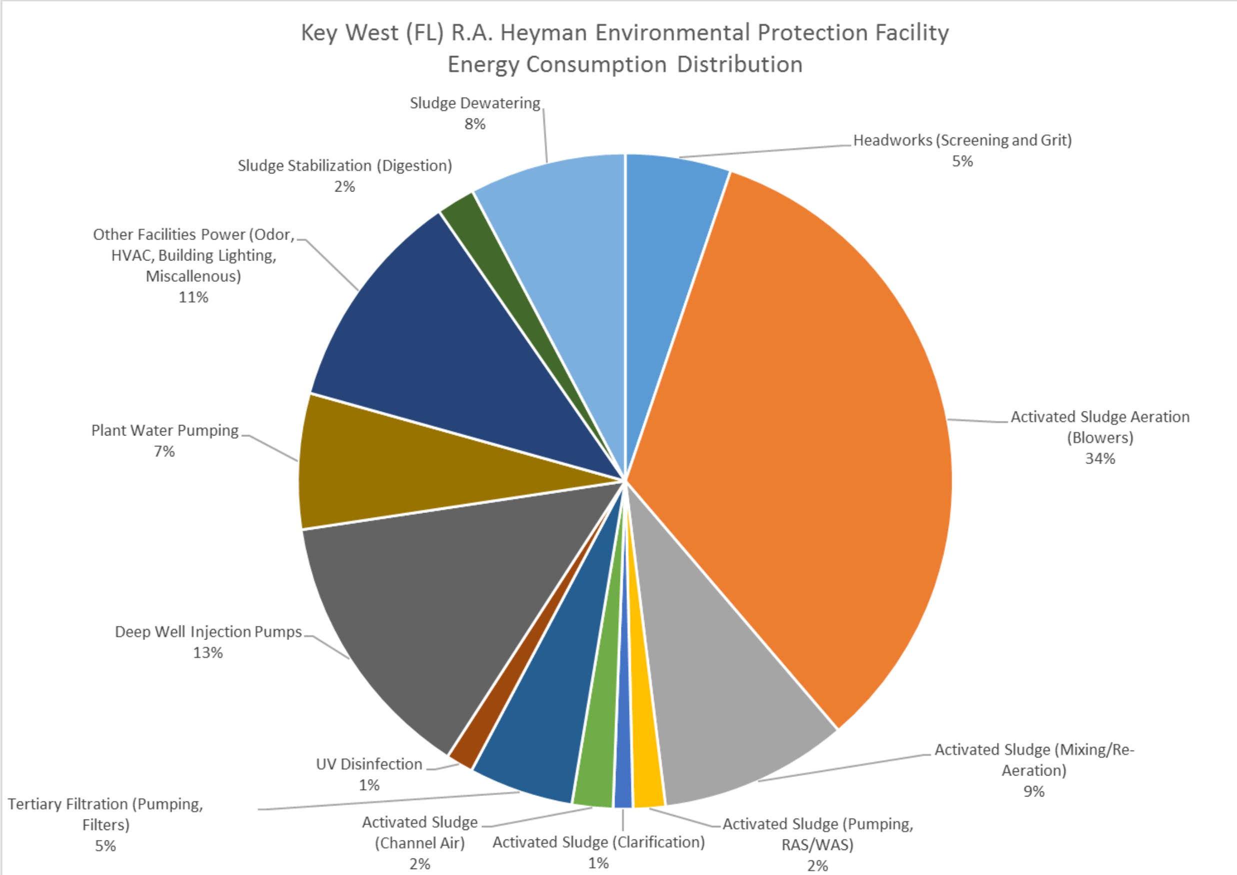
Executive Summary

The Richard A. Heyman Environmental Protection Facility (RAF EPF) is a wastewater treatment plant (WWTP) located on Fleming Key in Key West, Florida. The RAH EPF is designed to treat 12 million gallons per day (mgd) of maximum monthly average daily flow with a peak flow capacity of 20 mgd. Since commissioning the RAH EPF in 1989, the City of Key West (City) has proactively operated the WWTP by implementing improvements and retrofits to more efficiently operate and treat the City's wastewater using up-to-date technologies and best practices. Throughout the years, treatment processes have been modified, pumps and controls replaced, and concrete repaired. However, many of the electrical components and equipment throughout the WWTP are original to the structure and nearing 30 years old. With decades of new technology available, and interest in both fiscal and energy conservation, Jacobs Engineering Group Inc. (Jacobs) was tasked to evaluate the WWTP for ways to reduce power consumption and develop an Energy Master Plan under Task Order 7-18 SWR.

The objectives of the Task Order are to identify, analyze, and prioritize energy-efficiency opportunities, and to develop an implementation plan to help the City and the WWTP meet their energy reduction goals. This evaluation focused on both the WWTP process and equipment as well as facility-level systems, such as heating, ventilation, and air conditioning (HVAC), building envelope, and lighting.

To gain a detailed understanding of the current conditions and operations and identify potential energy reduction opportunities, Jacobs conducted an energy audit at the WWTP from August 13 to 15, 2018. Jacobs specialists met with key staff and observed the facility operations and equipment. Historical plant operational data as well as 1 full year of utility data were obtained from plant staff. In addition, equipment-specific data were gathered from the facility library's various manuals and cutsheets.

The WWTP uses approximately 5.3 megawatt-hours (MWh) of electricity annually, based on the most recent utility data. To gain a more in-depth understanding of where the energy is being consumed and to identify areas that may have the greatest potential for energy savings, baseline energy models were developed to provide a representative breakdown of energy consumption by primary category of use. The energy consumption profiles for each of these categories were developed using information collected during the field assessment and were calibrated to the existing utility data. **Figure ES-1** shows the allocation of total baseline energy usage by end-use category for the RAH EPF.



RAS = return-activated sludge
UV = ultraviolet
WAS = waste-activated sludge

Figure ES-1. Energy Consumption Distribution

Based on observations made during the field assessments and the energy distribution profiles developed, several energy conservation measures (ECMs) were identified, including making changes to the treatment process and upgrading equipment. In order to maximize energy and cost savings, the ECMs were primarily focused on equipment and systems with the largest energy consumption. Although the process facility is the greatest energy consumer and offers the greatest potential for energy savings, the support buildings and systems still offer opportunities for energy improvements.

Using a combination of energy models and spreadsheet calculations, preliminary calculations were performed for the potential ECMs to investigate cost-effectiveness based on their estimated energy savings and implementation costs. **Table ES-1** provides a list of the strongly recommended viable ECM opportunities that will provide the most impactful results to the RAH EPF.

Table ES-1. Recommended Energy Conservation Measures

ECM No.	Project Title/Description	Annual Energy Savings (kWh)	Annual Cost Savings	Project Cost	LCC SPB (years) [a]
Operations and Support Facilities					
ECM-F01	Energy-Efficient Lighting Upgrades	155,336	$17,087	$94,500	5.5
ECM-F02	Variable-Frequency Drives for Ventilation Fans	35,398	$3,812	$24,000	6.3
ECM-F03	Cool Roof Coating	2,502	$ 275	$2,000	7.3

Table ES-1. Recommended Energy Conservation Measures

ECM No.	Project Title/Description	Annual Energy Savings (kWh)	Annual Cost Savings	Project Cost	LCC SPB (years) [a]
WWTP Process					
ECM-P01[b]	Timer on Channel Aeration	88,190 (13.5 hp)	$10,000	$9,000	0.9
ECM-P02	Full Aeration System Optimization	993,525	$109,500	$2,120,000	19.4
ECM-P02A	Aeration System Optimization (not including diffuser replacement)	905,335	$108,640	$1,189,000	10.9
ECM-P03	New Deep Well Injection Pump	148,700 (23 hp)	$16,500	$192,000	13.2

[a] Simple payback (SPB) period is estimated based on calculated savings and preliminary estimates of costs and vendor quotes for equipment.
[b] ECM-P01 has a reduced annual energy savings because aeration efficiency is captured in ECM-P02.
hp = horsepower
kWh = kilowatt-hour(s)
LCC = lifecycle cost

By implementing the ECMs listed in **Table ES-1**, total process energy savings could be in the range of 25% to 30%, with additional energy savings resulting from operations and support facility ECMs. This equates to approximately 1.5 MWh in energy savings and $170,000 in cost savings annually.

Additional ECMs were evaluated but resulted in less favorable payback periods. However, these additional measures could be grouped together with the strongly recommended measures to create viable Energy Projects. All evaluated ECMs are listed in **Section 4** for the City's consideration.

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Acronyms and Abbreviations

°F	degree(s) Fahrenheit
ABAC	ammonia-based aeration control
AHU	air-handling unit
BPR	biological phosphorus removal
City	City of Key West
DHW	domestic hot water
DO	dissolved oxygen
ECM	energy conservation measure
EDCV	elliptic diaphragm control valve
FY	fiscal year
gpm	gallon(s) per minute
HID	high-intensity discharge
hp	horsepower
hp/MG	horsepower per million gallons
HPBFV	high-performance butterfly valve
HSTB	high-speed turbo blower
HTL	hydrothermal liquefaction
HVAC	heating, ventilation, and air conditioning
JCV	jet control valve
kW	kilowatt(s)
kWh	kilowatt-hour(s)
kWh/MG-treated	kilowatt-hour(s) per million gallons treated
LCC	life-cycle cost
LCCA	life-cycle cost analysis
LED	light-emitting diode
mg/L	milligram(s) per liter
mgd	million gallon(s) per day
MLSS	mixed liquor suspended solids
mV	millivolt(s)
$mW\text{-}s/cm^2$	milliwatt-second(s) per square centimeter
MWh	megawatt-hour(s)
N/A	not applicable
NPDES	National Pollutant Discharge Elimination System
ORP	oxidation reduction potential
$Pro2D^2$	Professional Process Design and Dynamics
psig	pound(s) per square inch gauge

PV	photovoltaic
RAH EPF	Richard A. Heyman Environmental Protection Facility
RAS	return-activated sludge
SCADA	supervisory control and data acquisition
scfm	standard cubic foot (feet) per minute
scfm/ft^2	standard cubic foot (feet) per minute per square foot
SPB	simple payback
UV	ultraviolet
VFD	variable-frequency drive
WAS	waste-activated sludge
WWTP	wastewater treatment plant

1. Introduction

1.1 Project Description

Since commissioning the Richard A. Heyman Environmental Protection Facility (RAH EPF) in 1989, the City of Key West (City) has proactively operated the wastewater treatment plant (WWTP) by implementing improvements and retrofits to more efficiently operate and treat the City's wastewater using current technologies and best practices.

Throughout the years, treatment processes have been modified, pumps and controls replaced, and concrete repaired. The following are some of the most recent energy-efficiency projects that have been implemented at the WWTP:

- Ongoing Light-emitting diode (LED) interior and exterior lighting upgrades in select locations
- Heating, ventilation, and air conditioning (HVAC) system replacement at the Operations Building in 2008

However, many of the electrical components throughout the WWTP are from the original construction and nearing 30 years old. With decades of new technology available, and interest in both fiscal and energy conservation, Jacobs Engineering Group Inc. (Jacobs) was tasked to evaluate the WWTP for ways to reduce power consumption and develop an Energy Master Plan, under Task Order 7-18 SWR.

The objectives of the Task Order are to identify, analyze, and prioritize energy-efficiency opportunities, and to develop an implementation plan to help the City and the WWTP meet their energy reduction goals. This evaluation focused on both the WWTP process and equipment as well as facility-level systems, such as HVAC, building envelope, and lighting.

1.2 Facility and Process Overview

The Richard A. Heyman Environmental Protection Facility is designed to treat 12 million gallons per day (mgd) of maximum monthly average daily flow with a peak flow capacity of 20 mgd. The following summarizes the major liquid treatment processes:

- Preliminary treatment (Headworks) using mechanically cleaned screens and vortex grit removal
- Four-stage activated sludge (anoxic, aerobic, post anoxic, and reaeration)
- Secondary clarification
- Return and waste-activated sludge (WAS) pumping
- Tertiary filtration using disk filters
- Ultraviolet (UV) disinfection
- Deep well injection effluent disposal

Sludge generated at the WWTP is treated using the following biosolids management facilities:

- WAS is stored in an aerobic storage tank with decanting.
- Belt filter press dewatering
- Dewatered cake is trucked to mainland Florida for disposal.

The two largest occupied buildings at the WWTP include the Operations Building and the Solids Building. The Operations Building houses the administration, operation, and laboratory functions, as well as the main electrical equipment and pump and motor room. The Solids Building consists mainly of unconditioned process equipment areas but does have some conditioned spaces including operator office areas, as well as an electrical room and controls room. There are also several unconditioned buildings at the process facilities, such as the Headworks and Chlorine Storage Building.

1.3 Site Work and Data Collection

Understanding the quantity and way energy is consumed is the first step in controlling energy costs. To gain a detailed understanding of the current conditions and operations and identify potential energy reduction opportunities, Jacobs conducted an energy audit at the WWTP from August 13 to 15, 2018. Jacobs specialists met with key staff and observed the facility operations and equipment as guided by Arnold Collins, Operations Supervisor. The Jacobs team took notes and photographs of operation details and equipment during the facility tour each day.

In addition, equipment-specific data were gathered from the facility library's various manuals and cutsheets. Historical plant operational data as well as utility data were obtained from plant staff. The Jacobs team had several follow-up phone calls with site management to clarify facility operations during the project development and analysis. The swift and helpful responses of the City staff enabled Jacobs' evaluation to be better tailored and represent more accurate conditions.

1.4 Existing Utility Summary

The WWTP uses approximately 5.3 megawatt-hours (MWh) of electricity annually. **Table 1-1** shows the electric energy usage and peak demand profile for the plant by month for 1 full year of electric utility data, from August 2017 to July 2018. This information was used to establish a baseline representing actual operating conditions and to calibrate the modeled energy usage profiles.

The total annual cost of energy is approximately $620,000. The costs include both usage and demand charges. This summary information is provided in **Table 1-1** for reference; further detail on the rate tariff is provided in **Section 3**.

Table 1-1. Annual Electric Utility Data

Usage Month	Monthly Electric Usage (kWh)	Monthly Peak Electric Demand (kW)	Total Cost
August 2017	474,600	768.0	$56,403
September 2017	322,350	913.5	$41,621
October 2017	469,350	945.0	$57,347
November 2017	470,400	808.5	$56,304
December 2017	434,700	777.0	$53,579
January 2018	426,300	798.0	$52,920
February 2018	460,950	808.5	$56,658
March 2018	466,200	840.0	$50,126
April 2018	453,600	757.7	$48,142
May 2018	475,650	976.5	$52,398
June 2018	460,950	840.0	$49,659
July 2018	427,350	808.5	$46,345
Total	**5,342,400**	**N/A**	**$621,500**

kW = kilowatt(s)
N/A = not applicable

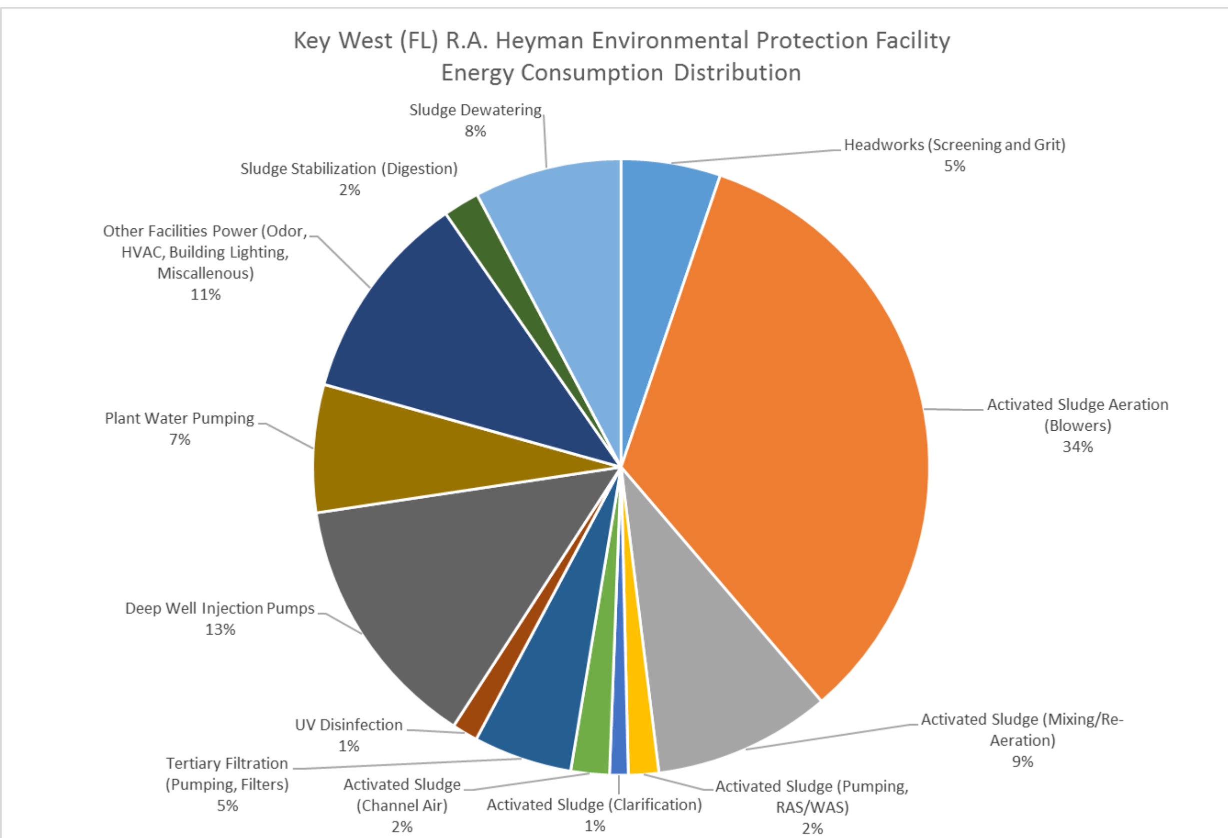
2. Baseline Energy Profile

Understanding the distribution of a facility's energy consumption helps to identify areas with significant energy consumption that may have the greatest potential for energy savings. Where utility meter data only provide usage information at the building or facility level, detailed energy models provide a representative breakdown of energy consumption by primary category of use.

The overall energy profile for RAH EPF consists of two main load categories: process facility and support building loads. Energy consumption profiles for each of these categories were modeled using information collected during the field assessment and as-built drawings.

2.1 Process Energy Modeling

A whole-plant wastewater process model was developed using Jacob's proprietary Professional Process Design and Dynamics (Pro2D^2) modeling tool to simulate the treatment plant and estimate energy demands for process-related equipment. Pro2D^2 is a whole-plant simulator developed to perform complete WWTP simulations and to calculate full-plant mass balances. The RAH EPF model and subsequent process energy distribution was developed using operational details such as operation hours, loading, lead/lag rotation, downtime for service, and similar information shared by plant staff during the onsite visit as well as operational logs from December 2017 to August 2018. Energy consumption estimates were then compared with actual utility energy records during the same time period and were calibrated to within a 92% match between the estimates and utility records. **Figure 2-1** shows the energy usage of the plant by end-use category.



RAS = return-activated sludge

Figure 2-1. Overall Energy Profile by End-Use Category

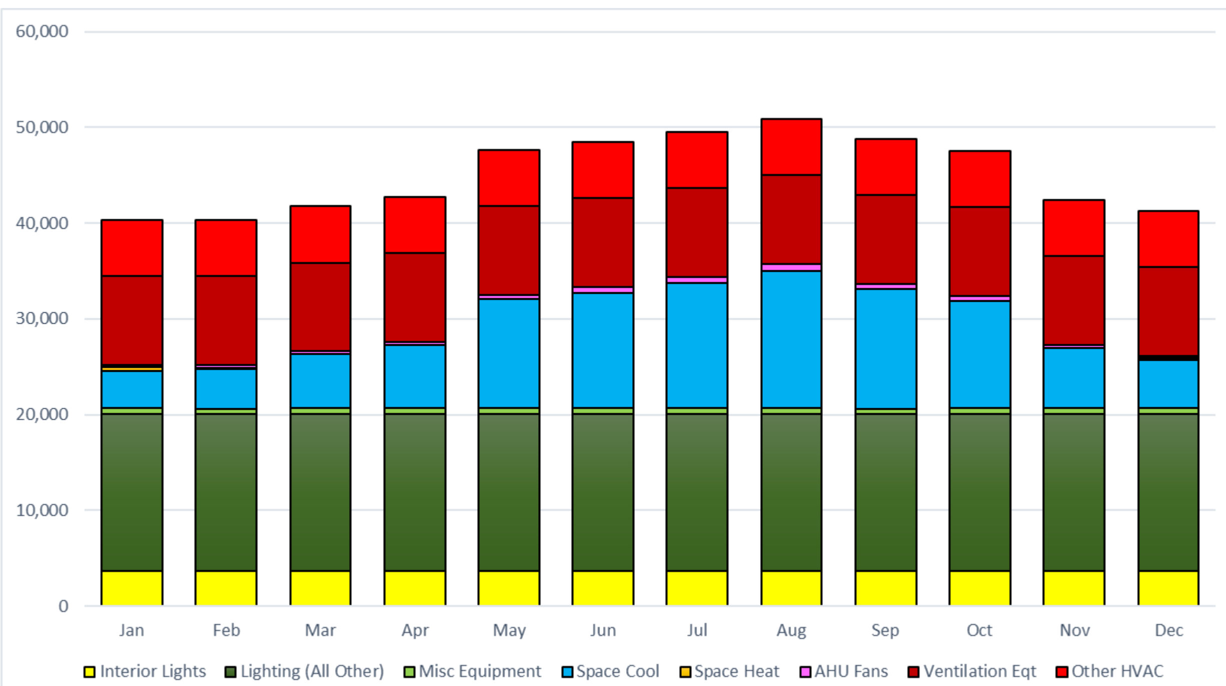
The majority of RAH EPF's energy consumption results from aeration of the activated sludge bioreactors (34%), the deep well injection pumps (13%), building HVAC and lighting (11%), and the second-stage mixing and reaeration of the bioreactors (9%). The energy use from these four end uses comprise more than 67% of the total energy for wastewater treatment and distribution at the WWTP. Overall, the activated sludge nutrient removal treatment process, including aeration, clarifiers, and pumping, is responsible for 48% of the total plant energy consumption.

Although pumping equipment and blowers are typically the largest energy consumers at WWTPs, this percentage of pumping and blower energy use indicates a potential opportunity for energy savings improvements. This disproportionate energy use is likely driving RAH EPF's wire-to-water efficiency to a value of 3,996 kWh per million gallons treated (kWh/MG-treated). This value is on the high end of the typical wire-to-water efficiency range of 2,500 to 4,000 kWh/MG-treated.

2.2 Facility Energy Modeling

To gain further understanding of the 11% of total energy usage represented by "Other Facilities" (such as HVAC, lighting, and similar), building- and system-specific energy models were developed. Energy consumption profiles for the support building loads, including area lighting and HVAC, were developed, using a combination spreadsheet calculations or eQUEST (http://www.doe2.com/equest), to establish a baseline for each facility or system external to the process equipment. Baseline energy profiles were modeled using information collected during the field assessment, as-built drawings, and professional judgment.

The modeling engine uses Typical Meteorological Year weather data to perform an hourly simulation of the building. The weather file for Key West, Florida was used in the energy simulations. The models were calibrated to the available utility data and modeled process energy profile to better represent the energy profiles of the support buildings and systems. **Figure 2-2** provides additional detail of the energy usage by end-use category for the support buildings and systems.



AHU = air-handling unit

Figure 2-2. Operations and Support Facilities Energy Profile by End-Use Category

When considering process operations observed during the site visit and the energy distribution of the RAH EPF, several viable energy conservation measures (ECMs) were identified, including making changes to the treatment process and introducing several equipment upgrades. Although the process facility is the greatest energy consumer and offers the greatest potential for energy savings, the support buildings and systems still offer opportunities for energy improvements.

2.3 Energy Profile Summary

Existing utility data were used to help calibrate the modeled profiles. **Figure 2-3** shows the trend of the modeled data as compared to the utility information provided for the months of August 2017 through July 2018. Cooling degree days for Key West, Florida are shown to illustrate the minimal impact of weather on the overall energy consumption of the facility. This is primarily due to the large process energy usage as compared to support facility loads. The anomaly in the utility data for September 2017 (shown on the October 2017 utility bill) is likely due to the recovery period for the City in the aftermath of Hurricane Irma (September 10, 2017), when power was out and many of the residents were evacuated and businesses were closed.

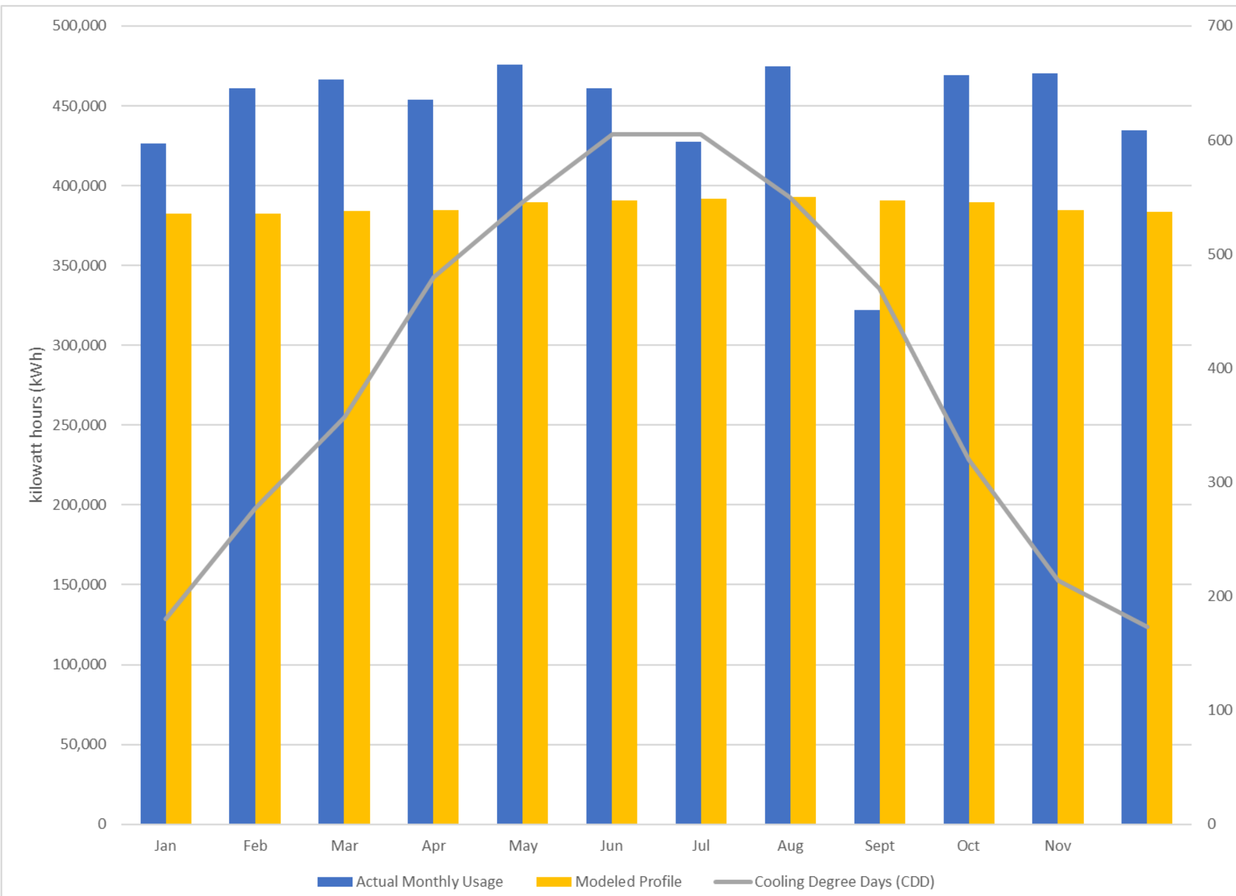


Figure 2-3. Calibrated Energy Profile Summary

3. Economic Analysis Methodology

3.1 Savings Development

Jacobs used multiple approaches to estimate savings opportunities from implementing the ECMs. Savings estimates were developed through a combination of energy models and spreadsheet calculations, including the use of Pro2D[2], eQUEST, U.S. Department of Energy-originated tools, vendor data, and other sources, depending on the opportunity.

The ECMs were generally analyzed as stand-alone measures and interactive effects from implementing multiple ECMs have not been included. For example, the savings associated with a controls ECM could negate the savings of an HVAC equipment upgrade ECM.

3.2 Cost Estimating

The cost estimates provided for each of the ECMs are considered Class 4 Parametric Feasibility Level as defined by the American Association of Cost Engineering. They are considered accurate to +50% to -30%. Generally, Class 4 estimates are prepared based on very limited information and subsequently have a wide range of accuracy. They are typically used as project screening, determination of feasibility, concept evaluation, and preliminary budget approval. The level of project definition required is 1% to 15% of the full project definition.

RSMeans 2019, vendor data, Jacobs historical data, national contractor associations, and estimator judgment provide the basis for parametric cost estimating. The quantities used in the calculations are based on field observations or take-offs from as-built drawings, when available. Labor costs were also developed from RSMeans 2019 data, which are most representative of projects executed by outside contractors. Use of other execution assumption methods may result in different costs and may substantially alter the economic analysis of these projects.

The general markups such as location factor, sales tax, and general requirements are based on local conditions and requirements and RSMeans 2019. The markups used in developing the estimates are as presented in **Table 3-1**.

Table 3-1. Cost-Estimating Markup Factors

Markup Description	Markup Factor
Location Factor (multiplier)	1.0
Local Sales Tax on Material and Equipment	7.5%
Project General Requirements	7%
Subcontractor Overhead/Profit	10%
Field Office Overhead	10%
Prime Profit	10%
Bond/Insurance	2%
Contingency	10%
Engineering Services (non-construction costs)	10%

Environmental assessments and testing were not conducted as part of this effort, so certain recommendations may require these activities as part of the project design and implementation. Such improvements generally benefit the facility in the long run and could result in additional energy savings, but they may increase implementation costs.

3.3 Utility Costs

Utility costs are a key component in evaluating the life-cycle cost of any energy-efficiency upgrade project. The following sections provide background on the utility rates as well as available incentives from the local utility provider that were used in the life-cycle cost analysis (LCCA) for each ECM.

Electricity is provided to the WWTP by Keys Energy Services. The bills include both usage and demand charges. **Table 3-2** provides a summary of the utility rate structures, based on the provided energy utility bills. The rate tariff was changed between 2017 and 2018; both structures are shown for reference. The fiscal year (FY) 2018 rate structure will be used for the LCCA for each ECM.

Table 3-2. Electric Utility Rate Tariff Summary

Billing Year	Electric Usage Rates ($/kWh)		Demand Rates ($/kW)	
	0 to 5,000 kWh	Greater than 5,000 kWh	0 to 20 kW	Greater than 20 kW
FY 2017	$0.10	$0.10	$8.45	$8.45
FY 2018	$0.13	$0.11	$0	$10.50

3.4 Utility Incentives

At the time this report was developed, no demand-side management programs or other rebate incentive initiatives were found to be available through Keys Energy Services. There are some minor rebates available for commercial/residential clients, such as ENERGY STAR heat pump upgrades and white roof installation. However, they are not significant enough to offset the overall cost of a potential project.

3.5 Life-Cycle Cost Analysis Methodology

ECMs are evaluated for viability based on a simple payback (SPB) analysis. Viable ECMs are those that result in an SPB period within the effective life of the respective technology, as described in the following sections. Cost estimates for ECMs identified as non-viable based on the initial SPB analysis are often not fully developed beyond initial screening-level calculations, as additional implementation costs only further extend payback periods.

In general, avoided capital costs are not included as savings to offset the cost of an ECM. Only the energy savings attributable to the new equipment or technology are used to offset the cost of the ECM.

4. ECM Recommendations

ECMs were identified based on the information gathered during the audit and evaluated for economic viability based on the methodology described in **Section 3**. Based on the analysis, Jacobs energy specialists developed a list of recommended ECMs, shown in **Table 4-1**. Recommended ECMs offer the greatest opportunity for energy savings and result in SPB periods within the economic life of the associated technology or equipment. Descriptions for each recommended ECM are provided in **Section 4.1**.

ECMs that were evaluated but did not result in desirable payback periods based on energy savings potential are included as "other opportunities." Many of these will require further investigation and data before implementation. These are presented in **Section 4.2**.

Table 4-1. Recommended Energy Conservation Measures

ECM No.	Project Title/Description	Annual Energy Savings (kWh)	Annual Cost Savings	Project Cost	LCC SPB (years)[a]
Operations and Support Facilities					
ECM-F01	**Energy-Efficient Lighting Upgrades:** Replace existing interior and exterior fixtures with LED fixtures and install occupancy sensors in areas with intermittent occupancy.	155,336	$17,087	$94,500	5.5
ECM-F02	**Variable-Frequency Drives for Ventilation Fans:** Install a VFD on the fan motor to reduce airflow when area setpoints are met.	63,307	$3,812	$24,000	6.3
ECM-F03	**Cool Roof Coating:** Upgrade the building envelope with a reflective white roof coating.	2,502	$275	$2,000	7.3
WWTP Process					
ECM-P01[b]	**Timer on Channel Aeration:** Install a timer to control channel aeration.	89,150 (13.6 hp)	$10,000	$9,000	<1.0
ECM-P02	**Full Aeration System Optimization:** Implement a combination of projects for a full system optimization.	993,525	$109,500	$2,120,000	19.4
ECM-P02A	**Aeration System Optimization:** Implement a combination of projects for system optimization (not including diffuser upgrade)	905,335	$108,640	$1,189,000	10.9
ECM-P03	**New Deep Well Injection Pump:** Install a new smaller deep well pump to match current flow requirements in the spare pump location.	148,700 (23 hp)	$16,500	$192,000	13.2

[a] SPB periods are estimated based on calculated savings and preliminary estimates of costs and vendor quotes for equipment.
[b] ECM-P01 has a reduced annual energy savings because aeration efficiency is captured in ECM-P02.
hp = horsepower
VFD = variable-frequency drive

4.1 Recommended ECM Descriptions

4.1.1 ECM-F01: Energy-Efficient Lighting

During the energy audit, lighting in accessible areas was counted and recorded. In some cases, the exact wattage could not be observed in the field, so wattage specified in lighting drawings was used. Lighting types in inaccessible areas were assumed and counts were taken from drawings or based on similar sized rooms.

Older technology lamps and fixtures at the end of their useful lives are being replaced with lower-wattage alternatives, typically LED fixtures. However, there are still several fixtures throughout the plant that use older technology, such as T-8 fluorescent or high-intensity discharge (HID) lamps.

Though some occupancy sensors were observed in the RAH EPF, most of the light fixtures are controlled by manual switches. In general, the occupants of the audited buildings appeared to turn off lights when leaving rooms and only used lighting that was needed. However, several areas surveyed during the audit appeared to have lights on during unoccupied times. Some of these areas have HID fixtures that remain on because of the long warm-up time required to reach the lamp's full intensity.

Replacing all fixtures with LED alternatives will increase efficiency and decrease wattage, which will result in decreased energy consumption. Including occupancy sensors with the new fixtures in areas with intermittent occupancy, such as offices, restrooms, and break rooms, will further increase energy savings. LED fixtures also have a longer economic life, which results in reduced operation and maintenance costs over the life of the fixture.

The energy savings shown in **Table 4-1** were based on a reduction in power (watts) and operating hours of fixtures in an area. Hours of operation were based on observations and by interviewing building managers or other occupants.

4.1.2 ECM-F02: Variable-Frequency Drive for Ventilation Fan

The Operations Building has a 20-hp centrifugal supply fan to provide heat relief ventilation in the pump room. This fan operates at a constant speed year-round. Energy savings can be realized by installing a VFD on the fan motor to reduce airflow when area temperature setpoints are met. Energy savings were based on an adjusted operating profile of the fans to simulate turn down as space temperature setpoints of approximately 95 degrees Fahrenheit (°F) are met.

Plant staff indicated that there are plans to provide mechanical cooling in the main electrical room. This project would offset the need to install a VFD to control the existing heat relief fan because mechanical cooling would make that fan equipment obsolete. Therefore, savings related to the electrical room ventilation system are not included in the ECM. Adding an air conditioning system will increase energy consumption, and thus is not included as an ECM. However, additional information and recommendations on providing an energy-efficient air conditioning system for this space are provided in **Section 4.2**.

4.1.3 ECM-F03: Cool Roof Coating

In a climate such as Key West, solar gain can play a large role in the cooling load of a building. Reducing this load with building envelope upgrades can result in significant savings. Energy savings can be realized with by applying a white roof coating to reduce the building's solar gain, consequently reducing the overall cooling load. The roof is approximately 3,900 square feet, and it is recommended that a roof coating of 80% reflectance or greater be used.

4.1.4 ECM-P01: Timer on Channel Aeration Blowers

The channel between Aeration 4 and the post-anoxic zone as well as the aeration basin effluent channel is equipped with coarse bubble diffusers for mixing of the channel contents to prevent sedimentation. Aeration to these diffusers is fed by a pair of dedicated 15-hp positive-displacement blowers (one duty, one spare). Within the channel, at current flows, the velocity at the widest section of the channel (6-foot-wide effluent channel) is estimated at 0.3 foot per second. With a total length of about 117 feet, the detention time in the channel would be roughly 400 seconds, or 6.7 minutes. Given that a typical activated sludge of mixed liquor suspended solids (MLSS) settles at a rate of approximately 6.5 feet per hour, it would be expected that mixing would be required because approximately 8.7 inches of MLSS would settle within the estimated detention time.

To reduce energy, the blowers could be operated on a timer. The blowers are rated at 716 standard cubic feet per minute (scfm), which aerate approximately 1.1 scfm per square foot (scfm/ft^2) of channel bottom area. The energy for mixing and resuspension of settled MLSS is between 0.06 and 0.12 scfm/ft^2 using diffused aeration. If the blowers are operated on a timer to run for 6 minutes out of every hour, the energy input associated with channel aeration could be reduced by 90% while aerating approximately 0.11 scfm/ft^2. These timer settings are an approximation only, and pilot testing by staff would be necessary to determine the best results.

It was also noted during the site visit that some of the existing channel diffusers may be damaged or broken, as exhibited by "eruptions" of bubbles instead of agitation (**Figure 4-1**). Repairing these diffusers should be a first step, prior to installing a timer, to ensure that the air agitation is properly distributed and applied to the channel.

Figure 4-1. MLSS Channel Aeration with Damaged or Missing Diffusers

4.1.5 ECM-P02: Full Aeration System Optimization

This ECM combines multiple ECM opportunities for full aeration system optimization. Combined, these measures could reduce overall plant energy consumption by an estimated 20%. **Table 4-2** provides a full summary of the energy savings potential, showing savings as stand-alone measures as well as the combined benefits.

Table 4-2. ECM-P02 Summary of Estimated Energy Savings

Process	Reduction Method	Est. Power Reduction (hp)	Estimated Annual kWh Reduction
Biological Treatment	Advanced Automation using Ammonia-based Control (Aeration Reduction)	25	163,300[a]
Biological Treatment	Upgrade to High-efficiency Aeration Diffusers	13.5	88,190[a]
Biological Treatment	Replace Aeration Butterfly Flow Control Valves with Jet Control Valves	22	143,700[a]
Biological Treatment	Replace existing blowers with High Speed Turbo Blowers	53	346,210[a]
Net Reduction of Combined Measures		**152/139[b]**	**993,525[a]/905,335[b]**

[a] Energy savings are presented as a stand-alone measure. ECM savings are not truly additive because there are some synergistic benefits when combined (example: blower sizing versus design pressure).

[b] Energy savings not including replacing the diffusers.

Advanced Aeration System Automation

The aeration system at the RAH EPF consists of multi-stage centrifugal blowers that feed the diffused aeration system. Each diffuser drop leg off the main air header is equipped with a flow meter and flow control valve that are controlled based on operator setpoints. Aerobic Zones 1 and 2 operate based on oxidation reduction potential (ORP), while Aerobic Zones 3 and 4 operate based on a dissolved oxygen (DO) setpoint. The general configuration of this system is a common type of control system for activated sludge plants. Using ORP effectively informs the operator that the zone is either aerobic (greater than 50 millivolts [mV]), anoxic (50 mV to -50 mV), or anaerobic (less than -100 mV). However, it does not indicate if the system is operating at a desired DO concentration.

Generally, it is more common to see all zones operate based on DO control similar to Zones 3 and 4. Recent advances in aeration automation, especially for those facilities that need to achieve nitrogen removal, suggest using ammonia to control the aeration control system. Ammonia-based aeration control (ABAC) is an extension of a traditional DO control system by using a measured ammonia concentration in the bioreactors to adjust the DO setpoint to control to an ammonia setpoint (**Figure 4-2**). ABAC has grown in popularity recently because it allows utilities to fine tune their biological treatment system to only nitrify as much as the discharge permit requires, thereby reducing energy consumption. In addition, by limiting the amount that is nitrified, the amount of nitrate that needs to be denitrified is reduced.

Figure 4-2. DO Probes in Bioreactors

Initial process simulations of the bioreactors indicate that an ABAC system could reduce bioreactor DO levels to less than 0.5 milligrams per liter (mg/L) while providing full treatment and an estimated 10% to 20% reduction in aeration energy. It should be noted that the high average wastewater temperatures still produce full nitrification by Aerobic Zone 3. A decrease in solids retention time would allow the ABAC to produce even greater savings if the effluent ammonia is allowed to increase to approximately 1 mg/L by Aerobic Zone 4.

These aeration reductions would need to be validated against the ability of the existing aeration equipment to turn down, which at the time of the visit appeared to already be at their maximum turn down. However, because blower upgrades are being evaluated, the advanced automation could be included to increase potential savings.

High-Efficiency Aeration Diffusers

The existing diffusers in the aeration system were installed over 10 years ago, in 2008. The typical lifespan of a fine bubble diffuser is between 7 and 12 years, which puts the existing diffusers near the end of their expected lifespan. The diffusers' age of the system may have been evident when, at the time of the site visit, Aeration Zone 3 was experiencing a break in the grid that required staff to choke the air to the zone while a repair plan was developed (**Figure 4-3**). This issue may provide an opportunity to upgrade the aeration diffusers. At a minimum, a small increase in aeration efficiency could be gained by replacing the aging diffusers with new diffusers that will not have any fouling on them.

Figure 1-3. Break in Grid in Aerobic Zone 3

Alternatively, the entire grid could be replaced with a higher-efficiency diffuser system. Although the current standard disc diffusers may achieve approximately 33% to 36% oxygen transfer efficiency in the existing tanks, an ultrafine bubble diffuser could achieve upwards of 45% oxygen transfer efficiency. This could reduce aeration rates by 20% to 30%.

As mentioned previously, these aeration reductions will need to be validated against the ability of the existing aeration equipment to turn down, which at the time of the visit appeared to be already at their maximum turn down. However, because the facility is currently evaluating blower upgrades, upgrading the diffusers could also increase potential savings.

Reduce Aeration Header Pressure using New Control Valve

A blower's power requirements are a function of the airflow required as well as the header pressure that must be maintained. Although there are several opportunities to reduce airflow rates, as discussed throughout this report, reducing the headloss in the air header is another opportunity to reduce power consumption.

The original design documentation for the existing blowers indicates the system was designed to operate at a discharge pressure of 9.13 pounds per square inch gauge (psig). At the time of the site visit, the blower system was operating at almost 10 psig (**Figure 4-4**), which is most likely due to a high degree of required turndown. Manufacturer information for the diffuser system indicates that 7.5 to 7.8 psig is required at the top of the drop leg for that system. The remaining 1.3 to 1.6 psig of system pressure is most likely due to the pressure loss across the butterfly-type flow control valves for airflow splitting with some minor losses for piping. The typical flow characteristic portion of high-performance butterfly valves generally only allows for control between 35% and 65% open. This requires a sizable amount of headloss to be experienced to allow for adequate aeration control.

Figure 4-4. Blow Discharge Pressure Gauge

Iris, elliptic, and jet control valves are examples of new types of aeration valves that provide reduced operating headloss and better aeration control. For this evaluation, jet control valves (JCVs) and elliptic diaphragm control valves (EDCVs) were considered. A JCV is unique because its venturi design results in the recovery of the portion of the headloss across the valve, which has a high energy efficiency. In addition, the design allows for a significantly better control range from 5% to 95% open. Alternatively, the geometry of the control opening on an EDCV provides a significantly larger range of control than butterfly valves and elimination of pressure losses at 100% open, but concentric reducers are usually required to achieve optimal control performance. Installation of the proposed valves would involve replacing the existing high-performance butterfly valve (HPBFV). Although the HPBFV itself is small (approximately 3 inches thick), the valve needs to be 3 feet upstream and 6 feet-8 inches downstream of the flow meter. Thus, the HPBFV requires nearly 12 feet of pipe length for proper measurement and operation. In contrast, the JCV would require 5.25 feet for a standard installation. A compact design could go as low as 3 feet-3 inches.

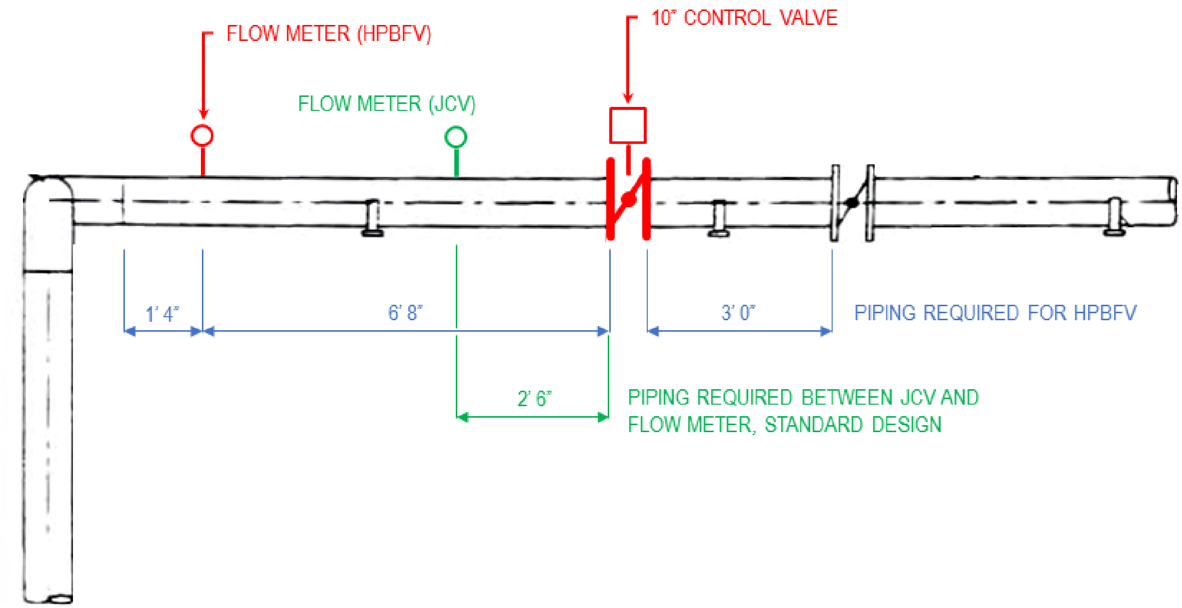


Figure 4-5. Piping Requirements for HPBFV versus JCV

For peak airflow rates when the valves are mostly open, there is very little difference in the pressure between an HPBFV and a JCV or EDCV. However, during average daily flows when airflows are a fraction of the peak, the headloss required for flow splitting is much higher for the HPBFV than for a JCV. Although the butterfly valve may require between 1.0 and 1.2 psig of headloss for control, the JCV will only require 0.15 psig of headloss. A conservative 1.0 psig savings in header pressure (8.13 versus 9.13 psig) could reduce aeration energy by 10-15% at the current average daily airflow of about 3,500 scfm. Hydraulic evaluation of the aeration system is recommended to accurately evaluate headloss requirements of the proposed valves.

It should be noted, however, that the existing multistage blowers are not designed to operate at the lower pressures required for JCVs or EDCVs, which would require high amounts of throttling to achieve the necessary aeration rates and thereby negate any potential energy savings. Therefore, new control valves should only be considered in conjunction with a blower upgrade project where the new blowers would be designed to operate at the lower pressures. Detailed hydraulics of the aeration system are necessary for implementation of new control valves and should be conducted to verify the potential savings in conjunction with the new blowers.

New High-Efficiency Blower for Aeration

A noted previously, current flows required the existing blowers to be throttled for turndown to achieve the desired aeration rates. The existing blower system is equipped with two 300-hp multistage centrifugal blowers with space for a third future blower. The dedicated future blower space presents an opportunity to install a more efficient blower to treat the current flows. An evaluation for new blowers is already underway by another consultant. Installing a new high-efficiency blower could potentially further reduce power consumption from aeration, given that it is 30% of the overall plant energy consumption. High-speed turbo blowers (HSTBs) offer the ability to provide high-efficiency (80%) aeration in a compact package. A similarly designed HSTB would only require about a 200-hp motor versus the 253-hp (300-hp motor) required by the existing multistage centrifugal blowers, representing a 20% energy savings.

4.1.6 ECM-P03: New Deep Well Injection Pump

The deep well injection system is equipped with dual 500-hp vertical turbine pumps rated at 13,500 gallons per minute (gpm) (18 mgd), at 84% efficiency. However, current flows are only 2,625 gpm (3.8 mgd). Based on a review of the pump curve and existing discharge pressure of 42 psig, the existing pumps are operating well outside of their preferred operating range at an estimated efficiency of 68%, drawing approximately 107 hp.

The deep well injection facility was constructed with space for a future third pump (**Figure 4-6**). A more efficient pump could be installed in this spaced to better match current flow conditions.

Figure 4-6. Deep Well Pumps with Future Pump Location

The existing pump curve for the deep well injection pumps could be reasonably turned down to approximately 5,750 gpm at 100 feet total dynamic head and remain within the preferred operating range (minimum of 80% efficiency). However, this is still double the existing flows. If some tolerance is provided to allow the pumps to operate just outside of the preferred operating range but still maintain 75% efficiency, the existing pumps could turn down to approximately 4,500 gpm (6.5 mgd). Therefore, 4,500 gpm was used as a goal capacity for a smaller, more efficient pump for existing flow rates.

It should be noted that the well system head curve was not available for this evaluation. For this pump selection calculation, a similar system head curve from another approximately 3,000-foot-deep injection well was used. The example curve provided the following pressures (as shown in **Table 4-3**) to be used for the pump selection evaluation.

Table 4-3. Deep Well Injection Pump Sizing

Flow (gpm)	Rated Head (psi)		Notes
5,000	48.0		Design Rating
5,000	23.1		Design, Low Pressure
3,472	45.0		Maximum Monthly Average Flow
2,640	41.7		Existing Flow and Pressure at Visit
2,083	41.0		Annual Average Flow
2,083	21.0		Annual Average Flow, Low Pressure

A review of potential pumps that would provide a similar vertical centrifugal arrangement determined that an Aurora 610 series 10x10x22 pump would provide the best opportunity to maximize efficiency. At the design condition (5,000 gpm), the pump achieves 77% efficiency using a 200-hp premium-efficiency motor (180-hp draw). At current average daily flow rates (2,640 gpm), the proposed pump is estimated to draw approximately 84 hp (76% efficiency, 42 psig), which would be a 21% reduction in effluent pumping energy. Design and multispeed pump curves are provided in **Appendix A**.

4.2 Other Opportunities

Table 4-4 lists the other opportunities that were evaluated but did not result in desirable payback periods based on energy savings potential. Detailed descriptions of each opportunity are provided in the following sections.

Table 4-4. Other Opportunities

Process/Location	Description of Opportunity	Potential Annual Energy Savings (kWh)	Notes
Biological Treatment	Install baffle wall for anoxic zone: optimization of denitrification process (aeration reduction).	Negligible	Providing a dedicated zone could provide the opportunity to create anaerobic conditions for biological phosphorus removal to reduce chemical consumption.
Headworks	Influent screening optimization: Use a single screen to match actual flow requirements.	1,306 (4 hp)	Savings assume the screening mechanism operates once every 10 minutes.
Biological Treatment	Replace aging RAS and WAS pumping.	13,075 (2 hp)	Existing pumps are nearing 30 years old and showing significant signs of wear and tear.
	Investigate unaerated zone mixing.	84,680 (13 hp)	Recent studies have shown that periodic mixing is sufficient for most plants, but savings need to be investigated to determine whether there are any impacts to process efficiency.
Tertiary Filtration	Upgrade filter influent pumps.	58,840 (9 hp)	--
Disinfection	Perform real-time monitoring to control UV dosing for disinfection.	44,370 (6.8 hp)	The NPDES discharge permit compliance dosage of 35 mW-s/cm^2 would need to be renegotiated as part of ECM-P01 to allow reduction in dosage.
WWTP Process	Investigate facility hydraulics.	--	Due to the inherently interconnected nature of plant hydraulics, a whole-plant dynamic simulation tool such as Replica should be used to evaluate the full plant hydraulics and controls. This is beyond the scope of this project; therefore, savings are not projected for this measure.
WWTP Process	Install alternative biosolids processing with energy production.	--	Treatment of biosolids provides an opportunity to produce energy. However, construction of new facilities will require a sizable investment with an unfavorable payback period based on energy alone.
Domestic Hot Water	Install solar DHW systems.	--	The existing DHW load is not large enough to warrant savings to offset the implementation costs of a solar DHW system
Overall Facility	Install solar PV systems.	--	Based on initial screening-level calculations and similar projects evaluated in the area, payback periods for solar PV systems are not favorable at this time
Overall Facility	Reduce and manage peak demand.	--	Demand charges account for around 15% of the total electric bill; investigate opportunities to shed load or use alternative energy resources during peak load conditions.
Main Electrical Room	Add energy-efficient mechanical cooling system.	--	--

DHW = domestic hot water
mW-s/cm^2 = milliwatt-second(s) per square centimeter
NPDES = National Pollutant Discharge Elimination System
PV = photovoltaic

4.2.1 Install Baffle Wall for Anoxic Zone

The existing biological treatment process uses an activated sludge system configured with four-stage biological nutrient removal. Pre- and post-unaerated anoxic zones are provided for denitrification and aeration zones are provided for 5-day carbonaceous biochemical oxygen demand removal and nitrification. The pre-anoxic zones were constructed with two floating mixers for agitation but do not have a dedicated baffle wall to separate the unaerated and aerated portions of the aeration basin.

During the site visit there was clear evidence of the airlift caused by the aerobic zone back flowing into the anoxic zone. This effectively creates an airlift-induced internal recycle between the aerobic and anoxic zones. This was evident by the scum trapped in the anoxic zone (**Figure 4-7**). However, the low DO (approximately 0.5 mg/L) maintained by plant staff in the first aerobic zones helps to mitigate any potential degradation in denitrification. In addition, the raw influent enters at the corner of the anoxic zone. Without a baffle wall, it is likely that much of the raw influent is short-circuiting the anoxic zone with little influent making it to the far side of the anoxic zone.

An optimal design would include a baffle wall to prohibit any unintentional recycle and to ensure that the raw influent is completely mixed and not short-circuiting the unaerated zone. However, it should be noted that the RAS enters the bioreactors about 40 feet from where the raw feed enters the basin. To ensure the raw influent mixes with the RAS to create MLSS, a channel should be created to extend the RAS discharge to the influent side of the baffle wall.

The biological treatment configuration described previously was modeled in Pro2D[2] to determine the impact provided by installing a new baffle wall. Without the baffle, the current operations and an underloaded pre- and post-anoxic zone are capable of fully denitrifying (to the point of potentially being anaerobic). Adding the baffle wall, if configured such that flow would enter the aerobic zone at the opposite side from where it entered, would completely denitrify within the anoxic zone to the point that it will go anaerobic, especially at summertime wastewater temperatures. Nitrate exiting the biological process effectively would remain unchanged because the flows would be low enough that pre- and post-anoxic zones could nearly completely denitrify. Therefore, energy production effectively would remain unchanged.

