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1.0 OVERVIEW

This document is intended to provide a description of the PLC functionality for the Marion Wastewater Pumping Station. It is written from a technical perspective, and is intended to be read along with the associated Process & Instrument Diagram (P&ID) drawings.

1.1 Associated Documents

The associated Process and Instrument Diagrams and Loop Diagrams are listed below.

Drawing Number	Rev	Description
1-0159L-P0001	00	P&ID, Wastewater Pumping
1-0159L-P0002	00	P&ID, Ventilation

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2.0 GENERAL REQUIREMENTS

2.1 Human Machine Interface

2.1.1 Screen Layout

The typical screen layout for the HMI graphic terminal shall be as shown in Figure 1. Navigation buttons shall reside across the bottom, a single-line alarm banner across the top, and the remainder of the screen allocated for the graphic display area. The graphic display area will be utilized for mimic displays, configuration screens, trends, and an alarm summary.

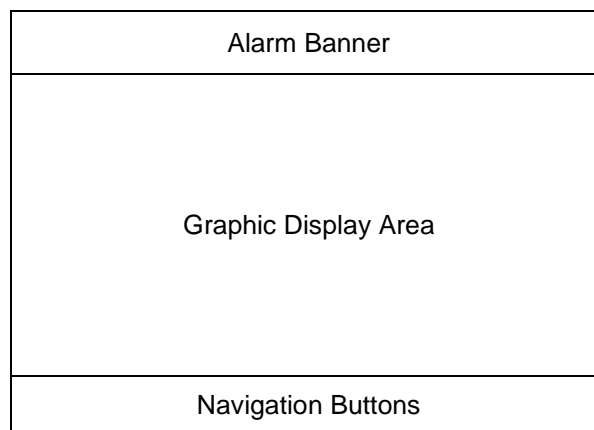



Figure 1: Screen Layout

2.1.2 Graphic Displays


A graphic (process mimic) display is a graphical representation of the process, showing pumps, instruments, and associated piping. Show sufficient detail from the P&IDs to allow operators a full understanding of the process. Metric units are to be used.

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2.2 HMI Animation Plan

Item	Condition	Color	Flash	Display Notes
Background	-	Lt Gray	-	
Equipment Graphic	Stopped	Green	-	
	Running	Red	-	
	Alarm	Magenta	-	
Valve / Gate Position	Closed	Green	-	
	Open	Red	-	
Equipment Local / Remote Switch	Local	Black	-	"Local" visible
	Remote	-	-	"Local" invisible
VFD Mode	VFD	Black	-	"VFD" visible
	Bypass	Black	-	"Bypass" visible
Starter Ready	Not Ready	Black	-	"Starter not Ready" visible
	Ready	-	-	
Analog Measurement Values	-	Black	-	Text in a border, with units. Display adjacent to the location on the process display where the measurement is made.
Starter H-O-A Switch	Not in Auto	Black	-	"Starter not in Auto" visible
	Auto	-	-	"Starter not in Auto" invisible
Heater Auto/Manual Mode	Manual	Black	-	"Starter in Manual" visible
	Auto	-	-	"Starter in Manual" invisible
Airflow switch	Flow	Black Text	-	F in gray circle
	No Flow	Blank	-	Blank gray circle
Equipment ID Tag	-	Black	-	Bold Text, adjacent to equipment
Piping – Path Lines	-	Dk Gray	-	
Faceplate Background	-	Med. Gray	-	
Trend Background	-	White	-	
Trend Pen Lines	-	Separate Contrasting Color for Each Pen	-	
Pushbuttons	Enabled	Lt Gray with Black Text	-	Pushbuttons are to appear bevelled.
	Disabled	Lt Gray with Dk Gray Text	-	Utilize pushbuttons for a single purpose only. Do not change the text on a pushbutton.

Note: For instruments / sensors mounted on equipment, display actual field inputs (after moving to internal PLC variables) on the HMI equipment graphic. Do not show specific alarms, which typically come after a delay on the graphic. The operator can look at the process graphic to see if the initiating cause of the alarm is still present or not.

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2.2.1 Equipment Faceplates (Popup Windows)

Create popup faceplates for each major piece of equipment that has control capability. Display equipment faceplates upon a click of the associated equipment on the graphic display. Display the equipment identifier at the top of the faceplate. Display status information and provide for control as specified.

Where a piece of equipment has an alarm that requires a manual reset, include an alarm reset pushbutton at the bottom of the faceplate.

2.2.2 Trends

Incorporate pre-configured trend displays. Make trend displays accessible via a button(s) in the bottom right corner of the graphic display. Display a legend which relates the tag name and description to the pen colours.

Group trend screens by system.

2.2.3 Configuration Screen

A configuration screen shall be provided that allows operators to adjust process and alarm setpoints. The configuration screen shall be accessible from a button in the navigation button area and shall utilize a light grey background colour with black text.

2.2.4 Alarms

New alarms are to be displayed in an alarm banner that resides across the top of the screen.

Create an Alarm Summary screen so that operators are able to view historical alarms. The Alarm Summary object is to have the *Alarm List* property set to *History*. The alarm banner need not be shown when the alarm summary is displayed provided that the alarm summary also displays current (active) alarms.

Use the scheme in Table 2-1 display of alarms as a function of their state:

State	Visible	Colour
Active	Yes	Red
ACK	Yes	Orange
RTN	No	N/A

Table 2-1: Alarm Summary Colours

2.2.5 PLC Control from HMI


Configure HMI commands to utilize a SET operation rather than the Momentary On operation. The PLC shall reset the bit. This prevents discrete PLC tags from being stuck on in the event of communication failures, timing issue, or control from multiple HMI nodes.

Enable and disable pushbuttons appropriately.

2.2.6 Security

Implement a logon / logoff security system. Allow for four levels of security: High (H), Medium (M), Low (L) and None (N)

When logged off, the security level will be None (N), however basic viewing of the HMI system will still be allowed.

