Water System Telemetry & Controls

SCADA Master Plan

July 2020

DRAFT Revision A

Industrial Systems Inc.

12119 NE 99th St. Suite 2090 Vancouver, WA 98682
Voice: (360) 718-7267 Fax: (360) 952-8958
OR CCB# 196597 · WA #INDUSSI880K9
AK #1018436

Table of Contents

GLOSSARY 4
OVERVIEW 5
EXISTING CONTROL SYSTEM 5
Tolt 1 Supply Station 6
Tolt 2 Supply Station 7
0.5MG Reservoir (Crestview Estates) 8
2.0 MG Reservoir (Big Rock Road) 10
Pressure Reducing Valve Sites 12
Residual Chlorine Monitoring 14
RECOMMENDED IMPROVEMENTS 15
Establish Communications to RTU Sites & Replace RTUs 15
Replace RTUs at Tolt 1, Tolt 2, and Reservoirs 15
Add RTUs for Chlorine Monitoring 16
Add RTUs to PRV Sites 16
SCADA Workstations 18
SCADA Software 19
Alarm Management 21
SCADA Cybersecurity 23
Maintenance 25
System Integrator 26
ALTERNATIVES 26
Telemetry Alternatives 26
Server and Virtualization 26
HMI Software Alternatives 27
IMPLEMENTATION, DEPENDENCIES AND COST 28
Install SCADA Workstations 28
Design and Program RTU Units 30
Install RTU at Tolt 1 31
Replace RTU at Big Rock Reservoir RTU 32
Replace RTU at Crestview Estates Reservoir 33
Replace RTU at Tolt 2 34

Pilot RTU at PRV site 35
Residual Chlorine Monitoring 36
P&ID 37
PROPOSED SCADA BLOCK DIAGRAM 39

GLOSSARY

ATS – Automatic Transfer Switch

DOH – Department of Health

HMI – Human Machine Interface - The user interfaces in a manufacturing or process control system. It provides a graphics-based visualization of an industrial control and monitoring system.

OIT – 0perator interface terminal – Industrial Hardened Human Machine Interface. Sometimes having slightly less features and functionality than an HMI but manufactured to be suitable for use in wet or dirty environments. These often have touch panel displays.

MCC – Motor Control Center

Modbus – A data communications protocol

MTU – Master Telemetry Unit. A controller (typically a PLC) that communicates with multiple RTUs.

PLC – Programmable Logic Controller – A digital computer used for automation of typically industrial electromechanical processes.

PRV – Pressure Reducing Valve

PRS – Pressure Relief Station

RTU – Remote Telemetry Unit. A controller (typically a PLC) that controls local equipment and communicates back to an MTU.

SCADA – Supervisory Control and Data Acquisition. An industrial automation control system at the core of many material handling and process control systems.

SPU – Seattle Public Utilities

Telemetry – Wireless communication process for remote data acquisition.

Tolt Pipeline – A water pipeline owned by City of Seattle and managed by Seattle Public Utilities. This pipeline provides water to several cities, including City of Duvall.

UPS – Uninterruptible Power Supply

VFD – Variable Frequency Drive

WWTP – Wastewater Treatment Plant

OVERVIEW

The City of Duvall buys water from Seattle Public Utilities (SPU). There are two intertie points to the Tolt pipeline, two reservoirs, a pump station, several pressure reducing valve sites, and residual chlorine monitors. The city lacks the ability to remotely monitor any of these sites due to a lack of telemetry and a SCADA system.

This SCADA Master Plan defines a plan to implement a reliable SCADA system using modern technology and functionality that will meet the current needs of the City as well as be scalable for any future requirements. Considerations include control system security, current industry standards, future city needs, alarm systems, data logging, reporting, and overall system reliability. This plan first identifies the state of the existing control system which was installed in the mid-1990s.

EXISTING CONTROL SYSTEM

There are two interties into the SPU Tolt pipeline, named Tolt 1 and Tolt 2. The City maintains two water storage reservoirs, one pump station and multiple pressure reducing valve (PRV) stations. Some of these sites have remote terminal units (RTUs) for local control and remote monitoring. The telemetry hardware for these RTUs is obsolete and not functioning anymore. When the telemetry did work for these sites they were tied into a SCADA system located at the WWTP. That system has been removed and there is currently no functioning telemetry or a SCADA system for the City's water system.

In 1995 & 1996 the City's water system underwent a significant update that added a PLC based telemetry system. This system update included the addition of Remote Telemetry Units (RTUs) at the two locations where the city takes water service from Seattle Public Utilities (SPU) as well as the two Reservoirs in the system. A Main Telemetry Unit (MTU) was installed at the City's wastewater treatment plant (WWTP). Essentially the same PLC panel was used at the City WWTP as the MTU, and at both Tolt 1 and Tolt 2 interconnection sites with SPU as well as the Crestview Estates 0.5 MG reservoir site. An expanded version of this panel design was used at the 2.0MG Big Rock Road reservoir.

The RTU and MTU panels all use Koyo- Automation Direct PLC hardware. The RTU panels included an operator interface. The RTU located at the WWTP included an alarm silence button and an audible alarm device. The RTU located at the Big Rock Road reservoir includes the I/O to control the pumps at that location and an alarm annunciator.

The telemetry system used leased telephone lines for communications between the various sites and it included the ability for the MTU to dial out to operations personnel under certain alarm conditions.

The leased telephone lines were problematic from early on and have been abandoned and the service via the local phone company (Frontier) has been discontinued. An attempt was made to install cellular telephone based communications modems to provide communications to the remote sites but that attempt failed as it too was found to be unreliable.

The MTU has been removed from the WWTP and nothing has replaced it. This City is currently without any kind of telemetry or Supervisory Control and Data Acquisition (SCADA) for its water system and without any ability to notify the operations staff in the event of a system failure or alarm condition.

None of the PRV sites have ever been connected to a SCADA system nor has chlorine monitoring ever been a part of the system. City personnel currently drive to various locations in the district to obtain grab samples to comply with DOH requirements to monitor chlorine in the system.

Tolt 1 Supply Station

The Tolt 1 site currently supplies all the water to the City of Duvall. There are two vaults at this site, one with a flow meter and one with the main flow control valve. Each vault has a 120VAC powered sump pump to remove water which would otherwise often fill the vaults. There used to be a remote terminal unit (RTU) panel with a PLC and cellular modem. This panel was destroyed in an auto accident and has not been replaced. Electrical service to this site was recently (mid-2020) re-established. The electrical receptacles and junction boxes for the flow meter and the sump pumps are located inside the vaults. The main flow control valve is equipped with Asco solenoid valves that used to be connected to the PLC to enable flow control, but this hasn't been used since the RTU panel was destroyed. The valves are currently manually adjusted in the field by City personnel.

