Desalination Plant Basis of Design

CARNIVAL GRAND PORT
GRAND BAHAMA, THE BAHAMAS

Project Number: 063-122019
December 2019

Seawater Systems, LLC

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INTRODUCTION

Purpose

The purpose of this report is to document the design effort required for fabrication and installation of the proposed 250,000-gpd seawater reverse osmosis water treatment system for the Carnival Grand Port Project to be built at Sharp Rock, Grand Bahama, Bahamas.

Approach

The Carnival Grand Park Project is subject to stringent requirements given the environmental sensitivity of the region and the strict potable water requirements established by Carnival. In response to these requirements, the following assumptions were made to develop the desalination system design and operation:

- ✓ All irrigation within the development will utilize either captured rainwater, reclaimed water from the membrane bioreactor wastewater treatment plant or non-post-treated desalinated water;
- ✓ Given the geology of the region, the feedwater source will be supply wells. It is anticipated that the extracted feedwater will have trace quantities of hydrogen sulfide that will need to be removed prior to finished water disinfection. Therefore, degasification has been included in the post treatment with provisions for off-gas scrubbing;
- ✓ Based on the membrane performance for plants in the region, media filters are not anticipated unless the feedwater well is constructed to draw feedwater from a high iron bearing formation. The inclusion of media filters in the final plant design will be determined once the production well is completed and tested. This document includes media filtration as an option, and
- ✓ The membrane concentrate will be combined with other waste streams and disposed via an injection well.
- ✓ During commissioning of the plant, the HES manager and the staff in charge for the operation of the plant will by fully trained by the Manufacturer- Supplier.
- ✓ A technical service agreement will be signed with the Manufacturer-Supplier which will include two visits per year, during which a full technical audit of the plant will be carried out as well as regular training of the staff responsible for the operation. Remote monitoring from the Manufacturer-Supplier will be also included in the technical service contract.

DESALINATION PLANT DESIGN

Overview

The project potable water requirements will be provided using single desalination plant with the Grand Bahama Port Authority water supply serving as the backup source. The overall desalination treatment process will consist of feedwater pumping, bag filtration, optional media filtration, the addition of a scale inhibitor, cartridge filtration, membrane separation, forced air degasification, re-pumping, and post treatment. Provisions have been included to bypass the post treatment systems for the production of irrigation water. The post aeration re-pump station will be designed to transfer either type of water to the appropriate storage tanks located within the project. Membrane concentrate will be disposed via an injection well to be constructed as part of this project.

The desalination process will consist of a dual treatment units or “trains” each equipped with a positive displacement axial piston first pass membrane feed pump, first pass membrane array, energy recovery system, second pass membrane feed pump, second pass membrane array, high- and low-pressure piping and instrumentation. The second pass system is designed to treat up to 60 percent of the first pass permeate. A membrane cleaning/flush system will be provided.

The membrane post treatment will be designed to receive the flow from both units and consists of a forced air degasifier, repumping, recarbonation, calcium carbonate up flow contactors to boost finished water hardness and alkalinity concentrations; and three chemical feed systems for the metering of a corrosion inhibitor, dilute hydrochloric acid for pH adjustment and sodium hypochlorite for residual disinfection. The final pH and chlorine residual will be controlled and recorded by a separate system.

The following sections describe the various aspects of the facility in greater detail. Process flow schematics are presented in Appendix A.

Process Design Criteria - Flowrate

In the proposed system design, seawater will be obtained from well(s); therefore, a membrane flux rate[1] of 9.2 GFD has been selected for the first pass membranes in the potable production mode, 8.1 GFD in the irrigation production mode and 14.2 GFD for the second pass. Hydraulic loading rates and pipe sizing have been done using a first pass recovery rate[2] of 42 percent and 90 percent for the second pass. Table 1 summarizes the design criteria used to size the proposed equipment.

Process Design Criteria – Water Quality

Table 2 presents typical seawater composition used for the system design along with the projected finished water compositions. The actual water quality will vary slightly, depending on feedwater temperature, the degree of membrane fouling and the percentage of additional treatment by the second pass.

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1 Defined as the feedwater loading rate on the membrane, generally expressed as gallons per day per square foot of active membrane area, GFD.

2 Defined as the volume of water produced as a percentage of the feedwater. A 42 percent recovery system produces 42 gallons of permeate for every 100 gallons of feedwater pumped into the membrane array.

Table 1
Basis of Design

Parameter	Potable	Irrigation
Feedwater Stream		
Quantity, normal operating, USgpm	441	413
Total Dissolved Solids, mg/L	36,100	
Design Feedwater Temperature	22° - 28° C	
1st Pass Permeate Stream		
Design Flowrate, USgpm	185	174
Recovery, %	42	42
Total Dissolved Solids, mg/L	Less than 500	Less than 500
2nd Pass Permeate Stream		
Design Flowrate, USgpm	104	N/A
Recovery, %	90	N/A
Total Dissolved Solids, mg/L	Less than 20	N/A
Overall Permeate TDS, mg/L	Less than 250	Less than 500
Concentrate Stream		
Quantity, normal operating, USgpm	267	240
Estimated Total Dissolved Solids, mg/L	58,400	58,400
Media Filter Backwashing (If required), USgpm	251	
Power Requirements		
Power Supply	480 VAC, 3Ø,60 HZ	
Estimated unit power consumption, KWH/1,000 gallons[3]	12.2	10.5

Table 2
Water Quality Profile

Constituent	Feedwater	Membrane Concentrate	Irrigation	Blended Permeate	Finished Water
Calcium, mg/l as ion	408	827	1.0	0.5	24
Magnesium, mg/l as ion	1,298	2,336	2.7	1.1	1.1
Sodium, mg/l as ion	10,768	18,521	85	37	49
Potassium, mg/l as ion	388	667	4.3	1.9	2.0
Bicarbonate, mg/l as ion	143	245	1.3	0.6	61
Sulfate, mg/l as ion	2,702	4,655	6.1	2.6	4.5
Chloride, mg/l as ion	19,380	33,570	139	59.3	70
Carbon Dioxide, mg/l as CO_2	2.6	2.6	0.2	0.2	0.1
Silica, mg/l as $Si0_2$	15	26	0.2	0.1	0.1
TDS, mg/l	36,100	60.750	239	102	212
pH, unit	7.8	8.0	8.0	8.0	7.6

3 Estimate power consumption for the plant for each operating configuration are presented as Exhibits 1 and 2.

FEEDWATER SUPPLY

The feedwater supply will consist of two wells, each equipped with submersible pumps. Only one well is required for normal plant operation with the second serving as a backup. The proposed well pump and motors would be fabricated from 904L duplex stainless steel. The pump drop pipe would be 6-inch Certalok PVC piping in 20-foot lengths. Each well head would be equipped with isolation and check valves, a manual air release valve, electrical power disconnect and discharge pressure gauge and transmitter. The well pumps will be controlled using variable frequency drives (VFD). A summary of the feedwater well and well pump design criteria is presented in Table 3. A summary of the feedwater and concentrate disposal piping design criteria is presented in Table 4 and shown on Drawing P-1.