This arrangement could potentially create conditions for biological phosphorus removal (BPR) to reduce chemical dosing. Initial model simulations with a baffle wall show that BPR could be implemented in the system with ample phosphorus accumulating organism growth with phosphate reducing to less than 0.2 mg/L by the end of the aerobic zone. Unfortunately, the underloaded and oversized post-anoxic zone would re-release most of that phosphate because nitrate is nearly fully denitrified recreating anaerobic conditions. The small reaeration zone would not be able to uptake this lost phosphate. However, if BPR and chemical micro-dosing are used in combination, it is estimated that chemical addition could be reduced by two thirds while still meeting the 1.0-mg/L permit.

Figure 4-7. Scum Trapped from the Aerobic to Pre-anoxic Zone Backflow Induced by Airlift

4.2.2 Influent Screening Optimization

The influent screening system at the RAH EPF consists of three channels that contain mechanical screens with capacities of 6, 9, and 15 mgd, respectively. The cleaning mechanism for the screens are operated using differential pressure across the screen with a timer backup. At the time of the site visit, all three screens were in operation. Operating all three screens appears to be unnecessary because influent flows have averaged 3.8 mgd with peak flows of 8.8 mgd over the last 5 years. Operating only one screen provides minimal savings of 1,306 kWh per year, assuming the screening mechanism operates once every 10 minutes.

Figure 4-8. Rags Collected from Secondary Clarifier

It was also noted during the site visit that rags were being removed during maintenance activities as far downstream as the secondary clarifiers (**Figure 4-8**). This indicates that the 1/2-inch bar screens are not sufficiently removing “stringy” influent screenings (such as hair, string, and similar). These types of screenings can agglomerate on mechanical equipment, increasing required maintenance and potentially increasing power draw. A perforated plate-type screen with smaller openings (such as 1/4-inch) would provide significantly more efficient removal of stringy materials. However, the current screens are still new (approximately 5 years old) and replacement at this time would not be cost-effective.

4.2.3 Replace Aging RAS and WAS Pumping

Figure 4-9. RAS Pumping

The existing RAS and WAS pumps are nearing 30 years old and, as noted during the visit, are showing significant wear and tear; RAS pumps are shown on **Figure 4-9**. Discussions with staff indicated that these pumps have been identified for replacement. This presents an opportunity to replace them with higher-efficiency equipment. The RAS pumps were very efficient pumps when originally installed, rated at 1,600 gpm, 78% efficiency, and equipped with a 25-hp motor. However, more modern pumps use premium-efficiency motors, which reduce power draw. Based on potential pump curves, the existing pumps should be replaced with Xylem/Flygt N-series N3153 pumps rated at 1,730 gpm, 77% efficiency, and equipped with a 17-hp motor. At current flows, the existing pumps are estimated to draw 12 hp. These new pumps would be expected to draw 10 hp, which would reduce the energy consumption by 20% over the existing pumps.

4.2.4 Investigate Anoxic Mixing

Recent research in treatment has investigated mixing in unaerated zones and has concluded that, in many cases, too much mixing energy has been installed historically. In addition, in some cases, periodic mixing can be used with little to no detrimental results. At a minimum, if full-time mixing is desired, the recommended mixing energy necessary has reduced from 50 hp per million gallons (hp/MG) to less than 25 hp/MG. The current mixers in the pre-anoxic zone (**Figure 4-10**) are 10 hp each (20 hp total), which results in a mixing energy of 55 hp/MG. For the post-anoxic zone, which uses dual 7.5-hp (15 hp total) mixers for two of the post-anoxic cells and dual 5-hp (10 hp total) mixers in the final unaerated cell, the mixing energy is much lower, at 27-29 hp/MG. Thus, the mixing energy in both unaerated zones could be reduced. Given the small power requirements for the mixers, replacement for the energy savings will most

Figure 4-10. Post-anoxic Mixers

likely be cost-prohibitive. However, facility staff could investigate operating the mixers periodically. For example, an investigation into the mixing of the pre-anoxic zone could be conducted to determine whether alternating operation of the mixers is detrimental to denitrification or whether substantial settling (that cannot be resuspended) occurs. If proven successful, this example could yield a 50% power savings (10 hp). A similar study could be conducted with the post-anoxic zone mixers. Testing and operating would require timers to be available for the mixers if that capability is not already provided by the supervisory control and data acquisition (SCADA) system. A review of the piping and instrumentation diagrams for the unaerated zone mixers does indicate that those mixers can be started and stopped by the programmable logic controller. Therefore, it may be feasible to conduct this investigation with some minor SCADA programming. Although the results of the investigation will yield the true potential savings, if the mixing energy for all the unaerated zones is reduced to 25 hp/MG, then the energy could be reduced by nearly 30% (13 hp) over existing operations.

4.2.5 Upgrade Filter Influent Pumping

Secondary effluent requires pumping for tertiary filtration and disinfection (**Figure 4-11**). The existing pumping system consists of three Flygt CT3300 pumps equipped with 60-hp motors rated at 7,000 gpm. The manufacturer’s pump curve indicates the design pump efficiency is 55%. These pumps could be upgraded to achieve significantly higher efficiency.

Figure 4-11. Filter Influent Pumps

A review of potential replacement pumps determined that a Xylem/Flygt C3400 equipped with a 30-hp motor would provide the best fit to reduce pumping energy. At current flows using a VFD, it is estimated that the existing filter influent pumps draw approximately 16 hp. The proposed C3400, rated at 7,000 gpm and 73% efficiency, at existing flows would draw and estimated 7 hp, resulting in a 44% reduction in pumping energy.

4.2.6 Install Real-Time Monitoring System to Aid in UV Dose Control

In general practice, the UV disinfection system is controlled based on flow pacing from the secondary effluent flume measurement. The set dose is generally adjusted based on the lamp intensity, lamp power, UV transmittance, and flow rates. However, the dose setpoint is ultimately determined by the results of the daily 24-hour coliform testing. Given the importance of this testing, not only for permit compliance but also to protect public health, this setpoint tends to be set artificially high. Although this is a standard approach, it is an extremely conservative. A more recent method of disinfectant dosing uses real-time monitoring to determine the necessary dose. Real-time monitoring of wastewater originated in the drinking water security field. These systems use a hybrid mix of measurements (absorption, fluorescence, scattering, and spectrophotometry) to determine and report concentrations of parameters within a single machine without the use of chemical reagents. These units have been shown to be capable of measuring *E. Coli* in effluent, enabling the ability to control disinfectant dosing, whether with chemicals or UV.

Figure 4-12. ZAPs LiquID Station for UV Dose Control

An example facility for the City of Grand Rapids, Michigan was able to successfully use real-time monitoring (ZAPs LiquID Station, **Figure 4-12**) of *E. Coli* to control its north and south UV disinfection system dosing. This allowed the facility to significantly reduce energy consumption when the dosing setpoint could be reduced by one third without a change in effluent *E. Coli* levels. The return on investment for this project was less than 3 years. A similar investment at the RAH EPF could also yield savings; however, savings achieved may not be nearly as much as those in the City of Grand Rapids. The NPDES discharge permit (refer to ECM-P01) stipulates a minimum

UV dosage of 35 mW-s/cm^2. The City of Grand Rapids was able to reduce UV dosing from 32 to 35 mW-s/cm^2 down to 20 mW-s/cm^2. Thus, if the compliance dosage is already artificially high, then no savings will be achievable unless this discharge criteria is renegotiated as part of ECM-P01. Pilot testing could potentially be used in conjunction with ECM-P01 to illustrate compliance at lower UV dosing rates.

4.2.7 Investigate Facility Hydraulics

Facility hydraulics are often overlooked as a potential energy savings measure. Although the ECMs in **Section 4.1** mention replacing equipment (such as pumps), minor changes to the hydraulic grade line could also produce energy savings. In addition, advanced controls for pumping (such as setpoints) could ensure that pumps are always operating in the highest efficiency/preferred operating range. Due to the inherently interconnected nature of plant hydraulics, a whole-plant dynamic simulation tool such as Replica could be used to evaluate the full-plant hydraulics and controls. Dynamic simulation could demonstrate alternative control strategies that reduce energy costs and reduce operational intervention at the treatment plant. With dynamic simulation, the plant's operations and controls, including filter influent and deep well injection pumping, collection system pumping, W3 pumping, peak flow shaving to the equalization basin, could be analyzed, optimized, and tested in a low-risk environment before implementation. Potential savings from a Replica investigation are to be determined. However, if a 10% savings could be realized at just the deep well injection system, it could potentially save 66,150 kWh per year.

4.2.8 Install Alternative Biosolids Processing with Energy Production

Treatment facilities have the potential to significantly reduce electrical consumption through the use of best practices and equipment selection. However, even with high-efficiency equipment and optimized operations, a facility cannot achieve self-sufficiency with production of its own energy. Energy production could be from multiple sources (such as wind or solar); however, the most common for wastewater treatment facilities has been from the capture and reuse of biogas produced by anaerobic digestion of sludge. Key components would be required if the RAH EPF were to implement anaerobic digestion with energy generation. These include installation of primary clarification with sludge pumping, installation of sludge thickening, the anaerobic digesters themselves, heating and mixing facilities for digesters, gas cleaning systems, and the combined heat and power system for energy generation. Given that this system would be new, thermal hydrolysis could also be employed to reduce digester sizing. With these facilities, not only would the facility be producing energy, but also activated sludge treatment energy would reduce (less loading) and the biosolids quantities would significantly reduce (50-60%) lowering biosolids hauling costs and those biosolids would be of Class A exceptional quality allowing for greater biosolids reuse potential. A very rough estimate of energy production estimates the existing facility could produce nearly 90 kW (715,000 kWh per year). However, the massive capital investment required for this relatively small sized facility (12 mgd) that treats on average less than one third of its capacity (4 mgd) likely makes this ECM non-viable.

For the RAH EPF a more unique option could be to investigate hydrothermal liquefaction (HTL). In HTL (example: GeniFuel), sludge generated is subject to high pressure (3,000 psi) and temperature (350 degrees Celsius) to convert the organic matter to raw biocrude oil and methane gas. The biocrude produced is considered "raw," which still requires further processing (refinery) until it becomes a fuel. The only sludge produced is a solid precipitate (quantity is approximately 1% of the feed) that is mostly phosphorus, which is recoverable. This process has been under extensive study by the U.S. Department of Energy and the Water Environment Research Foundation at the Pacific Northwest National Laboratory, but it still being very much a pilot study with years of work remaining until it becomes commercially viable. Currently, the RAH EPF produces about 3.5 dry tons per day of raw WAS (prior to any digestion). Based on the initial pilot results, if these solids went through HTL then it would produce an estimated 275 gallons per day of biocrude, 16,000 cubic feet per day of biogas, and 74 pounds per day of the phosphorus laden solid precipitate. The biogas could generate about 40 kW (350,000 kWh per year) of energy, while the biocrude could potentially be used by the nearby U.S. Navy installation, which has an interest in using biofuels. However, given that this technology is still in its infancy, it would be expected that significant pilot and research work is necessary until it is ready for commercialization.

4.2.9 Solar Domestic Hot Water Systems

The Operations Building and Solids Building each have electric water heaters for DHW production. Installing a solar DHW system to supplement the existing DHW system will offset a large part of the electric use. The solar DHW system would supplement the existing system, which would remain in place and provide auxiliary heating when the solar DHW system is unable to provide sufficient DHW heating. Open roof space is available on these buildings for solar thermal panel installation.

Based on initial screening-level calculations, the existing DHW load is not large enough to warrant savings to offset the implementation costs of a solar DHW system at this time. Therefore, this is not a recommended ECM.

4.2.10 Solar PV Systems

Installing a solar PV array will allow the WWTP to use energy generated by the array, reducing the amount of utility-supplied electricity used. The solar PV array would consist of several modules used to offset centrally supplied electricity. For the screening-level analysis, a variety of array sizes were evaluated between 2 and 500 kW, because most small-scale arrays fall within this size range due to limitations with available space, either on a roof or on the ground.

The screening-level analysis is based on solar irradiance data provided by the National Renewable Energy Laboratory's PVWatts tool and RETScreen 4. The performance of each solar array was then evaluated using specifications for a 230-watt monocrystalline silicon module, though similar results are expected with similar modules. Rigid panels were used for this analysis because of their increased efficiency and commercial availability compared to thin film alternatives.

Based on initial screening-level calculations and similar projects evaluated in the area, payback periods for solar PV systems are not favorable at this time. Therefore, this is not recommended as a stand-alone ECM.

4.2.11 Demand Reduction and Management

Under the current billing tariffs, the demand charge from Keys Energy Services accounts for around 15% of the total electric bill. During the analysis of the utility bills, concerns were raised about demand spike on a few of the months over the past year. The bills from September 2017, October 2017, and May 2018 particularly raised red flags with the increased demand-to-average-usage ratio (refer to the Utility Profile Demand Trend tab for reference).

The current billing tariff, Large Commercial Service, used by Keys Energy Services applies to large commercial facilities that do not own, operate, and maintain the transformer and primary conductors. By doing this, the billing tariff could be changed to Large Commercial Customer-Owned Primary Service. Switching to this billing tariff would reduce the energy charge realized by the facility and consequently reduce the monthly charges from Keys Energy Services. However, feasibility of gaining ownership of the transformer and primary conductors would need to be carefully considered and discussed by the City and RAH EPF personnel.

One strategy that can be used to reduce these demand spikes using existing equipment is the use of the onsite generator during peak demand hours, such as heavy rainfall and maintenance days. The generator will provide supplementary power to the plant to reduce the demand-to-usage ratio, subsequently reducing the overall demand charge from Keys Energy. More information on the capabilities of the generator, switch boards, and overall electrical system is needed to further analyze this solution.

Another option is to include additional onsite energy generation, such as solar PV or biofuels, as described previously. This can also provide an alternative source of power to support energy resiliency, in the event of loss of grid power. Although solar PV systems can provide renewable independent energy, it cannot generate power without the sun, leaving several hours of the day without an electric source should the grid fail. Therefore, consideration of additional energy sources, such as battery storage and generators, should be included if intended for stand-alone power production.

4.2.12 Energy-Efficient HVAC for Main Electrical Room

The VFDs for the new blowers will be located within the main electrical room, which is currently not temperature-controlled. When the VFDs are added, the space temperature will need to be controlled in order to provide an optimal environment for the new equipment. Avoiding extreme ambient temperatures extends equipment life and maximizes system reliability.

Although most VFDs have built-in fans to remove the heat as efficiently as possible to prevent power components from overheating, in environments with extreme temperatures, such as Key West, Florida, additional steps are needed to maintain the proper ambient temperature. Typically, an ambient temperature of 78 to 80°F is sufficient in for electrical equipment to maintain operation without overheating. It is estimated that approximately 5 tons of cooling capacity would be required for this space. However, a complete load analysis will be required to confirm exact sizing and selection of equipment.

5. References

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U.S. Green Building Council (USGBC). 2013. *LEED Reference Guide for Building Design and Construction.* Version 4. November 18.

Appendix A
Equipment Data Sheets

ECM-P02: High-Efficiency Diffusers

Xylem Water Solutions USA, Inc.
Sanitaire Products

9333 N. 49th Street
Brown Deer, WI 53223
Tel 414-365-2245
Fax 414-365-2210

October 9, 2018

ATTN: Muriel Steele - Jacobs

RE: Key West, FL – WWTP : Aeration Basin and Overflow Basins
Fine Bubble Aeration System Membrane Replacement

Xylem is pleased to provide a quote for the following equipment as part of the fine bubble aeration system membrane replacement in the Aeration Basin and Overflow Basin.

Quantity	Sanitaire P/N	Description	Unit Price	Extended Price
3101	2261-WE9	MEMBRANE DISC- 9" w/INTEGRAL O-RING (Aeration Basin)	$4.50	$13,954.50
2079	2261-WE9	MEMBRANE DISC- 9" w/INTEGRAL O-RING (Overflow Basin)	$4.50	$9,355.50
100	2300-2P9	RETAINER RING -9" DIFFUSER PVC (Spare)	$4.00	$400.00
100	2223-1SP	BASE PLATE- 9" MEMBRANE PVC (Spare)	$5.75	$575.00
3	HVS350-8	HUSKY-350 LUBRICANT- 8 LB. PAIL (estimate 2000 diffusers per pail)	$231.00	$693.00
10	2300-01-DIST	Diffuser Holder Repair Kit (1' Pipe w/Holder and Couplings)	$50.00	$500.00
		Total Price		**$25,478.00**

Terms & Conditions: The Xylem Water Solutions USA, Inc. North American Terms & Conditions of Sale apply to this offer.
Freight Terms: FCA Xylem Warehouse – Freight Prepaid & Add (Incoterms 2010
(Feight to Jobsite NOT included)
Lead Time & Shipping: 4 Weeks from Reciept of Accepted Order.
Taxes: The prices quoted above do not include any state, federal, or local sales or use taxes.
Terms of payment: 100% Net 30 days from invoice date.

Thank you for the opportunity to provide this quotation. Please contact us if you have any questions.

Francis Pastors
Senior Sales Engineer – Sanitaire Products
Tel 414-365-2256, Fax 414-365-2210
francis.pastors@xyleminc.com

To place an order, please send a purchase order or signed quote, including or accompanied by the following information:

Purchase Order Number
Billing Address
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Any applicable tax exemption certificates
Contact person and phone number

Accepted By (Authorized Signature):____

Printed name:____

Date:________________________

PO #:__________________________

Billing Address:	Shipping Address:
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______________________________	______________________________
______________________________	______________________________

Tax exemption #: __________________ OR % Sales Tax Applicable: ______________

Contact person:______________________________

Phone number:______________________________

This order is subject to the Standard Terms and Conditions of Sale – Xylem Americas effective on the date the order is accepted which terms are available at **http://www.xyleminc.com/en-us/Pages/terms-conditions-of-sale.aspx** *and incorporated herein by reference and made a part of the agreement between the parties.*

Aeration and Mixing System Design Summary

Project Name: Key West
Location: Florida

Design Brief # 181022-01-01-Disc
Date: 10/22/2018

Calculated By: RNM

General Notes

1) Each design calculation is for 1 tank only
2) System design under standard conditions in clean water according to ASCE standard.
3) System design based on limiting airflow requirement (oxygenation or mixing).
4) Cell values assumed by EDI are Bold and Underlined
5) Alternate inputs that differ from design inputs are highlighted blue
6) Estimated Blower Operating Pressure includes pressure to the top of the drop, estimated yard pipe and blower losses, and 0.5 psig overpressure.

Additional Notes

TDS = 1000 mg/L

aeration for life®

Pass 1 Geometry:

	Design Scenario	Units	AVE	MAX
(1)	Length	ft	90.00	90.00
(2)	Width	ft	76.50	76.50
(3)	Outer Diameter	ft	-	-
(4)	Inner Diameter (For Donut Shape)	ft	-	-
(5)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(6)	Water Depth	ft	17.10	17.10
(7)	Aeration Depth	ft	16.00	16.00
(8)	Aerated Tank Floor Area (AT)	ft2	6,885	6,885
(9)	Aerated Tank Volume (VT)	ft3	117,734	117,734

Pass 1 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(10)	Diffuser Membrane Type	-	9in Disc	9in Disc
(11)	Diffuser Assembly Type	-	9in Disc	9in Disc
(12)	Perforation Size	-	Nano	Nano
(13)	Quantity of Diffuser Membranes per Diffuser Assembly	-	1	1
(14)	Number of Diffuser Membranes Required	-	3,860	3,860
(15)	Number of Diffuser Assemblies Required	-	3,860	3,860
(16)	Perforated Membrane Area per Diffuser Membrane	ft2	0.41	0.41
(17)	Perforated Membrane Area per Diffuser Assembly	ft2	0.41	0.41
(18)	Total Perforated Membrane Area Requirement (AD)	ft2	1,582.60	1,582.60
(19)	Design Density - Floor Coverage (AD / AT)	-	0.23	0.23
(20)	Design Density - (AT / AD)	-	4.35	4.35

Pass 1 Mixing:

	Design Scenario	Units	AVE	MAX
(21)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(22)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(23)	Airflow Requirement for Mixing (Qmix)	scfm	826	826

Pass 1 Oxygen Requirement:

	Design Scenario	Units	AVE	MAX
(24)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	355	417
(25)	Airflow Requirement for Process (Qoxy)	scfm	786	967
(26)	System Determining Airflow (Qmix or Qoxy)	scfm	826	967
(27)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.14
(28)	Airflow per Diffuser Membrane	scfm	0.21	0.25
(29)	Diffuser Membrane Flux Rate	scfm/ft2	0.52	0.61
(30)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.23	41.36
(31)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.59
(33)	Estimated Pressure at Top of Drop Pipe	psig	7.81	7.83
(34)	Estimated Blower Operating Pressure	psig	8.96	8.98

Pass 2 Geometry:

	Design Scenario	Units	AVE	MAX
(70)	Length	ft	90.00	90.00
(71)	Width	ft	76.50	76.50
(72)	Outer Diameter	ft	-	-
(73)	Inner Diameter (For Donut Shape)	ft	-	-
(74)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(75)	Water Depth	ft	17.10	17.10
(76)	Aeration Depth	ft	16.00	16.00
(77)	Aerated Tank Floor Area (AT)	ft2	6,885	6,885
(78)	Aerated Tank Volume (VT)	ft3	117,734	117,734

Pass 2 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(79)	Diffuser Membrane Type	-	9in Disc	9in Disc
(80)	Diffuser Assembly Type	-	9in Disc	9in Disc
(81)	Perforation Size	-	Nano	Nano
(82)	Quantity of Diffuser Membranes per Diffuser Assembly	-	1	1
(83)	Number of Diffuser Membranes Required	-	3,860	3,860
(84)	Number of Diffuser Assemblies Required	-	3,860	3,860
(85)	Perforated Membrane Area per Diffuser Unit	ft2	0.41	0.41
(86)	Perforated Membrane Area per Diffuser Assembly	ft2	0.41	0.41
(87)	Total Perforated Membrane Area Requirement (AD)	ft2	1,582.60	1,582.60
(88)	Design Density - Floor Coverage (AD / AT)	-	0.23	0.23
(89)	Design Density - (AT / AD)	-	4.35	4.35

Pass 2 Mixing:

	Design Scenario	Units	AVE	MAX
(90)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(91)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(92)	Airflow Requirement for Mixing (Qmix)	scfm	826	826

Pass 2 Oxygen Requirement

	Design Scenario	Units	AVE	MAX
(93)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	335	394
(94)	Airflow Requirement for Process (Qoxy)	scfm	742	893
(95)	System Determining Airflow (Qmix or Qoxy)	scfm	826	893
(96)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.13
(97)	Airflow per Diffuser Unit	scfm	0.21	0.23
(98)	Diffuser Membrane Flux Rate	scfm/ft2	0.52	0.56
(99)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.23	42.25
(100)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.64
(102)	Estimated Pressure at Top of Drop Pipe	psig	7.81	7.82
(103)	Estimated Blower Operating Pressure	psig	8.96	8.97

Pass 3 Geometry:

	Design Scenario	Units	AVE	MAX
(139)	Length	ft	90.00	90.00
(140)	Width	ft	105.20	105.20
(141)	Outer Diameter	ft	-	-
(142)	Inner Diameter (For Donut Shape)	ft	-	-
(143)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(144)	Water Depth	ft	17.10	17.10
(145)	Aeration Depth	ft	16.00	16.00
(146)	Aerated Tank Floor Area (AT)	ft2	9,468	9,468
(147)	Aerated Tank Volume (VT)	ft3	161,903	161,903

Pass 3 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(148)	Diffuser Membrane Type	-	9in Disc	9in Disc
(149)	Diffuser Assembly Type	-	9in Disc	9in Disc
(150)	Perforation Size	-	Nano	Nano
(151)	Quantity of Diffuser Membranes per Diffuser Assembly	-	1	1
(152)	Number of Diffuser Membranes Required	-	5,300	5,300
(153)	Number of Diffuser Assemblies Required	-	5,300	5,300
(154)	Perforated Membrane Area per Diffuser Membrane	ft2	0.41	0.41
(155)	Perforated Membrane Area per Diffuser Assembly	ft2	0.41	0.41
(156)	Total Perforated Membrane Area Requirement (AD)	ft2	2,173.00	2,173.00
(157)	Design Density - Floor Coverage (AD / AT)	-	0.23	0.23
(158)	Design Density - (AT / AD)	-	4.36	4.36

Pass 3 Mixing:

	Design Scenario	Units	AVE	MAX
(159)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(160)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(161)	Airflow Requirement for Mixing (Qmix)	scfm	1,136	1,136

Pass 3 Oxygen Requirement

	Design Scenario	Units	AVE	MAX
(162)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	406	477
(163)	Airflow Requirement for Process (Qoxy)	scfm	900	1,058
(164)	System Determining Airflow (Qmix or Qoxy)	scfm	1,136	1,136
(165)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.12
(166)	Airflow per Diffuser Membrane	scfm	0.21	0.21
(167)	Diffuser Membrane Flux Rate	scfm/ft2	0.52	0.52
(168)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.20	43.20
(169)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.70
(171)	Estimated Pressure at Top of Drop Pipe	psig	7.81	7.81
(172)	Estimated Blower Operating Pressure	psig	8.96	8.96

Pass 4 Geometry:

	Design Scenario	Units	AVE	MAX
(208)	Length	ft	90.00	90.00
(209)	Width	ft	71.70	71.70
(210)	Outer Diameter	ft	-	-
(211)	Inner Diameter (For Donut Shape)	ft	-	-
(212)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(213)	Water Depth	ft	17.10	17.10
(214)	Aeration Depth	ft	16.00	16.00
(215)	Aerated Tank Floor Area (AT)	ft2	6,453	6,453
(216)	Aerated Tank Volume (VT)	ft3	110,346	110,346

Pass 4 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(217)	Diffuser Membrane Type	-	9in Disc	9in Disc
(218)	Diffuser Assembly Type	-	9in Disc	9in Disc
(219)	Perforation Size	-	Nano	Nano
(220)	Quantity of Diffuser Membranes per Diffuser Assembly	-	1	1
(221)	Number of Diffuser Membranes Required	-	3,620	3,620
(222)	Number of Diffuser Assemblies Required	-	3,620	3,620
(223)	Perforated Membrane Area per Diffuser Membrane	ft2	0.41	0.41
(224)	Perforated Membrane Area per Diffuser Assembly	ft2	0.41	0.41
(225)	Total Perforated Membrane Area Requirement (AD)	ft2	1,484.20	1,484.20
(226)	Design Density - Floor Coverage (AD / AT)	-	0.23	0.23
(227)	Design Density - (AT / AD)	-	4.35	4.35

Pass 4 Mixing:

	Design Scenario	Units	AVE	MAX
(228)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(229)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(230)	Airflow Requirement for Mixing (Qmix)	scfm	774	774

Pass 4 Oxygen Requirement

	Design Scenario	Units	AVE	MAX
(231)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	244	287
(232)	Airflow Requirement for Process (Qoxy)	scfm	540	635
(233)	System Determining Airflow (Qmix or Qoxy)	scfm	774	774
(234)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.12
(235)	Airflow per Diffuser Membrane	scfm	0.21	0.21
(236)	Diffuser Membrane Flux Rate	scfm/ft2	0.52	0.52
(237)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.23	43.23
(238)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.70
(240)	Estimated Pressure at Top of Drop Pipe	psig	7.81	7.81
(241)	Estimated Blower Operating Pressure	psig	8.96	8.96

Environmental Dynamics International

Aeration and Mixing System Design Summary

Project Name: Key West
Location: Florida

Design Brief # 181022-01-01-Panel
Date: 10/22/2018

Calculated By: RNM

General Notes

1) Each design calculation is for 1 tank only
2) System design under standard conditions in clean water according to ASCE standard.
3) System design based on limiting airflow requirement (oxygenation or mixing).
4) Cell values assumed by EDI are Bold and Underlined
5) Alternate inputs that differ from design inputs are highlighted blue
6) Estimated Blower Operating Pressure includes pressure to the top of the drop, estimated yard pipe and blower losses, and 0.5 psig overpressure.

Additional Notes

TDS = 1000 mg/L

aeration for life®

Pass 1 Geometry:

	Design Scenario	Units	AVE	MAX
(1)	Length	ft	90.00	90.00
(2)	Width	ft	76.50	76.50
(3)	Outer Diameter	ft	-	-
(4)	Inner Diameter (For Donut Shape)	ft	-	-
(5)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(6)	Water Depth	ft	17.10	17.10
(7)	Aeration Depth	ft	16.00	16.00
(8)	Aerated Tank Floor Area (AT)	ft2	6,885	6,885
(9)	Aerated Tank Volume (VT)	ft3	117,734	117,734

Pass 1 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(10)	Diffuser Membrane Type	-	9in Disc	9in Disc
(11)	Diffuser Assembly Type	-	9in Disc	9in Disc
(12)	Perforation Size	-	Nano	Nano
(13)	Quantity of Diffuser Membranes per Diffuser Assembly	-	1	1
(14)	Number of Diffuser Membranes Required	-	654	654
(15)	Number of Diffuser Assemblies Required	-	654	654
(16)	Perforated Membrane Area per Diffuser Membrane	ft2	2.64	2.64
(17)	Perforated Membrane Area per Diffuser Assembly	ft2	2.64	2.64
(18)	Total Perforated Membrane Area Requirement (AD)	ft2	1,726.56	1,726.56
(19)	Design Density - Floor Coverage (AD / AT)	-	0.25	0.25
(20)	Design Density - (AT / AD)	-	3.99	3.99

Pass 1 Mixing:

	Design Scenario	Units	AVE	MAX
(21)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(22)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(23)	Airflow Requirement for Mixing (Qmix)	scfm	826	826

Pass 1 Oxygen Requirement:

	Design Scenario	Units	AVE	MAX
(24)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	355	417
(25)	Airflow Requirement for Process (Qoxy)	scfm	787	988
(26)	System Determining Airflow (Qmix or Qoxy)	scfm	826	988
(27)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.14
(28)	Airflow per Diffuser Membrane	scfm	1.26	1.51
(29)	Diffuser Membrane Flux Rate	scfm/ft2	0.48	0.57
(30)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.22	40.46
(31)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.53
(33)	Estimated Pressure at Top of Drop Pipe	psig	7.80	7.82
(34)	Estimated Blower Operating Pressure	psig	8.95	8.97

Pass 2 Geometry:

	Design Scenario	Units	AVE	MAX
(70)	Length	ft	90.00	90.00
(71)	Width	ft	76.50	76.50
(72)	Outer Diameter	ft	-	-
(73)	Inner Diameter (For Donut Shape)	ft	-	-
(74)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(75)	Water Depth	ft	17.10	17.10
(76)	Aeration Depth	ft	16.00	16.00
(77)	Aerated Tank Floor Area (AT)	ft2	6,885	6,885
(78)	Aerated Tank Volume (VT)	ft3	117,734	117,734

Pass 2 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(79)	Diffuser Membrane Type	-	3P Panel Membrane	3P Panel Membrane
(80)	Diffuser Assembly Type	-	MiniPanel MP3	MiniPanel MP3
(81)	Perforation Size	-	Nano	Nano
(82)	Quantity of Diffuser Membranes per Diffuser Assembly	-	2	2
(83)	Number of Diffuser Membranes Required	-	654	654
(84)	Number of Diffuser Assemblies Required	-	327	327
(85)	Perforated Membrane Area per Diffuser Unit	ft2	2.64	2.64
(86)	Perforated Membrane Area per Diffuser Assembly	ft2	5.28	5.28
(87)	Total Perforated Membrane Area Requirement (AD)	ft2	1,726.56	1,726.56
(88)	Design Density - Floor Coverage (AD / AT)	-	0.25	0.25
(89)	Design Density - (AT / AD)	-	3.99	3.99

Pass 2 Mixing:

	Design Scenario	Units	AVE	MAX
(90)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(91)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(92)	Airflow Requirement for Mixing (Qmix)	scfm	826	826

Pass 2 Oxygen Requirement

	Design Scenario	Units	AVE	MAX
(93)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	335	394
(94)	Airflow Requirement for Process (Qoxy)	scfm	742	903
(95)	System Determining Airflow (Qmix or Qoxy)	scfm	826	903
(96)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.13
(97)	Airflow per Diffuser Unit	scfm	1.26	1.38
(98)	Diffuser Membrane Flux Rate	scfm/ft2	0.48	0.52
(99)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.22	41.75
(100)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.61
(102)	Estimated Pressure at Top of Drop Pipe	psig	7.80	7.81
(103)	Estimated Blower Operating Pressure	psig	8.95	8.96

Pass 3 Geometry:

	Design Scenario	Units	AVE	MAX
(139)	Length	ft	90.00	90.00
(140)	Width	ft	105.20	105.20
(141)	Outer Diameter	ft	-	-
(142)	Inner Diameter (For Donut Shape)	ft	-	-
(143)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(144)	Water Depth	ft	17.10	17.10
(145)	Aeration Depth	ft	16.00	16.00
(146)	Aerated Tank Floor Area (AT)	ft2	9,468	9,468
(147)	Aerated Tank Volume (VT)	ft3	161,903	161,903

Pass 3 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(148)	Diffuser Membrane Type	-	3P Panel Membrane	3P Panel Membrane
(149)	Diffuser Assembly Type	-	MiniPanel MP3	MiniPanel MP3
(150)	Perforation Size	-	Nano	Nano
(151)	Quantity of Diffuser Membranes per Diffuser Assembly	-	2	2
(152)	Number of Diffuser Membranes Required	-	900	900
(153)	Number of Diffuser Assemblies Required	-	450	450
(154)	Perforated Membrane Area per Diffuser Membrane	ft2	2.64	2.64
(155)	Perforated Membrane Area per Diffuser Assembly	ft2	5.28	5.28
(156)	Total Perforated Membrane Area Requirement (AD)	ft2	2,376.00	2,376.00
(157)	Design Density - Floor Coverage (AD / AT)	-	0.25	0.25
(158)	Design Density - (AT / AD)	-	3.98	3.98

Pass 3 Mixing:

	Design Scenario	Units	AVE	MAX
(159)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(160)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(161)	Airflow Requirement for Mixing (Qmix)	scfm	1,136	1,136

Pass 3 Oxygen Requirement

	Design Scenario	Units	AVE	MAX
(162)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	406	477
(163)	Airflow Requirement for Process (Qoxy)	scfm	899	1,057
(164)	System Determining Airflow (Qmix or Qoxy)	scfm	1,136	1,136
(165)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.12
(166)	Airflow per Diffuser Membrane	scfm	1.26	1.26
(167)	Diffuser Membrane Flux Rate	scfm/ft2	0.48	0.48
(168)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.23	43.23
(169)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.70
(171)	Estimated Pressure at Top of Drop Pipe	psig	7.80	7.80
(172)	Estimated Blower Operating Pressure	psig	8.95	8.95

Pass 4 Geometry:

	Design Scenario	Units	AVE	MAX
(208)	Length	ft	90.00	90.00
(209)	Width	ft	71.70	71.70
(210)	Outer Diameter	ft	-	-
(211)	Inner Diameter (For Donut Shape)	ft	-	-
(212)	Side Slope Ratio, Length / Height (if Applicable)	L/H	0.00	0.00
(213)	Water Depth	ft	17.10	17.10
(214)	Aeration Depth	ft	16.00	16.00
(215)	Aerated Tank Floor Area (AT)	ft2	6,453	6,453
(216)	Aerated Tank Volume (VT)	ft3	110,346	110,346

Pass 4 Diffuser Information:

	Design Scenario	Units	AVE	MAX
(217)	Diffuser Membrane Type	-	3P Panel Membrane	3P Panel Membrane
(218)	Diffuser Assembly Type	-	MiniPanel MP3	MiniPanel MP3
(219)	Perforation Size	-	Nano	Nano
(220)	Quantity of Diffuser Membranes per Diffuser Assembly	-	2	2
(221)	Number of Diffuser Membranes Required	-	614	614
(222)	Number of Diffuser Assemblies Required	-	307	307
(223)	Perforated Membrane Area per Diffuser Membrane	ft2	2.64	2.64
(224)	Perforated Membrane Area per Diffuser Assembly	ft2	5.28	5.28
(225)	Total Perforated Membrane Area Requirement (AD)	ft2	1,620.96	1,620.96
(226)	Design Density - Floor Coverage (AD / AT)	-	0.25	0.25
(227)	Design Density - (AT / AD)	-	3.98	3.98

Pass 4 Mixing:

	Design Scenario	Units	AVE	MAX
(228)	Specific Airflow Rate for Mixing	scfm/ft2	0.12	0.12
(229)	Volumetric Airflow Rate for Mixing	scfm/1000ft3	7.02	7.02
(230)	Airflow Requirement for Mixing (Qmix)	scfm	774	774

Pass 4 Oxygen Requirement

	Design Scenario	Units	AVE	MAX
(231)	Standard Oxygen Requirement (SOR = SOTR)	lb O2/hr	244	287
(232)	Airflow Requirement for Process (Qoxy)	scfm	540	635
(233)	System Determining Airflow (Qmix or Qoxy)	scfm	774	774
(234)	Specific Airflow per Aerated Tank Floor Area	scfm/ft2	0.12	0.12
(235)	Airflow per Diffuser Membrane	scfm	1.26	1.26
(236)	Diffuser Membrane Flux Rate	scfm/ft2	0.48	0.48
(237)	Standard Oxygen Transfer Efficiency (SOTE)	%	43.25	43.25
(238)	Specific Standard Oxygen Transfer Efficiency (SSOTE)	%/ft	2.70	2.70
(240)	Estimated Pressure at Top of Drop Pipe	psig	7.80	7.80
(241)	Estimated Blower Operating Pressure	psig	8.95	8.95

Steele, Muriel/CLT

From: Marc Salmi <Marc.Salmi@environmentaldynamics.com>
Sent: Wednesday, October 24, 2018 2:50 PM
To: Steele, Muriel/CLT
Cc: Shane Eckley (seckley@ew2.net); Chuck Hlavach (chuck@envirosalesofflorida.com)
Subject: RE: [EXTERNAL] RE: Key West
Attachments: DB181022-01-01-Panel.pdf; DB181022-01-01-Disc.pdf; ISM Disc Diffuser.pdf; MiniPanel.pdf

Muriel,

We have enclosed design brief calculations for both a panel system and disc system. Budget cost $500,000 can be used for either one.

EDI aeration for life

Marc W. Salmi, P.E.
Regional Manager - North America
C: +1 (636)448-0193
5601 Paris Rd Columbia, MO 65202

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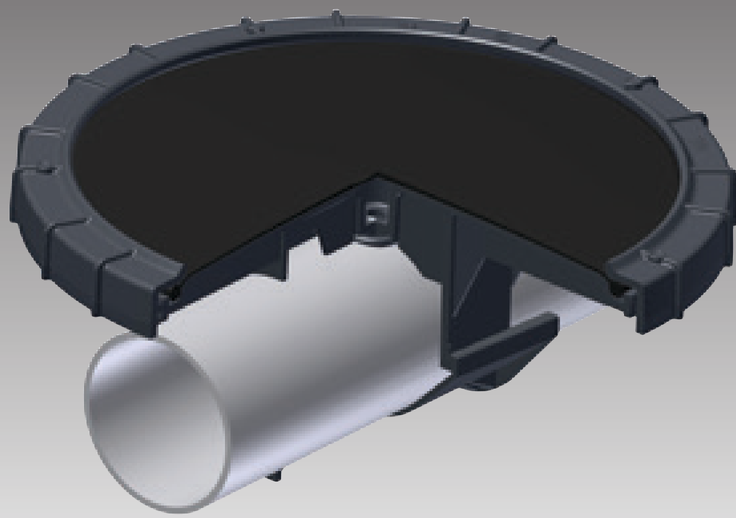

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Why the 9″ & 12″ ISM Disc is the best on the market

- 3 times stronger than conventional mounting or push-onsystems
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- High-capacity membrane option available for maximum airflow and low operating pressure
- Fits on any 3-inch or 4-inch pipe
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- Patented KlicLoc™ retainer for positive mechanical lock

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Discs do not stand a chance against our panels—we can prove it.

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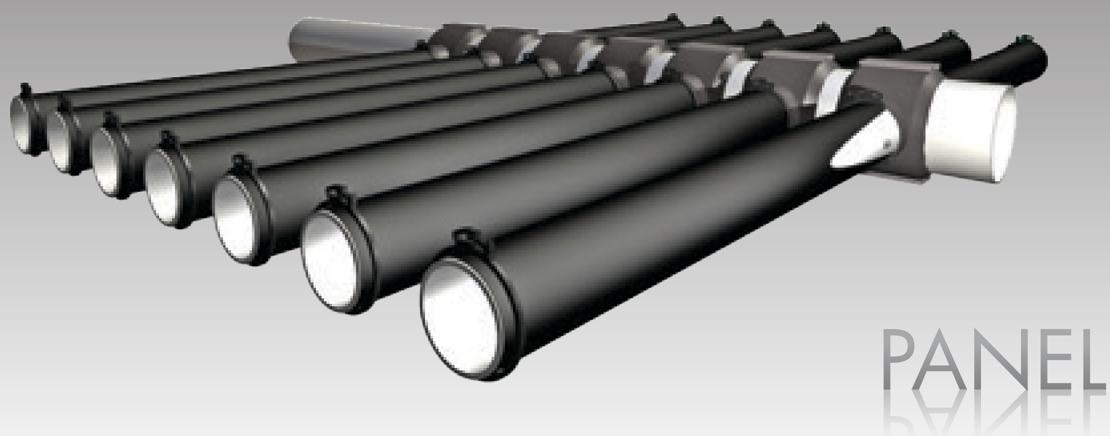
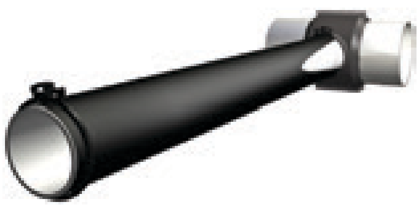


Why EDI's MiniPanel is the best in the market

- Economical capital cost and ease of installation
- Maximum OTE performance
- High-density application
- Saddle mount connector
- Assembled in our facilities



MADE IN THE USA

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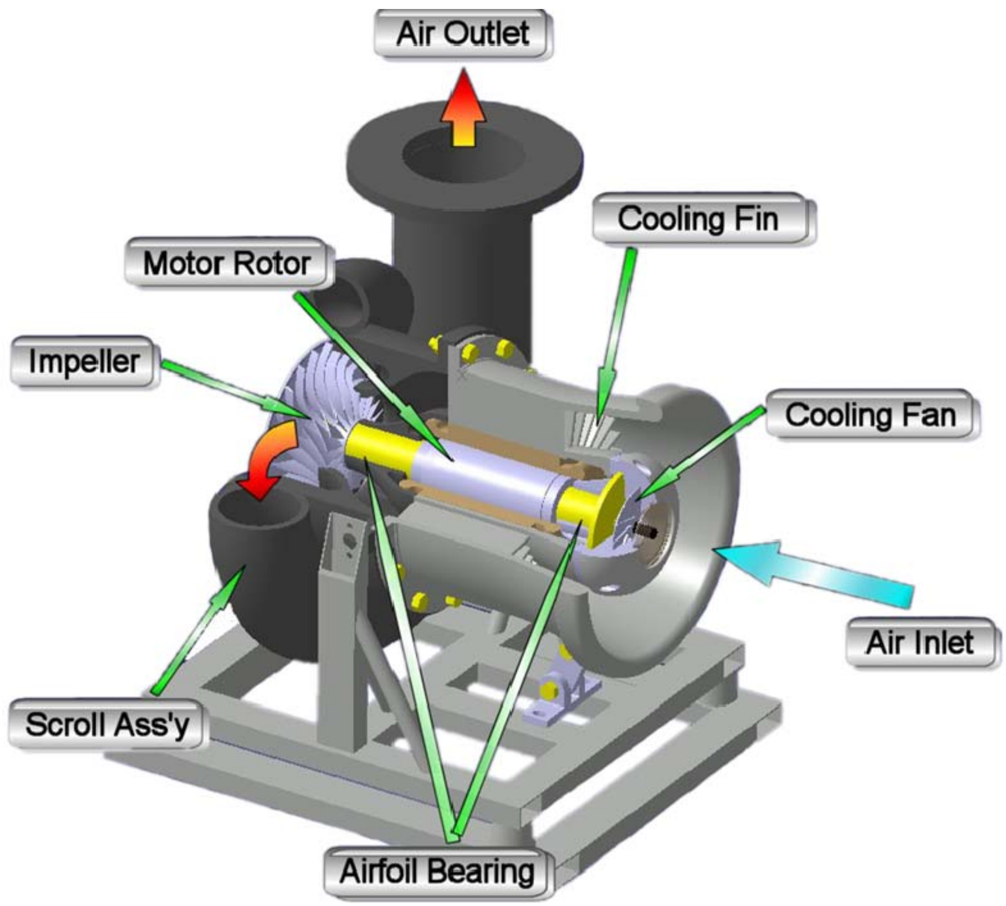
ECM-P02: High-Speed Turbo Blower (HTSB)

APG-Neuros Turbo Blower Scope of Supply Proposal

Key West WWTP

Prepared By APGN Inc. *dba* APG-Neuros
November 20, 2018
Proposal Reference # 10901 Option 1



APG-Neuros Turbo Blower Core

Key West WWTP - APG- Neuros Turbo Blower - Performance Data			
Ambient Conditions			
Application	Aeration		
Blower Installation Location	Indoor		
Working Fluid	Air		
Elevation	10		ft
Inlet Pressure	14.7		PSIA
Design Conditions			
	DP1	DP2	
Inlet Temperature	100	40	°F
Relative Humidity	95	50	%
Duty Discharge Pressure	9.13		PSIG
Flow Rate per Blower	4,500		SCFM
Number of Blowers - Duty	1		Units
Available Blower Performance			
Model	**NX300-C070**		
Rate Motor Output Power	300		HP
Maximum Air Flow @ Duty Discharge Pressure per Blower	6,078	6,763	SCFM
Minimum Air Flow @ Duty Discharge Pressure per Blower	2,609	2,904	SCFM
Turndown from Maximum Flow	57%		%
Wire-to-Air Power @ Design Air Flow per Blower	**157**	**132**	**kW**
Discharge Temperature @ Design Air Flow per Blower	206	136	°F
Maximum Discharge Pressure	13.4		PSIG
Rise-to-Surge	4.3		PSIG
Notes			
Maximum Noise Level @ 3 feet	80		dBA
Dimensions per Blower, L / W / H	83/55/85		Inches
Weight per Unit	5,639		lbs.
Heat Rejection inside Blower Room	0		kW
Cooling Requirements	0		kW
Input Voltage/Phase/Frequency	480/3/60		V/Phase/Hz
Full Load Amperage	324		Amps
Blower Inlet Air Entry type	Louvered		
Discharge Flange Size	14		Inches

Note:

Wire power figures are based on ISO 5389-2005 with allowable tolerances of 5% on flow, 0.5-1% on pressure and 1% on power.

SCFM defined at 68 Deg F, 14.7 psia and 36% relative humidity

APGN Inc.
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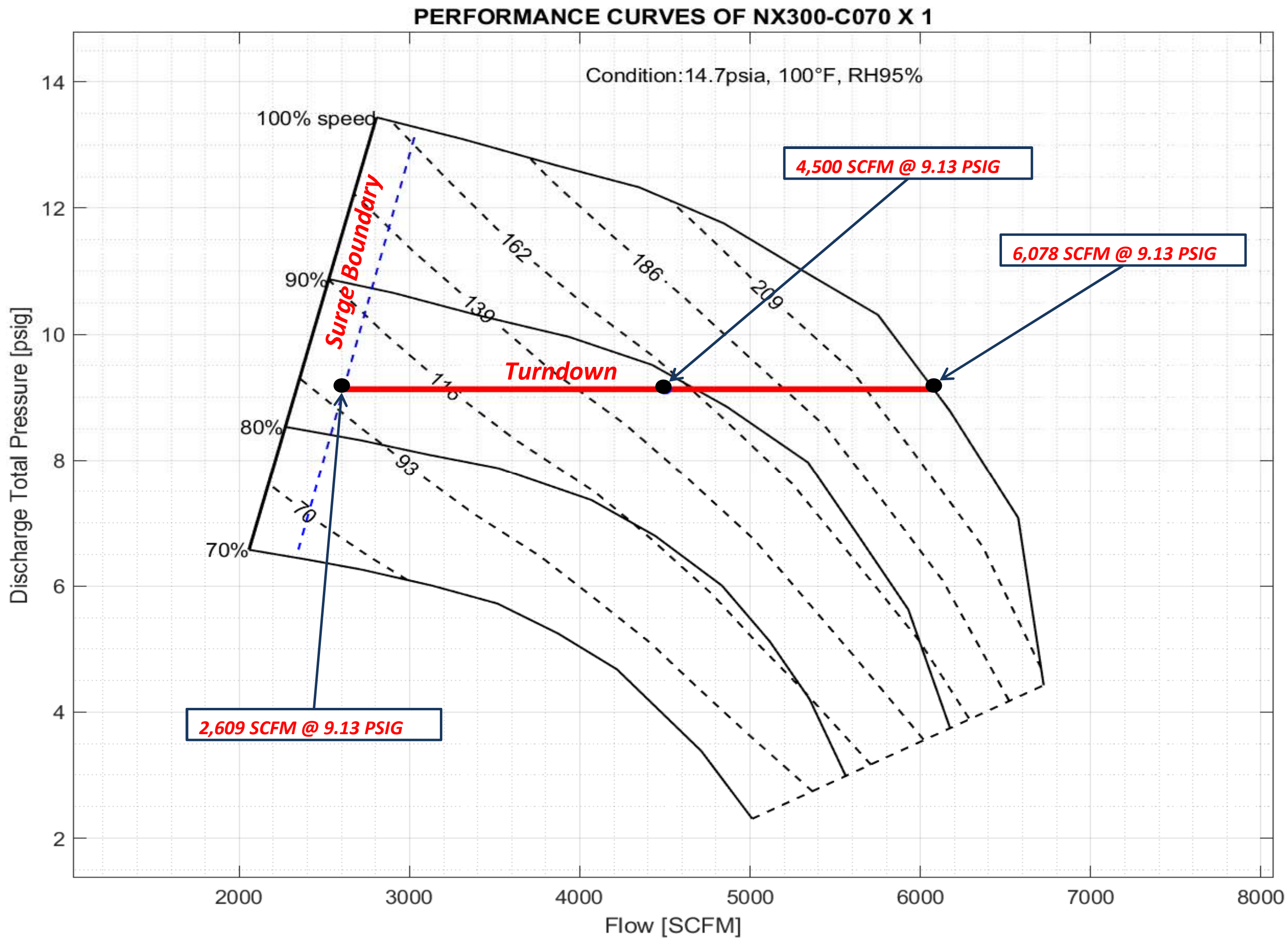
Tel: 450-939-0799 Fax: 450 939 2115
www.apg-neuros.com

Key West WWTP - APG - Neuros Turbo Blower - Performance Curves



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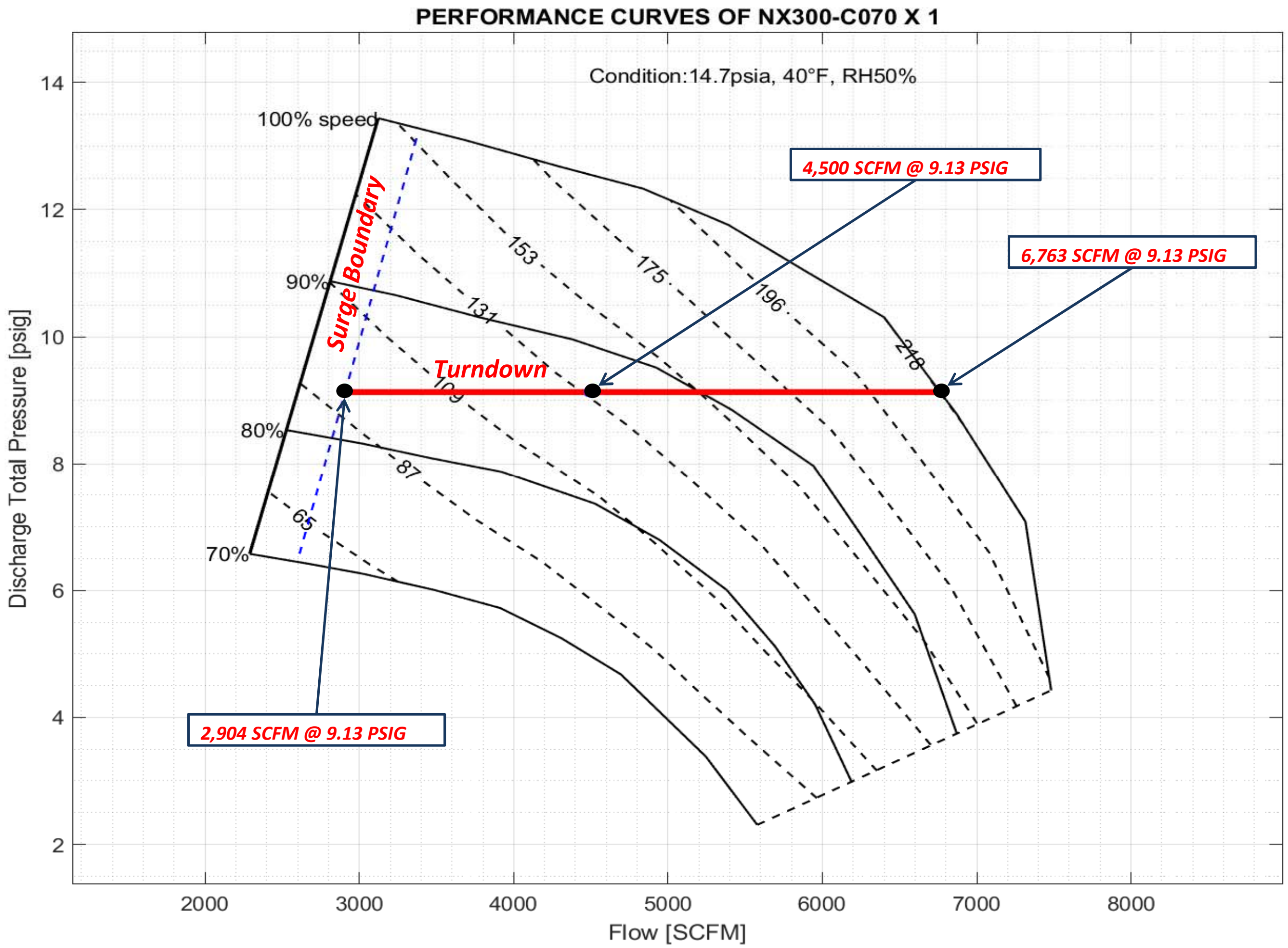
Key West WWTP - APG - Neuros Turbo Blower - Performance Curves



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APG - Neuros Turbo Blower - Blower Components

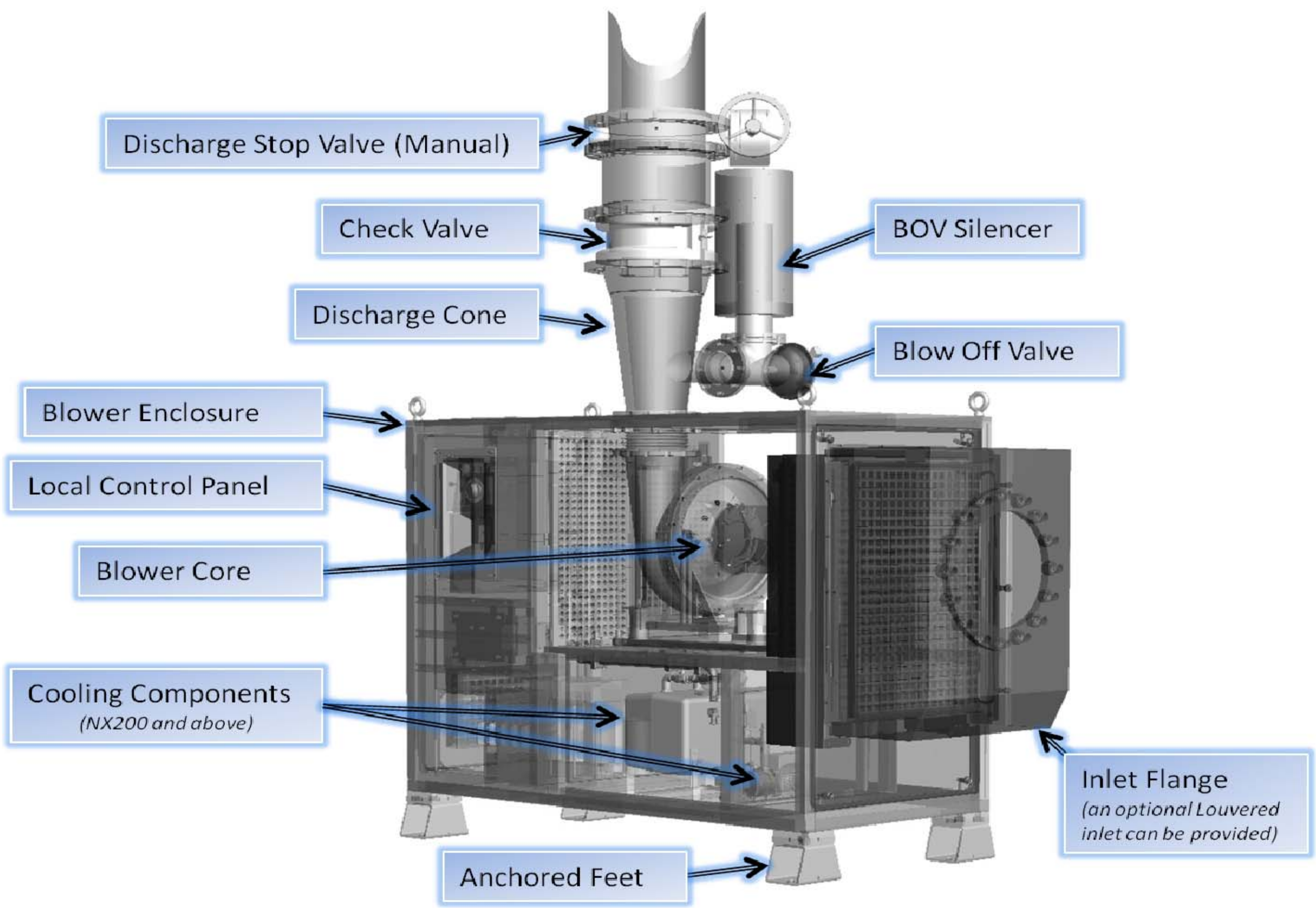

**Image is not project specific*.

Key West WWTP - APG - Neuros Turbo Blower - Price & Summary

Budgetary Price (U.S. Dollars, 2018 Economy Year)

November 20, 2018

Proposal Number: 10901 Option 1

Item	Equipment Item *(See Scope for more information)*	QTY		Price each (USD)	Total Price (USD)
1	NX300-C070 High Speed Turbo Blower	1	*Included*	$ 213,489.00	$ 213,489.00
	14 " Wafer Style Discharge Check Valve	1			
	14 " Discharge Butterfly Valve	1			
	14 " EPDM Discharge Duct Expansion Joint	1			
	Harmonic Filter - Installed inside of the blower enclosure	1			
	Warranty One (1) Year on Blower equipment	1			
	Freight FOB Job Site	1			
				Total Price	**$ 213,489.00**

Notes

Taxes and Duties are Not Included

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Key West WWTP - APG - Neuros Turbo Blower - Scope of Supply

APGN Inc., agrees to sell to the Buyer, the equipment designated as included in this proposal subject to the Seller's General Terms and Conditions of Sales available upon request and special conditions outlined herein in this proposal.