SITE HARDWARE

The hardware within the previous RTU panel is assumed to have included:

- PLC CPU: D4-430 CPU with a single serial port
- PLC Module: D4 16NA, 16 Pt. discrete input module
- PLC Module: F4-O8TR-1, relay output module
- PLC Module: F4-O8AD, analog input module
- PLC Module: F4-SLV-MB, serial communication module – used leased line modem module and for cell phone modem.
- Cellular Modem: Sierra AirLink GX440 Cellular Phone Modem with antenna
- Data Access Module: Automation Direct, Direct View 1000

The Instrumentation & control devices at the site include:

- Flow Meter
- Flow Control valve
- Sump Pumps, one for each vault
- Pressure Gauges

PLC INPUTS/OUTPUTS

The PLC I/O within the previous RTU is assumed to have included:

Inputs	Outputs
Power Fail	Small Valve Open
Vault Flood	Small Valve Close
Vault Intrusion	Large Valve Open
Battery Voltage	Large Valve Close
Flow	

TOLT 1 SITE CONCERNS

- No Telemetry
- No PLC control panel
- No high level floats in the vaults
- No intrusion detection on vaults
- No automatic or remote control of the valves
- No flow or pressure monitoring

Tolt 2 Supply Station

Tolt 2 is the City's second intertie into the Tolt Pipeline. It hasn't been used in approximately ten years. The City is currently planning on installing a new water main and putting this site back into service.

Much like Tolt 1 there are two vaults at this site, one for the flow meter and one for the flow control valve. Each of these vaults has a 120VAC powered sump pump to drain water which would otherwise often fill the vaults. The remote terminal unit (RTU) panel used to be located inside the main valve vault but has since been relocating outside, adjacent to the vaults. The RTU panel includes a PLC with an obsolete cellular modem. The main valve has Asco solenoid valves that are connected to the PLC for flow control. There is a small data access module for viewing and changing process setpoints, though it no longer works.

There is no automatic control at this site nor any telemetry.

SITE HARDWARE

The hardware within the RTU panel includes:

- PLC CPU: D4-430 CPU with a single serial port
- PLC Module: D4 16NA, 16 Pt. discrete input module
- PLC Module: F4-O8TR-1, relay output module
- PLC Module: F4-O8AD, analog input module
- PLC Module: F4-SLV-MB, serial communication module – used leased line modem module and for cell phone modem.
- Cellular Modem: Sierra AirLink GX440 Cellular Phone Modem with antenna
- Data Access Module: Automation Direct, Direct View 1000

The Instrumentation & control devices at the site include:

- Flow Meter
- Flow Control valve
- Sump Pumps, one for each vault
- Pressure Gauges

PLC INPUTS/OUTPUTS

The PLC I/O within the RTU is includes:

Inputs	Outputs
Power Fail	Small Valve Open
Vault Flood	Small Valve Close
Vault Intrusion	Large Valve Open
Battery Voltage	Large Valve Close
Flow	

TOLT 2 SITE CONCERNS

- No Telemetry
- The PLC control panel contains obsolete hardware
- The cellular modem is obsolete and does not function
- No high level floats in the vaults
- No intrusion detection on vaults
- No intrusion detection on RTU panel
- No automatic or remote control of the valves
- No flow or pressure monitoring

0.5MG Reservoir (Crestview Estates)

Crestview Estates Reservoir is located in a residential neighborhood. It is fenced in for security. There is a small kiosk with two control panels and a junction box for power. One of the control panels houses a PLC and OIT for monitoring and controlling the reservoir level. The second control panel has a 120 VAC panelboard, broken chart recorder, and old telephone modem equipment.

The reservoir level is maintained between 54 and 58 feet. There is a mechanical gauge on the side of the tank as well as a pressure transducer and display inside the valve vault. The pressure transducer signal is also wired into the PLC and displayed on the small OIT inside the control panel. The OIT blinks intermittently and isn't used by operations for any monitoring or alarming – most of the data on it is incorrectly displayed. The valve vault has a sump pump that is plugged into a receptacle inside the vault. A second vault has a pressure transducer and a sump pump.

The existing PLC control panel manages to properly maintain reservoir level at this site. However, there is no functioning telemetry to this site or any process or intrusion alarm monitoring. The control panel at this site has very outdated equipment.

SITE HARDWARE

The hardware within the RTU panel includes:

- PLC CPU: D4-450 CPU
- PLC Module: U-25N, 16 Pt. 120VAC discrete input module
- PLC Module: 9RLY-I, relay output module

- PLC Module: 405-8ADC, analog input module
- PLC Module: H4-ECOM100, Ethernet communication module
    - PLC IP Address: 192.168.200.161
- Uninterruptible Power Supply (UPS)
- Panel Heater: Hoffman, 100 Watts
- Industrial Ethernet Switch: Stride, 5 Port, Stride SE-SW5U
- Operator Interface: Automation Direct, touch screen, w/Ethernet
    - OIT IP Address: 192.168.200.160
- Flow Transmitter Display: SIGNET 3-8511.

The Instrumentation & control devices at the site include:

- Pressure Transducer for reservoir level
- Sump Pumps, one for each vault
- Pressure Gauges

PLC INPUTS/OUTPUTS

The PLC I/O within the RTU is includes:

Inputs	Outputs
Power Fail	Override Close (Flow Valve)
Overflow	
Battery Voltage	
Flow (incoming)	
System Pressure	
Valve Opened	
Valve Closed	

CRESTVIEW ESTATES RESERVOIR SITE CONCERNS

- No Telemetry
- The PLC control panel contains obsolete hardware
- The cellular modem is obsolete and does not function
- No high level floats in the vaults
- No intrusion detection on vaults
- No intrusion detection on RTU panel

2.0 MG Reservoir (Big Rock Road)

The pump station has two 60 HP pumps and a 30 HP pumps located in the main pump station building. These pumps each have a VFD that is controlled from the PLC via hardwired signals. The pumps only turn on if there's a dip in the main system pressure, otherwise they are usually off. The RTU panel with the PLC was installed in the late 1990s and has not been improved upon since.

The telemetry at this site used to involve leased telephone lines, sending Modbus Data back to the WWTP and to also relaying information from the Crestview Estates 0.5 MG Reservoir. The leased line stopped working years ago and a cellular modem setup was installed but never properly setup.

The touch screen interface displays the reservoir level, non-retentive reservoir level trends, valve positions, valve setpoints, and alarms. The adjustable setpoints cannot be changed because the necessary password is unknown. Similarly, the alarms cannot be acknowledged or cleared. This screen is used just for viewing the reservoir level.

