

## 1. Section 1 General

### 1.1 Project Background

The scope of work is to provide potable water systems to increase the availability of safe, reliable potable water supply. The designs shall provide solutions for serving villages with 10,000 people or less, be adaptable for a wide variety of locations, and provide solutions where one project may be utilized to serve several villages.

### 1.2 Scope of Work

Design, furnish materials, fabricate, assemble, test, and deliver stand alone on skids or in containers to be mounted on concrete foundations by others, compact water treatment plant of water supplies to provide potable water under two different classifications. The equipment to be furnished shall be the Supplier's standard design which will meet the required specification as detailed in the following sections.

General descriptions of treatment process:

#### Surface Water

1. Inlet control valve(s) - and actuators
2. Coagulant dosing/ Rapid Mix/ Flocculation
3. Sedimentation (clarification) tanks
4. Clarifier effluent reservoir
5. Pressure Filters with associated air-scour, backwash, and filter feed pumps.
6. Optional RO Unit in a climate controlled ISO container, as required to meet the quality standard
7. Disinfection equipment – gas chlorination
8. Effluent pumps (only required if RO option is not used)
9. Process shall be designed to be self contained from inlet glange of the raw water feed to outlet glange following chlorination.
10. All interconnection process pipe work, chemical pipe work, valves, and supports associated with the above from the inlet glange to outlet flange.
11. All electrical, control and instrumentation equipment and cabling associated with the above, and as outlined in APPENDIX A.
12. Operating and maintenance manuals (See Section 1.3)
13. Start-up and training

#### Ground Water

1. Inlet control valve(s) and actuator(s)
2. Optional RO Unit in a climate controlled ISO container as required to meet the quality standard
3. Disinfection equipment – gas chlorination
4. Eddluent pumps (only required if RO option is not used)
5. Process shall be designed to be self contained from inlet flange of the raw water feed to outlet flange following chlorination
6. All interconnection process pipe work chemical pipe work, valves, and supports associated with the above from the inlet flange to outlet flange.
7. All electrical control and instrumentation equipment and cabling associated with the above, and as outlined in APPENDIX A
8. Operating and maintenance manuals (See Section 1.3)
9. Start-up and training

The equipment shall be pre piped, pre tubed, and pre wired with appurtenances, including controls, instrumentation, piping, valves, and skid-mounting to the maximum extent possible, for shipping to the jobsite. Interconnecting piping that is furnished loose for the Owner's installation at the jobsite shall consist of shop fabricated spools. All electrical connections between skid mounted units shall be terminated with water proof quick disconnects.

All equipment shall be the heavy-duty industrial construction type designed for maximum reliability during continuous operation and maintenance. Any components of the system that are subject to ear, erosion, or deterioration shall be accessible for inspection and maintenance.

### 1.3 Submittals

Suppliers shall submit by type of water treatment plant (Ground Water and Surface Water) a complete and detailed qualification package. The package must contain as a minimum.

#### Bid Package

1. Conceptual P&ID (AutoCAD).
2. General Layout with over all dimensions for major equipment (Plus Weight).
3. Conceptual Design Description.
4. Required inlet flow and head to meet this specification
5. Total Electrical power demand include duty / standby equipment for the entire system
6. Volume / Flow of waste water stream
7. Chemical Demand
8. Detailed list of variations from the terms of this specification
9. Catakig cut sheets.

#### Award Package

1. Detailed Layout and the dimensional Drawings (AutoCAD).
2. Detailed component specifications
3. Process P&ID Drawing(s) (AutoCAD)
4. Spare Parts List
5. Performance Guarantee with appropriate remedies for non-performance.
6. Items required in Section 5

Note: Throughout the submittal process, a list of submittals shall be updated by the Supplier with each successive submittal.

## 2 Section 2 Standards

### 2.1 National and International Standards

The work shall be carried out to European, British, or US Standards as appropriate for water treatment plant. All material shall conform to the international standards for use with drinking water. Plant shall be designed to operate 20 hours a day 365 days a year, under the following climate conditions.

Maximum ambient temperature 55°C and minimum 0°C.

Maximum relative humidity is 95%

The altitude varies at 100 meters absolute sea level.

Plant will be installed by others - both Northern and Southern regions.

Package unit shall be able to withstand following conditions:

- Wind load of 160 km/hr.
- Earthquake load for seismic zone 1

Note: These packaged units will be located on a concrete foundation by others. The RO units shall be supplied in a climate controlled ISO container, to be mounted on a concrete foundation by others. Supplier will provide process covers where appropriate for the units as per standard design.

### 3 Section 3 Design Criteria

#### 3.1 Unit Capacity

The unit shall be selected from the Supplier's standard range of designs (shelf item) and construction patterns as best suited to the required capacity. The required capacities are shown on Table 1.