Table 3 – Feedwater Supply Design Criteria

Plant Production Mode	Potable	Irrigation
Source	Well	Well
No. of Supply Pumps in Operation	1	1
Total Feed Flowrate, gpm	441	413
Flow Per Pump, gpm	441	413
Proposed Pump -	475R-300-3	475R-300-3
Drop Pipe Diameter, in	6	6
Velocity, fps	5.01	4.69
Supply Discharge Pipeline Diameter, in	8.625	8.625
Velocity, fps	3.12	2.93
Pump Suction NPSHR, ft	21.50	21.50
Minimum Pump Discharge Head, psi	68.0	68.0
Pump Actual Input Head, psi	68.0	68.0
Pump Efficiency, %	75.1%	75.1%
Motor Efficiency, %	85.0%	85.0%
Motor Power Factor, %	99.0%	99.0%
Motor Rated HP:	30	30
Load HP	24.0	22.5
KWH/1000 gals	2.02	1.89

Table 4 – Feedwater and Concentrate Disposal Piping Design Criteria

Parameter	Potable	Irrigation
Pipeline to Plant Flowrate, gpm	441	413
Pipeline Outside Diameter, in	8.625	8.625
Pipeline Wall Thickness, SDR	11	11
Pipeline Inside Diameter, inches	7.1	7.1
Pipeline Velocity, fps	3.6	3.4
Pipeline Length, feet	200	200
Estimated Pressure Drop, feet (Hazen & Williams C=155)	1.1	1.0

Table 4 – Feedwater and Concentrate Disposal Piping Design Criteria

Parameter	Potable	Irrigation
Concentrate Flow, gpd	384,921	345,238
Concentrate Flow, gpm	267.3	239.7
Pipeline to Injection Well Outside Diameter, in	6.625	6.625
Pipeline to Injection Well Wall Thickness, SDR	17	17
Pipeline to Injection Well Inside Diameter, inches	5.8	5.8
Disposal Pipeline Velocity, fps	3.2	2.9
Estimated Disposal Pipeline Length, feet	400	400
Estimated Pressure Drop, feet (Hazen & Williams C=155)	2.1	1.8

MEMBRANE PRETREATMENT

Basis of Design

The pretreatment system has two purposes, filtration and chemical conditioning. The use of media and/or bag filters followed by cartridge filters protect the membranes from fouling by removing naturally occurring particulates found in the feedwater. Bag filters are used to protect the plant piping in the event of a well failure. Media filters are used to protect both the downstream piping and membranes from suspended solids in the feedwater. Most desalination plants operating in the Bahamas do not typically include media filters in the pretreatment as the feedwater drawn from the wells tends to be very low in suspended solids. For this plant, media filtration is an optional treatment process that will only be used if the wells produce high suspended solids or iron. Bag filters would not be included if the media filters were incorporated.

Most naturally occurring waters precipitate calcium carbonate when concentrated. During the treatment process, the dissolved solids, including sparingly soluble salts, are concentrated by the RO membranes. If any of these salts are allowed to precipitate, the resulting scale can foul the RO membranes. To prevent the “seeding” of sparingly soluble salts, a scale inhibitor is added to the feedwater ahead of the cartridge filters.

Bag Filtration

Bag filtration is a simple and proven technology. The filter housings are constructed from glass-reinforced polypropylene, eliminating any corrosion issues. There is an internal basket in which a 7-inch diameter by 32-inch long fabric filtration bag is placed. Feedwater enters the housing at the top and flows through the fabric filter, exiting at the bottom. The fabric bags come in different nominal pore sizes ranging from 1 to 800 microns. The housings are rated for 150 psi at 70 ^{o}F (non-shock).

The proposed filtration design will consist of two banks of four each, Hayward FLV Polyline double length units, each equipped with individual 2-inch PVC inlet, outlet and drain isolation valves. This design will provide a nominal loading rate of 55 US gallons per minute per housing in the potable production mode and 52 US gallons per minute per housing in the irrigation production mode. A summary of the bag filtration design criteria is presented in Table 5 and shown on Drawing P-1.

Cutaway view of a double length housing

Table 5 – Bag Filtration Design Criteria

Parameter	Potable	Irrigation
Number of Filters, each	8	8
Flow per Filter, gpm	55	52
No. of Filters on each Header	4	4
Filter Header Diameter, in	6.0	6.0
Header Velocity, fps	2.50	2.36
Minimum Pressure Drop, psid	3.0	3.0
Maximum Pressure Drop, psid	10.0	10.0

Media Filtration (Optional)

If required, the system has been designed to operate with eight each, 48-inch diameter, multi-media filters. This design will provide a maximum nominal surficial loading rate of 4.4 US gallons per minute per square foot of filter area (gpm/ft^2) in the potable production mode and 4.1 gpm/ft^2 in the irrigation mode. Periodically, typically every 3 to 5 days, the filters are backwashed to flush out all removed material. The required backwash rate ranges from 15 to 20 gallons per minute per square foot of filter media, depending on water temperature. For the selected filters, the backwash flowrate will range from 190 to 250 gpm. The backup seawater supply pump will be used for backwashing and the subsequent forward rinse steps.

The filter housing will be a composition vessel with the outer shell constructed from continuous fiberglass roving with an inner liner constructed from virgin polyethylene material. The maximum operating pressure of the pressure vessel will be 150 psi and designed with a factor of safety of 6 to 1 for minimum burst pressure. The maximum operating temperature of the pressure vessel will be rated at 120 Deg. F. The pressure vessel will be capable of withstanding negative pressure up to 5” Hg. The pressure vessel inner shell will isolate the fluid contents of the pressure vessel to eliminate corrosion, intrusion, or reaction. The pressure vessel inner shell material will be the only material in contact with the feedwater. The vessel will be tripod design with 6-inch flanged connections.

The influent distribution/backwash collection manifold will be precision molded polypropylene with a 3-inch piping connection. The effluent collection/backwash distribution will be a single row, slotted, precision molded polypropylene with a 3-inch piping connection.

Each filter has been designed to provide three working medias on top of a support gravel layer. All media will meet AWWA B100-96 specifications. The support media will be provided to keep the working media out of the underdrain collection system and to support even flow distribution during backwashing.