The pump station has a door intrusion switch that is wired into the PLC. The OIT alarm page indicates that there is an alarm but there is no way to acknowledge or temporarily disable this alarm.

There is a 125 kW diesel standby generator located in a separate room in the pump station building. There is also an Automatic Transfer Switch (ATS) located in this building. The ATS and generator status signals are wired into the PLC although it is unknown if they are displayed on the OIT.

The control system at this site monitors reservoir level and adequately controls the pump station. There is no telemetry and the PLC hardware is obsolete.

SITE HARDWARE

The hardware within the RTU panel includes:

- PLC CPU: D4-450 CPU
- PLC Module: D4-16ND2, 16 Pt. 24VDC discrete input module (2 each)
- PLC Module: 405-8ADC, analog input module
- PLC Module: F4-04DA-1, analog output module
- PLC Module: 9RLY-I, relay output module
- PLC Module: H4-ECOM100, Ethernet communication module
    - PLC IP Address: 192.168.3.151
- PLC Module: 405-1NCN, Modbus NCN CoProcessor (not in use)
- PLC Module: 405-1NIM, Modbus NIM CoProcessor
- Annunciator: Optimate O-1124, w/serial link, for local alarms
- Industrial Ethernet Switch: Stride, 5 Port, Stride SE-SW5U
- Uninterruptible Power Supply (UPS)
- Operator Interface: Automation Direct, touch screen, w/Ethernet, EA7-T6CL+11Y09B034
    - OIT IP Address: 192.168.3.150
- Cellular Modem: Sierra AirLink GX440 Cellular Phone Modem with antenna
    - [redacted]
    - [redacted]

The Instrumentation & control devices at the site include:

- Reservoir Level Transducer, LIT-102
- Reservoir Level Indicator, located in pump rom: Milltronics Hydroranger 200
- Pump Station Flow Meter, FIT-101: Water Specialties TR16
- Pressure Gauges
- Pressure Reducing Valve (PRV)
- Limit Switches on pump check valves (typical of 3)
- PRV vault flood switch, LSH-105A
- Flow meter vault flood switch, LSH-105B
- Sump Pumps, one for each vault
- Building smoke detector, XS-108
- Building door intrusion switches

PLC INPUTS/OUTPUTS

Inputs

RTU Power Fail
Utility Power Fail
Generator Power On
Generator Running
Generator Trouble
Generator Low Fuel
Generator not in Auto
Smoke
Intrusion
PRV Vault Flood
MTR Vault Flood
Overflow
Battery Voltage
Flow
Pump 1 Running
Pump 1 fault
Pump 1 Hand
Pump 1 Auto
Pump 1 Speed Feedback
Pump 1 Check Valve Closed
Pump 2 Running
Pump 2 fault
Pump 2 Hand
Pump 2 Auto
Pump 2 Speed Feedback
Pump 2 Check Valve Closed
Pump 3 Running
Pump 3 fault
Pump 3 Hand
Pump 3 Auto
Pump 3 Speed Feedback
Pump 3 Check Valve Closed

Outputs

RTU Fail
Call Pump 1
Call Pump 2
Call Pump 3
Pump 1 speed
Pump 2 speed
Pump 3 speed

BIG ROCK ROAD RESERVOIR SITE CONCERNS

- No Telemetry
- The PLC control panel contains obsolete hardware
- The cellular modem is obsolete and does not function
- No intrusion detection on vaults
- No automatic or remote control of the valves or pumps
- No flow or pressure monitoring

Pressure Reducing Valve Sites

The City Water Distribution System covers an area that changes in elevation by approximately 300 feet. 14 pressure reducing valves (PRVs) are distributed around the system to reduce system pressure as the water flows from the higher elevations to the lower. Three of these PRVs are either out of service, or will be soon, and were therefore not evaluated as part of this effort.

Typically only one PRV is operating at a time, depending on downstream demand. These PRV sites are not currently remotely monitored and don't have any onsite power. When a PRV site is not working, or floods, then the City is only notified after a nearby resident calls the City. It may be desirable to add electrical service to some or all of these sites in the future to allow the installation of RTUs to monitor flow and or pressure.

It would be beneficial to monitor pressure at these sites and to alarm high pressure. Less important but also useful would be adding flow monitoring to these sites. Adding flow monitoring would require installing solar power or utility power to the sites.

As part of this evaluation each of the PRV sites was visited and evaluated for the possibility of adding pressure monitoring and flow monitoring. Most of the sites were in residential neighborhoods, by the main roads leading into neighborhoods. The PRV sites were numbered as part of this Master Plan for clarification throughout.

All of the sites were in locations where Verizon cellular signal strength was strong.

Between 615 and 555 Pressure Zones

PRV 555-A The PRV on the southernmost end of the pressure zone, off of 282nd Pl NE, is located off a main road in a residential neighborhood.

Utility power runs overhead along this residential neighborhood road.

PRV 555-B The second PRV in this zone, on the corner of 278th Ave NE and NE 150th St, is off of a moderately busy road next to "The Ridge" neighborhood. "The Ridge" has a sign adjacent to the PRV vault that has power used for sign lighting and for an irrigation control box.

Utility power is buried at this location and also close by from the neighborhood "Ridge" sign.

PRV 555-C The PRV on the northernmost end of the pressure zone, off of NE 156th Pl and Manion Way NE, is located on a neighborhood street in front of a house.

Utility power is buried at this location.

Between 555 and 450 Pressure Zones

PRV 450-A The PRV on the southernmost end of the pressure zone, off of NE 144th Pl and near 272nd Pl NE, is located on a side neighborhood road. Utility power is buried at this location.

PRV 450-B The second PRV in this zone, located off of NE Miller St, is located at the end of a cols-de-sac in a neighborhood. Utility power is buried at this location.

PRV 450-C The PRV on the northernmost end of the pressure zone is located off of Bruett Rd which is a fairly busy road. The PRV vault is located on the road, whereas all the other PRV vaults are located off the road. Utility power runs overhead along the opposite side of the road. There may be buried power on the same side of the road, as there is a residential neighborhood set back about 50 feet from the road.

Between 450 and 330 Pressure Zones

PRV 330-A The PRV on the southernmost end of the pressure zone, off of NE Big Rock Rd, is located off a main road next to a new housing development.

Utility power is buried at this location, on the same side of the street as the PRV vault.

PRV 330-B The second PRV in this zone, off of NE 145th St, is on sidewalk next to a neighborhood access road.

Utility power runs overhead along this residential road, on the same side of the street as the vault.

PRV 330-C The third PRV in this zone, off of NE Kennedy Dr., is located just off of a neighborhood road.

Utility power runs overhead along this residential road, on the other side of the street from the vault.

PRV 330-D The fourth PRV in this zone, off of NE Stephens St and 3rd Ave NE, is located alongside a main street in front of a house.