Population	Treated Water Flow Rate (Cubic Meters/day)
1,000	132
2,500	330
5,000	660
10,000	1320

Supplier to state volume of flow required at inlet to achieve outlet value required. The process pump(s) shall be designed to provide a minimum of 10 static head at outlet of the package unit.

#### 3.2 Raw Water Quality

The treatment plants will be constructed utilizing a ground water or surface water source (i.e. river or canal). Available raw water quality is given in the table below.

	Ground Water AVG.		Surface Water AVG.	
<b>pH</b>	7.0-8.0		7.0-8.0	
<b>Turbidity</b>	1-5 NTU		3-10 NTU	
<b>Conductivity ( S/cm)</b>	500-1500	1500-2500	500-1500	1500-5000

Supplier shall provide pricing for units to treat raw water sources with a TDS of less than 1,500 mg/l and also treatment plants that require a RO at sites with a raw water source with a TDS greater than 1,500 mg/l but less than 5,000 mg/l.

### 3.3 Treated Water Quality

The compact water treatment plants shall be designed to produce treated water quality in general accordance with the current World Health Organizations (WHO) Guidelines and with the project-specific requirements listed in Table 2.

**Table 2 – Effluent Drinking Water Quality Parameters**

Parameter	Period	Basis	Requirements
Total & Fecal Coli Form	Daily	Maximum	0 (MPN/100 ml)
E. Coli	Daily	Maximum	0 (MPN/100 ml)
Turbidity	Daily	Average	5.0 NTU
Turbidity	Daily	Instantaneous	1.0 NTU
pH	Daily	Instantaneous	6.5-9.2
Free Residual Chlorine	Continuous	Instantaneous	1.5-2.0 mg/L at entrance to the distribution system
Taste and Odor	Daily		Acceptable
Color	Daily	Instantaneous	<20-30 Cibalt Platinum Scale <15 TCU
Total Dissolved Solids	Daily	Maximum	1,500 mg/L

### 3.4 Hydraulic Design

Pipe work shall be designed using roughness factors, k, appropriate for the pipe material in good, average and poor condition. The reference from which the k values are taken shall be state in any calculations submitted.

Surge pressures shall be taken into account in the design of pressure pipe work. Pressure pipe work shall normally be designed to remain full while in service, in line check valves shall be fitted where appropriate.

Air valves or air vents appropriate to the fluid in the pipeline and of adequate airflow capacity are required at high points.

Drain points shall be provided to allow the pipeline to be substantially emptied to appropriate discharge points for maintenance.

### 3.5 Performance Guarantee

The supplier shall provide performance guarantees stating that the Compact Water Treatment Plant being provided shall meet and/or exceed the unit capacities and range of operating conditions stated in Section 3.

## **4 Section 4 Plant Process Description**

The compact water treatment plant shall comprise as a minimum the following main process components.

For Surface water treatment plant:

- Pre-chlorination
- Rapid mixing/Alum dosing
- Coagulation
- Clarification
- Filtration
- RO (when required)
- Disinfection (Gas Chlorine)

For Ground water treatment plant:

- Cartridge Filtration
- RO (when required)
- Disinfection dosing (Gas Chlorination)

### **4.1 Rapid Mixer**

Raw water from designated source will be pumped to the process units directly through a control valve to in-line mixers and/or mechanical mixers able to satisfy the mixing requirements indicate below. Coagulant mixing shall have optimum retention period.

### **4.2 Flocculation Tank**

The mechanical mixer serves as the area in which alum is physically mixed with the influent raw water. The Flocculation mixer is driven by an electric motor. The flocculation tank shall be designed to provide sufficient agitation in sweeping coagulation, improving the overall efficiency of chemical dosing.

### **4.3 Clarification/Sedimentation Tanks**

Clarifiers (Sedimentation tanks) shall be provided downstream of flocculation tank affording a surface area, or combination of surface area and lamella plates (or similar technology), to achieve a suitable proportional reduction in suspended and (Total Dissolved) Solids load from the raw water. This chemically assisted sedimentation of solids in said tank(s), prior to the filtration stage, is to assure the required discharge water quality from the filtration stage.

The clarification/sedimentation tank(s) shall include all necessary equipment for the wastage of settled sludge from said tank(s) while water treatment from the overall process train is ongoing.

### **4.4 Clarifier Effluent Reservoir**

The clarified raw water shall flow to a single service reservoir immediately upstream of the filtration stage feed pump(s). The service reservoir shall be sized to afford an appropriate detention and volume prior to the filtration pumps.

All pumps associated with the raw and treated water systems referred to above shall be operated with access to local pressure monitoring for the operator. Provision of run/stop signals at an appropriate control panel is required.