The first working media will be a 12-inch layer of No. 12 garnet sand. The middle working media will be a 12-inch layer of No. 50 garnet sand. The top working media will be an 18-inch layer of anthracite. The process, backwash, and forward rinse headers, valves and fittings making up the media filtration system will be fabricated from schedule 80 PVC components. The face piping will include a sight glass tube to allow operators to adjust backwash flowrate and to visually verify whether media is being carried out. The sight glass tube will be constructed from clear PVC. The face piping will include a cleanout port to allow internal cleaning of the sight glass tube. All valves will be PVC with EPDM elastomers and non-metallic actuators with position settings. All bolts and anchors will be grade 316 stainless steel. A summary of the media filtration design criteria is presented in Table 6 and shown on Drawing P-2.

Table 6 – Media Filtration Design Criteria

Parameter	Potable	Irrigation
Filter Diameter, inches	48	48
Number of Filters, each	8	8
Flow per Filter, gpm	55	52
Loading Rate, gpm/ft2	4.39	4.12
No. of Filters on each Header	4	4
Filter Header Diameter, in	6.0	6.0
Header Velocity, fps	2.50	2.35
Minimum Pressure Drop, psid	3	3
Maximum Pressure Drop, psid	15	15
Minimum Backwash Rate, GPM/Ft2	15	15
Minimum Backwash Rate, GPM	188	188
Maximum Backwash Rate, GPM/Ft2	20	20
Maximum Backwash Rate, GPM	251	251
Backwash Duration, minutes	15	15
Maximum Backwash Volume per Filter, Gallons	3,770	3,770
Maximum Backwash Volume per Day, Gallons	30,160	30,160
Backwash Pressure, PSIG	30	30

Scale Inhibitor

To prevent scale formation within the membrane assembly, a scale inhibitor feed system will be provided. The proposed system includes one chemical feed system consisting of a positive displacement chemical injection pump, day tank, calibration column, and low-level sensor. The system has been sized to provide 2 mg/L of inhibitor. Scale inhibitor will be injected and mixed using the cartridge filter housing. Chemical pumping rate will be automatically controlled by the PLC to account for the number of trains in operation. A summary of the scale inhibitor design criteria is presented in Table 7 and shown on Drawing P-3.

Table 7 – Scale Inhibitor Design Criteria

Parameter	Potable	Irrigation
Feed Stream Concentration, mg/l	2	2
Daily Consumption, lbs/day	10.6	9.9
Daily Consumption, gallons/day	1.24	1.17
Monthly Consumption, gallons	34.1	32.0

Cartridge Filtration

Three-micron polypropylene cartridge filters are provided to protect the membrane feed pump and energy recovery units in the event of an upset in the seawater supply and/or media filters. The cartridge filtration step will consist of one fiber reinforced plastic (FRP) cartridge filter housing per SWRO train, each design to hold twenty-two, forty-inch long disposal cartridge filter elements. The nominal filter-loading rate is 10.0 USgpm per filter element in the potable production mode and 9.4 in the irrigation production mode. Cartridge filter elements will be of the conventional wound type, of polypropylene thread wound on polypropylene core. The cartridge filter housing will be equipped with inlet and outlet isolation valves to permit servicing. The outlet connection will include a 4-inch drain valve to allow the housing to be rinsed thoroughly during element replacement. All isolation valves would be constructed from PVC and equipped with EPDM elastomers. A summary of the cartridge filtration design criteria is presented in Table 8 and shown on Drawing P-3.

Table 8 – Cartridge Filtration Design Criteria

Parameter	Potable	Irrigation
Target Loading Rate, gpm/40" element	10	10
Minimum No of cartridge filter elements	44	41
No. of C/F Housings On-Line	2	2
No. of C/F Elements per Housing	22	22
Actual No. of 10" elements	44	44
Actual Loading Rate, gpm/ 40" element	10.0	9.4
Minimum Pressure Drop, psid	4.0	4.0
Maximum Pressure Drop, psid	10.0	10.0
Cartridge Filter Life, months	1	1

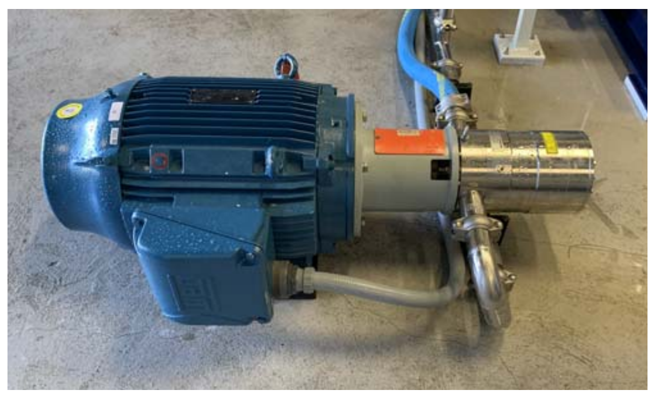
Membrane Process

The desalination plant consists of two treatment units, each rated to produce 125,000 gallons per day. To meet the potable water standards for the project, each unit will incorporate a partial second pass treatment system designed to treat up to 60 percent of the first pass permeate. The membrane arrays will be fabricated with dual permeate headers to permit the second pass unit to treat only the permeate collected from the concentrate end.

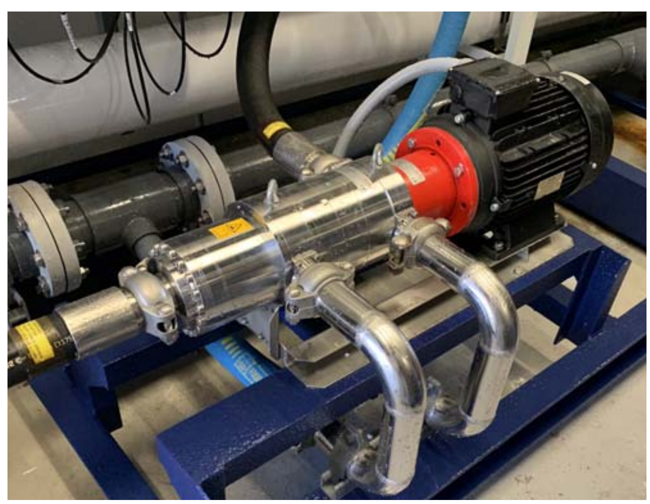
Each unit will consist of first and second pass membrane feed pumps, first and second pass membrane pressure vessels, elements and support structure, energy recovery unit, high- and low-pressure piping, and instrumentation. The system has been designed to use industry standard 8-inch diameter by forty-inch long, high rejection, composite membrane elements within the first pass and industry standard 8-inch diameter by forty-inch long, high rejection, low pressure composite brackish membrane elements in the second pass. The first pass membrane feed pump is a high efficiency axial piston positive displacement type operating in parallel with an isobaric energy recovery unit (iSave). The second pass membrane feed pump is a multistage centrifugal pump. Because of the high second pass recovery rate, energy recovery is not cost effective. A membrane cleaning/flush system will be included that will be used by both RO trains.