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2.3 Equipment and System General Requirements

2.3.1 HMI Interface Points

Not all points between the HMI and PLC are necessarily specified or listed under the HMI-PLC interface lists. Note that in many cases the points listed as PLC I/O might also be part of the HMI-PLC interface. The requirement is based upon the HMI logging or display requirements.


2.3.2 HMI Interface Type Codes

R	HMI Read
RA	HMI Read, Alarmed
RW	HMI Read/Write
W	HMI Write
W1	HMI Write, PLC will immediately reset to 0

Multiple W1 variables may be assigned within a given word, as these bits will be immediately zeroed by the PLC, and thus should never experience issues with overwriting bits.

2.3.3 HMI Display Type

HMI Display Type	Description
-	Do not show on the HMI
A	Alarm Banner
DD-T	Show as text on the data display.
EF-G	Show as graphic on the faceplate, which will popup when the operator clicks on the specific piece of equipment
EF-L	Show as an indicator light on the equipment faceplate.
EF-T	Show as a text display on the faceplate
EF-TE	Show as a text entry on the faceplate
GD-A	Show as an animation on the graphic display.
GD-G	Show as a graphic on the graphic display.
GD-L	Show as an indicator light on the graphic display.
GD-T	Show as text on the graphic display.
SW-T	Show as text on a settings window.
T	Trend

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Example:

HMI Display Type

Tag	Type	Description	0 State	1 State	Display
L101-EL	DI	Starter Ready	Not Ready	Ready	GD-T
L101-HS-4	DI	Starter in Remote Mode	Local	Remote	GD-T
L101-YS	DI	Bypass Mode	VFD	Bypass	PD-T

2.3.4 HMI Control Type

HMI Control Type	Description
-	Not Applicable
EF-PB	Show as a button on the equipment faceplate
EF-TE	Show as a text entry on the equipment faceplate
SW-CB	Show as a checkbox on the equipment settings window.
SW-TE	Show as a text entry on the equipment settings window.

Example:

HMI Control Location


Security

Discrete Control Bits:

Tagname	Description	Type	Control
L101_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (L)
L101_CtrlAutoCmd	Set to Auto Control Mode	W1	EF-PB (L)


2.3.5 Security

HMI Control Type	Description
N	None
L	Low (Accessible to operator security level)
M	Medium (Accessible to mid level maintenance technicians)
H	High (Accessible to senior personnel only)

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2.3.6 Alarm Priority

Pri	Description
1	High Priority
2	Medium Priority
3	Low Priority

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3.0 IMPLEMENTATION

3.1 Graphic Displays

3.1.1 Pump Graphic

Create a graphic (process mimic) display containing a representation of the process shown on P&ID 1-0159L-P0001. Specific requirements include, but are not limited to:

- Animate the wet well level using vertical fill animation. Also display the level value in the center of wet well in relative and absolute units.
- Provide access to the following controller faceplates:
 - L106-LC – Wet Well Level Speed Controller
 - L107-LC – Wet Well Level On/Off Controller
 - L108-LY – Wet Well Level Control Selector
 - L109-YC – Pump Sequence Controller
- Provide access to the Maintenance Screen.

3.1.2 Ventilation

Create a graphic (process mimic) display containing a representation of the process shown on P&ID 1-0159L-P0002. Specific requirements include, but are not limited to:

- Occupancy Status
- Supply Air Temperature
- HCE-L1 Heater Control Output (0-100%)
- Recirculation Air Dampers Position (from position feedback)
- SF-L1
- SF-L2
- Air Flow Switch
- Room Temperature
- Provide access to the following controller faceplates:
 - L601-FC – Mixed Air Damper Controller
 - L602-TC – Discharge Temperature Controller
 - L604-TC – Room Temperature Controller


3.1.3 Settings Window

- Create a settings window with settings as indicated in Section 4.0.

3.1.4 Data Display Screen

Display the runtime hours for each pump.

Display the current and previous hour and day station flow volumes in units of m³.

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3.2 Trend Displays

3.2.1 Trends

Create, at minimum, the following trend displays, with the indicated pens.

- Pump Trend
 - L100-LT-A, Wet Well Level
 - L100-LT-B, Wet Well Level
 - L101-ST, Pump 1 Speed Feedback
 - L102-ST, Pump 2 Speed Feedback
 - L110-FT, Pump Discharge Flow Rate

- Ventilation Trend
 - L601-FC, Damper Position Output
 - L602-TT, Discharge Temperature
 - L602-TC, Heater Output
 - L604-TT, Room Temperature

- Damper Trend
 - L601-FC, Damper Position Output
 - L601-FV-1, Outdoor Air Damper Position
 - L601-FV-2, Return Air Damper Position
 - L601-FV-3, Exhaust Air Damper Position


3.2.2 Equipment Faceplates

Create equipment faceplates for all controllable pieces of equipment and controllers. Note that a sample faceplate for P-L1 is provided in Section 4.6.6. Base other faceplates on the example provided.

Each piece of equipment with manual control capability shall have a *Manual* and *Auto* pushbutton. A text display above the buttons will indicate the appropriate Manual or Auto mode that the equipment is currently in.

Disable all buttons that are not currently active or available. Examples:

- Disable the *Auto* button when in Auto mode.
- Disable the *Start* and *Stop* buttons when in Auto mode.
- Disable the *Manual Speed* Entry when in Auto mode.

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4.0 EQUIPMENT AND SYSTEM REQUIREMENTS

4.1 Wet Well Level Indicator – L100-LI

Wet Well Level Indicator L100-LI provides a means for the user to manually control the level of the wet well. This feature is useful for testing, and could be utilized in some maintenance modes. While, in manual mode, an alarm will be set to ensure that the operators are aware of the situation. In addition, L100-LI provides level alarming.