#### **4.5 Filters**

Clarified water shall be pumped to pressure filter unit(s). More than one filtration unit shall be provided.

Provision of an isolation valve on the inlet of each filter unit inlet is required. The mode of filtration and the type and quantity of filtration media used is at the discretion of the Supplier, but must be compatible with the product water quality stated in Section 3.3.

Less than 1% of the mass of media shall be lost by attrition during 100 hours of simulated fluidization. Separation Equipment Scale-Up; Second Edition, Chapter 8 section 6.5 – Durability.

The filtration stage shall possess all necessary equipment to afford a backwash mode that reasonably preserves filter performance over time. The backwash capability shall include air and water scour. Scouring water shall be filtered water. Air used for scouring shall be vented from the filter via a dedicated air vent valve.

The backwash system will be designed to permit all filters to be washed consecutively within one continuous 24 (twenty four) hour period. Dirty backwash water shall pass from the backwash to be locally discharged as appropriate at the site of installation. The filter operation shall meet required treated flow at all times including back washing operation.

The means to monitor differential head loss across the filtration stage shall be provided. Some means for the operator to be able to assess backwash flow rates shall be provided.

Filters will normally be washed automatically, at regular intervals. Automatic filter washing shall comprise the following steps:

- Shut down
- Air Scour
- Backwashing
- Return to service

#### **4.6 Intermediate Storage (when required)**

The filtered water shall flow to an intermediate storage reservoir in front of the RO unit (when required). The service reservoir shall be sized to afford an appropriate detention and volume prior to the pumps or RO.

#### **4.7 Pump(s)**

The unit shall be provided with duty / standby process which also designed to backwash filters. The pump(s) shall be designed to account for waste operations including but not limited to clarifier sludge discharge operation, filter back operation, and RO reject flows (see section 3.1 and 4.5)

#### 4.8 Reverse Osmosis (RO)

The Supplier's system shall be designed to produce the design permeate flow listed in section 3.1. Flows shall be split to the RO unit and bypass to accomplish the treatment goals. The RO systems equipment shall be sized so that system reject flows are accounted for in maintaining the RO product water flow. The RO system may operate continuously or intermittently or with the train in lay-up. The Supplier shall provide detailed procedures on lay-up.

Prior to contract award, Supplier shall provide design specifications such as power demand, chemical demands, waste water volume, etc. Supplier shall provide submittals including components lists, materials of construction, and shop drawings. Cleaning, pH adjustment, and anti-scalant dosing will meet or exceed manufacturer's recommended flow and storage capacities at a minimum. The RO permeate pressure shall be sufficient to deliver the water to the treated water storage tank (supplied by others). See section 3.1

#### 4.9 Chemicals and Chemical Dosing

**All materials shall be compatible with the chemical being used.** Dosing systems shall include all the necessary equipment to ensure delivery of the chemical at the required flow rate, irrespective of variations access to enable the flushing of pumps and/or dosing lines if required. All chemical dosing equipment shall be included within the package plant skid limits.

The Plant Operator should be able to monitor contents of all storage tanks. Direct Chemical storage capacities on the process train will be sized to provide 2 days of supply of chemicals based upon the maximum dose rates at the specified minimum and maximum plant design flow rates respectively. Additional External bulk chemical storage will be provided on site by others.

The Alum dose rate shall be set proportional to the flow rate of water fed to flocculation, dosed at the rapid mixer. Aluminum sulphate (alum)  $[Al_2(SO_4)_3]$  shall be dosed upstream of flocculation to assist particulate removal. The chemical shall be added as solid by the operator to a chemical preparation (mixed) tank and dosed to the dosing point, in a controlled manner, by a dedicated alum dosing pump.

The Chlorine dose rate shall be set proportional to the flow rate of water fed to the effluent from filters or RO. A chlorine (gas) flow meter shall be provided giving a measurement range of at least 1-10, 1-15, 1-20 or 1-25kg  $Cl_2$  per hour depending on the plant capacity. A water pressure gauge and pressure regulating valve shall be provided at the chlorine dosing point. Gaseous Chlorine shall be used as the disinfection agent. The chemical shall not contain any substances at concentrations which could produce deleterious or injurious effects on the health of those consuming water with doses of up to 5/mg/l of  $Cl_2$ . Chlorine storage tanks shall be provided by others.

The design of all chemical storage and dosing systems shall take into account safety requirements, and shall ensure the safe reception, transfer and dosing of chemicals. As a minimum, the following safety features shall be included:

Tanker or annual chemical delivery points will be unique to each individual chemical, in order to avoid delivery to the wrong vessel.

Reactive chemicals will not be stored or prepared adjacent to each other.