Utility power runs overhead along this street.

PRV 330-E The PRV on the northernmost end of this pressure zone, on 3rd Ave NE and NE Virginia St, is located in a residential neighborhood. The PRV vault is located in the middle of the road on 3rd Ave. It has a circular valve vault lid, unlike all the others with a rectangular lid.

Utility power runs overhead along this street.

CONCERNS FOR ALL PRV SITES

- No Telemetry
- No pressure or flow monitoring
- No alarming, trending or data logging of system pressures

Residual Chlorine Monitoring

Residual chlorine monitoring is required by Washington Department of Health (DOH). The City monitors chlorine in their 330 pressure zone, the farthest point from where the water is received from SPU. The city does not add any chlorine but rather relies on upstream SPU additions. The chlorine is required to be at least 0.2 mg/L by DOH.

There is a Kuntze Neo Multi monitor installed at the M&O Shop. Other monitors are also installed at several points in the lowest pressure zone. Without further investigation it is unknown how many and what model numbers are there. The Kuntze monitor is still supported and has the capability of adding a 4-20mA analog output signal that can interface to a PLC. This unit has a local display with trending, although the display resolution is not very high and the trend isn't easily visible.

There are Kuntze Neo Multi monitors installed at several points in the lowest pressure zone. These units have a local display with trending, although the display resolution is not very high and the trend isn't easily visible. The units do have Wi-Fi capability and can be connected to a PC for data transfer.

SITE CONCERNS

- No Telemetry
- No centralized monitoring, logging or trending
- No 'Low Chlorine Level' alarm

RECOMMENDED IMPROVEMENTS

A SCADA system should take into account the current needs of the system as well as the future requirements. Future requirements include installing technology that will not be phased out in the near future, developing systems that are resistant to cybersecurity threats, and systems that help maintenance and operations effectively do their jobs.

This section recommends improvement across the City that are needed for a secure and reliable water SCADA system. Each component or aspect of the system is explained, detailing what is lacking and how it can be improved. The section after this, on Implementation, more clearly outlines how these recommended improvements can be executed through a series of projects.

Establish Communications to RTU Sites & Replace RTUs

Telemetry is one of the most important aspects of a water SCADA system. Telemetry allows all the sites to communicate back to a centralized location for alarming, monitoring, and control. The City's previous telemetry network architecture was built around several RTU units communicating to a single MTU station. The recommended approach is very similar except that an MTU unit is no longer required because SCADA workstations can now receive RTU data directly over the VPN-cellular network. The essentially means the RTU units would send data over cellular that would be picked up by a SCADA computer over a VPN internet connection. Adding an MTU as the data gateway instead of a SCADA workstation is also a common option, rather than using a SCADA computer. During the initial site visit and evaluation it was shown that cellular service across the city is strong.

There are several communication options available for telemetry systems, including cellular, licensed radio, unlicensed radio, cable internet, and fiber optic. Cellular was identified as the best option for City of Duvall because of the strong signal strength throughout the City. Radio is not recommended because of the amount of trees in the City. Cable internet and fiber optic would both be suitable for some of the sites but would involve higher installation costs.

The proposed SCADA Block Diagram at the end of the Master Plan shows the recommended network architecture for the water system.

Replace RTUs at Tolt 1, Tolt 2, and Reservoirs

It is recommended that replacement RTUs be installed at Tolt 1, Tolt 2, Crestview Reservoir, and Big Rock Road Reservoir. These RTU units should be standardized in their hardware, including the PLC, OIT, and cellular modem. Each RTU should also have an Uninterruptable Power Supply, which allows the RTU to keep running and send a critical power failure alarm out.

Recommended RTU Hardware:

- PLC with input/output modules– Allen Bradley CompactLogix
- OIT – Allen Bradley PanelView, or Cmore EA9 series touch panel
- Cellular Modem
- Cellular Antenna with surge protection, mounted outside to improve reception.
- Uninterruptable Power Supply
- DC Power Supply

- Electrical Surge Protection
- Terminal blocks and fuses required to integrate existing equipment and instrumentation
- Nema 4 Enclosure with 3-point latch and lock

Each RTU's PLC and OIT should be programmed to control the existing equipment and instrumentation. This program should be written after uploading and looking at the existing PLC program. Additional alarms should be added as recommended in the Alarm section of this Master Plan.

Add RTUs for Chlorine Monitoring

It is also recommended that a design be completed for typical RTUs to be installed at each chlorine monitoring site and that the overall SCADA system be developed to accommodate the installation of RTUs at these sites as budgeting allows.

It is recommended that the Kuntze chlorine monitors be connected to an RTU unit for integration into the SCADA system. This would allow the City to monitor and alarm residual chlorine levels from a centralized location, rather than requiring staff to visit each site. The Kuntze unit at the M&O Shop has the capability to send and analog output signal to a PLC. The other monitoring stations should be evaluated further to determine if they also have this capability, and replaced if they do not.

An alternative to adding an RTU unit with small PLC would be to replace the Kuntze units with a unit that has a cellular modem with Ethernet capability. This alternative would need to be evaluated further.

The Chlorine Monitoring site RTUs should include:

- PLC with input/output modules– Allen Bradley CompactLogix or MicroLogix
- Cellular Modem
- Cellular Antenna with surge protection, mounted outside to improve reception.
- Uninterruptable Power Supply
- DC Power Supply
- Electrical Surge Protection
- Terminal blocks and fuses required to integrate existing equipment and instrumentation
- Nema 4 Enclosure with 3-point latch and lock

Signals that should be monitored include:

- Chlorine Level (mg/L)
- Chlorine Monitor Fault Alarm
- RTU Power Okay
- RTU Intrusion Alarm

Add RTUs to PRV Sites

It is recommended that a design be completed for typical RTUs to be installed at each PRV site, and that the overall SCADA system be developed to accommodate the installation of RTUs at these sites as budgeting allows.

It would be beneficial to monitor pressure at these sites and to alarm high pressure. Less important but also useful would be adding flow monitoring to these sites. Adding flow monitoring would require

installing solar power or utility power to the sites. These two options should be evaluated further. They are described below.

Option 1: Pressure Monitoring, with battery units

It is recommended that the city install a pressure transducer with a cellular and battery unit at their PRV sites. The cellular antenna can either be flush mounted in the pavement or if reception in the area is lacking it can be mounted on a stand. Because there are few common options for this for these products, they should be looked at more thoroughly in a pre-design effort. This approach would allow alarming on high pressure or low pressure. It would allow trending these pressure readings on the SCADA.

One option that would work is the Hydro-Guard remote pressure monitoring system by Mueller. This product has a replaceable battery that lasts from 2 to 5 years, and a cellular RTU that sends data to Mueller's website for remote monitoring.