4.1.1 PLC I/O

Analog:

Tag	Type	Description	Range	Display
L100-LT-A	AI	Wet Well Level A	0 – 10.00 m	EF-T
L100-LT-B	AI	Wet Well Level B	0 – 10.00 m	EF-T

4.1.2 HMI-PLC Interface

Discrete Status Bits:


Tagname	Description	Type	Control
L100_CtrlMan	Control Mode in Manual	R	EF-T

Discrete Control Bits:

Tagname	Description	Type	Control
L100_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (H)
L100_CtrlAutoCmd	Set to Auto Control Mode	W1	EF-PB (H)

Analog Values:

Tagname	Description	Values	Type	Display
L100_LI	Wet Well Level (Utilized for Control)	221.000 – 231.000 m	R	GD-T
L100_LI_A	Wet Well Level A (Geodetic)	221.000 – 231.000 m	R	EF-T
L100_LI_B	Wet Well Level B (Geodetic)	221.000 – 231.000 m	R	EF-T

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Analog Set Points:

Tagname	Description	Values	Type	Control
L100_AutoMode	Control Mode: 0 = Average, 1 = L100-LT-A, 2 = L100-LT-B	0 - 2	RW	EF-T EF-PB (M)
L100_LI_Man	Manual Level	0 – 32.767 m	RW	EF-TE (H)
L100_LAHH_SP	Level High-High Alarm Setpoint	0 – 327.67 m	RW	SW-TE (M)
L100_LAH_SP	Level High Alarm Setpoint	0 – 327.67 m	RW	SW-TE (M)
L100_LAL_SP	Level Low Alarm Setpoint	0 – 327.67 m	RW	SW-TE (M)

4.1.3 Alarms


Tagname	Description	Logic	Mask	Pri	Reset
L100_CtrlMode	Manual Control Mode	L100_CtrlMan	N/A	2	Auto
L100_Calibration	Calibration Warning	L100_AutoMode == 0 AND ABS(L100_LT_A - L100_LT_B) > 0.2m for > 15 sec	N/A	3	Auto
L100_ABError	Level Mismatch	L100_AutoMode == 0 AND ABS(L100_LT_A - L100_LT_B) > 0.4m for > 15 sec	N/A	2	Auto
L100_LAH	Level High	L100_LI >= L100_LAH_SP for > 5 sec	N/A	2	Auto
L100_LAHH	Level High-High	L100_LI >= L100_LAHH_SP for > 5 sec	N/A	2	Auto
L100_LAL	Level Low	L100_LI <= L100_LAL_SP for > 1 sec Reset when L100_LI > L100_LAL_SP for 10 sec	N/A	2	Auto

4.1.4 Control Narrative

When L100_CtrlManCmd is set, set L100_CtrlMan to 1 and utilize the value in L100_LI_Man as the current level and set an alarm.

When L100_CtrlMan is not set, set L100_LI_Man = L100_LI to allow bump-less transfer when switching to Manual mode.

When L100_AutoMode is set to 0, move the average of L100_LI_A and L100_LI_B into L100_LI. When L100_AutoMode is set to 1, move L100_LI_A into L100_LI. When L100_AutoMode is set to 2, move L100_LI_B into L100_LI.

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4.2 Wet Well Level Speed Control – L106-LC

Wet well level speed controller L106-LC utilizes PID control loops to control the pump speed, and thus the wet well level. The speed controller will be used when both pumps are operating from the VFDs, as opposed to the bypass contactors.

4.2.1 PLC I/O

None

4.2.2 HMI-PLC Interface

Discrete Status Bits:

Tagname	Description	Type	Display
L106_D1_Run	Duty 1 Pump Called to Run	R	EF-L
L106_D2_Run	Duty 2 Pump Called to Run	R	EF-L
L106_D3_Run	Duty 3 Pump Called to Run	R	EF-L
L106_Cleanout	Wet Well in Cleanout State	R	GD-L

Discrete Control Bits:


None

Analog Values:

Tagname	Description	Values	Type	Display
L106_CV	Speed Output Signal	0 – 100%	R	EF-T

Analog Set Points:

Tagname	Description	Values	Type	Control
L106_CO_Enbl	Daily Cleanout Enabled	0 (Off), 1 (On)	RW	SW-CB (M)
L106_CO_Time	Daily Cleanout Time (Hour)	0 – 24	RW	SW-TE (M)
L106_SC_Min	Minimum Speed Output	0 – 100%	RW	SW-TE (H)
L106_LC_SS_Lim	Level Control Pump Start / Stop Limit	0 – 327.67 m	RW	SW-TE (M)
L106_LC_SP	Level Control Setpoint	0 – 327.67 m	RW	SW-TE (M)
L106_LC_Stop	Level Control Stop Setpoint	0 – 327.67 m	RW	SW-TE (H)
L106_CO_SP	Wet Well Cleanout Level Setpoint	0 – 327.67 m	RW	SW-TE (M)
L106_SC_2P_Init	Initial Speed for Transition to Two Pumps	0 – 100%	RW	SW-TE (M)
L106_SC_3P_Init	Initial Speed for Transition to Three Pumps	0 – 100%	RW	SW-TE (M)

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4.2.3 Alarms

None

4.2.4 Control Narrative

The pump control logic shall be set up for two pumps, which will currently be installed. While control logic for the 3rd pump is not required at this time, the two pump logic shall be set up in a manner to allow for straightforward addition of the 3rd pump logic in the future.

The pump speed control shall be PID controlled based upon the level in the wet well. The PID tuning parameters will only be adjustable via modifications in the PLC program. Two PID control loops will be utilized, with separate tuning parameters. The first PID control loop will be utilized with one pump active. The second PID control loop will be utilized with two pumps active.

Typically, only one pump will operate. This pump will be the 1st duty pump, as set in the tag L109_Duty1. However, the second duty pump will be called for in the following case:

- The pump speed is $\geq 98\%$, AND
- The wet well level is L106_LC_SS_Lim above the normal level setpoint.

Upon switching to two pumps being active, utilize the second PID controller, which shall be forced to an initial output value of L106_SC_2P_Init %. The output from the second PID will be used as the speed reference for both pumps in order to have them operate at the same speed.