#### **4.9.1 Chemical Specification**

##### **Coagulant and/or Flocculent Dosing: General Description**

The coagulant chemical shall be  $Al_2(SO_4)_3$  and the physical form is solid. Supplier to supply expected daily operation usage of the chemical.

##### **Chemical Disinfection: General Description**

The disinfection chemical shall be Chlorine and the physical form is solid. Supplier to supply expected daily operation usage of the chemical.

#### **4.9.2 Chemical Specification**

Supplier to specify chemicals and quantited required for the RO process unit(s).

#### **4.10 Electrical, Controls and Instrumentation**

The supplier shall provide a complete safe and reliable integrated control system suitable for Automatic/Manual operation. Supplier shall arrange the control system equipment in a way that minimizes the filed connections among the pre-fabricated, pre-wired equipment skid panels. The Supplier shall provide complete instrumentation/interlocks for the RO system (if RO is required) according to the P&IS and this specification.

The following as minimum shall be provided for monitoring (visual indication) at local control panel:

1. Program steps for system (service, back wash, rinse and duty /standby)
2. Valve status (Open, close, percent open for control valve)
3. Pump/motor status (On, Off, Trip, available)
4. Blower status (on, off, trip)
5. Analogue meters (Temperature, pressure, PH, conductivity, tank level)
6. Treated water Tanks- Low-low level, high level and high-high level (audible alarm as well) Tanks to be provided by others.
7. Raw Water Supply – low pressure sensor (audible alarm as well)
8. Controls shall be provided to start and stop either the well or river intake pumps, both of which are provided by others.

Supplier shall provide electrical interlock in local control panel to enable Start or Stop the RO system based on low or high water level respectively, in treated water tanks (provided by others). Supplier shall provide electrical interlock in Local control panel to stop the system at low water pressure in water Intake. The water level signals from treated water tanks and intake will be furnished by others for Supplier interface.

The system shall be designed to alarm at main control panel the abnormal or unsafe operating conditions. The Supplier shall design the water treatment control system to include automatic control and interlock functions, to minimize the Plant Operator's action. The Plant Operator shall also have the capability of manually performing all start-up, operation and shutdown functions. The control system shall enable the operator to interrupt, resume or take manual control of the system operation at any time. The Plant Operator shall be able to adjust the key set points manually.

Supplier shall furnish the flow diagram (mimic diagram on front panel) for the entire system, including intake and treated water storage tanks (by others). The Supplier shall supply sufficient quantities of field mounted instruments including sensors, transmitters, gauges, control valves, process switches in order to provide necessary control and monitoring requirements.

Limit switches shall be provided for critical open/close automatic valves.

Only one low voltage power (3 phase, 400V+/-10%, 50 Hz, 4 Wire system) shall be supplied by others to Supplier local control panel. The Supplier shall transform and distribute power as required from this single power supply. All electrical equipment and control panels shall be suitably rated for outdoor use in the ambient conditions specified above. The electrical equipment enclosures shall be rated NEMA 4X or IP55 for outdoor and NEMA 4 or I{ 54 for indoor locations. Control panels shall be provided with sun shields and constructed with heat resistant and dust proof components. The Supplier shall provide temperature controlled enclosures if required.

All supplier supplied electrical raceway system, fittings, components and cable shall be in accordance with applicable international standards. Supplier to ground/earth all electrical equipment in accordance with applicable codes and manufacturer's recommended practice.

#### **4.11 Manuals, Training and Start-up**

Upon completion of the installation of the compact treatment units, start-up and basic training of operational personnel will be provided at each plant. Five Plant manuals in English and Arabic will be provided and distributed to the operators at each site. A commitment to completion of start-up and 14 days support per site by a Supplier representative to afford basic training to operators is required.

#### **4.12 Spare Parts**

Spare Parts section to include two of each type of equipment that has the possibility of failure including, gaskets, pump seals, relays, fuses, switches, buttons, and indicator lamps. The Supplier shall quote as a separate line item to provide one complete set of tools required to operate and maintain the treatment plant including hand tools, power tools, special tools, and calibration equipment. If the treatment plant has pH adjustment include a handheld pH meter and calibration kit.

#### **4.13 Warranty**

Supplier shall warrant all components to be free of defects in materials or workmanship for 12 months from date of satisfactory completion of commissioning.

### **5 Section 5 General Responsibilities**

The Supplier shall be responsible for the following design outputs:

Installation Manual

Process design of components of treatment units to meet water quality standard as stated.

Hydraulic design of components including preparation of a hydraulic gradient for the component.

Head loss calculations for the specified pump flow rates

Detailed layouts for all Supplier supplied equipment, including access for operation and maintenance and lifting facilities.