1. Standard Turbo Blower Equipment *(Included)*

1.1 Blower Package

1. Blower Core with Permanent Magnet Synchronous Motor, Air Bearing and Forged Impeller
2. High Performance Variable Speed Drive / Inverter
3. Local Control Panel for Control and Monitoring with Allen Bradley - Compact Logix L24 PLC
4. Remote Control capability via Ethernet, LAN or Hard wiring
5. Temperature Sensors for motor, bearing, inlet and discharge air flow
6. Pressure Sensors for discharge conditions
7. Pressure Sensor and alert for air filter condition
8. Built in Flow Calculation
9. Built in Speed Measurement
10. Internal Expansion Joint
11. Internal vibration and dynamic effect Absorption Mounts
12. Line Input Reactor to maintain high power factor
13. Sinewave (Sinus) Filter
14. Built in Hi-Flow Synthetic pleated inlet air filters with 98% efficiency @ 10-microns
15. Set of pre-filters with 89% by weight per ASHRAE 52-76 and MERV 8 rating
16. Voltage Surge Protection
17. Uninterruptable Power Supply (UPS) - with 10 minute power supply to the Blower PLC
18. Remote Monitoring System (RMS)
19. All the component above are included in a Sound Enclosure

2. Standard Documentation *(Included)*

Submittal Information & Shop Drawings: PDF Electronic File

1. Bill of Material
2. Installation Drawings
3. Electrical and Control Drawings
4. Operation and Maintenance Manual
5. Commissioning Instructions

3. Standard Tests (Included)

1. Standard Blower Package Functional Acceptance Test
2. Unwitnessed PTC-10 Factory Performance Test

4. Quality Assurance and Control and Product Certification

A. APG-Neuros Quality Assurance program is ISO 9001 certified

B. APG-Neuros Turbo Blower is UL / CSA/ CE certified

Key West WWTP - APG - Neuros Turbo Blower - Scope of Supply

5. Proposal Validity and Seller Terms and Conditions

A. Unless otherwise specified elsewhere in the Sales Agreements, the prices in this proposal are for ninety (90) days from the issue date on the cover page.

B. This proposal, unless otherwise specified herein this document, is subject to the Seller Standa Terms and Conditions available upon request.

C. The final selling price is subject to change contingient on final conformed specification review

6. Payment Terms:

10% on approval of Shop drawings

40% on release for production for material procurement

40% on equipment delivery to site

5% on issuance of preliminary O&M Manual

5% on completion of start-up and acceptance by owner

All invoices are to be paid Net 30 days

APG-Neuros will bill if delivery does not occur within 30 days after completion of production and will store the equipment at no extra charge.

1.5% Interest charge per month will be added to past due accounts of 45 days and over

Letter of Credit listing draw of payments against above deliverables will apply for Sales outside US and Canada.

100 % of invoice amount shall be payable by bank wire transfer without deduction and to be paid Net 30 days after invoice date.

Payment shall not be dependent on the buyer being paid by any third parties or equipment acceptance by owner.

7. Delivery Lead time:

Submittal package will be provided within 1-2 weeks of acceptance of Order.

Shipment will be made 10-12 weeks after approval of Submittals

Add Five percent (5%) escalation to Price for each partial or full quarter that shipment is extended beyond one year after order acceptance

8. Warranty

A. Standard Warranty (INCLUDED)

One (1) year from commissioning date or Eighteen (18) months from delivery, whichever occurs first.

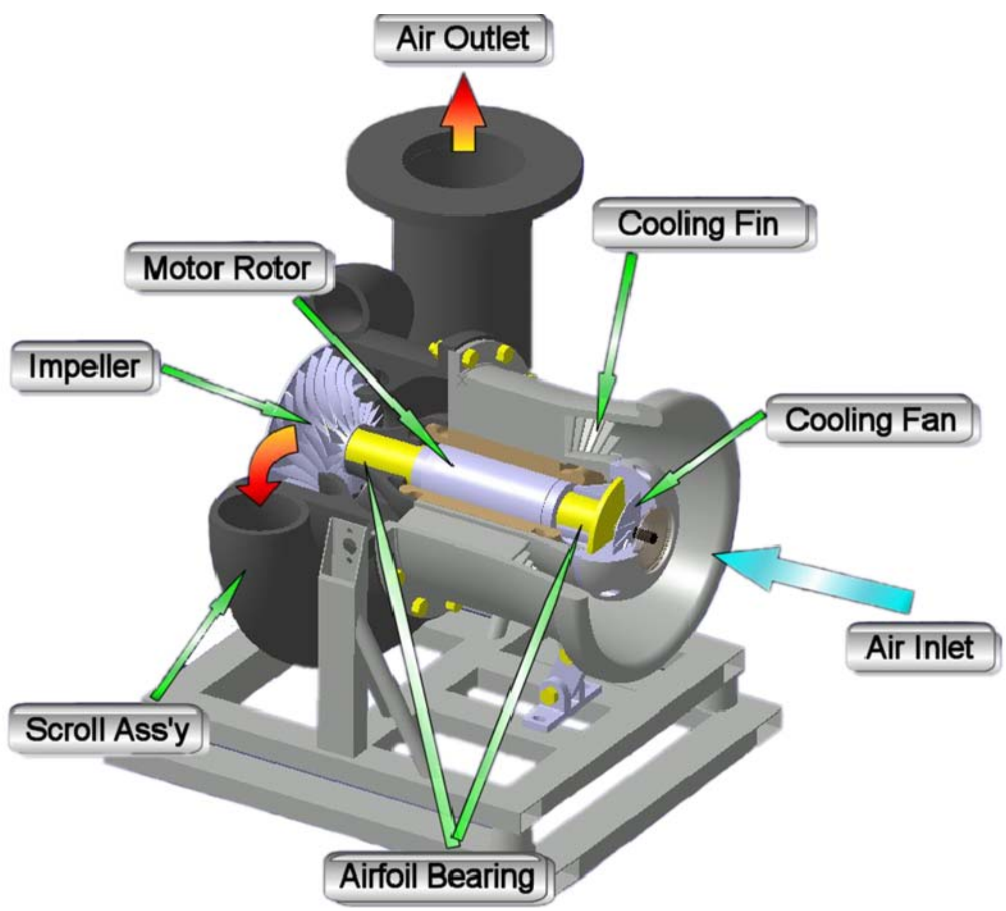
Warranty will begin upon successful completion of start-up and certification for full-scale operation by APG-Neuros, or Six (6) months after shipment, whichever occurs first.

Under no circumstances will the warranty begin upon "beneficial use", completion of the project, or acceptance of the equipment as determined by the Engineer or End User.

APG-Neuros Turbo Blower Scope of Supply Proposal

Key West WWTP

Prepared By APGN Inc. *dba* APG-Neuros
November 20, 2018
Proposal Reference # 10901 Option 2



APG-Neuros Turbo Blower Core

Key West WWTP - APG- Neuros Turbo Blower - Performance Data

Ambient Conditions

Application	Aeration		
Blower Installation Location	Indoor		
Working Fluid	Air		
Elevation	10		ft
Inlet Pressure	14.7		PSIA

Design Conditions

	DP1	DP2	
Inlet Temperature	100	40	°F
Relative Humidity	95	50	%
Duty Discharge Pressure	8.13		PSIG
Flow Rate per Blower	4,500		SCFM
Number of Blowers - Duty	1		Units

Available Blower Performance

Model	**NX200-C060**		
Rate Motor Output Power	200		HP
Maximum Air Flow @ Duty Discharge Pressure per Blower	4,583	5,100	SCFM
Minimum Air Flow @ Duty Discharge Pressure per Blower	1,696	1,888	SCFM
Turndown from Maximum Flow	63%		%
Wire-to-Air Power @ Design Air Flow per Blower	**152**	**125**	**kW**
Discharge Temperature @ Design Air Flow per Blower	194	121	°F
Maximum Discharge Pressure	11.7		PSIG
Rise-to-Surge	3.6		PSIG

Notes

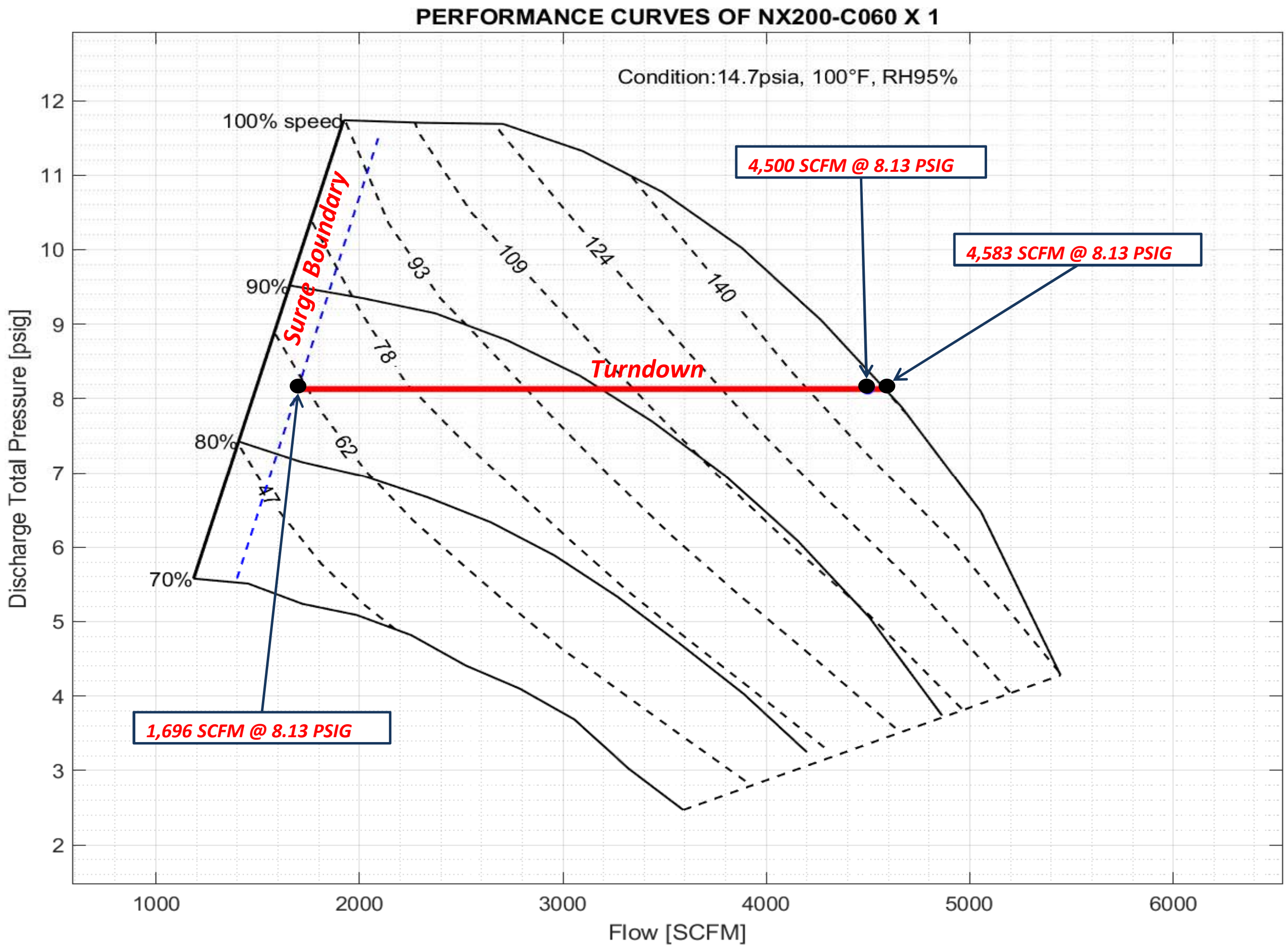
Maximum Noise Level @ 3 feet	80	dBA
Dimensions per Blower, L / W / H	83/39/70	Inches
Weight per Unit	3,652	lbs.
Heat Rejection inside Blower Room	0	kW
Cooling Requirements	0	kW
Input Voltage/Phase/Frequency	480/3/60	V/Phase/Hz
Full Load Amperage	216	Amps
Blower Inlet Air Entry type	Louvered	
Discharge Flange Size	12	Inches

Note:

Wire power figures are based on ISO 5389-2005 with allowable tolerances of 5% on flow, 0.5-1% on pressure and 1% on power.

SCFM defined at 68 Deg F, 14.7 psia and 36% relative humidity

Key West WWTP - APG - Neuros Turbo Blower - Performance Curves



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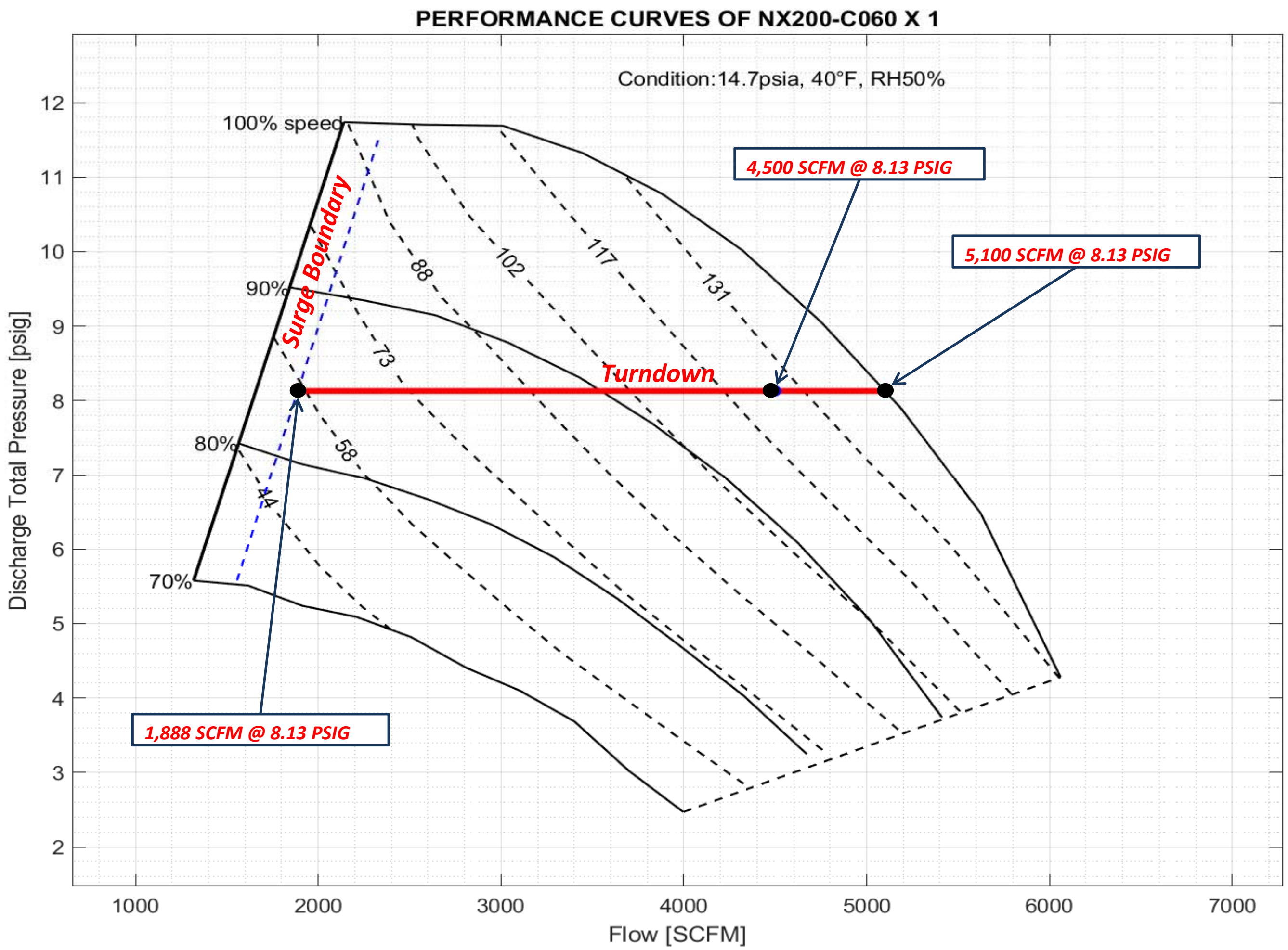
Key West WWTP - APG - Neuros Turbo Blower - Performance Curves



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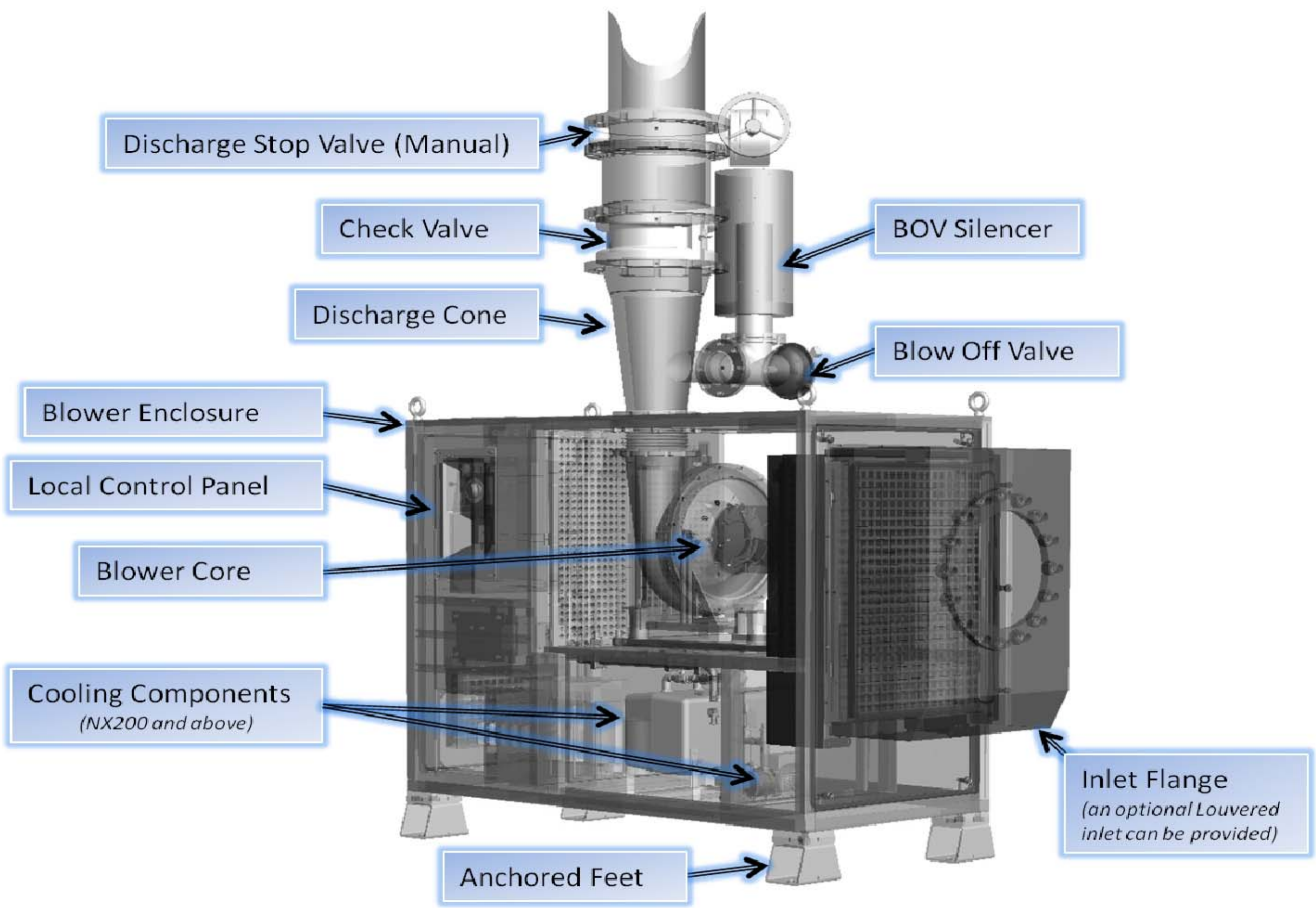
APG - Neuros Turbo Blower - Blower Components



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Key West WWTP - APG - Neuros Turbo Blower - Price & Summary

Budgetary Price (U.S. Dollars, 2018 Economy Year)

November 20, 2018

Proposal Number: 10901 Option 2

Item	Equipment Item *(See Scope for more information)*	QTY		Price each (USD)	Total Price (USD)
1	NX200-C060 High Speed Turbo Blower	1	*Included*	$ 168,034.00	$ 168,034.00
	12 " Wafer Style Discharge Check Valve	1			
	12 " Discharge Butterfly Valve	1			
	12 " EPDM Discharge Duct Expansion Joint	1			
	Harmonic Filter - Installed inside of the blower enclosure	1			
	Warranty One (1) Year on Blower equipment	1			
	Freight FOB Job Site	1			
				Total Price	**$ 168,034.00**

Notes

Taxes and Duties are Not Included

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www.apg-neuros.com

Key West WWTP - APG - Neuros Turbo Blower - Scope of Supply

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1. Standard Turbo Blower Equipment *(Included)*

1.1 Blower Package

1. Blower Core with Permanent Magnet Synchronous Motor, Air Bearing and Forged Impeller
2. High Performance Variable Speed Drive / Inverter
3. Local Control Panel for Control and Monitoring with Allen Bradley - Compact Logix L24 PLC
4. Remote Control capability via Ethernet, LAN or Hard wiring
5. Temperature Sensors for motor, bearing, inlet and discharge air flow
6. Pressure Sensors for discharge conditions
7. Pressure Sensor and alert for air filter condition
8. Built in Flow Calculation
9. Built in Speed Measurement
10. Internal Expansion Joint
11. Internal vibration and dynamic effect Absorption Mounts
12. Line Input Reactor to maintain high power factor
13. Sinewave (Sinus) Filter
14. Built in Hi-Flow Synthetic pleated inlet air filters with 98% efficiency @ 10-microns
15. Set of pre-filters with 89% by weight per ASHRAE 52-76 and MERV 8 rating
16. Voltage Surge Protection
17. Uninterruptable Power Supply (UPS) - with 10 minute power supply to the Blower PLC
18. Remote Monitoring System (RMS)
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2. Standard Documentation *(Included)*

Submittal Information & Shop Drawings: PDF Electronic File

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2. Installation Drawings
3. Electrical and Control Drawings
4. Operation and Maintenance Manual
5. Commissioning Instructions

3. Standard Tests (Included)

1. Standard Blower Package Functional Acceptance Test
2. Unwitnessed PTC-10 Factory Performance Test

4. Quality Assurance and Control and Product Certification

A. APG-Neuros Quality Assurance program is ISO 9001 certified

B. APG-Neuros Turbo Blower is UL / CSA/ CE certified

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40% on release for production for material procurement

40% on equipment delivery to site

5% on issuance of preliminary O&M Manual

5% on completion of start-up and acceptance by owner

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Shipment will be made 10-12 weeks after approval of Submittals

Add Five percent (5%) escalation to Price for each partial or full quarter that shipment is extended beyond one year after order acceptance

8. Warranty

A. Standard Warranty (INCLUDED)

One (1) year from commissioning date or Eighteen (18) months from delivery, whichever occurs first.

Warranty will begin upon successful completion of start-up and certification for full-scale operation by APG-Neuros, or Six (6) months after shipment, whichever occurs first.

Under no circumstances will the warranty begin upon "beneficial use", completion of the project, or acceptance of the equipment as determined by the Engineer or End User.

ECM-P02: Jet Valves

City of Key West Wastewater Treatment Plant
Key West, Florida
Aeration Control Valves

Preliminary Proposal

1. Background

The Key West WWTP is investigating energy efficiency improvements in the aeration system. Binder has been asked to propose energy efficient aeration control valves.

The plant has 4 aeration control zones, with maximum and average flow rates in the table below.

Airflows in scfm	Zone 1	Zone 2	Zone 3	Zone 4	Total
Maximum	1241	1260	1532	952	4984
Average	1034	1047	1273	790	4143

For the purpose of valve sizing, based on the assumption that plant loading in Key West is very seasonal, and using the conventional wisdom that minimum flows are mostly lower than calculated, we will conservatively assume a minimum flow of one quarter of average flow.

Based on our limited knowledge of the plant piping, we recommend that the arrangement of valves and flow meters be reviewed and discussed.

2. Technical Proposal

2.1 Valve Description

a. Elliptic Diaphragm Control Valve

The **VACOMASS® elliptic diaphragm control valve (EDCV)** is a technically optimized sliding gate control valve with gas-tight shut-off and an elliptical control aperture. It is used for precise and low-loss control of air flow and distribution in the aeration tanks of a wastewater treatment plant. The valve has a falling flow axis to achieve sensitive control of normal and tangential flows (e.g. after elbows).

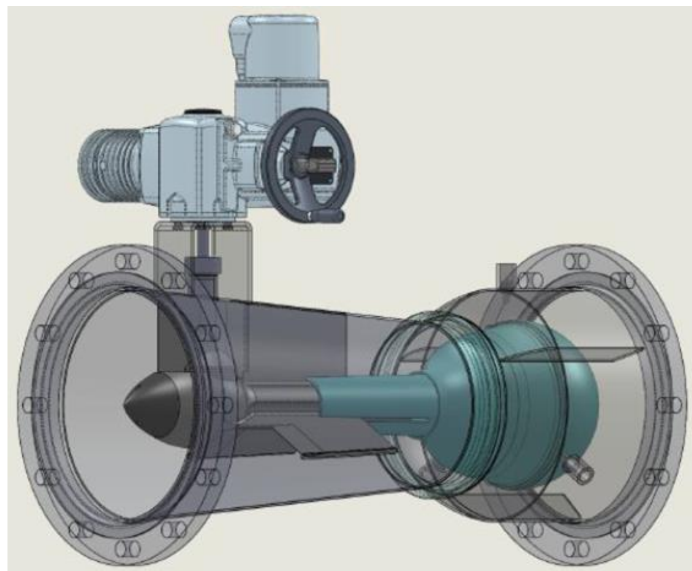
The main features of the valve are:

- Gas-tight shut-off allows use in swing zones or intermittently aerated tanks without any further measures (no additional actuated isolation valves with are required)
- Valve sizing is based on given airflow rates and is designed for optimal control performance at average airflows
- 20 actuator turns for 100% stroke provides accurate and repeatable valve positioning for precise airflow control and biological process control
- At 100% stroke the entire pipe cross section is open, eliminating any pressure losses
- The geometry of the control aperture provides a significantly larger range of control than butterfly valves or comparable triangular, square, pentagonal or hexagonal diaphragm valves.
- Design with a falling flow axis: the flow remains partially attached to the wall, which leads to pressure recovery and reduced total pressure drop of the valve during operation
- Usually a pipe reduction upstream and expansion downstream are required to achieve best control performance
- Design and construction of the valve with corrosion-proof sliding gate in stainless steel; Teflon/ Carbon/ Viton seals for ambient and media temperatures up to + 150°C; and self-lubricating and hermetically sealed spindle to protect against dry running, humidity and dust particles – reduces costs for operation and maintenance
- Valves are supplied with an AUMA or ROTORK actuator for precise aeration control.
- For limited straight pipe runs (less than 15XD upstream of the valve) a compact configuration with specific calibration and stroke compensation is available.

b. Jet Control Valve

The **VACOMASS Jet Control Valve (JCV)** has a number of features that make it ideal for aeration control processes:

- The JCV works as a flow straightener, allowing positioning of the mass flow meter 0.5 pipe diameters in front of the valve without extensive straight pipe runs.
- The aerodynamic flow path along the valve wall generates low turbulence and facilitates high pressure recovery in the venturi-shaped outlet, causing very low differential pressure across the valve, and therefore minimal energy loss.
- The design of the control element ensures absolutely linear performance of the valve from completely closed (bubble-tight) to 95% open.
- The high mechanical advantage of the linear drive ensures high positioning accuracy and repeatability, low wear, and allows the use of a low-torque multi-turn actuator.
- The combination of the multi-turn actuator with the 40-turn drive spindle provides positioning accuracy and repeatability of 0.2% of stroke.



- The net result of the JCV design features is improved process control and measureable aeration energy savings.

2.2 Valve Sizing and Performance:

The **Elliptic Diaphragm Control Valve** requires at least 0.12 psi pressure differential across the valve to control airflow. To be on the safe size, valve performance was determined at a pressure loss of 0.135 psi. Note that in all of our tests and observations, butterfly valves require at least 0.5 psi pressure loss to control airflow.

For this application, the 5 inch EDCV is suitable for all four control zones. Valve openings are shown to 0.1%, but opening accuracy and repeatability is typically better than 0.4%, so the shown level of resolution cannot quite be achieved in practice. This is still significantly better than the positioning accuracy of a butterfly valve.

Calculated valve performance is in the table below.

		Airflow	Valve Performance		Airflow	Valve Performance		Airflow	Valve Performance	
Zone	Valve	Max scfm	dp	% open	Ave scfm	dp	% open	min scfm	dp	% open
1	5" EDCV	1241	0.135	75.6	1034	0.135	71.8	259	0.135	41.2
2	5" EDCV	1260	0.135	76.0	1047	0.135	72	262	0.135	41.5
3	5" EDCV	1532	0.135	80.7	1273	0.135	76.2	318	0.135	46.5
4	5" EDCV	952	0.135	70.2	790	0.135	65.9	198	0.135	34.6

At maximum loading and a differential pressure of 0.135 psi the valve will be open between about 70% and 80%. At average flows it will open from about 66% to 76%, and at the assumed minimum flows it will open from about 35% to 47%. This shows that the valve has ample range for both higher and lower flowrates, should they occur in practice.

The **Jet Control Valve** can reliably and accurately control airflow at pressure differentials as low as 0.015 psi.

For the given application, the 10 inch JCV is the most suitable. Its performance is shown in the table below. Valve openings are shown to 0.1% resolution to eliminate rounding errors due to the small differences between flow rates in zones 1 and 2. Note that the positioning accuracy of the JCV is better than 0.2%, so the valve can adjust to these small differences.

		Airflow	Valve Performance		Airflow	Valve Performance		Airflow	Valve Performance	
Zone	Valve	Max scfm	dp	% open	Ave scfm	dp	% open	min scfm	dp	% open
1	10" JCV	1241	0.06	83.4	1034	0.03	86.9	259	0.03	48.4
2	10" JCV	1260	0.06	83.7	1047	0.03	87.2	262	0.03	48.9
3	10" JCV	1532	0.06	88.0	1273	0.03	92.1	318	0.03	56.7
4	10" JCV	952	0.06	77.8	790	0.03	91.4	198	0.03	34.6

At maximum airflow the JCV can operate at 0.06 psi pressure loss with valve openings from about 78% to 88%. At average airflow it can operate at 0.03 psi pressure loss with openings from about 87% to 92%, and at the minimum assumed flow rate, openings are from about 34% to 49%.

3. Budget Pricing

Four (4) 5 inch VACOMASS elliptic diaphragm control valve with:

- Lugged valve body with ANSI hole pattern
- 316 SS moving parts, galvanized valve body, graphite/Viton seals
- Permalube spindle lubrication
- modulating duty 460V/3Ph AUMA SAR AC Actuator
  - optimized for minimum step size
  - control box double sealed against actuator body
  - 24VDC optically isolated control inputs for open/stop/close/alarm
  - 4 – 20 mA position control and position feedback
  - 6 selectable relay outputs, e.g. open, closed, local/remote

Budget Price: US$ 41,360.00

Four (4) 10 inch VACOMASS® Jet Control Valves with

- All stainless steel, with loose, lightweight ANSI flange
- VACOMASS® thermal mass flow meter, OEIN-F hot tap insertion unit with fixed insertion depth and orientation
- modulating duty 460V/3Ph AUMA SAR AC Actuator
  - optimized for minimum step size
  - control box double sealed against actuator body
  - 24VDC optically isolated control inputs for open/stop/close/alarm
  - 4 – 20 mA position control and position feedback
  - 6 selectable relay outputs, e.g. open, closed, local/remote

Budget price: US$ 113,000.00

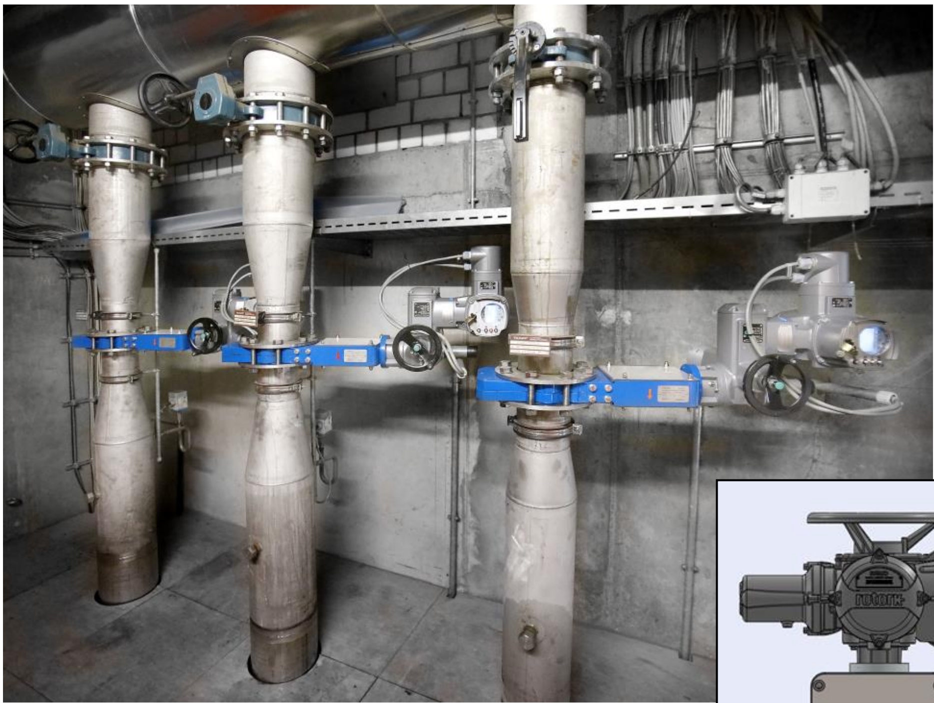
Tilo Stahl
Engineering Manager North America
Binder Group October 12, 2018

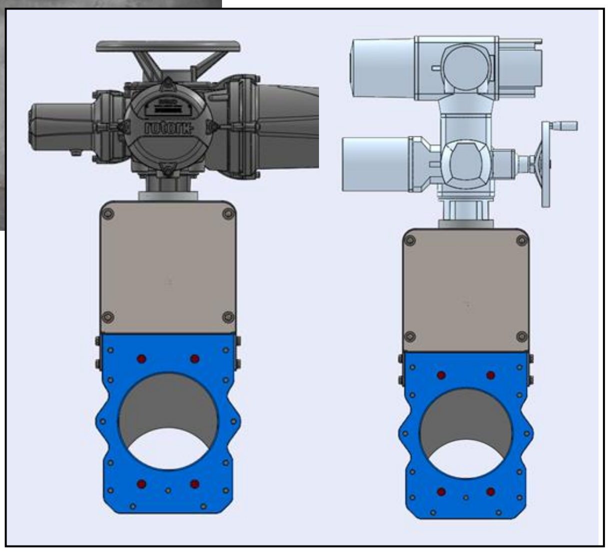
VACOMASS®

Technical information

VACOMASS® elliptic diaphragm control valve

Diaphragm control valve with an elliptical control aperture and falling flow axis





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VACOMASS® ELLIPTIC DIAPHRAGM CONTROL VALVE

The **VACOMASS® elliptic diaphragm control valve** is a technically optimized sliding gate control valve with gas-tight shut-off and an elliptical control aperture. It is used for precise and low-loss control of air flow and distribution in the aeration tanks of a wastewater treatment plant. The valve has a falling flow axis to achieve sensitive control of normal and tangential flows (e.g. after elbows), and is designed according to DIN EN 60534-2-3.

Within the usual control range the valve has a stable control curve, and it can be used from 0-100% stroke. It is designed to have a pressure loss of less than 10 mbar at full load and 100% stroke.

The control valve body consists of two identical halves that are designed to be of wafer or end-of-line type. The inner surface has a groove for a PTFE/ carbon gasket that makes the valve gas-tight and serves as an external guide for the valve´s knife-edge sliding gate. The combination of stainless steel on Teflon/carbon allows precision movement of the plate without vibrations or jamming.

The main features of the valve are:

- Gas-tight shut-off allows use in swing zones or intermittently aerated tanks without any further measures (no additional actuated isolation valves with are required) – reduction of capital expenditures
- Valve sizing is based on given airflow rates and is designed for optimal control performance at average airflows
- At 100% stroke the entire pipe cross section is open, eliminating any pressure losses
- The geometry of the control aperture provides a significantly larger range of control than comparable triangular, square, pentagonal or hexagonal diaphragm valves.
- Design with a falling flow axis: the flow remains partially attached to the wall, which leads to pressure recovery and reduced total pressure drop of the valve during operation – reduction in power consumption
- Usually a pipe reduction upstream and expansion downstream are required to achieve best control performance
- Design and construction of the valve with corrosion-proof sliding gate in stainless steel; Teflon/ Carbon/ Viton seals for ambient and media temperatures up to + 150°C; and self-lubricating and hermetically sealed spindle to protect against dry running, humidity and dust particles – reduces costs for operation and maintenance
- Valves are supplied with a **VACOMASS® actuator** for precise aeration control; besides AUMA or ROTORK, other manufacturers can be provided as long as they meet the technical specifications
- Valves can be supplied with a **VACOMASS® airflow meter** for measurement and control purposes
- The optional calibration of the valve and flow meter in a compact system (stroke compensation of the airflow measurement) reduces the required straight pipe length for measurement and control – ideal for retrofitting into existing pipe installations

DESIGN OF THE CONTROL PIPE SECTION

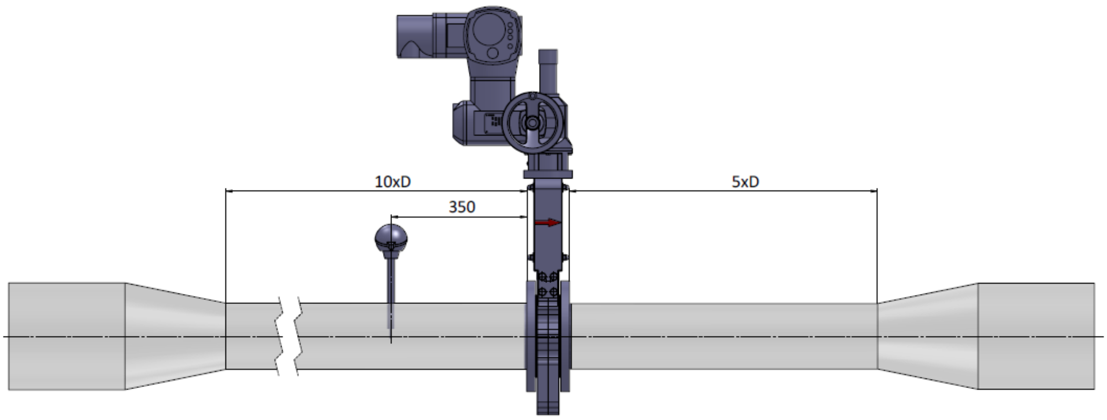
The **VACOMASS® elliptic diaphragm control valve** has to solve following tasks: 1. the control of air into an aeration zone based on actual demand and 2. the correct distribution of air into various tanks or zones from one main air header.

In the past, oxygen control loops were typically used. The valve was closed/ opened based on the difference between actual DO-concentration and set point DO-concentration. This led to a considerable delay in control loop. If air flow is measured and used as the correcting variable, then the control becomes much faster and smoother. In the control loop, the air flow becomes the calculated manipulated variable for the oxygen concentration and is adjusted by the use of a cascade control loop (blower speed control, valve stroke). This kind of control loop is able to react to disturbances (e.g. wet weather conditions or peak loads) much faster, so that cleaning capacity and effluent quality become more stable (see also the new German Wastewater Association standard paper DWA-M 264: Gas flow measurements in sewage treatment plants, May 2015).

Depending on the local situation and pipe layout, different types of the measurement and control concepts can be implemented. For diaphragm control valves or gate valves, the pipe diameter must usually be reduced in front of and expanded behind the valve to achieve good control performance. Especially gate and butterfly valves are of limited utility because of non-linear control performance at the upper and lower end of their stroke. This leads to unsatisfactory operation of the valve at both ends of its range – low control accuracy and repeatability – as well as high pressure drop in normal operation.

Air flow meters have specific requirements on straight inlet and outlet piping for precise flow measurement (also see M264). In addition, the opening/closing action of the control valve shifts the flow profile in front of and behind the valve. Therefore a minimum distance between the flow meter and the valve is required or the signal must be continuously corrected based on actual stroke (simultaneous flow profile correction). If the required minimum straight pipe runs are not available in existing installations (e.g. for upgrade projects), in most cases a high measurement accuracy can be achieved with a special calibration takes the actual pipe run into consideration.

CFD-simulations can be used to assess the installation situation and to optimize the measurement and control pipe section.



Compact System: The **VACOMASS® air flow meter** can be installed 350 mm in front of the **VACOMASS® elliptic diaphragm control valve** when using flow profile correction for very precise flow measurement. If necessary, piping related disturbances of the flow profile can be examined and compensated during calibration in Binder´s **CAMASS® Calibration-Lab**.

Separated system: If there is sufficient straight pipe run (depending on the type of pipe fittings and the geometry of the pipe run, a minimum distance of 10*D upstream of the **VACOMASS® flow meter**), the flow meter can be installed at least 5*D in front of the **VACOMASS® elliptic diaphragm control valve.** The level of calibration can be reduced and flow profile correction is not necessary. The total length of the measurement and control section is very long and in most cases not available.

CONSTRUCTION DETAILS

Material selection: Two versions are available: the higher grade **VACOMASS® elliptic diaphragm control valve premium** and the low-cost **VACOMASS® elliptic diaphragm control valve eco**.

The **premium** version is made of following materials: the seals are PTFE25C (Teflon/ Carbon) and FKM (Viton up to 150 °C), the spindle and diaphragm are A4 (316)stainless steel. The spindle and nut are designed self-lubricating run and are hermetically sealed against humidity and dust. The surface finish is Ra <= 0.3µ. A mechanical position indicator is a standard feature. The housing is made of galvanized steel S235JR, coated in RAL 5010. All screws are A4 (316) stainless steel.

The **eco** version is made of the following materials: the seals are PTFE25C (Teflon/ Carbon) and HNBR (High temperature Perbunan up to 120 °C), the spindle and diaphragm are A2 (304) stainless steel. The lubrication of the spindle/nut manual or an optional automatic perma-lube system, the spindle cover is A2 (304) stainless steel. The housing is made of galvanized steel S235JR, coated in RAL 5010. All screws are A2 (304) stainless steel.

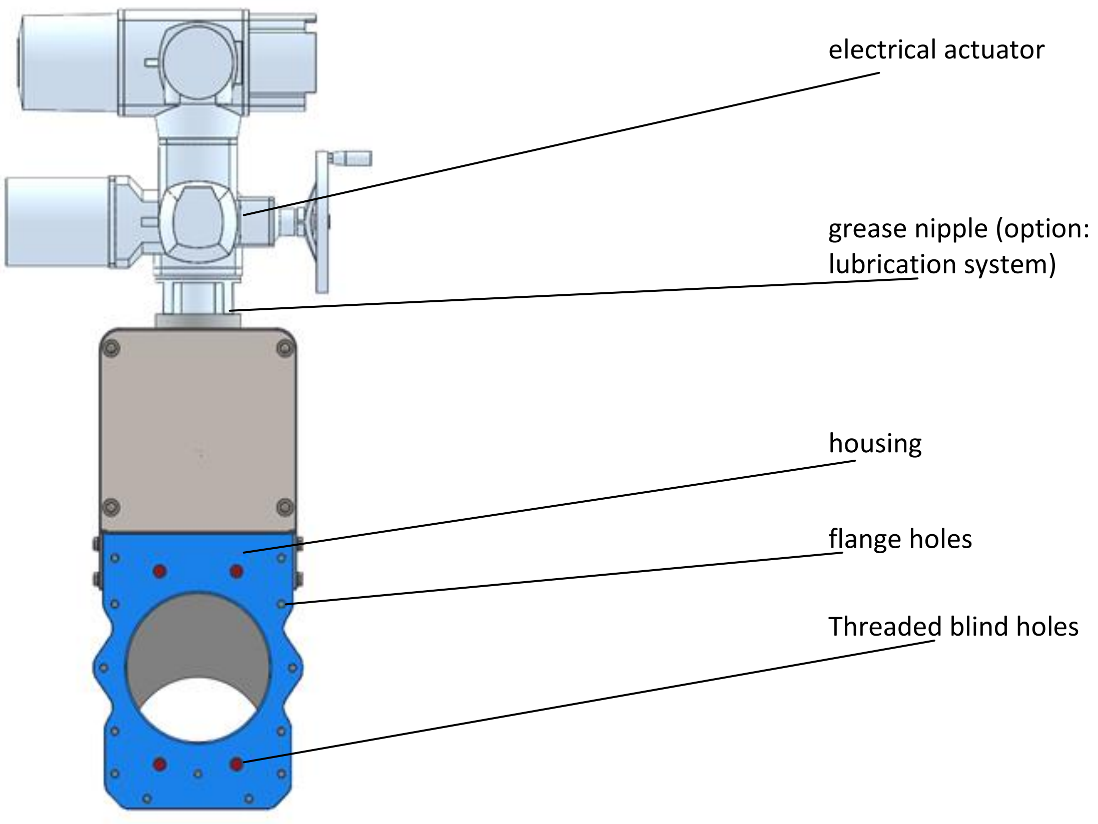
Maintenance: The valve spindle must be lubricated and the actuator has to be maintained according to manufacturer´s recommendation. The lubrication of the spindle can be done either manually (**eco**), Perma-lubrication (**eco**) or with self-lubricating in bellows (**premium**).

Connections and Assembly: The elliptic diaphragm control valve can be mounted between two flanges. The length is generally according to DIN 3202/K1. The threaded flange holes with are consistent with DIN 2501/ PN 10. All fittings for pipe reduction/ expansion are to be provided by the contractor.

Design:

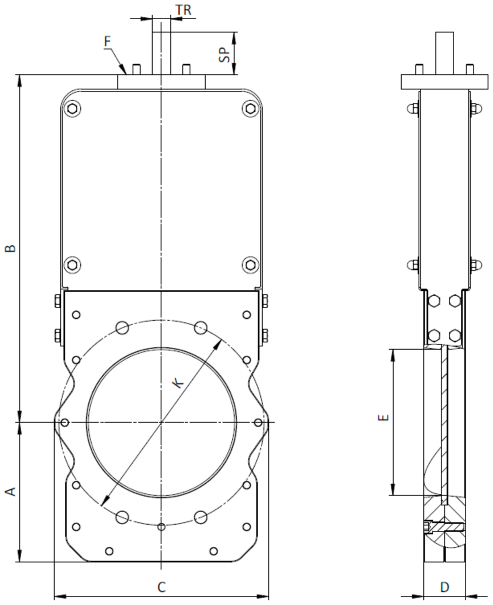
The design is done on a project basis, for which the information is required:

- Air flow range (min/average/max)
- Nominal size/nominal pressure of the connecting flange
- Operating pressure (min/average/max)
- Operating temperature of the medium (min/average/max)
- Ambient temperature and conditions at site
- Supply voltage/ data communication



VACOMASS® elliptic diaphragm control valve

DIMENSIONS



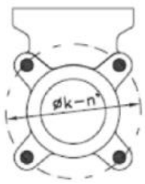
Application as a wafer valve, flange hole pattern: DN – PN10

DN	A	B	C	D	E	F	SP_close	SP_opn	K*	TR
50	76	239	140*	43	54	F07	42	96	125	TR 20x4
65	85	244	155*	46	71		47	118	145	
80	107	299	166	46	82		68	150	160	
100	120	328	187	52	108		50	158	180	
125	141	352	219	56	133		63	196	210	
150	159	427	246	56	160	F10	111	271	240	TR26x5
200	200	500	308	60	210		61	271	295	
250	245	615	355	68	264		56	320	350	TR30x6
300	310	700	438	78	312		91	403	400	

*max. width

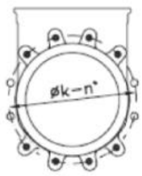
EN 1092-2 PN10

DN	K	n°	M	T	● ⌖
50	125	4	M-16	11	4 - —
65	145	4	M-16	11	4 - —
80	160	8	M-16	11	4 - 4
100	180	8	M-16	11	4 - 4
125	210	8	M-16	11	4 - 4
150	240	8	M-20	14	4 - 4
200	295	8	M-20	14	4 - 4
250	350	12	M-20	18	8 - 4
300	400	12	M-20	18	8 - 4

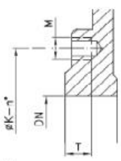


DN50-65

DN80-200



DN250-300



● threaded blind holes

⌖ holes guided around the housing

Nominal pipe size DN	inches	Recommended air flow range (depending on temperature and pressure) Nm³/h	scfm	kv-value[1)]
50	2	20 - 953	11.7 - 560	309
65	2 ½	30 - 1,611	17.7 - 948	522
80	3	50 - 2,440	29.4 - 1,436	791
100	4	79 - 3,812	46.5 - 2,243	1,236
125	5	123 - 5,956	72.4 - 3,505	1,932
150	6	177 - 8,577	104.2 - 5,048	2,781
200	8	315 - 15,248	185.4 - 8,974	4,945
250	10	493 - 23,825	290.2 - 14,022	7,726
300	12	709 - 34,307	417.3 - 20,192	11,126

1) max. air flow depends on permissible pressure loss during operation

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BIDE-M-D-VACOMASS-EN-R00 Data Sheet
VACOMASS elliptic diaphragm control valve

VACOMASS®

Technical Information

VACOMASS® jet control valve

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THE VACOMASS® jet control valve

The **VACOMASS® jet control valve** is an innovative, flow-optimized stainless steel control valve that closes gas-tight and offers a linear operating characteristic over virtually the entire operating range. The valve has been developed and optimized specifically for high precision air control and distribution with minimal pressure loss, resulting in comparatively low operating costs.

In terms of control range and product quality, this development represents a milestone in the evolution of air control valves and fittings. It is unique and with worldwide patent applications.

Other features include:

- A central control axis with actuator for sensitive control of air supply with 360° free-flow annular orifice – allows the installation of the air flow meter ½ D directly in front of the control valve
- Stroke adjustment takes place in the direction of flow: this means the flow remains attached to the wall, thereby facilitating rapid and effective pressure recovery with extremely low pressure loss – saves energy costs
- In most cases the valve can be fitted directly in the pipe without pipe reduction/expansion – saves installation costs
- The flow in the Venturi outlet is homogeneous, so that the first drop leg to a diffuser grid can be located directly behind the valve – improves the process
- The required (measurement and) control section is comparatively short – the ideal prerequisite for retrofitting in existing installations
- The control element has a very low coefficient of drag and therefore requires only low drive torque; low friction operation allows for compact actuator sizes – reduced investment and operating costs
- Corrosion-proof high grade stainless steel control valve designed for ambient and gas temperatures from -40 °C to +150 °C, lubricant-free in exposed areas – reduced operating and maintenance costs
- Gas-tight closure, making it suitable for swing zone operation and process optimization, making an additional automated shut-off valve and its associated costs unnecessary
- A virtually linear operating characteristic and control precision of better than 0.2%, constant control accuracy and virtually constant low coefficient of drag over the entire control range – these are optimum prerequisites for precise and stable control in conjunction with an ideal gain factor of around 1
- Comes with the **VACOMASS® actuator**, direct flange mounting with low drive torque – the innovative control valve is designed to operate with very low actuating forces; in addition to AUMA and ROTORK other makes are possible provided they meet the technical specifications

LAYOUT OF THE CONTROL PIPE SECTION

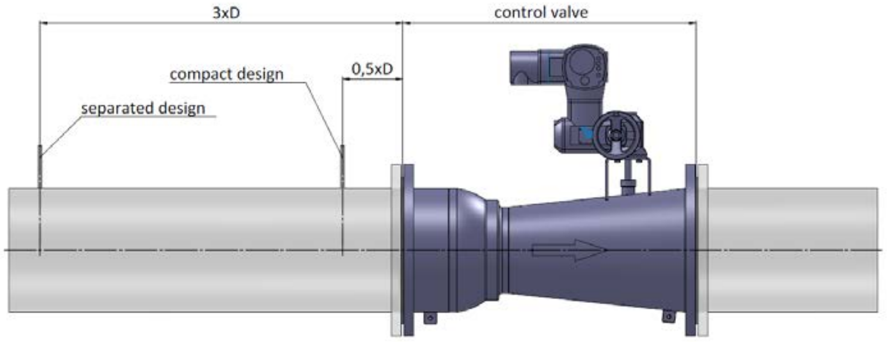
The **VACOMASS® jet control valve** performs the following tasks in aeration tanks: 1. controlling the flow of oxygen into a tank based on actual demand and 2. distributing aeration air to individual tanks or aeration zones as required in interconnected systems.