Mission Communications also makes similar pressure monitoring stations with cellular RTUs. These units would require power, either from a solar unit or the utility. This product includes a website interface for monitoring data.

The PRV Pressure Monitoring RTUs should include:

- Pressure Transducer
- Cellular Modem
- Cellular Antenna with surge protection
- Waterproof enclosure
- Replaceable Battery

Signals that should be monitored include:

- Pressure
- Pressure High Alarm
- RTU Power Okay

Option 2: Pressure and Flow Monitoring, with site power installed

Monitoring flow between the pressure zones would be advantages but would also require adding power to numerous PRV sites. There are 11 active PRVs, although there is typically only one lead PRV per zone. It is not considered a high priority but would allow the City to more accurately monitor their water system. Most of the sites have enough existing piping that a flow meter could be installed. A few do not and would require a more complicated installation, such as changing or adding pipe runs.

The Mission Communications MyDro product has a cellular RTU unit that multiple analog or discrete devices can be connected to. The data can be monitored on their website and it can also be extracted continuously and integrated into the main SCADA.

There are many flow meters that could be connected to an RTU unit. Magnetic flow meters are recommended. Toshiba, Siemens and E+H are a few brands that make commonly used flow meters. The exact make and model should be selected during the pre-design phase.

The PRV Pressure & Flow Monitoring site RTUs should include:

- PLC with input modules– Allen Bradley MicroLogix
- Cellular Modem
- Cellular Antenna with surge protection, mounted outside to improve reception.
- DC Power Supply
- Electrical Surge Protection
- Nema 4 Enclosure with 3-point latch and lock

Signals that should be monitored include:

- Pressure
- Pressure High Alarm
- Flow
- Vault Intrusion Alarm
- RTU Power Okay

SCADA Workstations

It is recommended that three SCADA workstation be installed for the City's water system. These workstations would be standard PCs with Windows 10 operation stations. Multiple stations are recommended in order to provide adequate redundancy, and to allow multiple users simultaneous access to important water system information. Each of these workstations would be accessible via a VPN remote desktop connection. They should all be installed at the Public Works Engineering Office on their own dedicated SCADA network, though any number of these workstations could be dedicated for a remote user such as a remote user at the M&O Shop.

One of the workstations should be designated as the primary station where the main HMI application and data logging occurs. It would communicate with the RTUs over a VPN cellular network. It would distribute this data via the HMI application to the other workstations. This primary station would also contain HMI development software, the main data logging and reporting software. This workstation should have limited users because of its critical role in managing SCADA data and HMI performance.

A second workstation should be installed in the Public Works Engineering Office in a location where multiple staff members can monitor it. This system should be made available for remote connection via RDP as described below.

A third workstation should be installed for Maintenance and Operations (M&O) Staff. This should be installed at the Public Works Engineering Office to allow a fast connection to the main SCADA workstation, which it continuously relies on for data. This computer can be remotely accessed from the M&O shop through a VPN and remote desktop connection (RDP) connection. This RDP connection works well and would also allow users to remotely access the system from anywhere they have a securely configured workstation, such as their homes.

Additional workstations with the HMI software can be added as the city sees fit. The above mentioned architecture lends its self well to adding future workstations. The primary workstation is the important computer in this setup, as it distributed data to however many workstations are out there.

SCADA Software

SCADA software includes all the different pieces of software required for a SCADA system to function. The most notable piece of this is the HMI software. The HMI software is a graphical based user interface system. The graphical screens are typically custom built, specific to the process or system being monitored and controlled. Other important software n a SCADA system includes the alarm software, data logging software, reporting software and PLC programming software.

HMI Software

There are several suitable HMI software platforms available. Wonderware Intouch is recommended because it is already used at the City's WWTP. It is also one of the most widely used platforms in the water/wastewater industry, has long term projected manufacturer support and has significant local support. Wonderware also has built in data logging that can be exported for reporting tools.

Historian

While Wonderware does include a built in data logging tool, it can be cumbersome to access this historical data without the deployment of the companies Historian add on.

Alarm Software

HMI software has built in alarm and event recording software. Additional software is important for after hours emergency situations. This software is typically installed on a SCADA computer. It can call, text and or email alarm situations to operators. Win911 and TopView are two common software solutions used for this. It is recommended that TopView by Exele be selected as the primary emergency alarm software. It should be installed on one of the SCADA computers at the Public Works Engineering Office.

Data Logging and Reporting Software

Data Logging is an important aspect of a water SCADA system. Basic data logging capabilities are included in all the main HMI software platforms. Microsoft SQL is typically used by these platforms to store the data. Historical data can be viewed and trended in the HMI software but sometimes additional reporting is required.

SyTech XLReporter is recommended for creating automatic reports as well as on-demand reports. This software relies on Microsoft Excel, which also can be used for some basic reporting needs. XLReporter is a reliable tool for automatic reporting.

Recommended data to be logged is listed below. This list should be developed further in a design effort.

Tolt 1

- Main Flow
- Main Flow Totals
- Supply Pressure

Tolt 2

- Main Flow
- Main Flow Totals
- Supply Pressure

Crestview Estates Reservoir

- Reservoir Level
- System Pressure
- Flow

Big Rock Reservoir

- Reservoir Level
- System Pressure
- Flows
- Pump Amperages

PRV Sites

- Pressure
- Flow

Chlorine Monitoring Sites

- Chlorine Level (mg/L)

PLC Software

PLC programming software must match whichever PLC hardware is used. If Allen Bradley CompactLogix hardware is used for the RTU sites then it should be programmed with Rockwell Studio 5000. The City can choose to buy the software themselves or they could rely on a system integrator to use their own software licenses, which is quite common in the industry.

Alarm Management

SCADA alarms are important for controlling and maintaining a water system. They can allow for fast and appropriate response when an emergency situation occurs. They also allow for better maintenance and operation of the system.

It is recommended that an alarm list and alarm category system is created and maintained. Alarm categories should be created based on the severity of the alarm and how it should be responded to. All alarms should be programmed into the HMI system. Additional alarms should be sent to the emergency alarm system. A proposed alarm list for City of Duvall is attached to this Master Plan.

Recommended alarms are listed below. This list should be developed further during the design effort when the SCADA system is being implemented. It should be revised as future sites are added to the SCADA.