Pipework sizes to maintain adequate velocities e.g. between 1 and 2 m/s

Chemical usage and power usage  
O&M manual.  
Design drawings  
Equipment catalog cuts, specifications, pump curves, motor data, dimensions, etc.  
Part numbers for all equipment  
Foundation dimensions with anchor bolt requirements

### **GW NO RO Plants Control Strategies**

- I. The plant has four control panels: main control panel, chlorination system control panel, in plant booster pump panel, and transfer pump control panel.
- II. The main control panel has the control interlocks for starting and stopping well pump motor, status indication, has storage tank level indication, and provides the interlocks for the transfer pumps.
- III. Set points have some dead band or timing relays to prevent motors from chattering (starting and stopping quickly).
- IV. Well pump is controlled by a hand-off auto (HOA) switch on the main control panel.
- V. Each pump motor will have a fail light that indicates a motor overload.

### **Operation Status**

1. To start-up plant
  - a. Switch the well pump hand-off auto switches to AUTO
  - b. Switch the chlorination system hand-off auto switches to AUTO
  - c. The well pump and chlorination system will start according to the storage tank level as described below.
2. The chlorination system will turn on and off with the well pumps under Auto mode
3. The transfer pumps will not run if the storage tank water level goes below the low level setpoint the analog level transmitter (pressure transducer) that will go into the main control panel through an indicator device and into a device with adjustable setpoint for LAL, LAH and LAHH required for proper operation.
4. The well pump and chlorination system will turn back when the water level in the storage tank reaches the high-high setpoint, LAHH.
5. The well pump and chlorination system will turn back on if the water level in the storage tank drops below the high level setpoint, LAH.
6. The well pump and chlorination system will shut off if the low-pressure switch for the well pump is activated during operation with an adjustable delay-timing relay. The well or well pump have to be checked for troubleshooting. After the problems are fixed, the alarm will be reset manually. Then the plant will be restarted according to item 1.
7. If the chlorinator goes into alarm, the chlorination system and well pump will shut down. The chlorination system has to be checked for troubleshooting. After the problems are fixed, the alarms will be reset manually. Then the plant will be restarted according to item 1.
8. To shut down the plant
  - a. Switch the well pump hand-off auto-switch to OFF
  - b. Switch the chlorination system hand-off-auto switch to OFF

### **Main Control Panel Input-Output List**

#### Discrete Inputs

Well pump pressure alarm low status (dry well indication)  
Chlorination system general alarm status

- Chlorination run status
- Chlorine system ready
- Pump run status for each pump
- Pump overload status for each pump
- Analog Input
  - Level Transmitter (pressure transducer)
- Outputs
  - Well pump run command
  - Chlorine system run command

### **LCP-1 List, Chlorination System**

- Inputs
  - Chlorine gas detection alarm
  - Low chlorine alarm
  - Low pressure alarm
  - High pressure alarm
- Outputs
  - Start recirculation pump command
  - Run status
  - Chlorine system ready
  - General alarm status

### **LCP-3 List, Transfer Pumps**

- Outputs
  - Pumps run status for each pump
  - Pump overload status for each pump

### **In Plant Water System**

The in-plant water system will operate with a low-pressure switch. If the water pressure in the system is released, the pump will start.

### **GW with RO Plants Control Strategies**

- I. The plant has four control panels: main control panel, in plant booster pump panel, RO unit control panel, disinfection system, and transfer pump control panel.
- II. The main control panel has the control interlocks for starting and stopping well pump motors, RO unit, status indication, has storage tank level indication, and provides the interlocks for the transfer pumps.
- III. Set points have some dead band or timing relays to prevent motors from chattering (starting and stopping quickly).
- IV. Well pump is controlled by a hand-off-auto (HOA) switch on the main control panel.
- V. Each pump motor will have a fail light that indicates a motor overload.

### **Operation Sequence**

- 1) To start-up the plant
  - a. Switch the chlorination system hand-off-auto switches to ATUO
  - b. Switch the RO unit hand-off-auto switches to AUTO