If two pumps are operating and the following conditions become true:

- The pump speed is $< 60\%$, AND
- The wet well level is L106_LC_SS_Lim below the normal level setpoint.

Then transition back to one pump operating. Reactivate the first (single pump) PID controller, with an initial output value of 100 %. Confirm this value during commissioning.

If one or more pumps are operating and the following conditions become true:

- The wet well level is drawn down at or below L106_LC_Stop

Then stop the pump(s). No alarms are to be generated as this will be a normal operating condition. Once the level reaches the Normal Level Setpoint then start the 1st duty pump.


Do not allow the speed output to drop below L106_SC_Min.

The VFD shall be programmed with a maximum slew rate of 1Hz / second, which translates into 1.67% / second. The PID maximum slew rate shall be less than this value.

When L108_ModeOnOff is true, set the following to provide bump-less control transfer:

- L106_D1_Run = L108_D1_Run
- L106_D2_Run = L108_D2_Run
- L106_D3_Run = L108_D3_Run
- L106_CV = 100%

An cleanout function is incorporated to automatically clean out the wet well at periodic intervals, defined by L106_CO_Time. When the current hour equals L106_CO_Time, set L106_Cleanout. When L106_Cleanout is set, the PID is to use L106_CO_SP as the setpoint variable. Once the level in the wet well is less than or equal to L106_CO_SP then reset L106_Cleanout. The process repeats again once the current hour reached L106_CO_Time on the next day.

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4.3 Wet Well Level On/Off Control – L107-LC

The wet well level on/off controller L107-LC operates the pumps using on/off control based on the pump duty level start and stop setpoints. This on/off controller is intended to be used if one or more of the pumps is operating with the bypass contactor, rather than the VFD speed control.

4.3.1 HMI-PLC Interface

Discrete Status Bits:

Tagname	Description	Type	Display
L107_D1_Run	Duty 1 Pump Called to Run	R	EF-L
L107_D2_Run	Duty 2 Pump Called to Run	R	EF-L
L107_D3_Run	Duty 3 Pump Called to Run	R	EF-L


Analog Set Points:

Tagname	Description	Values	Type	Control
L107_Duty1_N_SP	Duty 1 Level Start Setpoint	0 – 327.67 m	RW	SW-TE (M)
L107_Duty1_O_SP	Duty 1 Level Stop Setpoint	0 – 327.67 m	RW	SW-TE (M)
L107_Duty2_N_SP	Duty 2 Level Start Setpoint	0 – 327.67 m	RW	SW-TE (M)
L107_Duty2_O_SP	Duty 2 Level Stop Setpoint	0 – 327.67 m	RW	SW-TE (M)
L107_Duty3_N_SP	Duty 3 Level Start Setpoint	0 – 327.67 m	RW	SW-TE (M)
L107_Duty3_O_SP	Duty 3 Level Stop Setpoint	0 – 327.67 m	RW	SW-TE (M)

4.3.2 Control Narrative

Command the first, second, and third duty pump to start and stop based on the level setpoints. When L108_ModeOnOff is false, set the following to provide bump-less control transfer:

- L107_D1_Run = L108_D1_Run
- L107_D2_Run = L108_D2_Run
- L107_D3_Run = L108_D3_Run

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4.4 Pump Control Mode Selector – L108-LY

The Pump Control Mode Selector, L108-LY, selects between pump speed control and on-off control. This can be set either manually or automatically. In automatic mode, the controller will switch to on-off control if any of the pumps are ready to run and are in bypass mode.

4.4.1 PLC I/O

None

4.4.2 HMI-PLC Interface

Discrete Status Bits:


Tagname	Description	Type	Display
L108_CtrlManual	Manual Control Mode	R	GD-T, EF
L108_ModeOnOff	In On/Off Mode (not Speed Mode)	R	GD-T, EF
L108_D1_Run	Duty 1 Pump Called to Run	R	EF-L
L108_D2_Run	Duty 2 Pump Called to Run	R	EF-L
L108_D3_Run	Duty 3 Pump Called to Run	R	EF-L

Discrete Control Bits:

Tagname	Description	Type	Control
L108_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (M)
L108_CtrlAutoCmd	Set to Auto Control Mode	W1	EF-PB (M)
L108_ModeOnOffCmd	Set to On/Off Mode (when in manual)	W1	EF-PB (M)
L108_ModeSpeedCmd	Set to Speed Mode (when in manual)	W1	EF-PB (M)

Analog Values:

Tagname	Description	Values	Type	Display
L108_CV	Speed Output Signal	0 – 100%	R	EF-T

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4.4.3 Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L108_HA1	In Speed Mode and Pump in Bypass	NOT L108_ModeOnOff AND ((L108_P1_Run AND L101_YL) OR (L108_P2_Run AND L102_YL) OR (L108_P3_Run AND L103_YL))	N/A	2	Auto

4.4.4 Control Narrative

IF NOT L108_CtrlManual

IF (L101_UL and L101_HS_4_ AND NOT L101_Alarm AND NOT L101_CtrlMan AND L101_YL) OR (L102_UL and L102_HS_4_ AND NOT L102_Alarm AND NOT L102_CtrlMan AND L102_YL) THEN
L108_ModeOnOff = 1

ELSE

L108_ModeOnOff = 0

When L108_ModeOnOff is not set (Speed Mode):

L108_D1_Run = L106_D1_Run

L108_D2_Run = L106_D2_Run

L108_CV = L106_CV

When L108_ModeOnOff is set:

L108_D1_Run = L107_D1_Run

L108_D2_Run = L107_D2_Run

L108_CV = 100%

4.5 Pump Duty Sequencer – L109-YC

The Pump Duty Sequencer is utilized to decide which specific pump or pumps will be called to run.