Tolt 1

- Valve Vault Flood
- Flow Meter Vault Flood
- RTU Power Fail
- UPS Power Fail
- UPS Battery Low
- Intrusion
- High Pressure
- Communications Failure

Tolt 2

- Valve Vault Flood
- Flow Meter Vault Flood
- RTU Power Fail
- UPS Power Fail
- UPS Battery Low
- Intrusion
- High Pressure
- Communications Failure

Crestview Estates Reservoir

- Reservoir Level High
- Reservoir Level Low
- Valve Vault Flood
- Flow Meter Vault Flood
- RTU Power Fail
- UPS Power Fail
- UPS Battery Low

- Intrusion
- High Pressure
- Communications Failure

Big Rock Reservoir

- Reservoir Level High
- Reservoir Level Low
- Valve Vault Flood
- Flow Meter Vault Flood
- RTU Power Fail
- UPS Power Fail
- UPS Battery Low
- Intrusion
- High Pressure
- Communications Failure
- Pump #1 Fault
- Pump #2 Fault
- Pump #3 Fault
- Smoke Detector
- Utility Power Fail
- Generator Running
- Generator Trouble
- Generator Low Fuel
- Generator not in Auto

PRV Sites

- High Pressure
- Low Pressure
- RTU Power Failure
- Intrusion
- Communication Failure

Chlorine Monitoring Sites

- Low Chlorine Level
- Intrusion
- RTU Power Failure
- Chlorine Monitor Fault
- Communication Failure

Emergency Alarm System

An emergency alarm system should be installed to notify City staff after working hours. A typical system can call, email, and/or text. This system should be programmed to easily allow staff to change when the system is active and who it calls. It is recommended that Topview software by Exele be installed. A suitable alternative is Win911. These are both software based solutions that should be installed on either the SCADA server or main SCADA workstation computer.

SCADA Cybersecurity

The following recommendations are suggested for security of the SCADA network. These should enforced and maintained by both the City as well as the City's System Integrator.

General Guidelines

1. Internet access to the Server should be limited and only enabled when needed.
2. Remote access to the SCADA should only be done when necessary, and always through the City's firewall. Only trusted partners should be allowed to establish a remote connection.
    - Each connection to the SCADA should be analyzed to assess risk and necessity.
3. Two-factor authentication to access SCADA system remotely.
4. Passwords should be strong to avoid "brute force" attacks.
5. Passwords should be periodically changed, at least twice per year.
6. Implement Role-based access control for HMI operation.
    - Junior Operator – Can view the process but not change setpoints or acknowledge alarms
    - Operator – Can monitor/control the process, change basic setpoints and acknowledge alarms
    - Supervisor – Can change important setpoints and shelf non-critical alarms
    - Engineer – Can make programming and configuration changes to SCADA
    - IT – Can make changes to IT system, including changes to the firewall and remote login gateway
7. Accounts between users should not be shared.
8. SCADA computers should be dedicated for that purpose.
9. Unnecessary operating system services – email, internet, etc. – should be disabled from SCADA computers unless deemed necessary.
10. Software installed on SCADA computers should only be done so after careful consideration.
11. Use static IP addresses for SCADA computers and devices. Maintain list of IP addresses.

Protecting against Malicious Attacks

The SCADA computer should use technologies to protect against malicious threats. This includes, but is not limited to, anti-virus software, malware software and a firewall. Slow devices, difficulties logging in, internet connectivity issues and website redirects can all be signs of a potential cyberattack or data breach. New threats are continuously developed by malicious sources so it is important to keep software updated and reviewed under a maintenance plan.

Cyber-Security References

The US Department of Homeland Security publishes a lot of information about keeping the Nation's infrastructure secure. One such publication is geared specifically toward SCADA systems titled "21 steps to Improve Cyber Security of SCADA Networks".

The National Security Agency also has assembled a collection of reference material on their Security Configuration Guidance webpage. Specifically related to SCADA systems are "Securely Managing Industrial Control System (ICS) Networks" and "Securing Assets within a Closed Industrial Control System (ICS) Network".

In addition it is advised to consult with the manufacturer for the technologies deployed for specific recommendations on their products. Examples would be the Rockwell Automation "System Security Design Guidelines" and the "GE Cimplicity HMI/SCADA Secure deployment Guide".

Maintenance

Regular maintenance of a SCADA system is important for reliability, accuracy, security and disaster recover. It also helps reduce the large cost down the road of having to completely replace and fix a poorly maintained system. Maintenance can include software patches, replacing computers, adding site and monitoring capabilities, and regular backup of databases.

Spare Parts

Recommended spare parts include

- Spare PLC CPU module
- Spare PLC input/output module for the most commonly used modules
- Spare cellular modem
- Spare DC power supply
- Spare unmanaged network switch
- Spare control relays
- Spare fuses
- Spare Cat 6 Ethernet cables

Software Backups

Backups should be created annually, or after any big programming change is made. They should be stored in a secure location on the City's network.

- Complete backup of server
- HMI application
- Emergency Alarm Software configuration
- Historian logs
- Reports and reporting software configuration files
- PLC Programs

Misc SCADA Maintenance

- Evaluated SCADA computers once a year to ensure hardware and software are secure and operating reliably. The evaluation should identify any software security vulnerabilities, any software/hardware compatibility concerns, and any recommended upgrades. It is anticipated that a SCADA workstation will need to be replaced every 5 to 10 years.
- Maintain SCADA and control system documentation. This documentation should be stored in a secure file folder on the City's network. The SCADA network diagram should be updated any time additional sites are brought onto the SCAD network.

System Integrator

It is recommended that the City hire a System Integrator for control system design and programming efforts. A dedicated integration company will help the city maintain consistency across their SCADA system. Important qualifications include familiarity with HMI and PLC programming, instrumentation selection and field calibration, and significant experience with programming and maintaining water systems.

ALTERNATIVES

Telemetry Alternatives

There are several communication options available for telemetry systems, including cellular, licensed radio, unlicensed radio, cable internet, and fiber optic. Cellular was identified as the best option for City of Duvall because of the strong signal strength throughout the City. Radio is not recommended because of the amount of trees in the City. Cable internet and fiber optic would both be suitable for some of the sites but would involve higher installation costs.

Server and Virtualization

An alternative to installing workstation computers with HMI software is to install a Server with virtual workstation running the HMI software. These virtual machines would run the client HMI software and would be accessed by thin clients. The advantage of this server/client approach includes the capability to more easily add tablets and phones as SCADA monitoring devices. The disadvantage is the programming costs, server maintenance cost and server replacement costs. This configuration is typically only recommended for much larger systems.

The server should be mounted in a server rack. Because the existing server rack at the Public Works Engineering Office is excessively full, a new small server rack would need to be purchased and dedicated to this server. A UPS should be installed as well to provide emergency power to the server, which would allow alarms to be sent out during a power outage.