In the past, a conventional oxygen control loop was set up and the valve opened and closed based on the difference between the DO setpoint and actual DO value. This arrangement resulted in a distinct lag in the control system. The control system becomes notably faster when the air flow rate to a control zone is measured directly and integrated in the control concept. In the cascade control loop, the air flow rate is then the control variable for the oxygen concentration and is set with dedicated control circuits (speed control at blower, valve position). In this type of closed-loop control, the process, in the case of disturbances such as wet weather events or load fluctuations, is faster so that the treatment levels remain constant under the specified technical conditions (refer to new Guideline ATV-DVWK-M264: Gas Flow Measurement in Sewage Treatment Plants, May 2015).

Various configurations of the control system are possible depending on local conditions and the existing geometry of the piping system. When using diaphragm control valves or butterfly valves, the pipe cross section is typically reduced at the start of the measurement and control section and expanded again at the end in order to achieve the required control effect. These control elements generally exhibit a limited range of linear operation in the upper and lower stroke range. In control applications, this inevitably leads to unfavourable operation of the valve at low stroke and thus to high pressure losses and reduced control quality. Possible causes include:

- The range of air flow rates required due to daily load fluctuations
- Difficulties in achieving correct dimensioning of slide valves or butterfly valves
- Changes in air demand over time

In most cases, the **VACOMASS® jet control valve** can be installed directly in the pipe without the need to reduce/expand the diameter. Thanks to the linear operating characteristic over virtually the entire operating range, fluctuating air requirements, dimensioning errors or later changes scarcely have an impact on the performance of the valve.



Depending on piping geometry, two types of installation can be realized:

Separated system: If there is sufficient inlet and outlet straight piping length available, the single flowmeter can be positioned at least 3*D in front of the jet control valve, with no influence of the stroke of the valve on the flow signal.

Compact System (Standard): The air flow meter is positioned 0.5*D in front of the jet control valve. As an option, three sensors can be used for redundancy. Depending on the piping in front of the flow meter and on the requirements for absolute accuracy of the flow measurement, an automatic flow profile correction of the signal(s) as a function of the jet valve stroke is a possibility.

DESIGN DETAILS

Materials: The housing and all exposed parts are made of stainless steel (V4A/316). Viton, Teflon graphite and PEEK materials are also used. All seals are static O-rings.

Maintenance: The control valve is completely maintenance-free, only the actuator requires routine maintenance as specified by the manufacturer.

Connections and installation: The control valve features a loose flange (also as ANSI flange) on both ends and, thanks to its low weight, is easy and quick to install on-site. Other fittings for diameter reduction/expansion are generally not required.

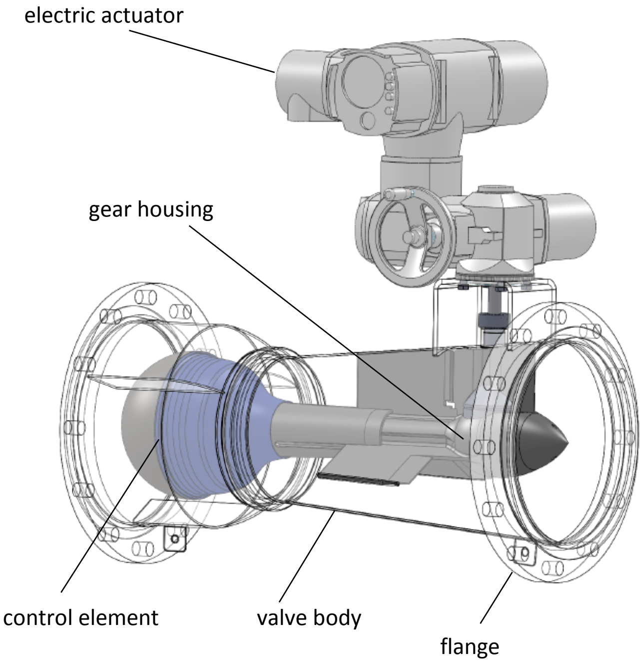
The **VACOMASS® flow meter** can be installed with a very short inlet section directly ahead of the control valve.

Option:
The control valves are available in a lightweight intermediate flange version. In both versions, the flange dimensions normally conform to DIN PN 10. The operating pressures are graduated according to the nominal diameters.

Design:

The design is done on a project basis, for which the following information is required:

- Air flow range (min/average/max)
- Nominal size/ pressure rating of the counter flange
- Operating pressure (min/average/max)
- Operating temperature of the medium (min/average/max)
- Ambient temperature and conditions at site
- Supply voltage/ data communication



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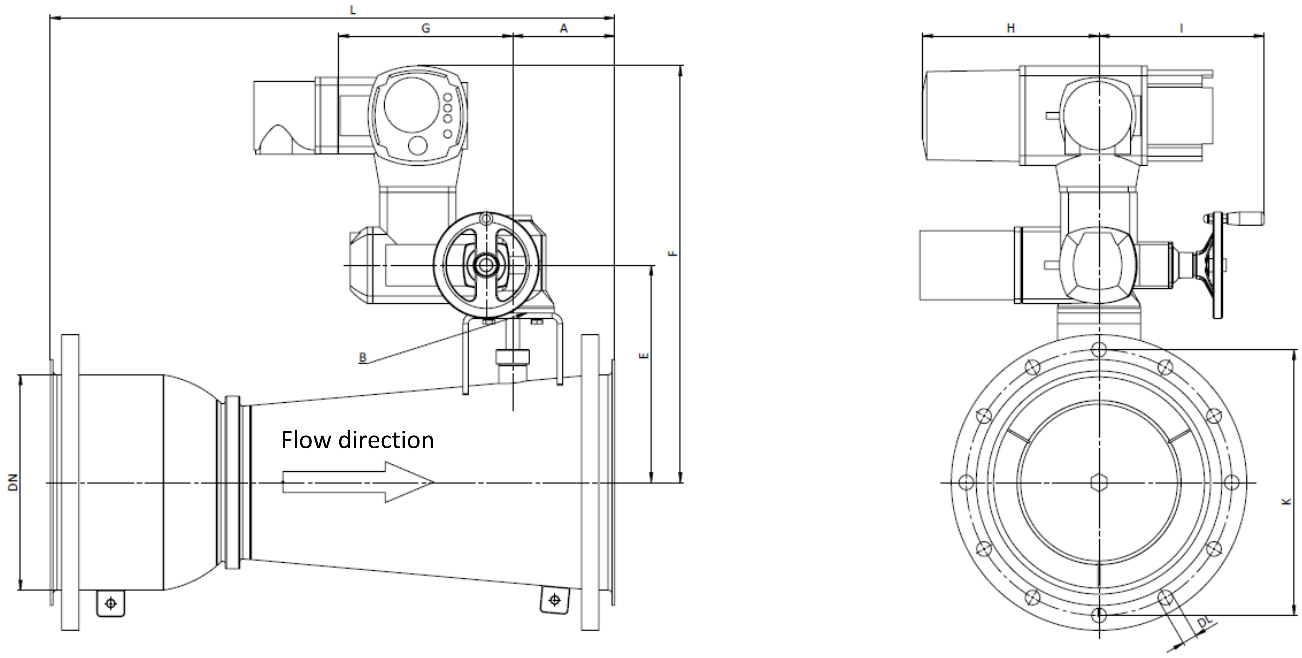
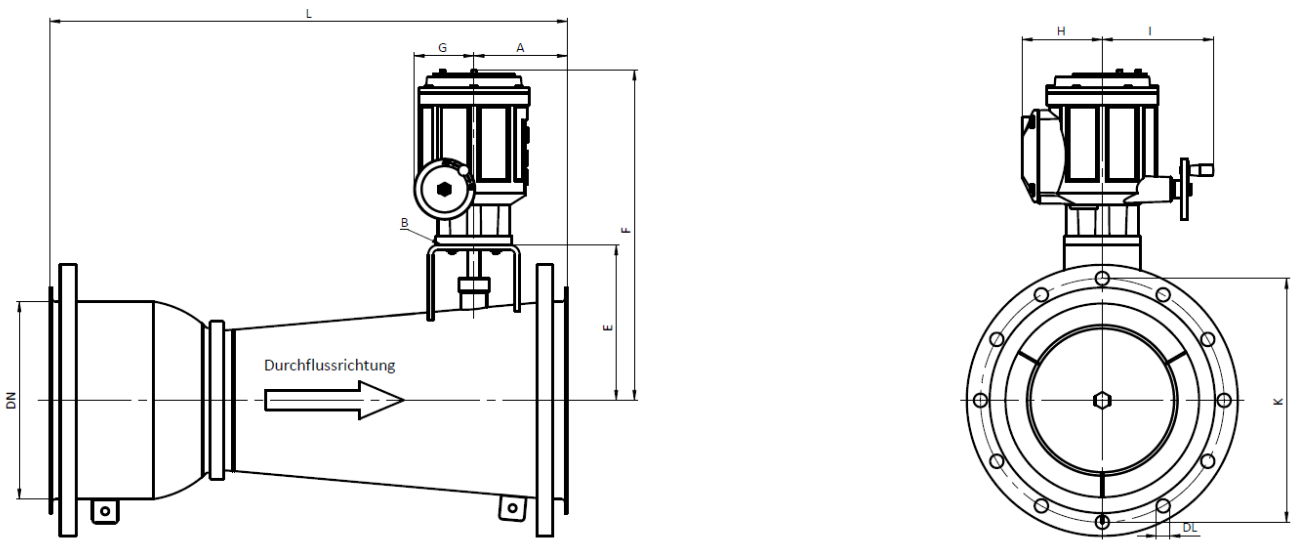
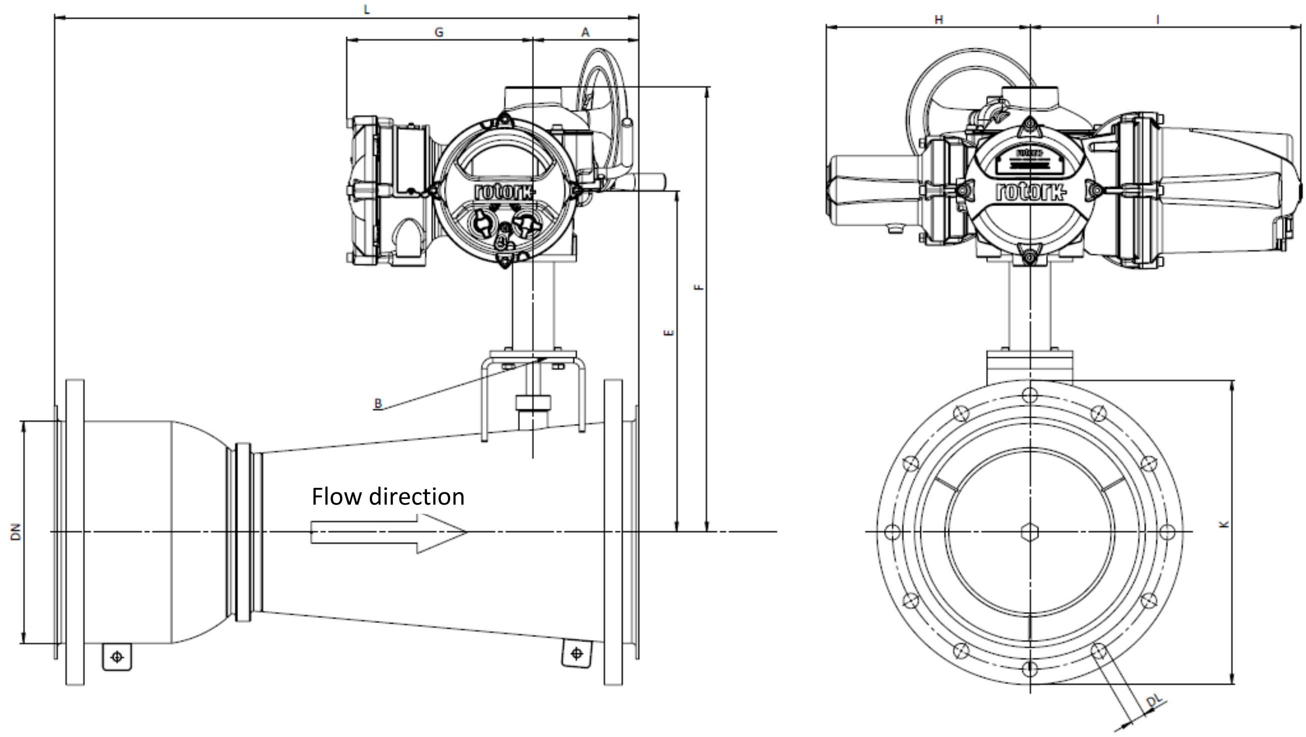


VACOMASS® jet control valve with an electric actuator **VACOMASS® actuator,** Type AUMA-SAR



VACOMASS® jet control valve with an electric actuator **VACOMASS® actuator,** Type AUMA-SD



VACOMASS® jet control valve with an electric actuator **VACOMASS® actuator,** Type ROTORK IQM

Dimensions according to EN 1092-1/2 PN 10 Standard Flange 1)											
Nominal pipe size DN	length L	A	B 1)	DL	No. of holes	Weight 2) kg	E	F	G	H	I
250	840	150	F10	22	12	94	depends on type of actuator				
300	850	154	F10	22	12	93					
350	900	195	F10	22	16	120					
400	970	230	F10	26	16	144					
500	1,355	215	F14	26	20						

1) ASME/ANSI flanges are also available

2) according to EN ISO 5210: Industrial valves - Multi-turn valve actuator attachments

3) depends on make and type of actuator

Nominal pipe size DN	Recommended air flow range in Nm³/h (depending on temperature and pressure)[4)]
250	80 - 4,000
300	100 - 7,000
350	130 - 9,000
400	160 - 11,500
500	200 - 15,000

[4)] The high end of the recommended airflow range is determined by the acceptable pressure loss. Accuracy and repeatability are constant across an operating ratio of 1:100.

Subject to technical modifications, no responsibility is accepted for the accuracy of this information (status: 01.01.2017).

IMPRINT

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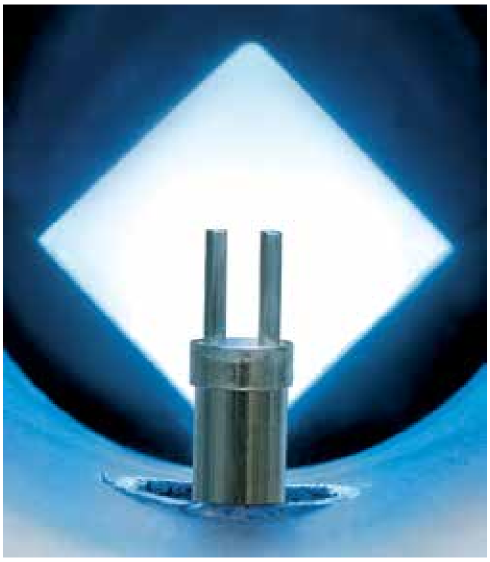
BIDE-M-D-VACOMASS-EN-R04 Data Sheet
VACOMASS jet control valve

VACOMASS®

The modular air supply system in wastewater treatment plants

Economical plant operation made possible by precise and efficient aeration control in the biological treatment



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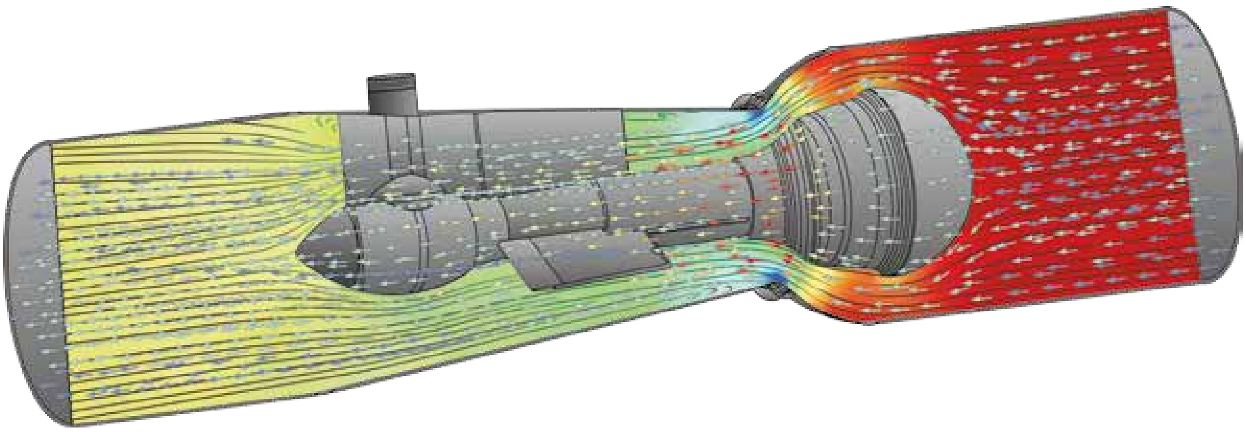
VACOMASS®
jet control valve



VACOMASS®
Biology under control

When the biological stage of a wastewater treatment plant is underaerated it will lead to process disruptions, and effluent limits can be exceeded. However, an over-supply of air wastes blower energy and results in uneconomical operation of the plant. Additionally the denitrification process can be compromized by surplus dissolved oxygen in the RAS flow (Return Activated Sludge).

Only innovative aeration control based on actual demand can ensure both a controlled and economical plant operation. The modular **VACOMASS®** system consists of components that are optimized for this application and matched to each other for precise measurement, control and distribution of air in wastewater treatment plants. **VACOMASS®** ensures that air is supplied according to actual oxygen demand in the various basins and aeration zones of the plant.

VACOMASS® therefore guarantees

- optimized treatment
- avoidance of disruptions to plant operations
- compliance with effluent permits
- and economical operation of your wastewater treatment plant.

With **VACOMASS®** your biological treatment is under control and energy consumption is significantly reduced.

VACOMASS® System integration

Aeration air has to overcome static and dynamic back pressures, e.g. changes in water level, condition of the aerators and pressure drop of the piping, on the way to the treatment tank. These factors change over time and are hard to control. Therefore, even very small changes will have a significant influence on the air distribution. This is exactly where the **VACOMASS®** concept can be applied: Each **VACOMASS®** system continuously monitors the local air supply and can immediately detect the smallest deviation from the setpoint. The local control immediately intervenes and compensates for any external disturbances of the air distribution. The system integration guarantees optimal interaction of the components and ensures the transmission of important data for the operation of the whole control system, even for complex installations.

Simultaneous flow profile correction
In the case of a compact VACOMASS® system, the thermal mass flow sensor is positioned directly upstream of the control valve. If a diaphragm control valve with falling flow axis is used, the flow profile will fluctuate steadily during system operation. Without correction, this will lead to errors when measuring the airflow rate. The information about the current valve position must be constantly communicated in order to correct for these flow profile distortions. With this information, the flow signal, the decisive variable for precise control of the air supply, can be corrected automatically. However when VACOMASS® jet control valve is used in a compact system, simultaneous flow profile correction is not needed.

Optimized operation of the control valve
Conventional controllers change the stroke of the control valve in a stepwise fashion. This inevitably leads to high switching frequencies and premature wear and tear of the actuator and the valve. However, the characteristic control curve of the valve and specific process data of the treatment plant are stored in each VACOMASS® electronic module. During setpoint deviations, the electronics precisely calculate the new opening position of the control valve, providing precise control in a single step.

Plausibility check
Each VACOMASS® system continuously monitors the airflow rate and checks this value for plausibility in relation to the valve position. In this way any disruptions, such as changes in the diffusers, can be detected immediately. The VACOMASS® system reacts to each disruption without delay and automatically initiates appropriate countermeasures. To reduce the pressure drop at the diffusers, a periodic and selective cleaning procedure can be implemented. This not only improves oxygen transfer efficiency but also reduces pressure drop and power consumption, and the life of the diffusers can be extended.

Redundant monitoring of process parameters
The aeration control is based on certain process parameters (e.g. O_2, ORP, NH_4-N, etc.). Faulty measurements of these parameters can indicate a low oxygen demand, resulting in an undersupply of activation air. To prevent this, VACOMASS® supports redundant monitoring of specific process parameters. Thus, any malfunction or failure of a probe can be detected immediately. To determine the oxygen demand, only signals of the properly functioning probes continue to be considered.

Alarm and safety functions
VACOMASS® provides comprehensive monitoring functions allowing each process disruption to be indicated immediately. Additionally, the SCADA system can always take over the aeration control. In the case of a fault, the control valve will automatically move into an operator specified safe position. This way, VACOMASS® ensures a surplus of oxygen at any time. Consequently, a VACOMASS® installation significantly improves the operational safety of a wastewater treatment plant. Process disruptions, as well as unnecessary costs due to late detection of failures, can be prevented.

Retrofitting and modernization

The modernization of the wastewater treatment plant at Ulm-Steinhäule in Germany demonstrates the possibilities for optimization that are now possible with a **VACOMASS® jet control valve**. The classic system was designed in the 1990s: a blower station with a generously-dimensioned common header to the basins and 20 electrically-operated DN 400 (16 inch) control valves in the drop pipes to the diffuser grids. The control valves typically operate in the range of 10 to 30 % open, generating a measurable pressure drop of up to 58 mbar (0.85 psi). With the installation of the **VACOMASS® jet control valve** DN 400 in the existing pipelines, the airflow

rates can be controlled precisely and according to the specific requirements at a fraction of the previous pressure loss. This reduces energy costs. A reduction and expansion of the pipeline was not necessary since the DN 400 **VACOMASS® jet control valve** guarantees accurate operation across the entire control range with as little as 1 mbar (0.4 inch WC) pressure drop, thanks to its design and precision. The design of the **VACOMASS® jet control valve**, which also functions as a flow conditioner, allows the installation of the air flow meter just 0.5 x D upstream of the control valve with a very short inlet pipe run from the header pipe.
Installation was therefore very easy, quick and cost-effective using pre-fabricated pipe sections.

VACOMASS®
System components

The modular design of the **VACOMASS®** measurement and control system operates on the building block principle. Depending on plant size, control concept and specific requirements, the system components of the **VACOMASS®** product family can be supplied individually or in combination with each other. The **VACOMASS®** system integration and precise calibration of the combined airflow measurement system in our **CAMASS®** Calibration Lab guarantees that all components fit together perfectly, ensuring highest precision for controlling the air supply.

VACOMASS® flow meter
Thermal dispersion mass flow meter for precise monitoring of the airflow at standard (DIN 1343)

VACOMASS® hot tapping unit
Hot tapping unit for the flow meter in various versions

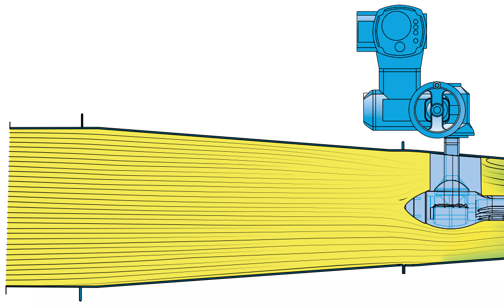
VACOMASS® flow conditioner
Flow conditioner for swirl reduction, damping of pulsations and equalization of flow profile at difficult installation points

VACOMASS® jet control valve
Gas-tight shut-off, aerodynamically optimized stainless steel control valve with a linear operating characteristic over the full stroke for highly precise air supply at minimum pressure loss

Constant positioning precision and repeatability across a nearly unlimited control range. Pressure recovery of up to 80 % thanks to low-turbulence flow and venturi outlet.

Very short installation lengths thanks to 3D design with flow conditioning and airflow meter 0.5 x D upstream of the control valve.
Patent no. DE102013110581

VACOMASS® actuator
Electrical or pneumatic actuator for precise control of air supply, mounted on the control valves

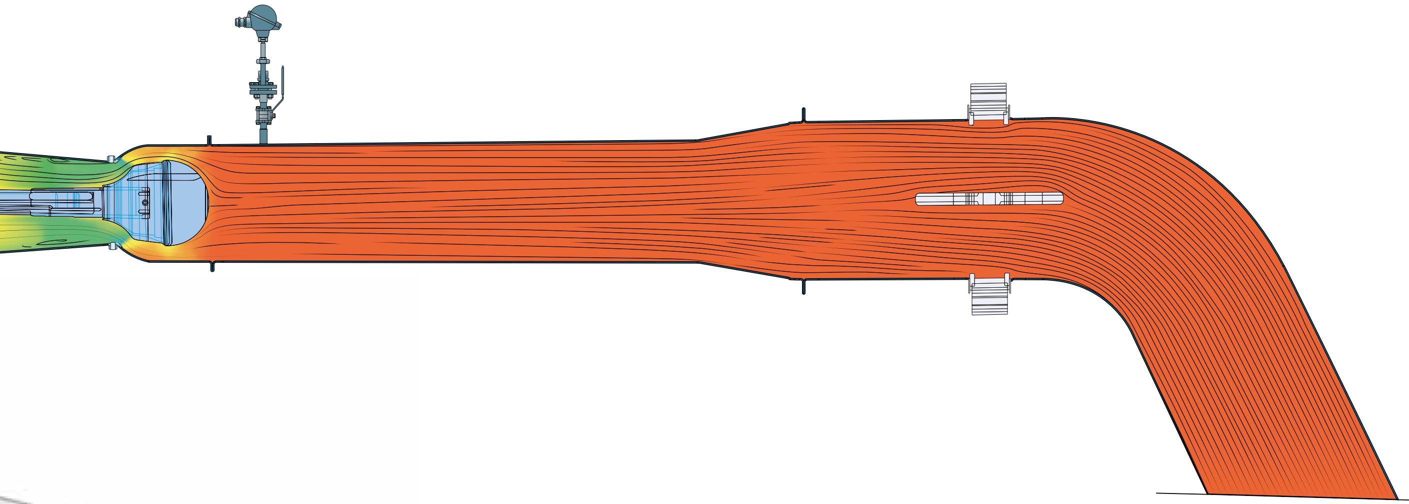


VACOMASS® square diaphragm control valve
Tried and tested in the market, gas-tight shut-off, square diaphragm control valve with falling flow axis and a stable and proportional operation characteristics in the normal operation range

VACOMASS® elliptic diaphragm control valve
Diaphragm valve with falling flow axis, elliptical control diaphragm and gas-tight shut-off. The control diaphragm opens the cross-section completely, allowing very high flow rates with minimum pressure drop and low noise emissions due to an integrated pressure wave breaker (patent pending)

VACOMASS® flexcontrol
PLC-based modular control system for precise air distribution in wastewater treatment systems. The control cabinet is suitable for indoor and outdoor installation. The following software packages are available as individual modules:

VACOMASS® master
Module for autonomous determination of the actual oxygen demand and control of the air supply



VACOMASS® multipoint
Module for multipoint measuring systems

VACOMASS® basic
Module for simultaneous flow profile correction of diaphragm control valves based on the stroke (if not directly compensated in the **AL100 flow meter**)

VACOMASS® simulation
Computational fluid dynamic simulation of actual piping layout, to improve the design of the measurement and control section

VACOMASS® calibration
Component or system calibration, considering actual piping layout and operating conditions

VACOMASS® silencer
Reduces noise level, used in systems where tanks have different water levels

VACOMASS® blow-off valve
Safety blow-off valve to prevent blower trip-out

VACOMASS® tune valve
Hand operated diaphragm valve with measuring stub for fine adjustment of air distribution into the drop pipes of the diffuser grids

VACOMASS® slave
Module for local control of air supply according to external airflow setting via **VACOMASS® master** or the main PLC

VACOMASS® econtrol
Module for control of minimum required header pressure based on actual air requirement

VACOMASS® blower monitoring
Module for detection of critical operating states, such as tripping

VACOMASS® biocontrol
Electronic module for the control of biological processes such as the load-dependent calculation of aeration time for intermittent nitrification/denitrification, load-dependent calculation of the required DO-setpoint, the nitrate recycle rate and required aerated volume

VACOMASS® start-up/fine tuning
Support during installation and start-up of the system, including adaptation of control parameters to the local situation and loads by Binder Service personnel on-site or via remote access


VACOMASS


VACOMASS®


VACOMASS

VACOMASS®
Valves and actuators

The heart of any air distribution and control loop is the valve. It should have a linear operating characteristic, preferably over its full stroke coupled with a low pressure drop. Additionally the air should exit the valve with low turbulence, to achieve a low noise level and keeping the pipe section to the first drop pipe of the diffuser grid as short as possible.

Binder offers two essentially different types of diaphragm control valves: the proven **VACOMASS® square diaphragm control valve** with a square shaped control aperture and the **VACOMASS® elliptic diaphragm control valve** with an elliptically shaped control aperture. The **VACOMASS® jet control valve** is superior to both diaphragm control valves in terms of energy consumption and control accuracy.

VACOMASS® square diaphragm control valve – proven for many years

The **VACOMASS® square diaphragm control valve** has a gas-tight control aperture for precise control of air with low losses. It has a falling flow axis for sensitive control of normal and tangential air flows (e.g. after elbows) according to DIN EN 60534-2-3 and has a proportional opening from 0 to 100 %. The operating range in the field is typically from 15 to 85 % stroke.

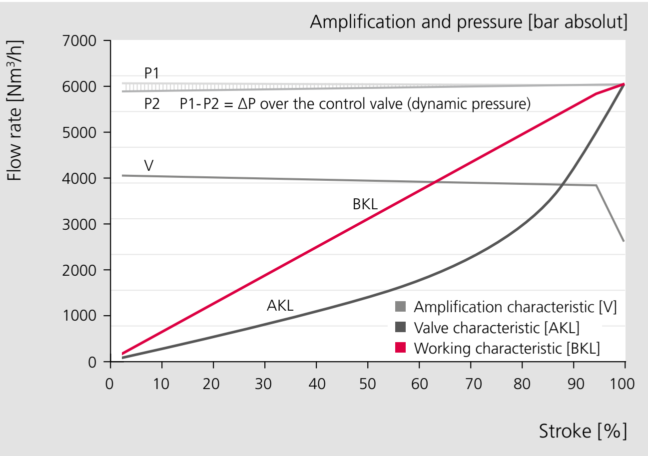
Depending on ambient conditions at the installation site, various materials for the gaskets, spindle and sliding gate plate cover are available. The spindle can be equipped with a fully automatic lubrication system.

VACOMASS® elliptic diaphragm control valve – for high air quantities in purge mode

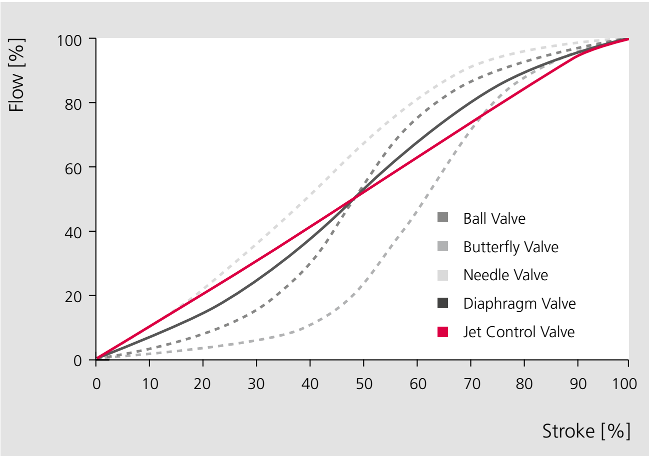
The **diaphragm control valve** with elliptical control aperture is an enhancement of the proven model with square aperture, however it is specially designed for high flow rates at low pressure drop and low noise level. Due to the geometric shape of the cross-section, a pressure wave breaker is integrated into the valve design to prevent noise in control operation. When it is 100 % open the pipe cross-section is completely available and maximum flow is possible. The installation length is identical to many sliding gate valves and butterfly valves, so a simple replacement on existing systems can be realized in order to achieve significantly higher air flow rates with lower pressure drop and better control. This optimization ensures sufficient oxygen supply to the aeration tanks and enables prescribed periodic high air rates to purge and clean the diffusers and increase their life span. The peak pressure of the blowers can be lowered and the risk of surge is reduced. If systems reach their limits due to higher effluent load or ageing diffusers generate an increased pressure drop due to ageing, the installation of a **VACOMASS® elliptic diaphragm control valve** can improve or prevent this stress situation. Expensive retrofitting measures can usually be delayed or omitted entirely.

VACOMASS® jet control valve – the special control valve

The **VACOMASS® jet control valve** is unique worldwide and combines aerodynamically optimized design with high precision manufacturing. It has a central control axis and an actuator for sensitive control of air flow. Stroke is adjusted along the flow axis, so the flow attaches to the wall, which allows a fast and high pressure recovery. The



Characteristics of VACOMASS® jet control valve

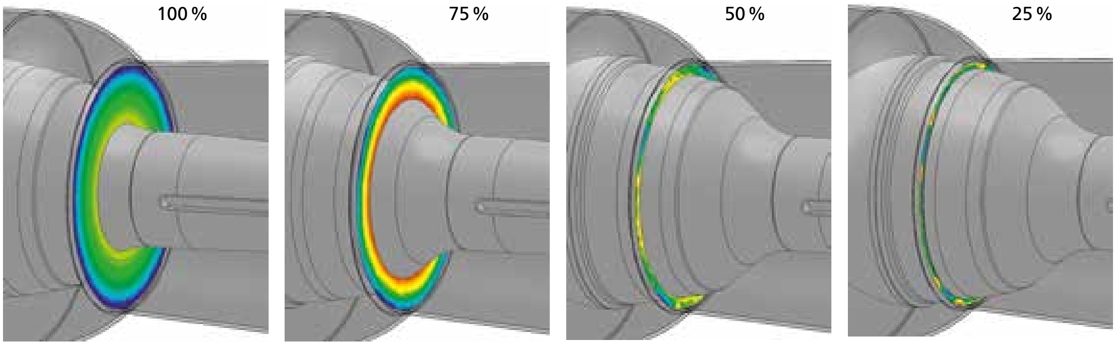


Comparison VACOMASS® jet control valve with conventional valves control body has a very low drag coefficient and therefore requires only a low driving torque. It has low friction so a smaller size actuator can be used. Usually the valve can be connected directly to the pipe without additional reduction and expansion pieces. The control valve's operating characteristic is nearly linear over the valve's entire operating range thanks to the 3D design of the valve trim. The resulting high-precision control characteristics and precision manufacturing of the components allow the resolution of minute control steps (0.15 %). Due to the flow-optimized geometry and up to 80 % pressure recovery, the pressure drop is comparatively very low and results in a significant reduction in operating costs. The valve closes 100 % gas-tight. All parts in contact with media are completely made of 316 stainless steel/Teflon/carbon/ PEEK/FKM (Viton), suitable for continuous operation at -40 °C to +150 °C (-40 °F to +300 °F) and virtually maintenance-free.

VACOMASS®
elliptic diaphragm control valve

VACOMASS®
square diaphragm control valve

VACOMASS®
jet control valve



3D-Design: Over-proportional increase of free flow area leads to the linear operational characteristics

Flow and pressure are equalized at the outlet of the valve hence the first drop pipe to a diffuser grid can be located directly behind the valve. This is a big advantage in upgrade projects and can significantly reduce the costs for pipe adaptation while improving the air distribution.

The air flow meter can be placed 0.5 x D upstream of the valve as this position has proven high repeatability of the flow profile, so an easy and cost-effective installation without the usual straight inlet and outlet pipe sections becomes possible.

The development of the jet control valve was supported by a CFD (Computational Fluid Dynamics) flow simulation software and parallel flow experiments in the CAMASS® Calibration Lab at a 1:1 scale, allowing real operational conditions of a plant to be simulated.

In addition to piping orientation, pipe size, pressure, temperature, air mass flow and noise level measurement, the dynamic pressure drop of a plant could be simulated.

VACOMASS® actuator

The control valves of the VACOMASS® series can be combined with various electrical as well as pneumatic actuators, taking into consideration that the drive of the actuator is optimized for minute steps to achieve a sensitive air adjustment.

Depending on ambient conditions at the site, different requirements in corrosion protection, mode of operation, data transmission and actuator duty cycles can be accomodated.

VACOMASS®
Air flow meter

Knowledge of the air flow at various locations in the aeration system not only improves system understanding, it also provides additional control possibilities.

Typical installation locations are:

- Downstream of the blowers for efficiency monitoring in ongoing operation and long-term tracking
- In header pipes to individual aeration basins in order to detect and reduce any uneven distribution of wastewater in multi-stream aeration basins
- In branch lines/drop pipes for direct determination of the oxygen supply to an aerated basin or an aerated zone, in order to monitor the ageing of diffusers or incorporate the air flow into the control of the oxygen supply and distribution

The left top photo shows the installation of the VACOMASS® flow meter SS in combination with the torsion-proof hot tapping unit OEIN-F. The right top photo shows the VACOMASS® flow meter AL 100 with the integrated simultaneous flow profile compensation of the flow signal.

Thermal air flow meter are well-suited for all of these measurement tasks. They measure the mass flow at standard conditions directly and require no pressure or temperature compensation, like all other measurement technologies. They also do not generate a pressure drop that would increase the power required by the blowers and raise the electricity costs.

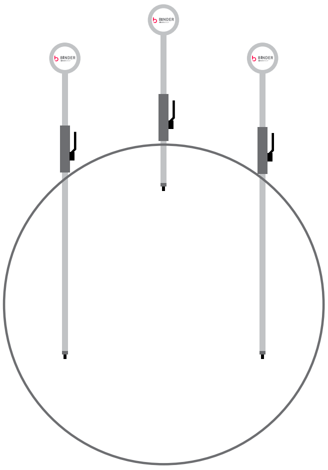
Requirements on the installation location
For precise measurement, they require an evenly-formed flow profile and sufficiently long straight inlet and outlet pipe sections.

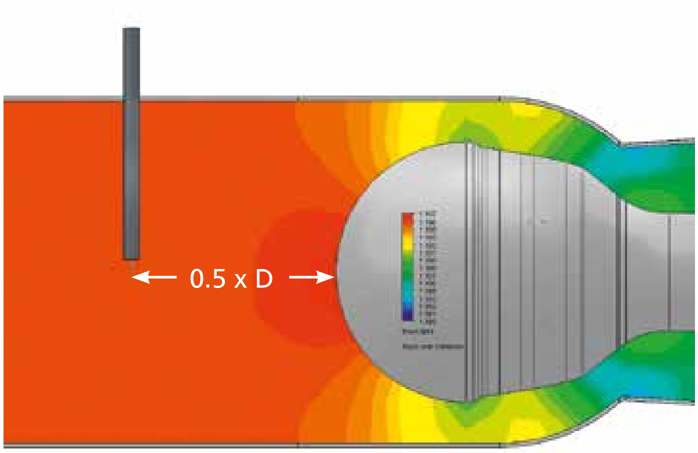
For large nominal pipe sizes and/or especially high precision and insufficient straight inlet and outlet pipe sections, a patented and pressure drop-optimized upstream **VACOMASS® flow conditioner** a multiple sensor system **VACOMASS® flow meter multi** with appropriate electronic compensation can be installed.

Alternatively, installation specific calibration in the **CAMASS® Calibration Lab** can compensate for local flow disturbances so that the precision of the measured value improves significantly.

One device, several models
There are several different sensor models available for indoor and outdoor installation. The electronics can be installed in a compact, pressure-proof stainless steel housing (type SS) with a separate connector box or in an aluminium housing (types AL, AL DIN or AL100). Optionally, for some housing models, an integrated display is available; all models can have an external 10-digit graphic display with control panel for display of the actual flow value and the totalized value.

Combination with control valves
If the air flow meters are mounted directly upstream of diaphragm control valves, generally a minimum distance is required so that the opening/closing control aperture does not disturb the measurement signal due to the profile shift of the flow. Commonly, and especially in retrofits, this space is not available. In these cases, the flow meter is calibrated together with the valve and the flow-conditioned influence is compensated in the **VACOMASS®** control modules or directly in the **VACOMASS® flow meter AL100** (integrated simultaneous flow profile correction). This allows the installation of the flow meter directly upstream of the control valve, thus reducing the required length of the measurement and control pipe section significantly. The **VACOMASS® hot tapping unit** allows removal of the sensor in operation for maintenance purposes even at higher temperatures and pressures without losing air. Various versions are available, from the simple tap model with variable immersion depth (Version S) to the torsion-proof model with locked installation depth and orientation of the sensor (Version F).





The left top graphic shows the arrangement of a multiple sensor system mounted in a large collector pipe DN800. This way, even with relatively short inlet sections and large diameters, acceptable precision can be achieved.
The CFD-picture explains the advantages and the efficiency of the integrated flow conditioner even after extremely short straight inlet piping: the airflow meter can be installed only 0.5 x D in front of the control valve.

VACOMASS® Calibration

Only the exact calibration of an air supply system can provide precise control of the air flow to the aeration basins of a wastewater treatment plant. To achieve this we simulate, in detail, the operating conditions at which our **VACOMASS®** air supply and distribution systems will be operated, in our **CAMASS® calibration center**. For this purpose, the pressure and temperature conditions as well as the various flow rates that will occur later in the treatment plant are precisely reproduced during calibration.

Generally, the existing straight pipe sections at the top of the basin are not long enough to provide an even flow profile and to position the air flow meter far enough upstream of the control valve.

Factory approval testing (FAT) of the VACOMASS® air supply systems for the municipal sewage treatment plant of Vienna in our CAMASS® calibration centre. Due to the precise simulation of the field operating conditions and its piping layout during the calibration of the VACOMASS® systems, an accuracy of 1.5 % of the airflow reading could be guaranteed despite the difficult piping.

In these cases, special calibration allows compact installation: the air flow meter is placed directly upstream of the control valve. The total length of the measurement and control pipe section is thus reduced significantly, and retrofitting is possible even in tight spaces.

When the air flow meter is mounted directly upstream of a **VACOMASS® diaphragm control valve**, the influence of control aperature movements on the flow profile and on the thermal sensor's raw signal can be accurately recorded during calibration.

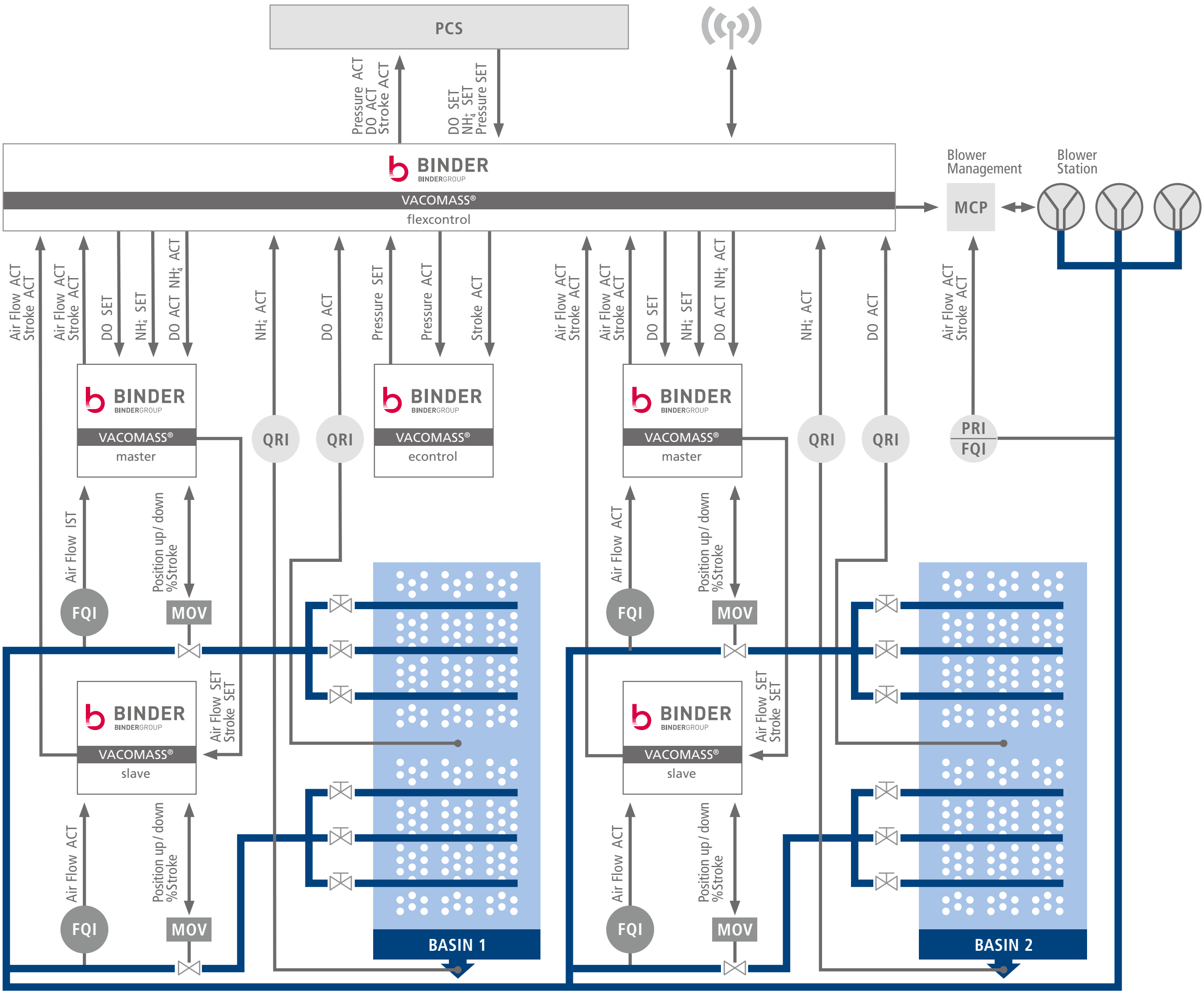
This data enables the calculation of correction factors and allows precise airflow measurement even under changing operating pressures and loads. Due to the flow-conditioning shape of the **VACOMASS® jet control valve**, the valve position does not influence the airflow signal and the airflow meter can be positioned just 0.5 x D upstream of the control valve.

The influence of the piping layout on the airflow measurement can be recorded and compensated by simulating the installation during calibration.



VACOMASS® Control concepts

Depending on loading and other plant conditions, customized concepts are needed for good aeration control. The control objective has traditionally been increased process stability and improved effluent quality; more recently in addition to the level of capital investment, the focus has moved to the potential for reducing energy costs. Approximately two-thirds of a wastewater treatment system's total energy consumption is solely for the supply of aeration air. **VACOMASS®** always guarantees an air supply tailored precisely to the specific needs.



Example of a complex VACOMASS® installation

The combination of **VACOMASS®** system components allows you to implement individual concepts for aeration control, as well as intermittent aeration. It begins with simple installations to ensure equal air distribution, continues to the implementation of conventional dissolved oxygen control, through to complex installations with cascading control loops for individual, local airflow control that adjust the dissolved oxygen setpoint based on NH_4-N concentration. By monitoring the positions of the control valves ("most open valve control"), the header pressure and airflow rates during nitrification can be adjusted according to the specific needs, and variable pressure control can be realized. A module for implementing cleaning cycles for the diffusers or pulse aeration can be activated. Based on additional process parameters such as ORP and pH, the time phases for nitrification and denitrification can be determined based on the load or aerated basins (swing zones) can be switched on or off. Special control concepts for systems with intermittent aeration as well as for systems with upstream denitrification are available. Plausibility checks increase process safety in case of signal failure. Standardized control modules allow easy and cost-effective configuration.

Use of air flow information – cuts energy costs

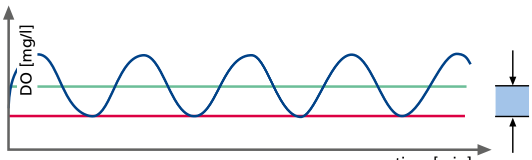
The inclusion of airflow rates in the control concept improves the aeration control especially for very large basins, very deep basins or basins with diffusers that do not cover the whole bottom area (see DWA-M 264 Gasdurchflussmessungen auf Abwasserbehandlungsanlagen, Mai 2015 [*DWA-M 264 gas flow measurements for sewage treatment systems, May 2015*]). Typically, the dissolved oxygen concentration in the aeration basin is measured and the air supply set via the blowers or control valves. The oxygen concentration fluctuates constantly around the setpoint. If the air flow in the interconnected control loop is used as the setpoint variable for the oxygen concentration and controlled by a cascading control loop via the valve setting, the control system will become much faster.

VACOMASS® reacts immediately to any disruption, so that even in wet weather conditions the dissolved oxygen concentration generally does not fluctuate much and cleaning performance remains more even. This frequently allows the dissolved oxygen setpoint to be lowered without compromizing the process outcome. Even with the same contamination load, the saturation deficit decreases, as does the airflow rate, and therefore the energy consumption.

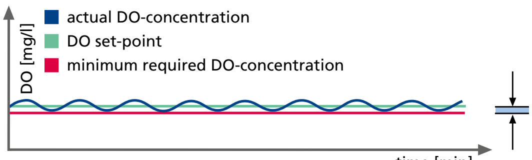
Since the aeration air is by far the wastewater treatment system's largest energy consumer, in addition to the use of low-differential-pressure control valves, special attention should be given to load-dependent aeration control. Monitoring of the pressure alone is not sufficient for this since the pressure provides no information about the required specific air distribution. The incorporation of direct airflow measurement into the automation process improves the efficiency and quality of the effluent.

Constant pressure control – variable pressure control – air distribution control

With constant pressure control, the individual valves provide the required aeration air from the constant pressure header to the diffuser grid independently of one another. The blowers are controlled by pressure. In partial load operation, the required air volume and thus the system pressure drop (pipeline and diffuser resistances) are low, and the excess pressure must be dissipated by throttling the control valves.

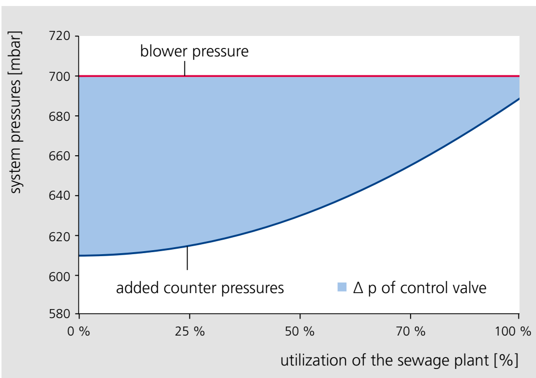


Without VACOMASS®

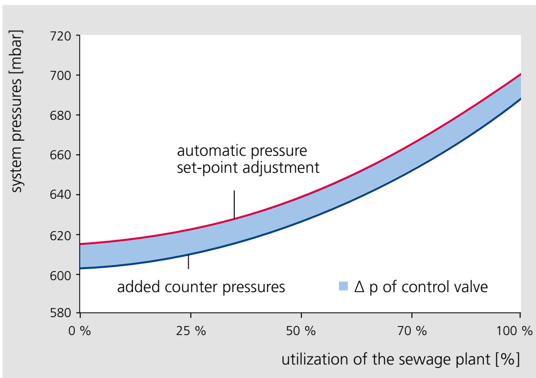


With VACOMASS®

More economic than throttling the air supply via the valves, however, is the variable adjustment of the blower pressure to the specific air requirement. For this, the **VACOMASS® econtrol** monitors the actual operating conditions of the control valves and determines the required pressure level to ensure that just enough air is supplied for the entire system. By reducing the pressure, the power consumption is also reduced.
With **VACOMASS® econtrol**, efficient system operation is ensured. Alternatively, air distribution control can be used. In contrast to pressure-based control, where the required pressure in the header must be kept constant and the air quantity to the diffusers is controlled by opening the control valve, with air distribution control a demand-based air



Constant pressure control system



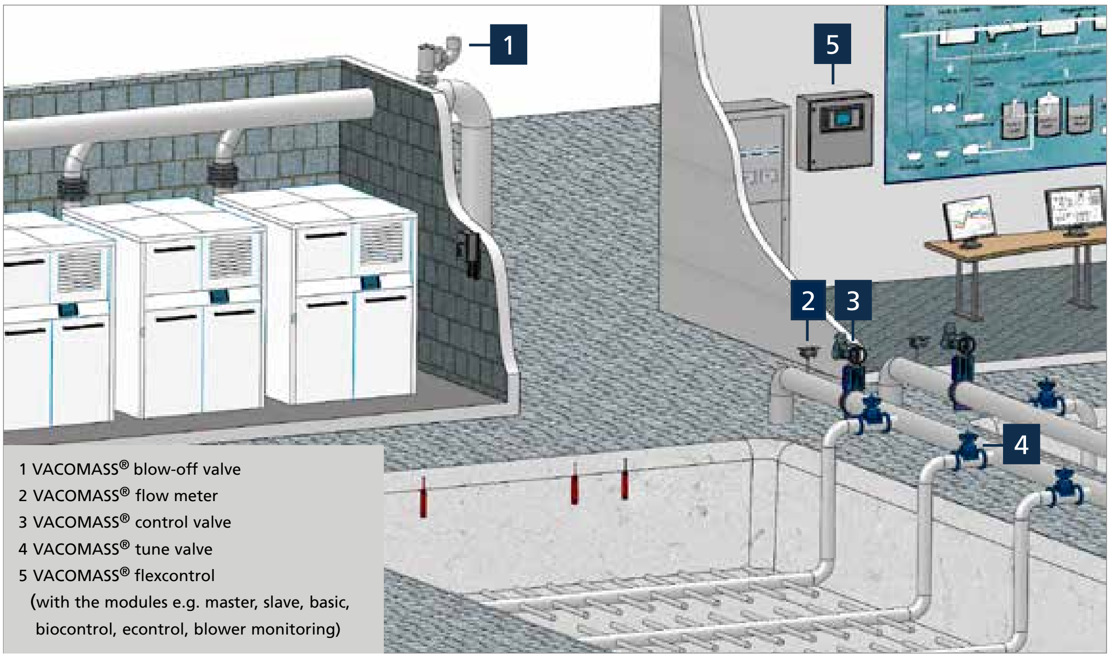
Variable pressure control system (e.g. with VACOMASS® econtrol) quantity is requested by the blower management. Detailed timing information about the switching of blowers can be incorporated into the control algorithms so that the air supply is kept as constant as possible during the blower switch and the danger of surging of single and multi-stage blowers can be largely avoided.

VACOMASS® flexcontrol – the PLC-based hardware platform for control software

The control cabinet is suitable for indoor and outdoor installation. Operator input is done with a 7″ touch screen with system-specific screens and menus. The complete flexibility and intuitive operation of this open system is its outstanding feature. It enables easy adaptation to system requirements, no "black box" that creates uncertainty, but rather standardized modules based on control algorithms that are easy and clear for any circuit and that have been used successfully worldwide for many years. All modules are mounted on top hat rails and can be changed easily by the operator. Up to 10 control loops can be implemented in a control cabinet. As many control cabinets as desired can be combined so that smaller systems and larger wastewater treatment systems can use the same standardized and thus cost-efficient modules. Each control loop has its own processor with software that is configured for the required tasks and works completely independently. This provides maximum operating reliability and flexibility. Therefore, cost-effective fine-tuning of control parameters for each individual control loop via remote access is also possible. The operator can change the control parameters on-site or remotely at any time. There are up to 40 parameters available for the fine-tuning of a system. All common interfaces are available. The freely-expandable number of inputs and outputs and data transmission via bus systems open up possibilities for data recording and evaluation for more sophisticated process monitoring and optimization. Security updates can be installed remotely. The software modules also offer an automatic mode for the calculation of correction factors for operation, plausibility queries, and thereby greater protection against manipulation. The modular structure allows after-the-fact programming and remote download of customer changes. All parameters can be set via remote access and alarms can be tracked (service). Transmission of standardized reports can be activated in order to rapidly detect trends in the wastewater treatment system.