4.5.1 PLC I/O

None

4.5.2 HMI-PLC Interface

Discrete Status Bits:

Tagname	Description	Type	Display
L109_Alternate	In Alternate Mode	R	GD-T, EF
L109_P1_Run	P-L1 Called to Run	R	EF-T
L109_P2_Run	P-L2 Called to Run	R	EF-T
L109_P3_Run	P-L3 Called to Run	R	EF-T

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Discrete Control Bits:

Tagname	Description	Type	Control
L109_AlternateOnCmd	Set to Alternate Mode	W1	EF-PB (M)
L109_AlternateOffCmd	Turn off Alternate Mode	W1	EF-PB (M)

Analog Set Points:

Tagname	Description	Values	Type	Control
L109_Duty1	Duty 1 Pump Number	0, 1, 2, 3	RW	EF-TE (L)
L109_Duty2	Duty 2 Pump Number	0, 1, 2, 3	RW	EF-TE (L)
L109_Duty3	Duty 3 Pump Number	0, 1, 2, 3	RW	EF-TE (L)

4.5.3 Alarms


Tagname	Description	Logic	Mask	Pri	Reset
L109_HA1	No Duty 1 Pump	L109_Duty1 == 0	N/A	2	Auto

4.5.4 Control Narrative

Alternate the pumps when L109_Alternate is set. Set up the alternator for three pumps. By entering a value of 0 into L109_Duty3, the 3rd pump alternation will be turned off. The first pump to be started should be the first pump to stop. The next pump to be started should be the pump that has been off the longest. When a pump is called to stop, the pump that has been running the longest should be stopped.

When L109_Alternate is not set, start the pumps by the Duty Pump assignments:

- When one pump is called for, run the pump referenced in L109_Duty1
- When two pumps are called for, run the pumps referenced in L109_Duty1 & L109_Duty2
- When three pumps are called for, run the pumps referenced in L109_Duty1 & L109_Duty2 & L109_Duty3

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4.6 P-L1 Wastewater Lift Pump – L101

P-L1 is a wastewater lift pump with VFD speed control and a bypass starter.

4.6.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L101-UL	DI	Starter Ready	Not Ready	Ready	GD-T
L101-HS-4	DI	Starter in Auto Mode	Not Auto	Auto	GD-T
L101-YL	DI	VFD Bypass Mode	VFD	Bypass	GD-T
L101-MM	DI	Pump Running	Off	Running	GD-G
L101-UA	DI	VFD Fault	OK	Alarm	A
L101-IA	DI	Bypass Overload Alarm	OK	Alarm	A
L101-MN	DO	Run Command	Stop	Run	-
L101-YC	DO	Bypass Mode Command	VFD	Bypass	-

Analog:


Tag	Type	Description	Range	Display
L101-SC	AO	Speed Command	0 – 100 %	EF-T
L101-ST	AI	Speed Feedback	0 – 100 %	GD-T, EF-T
L101-IT	AI	Current Feedback	0 – 75 A	EF-T

4.6.2 HMI - PLC Interface

The full HMI – PLC interface will include PLC I/O designated above.

Discrete Status Bits:

Tagname	Description	Type	Display
L101_Alarm	Alarm Present	R	GD-A
L101_CtrlMan	Manual Control Mode	R	GD-T, EF-T

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Discrete Control Bits:

Tagname	Description	Type	Control
L101_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (L)
L101_CtrlAutoCmd	Set to Auto Control Mode	W1	EF-PB (L)
L101_Reset	Reset	W1	EF-PB (L)
L101_ManualStart	Manual Start command	W1	EF-PB (L)
L101_ManualStop	Manual Stop command	W1	EF-PB (L)
L101_VFDBypassCmd	Set to VFD Bypass Mode	W1	EF-PB (L)
L101_VFDCmd	Set to VFD Mode	W1	EF-PB (L)

Analog Values:


Tagname	Description	Range	Type	Display
L101_II	Motor Current (% Full Load Amps)	0 – 160 %FLA	R	EF-T
L101_KI	Pump Runtime	0 – 2 ³¹ min	R	DD-T
L101_SI	Pump Speed	0 – 100%	R	EF-T, GD-T, T

Notes:

- (1) *Display in units of "0.0" hours*
- (2) *Set L101_SI = L101_ST when in VFD mode and L101_SI = 0 or 100%, based upon pump run signal, when in Bypass mode.*

Analog Set Points:

Tagname	Description	Range	Type	Control
L101_FAL_SP	Flow Alarm Low Setpoint	0 – 32767 l/s	RW	SW-TE (M)
L101_LL_SP	Low Level Stop Setpoint	0 – 327.67 m	RW	SW-TE (H)
L101_SC_Man	Manual Speed Control Output	0 – 100%	RW	EF-TE (L)
L101_SC_Min	Minimum Speed Control Output	0 – 100%	RW	EF-TE (H)

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4.6.3 PLC Generated Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L101_RunFault	Run Fault	L101-HS-4 AND ((L101-MN AND NOT L101-MM) for 2 seconds OR (NOT L101-MN AND L101-MM) for 8 sec)	N/A	2	HMI
L101_FAL	Flow Alarm	L101_MM AND L110_FT < L101_FAL_SP for > 10 sec	N/A	2	HMI

4.6.4 Interlocks

Initiating Event	Action	Control Mode		Description
		Auto	Manual	
NOT L101_UL	Stop	Y	Y	Starter Not Ready
L101_UA AND NOT L101_YL	Stop	Y	Y	VFD Fault
L101_IA AND L101_YL	Stop	Y	Y	Bypass Overload Fault
L101_FAL	Stop	Y	N	Low Flow Alarm
L100_LI <= L101_LL_SP	Stop	Y	Y	Low Level Interlock

4.6.5 Control Narrative

If L101_SC_Man < L101_SC_Min THEN SET L101_SC_Man = L101_SC_Min

.1 Starter in Manual (NOT L101-HS-4)

The PLC does not have control of the pump, so turn off the run and speed outputs:

Set L101-SC = 0
Set L101-MN = 0


All HMI control is disabled. The HMI continues to monitor the status and display alarms.