- c. Switch the well pump hand-off-switches to AUTO
    - d. The well pump, and RO unit will start according to the storage tank level as described below
  - 2) Well pump will turn on and off based on tank level in AUTO mode
  - 3) The RO unit will turn on and off based on the pressure switch on the RO high pressure pump intake and the RO feed pump (if present)\*are on.
  - 4) The transfer pumps will not run if the storage tank water level goes below the level alarm low (LAL) setpoint. The analog level transmitter (pressure transducer) will be installed into the treated water storage tank. The signal will go in the main control panel through an indicator device and into a device with adjustable setpoints for LAL, LAH, and LAHH required for proper operation.
  - 5) The RO unit feed pump (if present)\*, high pressure pump, coagulant\*\*, acid, anti-scalant, caustic metering pumps, and chlorination pumps will turn off when the water level in the storage tank reaches the high-high setpoint, LAHH.
  - 6) If the water level in the storage tank drops below the high level setpoint, LAH. The Well pump will start and after a short time delay the RO booster pump will start. If the Low-pressure switch is not active the RO feed pump will start. Antiscalant and acid injection pumps will start with the booster pumps. Caustic and chlorination system will start with the RO high-pressure pumps.
  - 7) RO unit
    - a. Filter backwash Feed Tank (if is used)\*\*
      - i. When the backwash water tank level is below LAL, the backwash pumps will not run.
      - ii. The backwash tank level low and high switches will open and close the feed valve.
      - iii. The backwash cycle will activate based on a timer or a differential pressure switch whichever is installed on the system. Differential pressure switch is preferred.
    - b. The RO unit shall contain a general alarm that will shut down the well pump. The alarm will include low chemical feed tank level, low-pressure alarm, high permeate TDS, and all motor overloads.
  - 8) The well pump will shut off if the low-pressure switch for the well pump is activated during operation with an adjustable timing relay.
  - 9) Any critical alarm that shuts equipment down must be reset manually. There shall be an alarm silence and reset pushbutton. When the problem is corrected the plant maybe restarted according to item 1.
  - 10) If the RO unit goes into alarm, well pump will shut down.
  - 11) To shut down the plant
    - a. Switch the well pump hand-off-auto switch to OFF
    - b. Switch the RO unit hand-off-auto switches to OFF
    - c. Switch the chlorination system unit hand-off-auto switches to OFF

### **Main Control Panel Input-Output List**

#### Discrete Inputs

- Well pump pressure alarm low status (low water table indication)
- RO unit run status
- RO unit general alarm status
- RO unit ready status
- Pump run status for each pump
- Pump overload status for each pump

#### Analog Input

- Level Transmitter (pressure transducer)

#### Outputs

- Well pump run command
- RO unit run command

Tank level low status

**LCP-2 I/O List, RO Unit**

Inputs

Coagulant metering pump run status (if used)\*\*  
Acid metering pump run status  
Feed pump run status\*  
High pressure pump run status  
Backwash pump run status (if used) \*\*  
Caustic metering pump run status  
Backwash tank high\*\*  
Backwash tank low\*\*  
Backwash low-low\*\*

Outputs

Run command for each pump  
Open/close command for each valve  
RO unit ready  
RO unit running  
RO unit general alarm

**LCP-2 I/O List, Transfer Pumps**

Inputs

Treated water storage tank low

Outputs

Pump run status for each pump  
Pump overload status

**LCP-4 I/O List, Chlorination system**

Inputs

Chlorination pump run status  
Chlorine gas detection alarm  
Low chlorine level/weight alarm  
Low chlorine pressure alarm  
High chlorine pressure alarm

Outputs

Chlorination system ready  
Chlorination system running  
Chlorination system general alarm

**In Plant Water System**

The in-plant water system will operate with a low-pressure switch. If the water pressure in the system is released, the pump will start.

Notes:

\* The RO feed pump may not be present for some of the RO unit depending on the manufacturer.

\*\* The prefilter with backwashing systems, and the coagulation metering system may not be used in the RO unit. However, cartridge filter is always present.

**SW NO RO Plants Control Strategies with Waterworks Package**

- I. The plant has four control panels: main control panel, in plant booster pump panel, package unit control panel, and transfer pump control panel.
- II. The main control panel has the control interlocks for starting and stopping surface water intake pump motors, package units, and chlorination system, status indication, has storage tank level indication, and provides the interlocks for the transfer pumps.
- III. Set points have some dead band or timing relays to prevent motors from battering (starting and stopping quickly).
- IV. Each surface water intake pump is controlled by a hand-off-auto (HOA) switch on the main control panel.
- V. Each pump motor will have a fail light that indicates a motor overload.