1st Pass Membrane Feed Pump

The membrane process will be driven using a single high-pressure pump to pressurize the pretreated feedwater to approximately 850 psig although the exact operating pressure of the membranes is dependent on feedwater temperature, salinity, and degree of membrane fouling. The first pass will utilize a Danfoss APP24 positive displacement, axial piston pump constructed from 2507 super duplex stainless and driven using a 75-horsepower electric motor controlled using a variable speed drive (VFD). A summary of the membrane pumping system is presented in Table 9 and shown on Drawing P-4.



Energy Recovery



Operating in parallel with the high-pressure pump will be a single Danfoss iSave 40 energy recovery unit with integral booster pump. This design results in the energy recovery unit operating at approximately 70 percent of rated capacity at 42 percent recovery in the potable production mode and 66 percent at 42 percent recovery in the irrigation production mode. This approach provides for flexibility in plant operation by allowing the system recovery to be altered if necessary and reduces the ambient sound level. All wetted components within the iSave 40 is constructed from 2507 super duplex stainless steel. The integral booster pump is powered by a 20 HP motor driven by a variable frequency drive. A summary of the energy recovery is presented in Table 10 and shown on Drawing P-4.

Table 9 – 1st Pass Membrane Pumping Design Criteria

Parameter	Potable	Irrigation
HP Pump Flowrate, gpm	187	175
No. of HP Pumps Operating, Each	2	2
Pump Model	APP24	APP24
Flow per HP Pump, gpm	96	88
Required Pump Speed, rpms	1041	946
Minimum Suction Pressure, psig	30	30
Estimated Operating Pressure, psig	850	850
Pump Mechanical Efficiency, %	90.0%	90.0%
Drive Efficiency, %	98%	98%
Motor Efficiency, %	94%	94%
Motor Power Factor, %	99.0%	99.0%
Estimated Running Load, Hp	52.26	47.49
Motor Rating, Hp	75	75
KW Input	41.5	37.7
KWH/1,000 gal Produced	7.96	7.24

Table 10 – Energy Recovery Design Criteria

Parameter	Potable	Irrigation
Concentrate Flow per train, gpm	127.9	119.9
No. of ER Units	1	1
Danfoss Model Number	iSave40	iSave40
Rated Capacity, gpm	182	182
Design vs Rated Capacity, %	70%	66%
Concentrate Flow per unit, gpm	127.9	119.9
Boost Pressure Required, psid	40	40
Boost Pump Efficiency, percent	60%	60%
Motor Efficiency, %	88.0%	88.0%
Motor Power Factor, %	99.0%	99.0%
Motor Rated HP:	20	20
Load HP	5.0	4.7
Kilowatts	4.22	3.95
KWH/1,000 gals	0.81	0.76

1st Pass Membrane Process Unit

Each RO train will be provided with first and second stage membrane arrays. Spiral wound seawater membrane elements will be provided in the first pass array to separate the pretreated feedwater into a concentrated stream and a low salinity permeate stream. The first pass membrane array will consist of five pressure vessels operating in parallel, each loaded with seven elements with a nominal effective membrane area of 440 square feet. All high-pressure piping will be fabricated from Allegany Steel Zeron 100. The membrane elements for use in the first pass will be model TM820M-440 as manufactured by Toray, or equal.

The membrane pressure vessels will meet the requirements of ASME Section X, entitled Fiber Reinforced Boilers and Pressure Vessels. The feed and concentrate ports will be located in the sidewall of the pressure vessel. Each side-ported feed/concentrate port will be constructed of 2507 super duplex stainless steel and will be designed to interface with a flexible grooved coupling. The pressure vessels will be model PRO 8-1000-SP-7 as manufactured by Protec Arisawa.

All high-pressure piping will be fabricated from schedule 10/40 Allegany Steel Zeron100. Threaded connections will be restricted to pressure taps for instrumentation connections. The permeate piping for the first pass units will be designed to extract permeate from both ends of each pressure vessel. For potable production, the feed end permeate, being of higher water quality, will not be treated by the second pass system. Permeate extracted from, the concentrate end will be fed into a multistage centrifugal pump and pressurized to approximately 130 PSI and fed into the second pass membrane array to provide additional removal of dissolved solids. The water produced by the second pass will be blended with feed end permeate and fed to the post treatment system. For the production of irrigation water, the permeate from both ends will be blended without using the second pass system. The permeate piping will include electrically actuated valves to permit desalinated water to be delivered to the degasifier or the membrane flush tank.

Each membrane system will be designed to include a two-step post operational flush to remove the concentrated seawater from the membrane array and the high-pressure pump assembly at shutdown. A summary of the first pass membrane array is presented in Table 11 and shown on Drawing P-4.

Table 11 – 1st Pass Membrane Array Design Criteria

Parameter	Potable	Irrigation
Train Capacity, gpd	133,333	125,000
Number of Vessels per Train	5	5
Membrane Operating Pressure, psig	850	850
Number of Elements per Vessel	7	7
Total No. of Elements per Train	35	35
Number of RO Trains	2	2
Cleaning Flowrate per Vessel, gpm	30	30
Projected Permeate TDS, mg/l	239	239
Active Membrane Area, ft2	440	440
Average Productivity, gfd	9.20	8.12
Estimated Useful Membrane Life, years	6	6

2nd Pass Membrane Feed Pump

The second pass membrane process will be driven using a single multistage centrifugal pump to pressurize the pretreated feedwater to approximately 130 psig although the exact operating pressure of the membranes is dependent on the percentage of second pass permeate flow required to meet the final water quality requirements. The second pass will utilize a Grundfos BM 17-8NE multistage centrifugal pump constructed from grade 316 stainless steel and driven using a 15-horsepower electric motor controlled using a variable speed drive (VFD). A summary of the 2nd pass membrane pumping system is presented in Table 12 and shown on Drawing P-4.