.2 Starter in Auto (L101-HS-4) AND Manual Control Mode (L101_CtrIMan)

Utilize the Manual Start (L101_ManualStart) and Stop (L101_ManualStop) signals to start and stop the pump.

IF VFD Mode (NOT L101-YL)
Set L101-SC = L101_SC_Man when the pump is commanded to start;
ELSE // Bypass Mode
Set L101-SC = 0;

Ensure that the manual speed setpoint (L101_SC_Man) is set to the actual speed when in Auto, so that upon the transition to manual control, the transition is bump-less.

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.3 Starter in Auto (L101-HS-4) AND Auto Control Mode (L101_CtrIMan)

Utilize the signals from L108-LY Pump Mode Selector and 109-YC Pump Duty Sequencer to start and stop the pump and set the pump speed.

Set L101-SC = L108_CV
Set L101-MN = L109_P1_Run

.4 Changing between VFD and Bypass Mode

Do not allow operators to change between VFD and Bypass modes while the pump is running as this may result in damage to the VFD.


4.6.6 Faceplate

An example faceplate is shown in Figure 2.

P-L1

Speed Command:	85 %
Actual Speed:	85 %
Motor Current:	80 %FLA
Control Mode:	<div style="border: 1px solid black; padding: 2px; display: inline-block;">Auto</div>
	<div style="display: flex; justify-content: space-around; gap: 10px;"> <div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">Auto</div> <div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">Manual</div> </div>
	<div style="display: flex; justify-content: space-around; gap: 10px;"> <div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">Start</div> <div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">Stop</div> </div>
Manual Speed:	<div style="display: flex; align-items: center; gap: 5px;"> <div style="border: 1px solid black; padding: 2px 10px; width: 40px; text-align: center;">85</div> % </div>
Starter Mode:	<div style="border: 1px solid black; padding: 2px; display: inline-block;">VFD</div>
	<div style="display: flex; justify-content: space-around; gap: 10px;"> <div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">VFD</div> <div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">Bypass</div> </div>
Alarm Reset:	<div style="border: 1px solid gray; padding: 2px 10px; background-color: #cccccc;">Reset</div>

Figure 2: P-L1 Equipment Faceplate

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4.7 P-L2 Wastewater Lift Pump – L102

Pump P-L2 is identical to P-L1. Utilize the P-L1 requirements as the basis for P-L2.

4.8 Flow Meter – L110-FT

4.8.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L110-FQ	DI	Flow Meter Pulse Input	-	Pulse 1000 l	

Analog:

Tag	Type	Description	Range	Display
L110-FT	AI	Pump Discharge Flow Meter	0 – 500 l/s	GD-T, T

4.8.2 HMI-PLC Interface

Analog Values:


Tagname	Description	Range	Type	Display
L110_FQ_HourC	Total Flow – Current Hour	0 – 32767 m ³	R	DD-T
L110_FQ_HourP	Total Flow – Previous Hour	0 – 32767 m ³	R	DD-T
L110_FQ_DayC	Total Flow – Current Day	0 – 2 ³¹ m ³	R	DD-T
L110_FQ_DayP	Total Flow – Previous Day	0 – 2 ³¹ m ³	R	DD-T

4.8.3 Control Narrative

Compute two flow totals from the pulse input:

- 1) Current hour flow total
- 2) Current day flow total

Copy the Current Hour and Current Day values to the Previous Hour and Previous Day values at the end of each hour and day respectively.

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4.9 Ventilation System – Occupied Switch – L600

The occupied switch is utilized to indicate to the ventilation controls whether the station is occupied. When occupied, the fresh air ratio is increased to 100%, to meet safety requirements as per NFPA 820.


4.9.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L600-HS-1	DI	Occupied Switch	Unoccupied	Occupied	GD-T

4.9.2 PLC Generated Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L600_KA	Occupied Over 8 hours	L600-HS-1 > 8 hours	N/A	3	Auto

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4.10 Mixed Air Dampers – L601-FV-1, L601-FV-2, L601-FV-3

Dampers L601-FV-1, L601-FV-2, and L601-FV-3 are utilized to control the mixed air ratio of the ventilation fan SF-L1. They allow for a fresh air ratio of between 25 – 100%, to meet temperature requirements. When the station is occupied, the fresh air ratio is increased to 100%, to meet safety requirements as per NFPA 820. When unoccupied, the dampers may modulate to provide cooling as required, with a minimum fresh air ratio of 25%. The damper position correlating to 25% fresh air flow should be tested at commissioning, and entered as a setting.

4.10.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L601-HS-1	DI	Recirculation Dampers Mode Switch	Recirc. Off	Auto	GD-T

Analog:

Tag	Type	Description	Range	Display
L601-FC	AO	L601-FC Mixed Air Ratio Control	0 – 100%	GD-T, T
L601-ZT-1	AI	Intake Air Damper Position Feedback	0 – 100%	GD-T
L601-ZT-2	AI	Return Air Damper Position Feedback	0 – 100%	GD-T
L601-ZT-3	AI	Exhaust Air Position Feedback	0 – 100%	GD-T

4.10.2 HMI - PLC Interface

Discrete Status Bits:


Tagname	Description	Type	Display
L601_CtrlMan	Control Mode Manual	RW	GD-T / EF

Discrete Control Bits:

Tagname	Description	Type	Control
L601_CtrlAutoCmd	Set to Auto Control Mode	W1	EF-PB (L)
L601_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (L)

Analog Set Points:

Tagname	Description	Range	Type	Control
L601_FC_Manual	Manual Mode Setpoint	0 – 100 %	RW	EF-TE (L)
L601_FC_Min	Min Operating Damper Position (Should Correspond to 25% Fresh Air, 75% Recirc)	0 – 100 %	RW	SW-TE (H)

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4.10.3 PLC Generated Alarms

Tagname	Desc.	Logic	Mask	Pri	Reset
L601_FV_1_Alarm	Position Alarm	ABS(L601_FC - L601_ZT_01) > 10% for > 120 seconds (Note 1)	N/A	2	Auto
L601_FV_2_Alarm	Position Alarm	ABS(L601_FC - (100% - L601_ZT_02)) > 10% for > 120 seconds (Note 1)	N/A	2	Auto
L601_FV_3_Alarm	Position Alarm	ABS(L601_FC - L601_ZT_03) > 10% for > 120 seconds (Note 1)	N/A	2	Auto

Notes:

(1) Position command and position feedback are in units of percent (%).