SCADA Server Configuration:

- Rack mounted server with two network interface cards
    - The first network should be tied into the City's network and used for remote connections
    - The second network should be used for a dedicated SCADA network. The MTU and SCADA workstations should be the only other devices connected to this.
- Rack mounted UPS, dedicated to server
- Small server rack, located in Public Works Engineering Office near existing server rack

HMI Software Alternatives

There are several HMI software platforms that would work well for the City's water SCADA system. Wonderware Intouch was selected as the best option for City of Duvall. As part of this Master Plan both FactoryTalk View and GE Cimplicity were also considered. Furthermore, cloud based HMI Software options were considered.

Traditional HMI Software Alternatives

FactoryTalk View by Rockwell is a very suitable alternative to the Wonderware Intouch platform. Rockwell has widespread support and is expected to be supported by Rockwell well into the future. Similarly to Wonderware, FactoryTalk has built in data logging that can also be interfaced with Microsoft Excel and other reporting tools.

GE's CIMPLICITY platform is the second most commonly used HMI software in North America. CIMPLICITY is a very powerful and flexible software package that has many advantages over Wonderware and FactoryTalk View. The software also includes comparable data logging capabilities. However, although CIMPLICITY is very well developed and commonly used it is not continually being developed and lacks the widespread support that Wonderware and FactoryTalk View both benefit from.

Cloud Based HMI Software

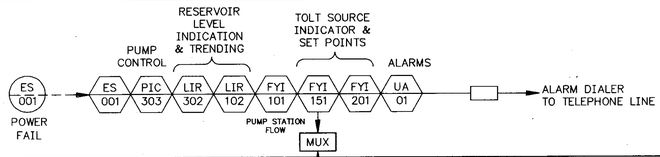
An alternative to traditional HMI software is using cloud based HMI platforms. Popular options in cloud based solutions are often paired with RTU and controller hardware. These options are useful for small applications but are not viable for SCADA system that require more customization, as is the case with the City of Duvall's water system.

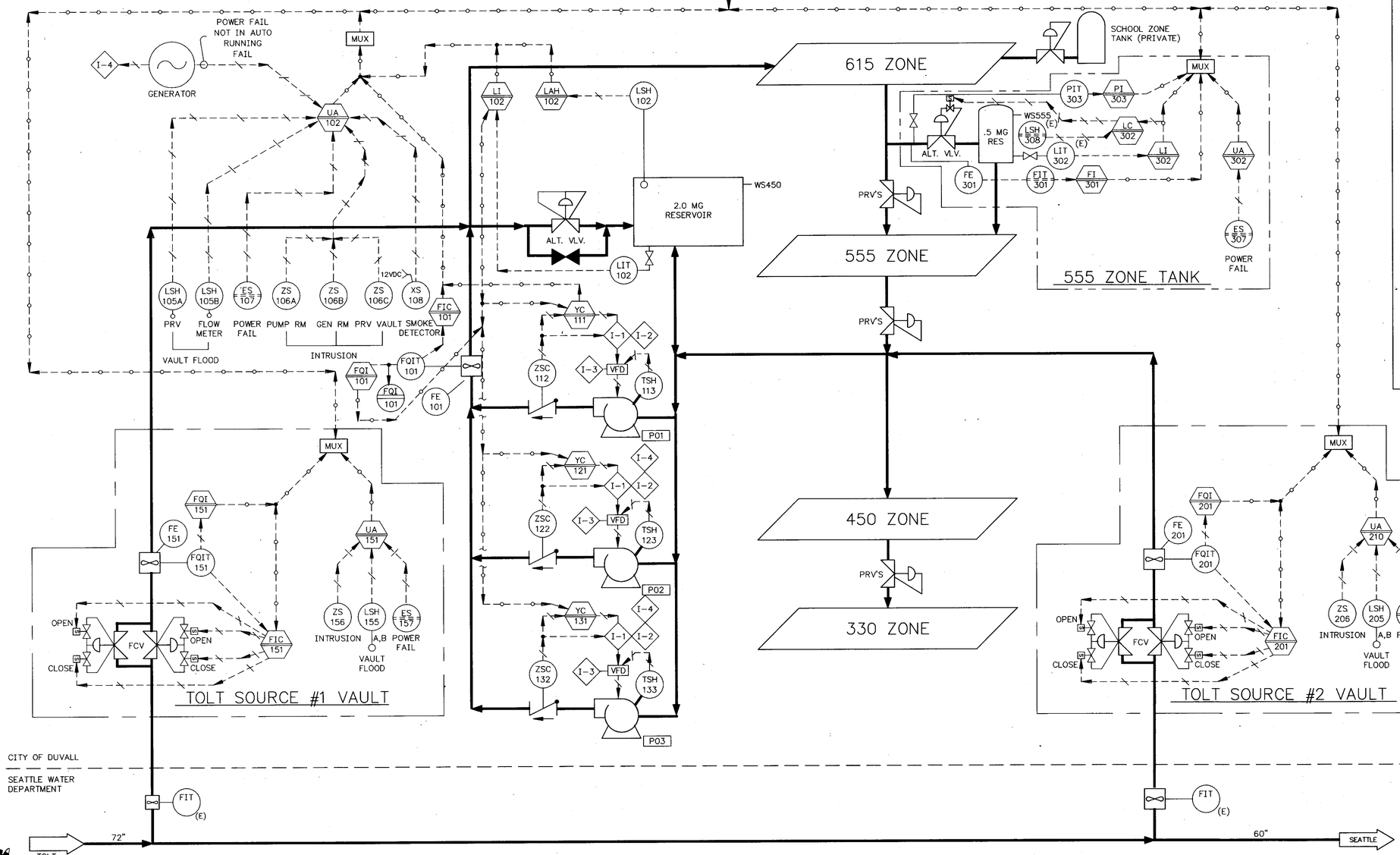
Mission Communications is one such software platform that is often used for small applications. An advantage of a cloud based HMI system is that there is less programming and configuration costs. Disadvantages include lack of customization and limited amount of hardware options. For instance, the pump station at the Big Rock Road Reservoir has too many devices to monitor and control for this option.

Cloud Based HMI software can be integrated into traditional HMI software packages. This is often a good fit when a product is offered that comes included with cloud based monitoring. These products include battery powered devices that transmit over cellular. There are few options for PRV site monitoring that fit this category.