Table 12 – 2nd Pass Membrane Pumping Design Criteria

Parameter	Potable
Parameter	Potable
HP Pump Flowrate, gpm	116
No. of Pumps Operating, Each	2
Feed Pump Model	Grundfos BM 17-8NE
Flow per HP Pump, gpm	58
Minimum Suction Pressure, psig	2
Estimated Pump Operating Pressure, psig	130
Pump Mechanical Efficiency, %	69.5%
Drive Efficiency, %	98%
Motor Efficiency, %	82%
Motor Power Factor, %	99.0%
Maximum Load, Hp	6.35
Motor Rating, Hp	15
KW Input	5.8

2nd Pass Membrane Process Unit

Partial second pass membrane treatment will be used for the production of potable water. Each second pass unit is designed to treat up to 60 percent of the first pass production or 75,000 US gallons per day per unit. Spiral wound low-pressure brackish membrane elements will be provided in the second pass array to provide additional salinity reduction by treating permeate collected from the concentrate end of the first pass array. The second pass membrane array will consist of two pressure vessels operating in series, each loaded with six elements with a nominal effective membrane area of 440 square feet. Second pass membrane feed piping will be fabricated from schedule 80 PVC. The membrane elements for use in the second pass will be model TMG20D-440 as manufactured by Toray, or equal.

The membrane pressure vessels will meet the requirements of ASME Section X, entitled Fiber Reinforced Boilers and Pressure Vessels. The feed and concentrate ports will be located in the sidewall of the pressure vessel. Each side-ported feed/concentrate port will be constructed of grade 316L stainless steel and will be designed to interface with a flexible grooved coupling. The pressure vessels will be model PRO 8-300-SP-6 as manufactured by Protec Arisawa.

The water produced by the second pass will be blended with feed end permeate and fed to the post treatment system. The second pass concentrate will be recovered by blending with the feedwater ahead of the cartridge filter housing. A summary of the second pass membrane arrays is presented in Table 13 and shown on Drawing P-4.

Table 13 – 2nd Pass Membrane Array Design Criteria

Parameter	Potable
Train Capacity, gpd	75,000
Number of Vessels per Train	2
Membrane Operating Pressure, psig	90
Number of Elements per Vessel	6
Total No. of Elements per Train	12
Number of RO Trains	2
Projected Permeate TDS, mg/l	10
Active Membrane Area, ft2	440
Average Productivity, gfd	14.2
Estimated Useful Membrane Life, years	8

Membrane Cleaning/Flush System

A dual-purpose membrane cleaning/flush system will be provided for periodic insitu cleaning of the membrane elements and for additional flushing of the first pass membrane unit during shutdown. The cleaning/flush system will include a closed storage tank, cleaning/flush pump, interconnecting piping, instrumentation and controls. Cleaning connections to the membrane system are made using removable piping spools and Victaulic type grooved connections. The post operational flush is done by supplying stored permeate to the individual train low pressure feed piping after the cartridge filter housing. A summary of the membrane cleaning/flush system is presented in Table 14 and shown on Drawing P-7.

Table 14 – Membrane Cleaning/Flush System Design Criteria

Parameter	Design Value
Number of Vessels per Cleaning	5
Detention time in Cleaning Tank, minutes	3
Cleaning flow, gpm	150
Cleaning Tank Volume, gals	500
Cleaning Feed Pipe Diameter, in	4
Cleaning Feed Velocity, fps	3.8
Cleaning Return (P & C) Pipe Diameter, in	4.0
Cleaning Return Velocity, fps	1.9
Cleaning Pump	ZC2 2.5" x 2" w/5.25" Imp.
Pump Actual Input Head, psi	45
Pump Efficiency, %	62.0%
Motor Efficiency, %	90.0%
Motor Power Factor, %	87.0%
Motor Rated HP	7.5
Load HP	6.42
Estimated Cleanings per Year	1

Post-Treatment

Basis of Design

The desalinated water produced by the partial two pass RO process will contain hydrogen sulfide and is very low in mineral content and lacking in alkalinity for pH stability. To reduce the corrosive tendency and improve the overall aesthetics, the permeate stream is post-treated. Post treatment will consist of degasification, and for potable water use, recarbonation followed by calcium carbonate contactors and three liquid chemical feed systems.

Carbon dioxide will be added to the process stream using a carbonator and a slip stream drawn from the degasifier transfer pump discharge piping. Calcium carbonate has the advantage of increasing both calcium ion and bicarbonate concentrations with the addition rate established based on the settings of the carbonator. Following the calcium carbonate bed, three chemical feed systems will be used to meter the addition of dilute hydrochloric acid for pH control, sodium hypochlorite to provide a residual disinfectant and sodium silicate to further reduce the corrosivity of the finished water. The dosage rate of the dilute hydrochloric acid and sodium hypochlorite will be controlled by a separate chlorine monitoring system. This unit will also record and store finished water free chlorine and pH values.

Forced Air Degasification and Transfer Pumping

The first step will be degasification for the removal of dissolved gases. A single forced air degasifier will be used to treat all permeate flow. The degassed permeate is collected in an integral sump located at the base of the tower. Transfer pumps will be used to repressurize the degassed permeate and transfer to either the irrigation storage tank or to additional post treatment to produce potable water.

The transfer pumping system consists of two end suction centrifugal pumps. Only one pump is required for normal plant operation with the second serving as a backup. The proposed transfer pump would be fabricated from 2205 duplex stainless steel. Each pump would be equipped with suction isolation and discharge isolation and check valves, manual air release valve, electrical power disconnect and suction and discharge pressure gauges. Pump control will be via VFDs based on the water level in the degasifier clearwell.

The transfer discharge piping would be equipped with two electrically actuated butterfly valves to direct flow to either the irrigation storage tanks or the potable water post treatment. A summary of the degasification and transfer pumping system is presented in Table 15 and shown on Drawing P-5.

Recarbonation

The recarbonation system will consist of one inline booster pump, a carbonator and related piping and valves. Source water for the carbonic acid solutioning will be drawn from the degasification transfer pump discharge piping. The degassed permeate will be pressurized to approximately 50 psi and fed to the carbonator. Bulk carbon dioxide will be provided and stored on site in multiple 150-pound vessels. A summary of the recarbonation system is presented in Table 16 and shown on Drawing P-6.