System integration

Only the interaction of all components enables secure and energy-optimised aeration of the biological cleaning stage: from the precise measurement of the air supply to low-differential-pressure control valves with linear performance curves and the use of standardized control modules for precise air distribution on through to process control of intermittent denitrification. The installation of low resistance control valves and VACOMASS® control systems frequently reduces energy consumption for aeration by up to 20%. VACOMASS® components or a complete system ensure this for your wastewater treatment system.



1 VACOMASS® blow-off valve
2 VACOMASS® flow meter
3 VACOMASS® control valve
4 VACOMASS® tune valve
5 VACOMASS® flexcontrol
(with the modules e.g. master, slave, basic, biocontrol, econtrol, blower monitoring)


VACOMASS®

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Please contact the company with the address shown in red or the local distributor.

ECM-P03: Deep Well Injection Pump

BARNEY'S PUMPS INC.
12080 NW 40th Street, Coral Springs, FL 33065-7602
Broward (954) 346-0669
Dade (305) 945-0279
Fax (954) 346-0993

To: Jacobs
Attn: Muriel Steele

Project: Key West

Date 10/10/18
Quote by Michael Braun
Email braunm@barneyspumps.com
Phone (212) 444-8094

Delivery	Via	From	F.O.B	Terms
18 weeks	BPI	BPI	Factory	Net 30 days with approved credit

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL PRICE
A	**COS: 4167 GPM @ 105 ft** Aurora Model 610 Horizontal Non-Clog Pump 10X10X22 with 200 HP Motor, 1175 RPM, 3/460/60	1	$60,000.00	$60,000.00

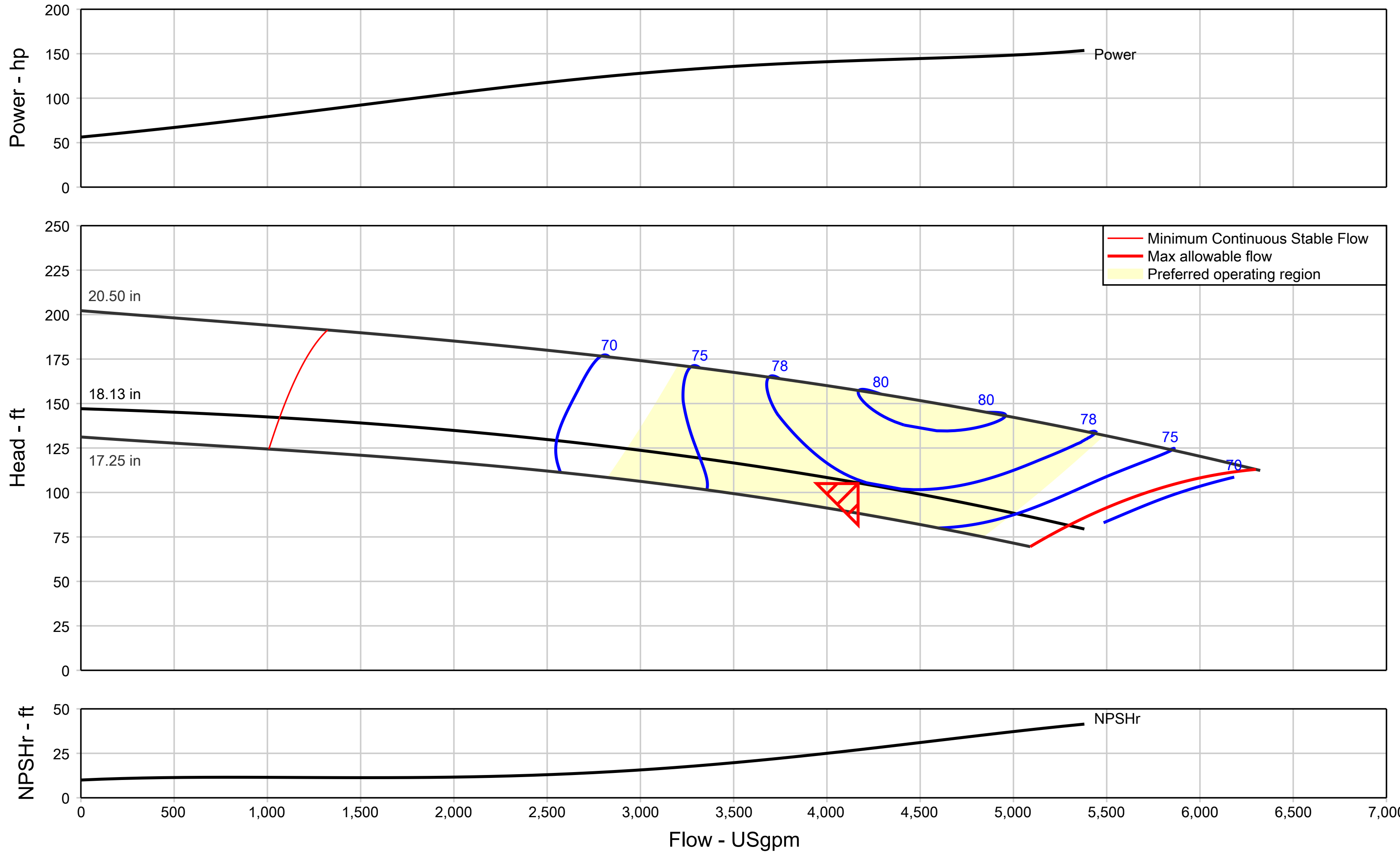
Prices quoted are firm for 30 days (unless otherwise noted), then subject to adjustment to agree with prices at time of shipment and subject to any tax required by law. This quotation is subject to Barney's Pumps standard terms of sale and warranty. Taxes, anchor bolts, piping, field wiring, etc. are not included. Start-up and training services are NOT included. If shop drawings are required for approval, please request them from our office.

BARNEYS PUMPS INC.
Michael Braun
Authorized Signature

Customer	: BARNEY'S PUMPS, INC. - CORAL SPRINGS FL	
Project name	: Key West 611 Relacement	

Pump Performance Curve

Encompass 2.0 - 18.3.6.0



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Quantity	: 1	Speed, rated	: 1175 rpm	NPSH required	: 26.97 ft
Quote number	: 23-18-1003	Based on curve number	: 16-10x10x22-1175	Fluid density, rated / max	: 1.000 / 1.000 SG
Date last saved	: 10 Oct 2018 9:41 AM	Efficiency	: 77.91 %	Viscosity	: 1.00 cP
		Power, rated	: 142 hp	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00

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2. Standard payment terms are net 30 days from invoice date. *For contractor sales: Minimum 90% net 30 days – Balance of retainage due at start-up OR eighty (80) days from invoice date, whichever occurs first*.
3. We reserve the right to charge one and one-half percent (1-1/2%) of the past due balance per month. If it becomes necessary for us to employ an attorney or to bring suit to recover any amount, the Purchaser agrees to pay all of our court costs, legal expenses, and reasonable attorney's fees in connection therewith. These remedies are not in lieu of any other remedies so provided by applicable law.
4. Shipping and shop drawing production schedules are estimates based on current market conditions; they are subject to revision. We will not be liable or responsible for any delays caused by late shipment to us, or by any other matters beyond our control (Force Majeure) either in whole or in part.
5. If requested, shop drawings will be provided for submittal, review and approval to ensure that you, our customer, can be sure that Barney's Pumps has the correct perception of what you require. Any order where shop drawings are provided is contingent upon the approval of those shop drawings that, when approved, shall become the only specifications for the materials/goods you wish to purchase. Barney's Pumps cannot and does not warrant, guarantee or represent that materials/goods are suitable for any particular purpose nor does Barney's Pumps warrant, guarantee or represent that the materials/goods will be or have been approved for use by any other party. The customer is not authorized to rely on any warranty or representation by Barney's Pumps not contained in this document or otherwise provided in writing.
6. Purchaser must inspect all materials/goods for damage or shortage at the time of delivery. Claims for damage or shortage must be given in writing at the time of delivery to the carrier, and we must be notified in writing of any such claim within five (5) days.
7. Materials/goods may not be returned without our consent and will be subject to a restocking charge plus any freight costs involved.
8. <u>LIMITED WARRANTY</u>: Materials/goods manufactured by others are warranted only under the conditions and to the extent that they are warranted by the manufacturer(s) of said materials/goods, whose warranties will be furnished and assigned to Purchaser on request. We will not be liable for any breach of such warranty and Barney's Pumps does not provide any express or implied warranty concerning such materials/goods.

   With respect to materials/goods manufactured by Barney's Pumps, including Unitron Controls® electrical control panels, we warrant said materials/goods only to the original purchaser and only against defects in workmanship and material, subject to the limitations described below. The warranty period shall be the lesser of one year from startup or eighteen (18) months from date of shipment. It is the original purchaser's responsibility to ensure that the equipment is properly lubricated and that electrical components used in the control panels are free from rust and operate properly prior to start-up. This warranty does not apply to damage resulting from accident, alteration, misuse or abuse. Parts of products, or accessories, manufactured by others are warranted only to the extent of the original manufacturer's express warranty, if any. We warrant to the original purchaser that any part which proves to be defective in material or workmanship will be repaired or replaced at no charge with a new or remanufactured part, F.O.B. Lakeland, Florida. The original purchaser shall assume all responsibility and expense for removal, reinstallation, and freight to and from Lakeland, Florida. Any item designated as manufactured by others shall be covered only by the express warranty of the manufacturer thereof, if any.

   <u>EXCLUSION OF ALL OTHER WARRANTIES</u>: THE WARRANTIES CONTAINED HEREIN ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED; ALL OTHER EXPRESSED OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTIBILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED AND EXCLUDED FROM THIS TRANSACTION AND SHALL NOT APPLY TO ANY GOODS OR MATERIALS PRODUCED OR MANUFACTURED BY BARNEY'S PUMPS.

   For those items partially or totally manufactured by others and incorporated into our system(s) for resale, we pass along their warranty in total, but do not offer additional warranties, nor certify that they meet the intent of any request.

   Other than the above express warranty, Barney's Pumps makes no other warranties or representations whatsoever. In order for our said warranty to be enforceable, we must first be given a written notice and a reasonable opportunity to inspect the materials/goods alleged to be defective, as well as the installation and use thereof. Warranty is determined solely by the manufacturer of the materials/goods.
9. Service, Repair and Maintenance Work: From time to time, Barney's Pumps may perform service, repair and maintenance work for the customer on materials/goods purchased by the customer and/or provide training to the customers concerning said materials/goods. For all repair and maintenance work performed by Barney's Pumps at Barney's Pumps facility, Barney's Pumps warrants said repair and maintenance work against defects in material and workmanship only for the ninety (90) days from the completion of said repair and maintenance work. For service, repair and maintenance in the field and for training to customers, Barney's Pumps warrants only that said service, repair and maintenance and field training shall be free from defects in materials and workmanship for ninety (90) days.
10. In no event will we be liable for consequential damages, incidental damages, special damages, indirect damages, loss of use, loss of performance, loss of operations, loss of profit, or any other damages with respect to any materials/goods supplied by us, whether solely manufactured by us or others. Barney's Pumps and the original purchaser agree that the sole and exclusive remedy against Barney's Pumps regarding goods and materials manufactured by Barney's Pumps shall be for the repair or replacement of defective parts as provided above.

    Indemnification and/or Hold Harmless is not accepted by Barney's Pumps. This in no way diminishes the rights of either party. It is simply our corporate policy to rely on our extensive warranty outlined above.

effective: 18 September 2013

Multiple Conditions Datasheet

Encompass 2.0 - 18.5.5

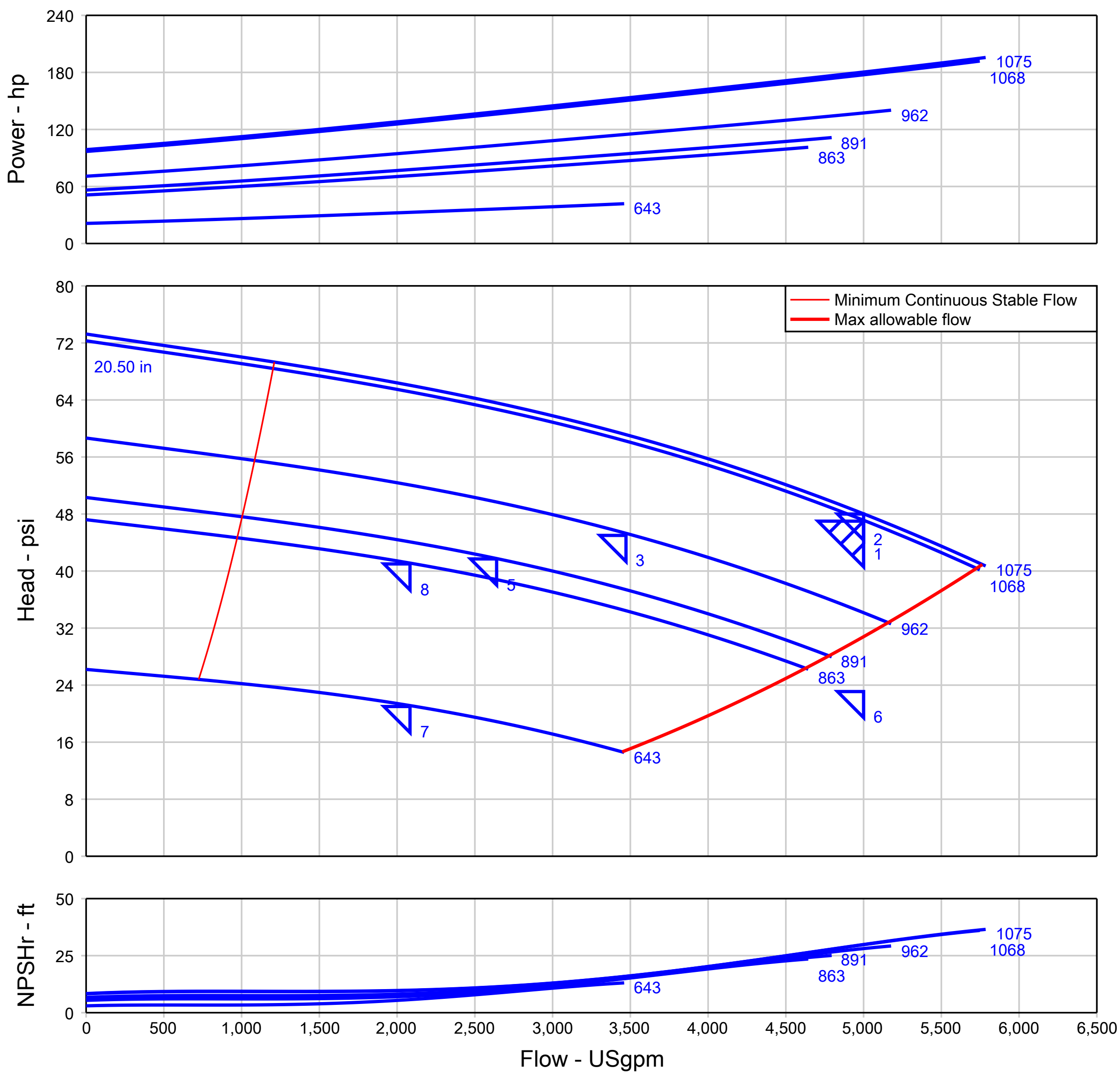
Item number	: Default	Quantity	: 1	Size	: 610 - 10x10x22
Service	:	Quote number	:	Stages	: 1
		Date last saved	: 18 Jan 2019 1:49 PM	Speed, rated	: 1068

Condition #		1	2	3	4	5	6	7	8
Description		-	-	-	-	-	-	-	-
Temperature, max	deg F	68.00	68.00	68.00	-	68.00	68.00	68.00	68.00
Fluid density, rated / max	SG	1.000 / 1.000	1.000 / 1.000	1.000 / 1.000	-	1.000 / 1.000	1.000 / 1.000	1.000 / 1.000	1.000 / 1.000
Viscosity, rated	cP	1.00	1.00	1.00	-	1.00	1.00	1.00	1.00
Primary condition		◉	○	○	-	○	○	○	○
Size		610 - 10x10x22							
Stages		1							
Impeller diameter, rated	in	20.50							
Flow, rated	USgpm	5,000.0	5,000.0	3,472.0	-	2,640.0	5,000.0	2,083.0	2,083.0
Head, rated (requested)	psi	47.00	48.00	45.00	-	41.70	23.10	21.00	41.00
Head, rated (actual)	psi	47.13	48.03	45.29	-	41.76	23.15	21.13	41.12
Suction pressure, rated / max	psi.g	0.00 / 0.00	0.00 / 0.00	0.00 / 0.00	-	0.00 / 0.00	0.00 / 0.00	0.00 / 0.00	0.00 / 0.00
NPSH available, rated	ft	Ample	Ample	Ample	-	Ample	Ample	Ample	Ample
Speed, rated	rpm	1068	1075	962	-	891	862	643	863
Selection status		Acceptable	Acceptable	Acceptable		Acceptable	**Full reject**	Acceptable	Acceptable
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]		1.00 / 1.00 / 1.00 / 1.00	1.00 / 1.00 / 1.00 / 1.00	1.00 / 1.00 / 1.00 / 1.00	-	1.00 / 1.00 / 1.00 / 1.00		1.00 / 1.00 / 1.00 / 1.00	1.00 / 1.00 / 1.00 / 1.00
Efficiency	%	77.45	77.66	79.90	-	76.29		78.32	70.03
NPSH required	ft	29.81	29.88	15.37	-	9.65		5.74	7.21
Power, rated	hp	177	180	115	-	84.29		32.79	71.34

Customer :
Project name :

Multiple Conditions Curve

Encompass 2.0 - 18.5.5



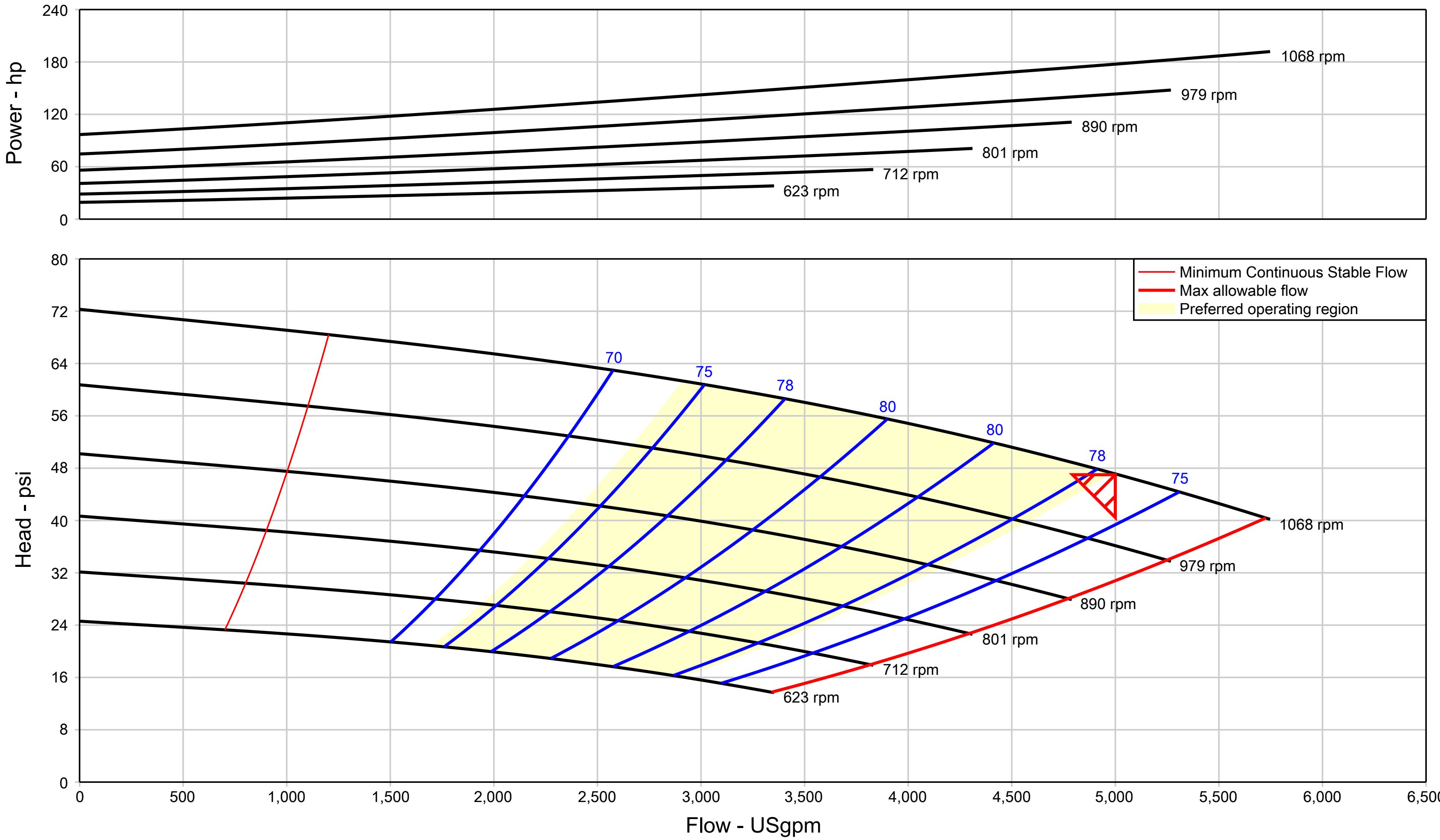
Item number	: Default	Size	: 610 - 10x10x22
Service	:	Stages	: 1
Quantity	: 1	Speed, rated	: 1068 rpm
Quote number	:	Based on curve number	: 16-10x10x22-1175
Date last saved	: 18 Jan 2019 1:49 PM	Efficiency	: 77.45 %
Flow, rated	: 5,000.0 USgpm	Power, rated	: 177 hp
Differential head / pressure, rated	: 47.00 psi	NPSH required	: 29.81 ft
		Viscosity	: 1.00 cP
Fluid density, rated / max	: 1.000 / 1.000 SG	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00

PENTAIR

Customer :
Project name :

Multi-Speed Performance Curve

Encompass 2.0 - 18.5.5



Item number	: Default	Size	: 610 - 10x10x22	Flow, rated	: 5,000.0 USgpm
Service	:	Stages	: 1	Differential head / pressure, rated	: 47.00 psi
Quantity	: 1	Efficiency	: 77.45 %	Speed, rated	: 1068 rpm
Quote number	:	Power, rated	: 177 hp	Impeller diameter, rated	: 20.50 in
Based on curve number	: 16-10x10x22-1175	NPSH required	: 29.81 ft	Fluid density, rated / max	: 1.000 / 1.000 SG
		Frequency	: 60 Hz	Viscosity	: 1.00 cP
Date last saved	: 18 Jan 2019 2:08 PM	Nominal speed	: 1068 rpm	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00

PENTAIR

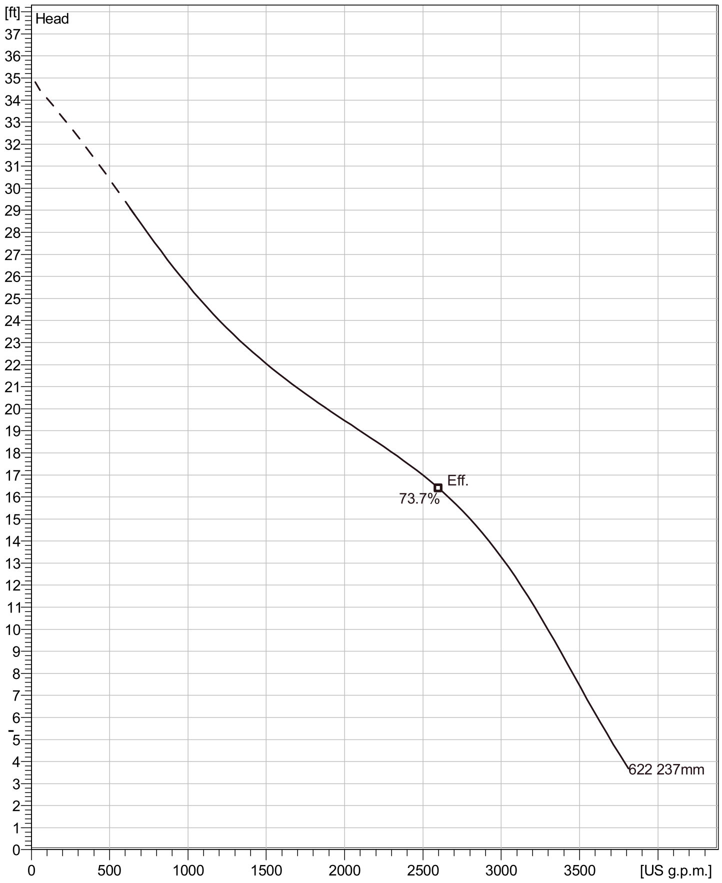
AURORA PUMP
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS 60542
WWW.AURORAPUMP.COM

PHONE: +1-630-859-7000 · FAX:

Other: RAS Pump

NP 3153 LT 3~ 622

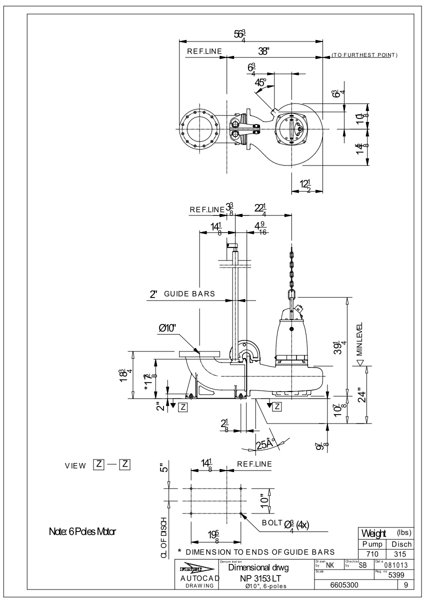
Technical specification



Water, pure

Curve ISO

Installation: P - Semi permanent, Wet



Note: Picture might not correspond to the current configuration.

General

Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Possible to be upgraded with Guide-pin® for even better clogging resistance. Modular based design with high adaptation grade.

Impeller

Impeller material	Hard-Iron ™
Discharge Flange Diameter	9 13/16 inch
Suction Flange Diameter	9 13/16 inch
Impeller diameter	237 mm
Number of blades	3

Motor

Motor #	N3153.095 21-18-6AA-W 15hp FM
Stator variant	5
Frequency	60 Hz
Rated voltage	460 V
Number of poles	6
Phases	3~
Rated power	15 hp
Rated current	22 A
Starting current	101 A
Rated speed	1155 rpm
Power factor	
1/1 Load	0.73
3/4 Load	0.67
1/2 Load	0.55
Motor efficiency	
1/1 Load	87.0 %
3/4 Load	88.0 %
1/2 Load	87.5 %

Configuration

Project	Project ID	Created by	Created on	Last update
			10/17/2018	

NP 3153 LT 3~ 622

Performance curve

Pump

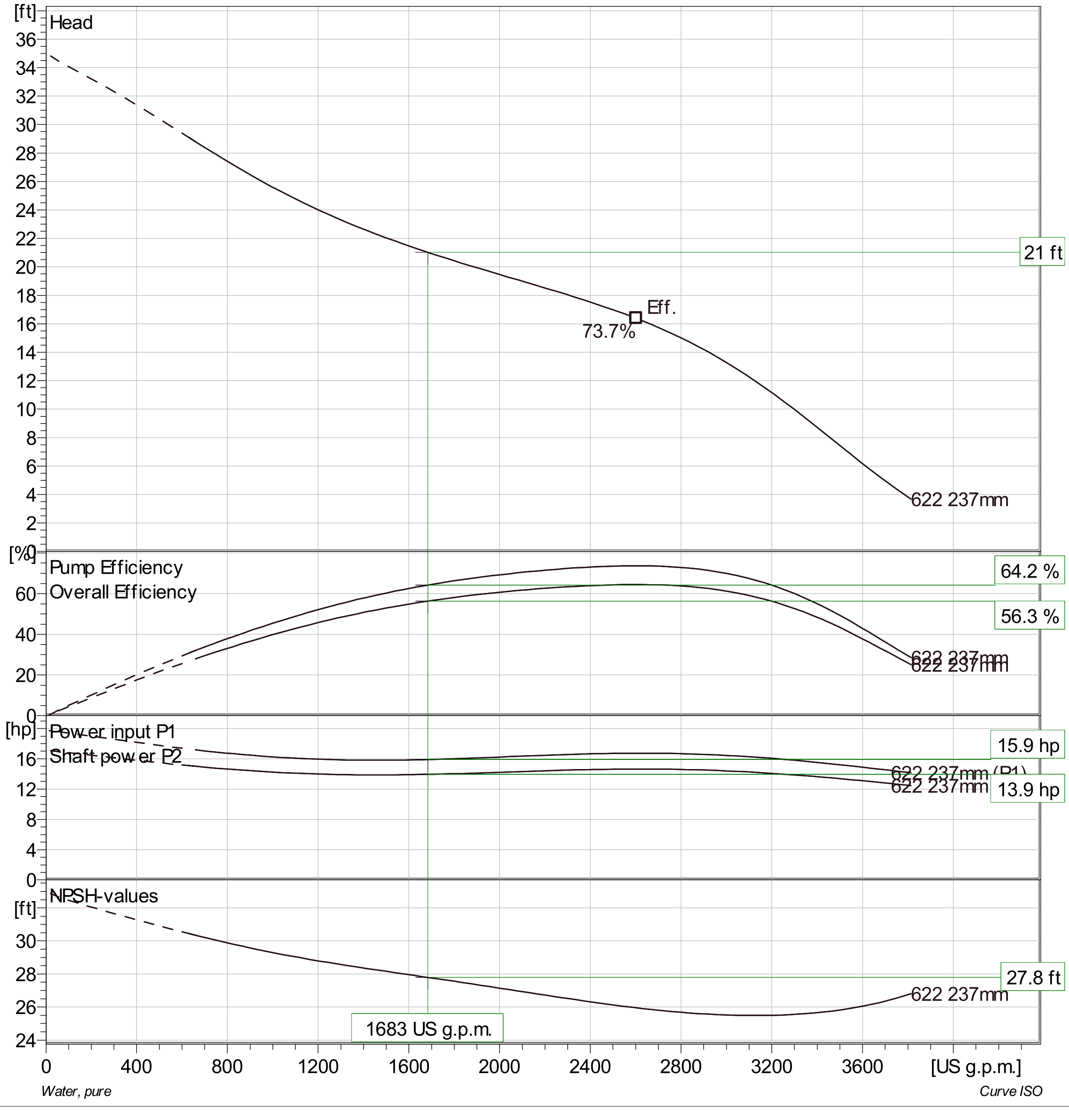
Discharge Flange Diameter	9 13/16 inch
Suction Flange Diameter	250 mm
Impeller diameter	9 5/16"
Number of blades	3

Motor

Motor #	N3153.095 21-18-6AA-W 15hp
Stator variant	5
Frequency	60 Hz
Rated voltage	460 V
Number of poles	6
Phases	3~
Rated power	15 hp
Rated current	22 A
Starting current	101 A
Rated speed	1155 rpm

Power factor	
1/1 Load	0.73
3/4 Load	0.67
1/2 Load	0.55

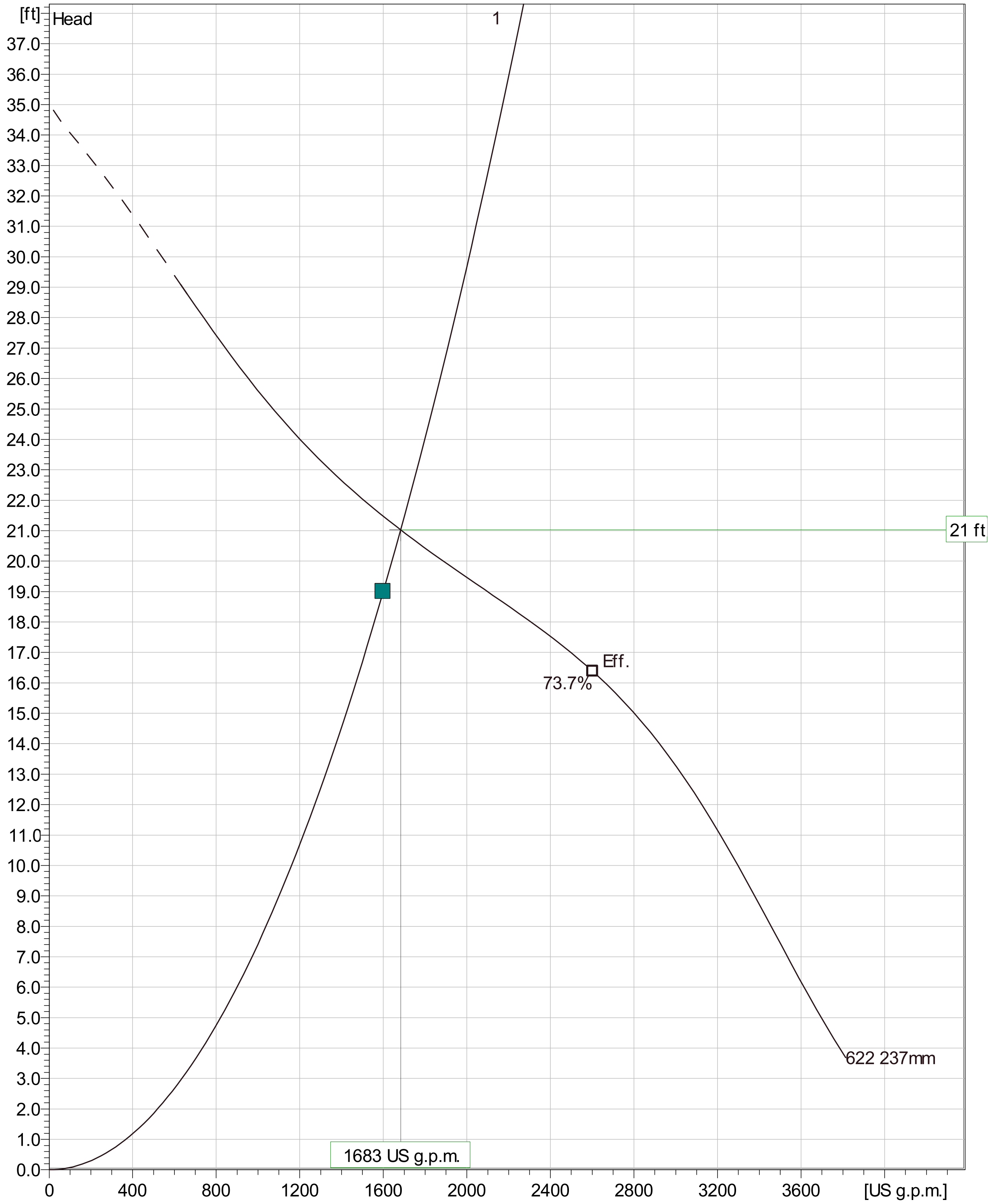
Motor efficiency	
1/1 Load	87.0 %
3/4 Load	88.0 %
1/2 Load	87.5 %



Project	Project ID	Created by	Created on	Last update
			10/17/2018	

NP 3153 LT 3~ 622

Duty Analysis



Water, pure *Curve ISO*

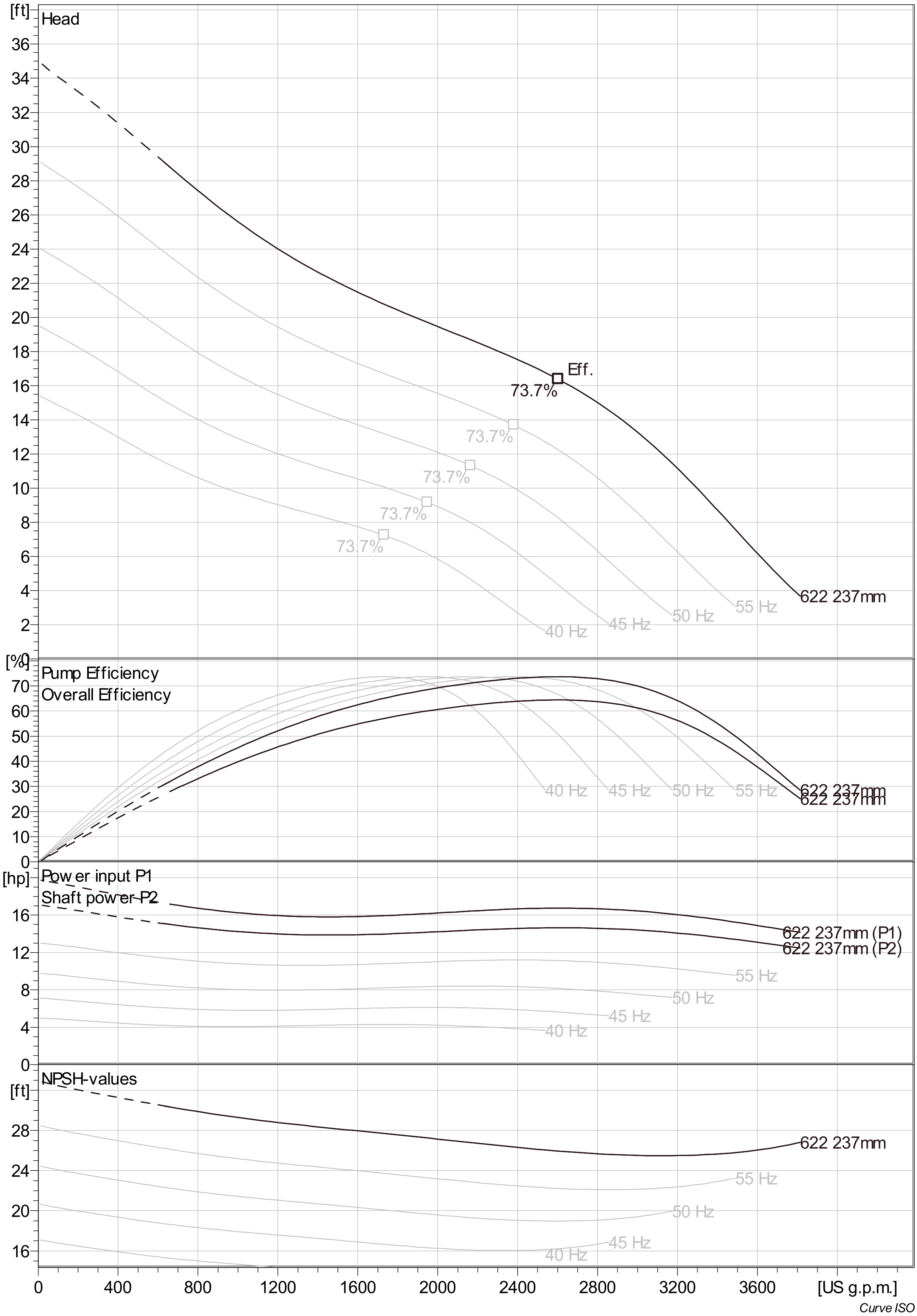
Curve issue 8

Pumps running /System	Individual pump Flow	Head	Shaft power	Total Flow	Head	Shaft power	Pump eff.	Specific energy	NPSHre
1	1680 US g.p.m.	21 ft	13.9 hp	1680 US g.p.m.	21 ft	13.9 hp	64.2 %	117 kWh/US MG	27.8 ft

Project	Project ID	Created by	Created on	Last update
			10/17/2018	

NP 3153 LT 3~ 622

VFD Curve

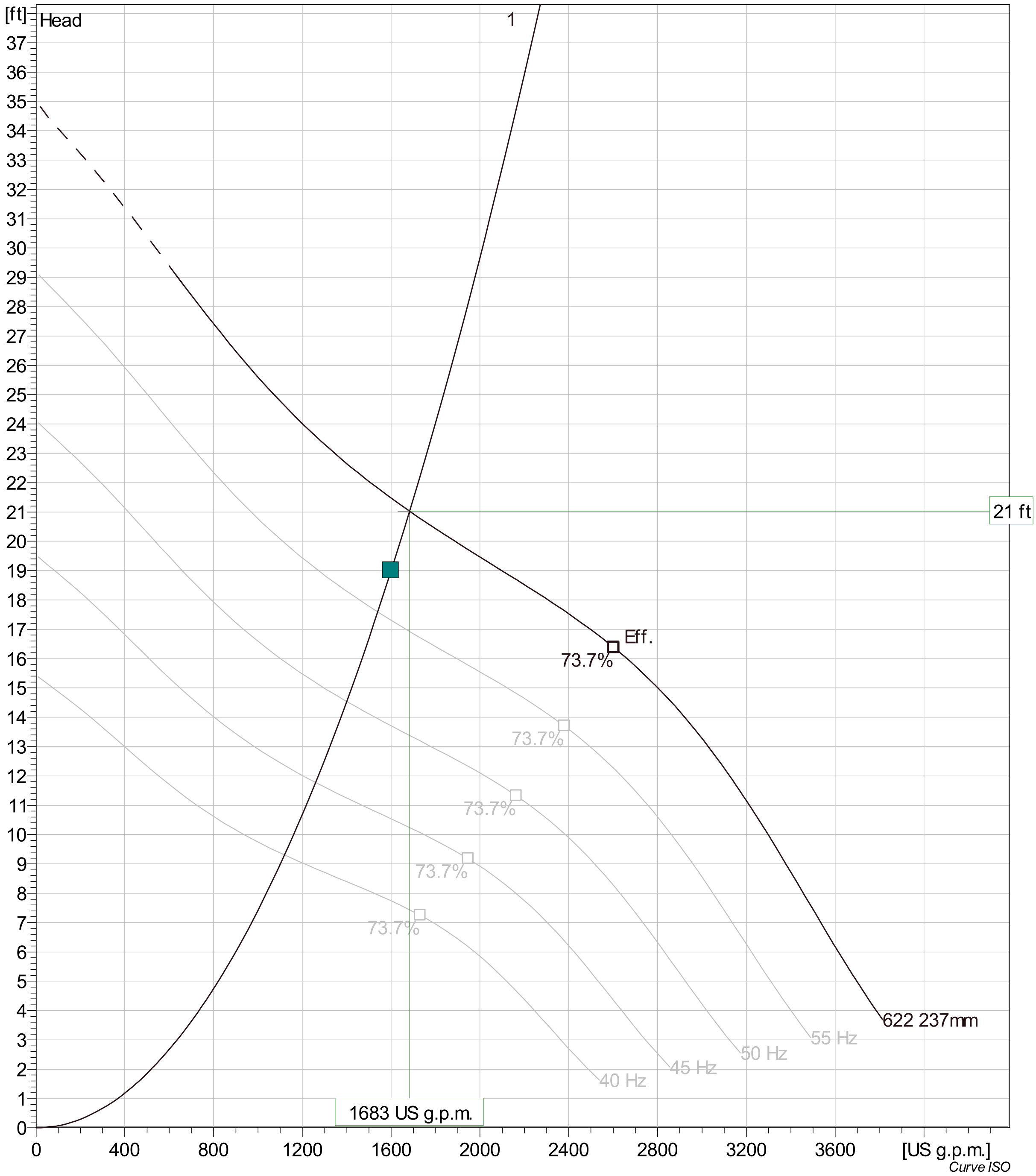


Project	Project ID	Created by	Created on	Last update
			10/17/2018	

xylem

NP 3153 LT 3~ 622
VFD Analysis

FLYGT



Pumps running /System	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hyd eff.	Specific energy	NPSHre
1	60 Hz	1680 US g.p.m.	21 ft	13.9 hp	1680 US g.p.m.	21 ft	13.9 hp	64.2 %	117 kWh/US MG	27.8 ft
1	55 Hz	1540 US g.p.m.	17.6 ft	10.7 hp	1540 US g.p.m.	17.6 ft	10.7 hp	64.2 %	97.4 kWh/US MG	24.1 ft
1	50 Hz	1400 US g.p.m.	14.5 ft	8.02 hp	1400 US g.p.m.	14.5 ft	8.02 hp	64.2 %	80.9 kWh/US MG	20.7 ft
1	45 Hz	1260 US g.p.m.	11.8 ft	5.85 hp	1260 US g.p.m.	11.8 ft	5.85 hp	64.2 %	66.6 kWh/US MG	17.5 ft
1	40 Hz	1120 US g.p.m.	9.31 ft	4.11 hp	1120 US g.p.m.	9.31 ft	4.11 hp	64.2 %	54.4 kWh/US MG	14.5 ft

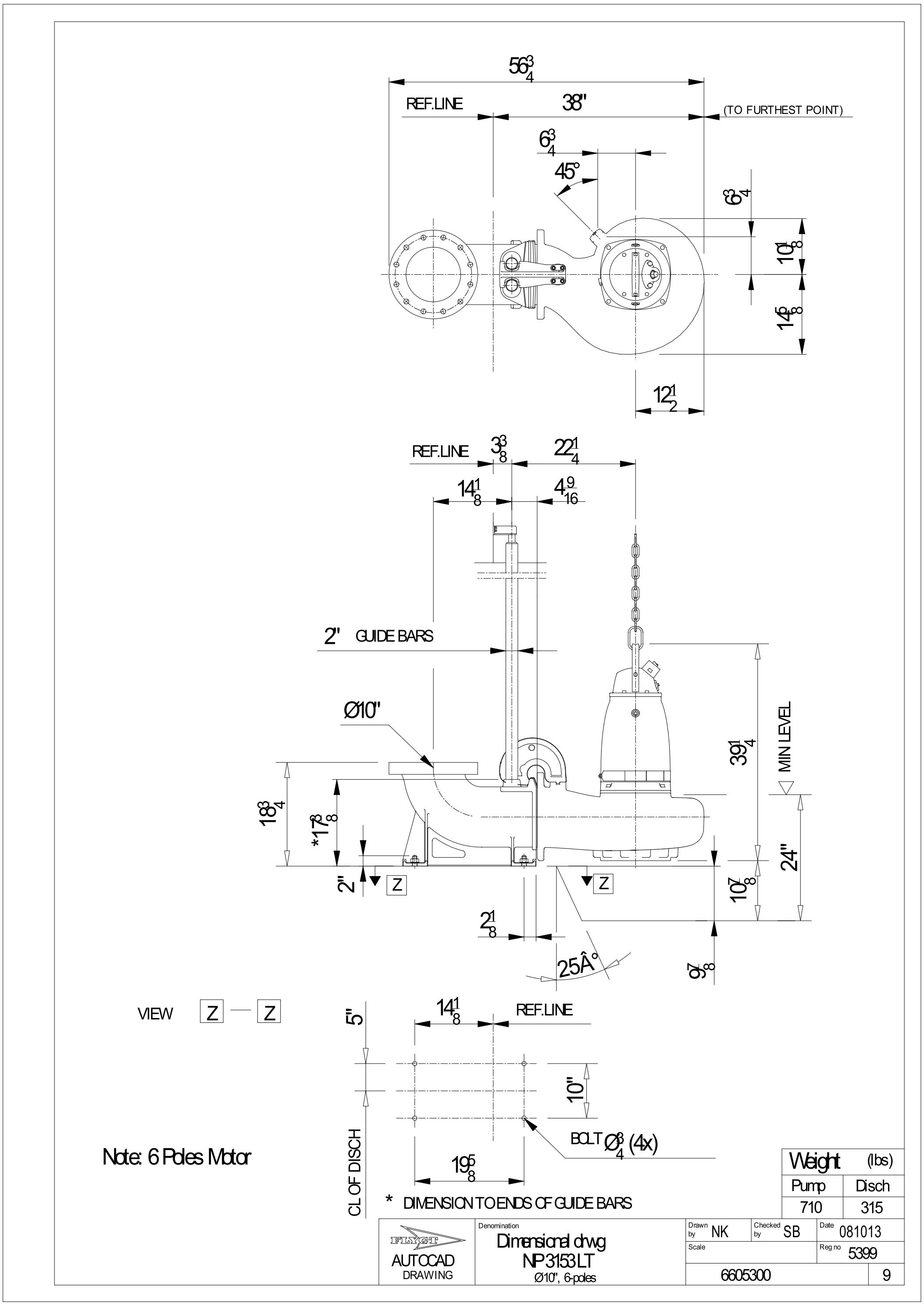
Project	Project ID	Created by	Created on	Last update
			10/17/2018	

xylem

NP 3153 LT 3~ 622

Dimensional drawing

FLYGT



Project	Project ID	Created by	Created on	Last update
			10/17/2018	

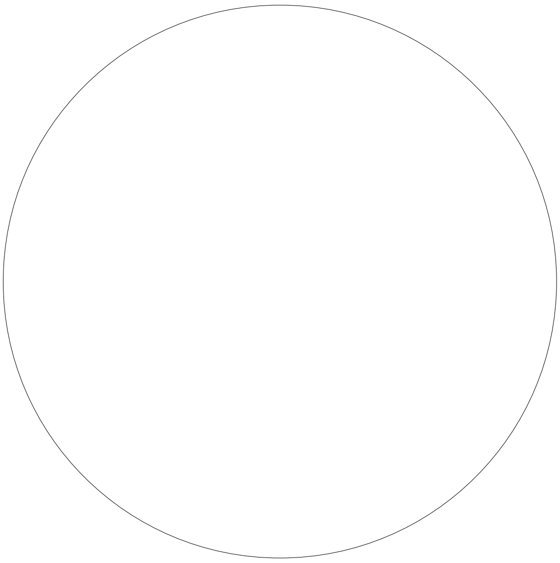
Version 10

NP 3153 LT 3~ 622

Life cycle costs (LCC)

Total lifetime	15	Inflation rate (rate of price increases)	2 %
Annual operating time	5600	Interest rate (for investment)	3 %
Energy cost per kWh	0.00 USD		
Power input P1			

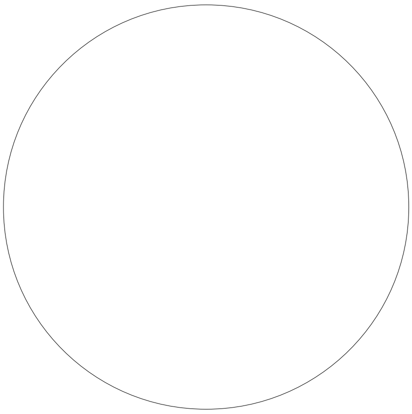
Total costs



0%	**0.00 USD**	Energy
0%	**0.00 USD**	Investment costs
0%	**0.00 USD**	Installation & commissioning
0%	**0.00 USD**	Operating cost
0%	**0.00 USD**	Maintenance & repair
0%	**0.00 USD**	Downtime
0%	**0.00 USD**	Environmental
0%	**0.00 USD**	Decommissioning

0.00 USD

First year costs

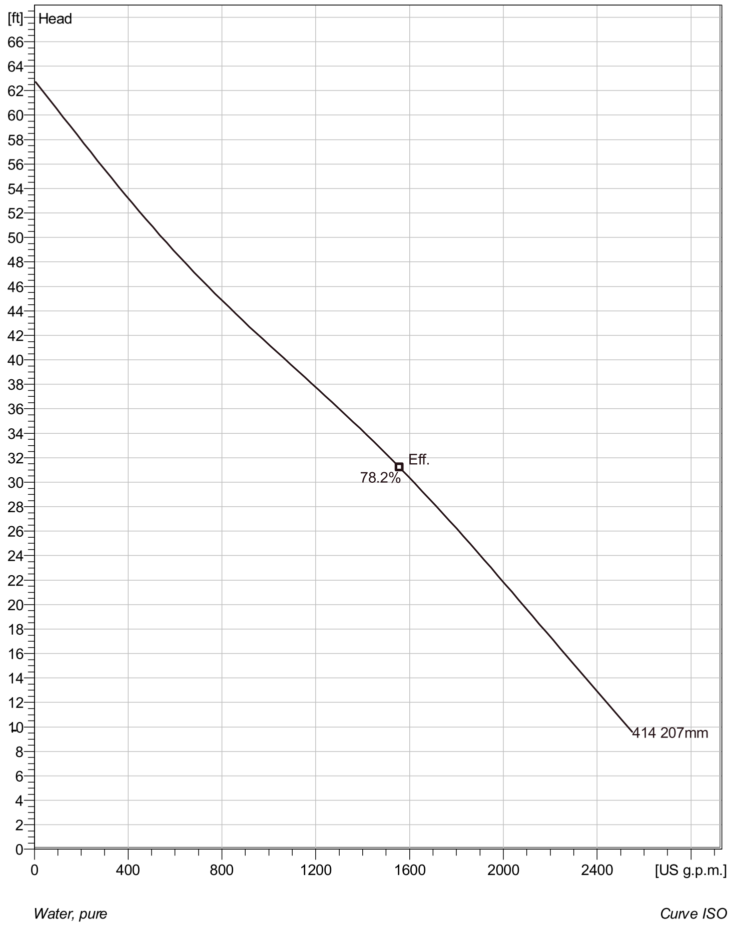


0%	**0.00 USD**	Energy (1st year)
0%	**0.00 USD**	Investment costs (1st year)
0%	**0.00 USD**	Installation & commissioning (1st year)
0%	**0.00 USD**	Operating cost (1st year)
0%	**0.00 USD**	Maintenance & repair (1st year)
0%	**0.00 USD**	Downtime (1st year)
0%	**0.00 USD**	Environmental (1st year)
0%	**0.00 USD**	Decommissioning (1st year)

0.00 USD

NT 3153 LT 3~ 414

Technical specification



Note: Picture might not correspond to the current configuration.

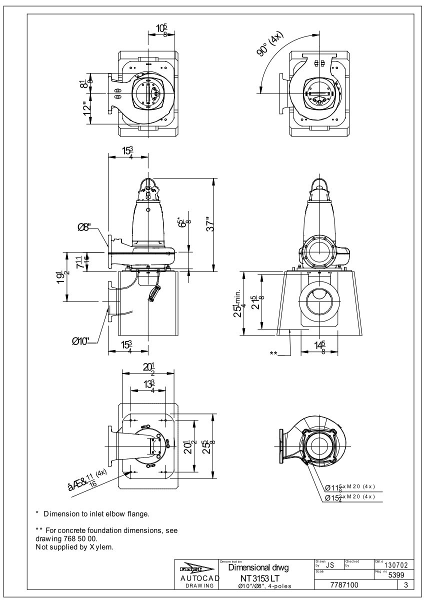
General

Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Possible to be upgraded with Guide-pin® for even better clogging resistance. Modular based design with high adaptation grade.