P&ID

CITY SHOP





SYMBOLS LEGEND

- CITY SHOP RTU
- RTU FUNCTION
  - 001 SERIES CITY SHOP
  - 100 SERIES RES/P.S. SITE
  - 150 SERIES TOLT #1 SOURCE
  - 200 SERIES TOLT #2 SOURCE (BIG ROCK RD.)
  - 300 SERIES 555 ZONE STANDPIPE
- S — SOLENOID VALVE
- DIAPHRAM (CLA) VALVE
- VFD — VARIABLE FREQUENCY DRIVE
- PUMP
- PROPELLER TYPE FLOW METER
- MUX — TELEPHONE COMMUNICATIONS EQUIPMENT

ABBREVIATIONS

ES	POWER FAIL SENSOR
FIC	FLOW CONTROLLER
FIT	FLOW TRANSMITTER
FQI	FLOW TOTALIZER
LIT	LEVEL TRANSMITTER
LSH	HIGH LEVEL SWITCH
UA	TROUBLE ALARM
XS	SMOKE DETECTOR
YC	EVENT CONTROLLER
ZS	INTRUSION (DOOR) SWITCH
ZSC	VALVE CLOSED POSITION SWITCH
(E)	EXISTING INSTRUMENT

INTERLOCK NOTES:

- I-1 — VFD CAN NOT DISENGAGE UNTIL CHECK VALVE IS FULLY CLOSED.
- I-2 — IF RESERVOIR REACHES A LOW LEVEL, PUMPS ARE STOPPED.
- I-3 — MOTOR OVER TEMP. SHALL SHUT DOWN VFD AND INITIATE A VFD FAULT ALARM.
- I-4 — ONLY ONE 100 HP PUMP CAN OPERATE AT A TIME ON STAND-BY POWER.

DAVID M. THARP — STATE OF WASHINGTON — 22642 — REGISTERED PROFESSIONAL ENGINEER — 4/4/95
EXPIRES 4/17/97

REVISIONS	GENERAL NOTES

DESIGNED BY	DMB
DRAWN BY	MAR
CHECKED BY	DRB
APPROVED BY	BL
DATE PRINTED	9/7/95
SCALE	NONE
F.B. NO.	X

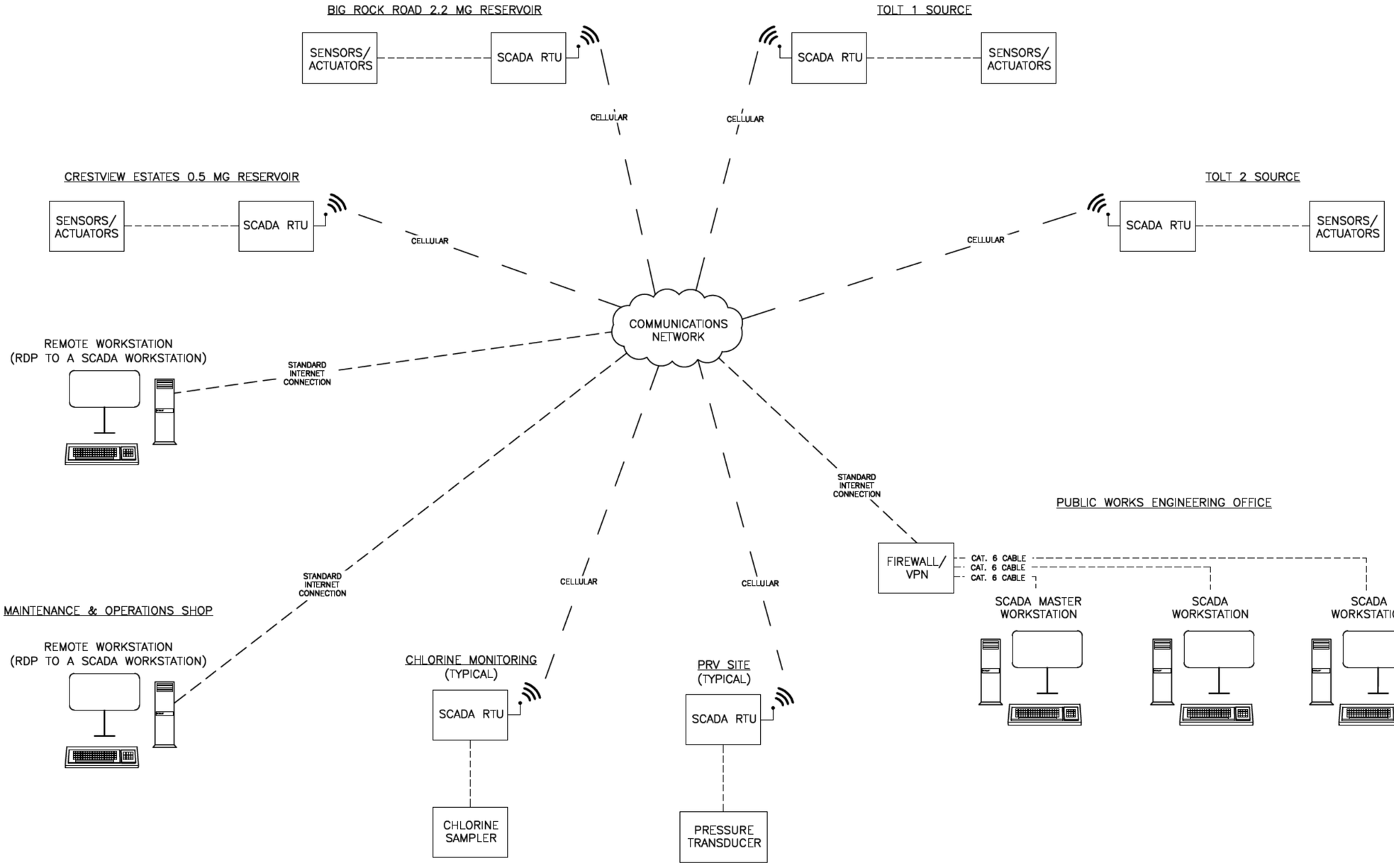
HAMMOND, COLLIER & WADE — LIVINGSTONE ASSOCIATES, INC.
CONSULTING ENGINEERS LAND SURVEYORS
SEATTLE (206) 632-2664 · WENATCHEE (509) 662-1762 · CHELAN (509) 682-2462
HCW-L

CITY OF DUVALL
1995 WATER SYSTEM IMPROVEMENTS
PROCESS & INSTRUMENTATION DIAGRAM

JOB NO. 95006.3
DRAWING NO. P1
SHEET 18 OF 27

ENGINEERING, INC.
P.O. BOX 12884
Mill Creek, WA. 98082-0884
(206) 338-2416

PROPOSED SCADA BLOCK DIAGRAM



REV	DATE	DESCRIPTION	BY

Industrial Systems NC
12119 NE 99th Street
Ste te #2090
Vancouver, Washington 98682
Phone (503) 262-0376
Fax (503) 262-0371
e-mail is@industrialsystems-inc.com
OR CCB #196597 WA #INDUSSI880K9
AK #1018436

CITY OF DUVALL
WATER SYSTEM

PROPOSED SCADA BLOCK DIAGRAM

DRAWN:	
CONTACT:	
PROJECT #:	19.100.02
DATE:	July 2020
DRAWING NO.	