**Operation Sequence**

1. To start-up the plant
  - a. Switch the package unit hand-off-auto switches to ATUO
  - b. Switch the surface water intake pump hand-off-auto switches to AUTO
  - c. The intake pumps and package unit will start according to the storage tank level as described below.
2. The package unit and intake pumps will turn on and off based on tank level in AUTO mode
3. The transfer pumps will not run if the storage tank water level goes below the level alarm low (LAL) setpoint. The analog level transmitter (pressure transducer) will be installed into the treated water storage tank. The signal will go in the main control panel through an indicator device and into a device with adjustable setpoints for LAL, LAH, and LAHH required for proper operation.
4. The package unit filter feed/discharge pumps and chlorination pumps will turn off when the water level in the storage tank reaches the high-high setpoint, LAHH.
5. The package unit filter feed/discharge pumps, and chlorination system will turn back on if the water level in the storage tank drops below the high level setpoint, LAH.
6. The intake pumps will turn off when if the high level switch is maintained in the clarified water tank for 60 seconds (adjustable 0-5 min).
7. Package unit
  - a. Clarified Water Holding Tank
    - i. The filter feed/discharge pumps will run based on the clarified water tank level switches.
    - ii. The flow rates will be adjusted manually such that the clarified water holding tank inflow rate is no higher than the filter pump flow rate, and the clarified water holding tank will not over flow during Backwash mode.
  - b. Backwash Feed Tank
    - i. When the backwash water tank level is below LAL, the backwash pumps will not run.
    - ii. The backwash tank level switches will open and close the feed valve.
    - iii. The backwash cycle will activate based on a timer or a differential pressure switch whichever is installed on the system. Differential pressure switch is preferred.
  - c. When package unit is under AUTO mode, the alum metering pump and the flocculant metering pump will run with the intake pumps.
  - d. The package unit shall contain a general alarm that will shut down the intake pumps. The alarm will include filter feed/discharge pump motor overloads and high clarified water tank alarm.
  - e. If the backwash pump overloads. If there is an overload and backwash is necessary, the back-up pump shall be automatically used.
8. The intake pump will shut off if the low pressure switch for the intake pump is activated during operation with an adjustable delay timing relay

9. Any critical alarm that shuts equipment down must be reset manually. There shall be an alarm silence and reset pushbutton. When the problem is corrected the plant may be restarted according to item 1.
10. If the package unit goes into alarm, intake pump will shut down.
11. To shut down the plant
  - a. Switch the surface water intake pump hand-off-auto switch to OFF
  - b. Switch the package unit hand-off-auto switches to OFF

**Main Control Panel Input-Output List**

Discrete Inputs

- Intake pump pressure alarm low status (low surface water table indication)
- Package unit run status
- Package unit general alarm status
- Package unit ready status
- Pump run status for each pump
- Pump overload status for each pump

Analog Input

- Level Transmitter (pressure transducer)

Outputs

- Intake pump run command
- Package unit run command
- Tank level low status

**LCP-2 List, Package Unit**

Inputs

- Coagulant metering pump run status for each pump
- Flocculant metering pump run status for each pump
- Filter feed pump run status for each pump
- Filter feed pump overload status for each pump
- Backwash pump run status for each pump
- Backwash pump overload status for each pump
- Chlorination pump run status
- Chlorination pump overload status
- Air compressor motor run status
- Air compressor motor overload status
- Valve open close status for each valve
- Clarified gas detection alarm
- Low chlorine level/weight alarm
- Low chlorine pressure alarm
- High chlorine pressure alarm

Outputs

- Run command for each pump
- Open/close command for each valve
- Package Unit ready
- Package unit running
- Package unit general alarm
- Clarified water tank high
- Clarified water tank low
- Start chlorination pump command
- Run status

### LCP-3 List, Transfer Pumps

Inputs

Treated water storage tank low

Outputs

Pump run status for each pump

Pump overload status for each pump

### In Plant Water System

The in-plant water system will operate with a low pressure switch. If the water pressure in the system is released, the pump will start.

### SW With RO Plants Control Strategies

- I. The plant has five control panels: main control panel, in plant booster pump panel, package unit control panel, RO unit control panel, and transfer pump control panel
- II. The main control panel has the control interlocks for starting and stopping surface water intake pump motors, package units, RO unit, status indication, has storage tank level indication, and provides the interlocks for the transfer pumps.
- III. Set points have some dead band or timing relays to prevent motors from chattering (starting and stopping quickly).
- IV. Each surface water intake pump is controlled by a hand-off-auto (HOA) switch on the main control panel
- V. Each pump motor will have a fail light that indicates a motor overload.