Impeller

Impeller material	Grey cast iron
Discharge Flange Diameter	7 7/8 inch
Suction Flange Diameter	7 7/8 inch
Impeller diameter	207 mm
Number of blades	2

Installation: T - Vertical Permanent, Dry



Motor

Motor #	N3153.800 21-18-4XS-D IE3 17hp Standard
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	17 hp
Rated current	18 A
Starting current	157 A
Rated speed	1800 rpm
Power factor	
1/1 Load	0.96
3/4 Load	0.95
1/2 Load	0.90
Motor efficiency	
1/1 Load	92.5 %
3/4 Load	92.4 %
1/2 Load	90.9 %

Configuration

Project	Project ID	Created by	Created on	Last update
			8/22/2018	

NT 3153 LT 3~ 414

Performance curve

Pump

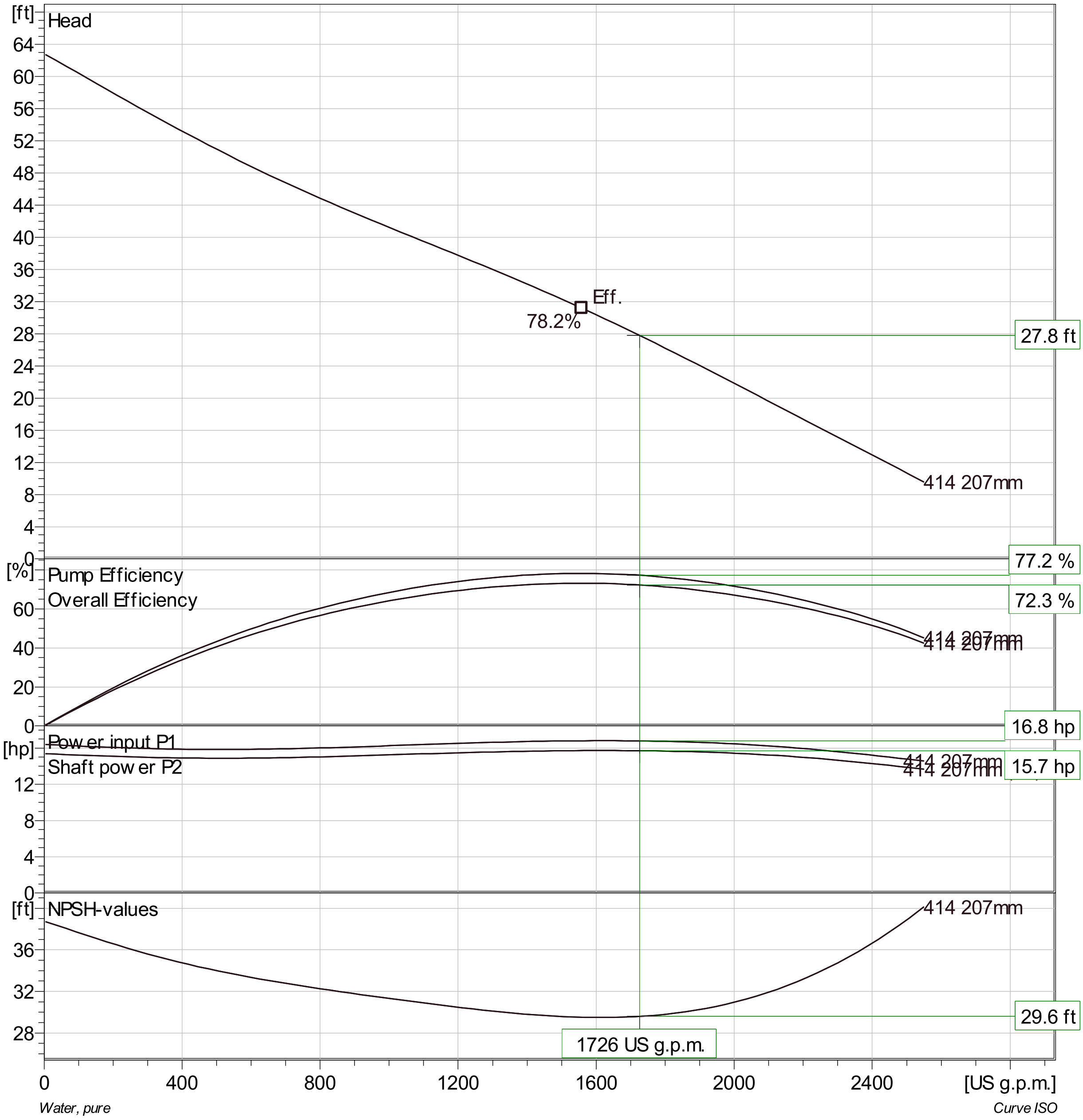
Discharge Flange Diameter	7 7/8 inch
Suction Flange Diameter	200 mm
Impeller diameter	8 1/8"
Number of blades	2

Motor

Motor #	N3153.800 21-18-4XS-D IE3 17hp
Stator variant	1
Frequency	60 Hz
Rated voltage	460 V
Number of poles	4
Phases	3~
Rated power	17 hp
Rated current	18 A
Starting current	157 A
Rated speed	1800 rpm

Power factor	
1/1 Load	0.96
3/4 Load	0.95
1/2 Load	0.90

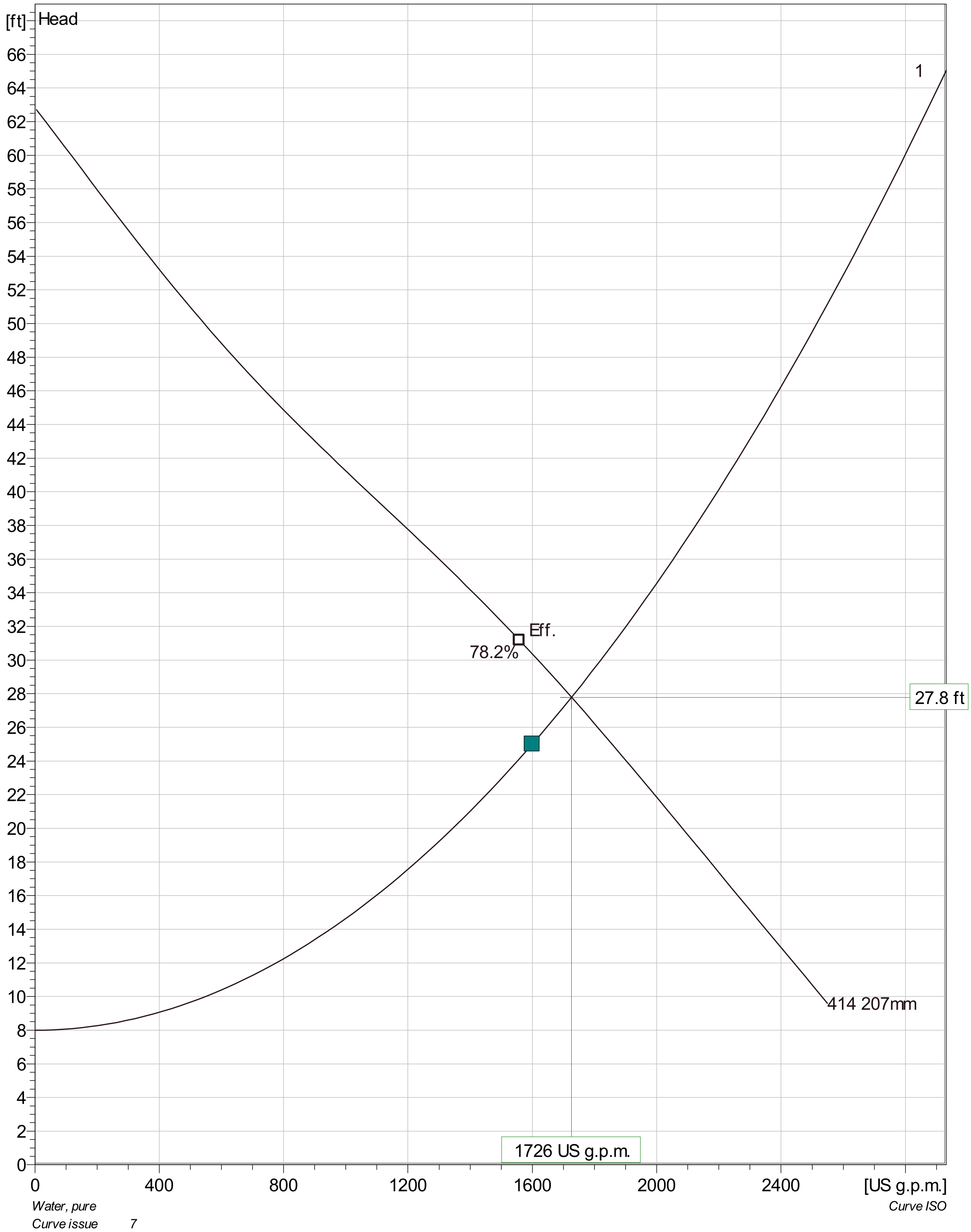
Motor efficiency	
1/1 Load	92.5 %
3/4 Load	92.4 %
1/2 Load	90.9 %



Project	Project ID	Created by	Created on	Last update
			8/22/2018	

NT 3153 LT 3~ 414

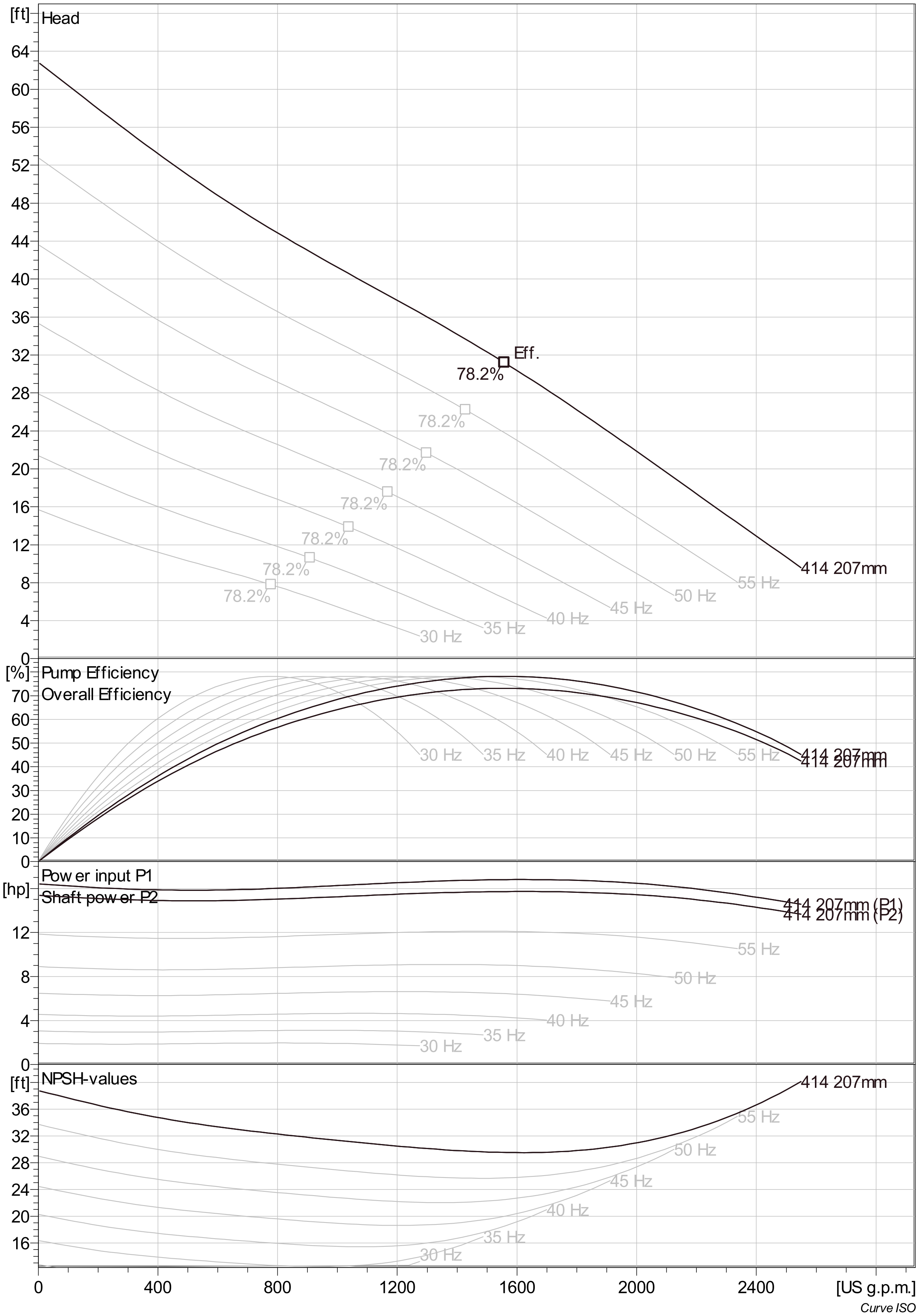
Duty Analysis



Pumps running /System	Individual pump Flow	Head	Shaft power	Total Flow	Head	Shaft power	Pump eff.	Specific energy	NPSHre
1	1730 US g.p.m.	27.8 ft	15.7 hp	1730 US g.p.m.	27.8 ft	15.7 hp	77.2 %	121 kWh/US MG	29.6 ft

Project	Project ID	Created by	Created on	Last update
			8/22/2018	

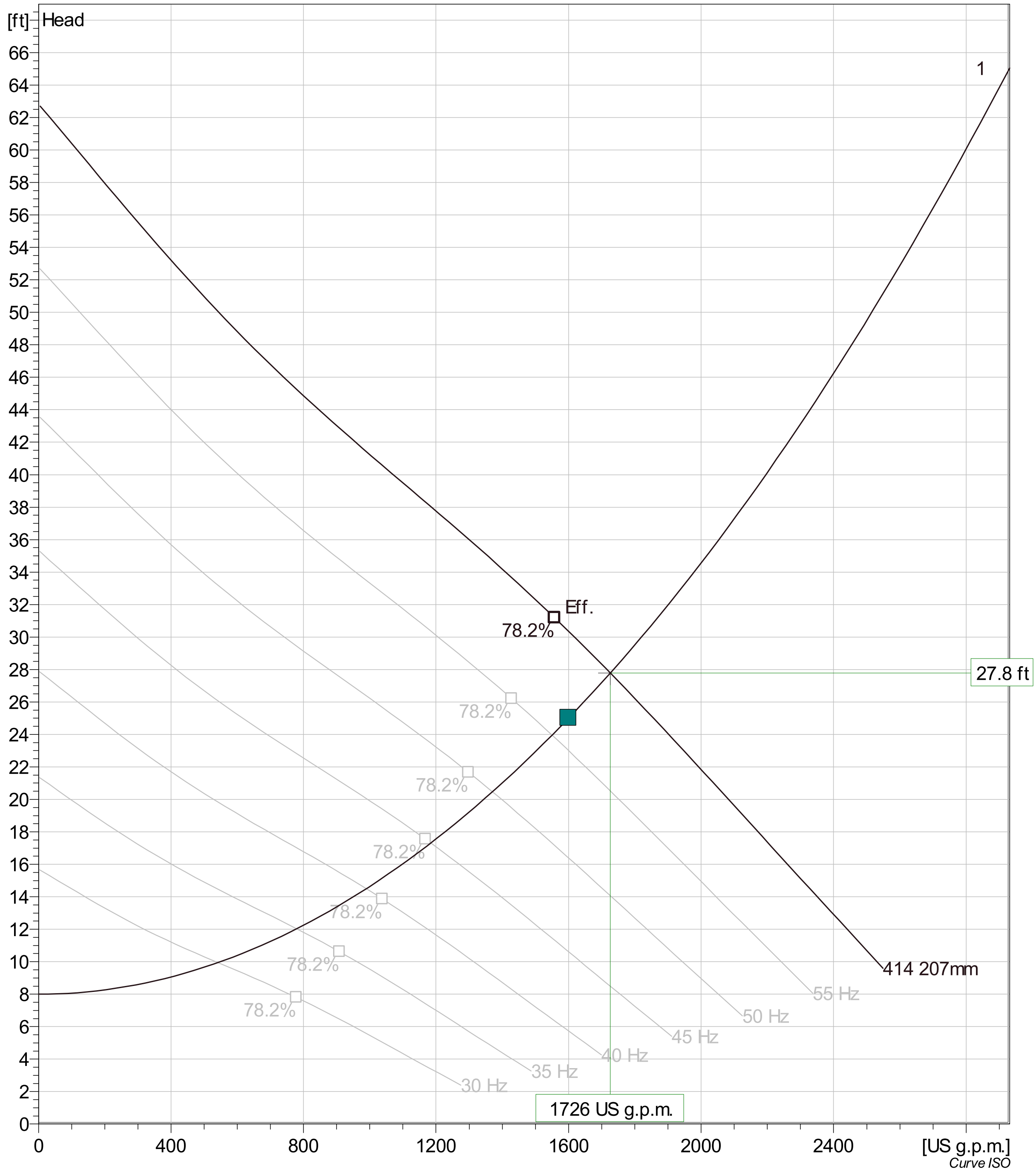
NT 3153 LT 3~ 414
VFD Curve



Project	Project ID	Created by	Created on	Last update
			8/22/2018	

NT 3153 LT 3~ 414

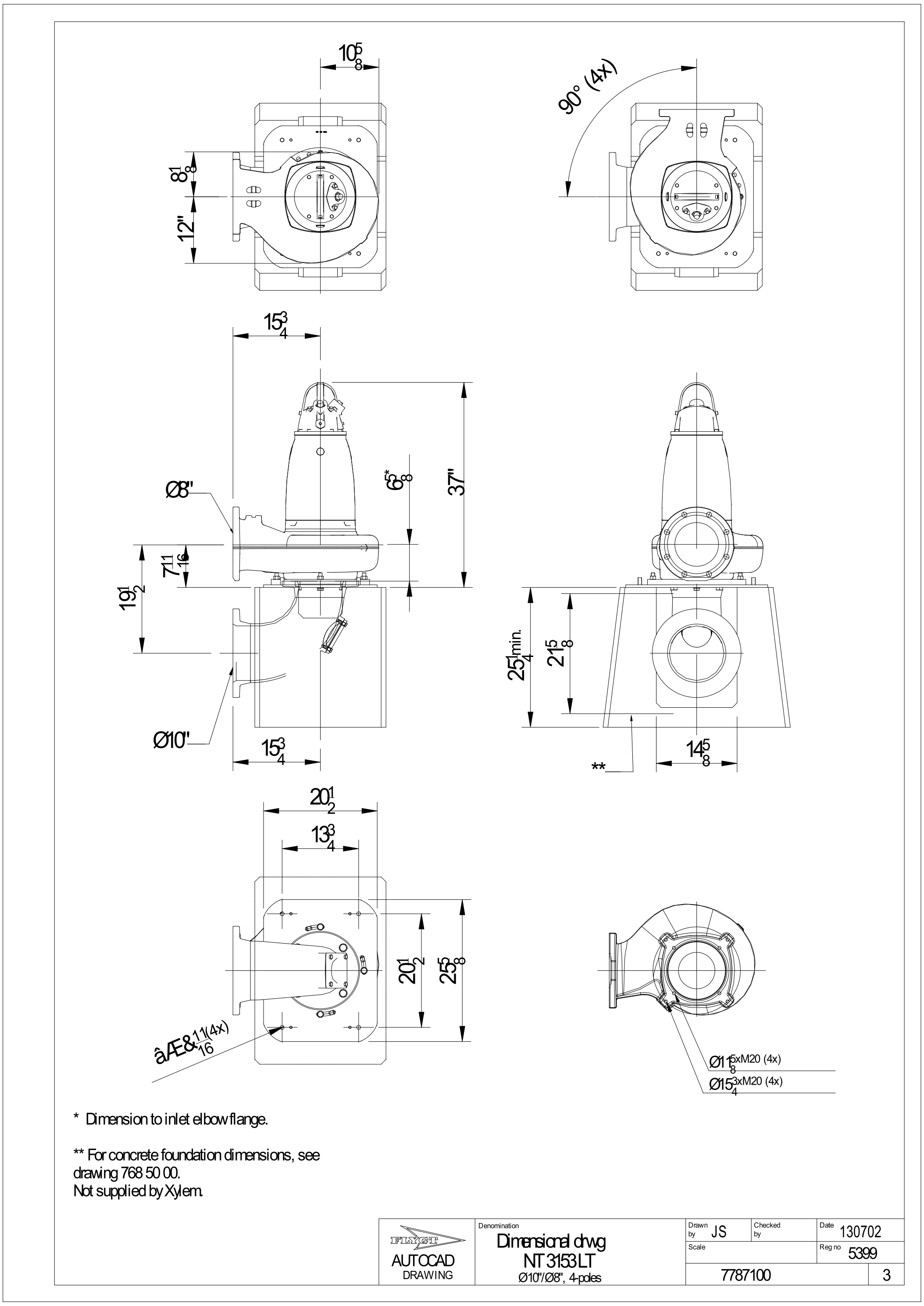
VFD Analysis



Pumps running /System	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hyd eff.	Specific energy	NPSHre
1	60 Hz	1730 US g.p.m.	27.8 ft	15.7 hp	1730 US g.p.m.	27.8 ft	15.7 hp	77.2 %	121 kWh/US MG	29.6 ft
1	55 Hz	1550 US g.p.m.	24 ft	12.1 hp	1550 US g.p.m.	24 ft	12.1 hp	77.6 %	105 kWh/US MG	25.7 ft
1	50 Hz	1370 US g.p.m.	20.5 ft	9.1 hp	1370 US g.p.m.	20.5 ft	9.1 hp	77.9 %	92.9 kWh/US MG	22 ft
1	45 Hz	1180 US g.p.m.	17.3 ft	6.63 hp	1180 US g.p.m.	17.3 ft	6.63 hp	78.2 %	79.2 kWh/US MG	18.6 ft
1	40 Hz	989 US g.p.m.	14.5 ft	4.65 hp	989 US g.p.m.	14.5 ft	4.65 hp	78 %	65.2 kWh/US MG	15.5 ft
1	35 Hz	779 US g.p.m.	12 ft	3.1 hp	779 US g.p.m.	12 ft	3.1 hp	76.6 %	55.3 kWh/US MG	12.7 ft

NT 3153 LT 3~ 414

Dimensional drawing



Project	Project ID	Created by	Created on	Last update
			8/22/2018	

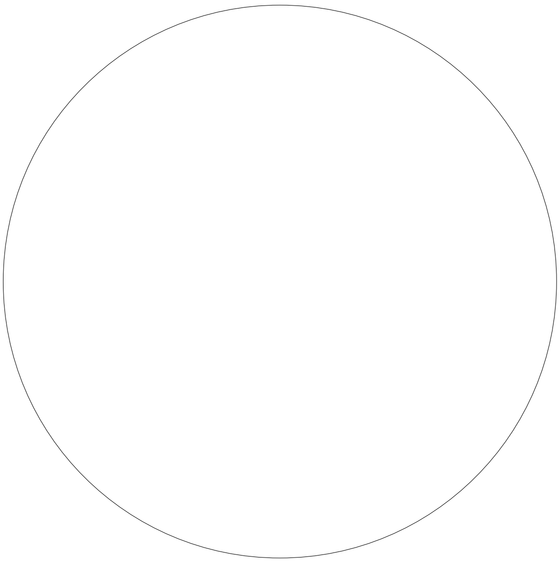
Version 10

NT 3153 LT 3~ 414

Life cycle costs (LCC)

Total lifetime	15	Inflation rate (rate of price increases)	2 %
Annual operating time	5600	Interest rate (for investment)	3 %
Energy cost per kWh	0.00 USD		
Power input P1			

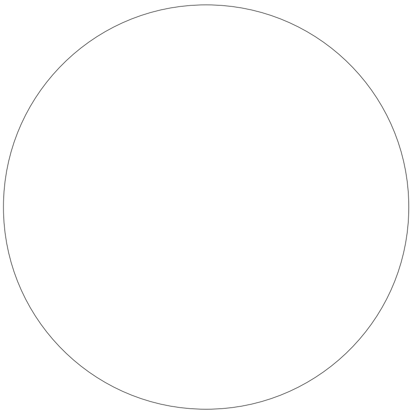
Total costs



0%	**0.00 USD**	Energy
0%	**0.00 USD**	Investment costs
0%	**0.00 USD**	Installation & commissioning
0%	**0.00 USD**	Operating cost
0%	**0.00 USD**	Maintenance & repair
0%	**0.00 USD**	Downtime
0%	**0.00 USD**	Environmental
0%	**0.00 USD**	Decommissioning

0.00
USD

First year costs



0%	**0.00 USD**	Energy (1st year)
0%	**0.00 USD**	Investment costs (1st year)
0%	**0.00 USD**	Installation & commissioning (1st year)
0%	**0.00 USD**	Operating cost (1st year)
0%	**0.00 USD**	Maintenance & repair (1st year)
0%	**0.00 USD**	Downtime (1st year)
0%	**0.00 USD**	Environmental (1st year)
0%	**0.00 USD**	Decommissioning (1st year)

0.00
USD

Disclaimer: The calculations and the results are based on user input values and general assumptions and provide only estimated costs for the input data. Xylem inc can therefore not guarantee that the estimated savings will actually occur.

Project	Project ID	Created by	Created on	Last update
			8/22/2018	

Steele, Muriel/CLT

From: Reyes, Rick - Xylem <Rick.Reyes@Xyleminc.com>
Sent: Wednesday, October 17, 2018 11:14 AM
To: Steele, Muriel/CLT
Subject: [EXTERNAL] RE: Flygt Contact for Pumps in Key West
Attachments: Key West WWTP RAS.pdf

Hello Muriel,

Attached please find a pump curve for your review. Please look it over and let me know what you think. Budgetary price for this pump is $20,000.

Please let me know if there is anything I can do to help.

Best regards,

Rick

Rick Reyes
Sales Representative
Flygt Products
3295 ST Charles Way
Boca Raton, FL 33434
M: 561-699-4077
rick.reyes@xyleminc.com

Other: Screens

CONTROLS SELECTION GUIDE

1. Main control panel power feed?

   ☐ 480V 3Ph ☐ 230V 3Ph ☐ 208V 3Ph ☐ 240V 1Ph ☐ 120V 1Ph

2. For multiple equipment installations?

   ☐ Separate main control panel(s) ☐ Combined main control panel(s)

3. Is the main control panel indoors or outdoors?
   Verify that the intended main control panel location is in an unclassified area.

   ☐ Indoors ☐ Outdoors

   1. NEMA rating? ☐ NEMA 12 ☐ NEMA 4X
   2. Panel material? ☐ 304SSTL ☐ 316SSTL ☐ Painted CS
   3. Climate controlled room if indoors?

      ____

   4. Under cover or shade structure if located outdoors?

      ____

   5. Panel size restrictions?

      ____

   6. Highest ambient temperatures?

      ____

4. Internet access at main control panel?

   ☐ None ☐ Wired ☐ Wireless

5. Interest in remote access and fault notifications via email/text (Internet access not required)?

   ☐ Yes ☐ No

6. Level control package preferred? (See Application Guide Below)

   ☐ A. No Level Control
   ☐ B. Single Upstream Float
   ☐ C. Dual Upstream Float
   ☐ D. Upstream Level Transducer
   ☐ E. Upstream/Downstream Level Transducer

7. Logic Control

   ☐ Relay
   ☐ Unitronics PLC
   ☐ Allen Bradley MicroLogix
   ☐ Other

CONTROLS APPLICATION GUIDE

A. NO LEVEL CONTROL – CYCLE TIMER/REMOTE START

WHEN:

- Plants that see low flows and where the peak flows don't vary from average flows significantly. Debris loading should be consistent. Optimum cycle timing can be achieved based on performance over time.
- Also suitable for pump station applications where the Flexrakes© can be cleared (exercised) using the cycle timer, but continuous operation initiated using the remote start input prior to starting the pumps.

WHY:

- Very simple, maintenance free, low cost impact

B. SINGLE UPSTREAM FLOAT WITH CYCLE TIMER/REMOTE START

WHEN:

- Plants that experience low but varying flows and consistent debris loading.
  - At very low flow conditions, float not tipped, the FlexRake© clears (exercises) based on the cycle timer. At higher flows, float tipped, the FlexRake© runs continuously at low speed.

WHY:

- Simple, low maintenance, low cost Impact

C. DUAL UPSTREAM FLOAT WITH CYCLE TIMER/REMOTE START

WHEN:

- Plants that experience varying flows and/or debris loading.
  - At very low flow conditions, lower float not tipped, the FlexRake© clears (exercises) based on the cycle timer. At higher flows, lower float tipped, the FlexRake© runs continuously at low speed. As flow or debris loading increases, level will build until the upper float tips, increasing the FlexRake© speed to high.

WHY:

- Simple, low maintenance, low cost impact

D. UPSTREAM LEVEL TRANSDUCER WITH CYCLE TIMER/REMOTE START

WHEN:

- Functionally similar to the dual upstream float. Optional back up float switches are common.

WHY:

- Transducers can allow for easier level setpoint adjustability as well as multiple level setpoints and speed settings.
- Ultrasonic transducers provide for level sensing that is not in the flow.
- Submersible transducers require the addition of a PLC. They are generally easier to set up but do require occasional cleaning. Often used in very tight channels or where foaming is a concern.
- This is a more complex solution and may require a higher level of site expertise and training. It is also more expensive than float level control and those costs can vary widely depending on the transducer technology used and the PLC platform specified.

E. UPSTREAM AND DOWNSTREAM LEVEL TRANSDUCER WITH CYCLE TIMER/REMOTE START

WHEN:

- For plants with high and/or highly varying flows and debris. FlexRake© 3mm and FlexRake© Sentinel PFE applications
  - The use of upstream and downstream level transducers allow the differential level across a screen to be calculated. Differential level is a direct indication of screen blinding.

WHY:

- Differential level can be used to optimize FlexRake© performance. Generally, as the differential level increases, so does the speed of the FlexRake©. Upstream level is also used to increase the speed of the FlexRake©.
- Again, this is a more complex solution and may require a higher level of site expertise and training. It also has a higher cost impact than float level control and those costs can vary widely depending on the transducer technology used and the PLC platform specified.

Steele, Muriel/CLT

From: larry.hickey@equipmentplusinc.com
Sent: Friday, October 12, 2018 12:10 PM
To: Steele, Muriel/CLT
Cc: Mark Hickok
Subject: [EXTERNAL] P9943 Key West WWTP, FL Prelim Budget
Attachments: Controls Selection Guide.docx; FPFS TEMPLATE.DWG; P9943 Key West WWTP, FL Prelim Budget.pdf

Importance: High

Muriel,

Attached is the preliminary budget costs for the ¼" Bar screen option for Key West WWTP.

The Hydraulic Calculations are for 15MGD at each screen and 7.5MGD for the 2'6" and 3'2" screen. All calculations were run with the upstream water depth of 4ft. Attached also is Average Flow of 3.8MGD with the recommended downstream water level of 1ft. I have attached the Controls Selection Guide and Template drawings for your reference.

We will be sending the perforated plate screen quote next week.

If you should have any questions, let me know.

Sincerest regards,

Larry Hickey
Equipment Plus Solutions, Inc.
6600 South Magnolia Avenue
Ocala, FL 34476

352.895.2656 cell
352.237.1869 ofc

Larry.Hickey@equipmentplusinc.com

Please visit our web site at www.equipmentplusinc.com

Steele, Muriel/CLT

From: larry.hickey@equipmentplusinc.com
Sent: Thursday, October 18, 2018 6:41 PM
To: Steele, Muriel/CLT
Cc: Mark Hickok
Subject: [EXTERNAL] P9943 Key West WWTP FL
Attachments: P9943 Key West WWTP FL Prelim Budget for Sentinel Screens.pdf

Muriel,

Attached please find the Sentinel PFE perforated plate screen quote for the Key West WWTP project. Pre-screening for these screens is not required but we do recommend the use of a washer compactor. I see in the site drawings that they will be discharging onto a conveyor and then into a washer compactor. This is an acceptable solution for this equipment.

Please keep in mind if the operating water levels change, we will need to recalculate the hydraulics for best fit. The maximum recommended flow for each channel is as follows:

- 5 MGD for the 2.5ft channel width
- 7 MGD for the 3' 2" channel width
- 10 MGD for the 4ft channel width

Two Sentinel screens would need to be in operation to manage the full peak flow of 15 MGD.

Sincerest regards,

Larry Hickey
Equipment Plus Solutions, Inc.
6600 South Magnolia Avenue
Ocala, FL 34476

352.895.2656 cell
352.237.1869 ofc

Larry.Hickey@equipmentplusinc.com

Please visit our web site at www.equipmentplusinc.com

Date: October 18, 2018

Project: Key West WWTP, FL **Proposal Number:** P9943

PRELIMINARY BUDGET EQUIPMENT SCOPE - Option #2

To: Key West WWTP, FL

From: **Your Duperon® Team**
Tammy Blanchard
Sales Project Manager
(989) 754-8800
tblanchard@duperon.com

Rep: Larry Hickey
Equipment Plus Solutions, Inc.
(352)237-1869
Larry.Hickey@equipmentplusinc.com

Mark Hickok
Regional Sales Manager
(989) 412-0289
mhickok@duperon.com

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: October 18, 2018

Project: Key West WWTP, FL **Proposal Number:** P9943

PRELIMINARY BUDGET EQUIPMENT SCOPE - Option #2

Thank you for considering **Duperon®** system solutions for your project. We appreciate the opportunity to provide you with a **Preliminary Budget Equipment Scope**. Please do not hesitate to contact your **Duperon® Team** with any questions as we work with you through the design process and ensure a successful project.

Equipment Scope

SCREENS:

QTY	UNIT	DESCRIPTION		
3	EA	**Duperon® FlexRake® - Front Clean Front-Return**		
		Model:	Sentinel PFE - Perforated Fixed Element Screen	
		Enclosure (& Material):	Fully Enclosed (304)	
		Nom Width x Length:	2.5ft x 15ft 3ft x 15ft 4ft x 15ft	Feet
		Clear Opening Size:	6 mm	
		Angle of Installation:	0	Deg. from Vertical
		Material Construction:	316	SSTL

Notes: 316SSTL custom close outs included for 3' 2" channel width.

Screenings Processing

QTY	UNIT	DESCRIPTION
		Provided by others

CONTROLS

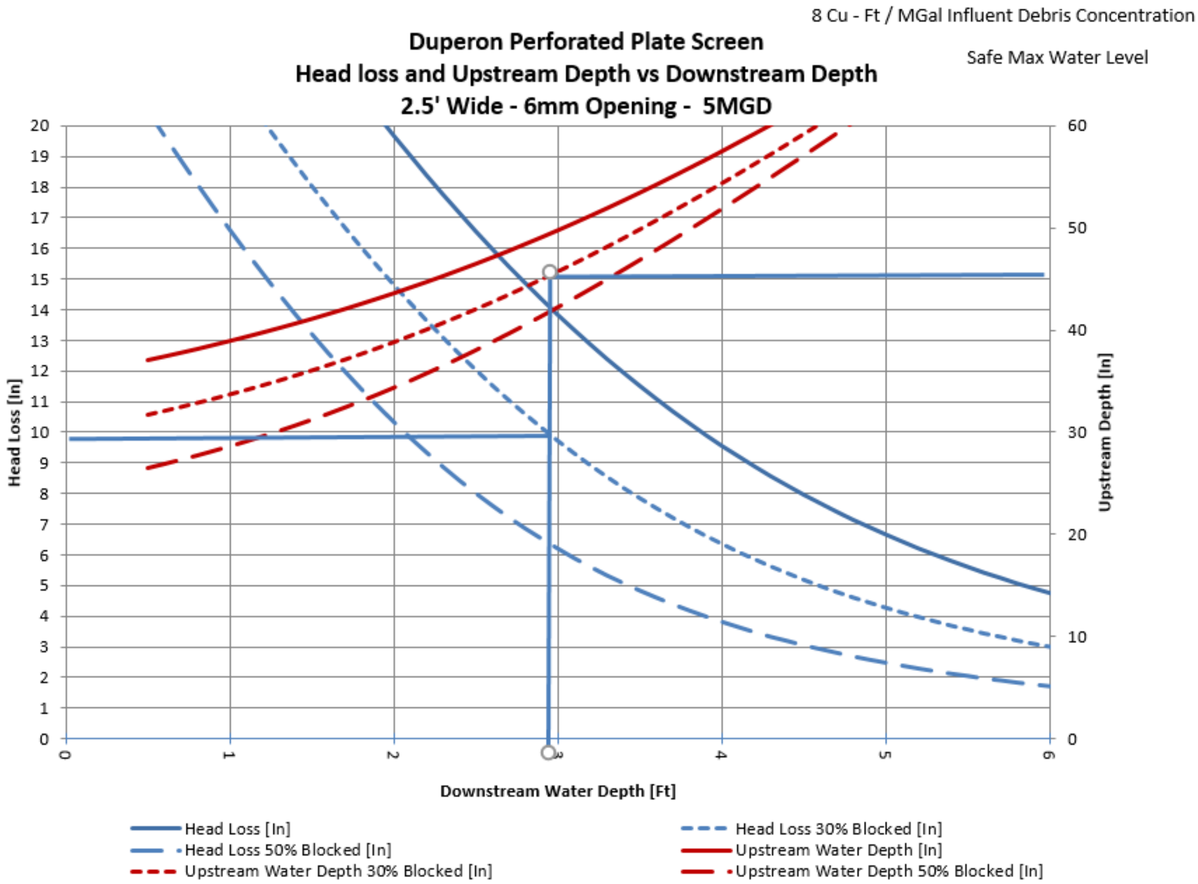
QTY	UNIT		
1	EA	**Main Control Panel:**	**3 - Sentinel PFE Perforated Fixed Element Screen**
		Power:	480V/3ph/60hz
		Panel Rating:	NEMA 4X
		PLC/Relay Based:	PLC - Unitronics V350
		Screen Instrumentation:	(2) Transducers w/ HydroRanger
		Local Pushbutton Station(s):	Three Button (E-Stop/Run/Jog Rev)

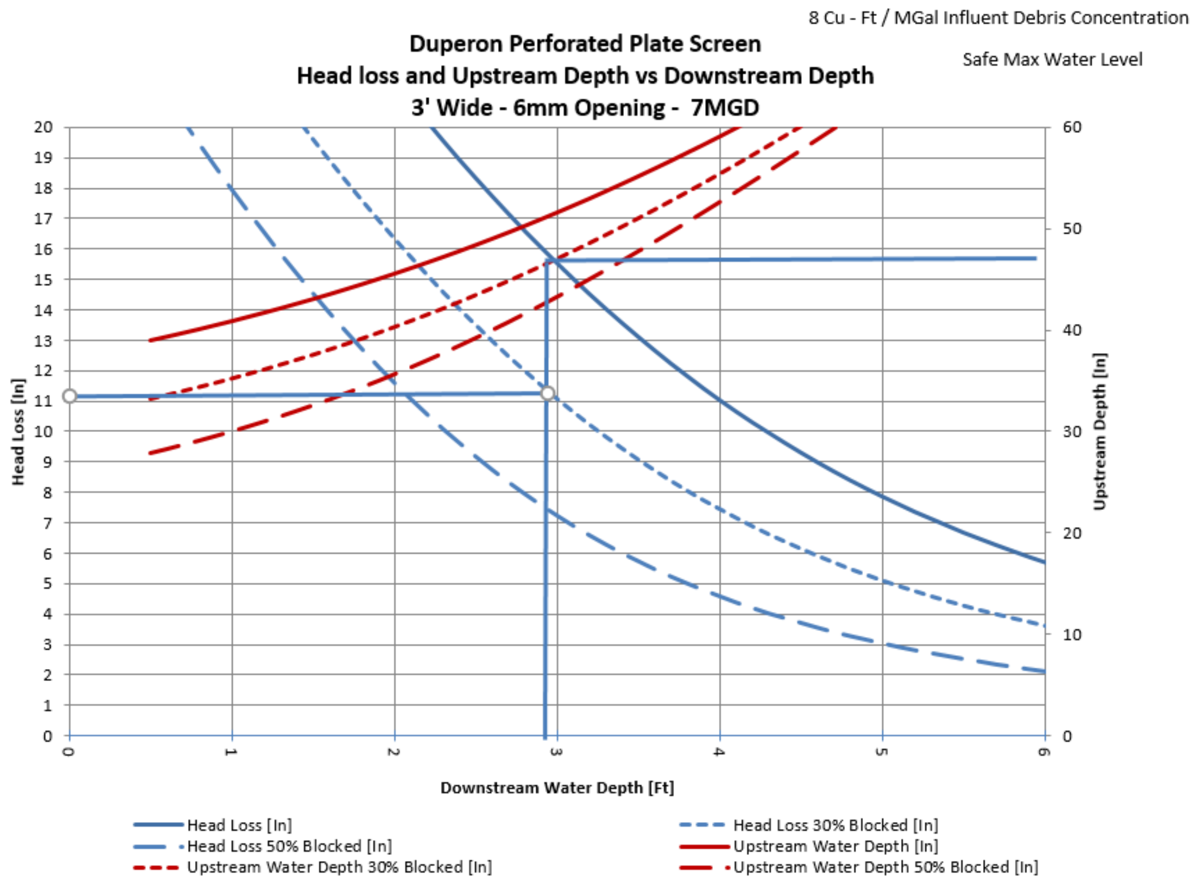
TECH/FREIGHT

QTY	UNIT	DESCRIPTION		
1	LOT	**On-Site Technical Assistance**		
		Number of Trips:	1	Trip(s)
		Days On-Site per Trip:	2	8-hour man-day(s)
1	LOT	**Freight**		
		FOB Factory, Full Freight Allowed		

Clarifications:
- This is not a fully designed project; preliminary pricing may be affected by scope change/project development
- Operational, structural, wind, or seismic calculations are not included
- Scope is based on models and assumptions widely utilized in the industry
- Scope does not convey an offer to sell; installation and taxes are not included
- **For reference only:** Standard Delivery Schedule: Submittals 4-6 week from PO - Delivery 8-12 weeks from approval

PRELIMINARY BUDGET PRICING: $659,000.00


8 Cu - Ft / MGal Influent Debris Concentration
Safe Max Water Level
Duperon Perforated Plate Screen
Head loss and Upstream Depth vs Downstream Depth
2.5' Wide - 6mm Opening - 5MGD
Head Loss [In]
Upstream Depth [In]
Downstream Water Depth [Ft]
Head Loss [In]
Head Loss 30% Blocked [In]
Head Loss 50% Blocked [In]
Upstream Water Depth [In]
Upstream Water Depth 30% Blocked [In]
Upstream Water Depth 50% Blocked [In]



8 Cu - Ft / MGal Influent Debris Concentration
Duperon Perforated Plate Screen
Head loss and Upstream Depth vs Downstream Depth
3' Wide - 6mm Opening - 7MGD
Safe Max Water Level
Head Loss [In]
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Head Loss 30% Blocked [In]
Head Loss 50% Blocked [In]
Upstream Water Depth [In]
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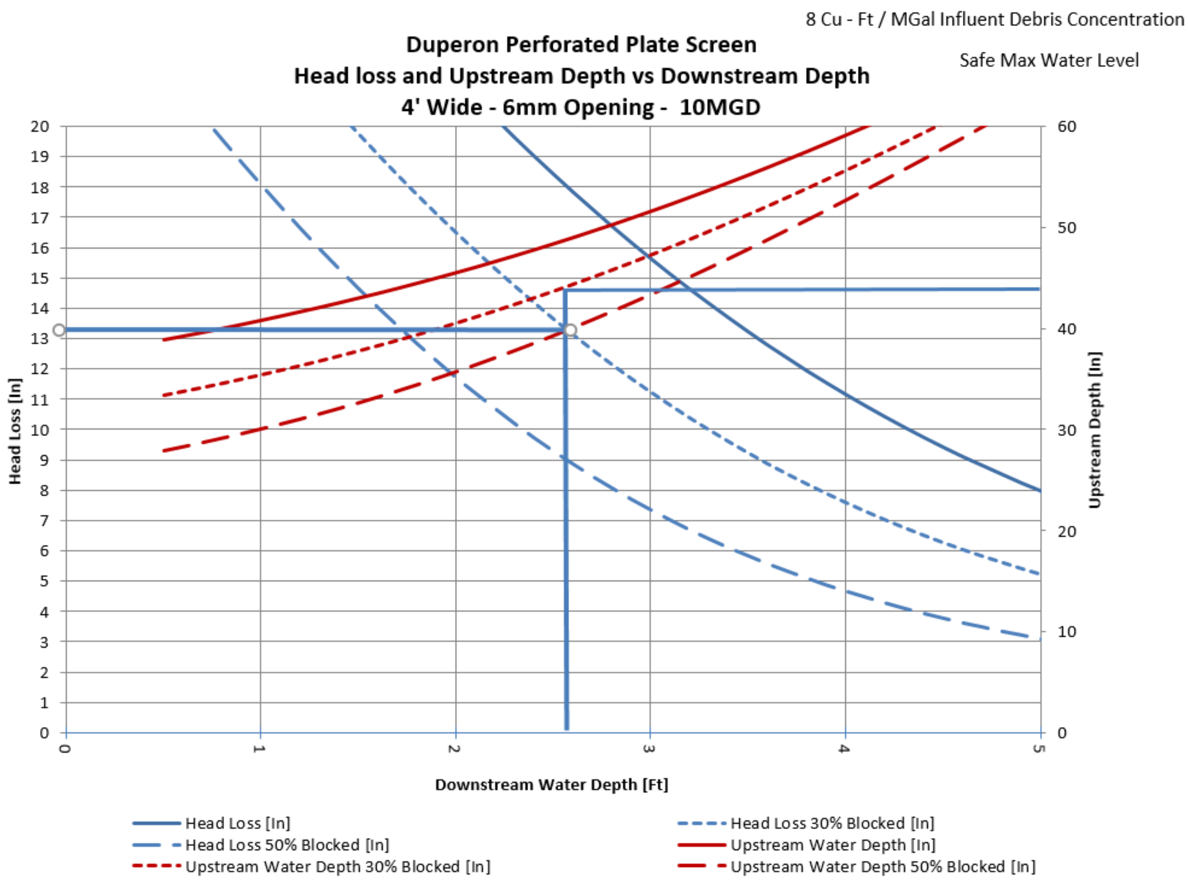
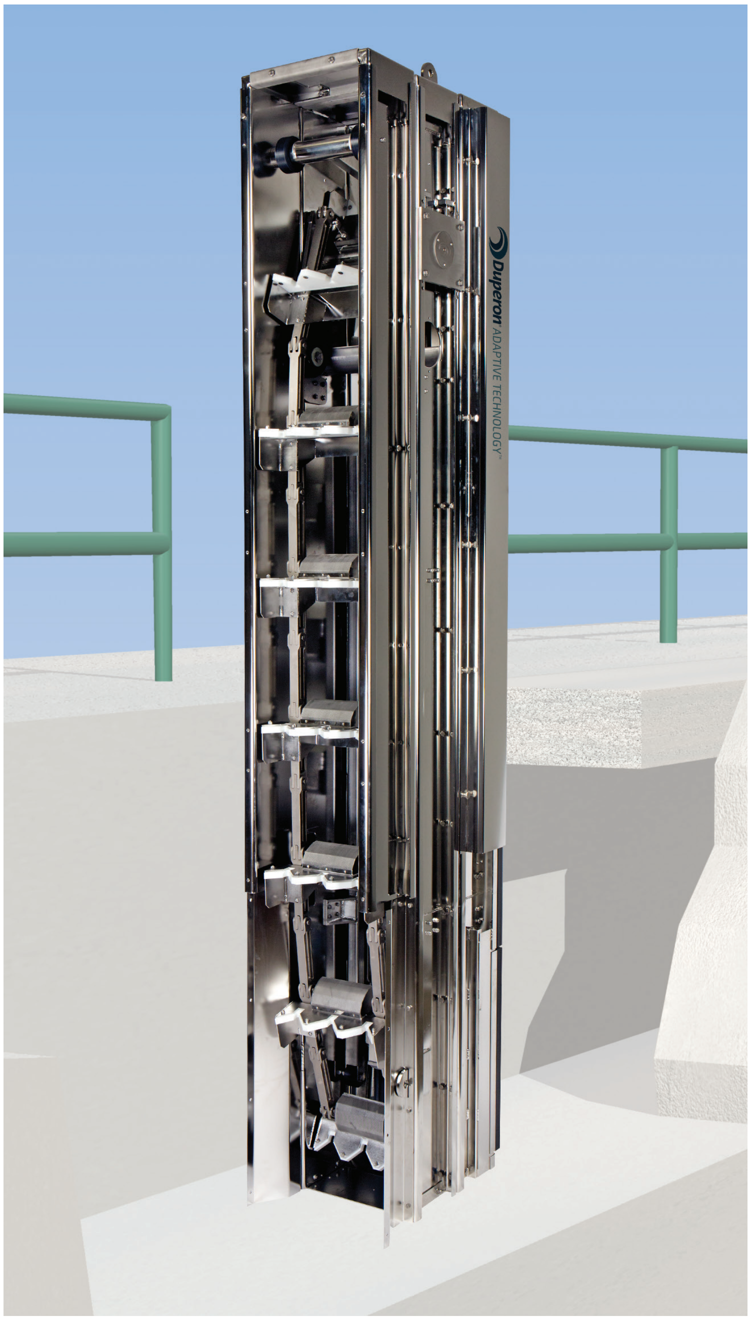

8 Cu - Ft / MGal Influent Debris Concentration
Safe Max Water Level
Duperon Perforated Plate Screen
Head loss and Upstream Depth vs Downstream Depth
4' Wide - 6mm Opening - 10MGD
Head Loss [In]
Upstream Depth [In]
Downstream Water Depth [Ft]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
10
20
30
40
50
60
Head Loss [In]
Head Loss 30% Blocked [In]
Head Loss 50% Blocked [In]
Upstream Water Depth [In]
Upstream Water Depth 30% Blocked [In]
Upstream Water Depth 50% Blocked [In]

An Absolute Barrier of Protection for Your Downstream Processes



Duperon® FlexRake® Sentinel™ PFE

Perforated Fixed-Element

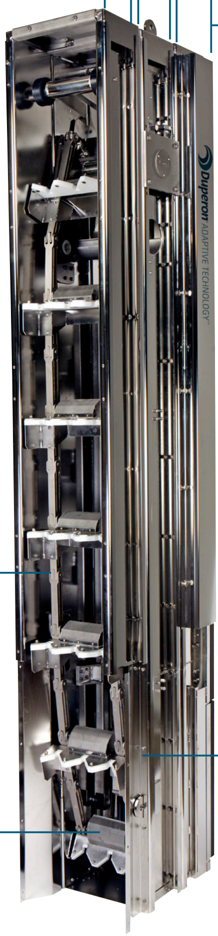
Front-cleaning, front-return Duperon® fixed-element perforated screening for 2mm, 3mm, 4mm and 6mm applications.

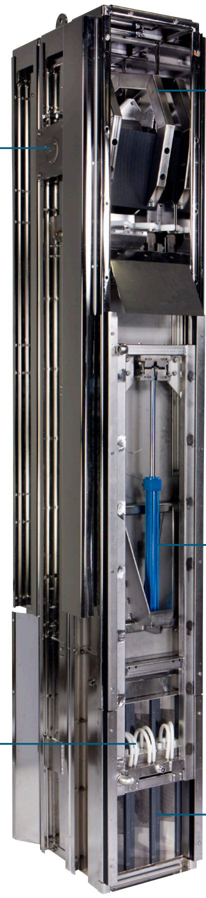
- Move the Debris, Not the Screen to Eliminate Carryover
- Eliminates Leakage, Stapling, Blinding, Seal Wear and the Need for Brushes
- A Complete Barrier; Provides Process Security
- Millennial™ Platform, Adaptive for Life
- Operational Reliability with Proven FlexLink™ Technology
- Individual Hole Cleaning with Active Hydropression™

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

The Duperon® FlexRake® Sentinel™ PFE

Perforated Fixed-Element





TYPICAL APPLICATIONS
Municipal and industrial wastewater, pre-process debris removal, membrane protection, tertiary screening, scum screening, pre-screening of process waters.

UNIT WIDTHS
- 2 to 5 feet
- Other widths considered dependent on site constraints

UNIT LENGTH
10 to 50 feet

ANGLE OF INSTALLATION
0 degrees (vertical)

STANDARD MATERIALS OF CONSTRUCTION
- Standard: 304 Stainless Steel
- Alternative: 316 Stainless Steel

APERTURE OPENING
2.0 mm, 3.0 mm, 4.0 mm, 6.0 mm

DEBRIS LIFT
- 304 SSTL, 316 SSTL and HDPE
- Lifts positioned every 21 inches

UTILITY REQUIREMENTS
Water connection: 1 inch NPT
Water type: Filtered effluent

DRIVE
- Hydraulic Power Unit Pump Motor
- Continuous Duty, 3 PH, 60 Hz

LIFTING CAPACITY
1,000 pounds

STANDARD OPERATING SPEED
3-6 RPM

SHIPPING DATA
Ships fully assembled

STANDARD CONTROLS OPTIONS
Packages require differential level sensing, which includes the use of upstream/downstream level transducers. Motor overload protection provided. Contact Duperon® for further details and assistance in selecting the perfect package for your site.