4.10.4 Interlocks

Initiating Event	Action	Control Mode		Description
		Auto	Manual	
NOT L603_MM	Set L601_FC = 0 %	Y	N	Close Intake and Exhaust Dampers when SF-L1 Supply Fan is stopped
L600_HS_1	Set L601_FC = 100 %	Y	N	Open fresh air damper fully (0% recirc) when the occupied switch is in the occupied position.
NOT L600_HS_1 AND L602_TC > 0	Set L601_FC = L601_FC_Min	Y	N	Ensure dampers are closed to 75% recirc position when not occupied and the heater is operating.
L602_TALL	Set L601_FC = L601_FC_Min	Y	N	Close intake and exhaust dampers to the minimum position when there is a low-low supply temperature alarm.
L604_TALL	Set L601_FC = 0 %	Y	N	Close Intake and Exhaust Dampers when there is a room low-low temperature alarm to prevent freezing.

4.10.5 Control Narrative


Utilize PID control to control the damper output:

PV: L602-TT
 SP: Based on L604-TC
 CV: L601-FC (Direct Acting)

CV_Limits: Low: L601_FC_Min (Note: Interlocks may override this minimum)
 High: 100%

The setpoint of the mixed air dampers' PID controller is based on the output of the room temperature controller L604-TC. As the room temperature warms up the mixed air damper PID controller will open the outdoor air dampers to provide cooling.

Ensure bump-less transfer is provided between manual and automatic modes, and occupied / unoccupied modes.

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4.11 HCE-L1 Ventilation Heater – L602-TC

Ventilation Fan SF-L1 is equipped with an inline electric duct heater and temperature sensor. The heater is modulated to control the discharge temperature to the desired discharge temperature. Note that the discharge temperature setpoint is controlled by the temperature control, L604-TC.

4.11.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L602-HS-1	DI	HCE-L1 Heater Mode	Manual	Auto	GD-T

Analog:

Tagname	Type	Description	Range	Display
L602-TC	AO	HCE-L1 Heater Output Command	0 – 100 %	EF / GD-T, T
L602-TT	AI	Supply Air Temperature	-40 – 60 °C	GD-T, T

4.11.2 HMI - PLC Interface

Discrete Status Bits:

Tagname	Description	Type	Display
L602_CtrlMan	Control Mode Manual	R	GD-T, EF

Discrete Control Bits:


Tagname	Description	Type	Control
L602_CtrlAutoCmd	Set to Automatic Control Mode	W1	EF-PB (L)
L602_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (L)

Analog Set Points:

Tagname	Description	Range	Type	Control
L602_TC_Man	Manual Mode Output Setpoint	0 – 100 %	RW	EF-TE (L)

4.11.3 PLC Generated Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L602_TAHH	Supply Air Temperature High-High	L602_TT => 40°C for > 10 sec	N/A	2	Auto

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L602_TAH	Supply Air Temperature High	NOT (L601_CtrlMan AND L602_CtrlMan) AND (L602_TT - Controller SP) >= 5 °C for > 5 minutes	N/A	3	Auto
L602_TAL	Supply Air Temperature Low	NOT (L601_CtrlMan AND L602_CtrlMan) AND (L602_TT - Controller SP) <= -5 °C for > 5 minutes	N/A	3	Auto
L602_TALL	Supply Air Temperature Low-Low	L602_TT <= 0°C for > 10 sec	N/A	2	Auto

4.11.4 Interlocks

Initiating Event	Action	Control Mode		Description
		Auto	Manual	
NOT L603_MM	Set L602_TC = 0 %	Y	N	Turn off duct heater when fan is not running.
NOT L600-HS-1 L601_FC > L601_FC_Min	Set L602_TC = 0 %	Y	N	Force heater off when unoccupied and outside air damper is commanded to open more than 25%.


4.11.5 Control Narrative

Utilize PID control to control the heater output:

PV: L602-TT
 SP: Based on L604-TC
 CV: L602-TC (Reverse Acting)

The setpoint of the supply temperature PID controller is based on the output of the room temperature controller L604-TC. As the room temperature cools, the supply temperature PID controller will call for additional heating.

Ensure bump-less transfer is provided between manual and automatic modes.

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4.12 Room Temperature Control L604-TC

A room temperature sensor is located on the main floor of the building. The Room Temperature Control L604-TC does not directly control the duct heater or the recirculation / mixed air dampers, but rather controls the discharge air setpoint, which in turn affects the heater and dampers.

4.12.1 PLC I/O

Analog:

Tagname	Type	Description	Range	Display
L604-TT	AI	Room Temperature	-40 – 60 °C	GD-T, T

4.12.2 HMI - PLC Interface

Discrete Status Bits:

Tagname	Description	Type	Display
L604_CtrlMan	Control Mode Manual	R	GD-T, EF

Discrete Control Bits:


Tagname	Description	Type	Control
L604_CtrlAutoCmd	Set to Automatic Control Mode	W1	EF-PB (L)
L604_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (L)

Analog Values:

Tagname	Description	Range	Type	Display
L604_TC	Discharge Temperature Setpoint (Control Value)	0 - 40°C	R	EF-T

Analog Set Points:

Tagname	Description	Range	Type	Control
L604_TC_Man	Manual Mode Output Setpoint	0 - 40°C	RW	EF-TE (L)
L604_T_SP_Occ	Occupied Room Temperature Setpoint Default = 20°C	0 - 40°C	RW	EF-TE (L)
L604_T_SP_UnOcc	Unoccupied Room Temperature Setpoint Default = 10°C	0 - 40°C	RW	EF-TE (L)