Table 15 – Degasification and Transfer Pumping System Design Criteria

Parameter	Design Value
Number of Degas Towers	1
Flow per tower, gpm	173.6
Tower Diameter, feet	3.0
Tower Area, ft2	7.07
Hydraulic Loading, gpm/ft2	24.6
Blower HP	2
KWHr/1000 gals	0.14
Degasifier Sump Retention Time, minutes	3.0
Degasifer Sump Minimum Capacity, gallons	521
Degasifier Sump Diameter, inches	60
Degasifier Sump Height, inches	48
Degasifier Sump Actual Capacity, gallons	587
No. of Pumps in Operation	1
Total Flowrate, gpm	182.3
Flow Per Pump, gpm	182.3
Proposed Pump -	Ampco ZC2 3x2 w/9.375
Supply Pipe Diameter, in	4.0
Velocity, fps	4.7
Supply Discharge Pipeline Diameter, in	4.0
Velocity, fps	4.7
Pump Suction NPSHR, ft	10.0
Pump Actual Input Head, psi	23.8
Pump Efficiency, %	56.0%
Motor Efficiency, %	87.50%
Motor Power Factor, %	88.10%
Motor Rated HP:	5.0
Load HP	4.5
KWHr/1000 gals	0.37

Table 16 – Recarbonation System Design Criteria

Parameter	Design Value
Feed Stream Concentration, mg/l	44
Daily Consumption, lbs/day	92
Downstream Injector Pressure, psi	10
Upstream Injector Pressure, psi	50
Required CO2 Injector Flow, gpm	20
Selected Throat & Tailpiece Injector Model	312L
Pump Manufacturer and model	Grundfos CRN5-5
Boost Pump Efficiency, percent	55%
Motor Efficiency, percent	82.0%
Motor Power Factor, percent	85.5%
Motor Rating, HP	1.5
Load, HP	1.1
Kilowatts	0.8
KWH/1,000 gals	0.1

Calcium Carbonate Contactor

Granular calcium carbonate will be loaded into two parallel free-standing fiber reinforced plastic housing, each four feet in diameter with a sideshell height of six feet with similar construction specifications as the media filter housings. The empty bed contact time is 7.6 minutes. Both housings will be plumbed for operation in an up-flow mode with a bypass valve provided to allow split treatment to control finished water hardness, pH and alkalinity levels. A summary of the calcium carbonate contactors is presented in Table 17 and shown on Drawing P-6.

Table 17 – Calcium Carbonate Contactor Design Criteria

Parameter	Design Value
Dosage	40
Daily Consumption, lbs/day	83.4
Contactor Diameter, feet (m)	4.0
Contactor Area, ft^2	12.6
Contactor Sideshell, ft (m)	7.0
Number of Contactors, each	2
Flow per Contactor, gpm	86.8
Percent Voids, percent	100%
Throughput Velocity, fps	0.02
Empty Bed Contact Time, minutes	7.6

Corrosion Inhibitor

Corrosion inhibitor will be fed into a static mixer following the calcium carbonate contactor. NSF certified sodium silicate will be added to stabilize the water prior to discharge into the potable water storage tank. The system includes a metering pump capable of providing a 25 mg/L passivation dosage and a 6 mg/L maintenance dose to the finished water. The chemical feed system will be identical to the scale inhibitor feed system. Chemical pumping rate will be automatically controlled by the PLC to account for the number of trains in operation. A summary of the corrosion inhibitor feed system is presented in Table 18 and shown on Drawing P-6.

Table 18 – Corrosion Inhibitor Feed Design Criteria

Parameter	Design Value
Feed Concentration (Maintenance Dosage), mg/l	6
Daily Consumption @ 100% OLF, lbs/day	12.5
Daily Consumption Type N@ 100% OLF, gpd	3.8
Monthly Consumption Type N at 100% OLF, gallons	114.3
Feed Concentration (Passivation Dosage), mg/l	25
Daily Consumption @ 100% OLF, lbs/day	52.1
Daily Consumption Type N@ 100% OLF, gpd	15.7

Disinfection

Sodium hypochlorite will be fed into a static mixer following the calcium carbonate contactor. The dosage of 2.0 mg/L has been established. It is anticipated that the 12.5% liquid sodium hypochlorite will be delivered in 55-gallon carboys. A summary of the disinfection system is presented in Table 19 and shown on Drawing P-6.

Table 19 – Disinfection System Design Criteria

Parameter	Design Value
Feed Stream Concentration, mg/l	2
Chemical Strength, percentage	12.5%
Daily Consumption at 100% OLF, lbs/day pure	4.2
Daily Consumption at 100% OLF, gallons/day at strength	4.17
Monthly Consumption at 100% OLF, gallons at full strength	127

Potable Water pH Control

Diluted hydrochloric acid will be fed into a static mixer following the calcium carbonate contactor. The dosage rate will be controlled by the chlorine analyzer to maintain a pH between 7.2 and 7.8 pH units. It is anticipated that 37% hydrochloric acid will be delivered to the site and diluted to approximately 10 percent in the day tank using potable water. A summary of the pH control system is presented in Table 20 and shown on Drawing P-6.

Table 20 – Potable Water pH System Design Criteria

Parameter	Design Value
Feed Concentration, mg/l	5
Daily Consumption @ 100% OLF, lbs/day	10.4
Daily Consumption 37% @ 100% OLF, gpd	2.8
Monthly Consumption 37% at 100% OLF, gallons	85.6

Support Systems

Concentrate Disposal

The membrane concentrate stream produced by the desalination process will be combined with other waste streams and disposed via an injection well.

Instrumentation and Controls

All operating data and plant status would be displayed on a human machine interface (HMI) touch screen mounted on the main control panel located in the control room. In the event of a parameter excursion, the panel would display the alarm and would initiate contact with the plant supervisor via the internet. The touch screen would log the alarm event for future inspection. The control system features are summarized in Table 21.

Magnetic flow meters with flow transmitters will be provided for process control and reporting purposes on:

- ✓ 1st pass concentrate discharge
- ✓ 1st pass RO permeate flow
- ✓ finished water streams to storage

Pressure transmitters with local indicators will be provided for process control and reporting purposes on:

- ✓ Well pump discharge,
- ✓ Media and cartridge filter influent and effluent
- ✓ 1st pass membrane feed pump suction, membrane feed, membrane concentrate, and permeate

Pressure indicator only (no transmitter) will be provided for reporting purposes on:

- ✓ Bag filter influent and effluent
- ✓ 2nd pass membrane feed pump suction and membrane feed
- ✓ Degasifier tower packing differential and blower discharge
- ✓ Degasifier transfer pumps discharge
- ✓ Cleaning/flush pump discharge
- ✓ Carbon dioxide solution pump suction and discharge

Analytical meters will be provided for process control and reporting purposes on:

- ✓ Membrane permeate conductivity
- ✓ Final potable water to storage conductivity, pH and free chlorine

Level sensors and transmitters will be provided for process control and reporting purposes on:

- ✓ Degasifier clearwell
- ✓ Finished storage
- ✓ Irrigation storage

Level switches will be provided for process control and reporting purposes on:

- ✓ Chemical day tanks
- ✓ Cleaning/flush tank

Table 21
Control System Features

Feature	Shutdown	Display Condition	Comment
Under voltage and loss of phase monitor	Yes	Yes	Auto reset capability
Well pump failure to start		Yes	VFD fault
Well pump discharge pressure	No	Yes	
Media filter influent pressure	No	Yes	If MF included with project
Media filter differential pressure	Yes	Yes	If MF included with project
Cartridge filter differential pressure	Yes	Yes	
1st Pass Membrane feed pump suction pressure	Yes	Yes	
1st Pass Membrane feed pressure	Yes	Yes	
1st Pass Membrane feed pump failure to start		Yes	VFD fault
ER Boost Pump failure to start	Yes	Yes	VFD Fault
1st Pass Membrane concentrate high pressure flow	Yes	Yes	
1st Pass Membrane concentrate low pressure flow	Yes	Yes	
1st Pass Membrane permeate flow	Yes	Yes	
1st Pass Membrane differential pressure	Yes	Yes	
1st Pass High membrane permeate conductivity	Yes	Yes	Adjustable time delay on fault to permit rinse up
2nd Pass Membrane feed pump suction pressure	Yes	Yes	Adjustable start up override
2nd Pass Membrane feed pressure	Yes	Yes	
2nd Pass Membrane feed pump failure to start		Yes	VFD fault
Chemical feed interlocks			Controls chemical addition.
Chemical pump failure	Yes	Yes	
Chemical day tank low level	Yes	Yes	
Degasifier blower failure to start	Yes	Yes	
Degasifier clearwell level		Yes	Controls transfer pump operation
Degasifier transfer pump failure to start		Yes	VFD fault
Carbon dioxide solutioning pump failure to start		Yes	Tripped overloads
Carbon dioxide low suction pressure	Yes	Yes	
Carbon dioxide high discharge pressure	Yes	Yes	Closed discharge valve
Bulk carbon dioxide storage low level	Yes	Yes	
Potable water conductivity	Yes	Yes	
Potable water pH		Yes	
Potable water free chlorine residual		Yes	
Irrigation water tank level	Yes	Yes	Direct readout of finished water level and adjustable set points to operate RO system in automatic mode
Finished water tank level	Yes	Yes	Direct readout of finished water level and adjustable set points to operate RO system in automatic mode
Cleaning/Flush tank low level	Yes	Yes	
Cleaning/Flush Pump failure to start	Yes	Yes	
Alarm conditions			Dry contacts provided to drive remote alarm system

Facilities

The process building will be constructed from reinforced concrete providing a process room, a control/electrical room, spare parts storeroom and chemical storage. The facility will be designed to provide the following:

- ✓ A reinforced concrete building for protection of the major plant equipment.
- ✓ Eyewash and showers adjacent to chemical injection systems.
- ✓ Placement of control system and three phase power distribution in a controlled environment room not subject to splash.
- ✓ Use of NSF rated equipment and chemicals for the potable water systems.
- ✓ Protective shields around all chemical feed pumps.
- ✓ Noise attenuation

Electrical Site Facilities

The control room will also serve as the electrical room. All pumps will utilize variable frequency drives mounted in NEMA 4 enclosures. The main power distribution panel will be mounted in the control room with branch circuits running to the RO units, pump VFDs and single-phase regulating transformer. The main power distribution panel will be furnished with a separate, conditioned, 1.5 kVA power supply for the plant control system as well as a three-phase power monitor. The three-phase power panel will be furnished to operate on a 480 volt, 60HZ, three phase power supply.

All electrical conduits will be furnished in PVC and will be surface mounted. Power supply to the well pumps will be buried. A fiberglass elevated wire trough will be used to carry all three-phase power to each motor and field panel. The estimated power requirements for the system are presented as Exhibits 1 and 2.

Exhibit 1

SWRO Process Power Summary – Potable Production Mode[4]

Grand Port, Grand Bahama Island

Power Estimate

Plant Capacity:	250,000	GPD										
Electrical Power:	480	VAC	60 Hz									
Total Operating Loads Source	Motor Rating, KW	Quantity	Actual Load KW each	Actual Load KW, total	eff., %	Line Load KW	Operating Hours per Day	PF	Amps	KVA	KWH/D	KWH/KG
Feedwater Supply Pump	*22.4*	*1*	*17.9*	*17.9*	*85.0%*	*21.0*	*24*	*99.0%*	*25.6*	*21.3*	*505*	*2.02*
Membrane Feed Pump	*56.0*	*2*	*39.0*	*78.0*	*94.0%*	*82.9*	*24*	*99.0%*	*100.8*	*83.8*	*1991*	*7.96*
ER Boost Pump	*14.9*	*1*	*3.7*	*3.7*	*88.0%*	*4.2*	*24*	*99.0%*	*5.1*	*4.3*	*101*	*0.40*
2nd Pass Pump	*11.2*	*2*	*4.7*	*9.5*	*82.0%*	*11.5*	*24*	*99.0%*	*14.0*	*11.7*	*277*	*1.11*
Degasifier Blower	*0.7*	*1*	*1.5*	*1.5*	*87.5%*	*1.7*	*24*	*88.1%*	*2.3*	*1.9*	*41*	*0.16*
Degasifier Transfer Pumps	*0.6*	*1*	*3.4*	*3.4*	*87.5%*	*3.9*	*24*	*88.1%*	*5.3*	*4.4*	*93*	*0.37*
CO2 Solutioning Pump	*1.1*	*1*	*0.0*	*0.0*	*82.0%*	*0.0*	*24*	*85.5%*	*0.0*	*0.0*	*0*	*0.00*
Cleaning/Flush Pump	*5.6*	*1*	*4.8*	*4.8*	*90.0%*	*5.3*	*0.5*	*87.0%*	*7.4*	*6.1*	*3*	*0.01*
Subtotal 480 VAC 3 Phase				118.7		130.6			160.4	133.4	3,010	12.0
Single Phase Power:	110	VAC	60 Hz									
Control Power					99.0%	2.0	24	100.0%	18.2	2.0	48	0.19
Subtotal 110 VAC Single Phase						2.0	KW		18.2	2.0	48.0	
Equivalent 480 VAC 3 Phase Amps									2.4			
Single and 3 Phase Total						132.6	KW		162.8	133.4	3,058	
						12.2	KWH/KGAL					

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4 Unit power consumption is based on published information for the various components used in the system. Actual performance may vary depending on equipment age and membrane operating pressure. Value shown is based on a 1st pass membrane operating pressure of 850 psi, Membrane/PX differential pressure of 35 psid, 2nd pass membrane feed pressure of 130 psi, 98 percent VFD efficiency and includes feedwater supply pump, degasifier blower and transfer pumps, CO2 solutioning pump, chemical addition systems and control power.