OPERATION OPTIONS
- Continuous/Manual
- Automatic with timer, float, SCADA
- Differential/high level sensing options with I/O as needed

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

1200 Leon Scott Court | Saginaw, MI 48601 | P 989.754.8800 | F 989.754.2175 | TF 800.383.8479 | www.duperon.com

3329/1/18/1M

REVISIONS				
REV.	DESCRIPTION	DATE	REVISED	APPROVED

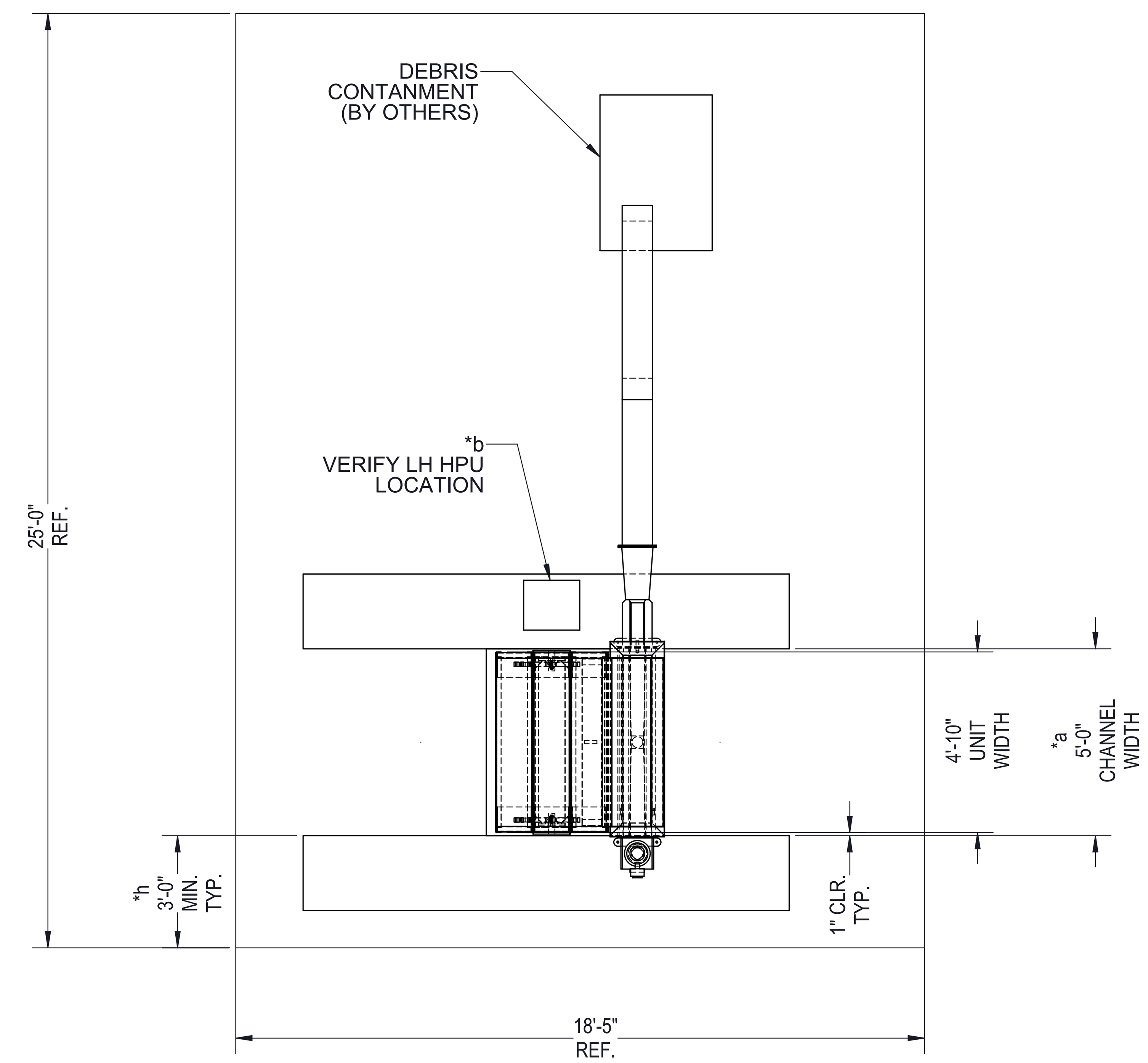
NOTE #1

VERIFY THAT THE PROPOSED
INSTALLATION IS SUITED TO THE SITE

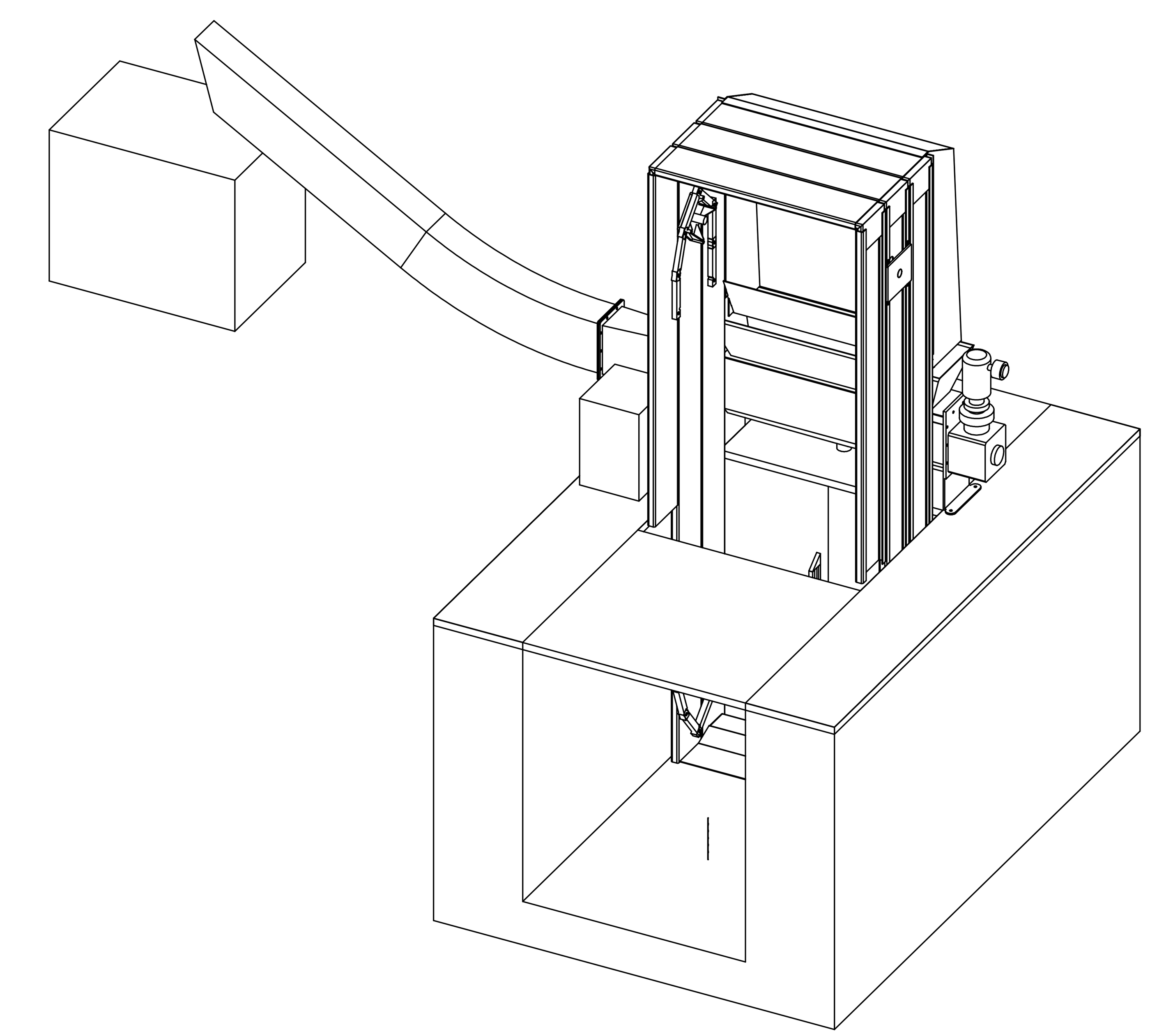
a. VERIFY CHANNEL WIDTH DIMENTION, FULL HEIGHT OF CHANNEL.
b. VERIFY HPU LOCATION LEFT SIDE OF UNIT
c. VERIFY CHANNEL HEIGHT.
d. VERIFY CHANNEL DEPTH. (2) PLACES.
e. VERIFY MAXIMUM WATER EL.
f. VERIFY DEBRIS CONTAINMENT HEIGHT AND LOCATIONS (3) PLACES.
g. VERIFY CEILING HEIGHT.
h. VERIFY UNIT CLEARANCE FROM WALL

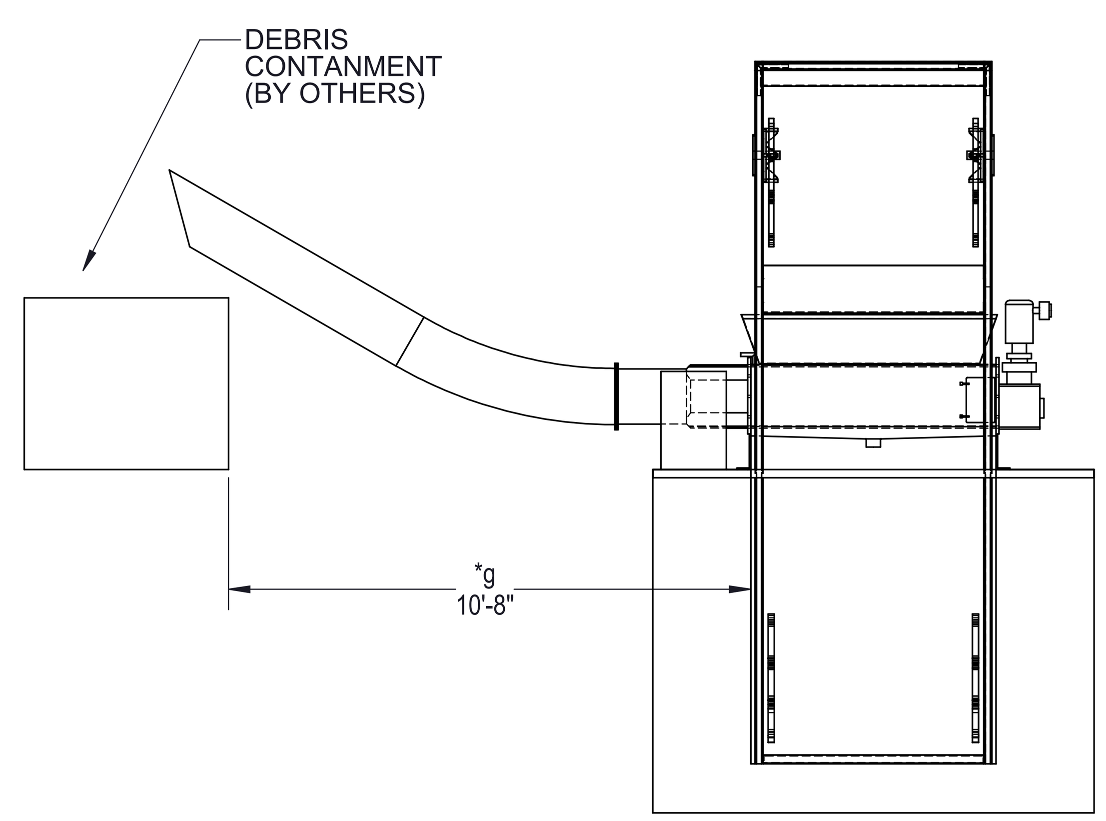
NOTE #2

1. SITE DIMENSIONS ARE SUBJECT TO CHANGE UPON SITE VERIFICATIONS.
2. FRONT AND REAR ENCLOSURES INCLUDE. FRONT ENCLOSURE IS INCLUDED FROM OPERATING DECK TO DISCHARGE AND IS 14 GA. SSTL. AND HAS 16 GA. REMOVEABLE PANELS FOR ACCESS. REAR ENCLOSURE IS 14 GA. SSTL. AND HAS HINGED DOORS w/ INTEGRAL VIEWING DOOR FOR A QUICK LOOK. DOORS ALL HAVE THE LIFT -SLIDE LATCH HANDLE FOR EASY ACCESS.
3. PLATE/GRATING AND HANDRAIL MODIFICATION AS REQUIRED (BY OTHERS)
4. 12" MINIMUM CLEARANCE ABOVE UNIT REQIRED FOR OPERATION OF UNIT. MODULAR UNIT CONSTRUCTION AVAILABLE.

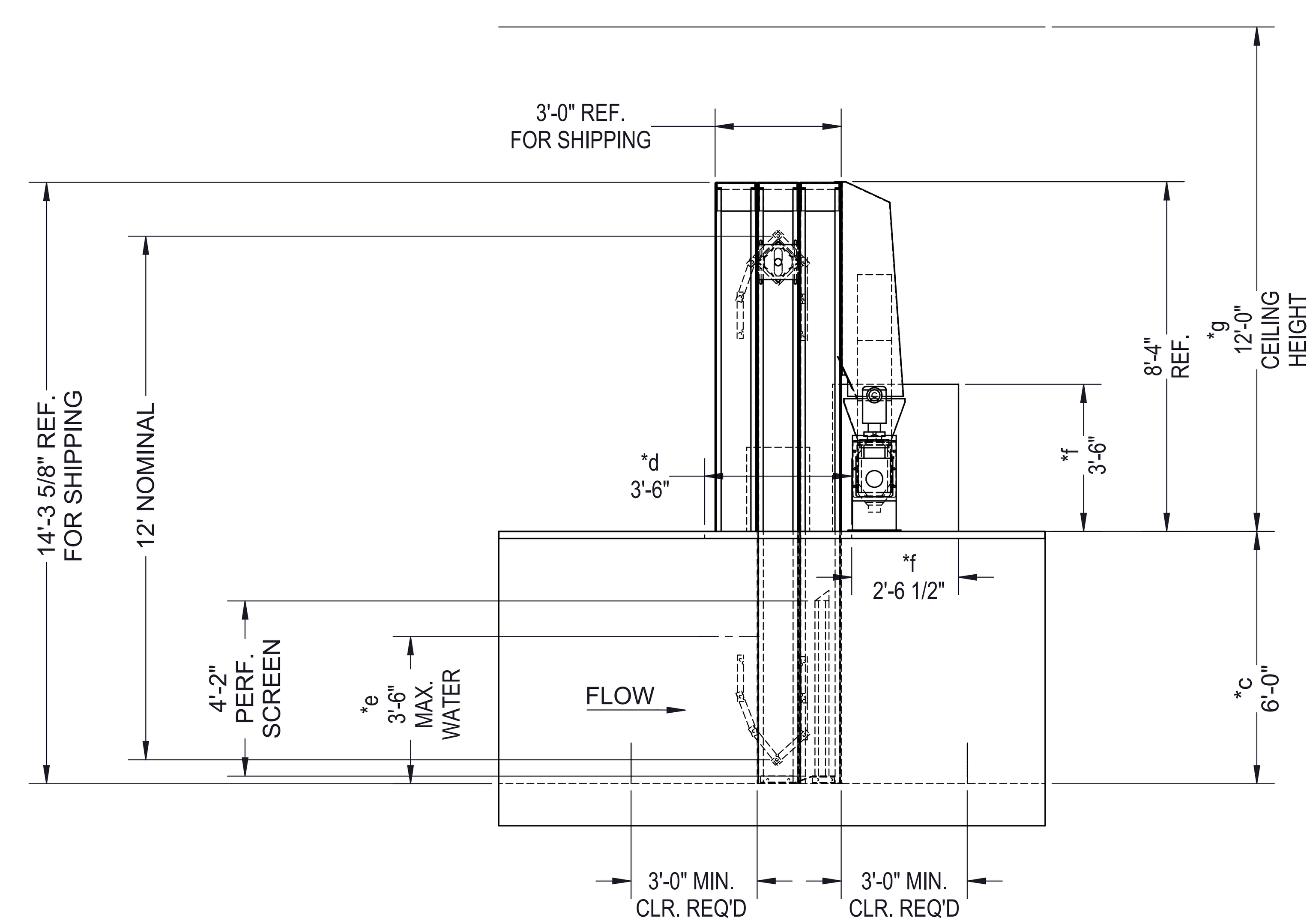


PLAN VIEW





FRONT VIEW



SIDE VIEW

PERFORATED SCREEN PRELIMINARY

CONCEPTUAL

THIS PROPOSAL DRAWING IS BASSED UPON THE INFORMATION AVAILABLE AT THE TIME AND MAY BE IMPACTED BY FUTURE SPECIFICATION, SCOPE, AND OTHER REQUIREMENTS. PLEASE BE ADVISED THAT DUPERON CORPORATION RETAINS THE RIGHT TO REFUSE, WITHDRAW, OR NEGOTIATE THIS PROPOSAL AT ANY TIME PRIOR TO SIGNING MATERIAL CONTRACT

PROPRIETARY

DIMENSIONING & TOLERANCING IN ACCORDANCE WITH ANSI Y14.5M-1982

TOLERANCES - UNLESS OTHERWISE SPECIFIED

.X =±0.03
.XX =±0.01
.XXX =±0.005
.XXXX =±0.0005
ANGULAR =±0.5°

DRAWN	DATE
XXX	XX/XX/XX
CHECKED -	DATE
APPROVED -	DATE
APPROVED -	DATE

Duperon®
Saginaw, Michigan 48601
TF 800.383.8479

SHEET TITLE
DUPERON CORPORATION
PERFORATED PLATE SCREEN

PART NAME
TEMPLATE

SIZE	FSCM NO.	DWG. NO.	REV
D		PROPOSAL NO.	-
SCALE 1:40		SHEET 1 OF 1	

C:\Users\mgusha\Desktop\SALES DWG\PXXXX-PP SALESMAIN

PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: October 18, 2018

Project: Key West WWTP, FL **Proposal Number:** P9943

PRELIMINARY BUDGET EQUIPMENT SCOPE - Option #2

To: Key West WWTP, FL

From: **Your Duperon® Team**
Tammy Blanchard
Sales Project Manager
(989) 754-8800
tblanchard@duperon.com

Rep: Larry Hickey
Equipment Plus Solutions, Inc.
(352)237-1869
Larry.Hickey@equipmentplusinc.com

Mark Hickok
Regional Sales Manager
(989) 412-0289
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Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: October 18, 2018

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Equipment Scope

SCREENS:

QTY	UNIT	DESCRIPTION		
3	EA	**Duperon® FlexRake® - Front Clean Front-Return**		
		Model:	Sentinel PFE - Perforated Fixed Element Screen	
Notes:	316SSTL custom close outs included for 3' 2" channel width.	Enclosure (& Material):	Fully Enclosed (304)	
			2.5ft x 15ft	
			3ft x 15ft	
		Nom Width x Length:	4ft x 15ft	Feet
		Clear Opening Size:	6 mm	
		Angle of Installation:	0	Deg. from Vertical
		Material Construction:	316	SSTL

Screenings Processing

QTY	UNIT	DESCRIPTION	
			Provided by others

CONTROLS

QTY	UNIT		
			3 - Sentinel PFE
1	EA	**Main Control Panel:**	**Perforated Fixed Element Screen**
		Power:	480V/3ph/60hz
		Panel Rating:	NEMA 4X
		PLC/Relay Based:	PLC - Unitronics V350
		Screen Instrumentation:	(2) Transducers w/ HydroRanger
		Local Pushbutton Station(s):	Three Button (E-Stop/Run/Jog Rev)

TECH/FREIGHT

QTY	UNIT	DESCRIPTION		
1	LOT	**On-Site Technical Assistance**		
		Number of Trips:	1	Trip(s)
		Days On-Site per Trip:	2	8-hour man-day(s)
1	LOT	**Freight**		
		FOB Factory, Full Freight Allowed		

Clarifications:

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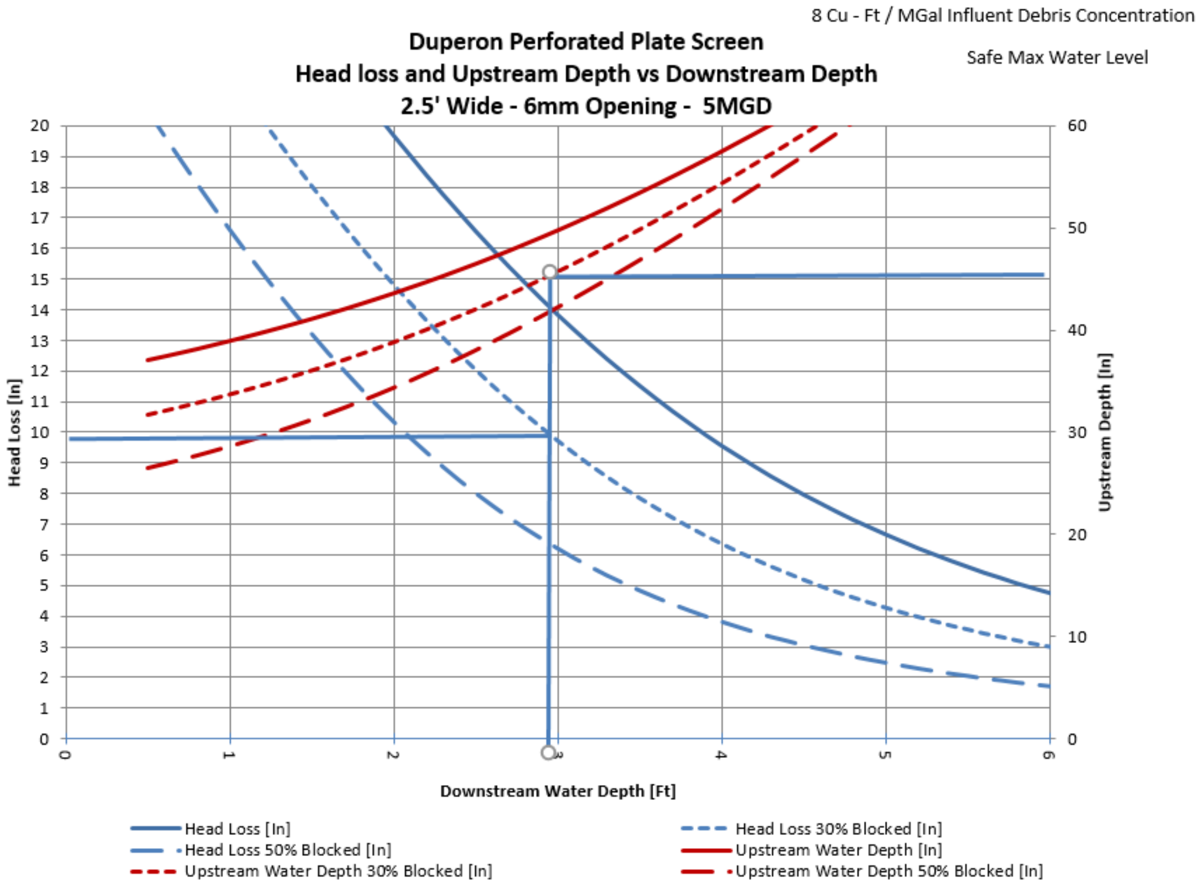
PRELIMINARY BUDGET PRICING: **$659,000.00**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2.5' Wide - 6mm Opening - 5MGD
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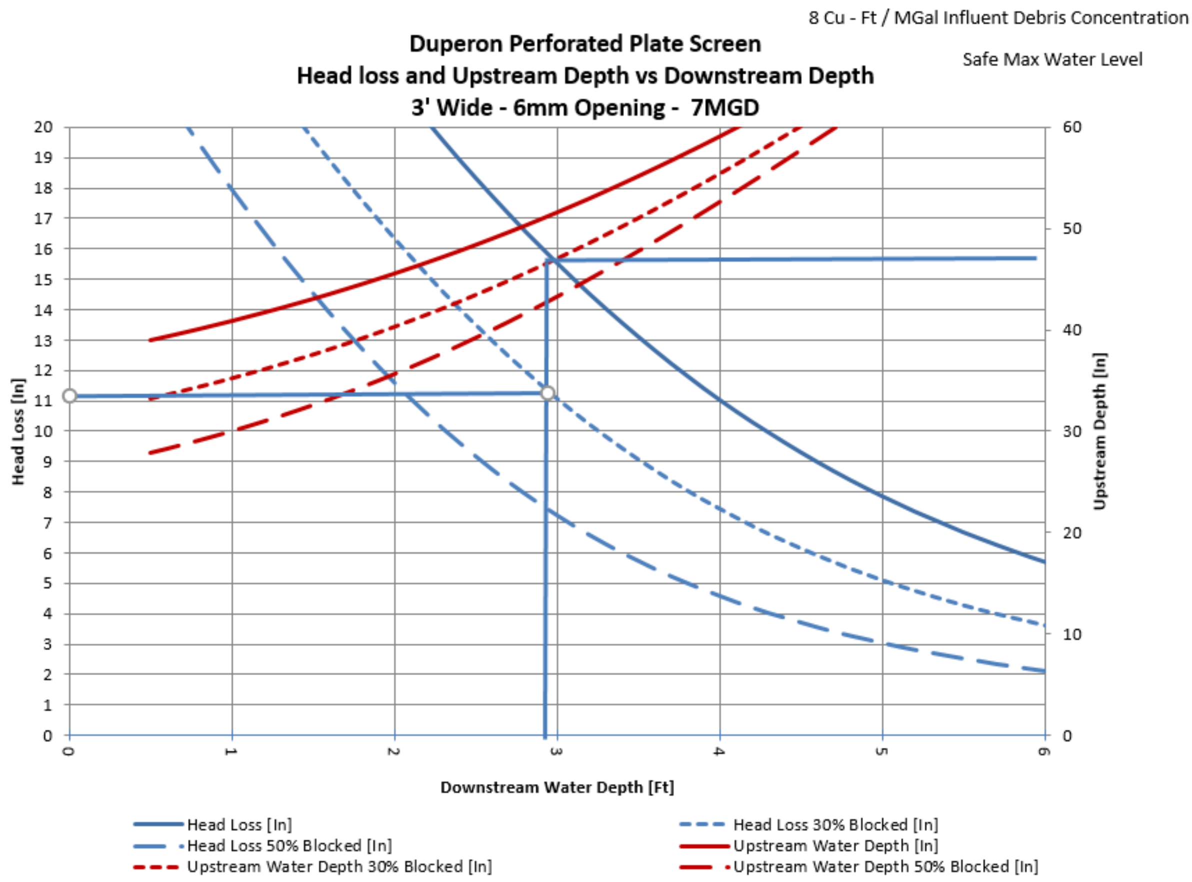

8 Cu - Ft / MGal Influent Debris Concentration
Duperon Perforated Plate Screen
Head loss and Upstream Depth vs Downstream Depth
3' Wide - 6mm Opening - 7MGD
Safe Max Water Level
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Head Loss 30% Blocked [In]
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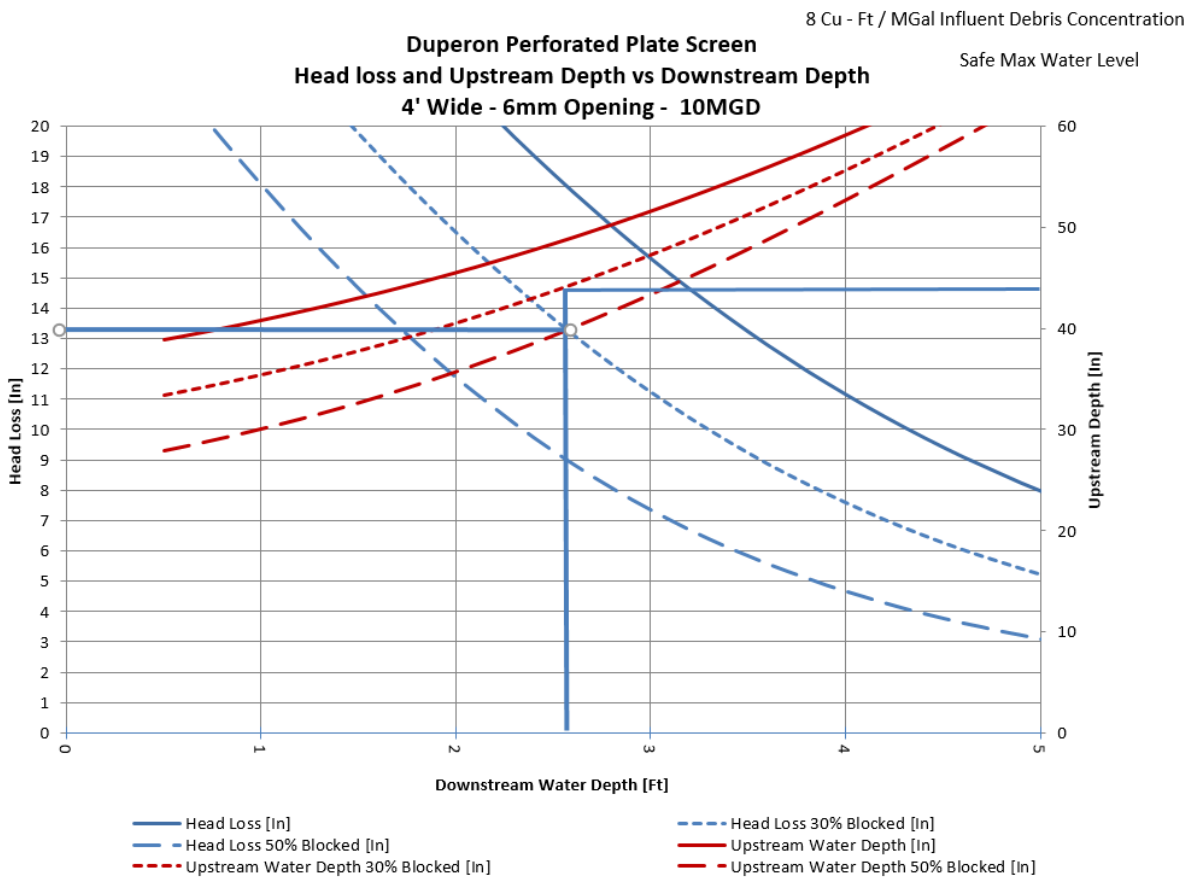
8 Cu - Ft / MGal Influent Debris Concentration
Safe Max Water Level
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Head loss and Upstream Depth vs Downstream Depth
4' Wide - 6mm Opening - 10MGD
Head Loss [In]
Upstream Depth [In]
Downstream Water Depth [Ft]
Head Loss [In]
Head Loss 30% Blocked [In]
Head Loss 50% Blocked [In]
Upstream Water Depth [In]
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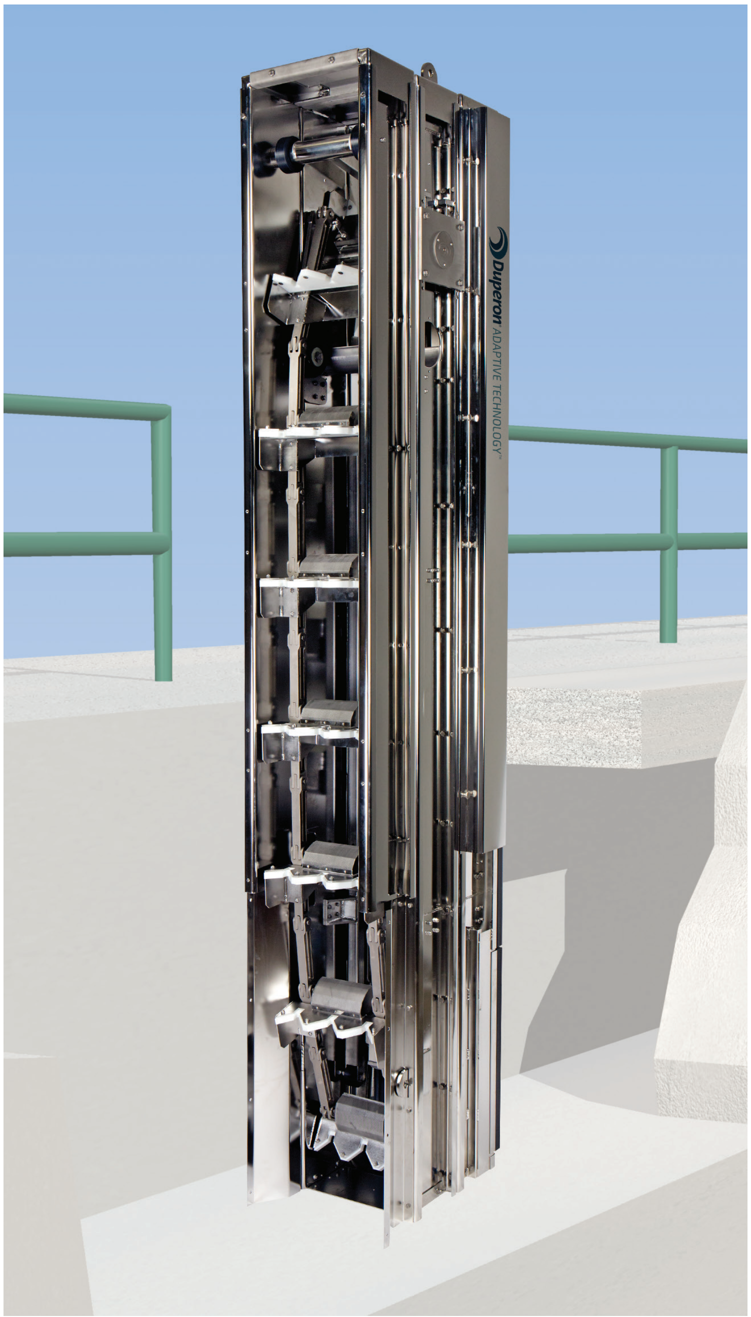
An Absolute Barrier of Protection for Your Downstream Processes



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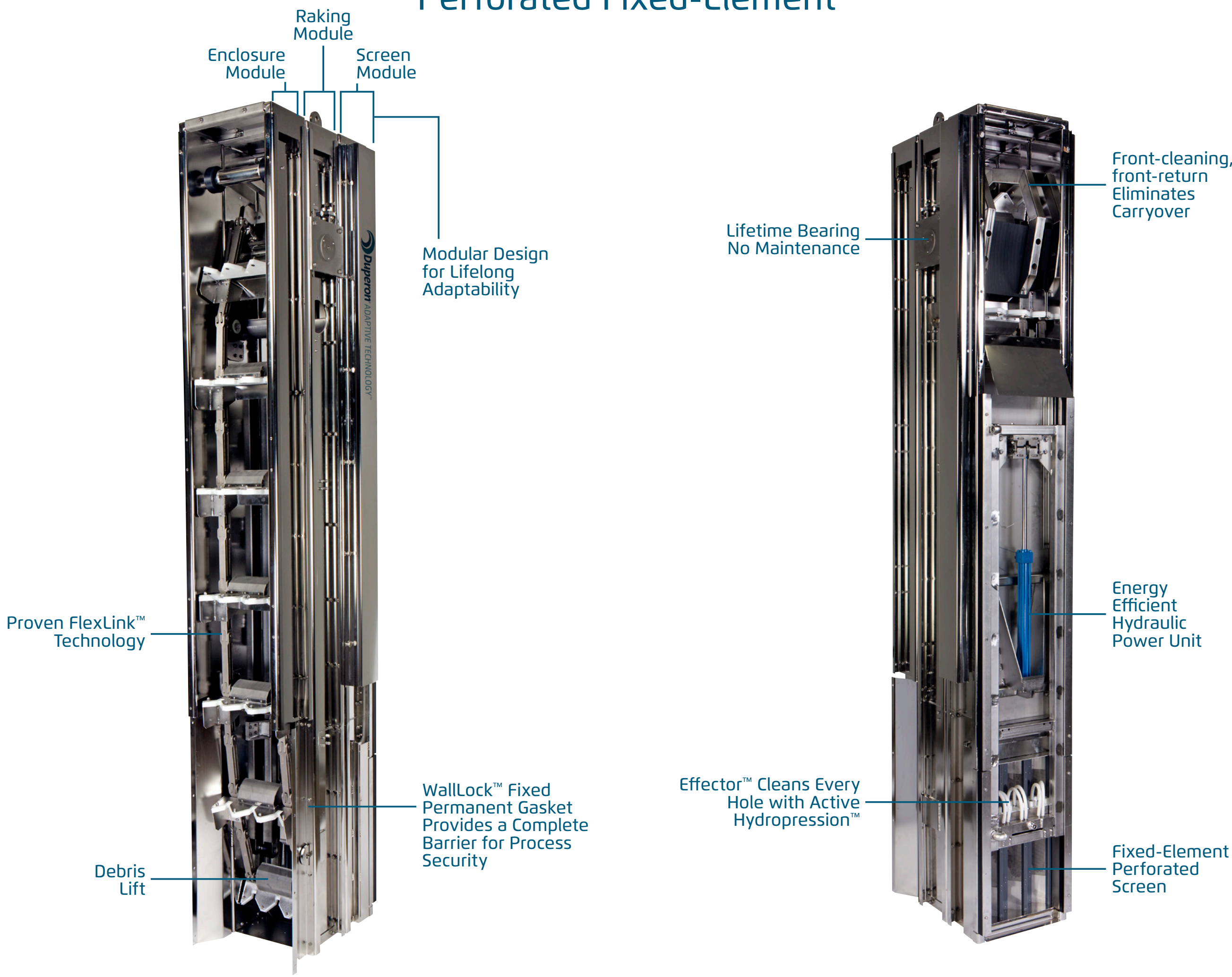
The Duperon® FlexRake® Sentinel™ PFE

Perforated Fixed-Element



TYPICAL APPLICATIONS

Municipal and industrial wastewater, pre-process debris removal, membrane protection, tertiary screening, scum screening, pre-screening of process waters.

UNIT WIDTHS

- 2 to 5 feet
- Other widths considered dependent on site constraints

UNIT LENGTH

10 to 50 feet

ANGLE OF INSTALLATION

0 degrees (vertical)

STANDARD MATERIALS OF CONSTRUCTION

- Standard: 304 Stainless Steel
- Alternative: 316 Stainless Steel

APERTURE OPENING

2.0 mm, 3.0 mm, 4.0 mm, 6.0 mm

DEBRIS LIFT

- 304 SSTL, 316 SSTL and HDPE
- Lifts positioned every 21 inches

UTILITY REQUIREMENTS

Water connection: 1 inch NPT
Water type: Filtered effluent

DRIVE

- Hydraulic Power Unit Pump Motor
- Continuous Duty, 3 PH, 60 Hz

LIFTING CAPACITY

1,000 pounds

STANDARD OPERATING SPEED

3-6 RPM

SHIPPING DATA

Ships fully assembled

STANDARD CONTROLS OPTIONS

Packages require differential level sensing, which includes the use of upstream/downstream level transducers. Motor overload protection provided. Contact Duperon® for further details and assistance in selecting the perfect package for your site.

OPERATION OPTIONS

- Continuous/Manual
- Automatic with timer, float, SCADA
- Differential/high level sensing options with I/O as needed

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

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3329/1/18/1M

REVISIONS				
REV.	DESCRIPTION	DATE	REVISED	APPROVED

NOTE #1

VERIFY THAT THE PROPOSED
INSTALLATION IS SUITED TO THE SITE

a. VERIFY CHANNEL WIDTH DIMENTION, FULL HEIGHT OF CHANNEL.
b. VERIFY HPU LOCATION LEFT SIDE OF UNIT
c. VERIFY CHANNEL HEIGHT.
d. VERIFY CHANNEL DEPTH. (2) PLACES.
e. VERIFY MAXIMUM WATER EL.
f. VERIFY DEBRIS CONTAINMENT HEIGHT AND LOCATIONS (3) PLACES.
g. VERIFY CEILING HEIGHT.
h. VERIFY UNIT CLEARANCE FROM WALL

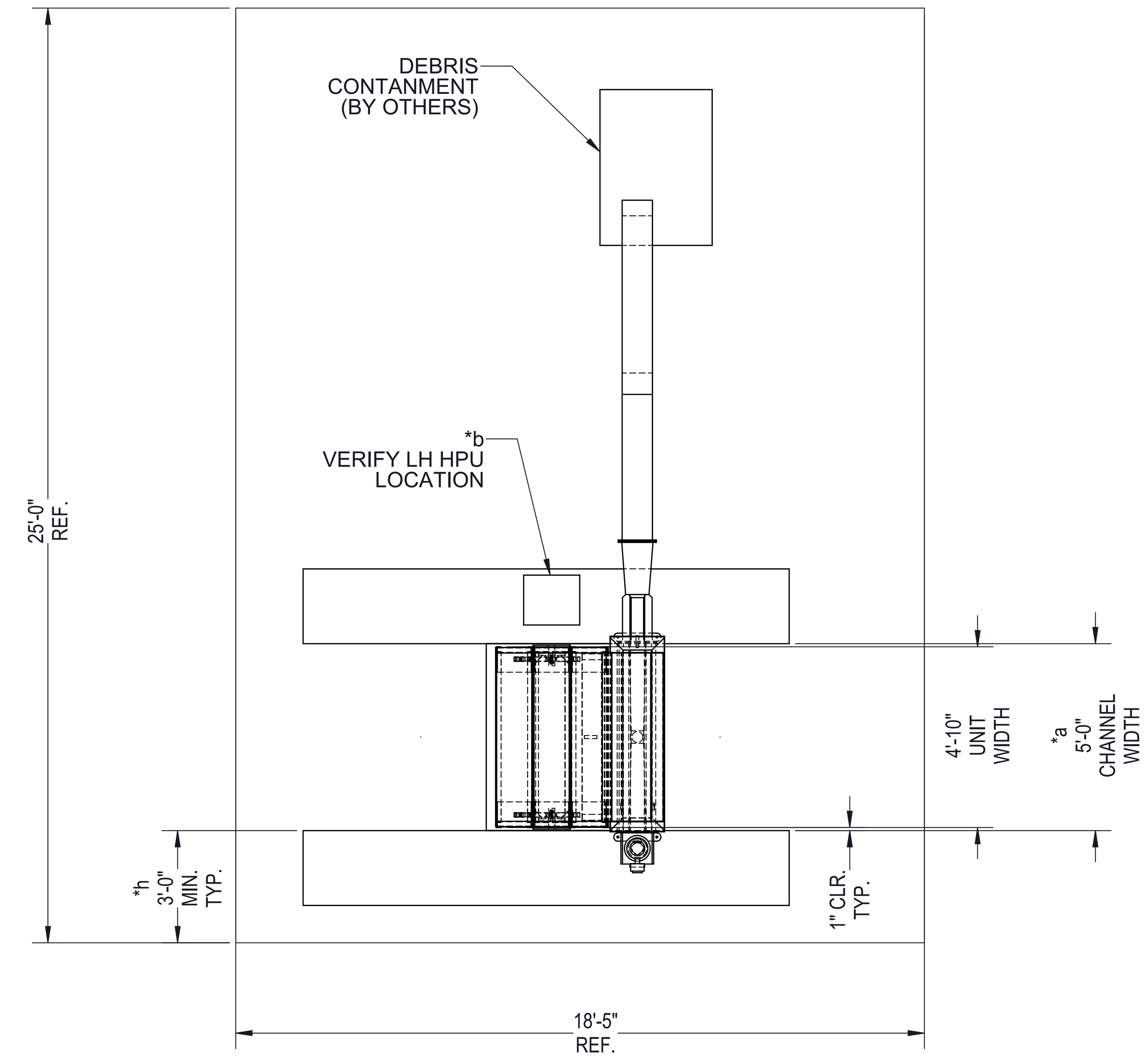
NOTE #2

1. SITE DIMENSIONS ARE SUBJECT TO CHANGE UPON SITE VERIFICATIONS.

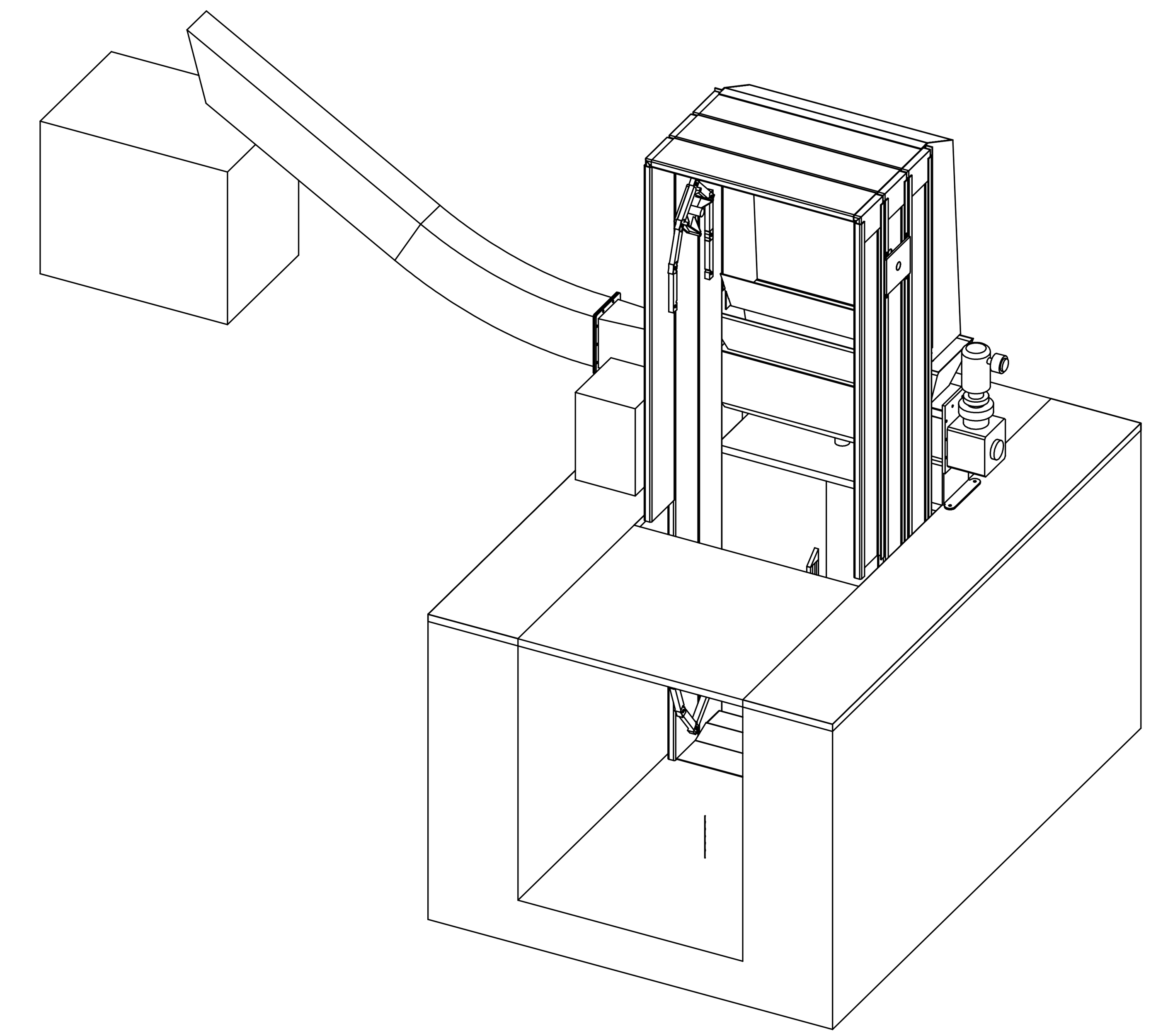
2. FRONT AND REAR ENCLOSURES INCLUDE. FRONT ENCLOSURE IS INCLUDED FROM OPERATING DECK TO DISCHARGE AND IS 14 GA. SSTL. AND HAS 16 GA. REMOVEABLE PANELS FOR ACCESS. REAR ENCLOSURE IS 14 GA. SSTL. AND HAS HINGED DOORS w/ INTEGRAL VIEWING DOOR FOR A QUICK LOOK. DOORS ALL HAVE THE LIFT -SLIDE LATCH HANDLE FOR EASY ACCESS.

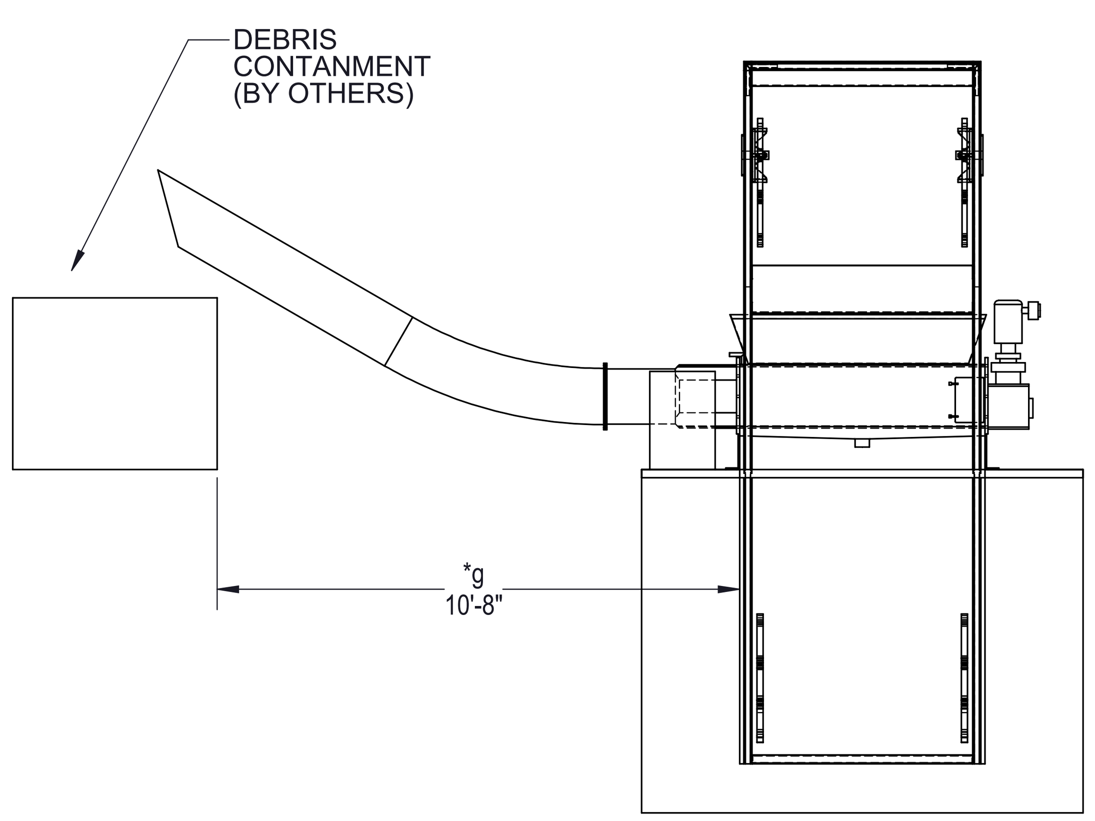
3. PLATE/GRATING AND HANDRAIL MODIFICATION AS REQUIRED (BY OTHERS)

4. 12" MINIMUM CLEARANCE ABOVE UNIT REQIRED FOR OPERATION OF UNIT. MODULAR UNIT CONSTRUCTION AVAILABLE.

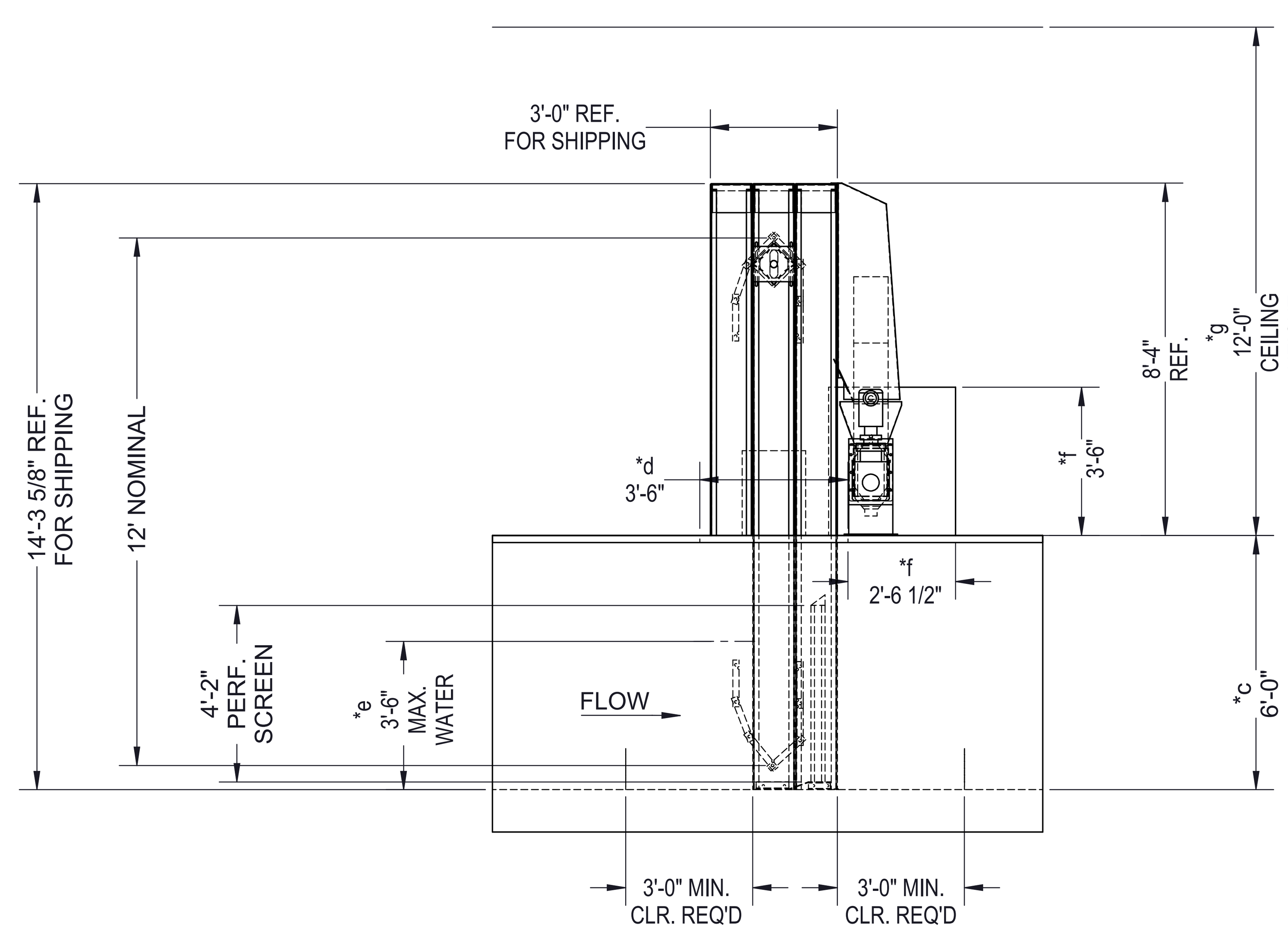


PLAN VIEW





FRONT VIEW



SIDE VIEW

PERFORATED SCREEN PRELIMINARY

CONCEPTUAL

THIS PROPOSAL DRAWING IS BASSED UPON THE INFORMATION AVAILABLE AT THE TIME AND MAY BE IMPACTED BY FUTURE SPECIFICATION, SCOPE, AND OTHER REQUIREMENTS. PLEASE BE ADVISED THAT DUPERON CORPORATION RETAINS THE RIGHT TO REFUSE, WITHDRAW, OR NEGOTIATE THIS PROPOSAL AT ANY TIME PRIOR TO SIGNING MATERIAL CONTRACT

PROPRIETARY

DIMENSIONING & TOLERANCING IN ACCORDANCE WITH ANSI Y14.5M-1982

TOLERANCES - UNLESS OTHERWISE SPECIFIED
.X = ±0.03
.XX = ±0.01
.XXX = ±0.005
.XXXX = ±0.0005
ANGULAR = ±0.5°

DRAWN XXX	DATE XX/XX/XX
CHECKED -	DATE
APPROVED -	DATE
APPROVED -	DATE

Duperon®
Saginaw, Michigan 48601
TF 800.383.8479

SHEET TITLE
DUPERON CORPORATION PERFORATED PLATE SCREEN

PART NAME
TEMPLATE

SIZE	FSCM NO.	DWG. NO.	REV
D		PROPOSAL NO.	-
SCALE 1:40		SHEET 1 OF 1	

C:\Users\mgusha\Desktop\SALES DWG\PXXXX-PP SALESMAIN

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: October 11, 2018

Project: Key West WWTP, FL **Proposal Number:** P9943

PRELIMINARY BUDGET EQUIPMENT SCOPE

To: Key West WWTP, FL

From: **Your Duperon® Team**
Dan Satryano
Sales Project Manager
(989) 754-7151
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Rep: Larry Hickey
Equipment Plus Solutions, Inc.
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(989) 412-0289
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Date: October 11, 2018

Project: Key West WWTP, FL **Proposal Number:** P9943

PRELIMINARY BUDGET EQUIPMENT SCOPE

Thank you for considering **Duperon®** system solutions for your project. We appreciate the opportunity to provide you with a **Preliminary Budget Equipment Scope**. Please do not hesitate to contact your **Duperon® Team** with any questions as we work with you through the design process and ensure a successful project.

Equipment Scope

SCREENS:

QTY	UNIT	DESCRIPTION		
3	EA	**Duperon® FlexRake® - Front Clean Front-Return**		
		Model:	FPFS - Full Penetration, Fine Screen	
Notes: 316SSTL Custom Closeouts provided with 3' 2" screen. Based on 4'8" channel height.		Enclosure (& Material):	Fully Enclosed (316)	
			2' 6"' x 13' 3' 2" x 13'	
		Nom Width x Length:	4'x 13'	Feet
		Clear Opening Size:	0.25 in	
		Angle of Installation:	15	Deg. from Vertical
		Material Construction:	316	SSTL

Screenings Processing

QTY	UNIT	DESCRIPTION	
			Provided by others.