### Operation Sequence

1. To start-up the plant
  - a. Switch the RO unit hand-off-auto switches to AUTO
  - b. Switch the package unit hand-off-switches to AUTO
  - c. Switch the surface water intake pump hand-off-auto switches to AUTO
  - d. The intake pump, package unit, and RO unit will start according to the storage tank level as described below.
2. The package unit and intake pumps will turn on and off based on the storage tank level in AUTO mode.
3. A ready signal will be pulled off of the package unit clarified water holding tank High level switch. This shall determine a requirement for water and the intake pump will start.
4. If there is a ready signal present from the RO unit and there is a requirement for water from the storage tank level system, the package unit filter feed/discharge pumps will run based on the clarified water holding tank level switches.
5. The RO feed pump will receive a start command from the package unit filter feed/discharge pumps with an adjustable delay timer. Antiscalant and acid injection pumps will start with the RO feed pump.
6. When the low pressure switch in the high pressure pump suction is no longer active, with a permissive delay timer the RO feed pump will start. Caustic and chlorination will start with the RO feed pump.
7. The transfer pumps will not run if the storage tank water level goes below the level alarm low (LAL) setpoint. The analog level transmitter (pressure transducer) will be installed into the treated water storage tank. The signal will go in the main control panel through an indicator device and into a device with adjustable setpoints for LAL, LAH, and LAHH required for proper operation.
8. The package unit filter feed/discharge pumps, the RO unit feed/discharge pumps, the RO unit feed pump, high pressure pump, acid, anti-scalant, caustic metering pumps, and

- chlorination pumps will turn off when the water level in the storage tank reaches the high-high setpoint, LAHH.
9. The intake pumps will turn off when if the high level switch is maintained in the clarified water tank for 60 seconds (adjustable 0-5 min).
  10. The requirement for water will be activated when the level goes below the level alarm high (LAH) set point.
  11. Package unit
    - a. Clarified Water Holding Tank
      - i. The filter feed/discharge pumps will run based on the clarified water tank level switches.
      - ii. The flow rates will be adjusted manually such that the clarified water holding tank inflow rate is no higher than the filter pump flow rates, and the clarified water holding tank will not over flow during filter Backwash mode.
    - b. Backwash Feed Tank
      - i. When the backwash water tank level is below LAL, the backwash pumps will not run.
      - ii. The backwash tank level switches will open and close the feed valve.
      - iii. The backwash tank level switches will open and close the feed valve.
      - iv. The backwash cycle will activate based on a timer.
      - v. At the end of the backwash cycle the feed valve will open and fill the tank.
    - c. When package unit is under AUTO mode, the alum metering pump and the flocculant metering pump will run with the intake pumps.
    - d. The package unit shall contain a general alarm that will shut down the intake pumps and RO unit. The alarm will include filter feed/discharge pump motor overloads and high clarified water tank alarm.
  12. The RO unit shall contain a general alarm that will shut down the package plant. The alarm will include low chemical feed tank level, low pressure alarm; high permeate TDS, and all motor overloads.
  13. The intake pump will shut off if the low pressure switch for the intake pump is activated during operation with an adjustable delay timing relay
  14. Any critical alarm that shuts equipment down must be reset manually. There shall be an alarm silence and reset pushbutton. When the problem is corrected the plant may be restarted according to item 1.
  15. To shut down the plant
    - a. Switch the surface water intake pump hand-off-switch to OFF
    - b. Switch the package unit hand-off-auto switches to OFF
    - c. Switch the RO unit hand-off-auto switches to OFF

### **Main Control Panel Input-Output List**

#### Discrete Inputs

Intake pump pressure alarm low status (low surface water table indication)  
Package unit run status  
Package unit general alarm status  
Package unit ready status  
RO unit run status  
RO unit general alarm status  
RO unit ready status  
Pump run status for each intake and transfer pump  
Pump overload status for each intake and transfer pump

#### Analog Input

Level Transmitter (pressure transducer)

#### Outputs

Intake pump run command

Package plant discharge permissive  
RO unit run command  
Tank level low status

**LCP-2 List, Package Unit**

Inputs

Coagulant metering pump run status for each pump  
Flocculant metering pump run status for each pump  
Filter feed pump run status for each pump  
Filter feed pump overload status for each pump  
Backwash pump run status for each pump  
Backwash pump overload status for each pump  
Air compressor motor run status  
Air compressor motor overload status  
Valve open close status for each valve  
Clarified water tank high  
Clarified water tank low  
Backwash tank high  
Backwash tank low  
Chlorination pump run status  
Chlorine has detection alarm  
Low chlorine level/weight alarm  
Low chlorine pressure alarm  
High chlorine pressure alarm

Outputs

Run command for each pump  
Open/close command for each valve  
Package Unit ready  
Package unit running  
Package unit general alarm

**LCP-3 I/O List, RO Unit**

Inputs

Acid metering pump run status  
Feed pump run status\*  
High pressure pump run status  
Caustic metering pump run status

Outputs

Run command for each pump  
Open/close command for each valve  
RO unit ready  
RO unit running  
RO unit general alarm

**LCP-4 List, Transfer Pumps**

Inputs

Treated water storage tank low

Outputs

Pump run status for each pump  
Pump overload status for each pump

**In Plant Water System**

The in-plant water system will operate with a low pressure switch. If the water pressure in the system is released, the pump will start.

Notes:

- \* The RO feed pump may not be present for some of the RO unit depending on the manufacturer.