Exhibit 2

SWRO Process Power Summary – Irrigation Production Mode[5]

Grand Port, Grand Bahama Island

Power Estimate

Plant Capacity:	250,000	GPD										
Electrical Power:	480	VAC	60 Hz									

Total Operating Loads Source	Motor Rating, KW	Quantity	Actual Load KW each	Actual Load KW, total	eff., %	Line Load KW	Operating Hours per Day	PF	Amps	KVA	KWH/D	KWH/KG
Feedwater Supply Pump	*22.4*	*1*	*16.8*	*16.8*	*85.0%*	*19.7*	*24*	*99.0%*	*24.0*	*19.9*	*474*	*1.89*
Membrane Feed Pump	*56.0*	*2*	*36.6*	*73.3*	*94.0%*	*78.0*	*24*	*99.0%*	*94.7*	*78.8*	*1871*	*7.48*
ER Boost Pump	*14.9*	*1*	*3.5*	*3.5*	*88.0%*	*4.0*	*24*	*99.0%*	*4.8*	*4.0*	*95*	*0.38*
Degasifier Blower	*0.7*	*1*	*1.5*	*1.5*	*87.5%*	*1.7*	*24*	*88.1%*	*2.3*	*1.9*	*41*	*0.16*
Degasifier Transfer Pumps	*0.6*	*1*	*3.4*	*3.4*	*87.5%*	*3.9*	*24*	*88.1%*	*5.3*	*4.4*	*93*	*0.37*
Cleaning/Flush Pump	*5.6*	*1*	*4.8*	*4.8*	*90.0%*	*5.3*	*0.5*	*87.0%*	*7.4*	*6.1*	*3*	*0.01*
Subtotal 480 VAC 3 Phase				103.2		112.5			138.4	115.1	2,576	10.3
Single Phase Power:	110	VAC	60 Hz									
Control Power					99.0%	2.0	24	100.0%	18.2	2.0	48	0.19
Subtotal 110 VAC Single Phase						2.0	KW		18.2	2.0	48.0	
Equivalent 480 VAC 3 Phase Amps									2.4			
Single and 3 Phase Total						114.5	KW		140.8	115.1	2,624	
						10.5	KWH/KGAL					

[5] Unit power consumption is based on published information for the various components used in the system. Actual performance may vary depending on equipment age and membrane operating pressure. Value shown is based on membrane operating pressure of 850 psi, Membrane/PX differential pressure of 35 psid, 98 percent VFD efficiency and includes feedwater supply pump, degasifier blower and transfer pumps, chemical addition systems and control power.

Desalination Plant Basis of Design

CARNIVAL GRAND PORT
GRAND BAHAMA, THE BAHAMAS

Project Number: 063-122019
December 2019

Attachment A – P&ID Drawing

NOTES:

1. ALL 8 INCH HDPE SDR11 IS YARD PIPING.
2. BAG FILTERS ARE LOCATED IN THE RO BUILDING.

DSGN	DE BEDFORD						
DR	LE FINK 631219p01.dlv						
CHK	S DOBBS						
APVD	DE BEDFORD	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

GEMINI

GEMINI Seawater Systems, LLC
GAINESVILLE, FLORIDA - CERTIFICATE OF AUTHORIZATION #31523

GRAND PORT
GRAND BAHAMA, THE BAHAMAS

250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS
RAW WATER SUPPLY
P & I DIAGRAM

DWG NO. P-1
DATE DEC 2019
PROJ NO. 063-1219

BASIS OF DESIGN

631219p01.dlv 06-DEC-2019

DSGN	DE BEDFORD			
DR	LE FINK 631219p02.dlv			
CHK	S DOBBS			
APVD	DE BEDFORD			
NO.	DATE	REVISION	BY	APVD

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GRAND PORT
GRAND BAHAMA, THE BAHAMAS

250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS

MEDIA FILTRATION OPTION P & I DIAGRAM

DWG NO.	P-2
DATE	DEC 2019
PROJ NO.	063-1219

BASIS OF DESIGN

631219p02.dlv 06-DEC-2019

DSGN DE BEDFORD						
DR LE FINK 631219p03.dlv						
CHK S DOBBS						
APVD DE BEDFORD	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
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0 — 1"
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GRAND PORT
GRAND BAHAMA, THE BAHAMAS

250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS
PRETREATMENT AND CARTRIDGE FILTRATION P & I DIAGRAM

DWG NO. P-3
DATE DEC 2019
PROJ NO. 063-1219

BASIS OF DESIGN

631219p03.dlv 08-DEC-2019

DSGN	DE BEDFORD				
DR	LE FINK 631219p04.dlv				
CHK	S DOBBS				
APVD	DE BEDFORD	NO.	DATE	REVISION	BY APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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GRAND PORT
GRAND BAHAMA, THE BAHAMAS
250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS
SEAWATER REVERSE OSMOSIS UNIT
TRAIN "A"
P&I DIAGRAM

DWG NO. P-4
DATE DEC 2019
PROJ NO. 063-1219

BASIS OF DESIGN

631219P04.DLV 08-DEC-2019

DSGN	DE BEDFORD
DR	LE FINK 631219p05.dlv
CHK	S DOBBS
APVD	DE BEDFORD

NO. | DATE | REVISION | BY | APVD

VERIFY SCALE
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0 1"
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GEMINI Seawater Systems, LLC
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GRAND PORT
GRAND BAHAMA, THE BAHAMAS
250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS
DEGASIFIER POST TREATMENT
P & I DIAGRAM

DWG NO.	P-5
DATE	DEC 2019
PROJ NO.	063-1219

BASIS OF DESIGN

631219p05.dlv 05-DEC-2019

DSGN	DE BEDFORD					
DR	LE FINK 631219p06.dlv					
CHK	S DOBBS					
APVD	DE BEDFORD	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
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0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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GEMINI Seawater Systems, LLC
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GRAND PORT
GRAND BAHAMA, THE BAHAMAS
250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS
POST TREATMENT
P & I DIAGRAM

DWG NO. P-6
DATE DEC 2019
PROJ NO. 063-1219

BASIS OF DESIGN

631219p06.dlv 08-DEC-2019

BASIS OF DESIGN

DSGN	DE BEDFORD					
DR	LE FINK 631219p07.dlv					
CHK	S DOBBS					
APVD	DE BEDFORD	NO.	DATE	REVISION	BY	APVD

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0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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GEMINI Seawater Systems, LLC
GAINESVILLE, FLORIDA - CERTIFICATE OF AUTHORIZATION #31523

GRAND PORT
GRAND BAHAMA, THE BAHAMAS

250,000 GALLONS PER DAY
SEAWATER REVERSE OSMOSIS FACILITY

PROCESS

DISPOSAL AND CLEANING SYSTEM
P&I DIAGRAM

DWG NO. P-7
DATE DEC 2019
PROJ NO. 063-1219

631219P07.DLV 08-DEC-2019