CONTROLS

QTY	UNIT		
1	EA	**Main Control Panel:**	**3- FPFS**
		* Power:	480V/3ph/60hz
Notes: Includes AC unit in control panel.		* Panel Rating:	NEMA 4X
		* PLC/Relay Based:	Relay
See attached Controls selection guide for additional options.		* Screen Instrumentation:	Dual Mechanical Float
		* Local Pushbutton Station(s):	Three Button (E-Stop/Run/Jog Rev)

TECH/FREIGHT

QTY	UNIT	DESCRIPTION		
1	LOT	**On-Site Technical Assistance**		
		Number of Trips:	1	Trip(s)
		Days On-Site per Trip:	2	8-hour man-day(s)
1	LOT	**Freight**		
		FOB Factory, Full Freight Allowed		

Clarifications:
- This is not a fully designed project; preliminary pricing may be affected by scope change/project development
- Operational, structural, wind, or seismic calculations are not included
- Scope is based on models and assumptions widely utilized in the industry
- Scope does not convey an offer to sell; installation and taxes are not included
- **For reference only:** Standard Delivery Schedule: Submittals 4-6 week from PO - Delivery 8-12 weeks from approval

PRELIMINARY BUDGET PRICING: $396,000.00

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Date: October 10, 2018
Project: Key West WWTP, FL
Number: P9943

HYDRAULIC CALCULATIONS

Notes: Peak Flow = 15 MGD at set 4ft upstream water level. 4' channel width. High Slot Velocity

INPUT: Channel Physics

Flow in MGD	15.00	MGD
Upstream water level	4.00	ft
Channel width	4.00	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

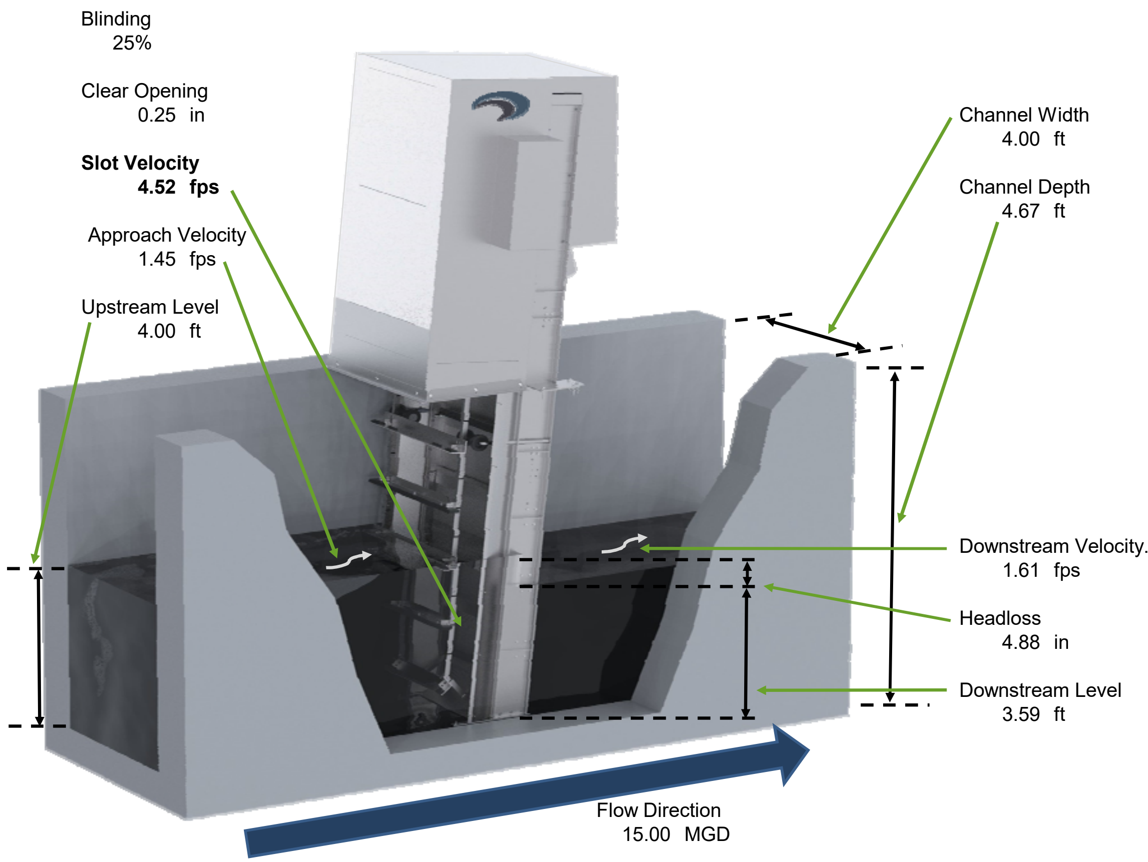
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	2.32	sft
Flow area between side fab & closeouts	13.68	sft
Number of bars	82.00	ea
Flow area taken up by bars	6.83	sft
Total Channel flow without screen	16.00	sft
Flow area after screen area and blinding taken out	5.14	sft
Approach Velocity	1.45	fps
Slot Velocity	4.52	fps
Downstream Velocity	1.61	fps
Downstream Depth	3.59	ft
Head Loss	4.88	in

Bernoulli Calculations

Velocity thru bar screen	4.52	fps
Velocity upstream of bar screen	1.45	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.41	ft
Headloss	4.88	inches



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Duperon recommends using Water Environment Federation (WEF) & "10 States" standards as deign guidelines:
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HYDRAULIC CALCULATIONS

Notes: Average Flow = 3.8 MGD at recommended 1ft downstream water level. 4' channel width.

INPUT: Channel Physics

Flow in MGD	3.80	MGD
Upstream water level	1.26	ft
Channel width	4.00	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

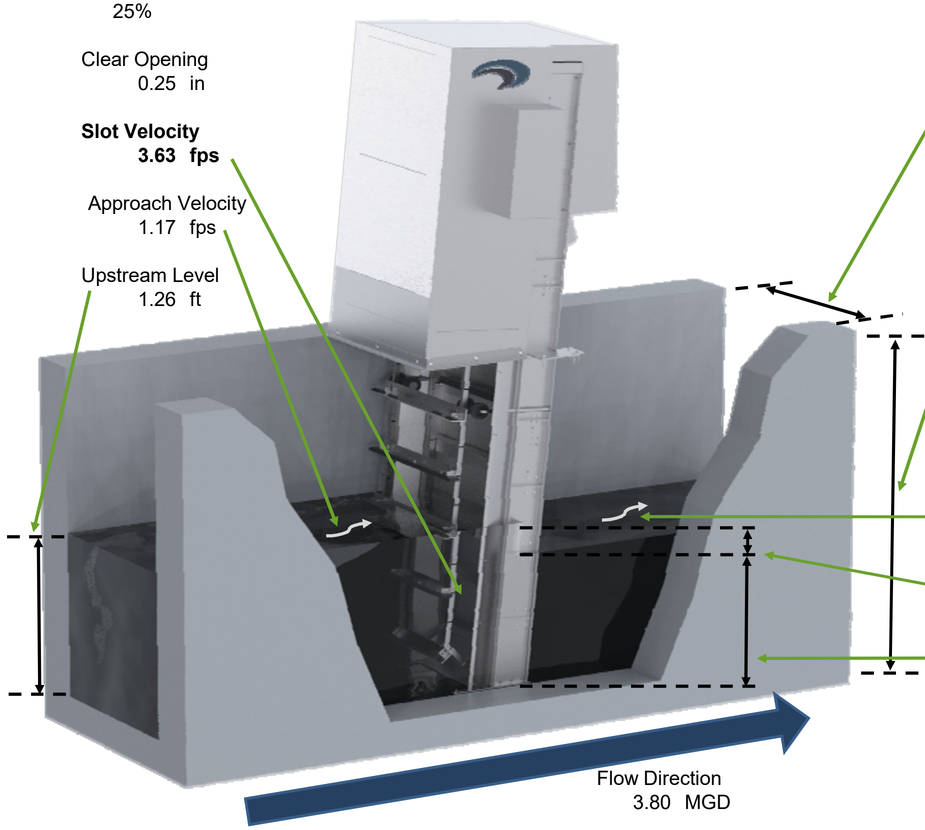
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	0.73	sft
Flow area between side fab & closeouts	4.31	sft
Number of bars	82.00	ea
Flow area taken up by bars	2.15	sft
Total Channel flow without screen	5.04	sft
Flow area after screen area and blinding taken out	1.62	sft
Approach Velocity	1.17	fps
Slot Velocity	3.63	fps
Downstream Velocity	1.47	fps
Downstream Depth	1.00	ft
Head Loss	3.16	in

Bernoulli Calculations

Velocity thru bar screen	3.63	fps
Velocity upstream of bar screen	1.17	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.26	ft
Headloss	3.16	inches



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Date: October 10, 2018
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HYDRAULIC CALCULATIONS

Notes: Peak Flow = 15 MGD at set 4ft upstream water level. 3' 2" channel width. High Slot velocity

INPUT: Channel Physics

Flow in MGD	15.00	MGD
Upstream water level	4.00	ft
Channel width	3.17	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

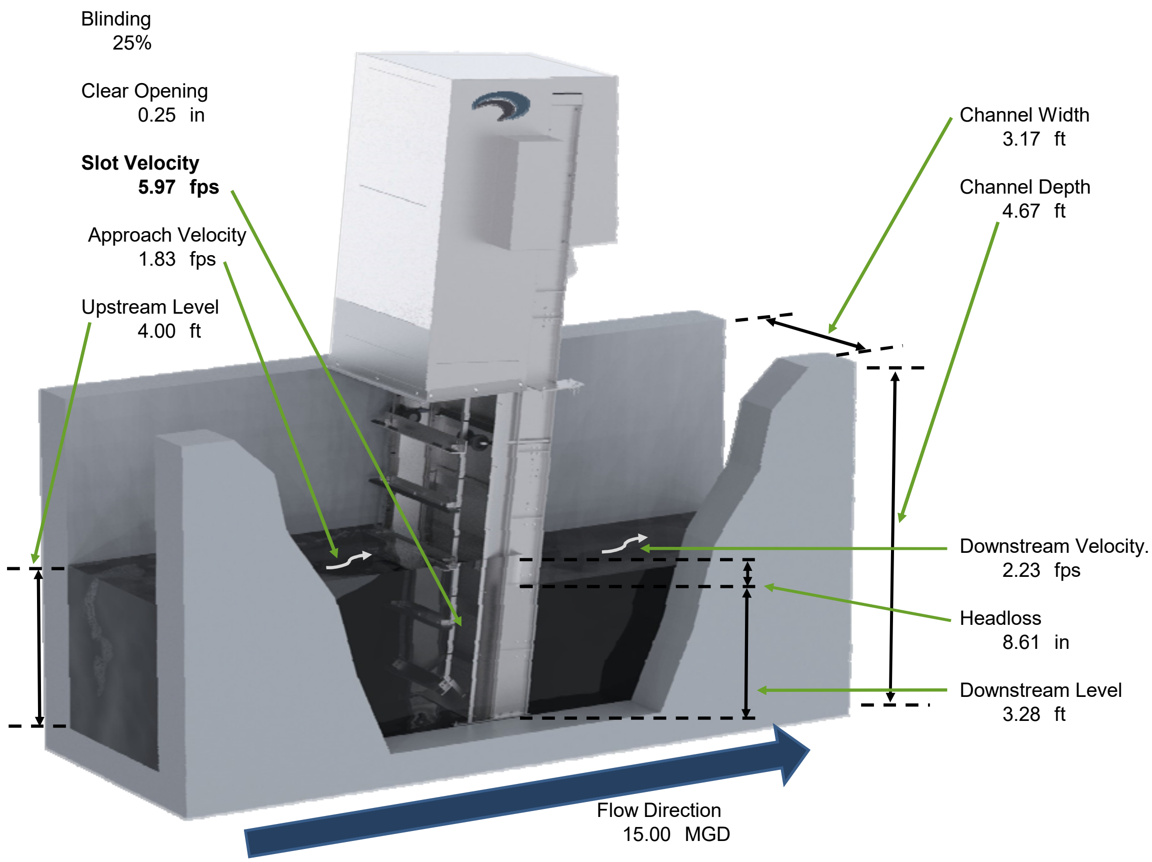
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	2.32	sft
Flow area between side fab & closeouts	10.35	sft
Number of bars	62.00	ea
Flow area taken up by bars	5.17	sft
Total Channel flow without screen	12.67	sft
Flow area after screen area and blinding taken out	3.89	sft
Approach Velocity	1.83	fps
Slot Velocity	5.97	fps
Downstream Velocity	2.23	fps
Downstream Depth	3.28	ft
Head Loss	8.61	in

Bernoulli Calculations

Velocity thru bar screen	5.97	fps
Velocity upstream of bar screen	1.83	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.72	ft
Headloss	8.61	inches



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Project: Key West WWTP, FL
Number: P9943

HYDRAULIC CALCULATIONS

Notes: Peak Flow = 7.5 MGD (15 MGD plant Total) at set 4ft upstream water level. 3' 2" channel width.

INPUT: Channel Physics

Flow in MGD	7.50	MGD
Upstream water level	4.00	ft
Channel width	3.17	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

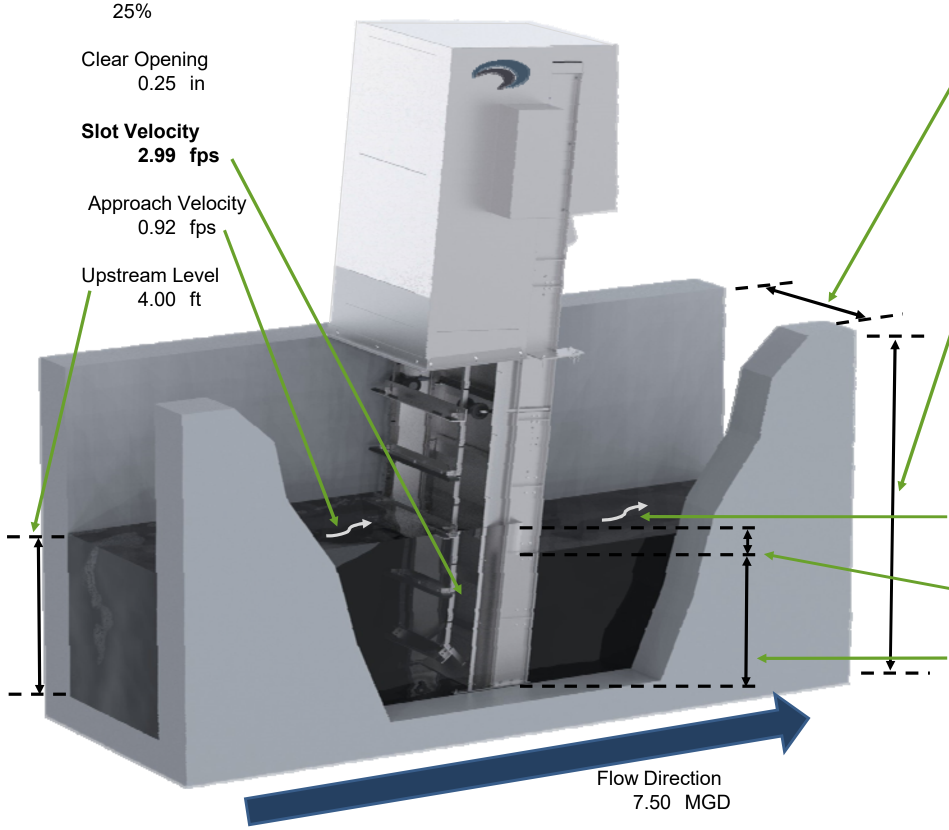
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	2.32	sft
Flow area between side fab & closeouts	10.35	sft
Number of bars	62.00	ea
Flow area taken up by bars	5.17	sft
Total Channel flow without screen	12.67	sft
Flow area after screen area and blinding taken out	3.89	sft
Approach Velocity	0.92	fps
Slot Velocity	2.99	fps
Downstream Velocity	0.96	fps
Downstream Depth	3.82	ft
Head Loss	2.15	in

Bernoulli Calculations

Velocity thru bar screen	2.99	fps
Velocity upstream of bar screen	0.92	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.18	ft
Headloss	2.15	inches



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HYDRAULIC CALCULATIONS

Notes: Average Flow = 3.8 MGD at recommended 1ft downstream water level. 3'2" channel width.

INPUT: Channel Physics

Flow in MGD	3.80	MGD
Upstream water level	1.38	ft
Channel width	3.17	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

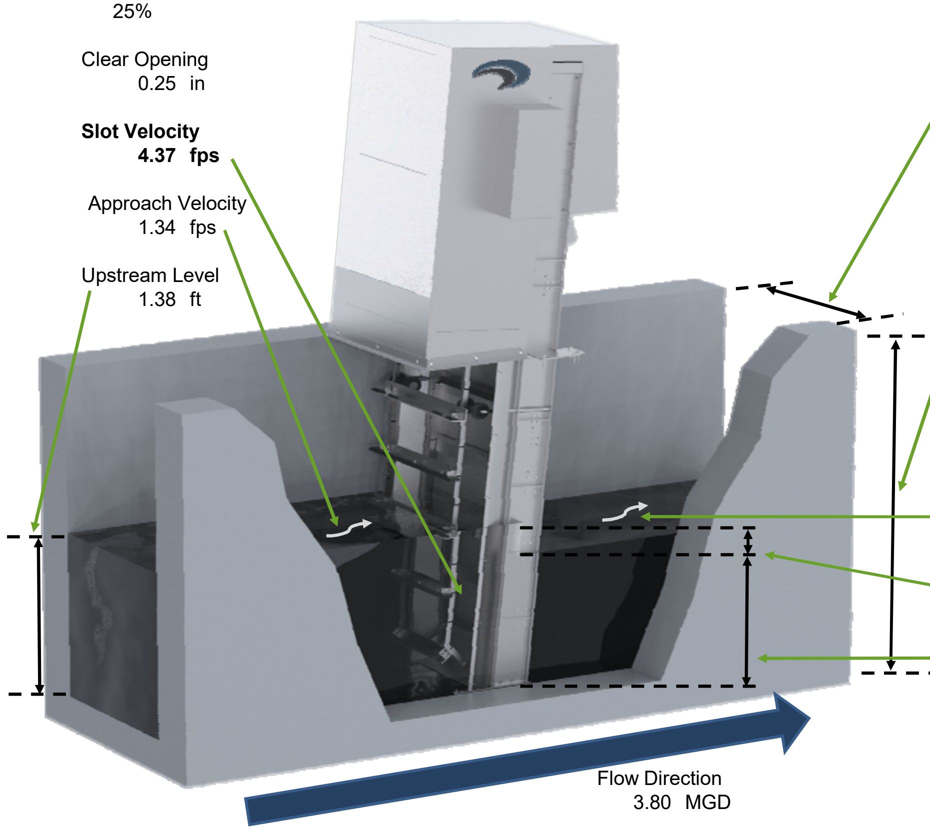
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	0.80	sft
Flow area between side fab & closeouts	3.57	sft
Number of bars	62.00	ea
Flow area taken up by bars	1.78	sft
Total Channel flow without screen	4.37	sft
Flow area after screen area and blinding taken out	1.34	sft
Approach Velocity	1.34	fps
Slot Velocity	4.37	fps
Downstream Velocity	1.86	fps
Downstream Depth	1.00	ft
Head Loss	4.62	in

Bernoulli Calculations

Velocity thru bar screen	4.37	fps
Velocity upstream of bar screen	1.34	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.38	ft
Headloss	4.62	inches



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Date: October 10, 2018
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Number: P9943

HYDRAULIC CALCULATIONS

Notes: Peak Flow = 15 MGD at set 4ft upstream water level. 2' 6" channel width. High Slot Velocity

INPUT: Channel Physics

Flow in MGD	15.00	MGD
Upstream water level	4.00	ft
Channel width	2.50	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

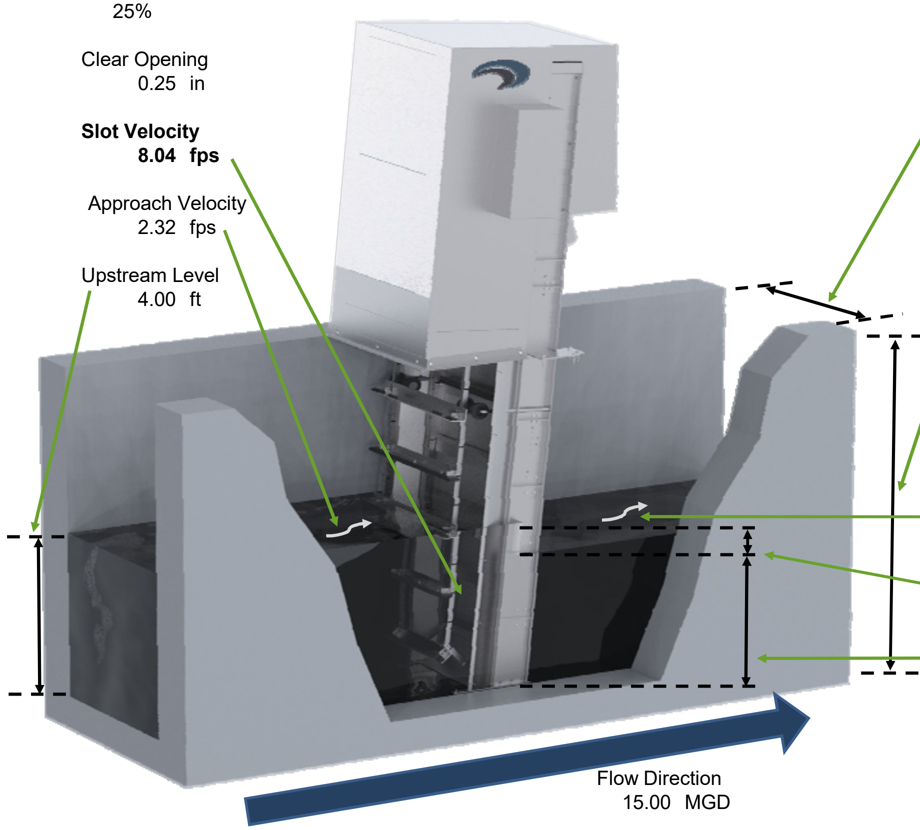
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	2.32	sft
Flow area between side fab & closeouts	7.68	sft
Number of bars	46.00	ea
Flow area taken up by bars	3.83	sft
Total Channel flow without screen	10.00	sft
Flow area after screen area and blinding taken out	2.89	sft
Approach Velocity	2.32	fps
Slot Velocity	8.04	fps
Downstream Velocity	3.46	fps
Downstream Depth	2.68	ft
Head Loss	15.80	in

Bernoulli Calculations

Velocity thru bar screen	8.04	fps
Velocity upstream of bar screen	2.32	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	1.32	ft
Headloss	15.80	inches



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HYDRAULIC CALCULATIONS

Notes: Peak Flow = 7.5 MGD (15 MGD plant Total) at set 4ft upstream water level. 2' 6" channel width.

INPUT: Channel Physics

Flow in MGD	7.50	MGD
Upstream water level	4.00	ft
Channel width	2.50	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

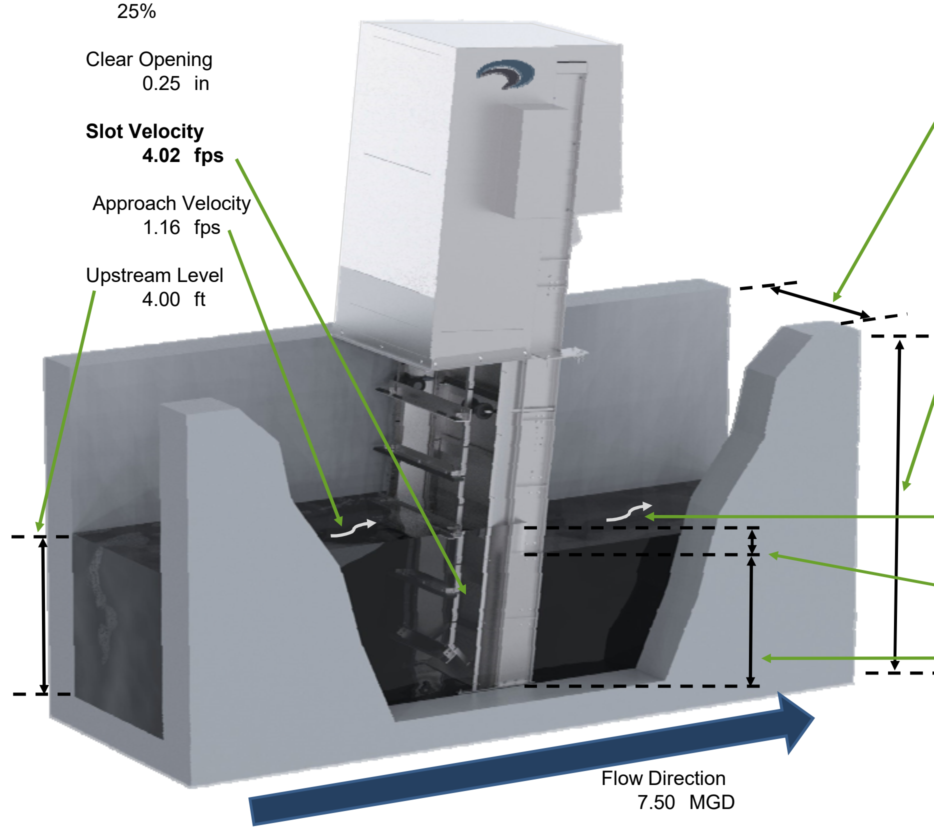
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	2.32	sft
Flow area between side fab & closeouts	7.68	sft
Number of bars	46.00	ea
Flow area taken up by bars	3.83	sft
Total Channel flow without screen	10.00	sft
Flow area after screen area and blinding taken out	2.89	sft
Approach Velocity	1.16	fps
Slot Velocity	4.02	fps
Downstream Velocity	1.26	fps
Downstream Depth	3.67	ft
Head Loss	3.95	in

Bernoulli Calculations

Velocity thru bar screen	4.02	fps
Velocity upstream of bar screen	1.16	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.33	ft
Headloss	3.95	inches



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HYDRAULIC CALCULATIONS

Notes: Average Flow = 3.8 MGD at recommended 1ft downstream water level. 2'6" channel width. High Slot Velocity

INPUT: Channel Physics

Flow in MGD	3.80	MGD
Upstream water level	1.56	ft
Channel width	2.50	ft
Channel depth	4.67	ft
Degree of blinding	25%	

INPUT: Screen Physics

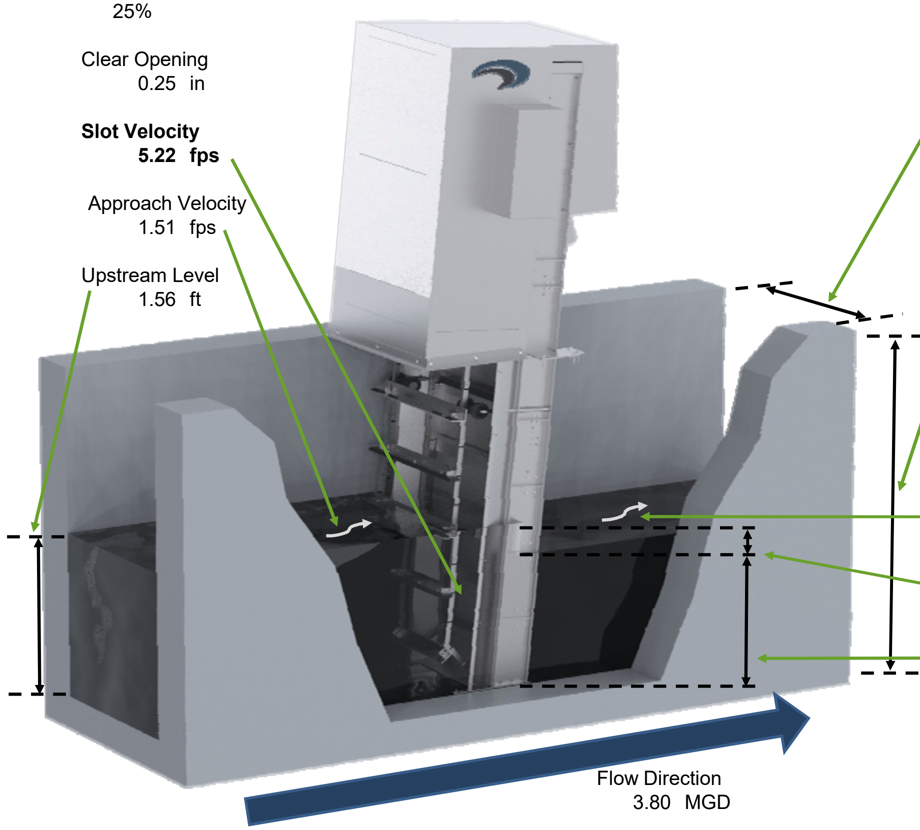
Clear Opening	0.25	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	0.90	sft
Flow area between side fab & closeouts	3.00	sft
Number of bars	46.00	ea
Flow area taken up by bars	1.50	sft
Total Channel flow without screen	3.90	sft
Flow area after screen area and blinding taken out	1.13	sft
Approach Velocity	1.51	fps
Slot Velocity	5.22	fps
Downstream Velocity	2.34	fps
Downstream Depth	1.00	ft
Head Loss	6.67	in

Bernoulli Calculations

Velocity thru bar screen	5.22	fps
Velocity upstream of bar screen	1.51	fps
Gravitational acceleration (constant)	32.20	fps
Frictional coefficient (constant)	1.43	c
Headloss	0.56	ft
Headloss	6.67	inches



These calculations are an estimation based upon the information available. Flow channel hydraulics are highly dependent on water levels and the degree of blinding. The calculations above are a snapshot of only one condition. To fully analyze the hydraulics please contact your local Duperon representative.
Duperon recommends a minimum of 1.00 ft water depth when the unit is in operation to keep the SSTL FlexLinks lubricated and ensure an optimal amount of screening area.
Duperon recommends using Water Environment Federation (WEF) & "10 States" standards as deign guidelines:
Approach velocity should be greater than 1.25 ft/s to prevent settling. Slot velocities should be less than 4 ft/s to prevent forcing material thru openings.

Full-Range Flexibility and Maximum Capture with Thru-Bar™ Cleaning; Adapts Automatically to Wide Variations in Debris

FlexRake® FPFS

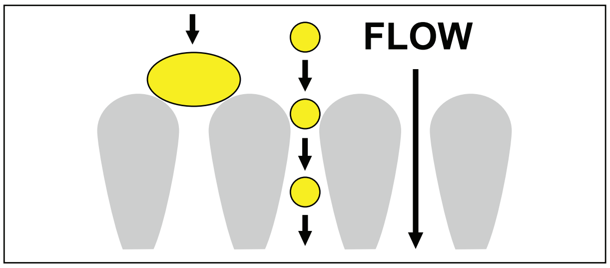
Thru-Bar™ Cleaning Fine Screen

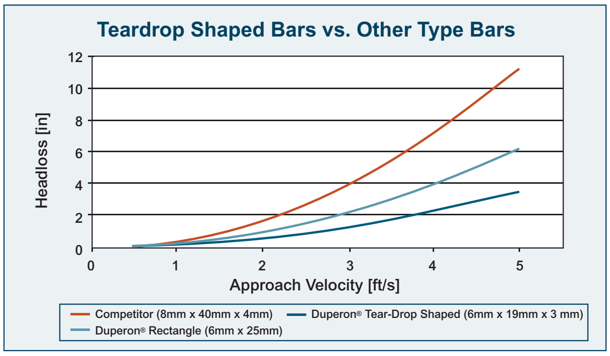
Simple front-cleaning, front-return Duperon® FlexRake® technology. Utilizes stainless steel teardrop shaped bars with 1/4 inch, 3/8 inch or 1/2 inch openings.

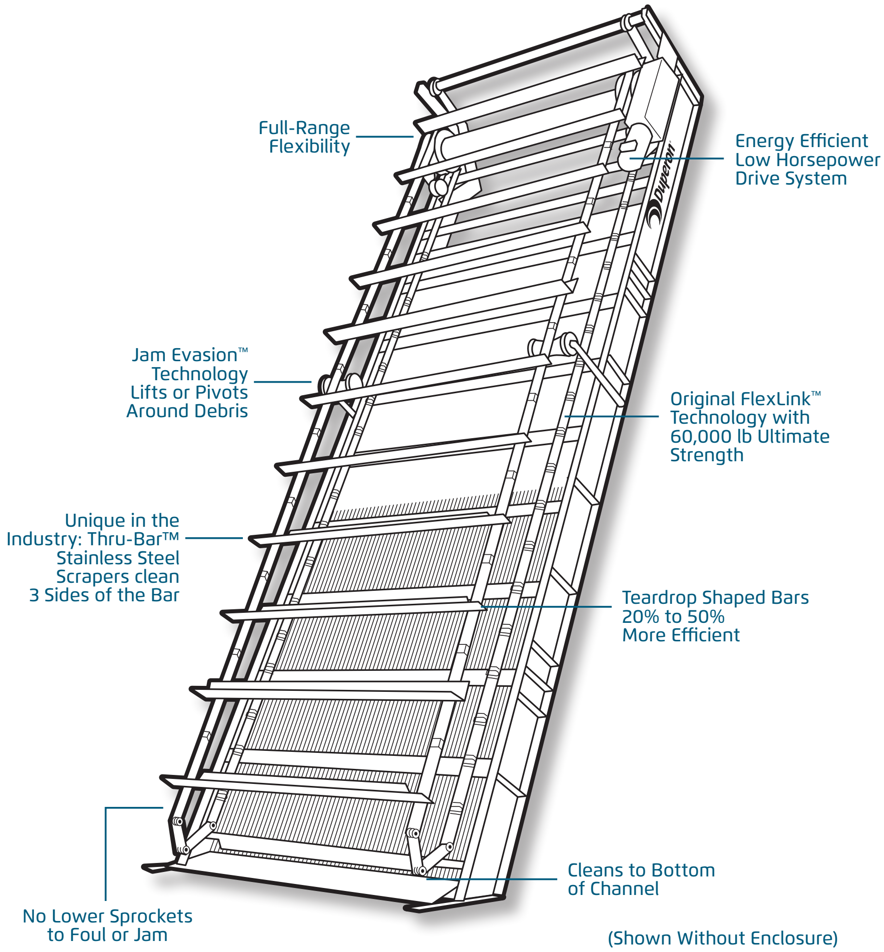
- No Lower Sprockets, Bearings or Tracks to Foul or Jam
- Adapts to Debris Variations; Full-Range Flexibility
- High Capture Thru-Bar™ Stainless Steel Scrapers
- Low Horsepower, Energy Efficient Drive System
- Teardrop Shaped Bars Most Efficient in the Market
- Five-Year Warranty for Wastewater Applications

The Duperon® FlexRake® FPFS

TEARDROP SHAPED BARS ARE THE MOST EFFICIENT BARS IN THE INDUSTRY







(Shown Without Enclosure)

TYPICAL APPLICATIONS
Wastewater, combined sewer overflows and prison applications. Also used in pulp/paper mills, raw water intakes, and other applications where debris is highly variable or difficult to capture.

UNIT WIDTH
- 2 feet to 12 feet
- Single Strand FlexRake® configuration available for channel widths of 18 inches to 24 inches

UNIT LENGTH
10 feet to 100 feet

ANGLE OF INSTALLATION
Range from 10 degrees to 45 degrees.

STANDARD MATERIALS OF CONSTRUCTION
- Standard: 304 Stainless Steel
- Available in: 316 Stainless Steel

BAR OPENING
1/4 inch, 3/8 inch and 1/2 inch

STANDARD SCRAPER SPACING
Every 2nd link (21 inches)

SCRAPER CONFIGURATION
- 3:1 UHMW-PE staging scraper/stainless steel Thru-Bar™ teeth ratio

TYPICAL MOTOR
1/2 HP, 1 PH/3 PH explosion-proof inverter-duty motor

STANDARD OPERATING SPEED
- 0.5 RPM
- Can be increased to 2.2 RPM in high flow conditions
- 1 discharge/minute on low; 4 discharges/minute on high
- Scrapers move 28 inches/minute

SHIPPING DATA
Ships fully assembled or can be provided in modular form.

STANDARD CONTROLS OPTIONS
Base packages range from simple start/stop to sophisticated automation. Motor overload protection provided. Contact Duperon® for further details and assistance in selecting the perfect package for your site.

OPERATION OPTIONS
- Continuous/Manual
- Automatic with timer, float, SCADA, differential/high level sensing options with I/O as needed

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

1200 Leon Scott Court | Saginaw, MI 48601 | P 989.754.8800 | F 989.754.2175 | TF 800.383.8479 | www.duperon.com

3340/7/18/1M

NOTE:

THIS TEMPLATE DRAWING IS SUBJECT TO CHANGE PENDING SITE VERIFICATIONS AND PER THE INFORMATION MADE AVAILABLE AT THE TIME IT WAS CREATED. DRAWING MAY BE IMPACTED BY FUTURE SPECIFICATIONS, SCOPE AND OTHER UPDATES PER REQUIREMENTS.

SITE SPECIFIC DRAWING IS AVAILABLE FROM DUPERON CORPORATION UPON REQUEST.

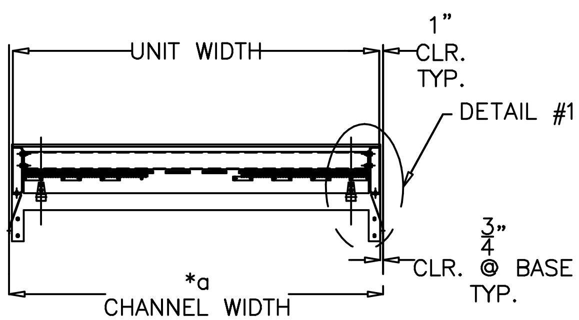
REVISIONS				
REV	DESCRIPTION	DATE	REVISED	APPROVED
1	ADDED LOGO	9/27/10	JKL	
2	ADDED VERIFICATION NOTES, DECK ANCHOR OPTION	1/30/12	JKL	
3	ADDED DIMENSIONS	5/26/16	JKL	

NOTE:

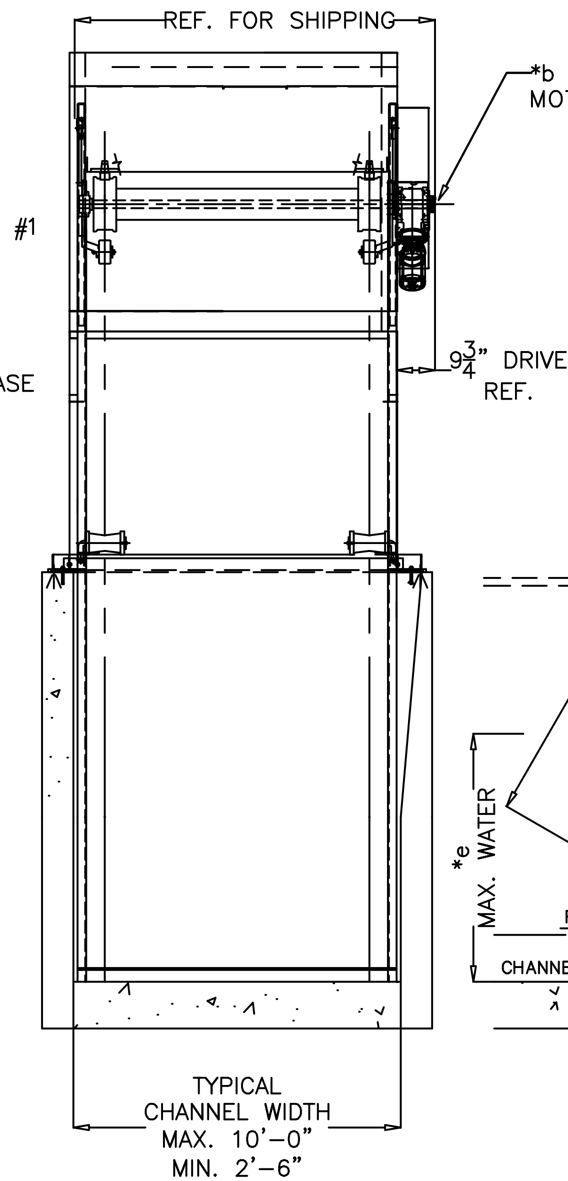
CUSTOMER IS RESPONSIBLE FOR VERIFYING THAT THE PROPOSED INSTALLATION IS SUITED TO EXISTING SITE.

SPECIFICALLY, CUSTOMER TO VERIFY THE FOLLOWING AND NOTES COMMENTS ON THE PRE-SUBMITTAL VERIFICATION FORM:

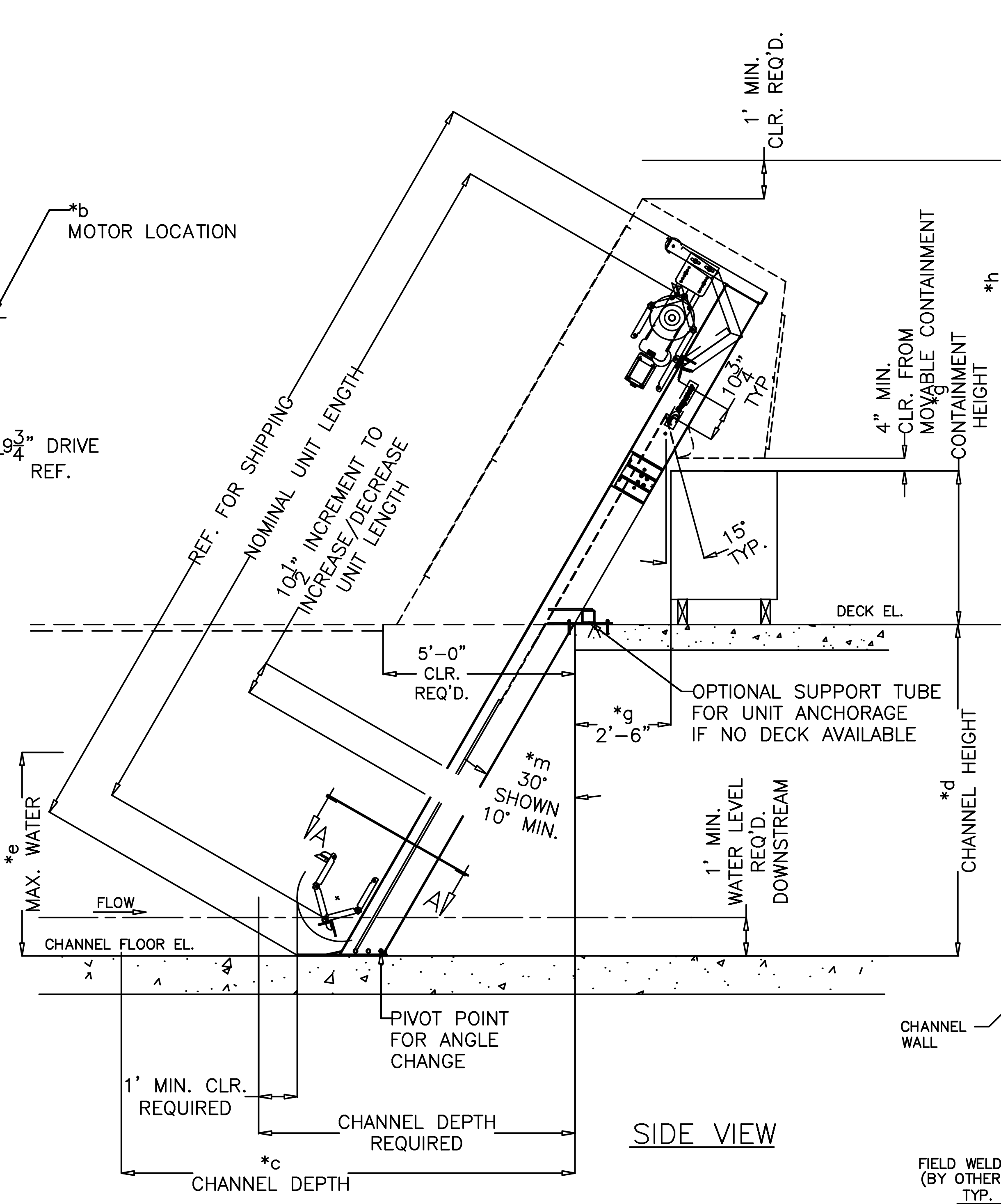
a. VERIFY EXISTING CHANNEL WIDTH DIMENSION, FULL HT. OF CHANNEL. (1) PLACE.
b. VERIFY MOTOR LOCATION ON RIGHT SIDE OF UNIT AND NOTE POWER REQUIREMENTS AT SITE. (i.e. PHASE).
c. VERIFY EXISTING CHANNEL; OPENING DIMENSION FROM DECK EDGE UPSTREAM TO FIRST OBSTRUCTION (1) PLACE.
d. VERIFY EXISTING CHANNEL HEIGHT DIMENSIONS (1) PLACE.
e. VERIFY MAXIMUM WATER HEIGHT.
f. VERIFY NORMAL WATER HEIGHT.
g. VERIFY DEBRIS CONTAINMENT HEIGHT AND NOTE LOCATION AND WIDTH– SHOWN (3) PLACES TO ASSURE SCREENING EQUIPMENT INTERACTION.
h. CUSTOMER TO NOTE ANY SITE CONSTRAINTS (I.E. CEILING HEIGHT, ETC.)
j. VERIFY IF ANY INSTALLATION CONSTRAINTS EXIST. (I.E. ACCESS DOOR OPENINGS, DECK OPENING, ETC.).
k. VERIFY REQUIRED SCREEN CLEAR OPENING.
l. VERIFY IF INTERIOR OR EXTERIOR INSTALLTION. IF EXTERIOR VERIFY IF FREEZING CONDIDTIONS ARE PRESENT.
m. VERIFY UNIT ANGLE OF INSTALLATION.
n. VERIFY IF EXISTING CHANNEL WALL OR FLOOR VOIDS EXIST? IF YES MUST BE FILLED w/ INTEGRAL STRUCTURAL FILL (BY OTHERS).



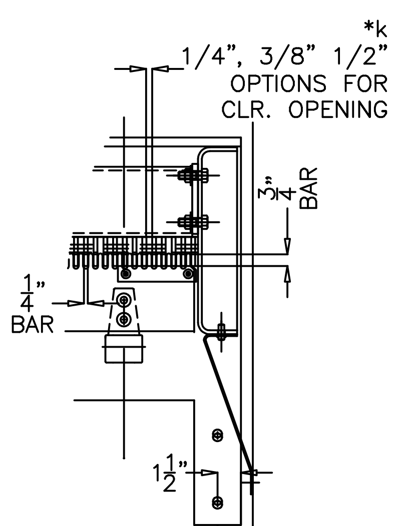
SECTION VIEW A–A



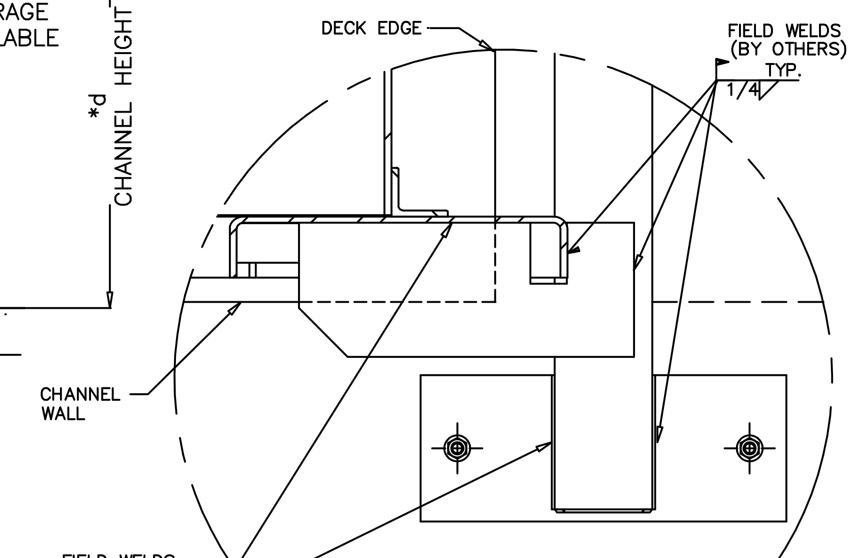
FRONT VIEW



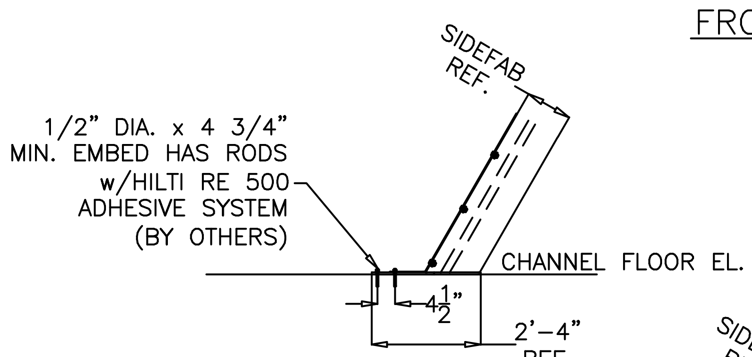
SIDE VIEW



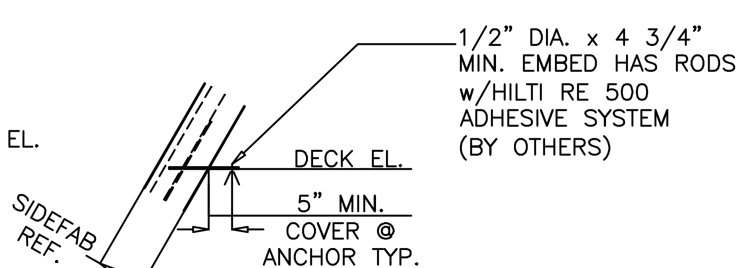
DETAIL #1



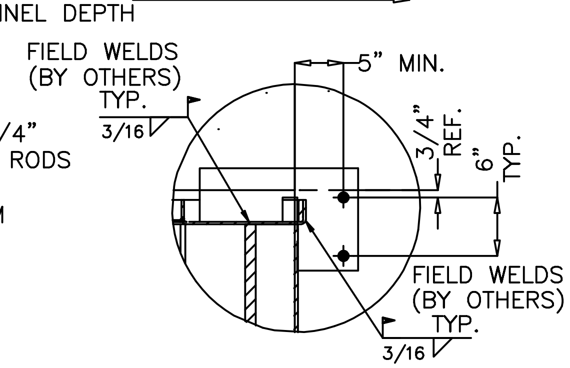
ANCHOR PLAN OPTION @ DECK



SIDE VIEW @ UNIT BASE TYP. EACH SIDE



TYP. SIDE VIEW @ DECK



ANCHOR PLAN @ DECK

FPFS PRELIMINARY

CONCEPTUAL

THIS PROPOSAL DRAWING IS BASED UPON THE INFORMATION AVAILABLE AT THE TIME AND MAY BE IMPACTED BY FUTURE SPECIFICATIONS, SCOPE, AND OTHER REQUIREMENTS. PLEASE BE ADVISED THAT DUPERON CORPORATION RETAINS THE RIGHT TO REFUSE, WITHDRAW, OR NEGOTIATE THIS PROPOSAL AT ANY TIME PRIOR TO SIGNING A MATERIAL CONTRACT.

PROPRIETARY

DIMENSIONING & TOLERANCING IN ACCORDANCE WITH ANSI Y14.5M–1982

TOLERANCES – UNLESS OTHERWISE SPECIFIED
.X = ±0.03
.XX = ±0.01
.XXX = ±0.005
.XXXX = ±0.0005
ANGULAR = ±0.5°

DRAWN	JKL	DATE 04/20/10
CHECKED		DATE
APPROVED		DATE
APPROVED		DATE
APPROVED		DATE

Duperon®
Saginaw, Michigan 48607
TF 800.383.8479

SHEET TITLE: DUPERON CORPORATION FlexRake®

PART NAME: TEMPLATE

SIZE	FSCM NO.	DWG. NO.	REV
D		PROPOSAL NO.	3

SCALE 1:50 | SHEET

Appendix B
Cost Estimates

			Unit price	Number	Total cost	Annual Cost Savings	Payback Period, years
ECM-P01	**Timer on Channel Aeration Blowers**						
		Timer (including installation)	$271	2	$542		
		Wire, conduit, fittings (per linear foot)	$29	150	$4,300		
		Subtotal			$5,000		
		Markups[1]			$3,000		
		Construction Estimate			$8,000		
		Non-construction (Engineering)[2]			$1,000		
		Estimated Capital Cost			**$9,000**	**$10,000**	**0.9**
ECM-P02	**Full Aeration System Optimization**						
	Advanced Aeration System Automation						
		Ammonia probes (includes calibration)	$14,000	2	$28,000		
		Dissolved oxygen probes (includes calibration)	$4,000	2	$8,000		
		Controller system	$3,000	1	$3,000		
		Ammonia analyzer	$20,000	1	$20,000		
		Wire, conduit, fittings (per linear foot)	$29	400	$11,466		
		Subtotal			$71,000		
		Markups[1]			$41,000		
		Construction Estimate			$112,000		
		Non-construction (Engineering)[2]			$12,000		
		Estimated Capital Cost			**$124,000**		
	High Efficiency Aeration Diffusers						
		High-efficiency diffusers	$500,000	1	$500,000		
		Diffuser installation (per sqare foot)	$6	6,885	$39,933		
		Subtotal			$540,000		
		Markups[1]			$306,000		
		Construction Estimate			$846,000		
		Non-construction (Engineering)[2]			$85,000		
		Estimated Capital Cost			**$931,000**		
	Reduce Aeration Header Pressure using New Control Valve						
		5" Elliptic diaphragm control valves	$10,340	4	$41,360		
		Valve/meter installation	$599	4	$2,394		
		Existing pipe demolition (per linear foot)	$19	12	$228		
		10" ALP SSTL pipe replacement (per linear foot)	$320	12	$3,840		
		Concentric reducers (includes installation)	$372	4	$1,488		
		OR			*$119,462*		
		10" Jet control valves	*$28,250*	*4*	*$113,000*		
		Valve/meter installation	*$599*	*4*	*$2,394*		
		Existing pipe demolition (per linear foot)	*$19*	*12*	*$228*		
		10" ALP SSTL pipe replacement (per linear foot)	*$320*	*12*	*$3,840*		
		Subtotal			$50,000		
		Markups[1]			$29,000		
		Construction Estimate			$79,000		
		Non-construction (Engineering)[2]			$8,000		
		Estimated Capital Cost			**$87,000**		
	New High Efficiency Blower for Aeration						
		High speed turbo blower (8.13 psig discharge)	$168,034	1	$168,034		
		Piping (per linear foot)	$753	75	$56,487		
		Electrical (motor connection, wire, fittings)	$37,114	1	$37,114		
		Subtotal			$262,000		
		Markups[1]			$149,000		
		Construction Estimate			$411,000		
		Non-construction (Engineering)[2]			$42,000		
		Estimated Capital Cost			**$453,000**		
		Combined Estimated Capital Cost			**$1,595,000**	**$109,500**	**14.6**
ECM-P03	**Install New Deep Well Injection Pump**						
		Pump	$60,000	1	$60,000		
		Pump pad (per cubic foot)	$580	75	$43,505		
		Coupling adapters (influent and effluent)	$2,906	2	$5,812		
		Check valve	$366	2	$731		
		Subtotal			$111,000		
		Markups[1]			$63,000		
		Construction Estimate			$174,000		
		Non-construction (Engineering)[2]			$18,000		
		Estimated Capital Cost			**$192,000**	**$14,500**	**13.2**

Subtotals, markups, construction estimates, non-construction, and estimated capital costs rounded to the nearest $1,000

Annual costs savings rounded to the nearest $500

[1]Markups include (as percent of subtotal): sales tax (7.5%), general requirements (7%), contingency (10%), contractor overhead and profit and field office (20%), prime profit (10%), bond/insurance (2%)

[2]Non-contruction (engineering) cost: 10% of construction estimate

			Unit price	Number	Total cost	Annual Cost Savings	Payback Period, years
ECM-F01	**Energy-Efficient Lighting Upgrades**						
		Operations Bldg Process Areas - 38W LED strip light	$382	32	$542		
		Operations Bldg Server Room - 23W LED strip light	$371	6	$2,228		
		Underground Corridor - 38W LED strip light	$382	16	$6,112		
		Headworks - 38W LED strip light	$382	16	$6,112		
		Exterior Wallpacks - 26W LED wall pack	$537	5	$2,684		
		Solids Bldg - 38W LED strip light	$382	52	$19,865		
		Solids Bldg - 23W LED strip light	$371	7	$2,600		
		Solids Bldg - 26W LED wall pack	$537	18	$9,663		
		Solids Bldg - 2ft x 4ft LED Troffer for 4 lamp system	$335	7	$2,342		
		Solids Bldg - LED high bay, 3 bar	$1,076	2	$2,153		
		Subtotal			$54,500		
		Markups[1]			$31,000		
		Construction Estimate			$85,500		
		Non-construction (Engineering)[2]			$9,000		
		Estimated Capital Cost			**$94,500**	**$17,087**	**5.5**
ECM-F02	**Variable-Frequency Drives for Ventilation Fans**						
		20 HP Variable Frequency Drive	$5,400	1	$5,400		
		20 HP Motor	$2,399	1	$2,399		
		Controls and Electrical Allowance	$3,000	1	$3,000		
		Demolition	$2,000	1	$2,000		
		Subtotal			$13,000		
		Markups[1]			$8,000		
		Construction Estimate			$21,000		
		Non-construction (Engineering)[2]			$3,000		
		Estimated Capital Cost			**$24,000**	**$3,812**	**6.3**
ECM-F03	**Cool Roof Coating**						
		Coating - Henry Extreme Enviro-White 55 Gal.	$980	1	$980		
		Additional Materials Allowance	$211	1	$211		
		Subtotal			$1,500		
		Markups[3]			$500		
		Construction Estimate			$2,000		
		Non-construction (Engineering)[4]			$0		
		Estimated Capital Cost			**$2,000**	**$275**	**7.3**

Subtotals, markups, construction estimates, non-construction, and estimated capital costs rounded to the nearest $1,000

Annual costs savings rounded to the nearest $500

[1]Markups include (as percent of subtotal): sales tax (7.5%), general requirements (7%), contingency (10%), contractor overhead and profit and field office (20%), prime profit (10%), bond/insurance (2%)

[2]Non-contruction (engineering) cost: 10% of construction estimate

[3]Mark-ups include sales tax (8%), materials can be purchased locally.

[4]ECM can be performed as an O&M activity, no additional design or engineering is anticipated.