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4.12.3 PLC Generated Alarms


Tagname	Description	Logic	Mask	Pri	Reset
L604_TAHH	Room Temperature High-High	L604_TT => 35°C for > 10 sec	N/A	3	Auto
L604_TAH	Room Temperature High	NOT L604_CtrlMan AND (L604_TT - Controller SP) >= 5 °C for > 5 minutes	N/A	3	Auto
L604_TAL	Room Temperature Low	NOT L604_CtrlMan AND (L604_TT - Controller SP) <= -5 °C for > 5 minutes	N/A	3	Auto
L604_TALL	Room Temperature Low-Low	L602_TT <= 3°C for > 10 sec	N/A	2	Auto

4.12.4 Control Narrative

Utilize PID control to control the supply air temperature based upon the room temperature:

PV: L604-TT
 SP: IF HS-600 (occupied): L604_T_SP_Occ
 IF NOT HS-600 (unoccupied): L604_T_SP_UnOcc
 CV: L604_TC (Reverse Acting)
 CV Limits: Low: 5°C
 High: 35°C

Ensure bump-less transfer is provided between manual and automatic modes.

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4.13 SF-L1 Ventilation Fan – L603

SF-L1 is the primary ventilation fan for the pumping station. SF-L1 should be operated at all times to provide adequate ventilation to the building. SF-L1 is started and stopped via a two-position maintained on/off selector switch on the starter.

4.13.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L603-UL	DI	Ready	Not Ready	Ready	GD-T
L603-IA	DI	Overload Alarm	Normal	Tripped	A
L603-MM	DI	Running	Stopped	Running	GD-A
L603-FSL	DI	Flow Switch	No Flow	Flow	GD-A, A

4.13.2 HMI - PLC Interface

Discrete Status Bits:


None

4.13.3 PLC Generated Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L603_FAL	Low Flow Alarm	L603_Running AND NOT L603-FSL for > 10 seconds	N/A	2	Auto

4.13.4 Control Narrative

A downstream flow switch, L603-FSL, is used to generate an alarm if the fan is running but the flow switch input is in a 0 State for at least 10 seconds. The 10 second on-delay timer gives time for the intake damper to open so as to prevent the alarm at startup.

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4.14 SF-L2 Ventilation Fan – L605

SF-L2 is a secondary ventilation fan for the pumping station, utilized during warm weather to provide additional cooling ventilation for the building. SF-L2 is normally controlled by the PLC, although it can be controlled from the starter via a local H-O-A switch. Note that the start command signal does not directly start the motor, but rather opens the exhaust damper (L605-YV) first. Once the exhaust damper is open, the fan motor starts.

4.14.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L605-HS-1	DI	Starter in Auto	Not Auto	Auto	GD-T
L605-MM	DI	Running	Stopped	Running	GD-A
L605-MN	DO	Run Command	Stop	Run	-

4.14.2 HMI - PLC Interface

The full HMI – PLC interface will include PLC I/O designated above.

Discrete Status Bits:

Tagname	Description	Type	Display
L605_Alarm	Alarm Present	R	GD-A
L605_CtrlMan	Manual Control Mode	R	GD-T, EF-T

Discrete Control Bits:


Tagname	Description	Type	Control
L605_CtrlManCmd	Set to Manual Control Mode	W1	EF-PB (L)
L605_CtrlAutoCmd	Set to Auto Control Mode	W1	EF-PB (L)
L605_Reset	Reset	W1	EF-PB (L)
L605_ManualStart	Manual Start command	W1	EF-PB (L)
L605_ManualStop	Manual Stop command	W1	EF-PB (L)

Notes:

(1) The above could potentially be implemented as bits in a single register.

Analog Set Points:

Tagname	Description	Range	Type	Control
L605_TC_SP	Fan Start Temperature Setpoint Default = 30°C	0 - 40°C	RW	SW-TE (M)

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4.14.3 Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L605_RunFault	Run Fault	L605-HS-1 AND ((L605-MN AND NOT L605-MM) for 120 seconds OR (NOT L605-MN AND L605-MM) for 20 sec)	N/A	2	Auto


Note: Time is allowed for the exhaust damper to open.

4.14.4 Interlocks

Initiating Event	Action	Control Mode		Description
		Auto	Manual	
L604_TALL	Stop	Y	N	Room low-low temperature alarm
L605_RunFault	Stop	Y	Y	Run Fault

4.14.5 Control Narrative

Turn on SF-L2 when the room temperature (L604-TT) equals or exceeds L605_TC_SP. Turn off SF-L2 when the room temperature (L604-TT) is 1 degree below L605_TC_SP.

 SNC-LAVALIN	FUNCTIONAL REQUIREMENTS SPECIFICATION		Document Code: 113368-0000-48ER-0001
			Revision: 00
Client: City of Winnipeg	Project: Marion Wastewater Pumping Station	Package / Area:	

4.15 Miscellaneous

4.15.1 PLC I/O

Discrete:

Tag	Type	Description	0 State	1 State	Display
L105-LSH	DI	Station Flood	Normal	Alarm	GD-A
L501-EA	DI	600 VAC Power Failure	Power Fail	Normal	GD-T
L502-EA	DI	120 VAC Power Failure	Power Fail	Normal	GD-T
L503-QA	DI	TVSS Status	Alarm	Normal	GD-T

4.15.2 Alarms

Tagname	Description	Logic	Mask	Pri	Reset
L105_LSH	Station Flood	L105_LSH for > 3 seconds	N/A	2	Auto
L501_EA	600 VAC Power Failure	NOT L501_EA > 0.5 seconds	N/A	2	Auto
L502_EA	120 VAC Power Failure	NOT L502_EA > 0.5 seconds	N/A	2	Auto
L503_QA	TVSS Failure	NOT L503_QA > 0.5 seconds	N/A	3	Auto